Internet Workflows

YEAR - ONE

Science INTERGRATED

Recent advances in Internet and grid technologies have greatly enhanced scientific experiments' scope. In addition to compute- and data-intensive tasks, large-scale collaborations involving geographically distributed scientists and e-infrastructures are now possible. Scientific workflows encode the logic of these complex experiments, orchestrating these resources and services to provide end-to-end support for the experiment in areas ranging from managing and speeding up the development process to challenges involved in the execution and monitoring of the experiment. This article proposes a portion of the different phases of the scientific experimentation lifecycle.

Complex scientific experiments involve distributed data and computing resources and require collaboration among scientists with various backgrounds. Recently, workflows have become a popular approach to modeling and organizing such experiments.

A workflow specification abstractly models the dependencies between processes within an experiment and orchestrates resources to realize behavior. Over the past few years, various research groups have developed workflow management systems. Successful scientific workflows are evolving into community tools that we can use to build and run more complex and challenging applications.

A new generation of social networking and sharing sites has emerged, one mindful of scientific specific needs — a good example being the myExperiment site (www.myexperiment.org), which makes it easy to find, use, and share scientific workflows and build communities. The Taverna suite is flexible enough to support various aspects of a scientific workflow's life cycle.

In his article "Science 2.0," Ben Shneiderman argues that we must expand traditional scientific methods to deal with the complex issues that arise in social systems and technological innovation. This vision extends the e-Science concept, introduced a decade ago, which focuses mainly on computationally intensive science.

Adam Belloum,
Marian A. Inda,
Dmitry Vasunin,
Vladimir Korkhov,
Zhiming Zhao,
Han Rakhmawida,
and Tiino M. Breit
University of Amsterdam

Mariam Bubak
AGH University of Science and Technology, Poland

Luis O. Hertzberger
University of Amsterdam

PREFACE

This book is written to provide for the needs of all students who may appear for the WASSCE and NABTEX.

After visiting the icampus site, I realized it was interesting but it had a little complex interface that needed time to get used to. And I also noticed it was not accessible by some smartphones. So I dived in into probing for ways to have the lessons offline so I can have the chance to go through It anytime without using the internet.

So after finding a way to do so I realized it was cool and decided to share it with all WASSCE(West Africa Senior School Certificate Examination) and NAPTEX(National Board for Professional and Technician Examinations) candidates.

The book has been so structured that brief and concise notes are given under each topic with a couple of questions after each lesson.

It got to a point in time while putting things together I had almost given up on making the book because of slow network glitches.

I wish you the best and hope you find reading this book interesting and useful.

You can reach me on the handles below to share your view and opinion relating to the book.

Facebook @fb.me/MANeBOOks

Instagram @mario_amando_norplah

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INTERGRATED SCIENCE FOR SHS

YEAR ONE

LESSON NOTE

LESSON 1

TOPIC: Nature of science

OBJECTIVES

By the time you finish reading this session you should be able to:

- Explain the meaning of science
- Explain what scientific method is
- State the processes of scientific method such as

1. observation
2. posing a problem
3. Hypothesis and
4. Experimentation

- Explain the following terms

1. Independent variable
2. Dependent variable and
3. Control

Every human being is a curious or inquisitive person and in biological terms we say 'animal' including you. Isn't it... Good!

This behavior is even more striking in children. They are more curious than even the adult.

Since creation, man has always sought to understand and sometimes explain some of the happenings around him.

For example, what causes the formation of rainbow in the sky?

What causes day and night?

What makes an aeroplane fly in the air like a bird without falling down?

Thus, the curious active mind is always searching to know more about things around him.

The quest for answers to these endless questions can take one or two approaches:

- Supernatural explanations which include beliefs, dogmas and superstitions (an irrational fear of the unknown coming from beliefs which are not based on reasons or facts but on old ideas about lack or magic).

But the question is, is this science?

I hope you guessed rightly. That is not science! What then is science?

But before we start today's lesson, cast your minds back to some of the things you treated at the J.H.S level that relate to science.

- Calculating the volumes of water using different measuring cylinders
- Comparing the masses of different objects such as large rectangular foam, a bag of feathers and a small book.

What is Science?

Science is a continuous process of *investigating*/**examining/exploring** and *experimentation/testing* in order to widen your understanding of the natural world.

Another school of thought also defines *science* as a *process* by which people accumulate *knowledge* and *skills* in which they can place a high and often a measurable degree of confidence.

Simply put, *science* is an organized body of *knowledge* through *enquiry*.

How do scientists make enquiry?

HOW SCIENTISTS WORK

Conducting a scientific investigation/enquiry involves a series of steps (scientific methods).

Scientific methods are systematic approach of gathering

1. observable/ visible,
2. empirical/practical and
3. Measurable evidence that are critically evaluated to arrive at a solution to a problem.

The very first step is to make an *Observation.*

The scientific approach seeks to provide answers to questions through observation.

Observation means looking at things yourself, making use of your **sense organs** of **sight, touch, hearing, taste and smell.**

You observe your body, surroundings, classrooms, a playing field etc using these senses.

Your observation may take either of two forms:

- *quantitative, involving measurements*
- *qualitative or descriptive*

What follows after Observation is to *pose a Clear Question/ State a Problem.*
Stating a question to the activity is the second step to embark on this method.

The question can be in a form of *Why, Where, How, What, Who* and so on.

For example, *why do fruits for example mangoes fall down straight to the earth's centre and not up?*

See to it that the question you pose is clear and precise.

Secondly see to it that it makes sense pertaining to what you already know about the subject.

Example: Can I run a marathon race faster when I eat a big ball of kenkey the night before the race or drink milo the morning of the race?

What follows after the question is a *Hypothesis.*

A hypothesis is a proposed scientific explanation or an intelligent guess for a set of observations.

It is an "educated guess."

We set out to prove or disprove the hypothesis.

Hypotheses are generated using prior knowledge, logical inference and informed creative imagination. Scientific hypotheses must be designed in ways that enable them to be tested.

Example: "The time it takes to run a marathon is improved by consuming large quantities of carbohydrates before a race".

The **fourth** step in conducting a scientific investigation is *experimentation.*

An *experiment* is a test that is used to eliminate one or more of the possible hypotheses until one hypothesis remains.

The experiment is the cornerstone in the scientific approach to gaining deeper knowledge about the physical world.

Scientific experiments involve *controls,* or subjects that are not tested during the investigation.

In this way, a scientist limits the factors or variables that can cause the results of an investigation to differ.

The controlled variable answers the question '**what do I keep the same'?**

You would have to run a marathon ***without*** *eating kenkey the night before or drinking tea the morning of the race.*

Meaning the kenkey and the tea are the variables which need not to be tested.

A *variable* is a factor that can change over the course of an experiment.

The variable which is deliberately changed is called the *manipulative variable/independent variable.*

The independent variable answers the question '**what do I change'**?

Now from the question "can I run a marathon race faster when I eat a big ball of kenkey the night before the race or drink tea the morning of the race"?

The ***independent variable*** *is the consumption of kenkey.*

The variable that is observed and changes in response to the manipulative variable is called the *responding variable/dependent variable.*

The dependent variable answers the question '**what do I observe**'? *The dependent variable is how fast you run the race.*

The truth is, how fast you run depends on the kenkey (the independent variable), so how fast you run is the ***dependent variable****.*

If you eat a big ball of kenkey at 7 p.m the night before the race, but then get up the next morning and drink two cups of tea before you head to the start line your experiment becomes invalid. Why?

.....because by drinking the tea, you introduce a second independent variable and therefore you will not know whether the faster race time is due to the kenkey you ate the night before the race or the tea you took in the morning before the race.

Note that experiments can only have one independent variable at a time.

If you want to know the effect of tea on your race time, you would have to design a second experiment. This experiment would have the hypothesis "Consuming tea the morning of a marathon improves running time".

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

A hypothesis

Select one:

- is a guess
- is an explanation of a scientific concept.
- is based on what a scientist thinks could happen.
- is a suggested explanation for a phenomena based on evidence that can be tested by observation or experimentation.

Question **2**

Not yet answered

Marked out of 20.00

Flag question

The use of beliefs to explain the natural phenomenon which are not based on any scientific reasons is

Select one:

- Dogma
- Witchcraft
- Superstition
- Taboo

Question **3**

Not yet answered

Marked out of 20.00

Flag question

I will run the marathon race without eating waakye the morning of the race. The waakye here is a

Select one:

- Experiment
- Variable
- Data
- Booster

Question **4**

Not yet answered

Marked out of 20.00

Flag question

I will run the marathon race faster when I drink a bottle of Soobolo. The bottle of Soobolo is

Select one:

- A control
- A responding variable
- An independent variable
- A dependent variable

Question **5**

Not yet answered

Marked out of 20.00

Flag question

A test that is used to eliminate one or more of the possible hypotheses is referred to as

Select one:

- Variable
- Experiment
- Control
- Data collection

LESSON NOTE

LESSON 2

TOPIC: NATURE OF SCIENCE (CONTINUATION) **OBJECTIVES**

As you go through this session, you should be able to

1. **Record, analyze results** and
2. **Draw conclusion** on experiments or observations made.

Following our previous discussion, you should be familiar with the following terms as applied to the meaning of science. These include;

1. Observation
2. posing a question/problem,
3. hypothesis and
4. Experimentation.

Today we shall be looking at the rest of the processes of the scientific method which are

1. Recording and analyzing through observation and
2. Conclusion

Before you begin today's session, consider another example. The example is

*To demonstrate the **minimum** exposure time of light before starch can be detected in a leaf.*

In this experiment, four or more de-starched plants (that is plants deprived of light for 72 hours) in pots are prepared.

Pot 1 is placed in light for 2 hours and then a leaf is tested for starch.

Pot 2 is placed in light for 3 hours and then a leaf is tested for starch.

Pot 3 is placed in light for 4 hours and then a leaf is tested for starch.

Pot 4 is placed in light for 5 hours and then a leaf is tested for starch.

Pot 5 is placed in light for 6 hours and then a leaf is tested for starch.

Pot 6 is placed in light for 7 hours and then a leaf is tested for starch.

In the above experiments, the general observation is that light is directly involved in starch formation in green plants.

Light in these experiments is the **independent variable. Why?**

…… because it is the variable that was deliberately **manipulated (as you can see from the exposure time differences in light)**……2, 3, 4…hours

The test result of **starch** is the dependent variable. Why?

…….. because it is the *observe* variable and changes in response to the manipulative/independent variable which is *light*.

The **fifth** step in conducting a scientific investigation is *recording* and *analyzing* results.

This is the process of gathering information about events in a careful, orderly manner using our *senses*. The information obtained from observation is called *data.*

From the above experiment, we looked at an activity to demonstrate the exposure time of light before starch can be detected in a leaf.

We assume that after the duration of light exposure and the leaves were tested for starch, the following information were gathered:

For 2 hours of light exposure, we have the amount of starch in pot 1 to be 70µg

For 3 hours of light exposure, we have the amount of starch in pot 2 to be 120µg

For 4 hours of light exposure, we have the amount of starch in pot 3 to be 150µg

For 5 hours of light exposure, we have the amount of starch in pot 4 to be 187µg

For 6 hours of light exposure, we have the amount of starch in pot 5 to be 192µg

For 7 hours of light exposure, we have the amount of starch in pot 6 to be 192µg

The above information can be put under these two headings in a two column table

Light Duration (hours)	Amount of starch (µg)
2	70
3	120
4	150
5	187
6	192
7	192

The information gathered above and put in a tubular form as you can see is referred to as *data.*

Scientists use data to make *inferences or draw conclusions.*

An inference is a logical interpretation based on prior knowledge or experience.

These are done using charts, tables and graphs to display your results and draw conclusions.

Now we are going to put this data in a graphical form so we can analyze and make inferences.

From the data provided one can analyze that there is a corresponding increase in the amount of starch with light duration.

Meaning as light duration increases, amount of starch also increases.

The **sixth** step is the *conclusion.*

The key assumption in science is that, experimental results can be reproduced or further experiments could be carried out to check and test for unexpected results.

As evidence builds up, a particular hypothesis may become so well supported that scientists may consider it as a *theory*.

A theory is a well-tested explanation that unifies a broad range of observations.

From the experiment conducted above, *the conclusion* would be;

To obtain maximum starch in plants, they (the plant) are to be exposed to light for about 6 hours.

SUMMARY

Today, we looked at how to record, analyze data and make inferences by using an experiment on plants

We looked also at how data gathered can be presented in a graphical form

We learnt also how to conclude an experiment performed and then communicate our results.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Information obtained from events or observation is called

Select one:

- Data
- Recording
- Analysis
- Observation

Question **2**

Not yet answered

Marked out of 20.00

Flag question

In the above experiment, the amount of starch is

Select one:

- An independent variable
- A dependent variable
- Control

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Well-tested principles that unify a broad range of observations is

Select one:

- Axiom
- Knowledge
- Theory
- Law

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Capturing and recording a sequence of values for later processing is called

Select one:

- Data security
- Data gathering
- Data compressing
- Data mining

Question **5**

Not yet answered

Marked out of 20.00

Flag question

The process of collecting information about events in a careful and orderly manner using our senses is called

Select one:

- Experimentation
- Observation
- Recording
- Data

Finish attempt ...

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Next Activity

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Finish attempt ...

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LESSON NOTE

LESSON 3

Branches of Science

In our previous lessons, we have been looking at science.

We explained science as an organized body of knowledge acquired through inquiry or investigation.

We also looked at how the inquiry is done.

We said scientific inquiry is achieved through the scientific methods.

Then we saw some applications of scientific concepts and principles in our day-to-day activities.

Now when we say **branches** which organism comes into mind? Good! Plants/Trees.

We can liken science to a tree with lots of branches.

But before we start today's session let us take a look at the objectives for today.

By the end of this session, you should be able to

1. Identify the differences between pure and applied science
2. State the sub-branches of both pure and applied science.
3. Name some renowned scientists in Ghana

Back to our example. Science could be liken to an entire tree.

Trees have two systems namely, the root system and the shoot system.

Now science also has two main branches: *Pure Science and Applied Science.*

Now let us look at the following scenarios and see where we can situate them in the different areas in science:

Let me answer the very first one. Then you do the rest

Animals grazing on the field……biology/agriculture

Brewing of akpeteshie……chemistry

You preparing a circuit to produce light……physics

Stars at night……astronomy

Weeding under your father's tomato or groundnut farm……agriculture

Working on somebody's car…… (Mechanical) engineering. Good!

Which of these areas of science above can we consider as pure science or applied science?

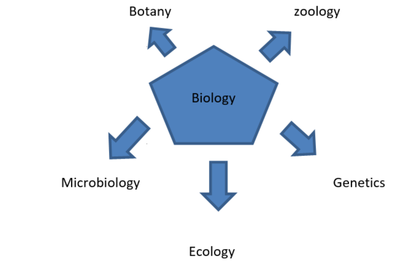
Before that let us explain these sciences (that is pure and applied sciences)

Pure science has to deal with the discovery and formulation of new facts, laws and theories.

It consists of three areas of study, namely *Biology*, *Chemistry* and *Physics.*

Let us explain these branches of pure science briefly.

Biology is a science devoted to the study of living things and how they interact with their surroundings. The living things here are plants, animal, microorganisms, etc. biology has its sub-branches. These are Botany, Zoology, Microbiology, Genetics, Ecology, etc



Now let us quickly explain these *sub-branches* of biology.

Botany: it is the study of plants in terms of where they are found, how they grow and their uses

Zoology: it is the study of animals in terms of where they are found, their structures and mode of lives.

Ecology: it is the study of the relationships living things have with each other and with their environment.

Genetics: it is the study of heredity and variation among living organisms.

If you look carefully at the definitions above, the common word(s) which run(s) through them is/are plants and animals (which are living organisms).

Let us look at another branch of pure science, chemistry.

Chemistry: it is the study of the composition, properties and structure of substances, and the changes they undergo.

The sub-branches of chemistry are, namely, organic chemistry, inorganic chemistry and physical chemistry.

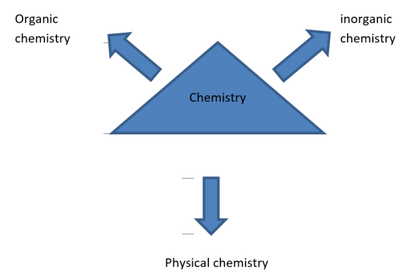
Organic chemistry: deals with the study of compounds that contain carbons. The German chemist, **Friendrich Wohler**, was the first to make an organic compound

Inorganic chemistry: deals with the study of all elements other than carbons and its compounds.

The Russian scientist, **Dmitri Mendeleev**, discovered that an element's properties depends in its atomic weight.

Physical chemistry: deals with the study that is concerned with the theories, laws and experiments that describes the behavior of chemicals.

A Scottish, **Thomas Graham**, is the founder of physical chemistry and explained how gases mix with each other.



Physics is the study of matter and energy (motion, light, electricity, radiation, gravity etc.) and how they interact with each other.

We shall quickly look at what these various sub-branches of physics deal with.

Even their names would tell you which energies they deal with.

They are *heat, light, sound, mechanics, electricity and magnetism.*

What then do we say **Applied Science** is?

Applied Science is the application of facts, laws and theories to matters of everyday living.

Some of the fields of applied science include *Engineering, Pharmacy, Agriculture, Medicine, Geography, Forestry, Environmental Health, Geology, Psychology, Astronomy, Meteorology and Horticulture.*

Now let us look at some renowned scientists in Ghana and elsewhere.

1. Professor Frimpong Boateng- A specialist in cardiology (heart surgeon). He set up the Cardio-thoracic Centre at the Korle-Bu Teaching Hospital.
2. Dr. Felix Komotey-Ahulu- A scientist who succeeded in the knowledge of sickle-cell
3. Professor Mariam Ewurama Addy (late)- A biochemist whose area of study was in biochemical methods for pollution monitoring and Scientific basis for local medical plants effects
4. Dr. Victoria Adobea Donkor- Introduced post-graduates to the new area of environmental photobiology and ultra-violet radiation effects
5. Professor F.K.A. Allotey- Physicist who has contributed a lot to Atomic Physics

Summary

We looked at the branches of science. That is pure and applied sciences.

We explained pure science as the science that deals with the discovery and formulation of new facts, laws and theories.

We gave examples as Biology, Chemistry and Physics. Then we looked at the sub-branches of each

We explained applied science as the application of facts, laws and theories to matters of everyday living. Then we looked at sub-branches of applied science.

Finally we looked at some Renowned Scientists in Ghana and their achievements

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SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Meteorology, geology, biology and mathematics support which career in science?

Select one:

- Chemical engineer
- Farmer
- Botanist
- Ecologist

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Biology, chemistry and mathematics support which career in science?

Select one:

- Pharmacist
- Farmer
- Nurse
- Veterinary officer

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is not applied science?

Select one:

- Physics
- Horticulture
- Engineering
- Agriculture

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is not product of technology in Agriculture?

Select one:

- Shifting cultivation
- GMOs
- Use of fertilizers
- Irrigation

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following scientists initiated the binomial system of naming organisms?

Select one:

- Robert Koch
- Ivan Pavlov
- Carolus Linnaeus
- Edward Jenner

Quiz navigation

NORPLAH MARIO AMANDO 1

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Finish attempt ...

LESSON NOTE

LESSON 4

TOPIC: *Using the Scientific Method in a Controlled Experiment*

(This is an activity based lesson. Students would be engaged in the lesson)

I hope you can now follow the steps of the scientific method. Let us then perform a simple *controlled* experiment in the laboratory or at home.

You can perform this experiment on your own or in a group with your friends.

Before we begin the experiment, let us look at the objective for this session

OBJECTIVES

After going through this session you should be able to

1. Perform one simple controlled experiment using the processes of scientific method.This experiment will involve the growth and development of maize seedlings.

You will be testing the importance of one factor - *light*

That is, *the effect of light in the growth and development of maize seedlings.*

So then how do you define the **problem?**

Remember the problem or question should be precise.

Is light necessary for the normal growth and development of maize seedlings?

Having defined the problem, you should now look for information in the library, on the internet and in books which are related or relevant to this subject (which is the effects of light on plant growth)

You might not find exact answers to the problem.

At this point of lacking full information, you form a **hypothesis** (you make an intelligent guess)

You might assume, for example, that *light is necessary for the normal growth and development of maize seedling*

This hypothesis must now be supported or disproved by an experiment.

So what do you do then?... you begin by planting three maize grains in each of six empty cans, of equal sizes and filled with equal volume of loose, sandy soil.

Mark three of the cans *control* and keep them in a dark room/closet

Mark the other three cans *experimental.*

Place them (the experimental cans) near a window or in some other place that gets full light.

Make sure temperature is nearly the same as possible for both sets of plants.

Water them regularly, making sure that all plants get the same amount of water.

Observe these plants for the next four weeks.

During the period of observation, keep an accurate daily records of the conditions of each seedling.

Now take note of the following:

1. Date on which each seed sprout
2. Daily length and width of stem (mm)
3. The size (mm) and number of leaves
4. Colour of plant

Now let us put the above information (data) in a table form:

Experimental plants	Sprouting date	Stem		Leaves		Colour of plant
		Daily length(mm)	Daily width(mm)	Size(mm)	Number of leaves	
1						
2						
3						

Control plants	Sprouting date	Stem		Leaves		Colour of plant
		Daily length(mm)	Daily width(mm)	Size(mm)	Number of leaves	
1						
2						
3						

Now the two sets of plants will develop very differently.

Those grown in the light may have thick stems and large, healthy green leaves.

Those grown in the dark may have long, weak stems and small yellow leaves.

These results would give strong support for the hypothesis *that Light is necessary for the normal growth and development of maize seedlings*

Remember that any controlled experiment must account for all factors, with one single variable. In this experiment, light was the only factor that varied for the two sets of plants.

If any other factor had been varied, our conclusion would not have been valid

For instance, if the dark set (controlled experiment) had been planted in a different kind of soil.

You could not have known whether their poor growth was caused by the lack of light or by poor soil.

Summary

We looked at how to use scientific method in a controlled experiment.

I believe you have understood the concept of c*ontrolled* experiment after going through this lesson.

Try yours hands on an experiment at home and send me your feedback. That is your recordings, observations and conclusion.

Project: using the procedure above plant beans seeds, two seeds per can.

Use six cans of equal size and use loose sandy soil as well. Keep three cans in a dark room and expose the other three cans to light. Use the table above to record your observations and findings.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Dependent variable
- Data
- Independent variable

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Control set of plants are set close to the window to be exposed to light

Select one:

- True
- False

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Plants kept in the dark room are experimental plants

Select one:

- True
- False

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Plants kept near the opened window are controlled plants

Select one:

- True
- False

Question **5**

Not yet answered

Marked out of 20.00

Flag question

controlled experiments ask the question,

Select one:

- What do I add?
- What do I change?
- What do I keep the same?
- What do I omit?

LESSON NOTE

LESSON 5

TOPIC: *Application of Scientific Concepts and Principles in Everyday Life Activities.*

You may have learnt of the scientific method: If not, please read about it to help you understand this lesson. We are looking at science through a **systematic process** to arrive at a conclusion.

I hope you were able to undertake the project on the effect of light on plants?

I hope you really did?

I want you to send your findings and the challenges you encountered in the comments box.

Today we are going to look at the applications of **scientific concepts** or **theories** in our everyday life activities.

Let me sight one common example of scientific concept at home…….the various plastic designs of (some alphabets, fruits and vegetables and animals) that you have in front of your fridge door.

Are you familiar with that?

Good.

Do you know what is inside these plastics that make them stick? Good… MAGNETS!

We shall talk about this in detail later. Now before we start this session look at what you should be able to achieve for going through this lesson.

You watch this video and read the additional notes bear in mind that you should be able to;

- Mention at least four scientific principles which are applicable in your everyday life activities.
- Explain how these principles work to help us in our everyday life activities

I guess most of you have bicycles. Do you ride your bicycles at night? What helps you to find your way in the dark whiles riding your bike? Awesome!

The light in front of the bicycle.

What makes the bulb shine or bright? Good. The rotation of a device called dynamo.

The dynamo works under a law called the *law of conservation of energy.*

It states that the total quantity of energy in the universe is constant and can be neither created nor destroyed but transformed from one form to another

You will see soon how energy transformation occur leading to the provision of light for your bicycle.

The question is what is a bicycle dynamo?

It is a small device (actually a generator) fitted to the rim of a bicycle tyre to provide electricity for the bulb at night.

Now this is how it works.

The top of the dynamo is touched against the rim of the tyre which rotates when the bicycle is moving (kinetic energy).

The rotation of the top of the dynamo rotates a permanent magnet in the middle of some coils of wire inside the dynamo (kinetic energy).

The rotation of the magnet produces a changing magnetic field and this generates electricity (which is electrical energy) in the coils of wire.

The electricity produced is conveyed through wires connected to a bulb. The electricity causes the bulb to bright (light energy).

So the transformation is from kinetic energy to electrical energy to light energy

Another principle or theory is the useful application of *forces*.

Now what is force? A *force* *is simply a push or a pull. It could also be defined as that which changes a body's state of rest or uniform motion in a straight line*.

One important force to consider is biological force. Here we are looking at muscle force.

The muscles of parts of your body are able to carry out certain functions by contracting and relaxing the muscles.

Movement of your body depends on two sets of muscles at each joint.

Some of the joints we may consider are the elbow and knee joints.

The elbow joint has two sets of muscles whose actions are opposite.

Meaning, when one sets contracts the other set relaxes.

Activity

Now straighten up your left arm.

Bring or pull your lower arm close to your body as if you want touch your shoulder with your fingers. Now do it again and again. What happens to the muscles in your upper arm?

The top muscles become thicker (contracts) to pull the lower arm bone close to the upper arm whiles the other muscles relaxes.

Skeletal muscles always work in pairs like this because they can only provide a pulling force. In fact, they never push

Another concept worth discussing is magnets. Magnets are used in homes, farmhouses and in the industries.

At home we use magnets to hold papers and other small items to the refrigerator.

For example, if you or your mum wants to leave a notice for your siblings, it could be placed in front of the refrigerator with the help of magnets

In industries, electromagnets in cranes are used to grab and move large containers and metals which cannot be lifted by humans.

Let us look at another application of scientific principles.

This has to do with saponification or soap making. Soaps are used for bathing, cleaning our homes, for laundry, etc.

Saponification is a name given to a chemical reaction that occurs when a vegetable oil or animal fat is mixed with a strong alkali.

The alkali are produced from dried and burnt cocoa pod or plantain peels.

The ash (which is the alkali) is mixed with the oil or fat to make soap. I believe you know a soap called 'Alata Samina'.

Summary

We looked at the application of scientific concepts and principles.

We studied the principles of energy conservation, where we looked at how the bicycle dynamo works to produce light at night for your bicycle. There are lots of examples involving transformation of energy. The Akosombo dam and your ceiling fans all work based on the law of conservation of energy.

We looked also at magnets and their uses at home, in industries and on the field.

Finally, we saw how the concept of saponification is applied to produce soap.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

The rotatory device on the tyre of a bicycle that generates electricity is called

Select one:

- Dynamo
- Rim
- Spokes
- Bulb

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which law or principle does the dynamo operate on?

Select one:

- The law of gravity
- Newton's law
- The law of energy
- The law of conservation of energy

Question **3**

Not yet answered

Marked out of 20.00

Flag question

which of the following will be the energy transformation of the dynamo in producing electricity?

A. Kinetic energy → electric energy

B. Potential energy → electric energy

C. Heat energy → electric energy

D. Sound energy → electric energy

Select one:

- B
- D
- C
- A

Question **4**

Not yet answered

Marked out of 20.00

Flag question

A gas used as a disinfectant in treating water is

Select one:

- Hydrogen
- Chlorine
- Fluorine
- Oxygen

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Animals which use sounds as their eyes are

Select one:

- Anteaters
- Snakes
- Cats
- Bats

LESSON NOTE

Lesson 6

SCIENCE, TECHNOLOGY AND HOW SCIENCE IS INTEGRATED

I hope you have read the lesson on the branches of science.

1. It is explained that like a tree with branches so is science. We looked at pure science and applied science.
2. We gave examples of both pure and applied sciences such as physics and engineering respectively.
3. We also identified some prominent scientists both in Ghana and on the international scene.

You are now going to study about science and technology.

Their importance, interrelationships and applications.

By the end of this lesson you should be able to

1. Explain Science and Technology
2. Recognize the importance of science
3. Identify interrelationships in science and technology
4. Differentiate between science and technology
5. Recognize the relevance of solving problems using the knowledge from different branches of science

Importance of Science

There are many reasons for studying science among which are,

1. Providing us with vocations
2. Enabling us to understand the basic principles of nature
3. Providing answers to questions about nature
4. Teaching us scientific attitudes and methods
5. Helping us to improve general health standard and to reduce the belief in superstition.
6. Helping us to acquaint ourselves with the contributions of outstanding scientists.

Science and Technology

Science, as we have explained previously, is the process by which individuals *accumulate knowledge* and *skills* in which they can place a high and often measurable, degree of confidence.

Technology on the other hand, is the **application** of **the knowledge** and *skills* acquired to improve life and satisfy the needs of individuals.

Today, we have Genetically Modified Organisms (GMO). Now we have genetically modified plants which are more resistant to pest and adverse weather conditions, produce high yields and have a relatively long shelf life than the ordinary plants. This is a result of Genetic engineering (technology). There are several examples we could site. Do think about some of these yourself.

Interrelationships between Science and Technology

- *Science discovers fundamental information about how the universe works.* **Technology is the practical application of the information about how the universe works.**

For example, in the study of science, it has been discovered that energy cannot be created nor destroyed but can be transformed from one form to another (*the law of conservation of energy*).

Technology has practicalised this discovery.

The generation of hydroelectric power is a typical example where the running water turn/propel fans to generate electricity.

The water in the Dam (static water) has potential energy.

The water is channeled through tunnels to propel huge fans.

The running water transforms the potential energy to kinetic energy; the fans propel (kinetic energy); the propelling fans generate electricity (electrical energy).

So in the generation of electric power, energy is transformed from one form to another.

Another classic example is Newton's 3rd law of motion which states that "Whenever a force acts on one body, an equal and opposite force acts on some other body".

Simply put, to every action there is an equal and opposite reaction.

This discovery of science by Newton has been applied by technologists to design and construct rockets.

The rockets which form a familiar feature of firework displays contain solid chemicals which burn to produce a high velocity blast of hot gas.

Space rockets which are designed to travel long distances have tanks of liquid fuel together with a supply of either liquid oxygen or some other liquid which produce oxygen to enable the fuel to burn.

A chemical reaction takes place inside the rocket and creates a large force which propels the gaseous products of combustion out through the tail nozzle with tremendous velocity (action). The reaction to this force propels the rocket forwards.

- **We use technology to learn about science and we use science to build technology.** In the discovery of new planets and how habitable they are, NASA has designed and developed state of the art space robots/crafts (technology) to study the weather, soil and other elements to see whether humans can inhabit those planets. So you see, the technology here is the space craft and the investigations made on other planets have to do with science discoveries.

Differences between Science and Technology

- The products (principles and theories) of science cannot be seen or felt but the products of technology can be seen or felt
- Science can only be demonstrated whereas technology can be bought and used
- Scientific principles and theories can be understood whereas technology can be used without understanding
- Changes in scientific knowledge occurs gradually whereas changes in technology occur within a short time
- Science is seen as *knowing why* and technology is seen as *knowing how*.
- Science is searching for and theorizing about cause whereas technology searches for and puts into practice new processes.
- Science analyzes, generalizes and *creates theories* whereas technology analyzes and s*ynthesizes designs*.

Let us now look at science as an integrated subject.

Integrated science involves teaching and learning several fields of science as a whole such that none of the fields stands out on its own. This is to enable students appreciate science and to identify the interrelationships that exist among the various subjects of science in solving problems.

A typical case in point is dealing with infected crops in a farm.

- One has to understand the pest and how it spreads- which is Biology
- One has to understand the science of cultivation- which is Agriculture
- One has to develop an effective pesticide- which is Chemistry
- One has to develop a pesticide that could kill the pest but would be safe on the crop without having any effect on individuals that would consume it- that is Biochemistry
- One has to design and produce sprayers for efficient spreading of the pesticides- Physics and Engineering
- One has to calculate the amount of pesticide required to spray, say, a land acre of infected crops – Mathematics

So in solving the problem of infected crops, you have Biology, Agriculture, Chemistry, Biochemistry, Physics and Mathematics at play. That is integrated science.

Summary

We explained what science and technology are and how they interrelate.

We talked about the differences between science and technology also.

Finally, we looked at integrated science and how the knowledge from the different branches of science are combined to solve problems in our lives

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

In solving the problem of day old chicks, use the branches of science above to answer the question below:

Providing lamps for the coop

Select one:

- physics
- engineering
- biochemistry
- mathematics

Question **2**

Not yet answered

Marked out of 20.00

Flag question

In solving the problem of day old chicks, use the branches of science above to answer the question below:

Composition of drugs to be provided to chicks.

Select one:

- physics
- chemistry
- agriculture
- engineering

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which one of the following is used as an explosive?

Select one:

- Graphite
- Phosphorus trichloride
- Mercuric oxide
- Nitroglycerine

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Silk is produced by

Select one:

- Egg of silkworm
- Larva of silkworm
- Pupa of silkworm
- Insects

Question **5**

Not yet answered

Marked out of 20.00

Flag question

In solving the problem of day old chicks, use the branches of science above to answer the question below:

Providing medicines for the chicks.

Select one:

- mathematics
- physics
- biochemistry
- engineering

LESSON NOTE

Lesson 7

CAREERS IN SCIENCE AND TECHNOLOGY

In our previous lesson we looked at science and technology: the interrelationships, the differences and how integrated the subject is.

Hope you were able to answer the questions given at the end of the previous lesson.

Today we shall be looking at the importance of science and technology and some careers you could pursue in science and technology. Now the **objectives** for today's lesson are,

1. To recognize the importance of science and technology to our society especially in education, health, transport and communication, agriculture, security, etc.
2. To identify some careers in science and technology.

Technology in Education

Technology is an increasingly important aspect of modern school life.

This has dramatically changed the way teachers and students go about their daily activities.

For students, computer technology has provided a great wealth of information and knowledge.

Since the introduction of the internet, students are now able to access information on whatever subject they want, wherever they are.

Resources include journals, articles, e-books, practice tests and examinations, model answers and research findings.

Research has also suggested that computer technology has helped students to improve their grades in other subjects, most notably science.

Practically, students can work much faster using a computer which enables them to do more studies in the same period of time.

For teachers, science and technology with the use of computers has enabled them to make their lessons more interactive and therefore much more interesting and rewarding.

This method has also been shown to improve pupil performance as lessons are more memorable and therefore students are able to retain information more effectively.

Teachers, like students, can also find a whole host of resources on the internet.

Teachers are also able to recommend good resources to student to further encourage and stimulate their learning.

Computer technology has enabled systems of obtaining and recording information much more efficient and effective.

Computer records are much harder to misplace than rims of paper records.

Finally, submission of work via email and responding to enquiries online save time and energy.

- *For telecommunication.*

Today we see the role of satellites in global communication.

It is been used by radio, television, cell phones, GPS (Global Positioning System) and computers to reduce the wide world into a global village.

Satellites are used to study weather patterns and predict weather conditions in order to avert natural disasters.

- *Transportation*

Under transportation, we have electric trains, planes, electric car, and submarines

- Entertainment

We have video games, virtual reality, iPod, mp3

- *Agriculture*

The use of fertilizers, genetically modified organisms (plants and animals), combined harvesters, irrigation.

- H*ealth and medicine*

Cloning, hybridization, embryonic cell research, in vitro fertilization, the use of magnetic, resonance and imaging (MRI) to diagnose diseases.

- *Security*

The use of closed circuit cameras/televisions (CCTV), alarm bells

- *Commerce*

e-banking, e-commerce by using the internet services.

Now let's look at some careers in science and technology. Perhaps you have a career in mind to pursue.

CAREER	MAJOR BRANCH OF SCIENCE INFLUENCING CAREER	SUPPORTING BRANCHES OF SCIENCE
Chemical Engineer	Physics	Geography, Mathematics and Meteorology
Ecologist	Biology	Meteorology, Geology, Mathematics
Botanist	Biology	Chemistry And Geology
Food Nutritionist	Biology	Chemistry, Physics And Mathematics
Mechanical Engineer	Physics	Mathematics And Chemistry
Chemical Engineering	Chemistry	Physics, Mathematics,
Farmer	Biology	Chemistry, Mathematics, Agriculture
Nurse	Biology	Chemistry And Mathematics
Agricultural Engineer	Physics	Mathematics And Chemistry, Agriculture
Veterinary Officer	Biology	Mathematics, Chemistry
Metallurgist	Physics	Chemistry, Mathematics
Meteorology	Physics	Mathematics, Geography
Pharmacist	Chemistry	Mathematics, Biology, Physics

Summary

We looked at the importance of science and technology. Mentioned some such as education, telecommunication, health and medicine, security, etc.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the careers below helps plan a voyage to another planet or moon?

Select one:

- Environmental Scientist
- Astronomist
- Geoscientist
- Space scientist

Question **2**

Not yet answered

Marked out of 20.00

Flag question

The space shuttle works on which law?

Select one:

- Newton’s 3rd law
- Newton’s 2nd law
- Newton’s law
- Law of conservation of energy

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the careers in science below conducts experiments with dyes to see how chemicals might disperse during a toxic spill?

Select one:

- Aquarist
- Chemist
- Oceanographer
- Environmental scientist

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following careers below investigates how to breed different species of fish in captivity?

Select one:

- Aquarist
- Geoscientist
- Oceanographer
- Fish farmer

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following energy transformation is involved in the generation of hydroelectric power?

Select one:

- Potential energy, kinetic energy to electrical energy
- Kinetic energy, potential energy to electric energy
- Potential energy, heat energy to electrical energy
- Potential energy, kinetic energy to electrical energy

LESSON NOTE

LESSON 8

Safety Precautions in the Science Laboratory

There is a great saying which states that "those who work the safest way - live to see another day". To what extent do you agree with this statement? This statement is essential to the activities that occur in the laboratory.

By the end of this lesson, you will be able to:

1. Identify the hazards and the safety symbols associated with chemicals
2. State at least five basic safety rules in the laboratory.

Safety Precautions in the Science Laboratory

The study of science involves exploration, invention and investigation. Most of these activities are usually carried out in the *laboratory*. The laboratory is a room equipped for scientific experiments or for testing and analysis.

In addition to the apparatus and procedures, the chemicals used for these investigations, have various forms of *hazards* associated with them.

A hazard is anything or circumstance that has the potential to cause an accident. If these chemicals are not used, stored and handled properly, they can cause injury, illness, diseases, fire and explosion. It is essential to know these hazards and the precautions needed to handle them.

The hazards associated with the chemicals in the laboratory include:

Corrosive substances. *They are materials that, upon contact, destroy tissues and metal surfaces. Examples of such substances are concentrated acids and bases. They are identified with a label on their bottle bearing the warning sign*

Toxic or poisonous substances. *These are substances that can cause death or malfunction of a living system when injected, inhaled, swallowed or absorbed through the skin. Solids such as lead, sodium cyanide, cadmium are examples. Other examples are pesticides, mercury and carbon(II) oxide gas. Their warning sign is*

Oxidizing substances. *They are also called oxidants. They supply oxygen to organic material to burn it fiercely. These substances should not be stored near flammable substance to avoid setting off fire. Examples are organic peroxide, potassium permanganate, trioxonitrate(V) acid and bleach. Their warning sign is:*

Flammable substances. **These substances produce vapour that can catch fire easily. Such substances should not be placed near a source of ignition. This is why lighted cigarette, mobile phones are allowed near petrol pump. Examples of flammable substances are petrol, acetone, LPG and ethanol. Their warning sign is**

Irritants. **They are materials that can cause** *inflammation* **of the skin. Inflammation is a condition of the body when it is reacting to injury of a tissue. The symptoms include reddening or blistering of the skin or swelling. Example are bleaching substances. The reagent bottles of irritants have the following hazard symbol:**

Biohazards. **They are biological agents or conditions that can cause diseases in humans or harm the environment. Examples are bacteria, virus and other microbes. They have the warning symbol:**

Radioactive substances. **These are materials that decay, giving off harmful or ionizing radiations that can cause cancer. Examples are uranium, polonium and radon. Their warning sign is:**

Non – Chemical Hazards

1. **Electrical Hazards:** Electrical injuries usually caused by the passage of electric current through the human body. It usually occur around electrical fixtures, electrical outlet that are overloaded, faulty electrical equipment, exposed live wires, using electric tools in wet conditions especially when the equipment is not properly grounded.
2. **Broken Glasses and Sharp Objects:** Sharpened implements such as knife used in school farm, scissors used for dissection in the biology laboratory, optical pins used in physics and broken glasses in chemistry laboratory can cause injury.
3. **Wet Floor:** Slippery floors have reduced friction and they serve as a hazard because it can cause accident.

Rules and regulations

Safety in the laboratory is important in preventing accidents, fire or explosion or diseases.

To ensure a safe, secure and healthy environment for you, your teachers and other students to carry out investigations, basic safety laboratory rules and procedures must be adhered to. These are:

a. General laboratory rules:

- Do not eat, drink or chew pens in the laboratory to avoid food or drink being contaminated with toxic substances.

- Do not taste any chemical in the laboratory unless you are told to do so by your teacher. It could contain toxic or corrosive substances.

- Do not open a gas tap before lighting a match. The gas might leak into the surrounding air around you and after lighting the match get you inflamed.

- When heating the content of a test tube, direct the mouth of the test tube away from yourself and from others.

- Never smell any gas evolved directly with your nose close to the mouth of the test tube. The gas may be toxic, harmful or irritant to the body.

- Always add concentrated acid to water and not water to a concentrated acid to avoid splashes and heat.

- No pets are allowed in the laboratory.

- Never under any circumstance, remove media or microbial culture from the laboratory.

- Cultures or chemicals should not be mouth – pipetted. A pipette filler should be attached to the pipette.

- If you accidentally spill materials containing live microorganism, pour disinfectant on the spill and inform your teacher.

b. Personal safety

- Always wear eye goggles in the laboratory when heating something or using hazardous chemical.

- Wear aprons or lab coats when performing experiment

- Long hair should be tied to the back so that it does not catch fire in a Bunsen burner or fall in a corrosive liquid.

- Wear gloves when handling chemicals especially toxic materials or corrosive substances.

c. Equipment's.

- Conduct all experiments that produce air- borne contaminants in a fume hood.

- Maintain and check all safety equipment regularly.

- Safety wash and eye wash must be provided in the laboratory.

- Agricultural tools should be washed after use and the metal parts oiled

- All glassware must be cleaned and stored properly after use.

- Do not use electric tools in wet conditions

- Switch tools off before connecting them to a power supply

- Do not plug several power cords into one outlet

- Always pull the plug and not the cord to avoid wear and eventually a shock.

d. Chemicals

- Store chemicals in stockrooms not in the laboratory.

- Chemicals should not be stored alphabetically.

e. Disposal

- Broken glasses should be disposed off in a dedicated container. Follow disposal plan for chemical prescribed

Summary

1. Science laboratory is a room equipped for scientific experiments.
2. Hazards associated with chemicals in the scientific laboratories include corrosive substance, flammable substance, toxic material, oxidant, irritant, radioactive substance and biohazard.
3. Non – chemical hazards include waste or broken glasses; sharpened metals and needles; faulty electrical equipment; exposed wires and wet floors.
4. There are basic laboratory rules and procedures to be followed when using the laboratory.
5. Failure to observe the basic rules could result in accident.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following substances can be described as an oxidant?

Select one:

- Peroxide
- Ammonia
- Carbon(IV) oxide
- Water

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following human system is directly affected when carbon(II) oxide is inhaled

Select one:

- Nervous system
- Digestive system
- Circulatory system
- Urino-genital system

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following hazard symbols are found on the pump of petrol?

Select one:

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Psittacosis is a disease carried handling birds or by inhaling dust infested birds. What precaution should an agriculture scientist cleaning the dried, powdery dropping from pigeons take?

Select one:

- The farmer should wear gloves and nose mask in handing them
- The former should wear liquids gloves
- The birds should be watered constantly.
- The farmer can wear a cap, a boot and hand gloves in handling them.

Question **5**

Not yet answered

Marked out of 20.00

Flag question

When diluting concentrated tetraoxosulphate(V) acid, it is advisable to add the slowly to the water while stirring continuously because

Select one:

- The acid does not dissolve easily in water
- The water has a lover density
- The acid and water mixture can explode
- Heat is absorbed during the reaction

LESSON NOTE

Lesson 9

Measurement

There is an old saying which goes like this, "Science is measurement, if I cannot make measurement, I cannot study a problem scientifically". What then is measurement?

By the end of the lesson, you will be able to:

1. Explain the meaning of measurement
2. Differentiate between fundamental unit and derived unit of measurement
3. State the symbols and SI units of base quantities and derived quantities.

Measurement

It is the determination of the magnitude of a *physical quantity*. A physical quantity of matter is a physical property of matter that can be measured. Example, height of an object.

The physical quantities are divided into *fundamental* or *basic quantity* and *derived quantity*. The fundamental quantity is a physical quantity that cannot be expressed in terms of any other quantity. These are:

1. Length
2. Mass
3. Temperature
4. Time
5. Electric current
6. Amount of substance
7. Luminous intensity

Measurements of fundamental quantities depend on a number expressing the magnitude and reference standard of unit. The units are the standards of measurement used to express the value of the quantity measured. For example, length has other units such as inch, foot, yard, mile based on the Imperial system and millimetre, centimetre, metre, kilometre based on the metric system. There was therefore the need for a consistent or standardized system of unit that is accepted and used internationally. This is the **International system of units**, abbreviated **SI**, after the French name **Le systeme Internationale d' Units**. The SI units of the seven fundamental quantities are shown in the table:

Units of Measurement		
Quantity	**SI base unit**	**Symbol**
Length	Metre	m
Mass	Kilogram	kg
Time	second	S
Thermodynamic temperature	Kelvin	K
Electric current	Ampere	A
Amount of substance	Mole	mol
Luminous Intensity	Candela	cd

Derived Quantities

They are physical quantities that can be expressed in terms of two or more basic or fundamental quantities. Their units are called **derived units**. They have units that are a combination of the fundamental or basic units. Some derived units have special names whiles others do not.

Determining the Units of Derived Quantities with no Special Names:

Worked Examples:

1. Derive the unit of volume.

Solution: Use the problem – solving approach

Analyze: Plan the problem solving strategy

· State the formula of finding volume of a substance

· List the quantities and their units

· Use the formula and units to solve the problem

Calculate: Apply the problem – solving strategy

· Volume = length x breadth x height

Quantities	**Units**
Length	metre (m)
Breadth	metre (m)
Height	metre (m)

Volume = m x m x m = **m^3**

Therefore, the SI unit of volume is cubic metre (m^3)

Evaluate: Does the results make sense?

2. Derive the unit of velocity.

Solution: Use the problem – solving approach

Analyze: Plan the problem solving strategy

· State the formula of finding velocity

· List the quantities and their units

· Use the formula and units to solve the problem

Calculate: Apply the problem – solving strategy

· Velocity is change in displacement over time taken

Quantities	**Units**
Displacement	metre (m)
Time	second (s)

Therefore, the SI unit of velocity is metre per second **(ms^{-1})**

Evaluate: Does the results make sense?

Other examples of units that do not have special names are summarized in the tables below:

Units of Measurement without Special Names			
Quantity	Symbol	SI base unit	Symbol
Area	A	square metre	m^2
Volume	V	cubic metre	m^3
Speed	S	metre per second	m/s or ms^{-1}
Density	r	kilogram per cubic metre	kg/m^3 or kgm^{-3}
Acceleration	a	metre per squared second	m/s^2 or ms^{-2}

Determining the Units of Derived Quantities with Special Names:

Worked Examples:

1. Derive the unit of force.

Solution: Use the problem – solving approach

Analyze: Plan the problem solving strategy

- State the formula of finding force
- List the quantities and their units
- Use the formula and units to solve the problem

Calculate: Apply the problem – solving strategy

- Force = mass x acceleration

Quantities	Units
Mass	kilogram (kg)
acceleration	metre per squared second (m/s^2)

- Force = $kg \times ms^{-2} = kgms^{-2}$
- $kgms^{-2}$ is called newton (N)

Therefore, the SI unit of force is newton and is denoted by N

Evaluate: Does the results make sense?

Yes, one newton is the force applied on a body of mass 1 kg to produce an acceleration of 1 m/s^2.

2. Derive the unit of work done.

Solution: Use the problem – solving approach

Analyze: Plan the problem solving strategy

- State the formula of finding work done
- List the quantities and their units
- Use the formula and units to solve the problem

Calculate: Apply the problem – solving strategy

- Work done = Force x distance

Quantities	Units
Force	newton (N)
Distance	metre (m)

- Work done = Nm
- Nm is called joule (J)

Therefore, the SI unit of work done is joule and is denoted by J

Evaluate: Does the results make sense? Yes, one joule is the work done when a force of 1 N moves a body through a distance of 1 m in the direction of the force.

The table below summarizes the other SI derived units that have no special names.

SI Derived Units with Special Names				
Quantity	**Symbol**	**SI Unit**	**Symbol**	**Expressed in terms of SI units**
Pressure	P	pascal	Nm^{-2}	Nm^{-2}
Quantity of electricity	Q	coulomb	C	As
Electric potential	V	Volt	V	WA^{-1}
Electric resistance	R	Ohm	Ω	VA^{-1}
Force	F	newton	N	$Kgms^{-2}$
Work or Energy	E	Joule	J	Nm
Power	P	Watt	W	Js^{-1}

-

SI Prefixes

For measurements of very large values such as the distance of the moon from the earth or very small values such as the size of bacteria, **SI prefixes** are added to the front of the name of the base unit. When an SI prefix is added to a unit, it multiplies or divides that unit by a certain factor, resulting in multiples or submultiples of the unit. The table below shows some of these SI prefixes.

Prefix	**Symbol**	**Meaning**	**Factor**	**Example**
kilo	k	1 000 times larger than the unit it precedes	10^3	km(kilometre)
deci	d	10 times smaller than the unit it precedes	10^{-1}	dm (decimetre)
centi	c	100 times smaller than the unit it precedes	10^{-2}	cm (centimetre)
milli	m	1 000 times smaller than the unit it precedes	10^{-3}	mm (millimetre)
micro	µ	1 million times smaller than the unit it precedes	10^{-6}	µm (micrometre)

-

Summary

1. Physical quantity is a physical property of matter that can be observed and measured.
2. Basic quantity is a physical quantity that cannot be expressed in any other quantity.
3. Derived quantity is a quantity that can be derived from two or more other quantities.
4. Units are the standards of measurement that express the value of the quantity measured.
5. Units are divided into basic units and derived units.
6. The international standardized system of unit is called the SI unit.
7. Some SI derived units have special names while others do not have special names.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following could be measured in the same units as force?

Select one:

- Energy x distance
- Distance/energy
- Energy/distance
- Momentum x distance

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which pair includes a basic quantity and a derived quantity

Select one:

- Amount of substance; current
- Time; length
- Temperature; force

Question **3**

Not yet answered

Marked out of 20.00

Flag question

A joule, the unit of work done is defined as the work done when an applied force of 1 newton moves a distance of 1 metre in the direction of the force. Which of the following expresses the joule in terms of kg, m and s?

Select one:

- Kgs^{-2}
- $Kgm^{2}s^{-2}$
- $Kgm^{2}s^{-1}$
- $Kgm^{-1}s^{2}$

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The unit of velocity is

Select one:

- m s
- $m^{2} s^{-1}$
- $m\ s^{-1}$
- $m\ s^{-2}$

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following quantities is a derived unit?

Select one:

- Density
- Length
- Mass
- Time

LESSON NOTE

LESSON 10

MEASURING INSTRUMENTS FOR LENGTH AND MASS

Would you use a thermometer to measure the length of an object if you have a ruler? Certainly not! In scientific investigations, measurements are made and the correct instrument is required for specific measurement.

By the end of the lesson, you will be able to:

1. Identify the main instruments of length and mass
2. Identify the types of length that can be measured by these instruments.
3. State SI unit and sub – units for measuring length and mass
4. Convert from one unit to another

Measuring length

Length is the distance between two points in space. The standard SI unit of length is metre and its symbol is m.

For very small or large distances, SI prefixes are used. The table shows some of the other units of length.

SI Prefixes of Length

Unit	Symbol	Number of metre	Example
kilometre	km	1 000 m	Distance of about 5 hockey pitches
metre	m	1 m	Length of a metre rule
centimetre	cm	0.01 m	Thickness of a shirt button
millimetre	mm	0.001 m	The thickness of a coin
micrometre	µm	0.000 001 m	The diameter of bacteria
nanometre	nm	0.000 000 001 m	Thickness of RNA molecule

Interconversion of Units of length

i. Converting from km to m

-

Question1: The distance between Bawku and Bolgatanga is 79.25 km. What is the distance in metre?

Solution: Use problem – solving approach

Analyse: list the known and the unknown

Known:	Unknown:
Distance in km = 79.25	Distance in m = ?

- Use the relationship between kilometre and metre to solve the problem.

1 km = 1 000 m

Calculate: Solve for the unknown

1 km = 1 000 m

Therefore, 79.25 km = 1 000 m x 79.25 km

1 km

= 79 250 m

Evaluate: Does the results make sense?

ii. Converting from m to km

Question2: The distance between Kumasi and Sanisaja is 50 000 m. What is the distance in kilometre?

Solution: Use problem – solving approach

Analyse: list the known and the unknown

Known:	Unknown:
Distance in m = 50 000	Distance in km = ?

- Use the relationship between kilometre and metre to solve the problem.

1 000 m = 1 km

Calculate: Solve for the unknown

1 000 m = 1 km

Therefore, 50 000 m = 1 km x 50 000 m

1 000 m

= 50 km

Evaluate: Does the results make sense?

iii. Converting from m to cm

Question3: The height of a plant from the ground is 0.25 m. What is the height in cm?

Solution: Use problem – solving approach

Analyse: list the known and the unknown

Known:	Unknown:
Length in m = 0.25	length in cm = ?

- Use the relationship between metre and centimetre to solve the problem.

1m = 100 cm

Calculate: Solve for the unknown

1m = 100 cm

Therefore, 0.25 m = 100 cm x 0.25 m

1 m

= 25 cm

Evaluate: Does the results make sense?

Measuring Instruments of Length

The **measuring instruments** for length are:

1. Ruler
2. Metre rule
3. surveyor's tape measure
4. Vernier callipers
5. Micrometre screw gauge
6. Pair of callipers.

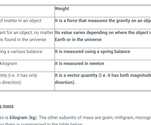
The table below shows the various measuring instruments of length and their uses.

Instrument	Dimensions and specific uses
Ruler	- To measure a few cm and mm - To measure length of line in lest of practical activities
Metre rule	- To measure a few cm - To measure the length of a pendulum - To measure the length of a wire
Vernier callipers	- To measure short distances of few mm to cm. - To measure the inner and outer diameter of a small cylinder pipe, cup etc)
Micrometer screw gauge	- To measure the diameter of a wire - To measure the thickness of a sheet of metal or a metal foil - To measure the thickness of a paper
Surveyor's tape measure	- To measure the length of several metres such as the dimensions of a hockey pitch

Using the ruler

The following precautions should be followed when using a ruler:

1. Place the ruler against the line or the object to be measured so that there is no space between the ruler and the line.
2. Ensure that the beginning of the mark on the object or line coincides with the zero mark on the ruler, so that the reading could start from there.
3. Avoid the error of parallax by placing the viewer's eye vertically above the correct mark on the scale



of the ruler.

Measuring Mass

The **mass** of an object is the quantity of matter contained in the body. It determines the degree to which an object is pulled by gravity and the extent of resistance of an object to changes in its motion. It is different from the weight of an object.

Difference between mass and weight

Mass	Weight
It is the quantity of matter in an object	It is a force that measures the gravity on an object
Its value is constant for an object, no matter where the object is found in the universe.	Its value varies depending on where the object is on Earth or in the universe.
It is measured using a various balance	It is measured using a spring balance
It is measured in kilogram	It is measured in newton
It is a scalar quantity (i.e. it has only magnitude but no direction).	It is a vector quantity (i.e. it has both magnitude and direction).

Unit of measuring mass

The SI unit of mass is **kilogram (kg)**. The other subunits of mass are gram, milligram, microgram etc. The relationship among them is summarized in the table below:

Units of Mass

Unit	Symbol	Relationship	Examples
tonne	t	1 000 kg	Mass of medium – sized car
kilogram	kg	1 Kg	Mass of salt
gram	g	0.001 Kg	Mass of a cedi note
milligram	mg	0.000 001 kg	The mass of 10 grains of salt

Interconversion of units of mass

Q4. The total mass of groundnut harvested from the agricultural Science school farm at Donkokrom is 5 000 kg. What is the mass in g?

Solution

Analyse: list the known and unknown.

Known:	Unknown
Mass of groundnut in kg = 5000	mass of groundnut in g =?

- Use the known mass and the relationship between kg and g to solve the problem.

1 kg = 1 000 g

-

Calculate: Solve the unknown

1 kg = 1 000 g

Therefore, 5000 kg = 1 000 g x 5 000 kg

1 kg

= 5 000 000 g

Evaluate: Does the result make sense?

Q5. The mass of an animal tissue required for an experiment in the biology laboratory at Sefwi – Wiaso Senior High School is 6 mg. What is the mass in kg?

Solution

Analyse: list the known and unknown.

Known:	Unknown
Mass of tissue in mg = **6**	mass of tissue in kg = ?

- Use the known mass and the relationship between mg and kg to solve the problem.

1 000 000 mg = 1 kg

Calculate: Solve the unknown

1 000 000 mg = 1 kg

Therefore, 6 mg = 1 kg x 6 mg

1 000 000 mg

$= 6.0 \times 10^{-6}$ kg

Evaluate: Does the result make sense?

Measuring instrument of mass

The instrument used in measuring mass is called the balance. There are different kinds of balances depending on their sensitivity and design. The sensitivity of a balance is related to the smallest mass that makes its pointer move one one division on its scale. For example, a balance with a sensitivity of 1 g, will need a mass of at least 1 g to move the pointer.

The following are the measuring instrument of mass:

1. Beam balance
2. Chemical balance
3. Lever arm balance
4. Dial spring balance
5. Electronic balance

Balance	Operation
Beam balance	Used for measuring mass of object by putting it into a dish that hangs from one end of a straight bar and balancing it with mass(standards) at the other end
Lever arm balance	The object whose mass is to be measured is placed in the pan. It has a sliding mass which moves along a graduated scale. The graduated scale which reads up to 30g. The sliding mass is shifted to the bottom when the outer scale is used. It is shifted up when the inner scale is used. The screw at the bottom is used to adjust the scale to zero before the object is placed in the pan.
Chemical balance	It has two pans. The object whose mass is to be measured is placed on the left – hand pan and standard masses are added to the right – hand pan until they are balanced. The total mass of the standard masses on the right – hand is equal to the mass of the object on the left side.
Electronic balance	It is an electronic device used to measures the mass of object more accurately. It gives precise readings. It gives digital results.

Summary

- Length is the distance between two points in space.

- Mass is the quantity of matter a substance contains and weight is the force of gravity acting on an object.

- The SI unit of length is metre and other units are kilometre, centimetre, millimetre, micrometre, nanometre etc

- The SI unit of mass is kilogram and other units are tonne, gram, milligram etc.

- The measuring instruments of length are ruler, metre rule, surveyor's tape, vernier callipers, micrometre screw-gauge and pairs of calipers.

- The measuring instruments of mass are beam balance, chemical balance, lever arm balance, dial spring balance, electronic balance and spring balance.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

The mass of a cedi note is measured in

Select one:

- milligram
- gram
- tonne
- kilogram.

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is correct about weight of an object?

Select one:

- It measures the quantity of matter.
- It is measured in newton
- It is a scalar quantity
- Its value is constant

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which unit of length will you use to report the measurement of the distance of Ho from Peki?

Select one:

- micrometre
- kilometre
- nanometre
- decimetre

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following instrument is used to measure the length of a pendulum?

Select one:

- Metre rule
- Venier callipers
- Micrometer screw gauge
- Pair of callipers

Question **5**

Not yet answered

Marked out of 20.00

Flag question

What is the length of 100m in km?

Select one:

- 0.100 km
- 1 000 km
- 1 000 000 km
- 0.001 km

LESSON NOTE

Lesson 11

Measurement of volume and other Physical Quantities

Can you think of a substance that has no volume? All matter has volume. Air has volume as well as the table and chair. What then is the volume of an object?

By the end of the lesson, you will be able to:

1. Define volume and state the SI unit and sub units of volume
2. Identify the apparatus used to measure the volume of liquids
3. Determine the volume of regular and irregular objects.
4. Identify the measuring instruments of time, temperature and current

Volume of substance

The volume of a substance is the amount of space occupied by it. All solids, liquids and gases have volume because they take up space.

Example,

1. Volume of diesel delivered by a pump to a truck.
2. Volume of water in a polytank or water reservoir
3. Volume of LPG in a gas cylinder

Unit of volume

The standard SI unit of volume is the space occupied by a cube that is 1 metre along each edge. It is described as cubic metre and denoted by m^3

The other sub-units of volume are:

1. The litre is a non-SI unit of volume, commonly used for volume of liquids and gases and denoted by l. The litre is equal to that of a cube that is 10 centimetres along each edge.
2. The millilitre denoted by ml or the non-SI unit of volume which is one-thousandth of a litre.
3. The cubic decimetre, denoted by dm^3 is the volume of a cube that is 1 decimetre along each edge.
4. The cubic centimetre, denoted by cm^3 is a unit of volume that is one – thousandth of a cubic decimetre.

The table below shows the relationship that exist among the various units of volume

Units of Volume			
Unit	Symbol	Relationship with SI base Unit	Other relationship
cubic decimetre	dm^3	$1\ 000\ dm^3 = 1\ m^3$	$1\ dm^3 = 1\ l$ $1\ dm^3 = 1\ 000\ cm^3$
cubic centimetre	cm^3	$1\ 000\ 000\ cm^3 = 1\ m^3$	$1\ cm^3 = 1\ ml$ $1\ 000\ cm^3 = 1\ dm^3$
cubic metre	m^3	$1\ m^3$	$1\ m^3 = 1\ 000\ dm^3$
millilitre	ml	$1\ 000\ 000\ ml = 1\ m^3$	$1\ ml = 1\ cm^3$ $1\ 000\ ml = 1\ dm^3$

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Inter conversion of units of volume

Question 1: The volume of humus applied to a tomato plant is 0.95 cm^3, what is its volume in cubic metre?

Solution

Analyse: List the known and the unknown

Known	Unknown
Volume of humus in $cm^3 = 0.95$	volume of humus in $m^3 = ?$

Use the known volume and the relationship between cm^3 and m^3 to solve the problem.

1 000 000 cm^3 = 1 m^3

Calculate: Solve for the unknown

1 000 000 cm^3 = 1 m^3

Therefore, 0.95 cm^3 = $\frac{1\ m^3}{1\ 000\ 000\ cm^3}$ x 0.95 cm^3

= 9.5 X 10^{-7} m^3

Evaluate: Does the results make sense?

Question 2:

The volume of Helium gas used to fill a balloon is 500 cm^3, what is its volume in dm^3?

Solution

Analyse: List the known and the unknown

Known	Unknown
Volume of helium gas in $cm^3 = 500$	volume helium gas in $dm^3 = ?$

Use the known volume and the relationship between cm^3 and dm^3 to solve the problem.

1 000 cm^3 = 1 dm^3

Calculate: Solve for the unknown

1 000 cm^3 = 1 dm^3

Therefore, 500 cm^3 = $\frac{1\ dm^3}{1\ 000\ cm^3}$ x 500 cm^3

1 000 cm^3

= 0.50 dm^3

Evaluate: Does the results make sense?

Calculating for volume of solid objects

The volume of regular solids are measured by using the dimensions of the object and a formula. Example,

1. **Cube**

V = l x b x h

Problems

Question 3

The dimension of a Cube was measured as l = 10 m, b =10 m and h = 10 m. What is the volume of the Cube?

Solution

Analyse: List the known and unknown.

Known	Unknown
Length (l) = 10 m	**Volume in m^3 = ?**
Breadth (b) = 10 m	
Height (h) = 10 m	

- **Use the known and unknown and the formula of volume**

V = l x b x h to calculate the volume of Cube.

Calculate: Solve for unknown

Substitute the known values into the formula and solve

V = l x b x h

= 10 m x 10 m x 10 m

= 1 000 m^3

Evaluate: Does the results make sense?

Measuring instruments for volume of liquid

The common apparatus used to measure the volume of liquid in the laboratory are:

1. **Measuring cylinders**
2. **beakers**
3. **Pipettes**
4. **Conical flasks**
5. **Burettes**
6. **Volumetric flasks**

The choice of apparatus depends on the type of experiment being undertaken and the degree of accuracy of the results.

Measuring cylinder
- It is used to measure rough volumes of liquid samples. It has different capacities (5 ml, 10 ml, 25 ml, 50 ml, 250 ml, 500 ml and 1000 ml).
- When using the measuring cylinder, use one having volume close to the volume being measured. Example, use 5 ml - measuring cylinder to measure a sample of volume 3 ml.

Pipette:
- It is used to measure a specific volume of liquid accurately.
- It is also used in titration process.

Beaker :
- It is used to hold and measure rough liquid volumes. It has different capacities (5 ml, 10 ml, 50 ml, 250 ml and 500 ml.

Conical flask:
- It is used to hold and measure rough liquid volumes. It has different capacities (5 ml, 10 ml, 50 ml, 250 ml and 500 ml.

Burette:
- It is used to measure accurate volume of liquids
- It is also used to perform titrations.

Volumetric flask:
- It is used to measure specific volume of liquid accurately.
- It is also used to prepare standard solution (i.e. a solution whose concentration is accurately known)

Measuring volume of irregular solid

The volume of solids without regular dimensions are determined by displacement method.

Procedures

- Fill the measuring cylinder partly with water
- Record the volume (V_1)
- Tie the irregular solid with a string and lower it into the partially filled measuring cylinder
- Record the new volume (V_2)
- The volume of water displaced by the irregular solid = Volume of irregular solid

Therefore, The volume of irregular solid = $V_2 - V_1$

Precautions to take when using these apparatus

- Do not use these glass apparatus to measure the volume of hot liquid to avoid expansion.
- Remove air bubbles when using the burette or pipette
- Reading of these measuring instruments should be done with eye level coinciding with the lower part of the meniscus
- Wash both burette and pipette with soap and rinse them several times with distilled water and then with solution to be contained.

Other Measuring Instruments

Several other instruments are used in measuring various quantities. The table below summarizes these instruments.

Instrument	Uses
Stop clock stop watch 	Used to measure the time of an event
Thermometer 	Used to measure the temperature of substances

Ammeter 	Used to measure electric current
Voltmeter 	Used to measure the potential difference across or voltage of a cell
Hydrometer 	Used to measure the density of liquids

Summary

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- The amount of space occupied by matter is its volume
- There are several units of measuring volume of a substance
- The SI unit of volume is a cubic metre (m^3)
- The volume of regular solids are measured by using formulae
- Volume of liquid sample is measured using apparatus such as measuring cylinder, burette, pipette, beaker, volumetric flask etc.
- Volume of irregular solid is measured by displacement method.

SHS 1 INTEGRATED SCIENCE

Question **1**
Not yet answered
Marked out of 10.00
Flag question

What is the device used to measure the duration of an event?

Select one:
- Thermometer.
- Slide rule.
- Microscope.
- Stop clock.

Question **2**
Not yet answered
Marked out of 10.00
Flag question

Which of the following is a measuring instrument of volume?

Select one:
- Filter funnel
- Balances
- Ruler
- Pipette

Question **3**
Not yet answered
Marked out of 10.00
Flag question

What is the device used to measure the duration of an occurrence?

Select one:
- Stop clock
- Microscope
- Thermometer.
- Slide rule

Question **4**
Not yet answered
Marked out of 10.00
Flag question

They should never be used to measure the volume of hot liquids. Correct they will have expanded, leading to incorrect results.

Select one:
- Measuring cylinder.
- Burette.
- Conical flask.
- Pipette.

Question **5**
Not yet answered
Marked out of 10.00
Flag question

Identify the apparatus below

Select one:
- Ammeter
- Voltmeter
- Hydrometer
- Balance

Question **6**
Not yet answered
Marked out of 10.00
Flag question

Which of the following apparatus is required for measuring accurate volume of liquid?

Select one:
- Burette
- Measuring cylinder
- Conical flask
- Beaker

Question **7**
Not yet answered
Marked out of 10.00
Flag question

Which of the following apparatus is not used in titration process?

Select one:
- Conical flask.
- Burette.
- Pipette.
- Beaker

Question **8**
Not yet answered
Marked out of 10.00
Flag question

What is the name of the following measuring instrument?

Select one:
- Stop clock
- Ammeter
- Stop watch
- Balance

Question **9**
Not yet answered
Marked out of 10.00
Flag question

Which of the following precautions is required for instrument use for the measuring of volume of liquid?

Select one:
- They can be used to measure hot liquid samples.
- They are not affected by heat
- They should be read with their eye level at the top of the meniscus.
- They can be heated.

Question **10**
Not yet answered
Marked out of 10.00
Flag question

Which one would you use a stop watch to measure?

Select one:
- The mass of a rock.
- The period of heartbeat.
- The mass of the milky way galaxy.
- Temperature of water in a pond.

LESSON NOTE

Lesson 12

Density

Consider a kilo of saw dust and a kilo of steel rod, which one is heavier? Your first answer might be to say the saw dust because it has a larger volume. But a kilo of saw dust has the same mass as a kilo of steel rod.

However, when the saw dust and steel rod of the same volume are weighed, the steel rod would be heavier than the saw dust. The relationship between mass of an object and its volume is density.

By the end of today's lesson, you will be able to:

- Define density and state its SI unit of measurement.
- Calculate the density of various objects.
- Measure the density of irregular object

The concept of density

The density of a substance is a measure of the ratio of the mass of the substance to its volume. It is denoted as ρ

Mathematically, it is expressed as:

Density = mass / volume

Mass = Density x volume

The fundamental SI unit of density is **kg/m³** (kilogram per cubic metre)

Density can also be expressed as **g/cm³** (gram per cubic centimetre)

The relationship between the two units is

1 g/cm³ = 1 000 kg/m³

Worked Examples

A: Inter – conversion of Units of Density

Q1. The density of a sulfuric is 50 g/cm³. What is its density in kg/m³?

Solution

Analysis: list the unknown and known

Known	Unknown
Density of sulfuric in g/cm³= 50	Density in kg/m³ =?

- Use the relationship between known and unknown to solve the problem

1 g/cm³ = 1 000 kg/m³

Calculate: solve for the unknown

1 g/cm³ = 1 000 kg/m³

Therefore, 50 g/cm³ = 1000 kg/m³ x 50 g/cm³

1g/cm³

= 50 000 kg/m³

Evaluate: Does the answer make sense?

Q2. The density of a piece of substance is 500 kg/m³. Convert it to g/cm³

Solution

Analysis: list the unknown and known

Known	Unknown
Density of in kg/m³ = 500	Density in g/cm³ =?

- Use the relationship between known and unknown to solve the problem

1 000 kg/m³ = 1 g/cm³

Calculate: Solve for the unknown

1 000 kg/m³ = 1 g/cm³

500 kg/m³ = 1 g/cm³ x 500 kg/m³

1 000 kg/m³

= 0.500 g/cm³

Evaluate: Does the answer make sense?

B Solving problems of density

(i) **Calculating density from mass and volume of substance**

Q3. A hard box used by students of Sacred Heart Senior High School has a mass of 10.5 g and volume of 4.45 cm³. What is its density?

Solution

Analysis: list the unknown and known

Known	Unknown
Mass = 10.5 g	Density in g/cm³ = ?
Volume = 4.45 cm³	

- Use the known and the definition of density

Density = mass / volume to solve the problem.

Calculate: Solve for the unknown.

The equation is already known. Density is the subject. Quantities are in their correct units so substitute the values.

Density = mass / Volume = 10.5 g / 4.45 cm³

= 2.36 g/cm³

Evaluate: Does the answer make sense?

(ii) **Calculating mass from density and volume of substance**

Q4. A Goldsmith needs a certain mass of gold to design a dangling jewellery of dimensions 0.4 m length, 0.3 m breadth and 0.2 m height, for a king. If the density of gold is 19 320 kg/m³, what is its mass?

Solution

Analysis: list the known and unknown

Known	Unknown
Length = 0.4 m	mass in kg =?
Breadth = 0.3 m	
Height= 0.2 m	
Density = 19 320 kg/m³	

- Use the known quantities and formula of volume to calculate for the volume.
- Use the calculated volume, the density and the density formula to calculate for the mass.

Calculate: solve for the unknown

Volume = l x b x h

= 0.4 m x 0.3 m x 0.2 m

= 0.024 m³

Density = mass / volume Make the mass the subject of the formula by multiplying both sides of the equation by the volume

Mass = Density x volume

= 19 320 kg/m³ x 0.024 m³ = 463.68 kg

Evaluate: Does the answer make sense?

(iv) **Calculating volume from mass and density of substance**

Q5. The density of ice is 0.920 g/cm³. If its mass is 500 kg, calculate its volume in m³.

Solution

Analysis: list the known and unknown

Known	Unknown
Density of ice = 0.920 g/cm³	volume in m³ =?
Mass = 500 kg	

- Use the relation **1 g/cm³ = 1 000 kg/m³** to convert the density from g/cm³ to kg/m³
- Use the calculated density, the mass and the density formula to calculate for the volume.

Calculate: solve for the unknown

Density of ice = 0.920 g/cm³

= 0. 920 x 1 000 = 920 kg/m³

Density = mass / Volume Make the volume the subject of the formula by multiplying both sides of the equation by the volume and dividing the results by density

Volume = Mass / Density Substituting the values

= 500 kg / 920 kg/m³

= 0.543 m³

Evaluate: Does the answer make sense?

Q6. Given that the densities of lead and aluminium are respectively 11 350 kg/m³ and 2 700 kg/m³, calculate the mass of lead having the same volume as 4 000 kg of aluminium

Solution

Analysis: list the unknown and known

Known	Unknown
Density of lead = 11 350 kg/m³	Mass of lead in kg =?
Density of aluminium = 2 700 kg/m³	
Mass of aluminium = 4 000 kg	
Volume of lead = volume of aluminium.	

- First, use the formula of density and mass of aluminium to calculate for its volume
- Equate it to the volume of lead
- Use the density formula and volume of lead found to calculate for the mass of lead.

Calculate: Apply the problem – solving strategy

- Y (**D**) Make **V** the subject
- V
- V = D = 4 000 kg / 2 700 kg/m³
- = 1.48 m³

Volume of lead = volume of aluminium = 1.48 m³

If the density of lead = 11 350 kg/m³

- Y (**D**) Make **m** the subject
- V
- m = ρv = 11 350 kg/m³ x 1.48 m³
- = 16 798 kg of lead

Evaluate: Does the answer make sense?

Some features of density

1. Density is a physical constant of a substance and does not depend upon the size of the sample.

Example, let us examine the relationship between volume and density for identical masses of three substances.

Substances	Cube of substance	Mass(g)	Volume(cm³)	Density(g/cm³
Water		10	10	1.0
Glass		10	4	2.5
Gold		10	0.52	19.3

It can be deduced that at constant mass, the density increases as the volume decreases.

1. Density of solids and liquids differ slightly with temperature due to thermal expansion and this reduces their densities. The only exception is water.
2. Density of gases varies with temperature, depending on the pressure.

Experimental Determination of the density of an irregularly shaped solid

The density of an irregular shaped solid is determined experimentally because it has no dimensions and its volume cannot be calculated. It is determined as follows;

Aim: To measure the density of an irregular shaped object by displacement method using measuring cylinder.

Material

- Measuring cylinder
- String
- Balance
- Pebble
- Water
- Calculator

Method

- Weigh the irregular solid using a top-pan balance and record as M in grams.
- Partially fill the measuring cylinder with water and record the initial volume of the water V_1 in cm^3
- Tie the irregularly shaped object (pebble) with a string and lower it into the water.
- Record the final volume when the solid is completely immersed in the water as V_2 in cm^3

Analysis

- The mass of pebble = M g
- Initial Volume of water= V_1 cm^3
- Final volume of water= V_2 cm^3
- Volume of pebble = $V_2 - V_1$ cm^3

Use the density formula to calculate the density of solid

Density = mass / volume = M / V_2-V_1

Lab 2: Method B

Aim: To measure the density of an irregular shaped object by displacement using Eureka can.

Material

- Eureka can
- Pebble
- Measuring cylinder
- String
- Water

Method

- Weigh the irregular shaped object and record its mass M in gram
- Fill the Eureka can with water until it overflows no more
- Place an empty measuring cylinder below the spout of the Eureka can
- Tie the pebble with a string and lower it into the filled Eureka can until it is completely immersed in the water.
- Record the volume of the water that overflows into the measuring cylinder as V in cm^3

Analysis

1. Mass of pebble = M g
2. Volume of pebble =V cm^3

Use the density formula to calculate the density of solid

Density = mass / Volume = M / V

Summary

- Density is defined as mass per unit volume.
- Its SI unit of measurement is kg/m^3 but can also be measured in g/cm^3
- The two density units are related by 1 g/cm^3 = 1 000 kg/m^3
- Density of a substance is its property which does not depend upon size
- Generally, the density of most solid and liquid substances varies with increasing temperature.
- Density of gases changes significantly with temperature depending on its pressure.
- Density of irregularly shaped object can be determined by displacement method using a measuring cylinder or Eureka can.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

lead has a density of 11 400 kg/m^3

What is the volume of 4000 g of lead?

Select one:

- *9.35 cm^3*
- *4.35 cm^3*
- *0.35 cm^3*
- *1.35 cm^3*

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is true about density of a substance?

Select one:

- It is inversely proportional to its mass
- It is independent of the mass
- It is directly proportional to its volume
- It is directly proportional to its mass

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following statement is correct?

Select one:

- Densities of all liquids decrease with increasing temperature.
- Densities of solids and liquids decrease with increase in temperature except water.
- Density of solids decrease slightly with decrease temperature.
- Density of gases increases always with increases in temperature no matter the pressure.

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The density of concrete and granite are respectively 2 400 kg/m^3 and 2 700 kg/m^3 . Calculate the mass of concrete having the same volume as 4 000 kg of granite?

Select one:

- *3554.4 kg*
- *3544.4 kg*
- *13554.4 kg*
- *5554.4 kg*

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is the SI unit of density?

Select one:

- kg/l
- kg/m^3
- g/m^3
- g/ l

LESSON NOTE

LESSON 13

Relative density

In our previous lesson we discussed ways of experimentally measuring the density of various substances.

At the end of today's lesson, you will be able to:

1. define relative density of a substance
2. solve problems involving relative density
3. experimentally determine the relative density of a substance.

Relative density

Relative density compares the density of a substance with the density of reference substance, usually at the same temperature. The commonly used reference substance is water at 4°C which has a density of 1 g/cm^3. Relative density therefore, is defined as the ratio of the density of the substance to the density of water.

Mathematically,

Relative density = density of substance / density of water

It has no units because the units cancel out. Other mathematical relations involving relative density are

Relative density = mass /volume of substance / mass of water/ volume of water

If the volume of substance = volume of water, then, the equation above will be reduced to:

Relative density = mass of substance / mass of equal volume of water

The mass of a substance is directly proportional to its weight. Thus, the above equation can be reduced to:

Relative density = weight of substance / weight of equal volume of water

Solving problems involving relative density

1. Copper has a density of 8.9 g/cm^3 and water has a density of 1 000 kg/m^3, what is the relative density of copper?

Solution

Analyse: list all the known and unknown

Known	Unknown
Density of copper = 8.9 g/cm^3	Relative density of copper =?
Density of water = 1 000 kg/m^3	

- Convert the density of water to g/cm^3 using the relationship between the two.
- Use the formula to solve the problem :

Relative density of substance = density of substance / density of water

Calculate: solve for the unknown

$$1\,000\ kg/m^3 = 1\ g/cm^3$$

By definition,

Relative density of substance = density of copper / density of water

= 8.9 g/cm^3 / 1 g/cm^3

= 8.9

Evaluate: Does the results make sense?

Measurement of relative density of an irregular solid

Lab 1

Aim: to measure the relative density of a stone

Materials

- Eureka can
- String
- Beaker
- Balance
- Water
- Stone

Set – up:

Procedure

- Fill the Eureka can with water to the spout.
- Measure and record the mass of a dry empty beaker, M_1 and place it under the spout of the displacement can.
- Tie the irregular object with a string, weigh and record its mass M_2.
- Carefully immerse the object in the water such that it is fully submerged in the water.
- Collect the displaced water from the spout of the can, remove the beaker and weigh it as M_3 hence find the weight of water displaced.

Analysis:

Mass of irregular solid = M_2

Mass of equal volume of water = $M_3 - M_1$

Relative density of stone = mass of stone / mass of equal volume of displaced water

= M_2 / $M_3 - M_1$

Worked example

The mass of empty beaker is 25 g. The mass of stone is 135 g. The mass of the beaker together with water that overflow after the stone had been fully immersed is 100 g. Calculate

i. The relative density of the stone.

ii. The density of the stone.

(Density of water =1 g/cm^3)

Solution

Analyse: list all the known and unknown

Known	Unknown
Mass of empty beaker = 25 g	Relative density =?
Mass of stone = 135 g	Density of stone =?
Mass of beaker and water displaced = 100 g	Mass of equal volume of water =?
Density of water = 1 g/cm^3	

- First, find the relative density
- Use the formula

Relative density of substance = density of substance / density of water

to calculate for the density of stone

Calculate: solve for the unknown

By definition,

Relative density of stone = mass of stone / mass of equal volume of displaced water

= M_2 / $M_3 - M_1$

= 135 g / (150 – 25) g

= 135 / 75

= 1.8

Given that, density of water = 1 g/cm^3

Relative density of stone = density of stone / density of water

= 1.8 x 1 g/cm^3

= 1.8 g/cm^3

Evaluate: Does the results make sense?

Measuring the relative density of liquids and insoluble powered solids

The relative density of liquids and insoluble powdered solids are determined using a relative density bottle

Features of the relative density bottle

- It has a ground glass stopper with a fine hole through it.
- The fine hole in the stopper enables excess liquid flow through and run down the outside when the bottle is filled and the stopper inserted.
- At constant temperature, the density bottle is filled with the same level at the top of the hole, making it have the same volume of the liquid.

Measurement of the relative density of a liquid

Lab 2

Aim: To measure the relative density of salt solution

Materials

- Relative density bottle
- Salt solution
- Balance
- Water

Set up

Method

- **Place an empty relative density bottle with its stopper on a chemical balance and record its mass as M_1.**
- **Fill the relative density bottle with the salt solution, replace the stopper and dry the outside of the bottle.**
- **Weigh the bottle filled with the salt solution and record the mass as M_2.**
- **Empty the bottle of the salt solution.**
- **Fill the bottle with water and weigh it on the balance and record its mass as M_3.**

Analysis

The relative density is calculated as below

- **Mass of empty relative density bottle = M_1 g**
- **Mass of relative density bottle full of salt solution = M_2 g**
- **Mass of relative density bottle full of water = M_3 g**
- **Mass of salt solution only = $(M_2 - M_1)$g**
- **Mass of water only = $(M_3 - M_1)$g**

By definition,

Relative density of liquid = mass of salt solution / mass of equal volume of water

= $M_2 - M_1$ / $M_3 - M_1$

Precautions to follow to avoid error and ensure accurate results

- **Ensure that the outside of the bottle is wiped clean of any liquid before weighing is done.**
- **Ensure that the relative density bottle is not held in warm hands to avoid expansion of the glass bottle which leads to inaccurate results.**

Worked Examples

The mass of an empty relative density bottle is 50 g. Its mass in 95 g when filled with kerosene and 100 g when filled with water.

1. **Calculate the relative density of kerosene**
2. **Calculate the density of kerosene**

(Density of water = 1 g/cm^3)

Solution

Analyse: List the known and unknowns.

Known	Unknowns
Mass of empty bottle = 50 g	Relative density of kerosene =?
Mass of bottle + water = 100 g	Density of kerosene =?
Mass of bottle + kerosene = 95 g	
Density of water = 1 g/cm^3	

- **First find the mass of kerosene only and the mass of equal volume of water.**
- **Use the definition of relative density to find the relative density of kerosene.**
- **Then, use the relationship between relative density and density of water to find the density of kerosene.**

Calculate: Solve for the

i. Unknown

- mass of kerosene = 95 – 50 = 45 g
- mass of equal volume of water = 100 – 50 = 50 g

By definition,

Relative density of liquid = Mass of kerosene / Mass of equal volume of water

= 45 / 50

= 0.9

ii. **Relative density of kerosene = Density of kerosene / Density of water**

0.9 = ? g/cm^3 / 1 g/cm^3

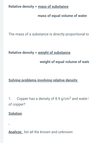
Density of kerosene = Relative density of kerosene x Density of water

= 0.9 x 1 g/cm^3 = 0.9 g/cm^3

Evaluate: Does the results make sense?

Practical Application of Relative density

Relative density of liquid is measured practically with a device called a hydrometer.



The depth to which a hydrometer sinks is determined by the relative density of the liquid being tested. It sinks deeper in liquids of low density. The scale is graduated such that the value of the relative density is the stem at the surface of the liquid indicates the relative density of the liquid and hence its density. It is used for common practical purposes.

- **Physicians use it to measure the relative density of a patient's urine to help diagnose diseases such as diabetes.**
- **It is used to check the condition of the antifreeze in a car radiator.**
- **It is used to measure the relative density of the acid in an automobile battery**

Differences between density and relative density

Density	Relative density
It involves the ratio of mass to volume of a substance	It involves the ratio of density of substance to density of water
Its unit is kg/m^3 or g/cm^3	It has no unit
It is a measured quantity	It compares two measured quantities

Summary

- **Relative density is the ratio of the density of a substance to the density of water.**
- **Relative density is the ratio of the mass of a substance to the mass of equal volume of water.**
- **Relative density is the ratio of the weight of a substance to the weight of equal volume of water.**
- **Relative density has no unit.**
- **The relative density of a liquid is measured with hydrometer.**
- **Relative density measurement gives a higher degree of accuracy than density measurements.**

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Modelling clay with a volume of 19.7cm^3 has a mass of 15.8g, what is its density?

Select one:

- 0.802 g/cm^3
- 0.82 g/cm^3
- 9.802 g/cm^3

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following apparatus is not needed to measure the relative density of liquid?

Select one:

- Balance
- Measuring cylinder
- Hydrometer
- Ruler

Question **3**

Not yet answered

Marked out of 20.00

Flag question

What is the reference substance for comparing density of substance?

Select one:

- Hydrometer
- Water
- Measuring cylinder
- Balance

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is the unit of relative density?

Select one:

- no unit
- newton
- kg/m^3
- g/cm^3

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following determines the depth to which a hydrometer sinks

Select one:

- The colour of the liquid
- The type of containing vessel
- The volume of liquid
- The relative density of the liquid

LESSON NOTE

Lesson 14

Sources of errors

In everyday life, the words 'accuracy' and 'precision' are used to mean the same thing but in science, they are different.

By the end of this lesson, you should be able to:

1. State the difference between accuracy and precision
2. Define error and state ways in which error may arise in the measurement of a physical quantity.
3. State reasons for replicating results.

Uncertainty in Measurement

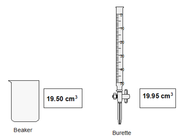
Science is an experimental subject and scientists perform experiments to test the prediction of a theory. However, all measurements have some uncertainty. The success of an experiment depends on our ability to make reliable measurements. That is, measurements that are correct and reproducible. Measured values are therefore compared with some standard value and with set of measured values to determine if the disagreement falls within the acceptable range or not.

If a measured value agrees closely with the actual or standard value, the measurement is said to be *accurate*.

Let us consider the following activities:

Activity 1: To illustrate an example of an accurate measurement:

- Pour 20 cm^3 of water into a graduated beaker
- Pour 20 cm^3 of water into a burette
- Record the volume readings of the two equipment



It would be observed that the closeness of the volume reading of the burette to the standard or true value is higher than that of the graduated beaker.

Therefore, a burette measures volume of liquid to a **higher degree of accuracy** than a measuring cylinder. If a set of measured values agree closely with each other, the values are said to be *precise* or *reproducible*.

Activity 2: To illustrate an example of precise measurements:

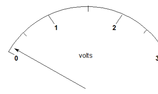
- Put a set of two (A and B) stones near a triple – beam balance
- Ask 3 students to determine the mass of each stone
- The table below shows the summary of their results

Stone	Results of mass (g) obtained by Student		
	1	2	3
A	20.1	20.3	20.2
B	36.0	35.5	34.0

The results of stone A agree closely with each other. They are reproducible and therefore more precise than the results of stone B. Measurement of physical quantity can be:

i. Precise but not accurate

For example, measurement of voltage using a voltmeter which was poorly calibrated with the pointer slightly away from the zero – mark.



If it is allowed to record repeated measurement of the same voltage, it will give the same reading making the measurements precise but not accurate.

i. Accurate but not precise

Example, three students were asked to measure 4.000 g of iron using an analytical balance. The results of two successive weighing by each student are summarized below:

	Student A	Student B	Student C
	4.000g	3.045g	4.001g
	4.002g	3.125g	4.001g
Average:	4.001g	3.085g	4.001g

Results of student A is accurate because the average value (4.001g) agree closely with the standard value of 4.000g but the measurements are not precise.

ii. Not precise and not accurate

Example is the results of student B. His average value (3.085g) does not agree closely with the standard value (4.000g) and the values do not agree closely with each other.

iii. Precise and accurate

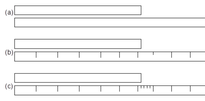
Example, the results of student C agree closely with each other and his average agrees closely with the standard or true value.

Precision and Accuracy of a Measuring Instrument

The use of a particular measuring device depends on

- The unit to be measured
- The **precision** of the quantity to be measured. The number of digits is determined by the precision of the instrument used to make the measurement.
- The **accuracy** of the measurement required. This depends on the sensitivity of the measuring device.

For example, consider three differently calibrated metre rule used to measure the length of a stick.



What measurement is obtained in each case?

In ruler (a) one can say with certainty that the length of the stick is between 0 and 1m, approximately 0.6m.

In ruler (b) one can say with certainty that the length of stick is between 60 to 70cm or approximately 61cm(0.61m) or 62cm(0.62m).

In ruler (c), one can say with certainty that the length is 0.607m.

Thus the greater the number of divisions on the metre rule, the greater the precision with which it can be read and the greater the numbers of significant figure in the measurement.

The table below summarises the precision of some measuring instruments of length.

Instrument	Precision
Ruler	0.1 mm or 0.01 cm
Metre rule	0.1 mm or 0.01 cm
Vernier callipers	0.1 mm or 0.01 cm
Micrometer screw gauge	0.1 mm or 0.01 cm

Errors of Measurement

An error of a measurement is the measure of how the experimental value deviates from the accepted or standard value. That is, the difference between the accepted value and the experimental value:

Mathematically,

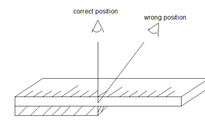
Error = Accepted value – Experimental value

The higher the deviation, the more inaccurate the experimental value is.

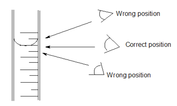
The experimental value could be too high or too low from the accepted value.

Sources of Error

- An error could result from inexperience or some defect of the observer. For example, consider using a ruler to measure the length of an object. The accuracy of the measurement will be determined by how the observer positions the eye.



Again, if we consider using a measuring cylinder to measure the volume of a liquid. The accuracy will depend on the position of the observer's eyes.



- An error could result from the use of a faulty instrument.
- Zero error could arise from poorly calibrated measuring instrument. Example if an ammeter having its pointer at 0.1A is not calibrated or adjusted to read zero before it is used, then the result will be inaccurate.
- Some observers intentionally falsify their results to achieve an intended goal.
- When a measuring instrument having inappropriate precision and accuracy are used.

Concept of replication of results

- In order to reduce some experimental errors and make our results more accurate and reliable, experiments are usually repeated.
- Sometimes a particular result is clearly incorrect, or very different from others in a repeated set of values, it is important to replicate the results or trying it again.
- As part of scientific method, different scientists may replicate and check results using the same procedure to ensure accuracy and consistency of results.
- Scientists may replicate results to form the basis for formulating a hypothesis, make informed predictions to scientific knowledge.

Summary

1. **Precision** is a measure of the closeness of series of measurements to each other.
2. **Accuracy** is a measure of the closeness of a measured value to the true or actual value.
3. **Error** is a measure of degree of deviation of a measured value from the true or measured value.
4. The larger the error the more inaccurate the measurement and vice versa.
5. A measured physical quantity could be precise and accurate, precise but inaccurate, accurate but not precise and inaccurate and not precise.
6. Errors can be caused by the fault of an observer or a measuring instrument or a process.
7. The use of a particular measuring instrument depends on unit, precision of the quantity to be measured and accuracy of measurement required

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following scale sensitivity is correct about electronic balance?

Select one:

- 0.001g
- 0.01g
- 0.10g
- 1.00g

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Results that are reproducible are

Select one:

- Inaccurate
- Anomalous
- Accurate
- Precise

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Four students recorded a series of measurements of acceleration due to gravity ($9.80ms^{-2}$). The table summarizes the results obtained.

	$g(ms^{-2})$			
A	9.81	9.79	9.82	9.83
B	9.81	10.11	9.89	8.94
C	9.45	9.21	8.88	8.76
D	8.45	8.50	8.42	8.41

Which set of results could be described as precise but not accurate?

Select one:

- B
- A
- C
- D

Question **4**

Not yet answered

Marked out of 20.00

Flag question

A metal rule can be read to the nearest millimetre. It is used to measure the length of table whose length is 785 mm. repeated measurements give the following readings:

Length/mm	792	791	792	791	791	792

Which results is precise and inaccurate

	Results are precise	Results are accurate
A	No	No
B	Yes	Yes
C	Yes	No
D	No	Yes

Select one:

- B
- D
- C
- A

Question **5**

Not yet answered

Marked out of 20.00

Flag question

When reading the volume of liquid in a measuring cylinder, which of the following errors is one likely to encounter?

Select one:

- Non reproductive results
- Reading changing with time
- Parallax error
- Zero error

LESSON NOTE

LESSON 15

DIVERSITY OF LIVING AND NON-LIVING THINGS

When you look around your environment, you would observe different objects.

Some are living others are non-living.

You learnt about living things and non-living things at the JHS level. Objects such as tables, chairs, stones, etc. are non-living.

Organisms such as houseflies, donkey, maize plant, cows, etc. are also classified as living things.

Today, you should be able to see the variety of living and non-living things.

But before that let us look at the objectives we seek to achieve by the end of this lesson.

By the end of this session you should be able to:

- Explain classification and its importance
- Describe the diversity of living and non-living things
- State the important features of living and non-living things

We all tend to group things which we come across around us.

Young children might differentiate things by putting them into their mouth to see whether they taste good or bad.

Those of you whose parents are traders, what do they do when they return from the shop or market with money?

Here, we are looking at a mixture of coins and notes. Your parents would begin to group the coins into denominations.

For example ten pesewa coins would be put together, twenty pesewa coins aside and then fifty pesewa coins aside.

Regarding the cedi notes too, they would be grouped into one cedi notes, two cedi notes, five cedi notes, etc.

Scientists also find it useful to group living and non-living things.

It is called *classification.*

What is classification then?

Classification is the grouping or sorting of living organisms based on their common physical features or characteristics and differences.

Why do scientists classify living and non-living organisms?

- For easy communication amongst scientists
- To see evolution at work or identify new varieties when they arise
- Formation of a common pool of knowledge for research
- Allows scientists to make reference for easy identification
- Allows description of organisms using one word or few words
- To determine the similarities and differences in organisms

Without classification, scientists would find it difficult, if not impossible, to handle knowledge about organisms.

There are one hundred and eighteen chemical elements now known to scientist. And more are even being discovered.

These chemical elements differ from each other and must be classified for easier study, recall and to make predictions. This leads us to Diversity of things.

Let us discuss Diversity.

What is diversity?

Diversity means a wide range of differences that a scientist can see when looking at a large number of different organisms.

For example, there is a great difference between a mahogany tree and a tomato plant.

There are also differences between a giraffe and a cockroach.

There are also differences between living and non-living things.

These differences stem from colour, shape, size, chemical composition and other features.

The basic features that distinguish **living things** from **non-living things** are *nutrition, reproduction, excretion, respiration, growth, irritability and movement.*

NUTRITION

It is the process by which living things make or obtain food.

The food obtained is to provide energy and materials for growth and repair of the organism's body. Plants manufacture their own food (carbohydrate) from carbon dioxide and water in the presence of light.

This is called *autotrophic nutrition.*

Animals do not produce their own food but rather depend on plants and on other animals.

They are *called heterotrophs.*

REPRODUCTION

It is a process in which living things give rise to new individuals of their own kind.

There are two types of reproduction namely, asexual and sexual reproductions.

Unicellular organisms such as Amoeba and Paramecium split into two or more parts (asexual reproduction) to give rise to new individuals of their own kind.

In Higher organisms, reproduction involves the fusion of special cells called **gametes** (sexual reproduction).

When the gametes fuse they form a zygote which grows into a new individual.

EXCRETION

It is the removal of harmful and metabolic waste products from the body.

Examples of metabolic waste products are sweat, urine, carbon dioxide, water vapour, urea and bile. Excretion should not be confused with egestion (the removal of undigested food substances from the intestine).

Example of undigested food is faeces.

MOVEMENT

Movement is the change in position of parts or whole organism.

Animals can generally move their whole bodies from one place to another ie **locomotion**

However, movement in plants is usually restricted to certain parts such as branches, leaves, closing and opening of petals, or growth movements.

IRRITABILITY (SENSITIVITY)

It is the ability of an organism to respond to a stimulus. The stimulus could be external such as temperature, light, touch, etc.

It could also be internal such as chemicals (example is hormones).

Obvious signs of sensitivity are the movements made by animals as a result of noises, or being touched, or seeing an enemy.

GROWTH

It is an irreversible increase in size, weight and complexity.

An illustration of this is an animal such as caterpillar changing its form from larva to butterfly (adult). Another example is the tadpole becoming a toad (adult).

The changes is as a result of new cells being added to the old existing ones leading to overall increase size and weight.

RESPIRATION

It is the release of energy from food with or without the use of oxygen.

Respiration also results in a rise of body temperature, which is more easily detectable in animal than in plants.

The energy released enables living things to carry out their life processes.

However, non-living things can show some of these characteristics exhibited by living things.

For example, cars, clouds, hurricanes can *move*, Clouds and crystals can *grow*, fire alarm is *sensitive* and cars do *respire*.

However, only living things show all these characteristics in one organism.

There are also relationships between living and non-living things.

For example, when a living thing dies it becomes non-living.

Plants need mineral salts, water, carbon dioxide and light to produce their food.

Animals need oxygen to respire to release energy.

Summary

We looked at classification and why living things and non-living things are classified.

We also looked at diversity in living and non-living things

We discussed characteristics of living things and some characteristics exhibited by non-living things like respiration, growth, movements, etc.

Finally, we discussed the relationships between living and non-living things.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is not an importance of classification of living and non-living things?

Select one:

- For speciation
- Allows scientists to make references for easy identification
- For easy communication amongst scientists
- To see evolution at work

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following characteristics is performed by motorbike?

Select one:

- Reproduction
- Respiration
- Growth
- Excretion

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following organisms performs all the functions of movement, growth, excretion and photosynthesis?

Select one:

- Euglena
- Spirogyra
- Rhizopus
- Paramecium

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Daughter organisms of Amoeba are genetically identical because they are reproduced by……..means

Select one:

- Sexual
- Asexual
- Budding
- Conjugation

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following characteristics is performed by cyclones?

Select one:

- Reproduction
- Excretion
- Growth
- Irritability

LESSON NOTE

Lesson 16

Biodiversity and Classification of living things

In our previous lesson we discussed classification. We said classification is the grouping or sorting of living organisms based on their common physical features or characteristics and differences.

Today we shall be looking at how biologists classify living things.

Before that, let us look at today's *objectives*.

1. Explain the term biodiversity
2. Outline the schemes of classification, using common features of living things and elements
3. Explain classification keys and the types

BIODIVERSITY

Biodiversity is a measure of the variation between different living organisms.

Biodiversity could be the variety of **different areas** where organisms can live, the number of **different species** in a community or the **differences between the genes** in a species.

The maintenance of biodiversity is important for ecological stability and as a resource for research.

The research could be into drugs or crops.

SCHEME OF CLASSIFICATION

Classifications are not strict schemes imposed from outside.

Rather, they are inventions of scientists based on the best available evidence and principles.

However, these evidence and principles change as our understanding changes.

That is why we say science is *tentative*.

Aristotle (384-322 BC), a Greek Biologist, was the first to produce a system of classification of living things.

Animals were classified by looking at the way they move.

That is, he put together animals that run, swim or fly.

For example animals such as insects, bats, birds, etc. were put under those that fly.

This system of classification was found to be improper since members of the group do not have anything in common except movement.

For instance, insects are invertebrates whereas birds are vertebrates.

Therefore, members in the group do not have any natural relationship.

Aristotle system of classification was therefore considered a less useful method.

In plants, he used appearance and size as a way of classification.

In the eighteenth century, a Swedish naturalist, Carolus Linnaeus began a system of classification based on natural relationships.

He started his classification from a group of organisms that can mate (interbreed) to produce offspring which are capable of reproducing.

He called this group of organisms the *species*.

Linnaeus' way of classification is called the natural system of classification because it puts all organisms with the same structure or body plan together.

In the middle of the nineteenth century, chemists were discovering a large number of new elements. They were also able to determine atomic weights of the elements (now called atomic masses) accurately.

About 55 elements and their properties were known by 1830.

Attempts were made by chemists, including John Newlands, Johann Dobereiner and Lothar Meyer, to produce a system to classify the elements.

John Newlands, in 1865, arranged the known elements in order of increasing atomic weight.

He realized that every eighth element in the series was similar.

H **Li** Be B C N O F **Na** Mg Al Si P S Cl **K.**

His system of classification was not supported because some of the atomic weights were inaccurate and there were elements that had not been discovered.

A Russian chemist, Dmitri Mendeleev, in 1869 produced a classification of the elements which has survived in the form of the modern Periodic

Table.

Mendeleev arranged the known elements in order of increasing atomic weight but in such a way that elements with similar properties were in the same vertical column.

He called these vertical columns **groups** and the horizontal rows **periods.**

The modern Periodic Table is a way of classifying the elements. This is why Mendeleev's grouping of the elements is called **periodic classification**.

The elements are arranged in order of increasing atomic number to avoid any elements out of order when atomic masses are used.

The Periodic Table helps you to make predictions about elements you have not yet met.

CLASSIFICATION KEYS

A classification key is a systematic information or feature used to identify organisms.

Classification keys help you to quickly name an organism.

Classification keys do so by using a number of easily seen external features. That is, features which one can easily see at a glance.

In classifying animals using keys, you need to choose some external features by which you can separate the animals into groups.

Now take note,

In using classification keys, *absolute size* is *not* a good feature to use.

This is because organisms grow throughout life.

However, the *relative size* of one of their parts (e.g. antennae one-third the length of the body) may be useful.

Additionally *colour* is *not* a good feature to use in a key.

This is because a number of species show *polymorphism* for colour patterns on their bodies.

For example, the male lizard differs from the female lizard in body colour.

Let us look at this example,

If a botanist wishes to classify leaves, it may be necessary for him/her to consider the appearance of the leaves in the following regard:

Are the edges smooth or toothed/serrated?

Are the veins parallel or network?

Are the tips pointed or rounded?

Are they simple or compound?

Types of keys

There are two types of classification key namely, Numbered and Dichotomous keys.

Numbered key are used for the identification of *large numbers* of organisms in one exercise.

On the other hand, Dichotomous keys are used for the identification of *few* organisms in one exercise.

Now let us look at this exercise: you have been provided with pictures of a lizard, lion, bat, domestic fowl, snake, fish and ostrich.

Let us begin with Dichotomous key

Are there any vertebrates and invertebrates?

Are there cold blooded animals and warm blooded animals?

Are there animals with feathers and others with hairs?

Do others have fins or not?

Do some have moist and naked skin while others have dry, scaly skin?

We shall continue with the classification keys in our next lesson.

Summary

We looked at biodiversity and its importance of stabilizing the ecosystem and also providing an avenue for research purposes.

We also discussed the schemes of classification and tentative classification.

Finally we looked at classification keys and the types.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is a threat to biodiversity?

Select one:

- Destruction of buildings in water ways
- Land rotation
- Destruction of rainforest
- Afforestation

Question **2**

Not yet answered

Marked out of 20.00

Flag question

How many elements were discovered by 1830?

Select one:

- 77
- 55
- 66
- 44

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following sets of elements are found in the same column in the modern Periodic Table?

Select one:

- Ca , Sr , Ba , Pb
- Be , Mg , Zn , Cd
- F , Cl , Br , I
- N , P , As , Sb , Bi

Question **4**

Not yet answered

Marked out of 20.00

Flag question

……. Put together insects, birds and bats under those that can fly

Select one:

- Mendel
- Wallace
- Aristotle
- Bateson

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Linnaeus system of classification of living things is based on

Select one:

- Body size
- Natural relationships
- Appearance and size
- Jointed system

LESSON NOTE

LESSON 17

Classification Keys, Taxonomy and Binomial Nomenclature

In our previous lesson, we looked at schemes of classification and classification keys. You learnt that keys are features which can be seen at a glance to put organisms into groups. You also learnt the types of keys: Numbered keys and Dichotomous keys. Today you would learn how to use keys to group organisms. But before that, let us consider the objective(s) for today's session.

By the end of today's lesson, you should be able to

1. Use the types of classification keys to put organisms into groups

At our last meeting, we looked at some organisms such as *lion, bat, lizard, fish, domestic fowl, ostrich and snake*

We shall begin with Dichotomous key which is used for the identification of few organisms in one exercise.

Let us begin by grouping them using their external features:

Are there scales on their bodies?

Are there fur on their body?

Do they have wings or limbs?

Are the organisms with scales have removable scales or not?

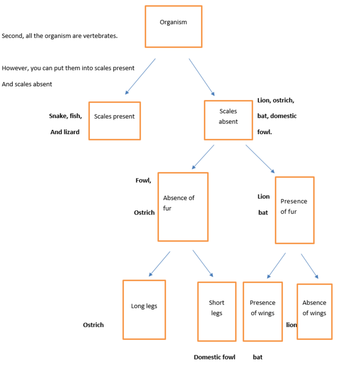
Do others have fins or not?

Do some have moist and naked skin with others having dry, scaly skin?

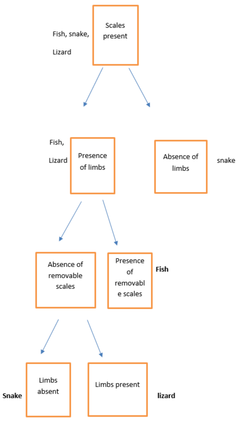
All these and many questions are asked to enable you group organisms using *Dichotomous Key.*

Now let us begin

First, they are all organisms



Try to put organisms under 'scales present' into groups



Good!

Now let us begin the **Numbered Key**.

I. Scales present……5

Scales absent……(move to 2).

The number '2' at the end of the second line tells you to refer to the second part of the key.

A number cannot be given to the first line at this stage, but it will be given one later.

Lion, ostrich, domestic fowl and bat do not have scales.

The second part of a key must use other features to sort them into two group.

The lion and the bat have fur or hairs which the ostrich and domestic fowl do not have. Again, the lion does not have leathery wings is which are present in the bat.

The ostrich and domestic fowl have one pair of legs but that of the ostrich is relatively long compared to the domestic fowl.

Any of these features could be used.

ii. Presence of fur…… 3

Absence of fur …… move to 4

Part 3 of the key must separate the lion from the bat

iii. Wings present……**bat**

Wings absent……**lion**

Now that the lion and bat has been dealt with in the key, we can return to animals such as fish, snake, ostrich, domestic fowl and lizard.

The next part of the key will be numbered '4'.

The snake does not have limbs whereas the fish, ostrich, domestic fowl and the lizards have limbs

iv. Long legs…… **ostrich**

Short legs…… **Domestic Fowl**

Now that we have also dealt with the ostrich and the domestic fowl, we can return to animals with scales present (snake, fish and the lizard).

The fish has removable scales but the lizard and the snake do not.

v. Removable scale present……**fish**

Removable scale absent ……go to 6

vi.Absence of limbs……**snake**

Presence of limbs……**lizard**

In summary, the whole key would therefore be

I. Scales present……5

Scales absent…… Go to 2

ii. Presence of fur……**go to 3**

Absence of fur…… Go to 4

iii. Wing present……**bat**

Wing absent……**lion**

iv. Long legs……**ostrich**

Short legs…… domestic fowl

v. Presence of removable scales……**fish**

Absence of removable scales…… **go to 6**

vi. Absence of limbs……snake

Presence of limbs……lizard

Summary

Today we looked at how to group organisms such as domestic fowl, snake, bat, lion, lizard, ostrich and fish using **Dichotomous Key** and **Numbered Keys.**

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Snake
- Domestic fowl
- Bat
- Ostrich

Question **2**

Not yet answered

Marked out of 20.00

Flag question

What does the lizard and the snake have in common?

Select one:

- They are cold blooded
- Presence of scales
- Presence of clawed digits
- Presence of beak

Question **3**

Not yet answered

Marked out of 20.00

Flag question

All members of the kingdom Plantae do not possess

Select one:

- Chitinous cell wall
- Chlorophyll
- Cellulose cell wall
- Multicellular body

Question **4**

Not yet answered

Marked out of 20.00

Flag question

What is the distinct feature between the snake and the fish?

Select one:

- Presence of a pair of eyes
- Both are cold blooded
- Presence of tail
- Presence of removable scale

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is useful in the construction of a dichotomous key?

Select one:

- Trophic level of organisms
- Similarities in anatomical features
- Observable external features
- Embryological similarities

LESSON NOTE

LESSON 18

Taxonomy, Linnaean System of Classification/Binomial Nomenclature

In our previous lesson, we looked at classification keys.

Some animals were considered and classified using the **Dichotomous Key** and the **Numbered Key**.

Today you shall be looking at taxonomy, the Linnaean system of classification or Binomial Nomenclature. Before that, let us look at the Objectives.

By the end of this session, you should be able to

1. Explain the meaning of taxonomy
2. State the general characteristics of the five kingdoms of biological classification
3. Explain the meaning of binomial nomenclature

Taxonomy

The system of classifying organisms into groups is called *taxonomy*.

Classification aims to use as many characteristics as possible in placing similar organisms together and dissimilar ones apart.

The general name for a classification grouping is a taxon (plural = taxa). The lowest or most exclusive taxon is the species; the highest or most inclusive is the *kingdom*.

Each kingdom can be subdivided into a number of progressively smaller groups.

It should be noted that, as the lower ranks are reached, reduced number of organisms with increased common characteristics are observed.

Meaning, as you move down the ladder, the NUMBER of organisms DECREASE but COMMON characteristics amongst them INCREASE. The rest of the seven principal taxa in a descending order are

· *Phylum*: organisms constructed on a similar plan. For example all members of phylum *Arthropoda* have a hard exoskeleton and jointed appendages.

1. *Class*: a group of orders within a phylum. For example all members of class *Insect*a have compound eyes and three pairs of walking legs.
2. *Order*: a group of apparently related families
3. *Family*: a group of apparently related genera
4. *Genus*: a group of similar and closely related species
5. *Species*: a group of organism similar in structure and function (capable of interbreeding to produce fertile offspring). The species concept was introduced by **John Ray.**

Below is a table showing the various kingdom and their characteristics in an increasing order of complexity:

		Increase in complexity		
Prokaryotae	**Protoctista**	**Fungi**	**Plantae**	**Animalia**
Most are microscopic	**They are unicellular**	**Heterotrophic and multicellular**	**They are multicellular, eukaryotic and photosynthetic (possess chlorophyll)**	**They are multicellular, eukaryotic and non-photosynthetic**
They have no nucleus and no membrane-bound organelles	**Have a membrane-bound nucleus and membrane-bound organelles**	**They have no root, stem and leaves.**	**They have cellulose in their cell walls**	**No cell walls present**
Their cytoplasm is surrounded by a cell wall which contain peptidoglycan	**Some are photosynthetic, others are heterotrophic**	**They are not photosynthetic**	**They have chloroplast in their cytoplasm**	**They are capable of locomotion**
They have few organelles	**Have many organelles**	**Some are parasitic others are saprophytic**	**Have large vacuoles with cell sap in them**	**They possess nerve tissue for co-ordination**
Many possess one or more flagella for movement	**Reproduction involves binary fission**	**They have a vegetative body called mycelium, which consist of a mass of fine threads called hypha**	**They reproduce by seeds or spores**	**e.g liver fluke, giant African snail, grasshopper, tilapia, lizard, leopard and man**
e.g bacteria and cyanobacteria	**They are neither plants, fungi nor animals**	**Have cell walls which contain chitin**	**e.g moss, fern and maize plant**	
	E.g algae and protozoa	**e.g mushroom, and rhizopus**		

Taxa have been standardized throughout the world as a result of the International Code of Botanical Nomenclature and the International Committee on Zoological Nomenclature.

Linnaean system of classification

People have always classified living things and they continue to do so.

Humans have recognized the difference between plants and animals.

Then animals and plants are divided into some obvious and useful groupings.

Early human communities classified the plants and animals useful for food.

Food plants were differentiated from plants that are exploited as sources of drugs and from others that were poisonous.

Early zoologists classified animals with backbones (vertebrates) and those without (invertebrates). These major groups were increasingly subdivided in various ways.

In most recent times, botanists have classified plants as herbaceous or woody.

Horticulturalists have also classified plants as annuals, biennials or perennials.

Classification system imposes an agreed name to each organism.

Many organisms have local names.

These local names differ in different countries around the world.

For example, the dog has different names among the tribes in Ghana.

However such a variety of names would cause confusion among biologists throughout the world.

This challenge is resolved by reference to the names of the taxa used in classification.

In whatever way biologists refer to "man" or a "woman" in their mother tongue, every biologist in the world would understand the following description:

Animalia,

Chordata,

Mammalia,

Primates,

Hominidae,

Homo,

sapiens

Therefore for Biologists throughout the world to communicate effectively, each different type of organism must have a unique name that is recognized worldwide.

For this reason, an internationally accepted system of naming was proposed by Carolus Linnaeus called *Binomial Nomenclature.*

This system gives each org*anism* a two-word Latin name: the generic name (from the genus) which begins with a *capital letter*, followed by the specific name (from the species) which begins with a *small letter*.

Both names are underlined separately in writing or italicized in printing, e.g. Homo sapiens or *Homo sapiens.*

Binomial Nomenclature is also called the Linnaean system of classification.

Examples of the two-part names are as follows,

Common name	**Genus**	**Species**
Domestic Dog	*Canis*	*familiaris*
Domestic Fowl	*Gallus*	*domesticus*
Man	*Homo*	*sapiens*
Mango	*Magnifera*	*indica*

Summary

We looked at the meaning of taxonomy and the general characteristics of organisms in the five kingdoms of biological classification.

Finally, we explained the binomial nomenclature with examples

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

A group of orders within a phylum belongs to

Select one:

- Kingdom
- Phylum
- Order
- Class

Question **2**

Not yet answered

Marked out of 20.00

Flag question

The group to which reptiles are is an example of

Select one:

- An order
- A class
- A family
- A genus

Question **3**

Not yet answered

Marked out of 20.00

Flag question

The lowest group into which an organism can be classified is

Select one:

- Phylum
- Species
- Genus
- Class

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Interbreeding organisms are members of the same

Select one:

- Species
- Family
- Class
- Genus

Question **5**

Not yet answered

Marked out of 20.00

Flag question

The correct order used in classifying organism is

Select one:

- Phylum, class, species, family
- Phylum, class, genus, species
- Phylum, species, class, genus
- Phylum, class, family, genus

LESSON NOTE

Lesson 19

Classification of Non – living things (Elements)

Imagine you went to a video shop and all the videos were mixed together, how would you tell Hollywood movies from Nollywood or Kumawood movies? How would you be able to differentiate an action movie from a comedy movie? Obviously, if the videos were not arranged in a regular pattern, you would not be able to make your choice.

Chemists faced similar problem in early 1817, and therefore needed a tool that organizes materials or elements to have a better understanding of how they interact with each other.

At the end of today's lesson, you will be able to:

1. Narrate the historical development of periodic classification of elements
2. State Mendeleev's periodic law, discuss the contributions and shortcomings of his periodic classification of elements
3. Explain how elements are arranged in the modern periodic table
4. Compare metals, non – metals and semi – metals based on their properties and position in the periodic table.

Historical Development of Periodic Classification of Elements

As chemists study the composition and properties of materials using the techniques available, they discovered that materials are made of substances which cannot be separated into simpler substances by chemical means. These substances were termed elements. They tried to find a way to organize these elements into groups or patterns according to their properties.

a. In **1817,** a German chemist called *Johann Dobereiner*

made the first link between atomic masses of some elements and their properties. He discovered that lithium, sodium and potassium showed similarities as did chlorine, bromine and iodine. He then organized

these elements in sets of three known as triads.

Alkali producers	Salt producers
Li Lithium	Cl Chlorine
Na Sodium	Br Bromine
K Potassium	I Iodine

Strength of Theory

- It could group lithium, sodium and potassium correctly.

Weakness

The theory was rejected by other Chemists because:

1. Only a few elements were known and
2. Not all elements fitted into triads

b. In 1864, a British called *John Newlands* arranged the elements in order of atomic weight and discovered a repeating pattern of elements beginning with each eighth element. That is, every element had similar properties to the element eight places before or after it. He then called his pattern, the Law of Octave. This is because the notes in musical octaves also show repeating pattern at each eighth note.

1	2	3	4	5	6	7
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe

Strength of the Theory

The theory was able to:

1. Classify successfully the first two members of each group
2. Recognised periodic trend of the elements

Weakness of the Theory

The theory was not accepted because:

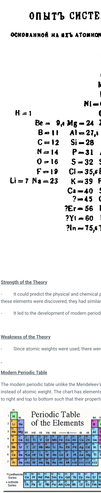
- Not all elements fitted the pattern of octaves. For example **Iron (Fe)** does not have similar properties with non – metals like **oxygen (O)** and **sulphur (S).**

a. **Mendeleev's Periodic law**

In 1869, a Russian Chemist called *Dimitri Mendeleev*

discovered that the physical and chemical properties of elements vary periodically with increasing atomic weight. This relationship is known as Mendeleev's periodic law. He listed the elements and arranged them in increasing order of atomic weight. He organized them into columns called groups having elements with similar properties lying side by side in a manner of seven rows called periodic table.

His table left spaces or gaps for undiscovered elements. This was because there were no elements with appropriate properties and atomic weight.



ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

				Ti = 50	Zr = 90	? = 180.	
				V = 51	Nb = 94	Ta = 182.	
				Cr = 52	Mo = 96	W = 186.	
				Mn = 55	Rh = 104,4	Pt = 197,4.	
				Fe = 56	Ru = 104,4	Ir = 198.	
				Ni = Co = 59	Pl = 106,6	O = 199.	
H = 1				Cu = 63,4	Ag = 108	Hg = 200.	
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112			
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?		
	C = 12	Si = 28	? = 70	Sn = 118			
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?		
	O = 16	S = 32	Se = 79,4	Te = 128?			
	F = 19	Cl = 35,5	Br = 80	I = 127			
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204.		
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207.		
		? = 45	Ce = 92				
		?Er = 56	La = 94				
		?Yt = 60	Di = 95				
		?In = 75,6	Th = 118?				

Д. Менделѣевъ

Strength of the Theory

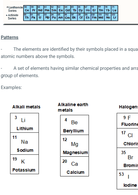
- It could predict the physical and chemical properties of undiscovered elements. Eventually, when these elements were discovered, they had similar properties as predicted by Mendeleev.
- It led to the development of modern periodic table.

Weakness of the Theory

- Since atomic weights were used, there were some discrepancies in the table.
-

Modern Periodic Table

The modern periodic table unlike the Mendeleev's, arranges elements in increasing order of atomic number instead of atomic weight. The chart has elements arranged in order of increasing atomic number from left to right and top to bottom such that their properties repeat at regular intervals.



Patterns

- The elements are identified by their symbols placed in a square, names below the symbols and atomic numbers above the symbols.
- A set of elements having similar chemical properties and arranged in vertical columns are called group of elements.

Examples:

- There are **18** groups of elements.
- A set of elements having different chemical properties and arranged in horizontal row from left to right is called a period of elements.

Example, hydrogen and helium are in period 1.

Sodium, beryllium, boron, carbon, nitrogen, oxygen, fluorine and neon are in period 2.

- Elements can also be classified into three main groups, namely metals, non – metals and semi – metals.
- Metals are located on the left – hand side and the centre of the periodic table. They have high melting and boiling points, good conductors of electricity and heat, malleable and ductile. Greater number of the elements are metals.
- Non – metals are located on the right – hand side of the periodic table. They have low melting and boiling points, poor heat and electrical conductivity, and are brittle. About ¼ (25%) of the elements are non – metals.
- Semi – conductors are located between the metals and non – metals. They have some properties similar to metals and some properties similar to that of non – metals.

Example, Germanium has the following properties:

Property	
Appearance	Grayish – white
State	Solid
Tensile strength	Brittle
Melting point	936.25°C
Boiling point	2833°C
Electrical conductivity	217 $Ω^{-1} m^{-1}$

- Germanium is brittle, its electrical conductivity is not as high as that of metals and not as low as that of non – metals.
- It has high melting and boiling points and a good conductor of electricity.
- Germanium is therefore a semi – metal or metalloid because it has both the properties of metals and non – metals.

Table of classification of elements into metals, non – metals and semi – metals

Table of elements of first 20 elements

Elements	Type of Element
Lithium Sodium Potassium Beryllium Magnesium Calcium Aluminium	**Metal**
Hydrogen **Carbon** **Fluorine** **Bromine** **Iodine** **Chlorine** **Oxygen** **Nitrogen** **Phosphorous** **Sulphur** **Neon** **Helium** **Argon**	Non – metal
Boron **Silicon**	Semi – metal

Summary

- Elements were classified by Johann Dobereiner as set of **triads.**
- John Newlands, arranged elements according to the **law of octave.**
- Mendeleev classified elements according to increasing order of **atomic weight** and **properties.**
- Modern periodic table classifies elements into vertical columns called **groups** and horizontal rows called **period.** It also classifies them in order of increasing atomic number.
- It is also classified elements into metals, non – metals and semi – metals depending on their properties.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

The set of elements arranged in vertical column and having similar properties are called

Select one:

- Metalloid
- Group
- Octave
- Period

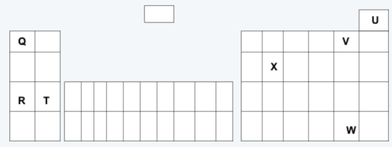
Question **2**

Not yet answered

Marked out of 20.00

Flag question

Consider the periodic table shown below. The letters represent some hypothetical elements.



Which elements are likely to be non – metals?

Select one:

- Q and R
- UV and W
- QR and T
- RT and W

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Moving down the group from top to bottom of the periodic table,

Select one:

- Atomic weight decreases
- Atomic number increases
- Atomic number remains the same
- Atomic number decreases

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Germanium is brittle, conducts electricity better than non – metals, has high melting and boiling points. Which of the following properties of germanium agrees with non- metals?

Select one:

- Have the same boiling point
- Have the same chemical properties
- Have the same period
- Have the same melting point

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Germanium is an element. It is silvery – white and brittle.

Element	Metal or non – metal	Melting point/^{o}C	Boiling point/^{o}C	Electrical Conductivity (Ω^{-1} m^{-1})
Iron	Metal	1538	2862	Above 59600000
Germanium	.....	938	2833	217
Phosphorus	Non - metal	44	280	Almost zero

Which of the following properties are similar to typical non - metals?

Select one:

- High melting point, high boiling point
- High melting point, poor electrical conductor
- Brittle
- Good conductor of electricity and brittle

LESSON NOTE

Lesson 20

Matter

What do air, water and stones have in common? Difficult to tell, isn't it? They have at least one characteristic in common and that is, they are all examples of matter. What then is matter?

By the end of the lesson, you will be able to:

- Define matter and give examples
- Explain the particulate nature of matter
- Describe the basic units of matter
- Identify different types of molecules

Matter

Matter is defined as anything that has mass and occupies space. The mass of a substance is the quantity of matter or materials contained in it. The space occupied by matter is termed as its volume. Examples of matter are stone, human body, water, air, book etc.

Matter is identified by its physical and chemical properties. The *physical property* of matter is the property that can be studied without changing the chemical composition of the substance. Examples are the temperature, colour, odour, melting point, boiling point etc. The *chemical property* of a substance is the property that cannot be studied without changing the chemical composition of the substance. Examples are the reaction of the substance with water, air, acid, base etc.

Particulate Nature of Matter

One of the basic characteristics of matter is that, it is made up of discrete particles. No matter the state or form matter takes, there are three different kinds of building units contained in it. These are:

- **Atoms**
- **Molecules or**
- **Ions**

The concept that matter is made up of discrete particles is termed as the *particulate nature of matter*. For example, air and water are made up of discrete molecules. Substances such as graphite and diamond are made up of carbon atoms. Rock salt is made up of sodium and chloride ions.

The atom

As far back as 460 – 370 BC, Greek philosopher *Democritus* believed that everything was made of solid particles. According to him, if matter is continuously divided a stage is reached where it could not be divided further.

In 1661, *Robert Boyle* came out with the definition of element as a substance that cannot be broken down into simpler substances.

In 1803, the English Chemist *John Dalton* proposed that all elements are made up of small indivisible particles called the atom. An atom therefore is defined as the smallest particle of an element that can exist and retain the chemical properties of that element and it takes part in a chemical reactions. Example, atoms of element carbon are represented as C or atoms of element sodium.

Sodium atom (Na)

Atoms of one element are identical in mass and size but different from atoms of other elements. For example, atoms of aluminium have identical mass, size and properties but are different from atoms of sodium even though both are metals.

Initially, it was believed that the atom cannot be created nor destroyed. It was further believed that the atom was indivisible. Further scientific investigations have revealed that the atom has sub – atomic particles called protons, neutrons and electrons.

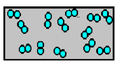
Molecules

For some substances such as oxygen, water and nitrogen, their building units are molecules. *A molecule is defined as an independent structural unit of matter made up of two or more atoms that are chemically bound together.* It can also be defined as the smallest particle in a chemical element or compound that has the chemical properties of that element or compound. A molecule may contain atoms of the same element or atoms of two or more different elements joined together in a fixed ratio.

A. Molecule, made up of a collection of identical elements is called *a molecule of an element.*

For example,

1. Nitrogen molecule (N_2) is a molecule of an element because it contains two nitrogen atoms held together by a chemical bond.

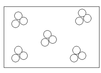


Nitrogen molecule

2. Chlorine molecule (Cl_2) contains two chlorine atoms held together by a chemical bond and therefore it is a molecule of an element.

Chlorine molecule

3. Ozone molecule (O_3) contains three oxygen atoms held together by a chemical bond.

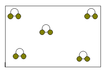


= Oxygen atom

B.*Molecules containing two or more different elements joined together in a fixed ratio are called molecules of a compound.*

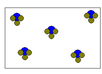
Examples,

1. A molecule of water (H_2O) contains one atom of oxygen and two hydrogen atoms combined chemically.



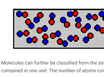
= Oxygen atom
= Hydrogen atom
= water molecule

2. A molecule of ammonia (NH_3) consists of one atom of nitrogen and three atoms of hydrogen joined chemically.



= nitrogen atom
= Hydrogen atom
= ammonia molecule

3. A molecule of hydrogen chloride (HCl) consists of one atom of hydrogen and one atom of chlorine held together by a bond.



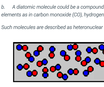
= Hydrogen atom
= Chlorine atom
= hydrogen chloride

Molecules can further be classified from the structural point of view, according to the number of atoms contained in one unit. The number of atoms contained in a molecule is called its *atomicity.*

1. *Diatomic molecule*

A molecule consisting of two atoms in its structural unit is called diatomic molecule.

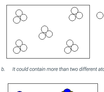
a. *A diatomic molecule could be made of the identical atom or element such as oxygen (O_2), nitrogen (N_2) or hydrogen (H_2). They are described as homonuclear diatomic molecule.*



Chlorine molecule

b. A diatomic molecule could be a compound. That is, a molecule made up of two different atoms or elements as in carbon monoxide (CO), hydrogen chloride (HCl) etc.

Such molecules are described as heteronuclear diatomic molecule.

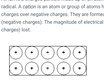


= Hydrogen atom
= Chlorine atom
= hydrogen chloride

2. *Polyatomic molecule*

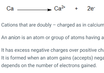
A molecule containing more than two atoms per unit is termed as polyatomic molecule.

a. *A polyatomic molecule could contain more than two identical atoms as in ozone (O_3)*



= Oxygen atom

b. *It could contain more than two different atoms or elements as in carbon dioxide or water.*



= Carbon atom
= Oxygen atom
= Carbon dioxide molecule

Ions

An ion is a charged particle made up of an atom or a group of atoms. It is classified as cation, anion or radical. A cation is an atom or group of atoms having a net positive electrical charge. It has excess positive charges over negative charges. They are formed when an atom of an element loses one or more electrons (negative charges). The magnitude of electrical charge depends on the number of electron's (negative charges) lost.

$Na \longrightarrow Na^+ + e^-$

Cation with unit charge as in sodium cation (Na^+).

$Ca \longrightarrow Ca^{2+} + 2e^-$

Cations that are doubly − charged as in calcium cation (Ca^{2+}).

An anion is an atom or group of atoms having a net negative electrical charge.

It has excess negative charges over positive charges. Therefore it has opposite electrical charge as cation. It is formed when an atom gains (accepts) negative charges (electrons). The magnitude of the charge depends on the number of electrons gained.

$F + e^- \longrightarrow F^-$

Anion with unit charge as in fluoride anion (F^-).

Radicals are polyatomic ions. Examples are ammonium cation (NH_4^+), nitrate (NO_3^-), sulphate (SO_4^{2-}) and carbonate (CO_3^{2-}).

Summary

1. Matter has mass and occupies space (volume).
2. The building units of matter are atoms, molecules and ions.
3. The concept that matter is made up of particles is termed as particulate nature of matter

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following particles is correct?

	Ion	Molecule
A.	Na^+	CO_3^{2-}
B.	K^+	Cl^-
C.	Na	Cl^-
D.	Ca	O^{2-}

Select one:

- A
- B
- C
- D

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following pair of substances are monoatomic?

Select one:

- Ozone and helium
- Nitrogen and argon
- Helium and neon
- Chlorine and bromine

Question **3**

Not yet answered

Marked out of 20.00

Flag question

A substance that has mass and volume is

Select one:

- Ion
- Matter
- Molecule
- Isotope

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is a radical?

Select one:

- N^{3-}
- S^{2-}
- NO_3^-
- Al^{3+}

Question **5**

Not yet answered

Marked out of 20.00

Flag question

An atom that carries an electrical charge is

Select one:

- Molecule
- Ion
- Isotope
- Compound

LESSON NOTE

Lesson21

States of matter

OBJECTIVES

By the end of this lesson you should be able to;

1. Classify matter according to their states, and properties
2. Explain the characteristics of the states of matter
3. Explain the change of state processes

States of matter

There are three different physical forms in which matter can exist depending on the temperature and pressure. These forms are called the states of matter. The three states of matter are the solid state, the liquid state and gaseous state. Each state has characteristics that distinguish it from the rest. These are summarized in the table below:

Property	Solid	Liquid	Gas
Arrangement of particles			
Shape	Fixed (definite)	Variable (takes the shape of the container)	Variable (takes the shape of the container)
Volume	Fixed (definite)	Fixed (definite)	Variable (expands to fill or takes the shape of the container)
Compressibility	Difficult to compress	Difficult to compress	Easy to compress
Fluidity (Ease of flow)	Cannot flow	Flows easily	Flows easily
Density	Usually have high density except ice	Less dense than solid but denser than gas	Have very low density

Explanation of the properties of each state

A theory called the *particle theory of matter* is used to explain the properties of each state. It is based on the following assumptions:

- All matter is made up of particles in constant motion
- The particles are so small that they cannot be seen with the naked eye
- The particles of the same substance are identical in size but different from the particles of other substances
- The individual particles of a substance are the same in each state
- The particles are held together by some forces of attraction
- The higher the energy of the particles, the faster their motion

The basic differences among the states of matter is determined by the nature of movement of the particles and their energy.

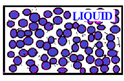
In the solid state, the particles:

- are closely packed in a definite pattern of arrangement. This close packing of particles in a crystal lattice/pattern makes solid difficult to compress.

- are held to a fixed position by strong forces of attraction. This explains why solids have fixed shape and volume.
- undergo vibrational motion about their fixed position. The strong force of attraction between the particles restrict their movement. This explains why solids do not flow.
- Sizes remain constant but move faster when heated.

The particles in the liquid state are:

- loosely packed but still quite close together and therefore have no fixed lattice and shape. This explains why liquids are difficult to compress. It also explains why they have a fixed volume.



held together by weak force of attraction. This allows the particles to have some degree of freedom to move past one another. The force of attraction is not strong enough to

- give liquids a fixed shape. The particles gain support from the walls of containing vessel and therefore takes its shape.
- move about in all directions and slide past each other from place to place. This explain why a liquid can be poured.
- size remains constant but moves faster than solid particle when heated.

The particles in gas are:

- far apart and randomly spaced with no order. This explains why gases have very low densities and can be compressed easily.

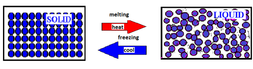
- have no force of attraction between them. Therefore, gas particles have high degree of freedom to move. This explains why gases flow freely, have no fixed volume and shape.
- move rapidly and randomly in all directions.
- size remains the same but move faster when its temperature increases.

Change of state processes

Matter can be changed from one physical state to another without altering the chemical composition of the substance. These processes are formed as *change of state processes*. Change of state processes are reversible and are described as physical change. They can be achieved by changing the temperature and pressure of the substance. They include melting, freezing, evaporation, boiling, condensation and sublimation.

Melting (solid to liquid)

Melting is the process of changing matter from the solid state to the liquid state at constant temperature. The temperature at which a solid melts is called its *melting point*.



The melting point of a pure substance is unique for that substance. No two pure substances have the same melting points. The melting point of a substance is lowered in the presence of an impurity. This principle is applied in melting snow from streets of very cold countries by sprinkling rock salt on them.

Freezing (liquid to solid)

Freezing is the process of changing matter from the liquid state to the solid state. When a liquid is cooled, the liquid loses energy to the surrounding causing the particles to be strongly attracted to a fixed point forming crystal lattice. The temperature at which a liquid freezes is called *freezing point*. The freezing point and melting point of a given substance are both the same temperature.

Example, the melting point and freezing point of pure water is 0 °C

Vapourization (liquid to gas)

The process of changing a liquid from the liquid state to the gaseous state is called vaporization. It involves evaporation or boiling. *Evaporation* is a process where surface molecules gain sufficient kinetic energy from surroundings and break away from the forces of attraction of neighbouring molecules and escape to form gas. This occurs at any temperature below the boiling point of the liquid. The resulting liquid becomes cooler because it loses its energetic molecules (latent heat). This explains why our body temperature cools after sweating. The refrigerator operates on this same principle.

Evaporation depends on factors such as:

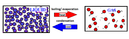
- Surface area of the liquid: The larger the surface area of the liquid the faster the rate of evaporation.
- Temperature: the higher the temperature, the faster of the rate of evaporation.
- Humidity: the higher the relative humidity, the slower the rate of evaporation or vice versa.

When a liquid is heated and the rate of evaporation increases, the rate of condensation increases as well until an equilibrium is established. When the vapour pressure of the liquid equals the atmospheric pressure, the temperature remains constant and a bulk of liquid molecules escape into the gaseous state. At this point the liquid is said to be *boiling*. The constant temperature at which pure liquid boils is called its *boiling point*. Boiling point depends on factors such as:

- The presence of impurities: impurities increase the boiling point of a liquid.
- Atmospheric pressure: the higher the atmospheric pressure, the higher the boiling point.

NB: Practical Application of the Concept (atmospheric pressure)

- Water boils at 100°C at standard atmospheric pressure, but on mountains where the atmospheric pressure is lowered, it boils below 100°C.
- In the pressure cooker, water boils at 120°C to cook food more quickly because it is designed to have increased surrounding pressure.
- The autoclave used in sterilizing surgical instruments work on similar principle to kill bacteria at higher temperatures



Condensation (Gas to Liquid)

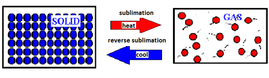
The reverse of vaporization involves cooling a gas to cause the molecules to lose their kinetic energy and become attracted together forming a liquid. This process is called *condensation*.

NB: Practical Application of Concept

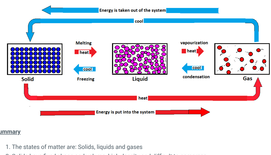
Clouds are formed in the sky by condensation of water vapour.

Sublimation

It is the process of changing solid directly to gas when heating without passing through the liquid state. When the gas is cooled, the solid is reformed directly without condensing to a liquid.



Substances that sublime are camphor balls, iodine crystals, ammonium chloride crystals and dry ice (carbon dioxide crystals).



Summary

1. The states of matter are: Solids, liquids and gases
2. Solids have fixed shape and volume, high density and difficult to compress
3. Solid particles are closely packed in a regular lattice, vibrate about a fixed point, held by strong force of attraction
4. Liquids have no fixed shape but definite volume and are difficult to compress
5. Liquid particles are loosely packed, held by weak force of attraction and move from place to place
6. Gases have no fixed shape and volume and are easily compressible
7. Gas molecules are far apart and have no force of attraction and move rapidly and randomly
8. Melting changes solids to liquid state at constant temperature. Freezing is the reverse of melting.
9. Vaporization changes matter to gas from liquid state. It involves boiling or evaporation. The reverse is condensation.
10. Sublimation changes matter directly from solid state to gaseous state and vice versa.

SHS 1 INTEGRATED SCIENCE

Question 1
Not yet answered
Marked out of 10.00
Flag question

Which of the following is a liquid at room temperature?

Select one:
- Kerosene
- Ice
- Hydrogen
- Stone

Question 2
Not yet answered
Marked out of 10.00
Flag question

Which of the following best describes the arrangement of particles in a solid?

Select one:
- Very far apart and move quickly
- Closely packed and vibrate
- Close together and undergo translational motion
- Far apart and vibrate

Question 3
Not yet answered
Marked out of 10.00
Flag question

Which of the following is the opposite of freezing?

Select one:
- Melting
- Sublimation
- Liquefaction
- Boiling

Question 4
Not yet answered
Marked out of 10.00
Flag question

Which of the following best explains why gases have a low density?

Select one:
- The particles move rapidly and randomly
- The attractive forces between the particles are very weak
- The particles are far apart
- The particles are very small

Question 5
Not yet answered
Marked out of 10.00
Flag question

Which state of matter has no shape and volume?

Select one:
- Liquid
- All of the above
- Gas
- Solid

Question 6
Not yet answered
Marked out of 10.00
Flag question

Which of the following is the opposite of condensation?

Select one:
- Freezing
- Sublimation
- Evaporation
- Melting

Question 7
Not yet answered
Marked out of 10.00
Flag question

When a pure liquid changes to a gas at constant temperature, it is said to be boiling. Consider the following factors:

I. Presence of impurities
II. Atmospheric pressure
III. Wind
IV. Surface area

Which factor(s) affect(s) the boiling point of the pure liquid?

Select one:
- I, III and IV only
- I and III only
- I and II only
- I, II and III only

Question 8
Not yet answered
Marked out of 10.00
Flag question

Which of the following statements is correct about evaporation?

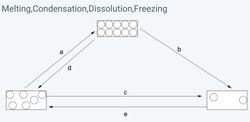
Select one:
- The temperature of resulting liquid remain constant
- It occurs at all temperatures between the melting pint and boiling point
- It involves the escape of the least energetic particles
- The smaller the surface area the faster the rate of evaporation

Question 9
Not yet answered
Marked out of 10.00
Flag question

The diagram below shows the change of state processes. Use the words in the box to answer the questions that follows.

Boiling,Sublimation,Diffusion,Crystallization

Melting,Condensation,Dissolution,Freezing



What is e?

Select one:
- melting
- freezing
- condensation
- sublimation

Question 10
Not yet answered
Marked out of 10.00
Flag question

Which of the following best explains why water flows more easily than ice?

Select one:
- Water particles can change sharp more easily than the ice particles
- Water particles have more energy than ice particles
- Water particles have weaker forces of attraction than the attractive forces in ice
- Water particles are lighter than ice particles

LESSON NOTE

Lesson 22

Classification of matter

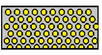
Gold is a precious metal, hydrochloric acid is a corrosive substance and oxygen is an essential gas for respiration in living things. What has these three substances have in common? The answer will be obvious at the end of the lesson.

At the end of the lesson, you will be able to:

1. Distinguish between an element and a compound
2. Define an element and give at least five examples
3. State the symbols of at least the first 20 elements of the periodic table
4. Classify elements according to their states and properties
5. Define a compound and give at least five examples

Classification of Matter

Matter can be grouped into two main categories, namely pure substances and mixtures. A pure substance has uniform and definite chemical composition. For example, gold, oxygen and hydrochloric acid are considered to be pure substances, because each one has uniform and definite composition.
On the other hand, a mixture is made of more than one components physically combined. For example, air is made up of different gases. Pure substances have definite melting and boiling points. This is because they contain only one type of particles, packed together in a particular manner. Pure substances are further classified as elements and compounds.
An element is the simplest form of matter that can exist under normal conditions and cannot be separated into simpler substances by chemical means. Elements are pure substances because they are made up of one kind of atoms.
For example, gold is made up of only gold atoms and it cannot be decomposed by passing electric current through it.



Other examples are:

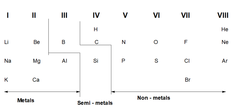
- oxygen which is made up of oxygen atoms,
- Sodium which is made up of sodium atoms etc.

An element has a unique physical and chemical properties. These properties help to identify them. They have definite physical properties such as density, melting point, boiling point, colour etc. The physical properties of some elements are summarized in the table below:

Element	Colour	Melting point/°C	Boiling point/°C	Density g/cm^3
Lithium	Blue – white	180.5	1347	0.534
Beryllium	Brown	1278	2970	1.85
Boron	Dark brown	2300	2550	2.34
Carbon	Black	3500	4827	2.25
Nitrogen	Colourless	-209.9	-195.8	1.25×10^{-3}
Oxygen	Green – yellow	-218.4	-183.0	1.4×10^{-3}
Fluorine	Colourless	-219.6	-188.1	1.69×10^{-3}
Neon	Colourless	-248.6	-246.1	0.89×10^{-3}
Helium	Silver – white	-272	-286.6	0.81×10^{-3}
Sodium	Silver – white	97.8	882.9	0.971
Magnesium	Silver – white	638.8	1090	1.738
Aluminium	Silver – white	660.1	2467	2.699
Silicon	Grey	1410	2355	2.33
Phosphorus	White, red or black	44.1	280	1.82
Sulphur	Dull yellow	112.8	444.6	2.07
Chlorine	Green – yellow	-100.9	-34.6	3.21×10^{-3}
Argon	Colourless	-189.3	-186	1.78×10^{-3}
Potassium	Silver – white	63.65	774	0.86
Calcium	Silver – white	839	1484.4	1.55

Classification of Elements

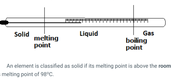
There are about 118 different elements. Of this number, 92 occur naturally and the rest were created through radioactivity. As was treated in lesson 14, elements can be classified according to their physical and chemical properties as metals, non – metals and semi – metals or metalloids. This is summarized by their arrangement in the periodic table.



Elements such as lithium, sodium, potassium, magnesium have similar physical properties such as malleability, ductility, high melting point, high boiling points etc. They are therefore classified as metals and located on the left hand side of the periodic table.

Elements such as oxygen, fluorine, nitrogen, carbon and sulphur have similar physical properties such as low melting point, low boiling points etc that allow them to be classified as non – metals and placed on the right hand side of the periodic table.

Elements can be classified according to their state. Most elements exist as solids. For example, all metals are solids at room temperature except mercury which exists as a liquid. Few non – metals exist as gases at room temperature. Examples are neon, helium, oxygen etc. Bromine and mercury exist as liquids.



- An element is classified as solid if its melting point is above the **room temperature**. Example, sodium has melting point of 98°C.
- An element is a gas if its boiling point is below the room temperature.

For example, the boiling point of oxygen is -183°C.

- An element is a liquid if its melting point is below the **room temperature** and the boiling point is above the room temperature. For example, water has a melting point of 0°C which is below room temperature of 25°C and boiling point of 100°C which is above room temperature of 25°C.

Chemical symbols of elements

Every element has a name and a one – letter or two – letter chemical symbol. The chemical symbol for most elements is the first one or two letters of the element's English name. For example, carbon (C), nitrogen (N), phosphorus (P) have one – letter chemical symbol and it is always the upper case of the letter. Elements such as calcium (Ca), Cobalt (Co), Neon (Ne), Lithium (Li) have two – letter chemical symbol of their names. Notice that the first letter is always upper case and the second letter is lower case.

Some elements have the chemical symbol made up of the first and third letters of their names. For example, Magnesium (Mg), Manganese (Mn), Chromium (Cr).

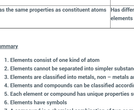
Some chemical symbols are derived from the Latin or Greek name of the elements. For example, the chemical symbol for iron, Fe, comes from the latin name for iron, Ferrum. The table below summarizes such elements

Name	Symbol	Latin or other names
Sodium	Na	Natrium
Potassium	K	Kalium
Copper	Cu	Cuprum
Gold	Au	Aurum
Iron	Fe	Ferrum
Silver	Ag	Argentum

A compound

A *compound* is **a pure substance made up of two or more different elements that have been chemically combined in a definite proportion. For example, one atom of oxygen combines chemically with two atoms of hydrogen to form water.**

- One atom of carbon combine chemically with two atoms of oxygen to form carbon dioxide.



- One atom of nitrogen combines chemically with three atoms of hydrogen to form ammonia

Properties of Compound

- **A compound has different physical and chemical properties from the constituent elements. For example, carbon is a black substance, oxygen is a gas that supports combustion and hydrogen is a flammable gas. When the three different elements are combined in a fixed ratio, they form a sweet – tasting substance called glucose. The properties of this new substance is different from the constituent elements.**
- **Compounds are combined in a fixed ratio. For example, when one atom of carbon combines with two atoms of oxygen, carbon dioxide is formed. On the other hand, when one carbon atom combines with one atom of oxygen, carbon monoxide is formed.**
- **Compounds cannot be separated into their components by physical means. Some can be separated by passing electricity through them in a process called electrolysis.**
- **Heat energy is usually given off or absorbed in forming a compound.**
- **Compounds have fixed melting and boiling points. The value of their melting and boiling points can be used to identify the substance.**

Compounds can also be classified according to their states. The scheme used in classifying the state of elements are also used in classifying compounds.

Substance	State at room temperature	Melting point/°C	Boiling point/°C
Nitrogen	Gas	-210	-196
Oxygen	Gas	-219	-183
Ethanol	Liquid	-117	78
Water	Liquid	0	100
Sulphur	Solid	115	444
Sodium chloride	Solid	801	1465
Copper	Solid	1083	2600

Differences between elements and compounds

Element	Compound
Consist of only one kind of atom	Consist of different kinds of atoms
Cannot be separated into simpler substances by chemical means	Can be separated into constituents by chemical means
Has the same properties as constituent atoms	Has different properties from constituent elements

Summary

1. **Elements consist of one kind of atom**
2. **Elements cannot be separated into simpler substances by chemical means**
3. **Elements are classified into metals, non – metals and metalloids.**
4. **Elements and compounds can be classified according to their state, as solid, liquid or gas**
5. **Each element or compound has unique properties such as fixed melting point and boiling point.**
6. **Elements have symbols**
7. **A compound is a chemical combination of two or more different elements in a fixed ratio.**

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Given the statement about element and compound, decide whether it is true or false for an element or compound.

Statement	True	False
Consist of different kinds of elements	True or false	True or false

Select one:

- True, false
- False, false
- True, true
- False, true

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following symbols represent silicon?

Select one:

- Si
- Se
- S
- Sc

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Type in the chemical symbol for each element in the table below:

Name of element	Chemical symbol
Chlorine	
Beryllium	
Sulphur	
Iron	
Magnesium	

Select one:

- (Cl, Be, S, Fe, M)
- (Cl, Be, S, F, Mg)
- (Cl, Be, S, Fe, Mg)
- (Cl, B, S, Fe, Mg)

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Type in the name of the elements represented by the chemical symbols in the table.

Chemical symbol	Name of element
Ne	
K	
He	
Ar	
Al	
Br	

Select one:

- Neon, potassium, helium, argon, alum and bromine
- Neon, potassium, helium, argon, aluminium and bromium
- Neon, potassium, helium, arg, aluminium and bromine
- Neon, potassium, helium, argon, aluminium and bromine

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following symbols represent silver?

Select one:

- Ag
- S
- Si
- Sl

LESSON NOTE

Lesson 23

Mixtures

What has these naturally occurring substances have in common? Air, seawater and blood.

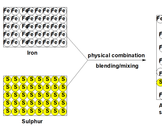
At the end of today's lesson, you will be able to:

1. Define mixture and give at least three examples
2. Classify mixtures according to the state of components
3. Distinguish among mixtures, compounds and elements
4. Distinguish among solution, suspension and colloid

Mixtures

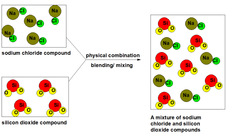
We recall that matter can be classified as pure and impure substances. Pure substances have constant melting and boiling points and exist as elements or compounds. A mixture on the other hand is formed by physical combination of two or more substances.

- The physical combination could be between two different elements. For example, sulphur and iron fillings can combine physically to give a mixture of iron and sulphur.



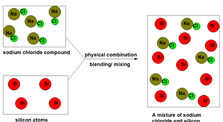
Other examples of such mixtures are alloys such as brass, bronze, steel etc.

- A mixture could be made by physically combining two different compounds. For example table salt (sodium chloride) can physically be combined with sand (silicon dioxide) to form a mixture.



Other examples of a mixture of compounds are paint, air, concrete, sea water, crude oil etc.

- A mixture could be made by physically combining a compound and an element. For example, a mixture of table salt and Sulphur



Other examples are salt and iron fillings

Characteristics of Mixtures

These characteristics are common to all mixtures.

1. They contain two or more substances physically combined.
2. No new chemical substance is produced in forming a mixture.
3. Mixtures can be separated easily into its constituents by physical means.
4. The composition of mixtures can vary. For example, tea can have a varying amount of sugar and milk.
5. The constituents of a mixture retain their identities. That is, constituents have identical properties as the mixtures.

For example, a mixture of water and sugar give a sugary solution.

6. No energy change occurs in forming a mixture.
7. Mixtures melt at a lower temperature than the pure components and the melting point is not sharp but occur over a range of temperatures. For example ice melts at 0°C but in the presence of salt or particles, it melts at a lower temperature.

Classification of Mixtures

Mixtures can be classified according to the state of its components. These are:

1. **Solid – solid mixture**

This type of mixture is made up of two or more different solid substances. They could be uniform (homogenous) such as brass, bronze, steel, solder etc. Others could be non – uniform (heterogeneous) such as iron fillings and sulphur, soil, sand and salt etc.

2. **Liquid – liquid mixture**

This type of mixture consists of two or more different liquids. If the liquids completely mix to form a homogenous mixture, the liquids are described as miscible. (i.e. they become one single state or phase). For example, a mixture of ethanol and water. If the liquids mix to give a heterogeneous mixture, the liquids are described as immiscible (that is, the phases separate out). For example, a mixture of water and kerosene.

3. **Gas – gas mixture**

It consists of two or more different gases. For example, air is made up of different gases such as carbon(IV) oxide, oxygen, nitrogen, water vapour etc.

4. **Solid – gas mixture**

This type of mixture consists of solid and gas. Example, smoke is made up of carbon particles and air. Another example is harmattan, which is made up of air and dust.

5. **Liquid – gas mixture**

This type of mixture is made of liquid and gas as components. For example, soda – water consist of water (liquid) and carbon(IV) oxide (gas). The following are also carbonated drinks: Coca – cola, Fanta, Sprite, Lemonade. Other example is the cloud which is made up of water (liquid) and air (gas).

6. **Solid – liquid mixture**

This type of mixture consists of solid and liquid constituents. It could be uniform or non – uniform depending on the size of the solid component. A uniform mixture of a solute and a solvent is called a solution. The solute is the substance that dissolves in the solvent to form a single phase (meaning you cannot distinguish one component from the other). The dissolving medium is called the solvent. For example, salt (solute) dissolves in water (solvent) to form a solution. There are several solvents used at home and in industry. They are also used to remove stains. Examples are summarized in the table below:

Solvent	What it dissolves
Lime or lemon	Rust stain
White spirit	Gloss paint
Propanone	Grease, nail polish
Dichloromethane	Grease
Kerosene, petrol	Grease
Ethanol	Perfumes, aftershaves, glues, printing inks
Borax solution	Coffee stains

Characteristics of solution, suspension and colloid

A solution has the following characteristic properties:

- Has particles that are so small that they cannot be seen with the naked eye
- Cannot be separated into components by filtration because the particles can pass through the filter paper
- Does not scatter light because the solute particles are small
- Has particles that do not settle on standing.

Examples of solutions are sugar solution, salt solution and sodium hydroxide solution.

A suspension is a heterogeneous mixture of a solid and a liquid. Such solid – liquid mixture forms two phases with the solid spread throughout the particles or droplets.

A suspension has the following properties:

- Has particles that are so large that they can be seen with the naked eye
- Can be separated by filtration because the particles are so large that they cannot pass through a filter paper.
- Settle on standing because of their large particles
- Scatter light because of the large particles

Examples of suspension are muddy water, milk of magnesia, white wash paint, cloud, smog, harmattan.

Colloid is a heterogeneous mixture in which the solute particles are permanently and uniformly distributed throughout the dissolving medium. It has the following characteristic properties:

- Has particles smaller than that of suspension but larger than that of solution
- Has particles do not settle on standing
- Scatters light
- Has particles that cannot pass through semi – permeable membrane and therefore can be separated by dialysis.

Examples of colloids are;

- Emulsion paint, salad dressing(salad cream)
- Aerosol such as mist, smoke, paint, milk spray
- Foam such as shaving foam, froth

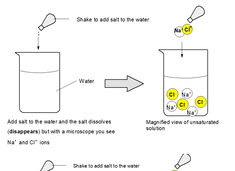
Types of Solution

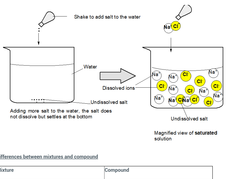
There are three types of solutions based on their ability to dissolve more solute at a particular temperature. These are:

i. Unsaturated solution: It is a solution that can dissolve more solutes at a given temperature. For example, if a teaspoon full of sodium chloride is added to a glass of water and stirred, it dissolves. It dissolves because solution contains less amount of solute than it can hold at that temperature.

ii. Saturated solution: It is a solution that cannot dissolve any more solute at a particular temperature. It holds the maximum amount of solute at that temperature. For example, if more of the sodium chloride is added to an unsaturated solution at a particular temperature, a stage is reached when the solution cannot dissolve any more of the solute. Such a solution is described as saturated solution.

iii. Supersaturated solution: It is a solution that has dissolved more solute than it can hold at a particular temperature.





Differences between mixtures and compound

Mixture	Compound
Components are physically combined	Components are chemically combined
Contains two or more substances	Contains only one kind of substance
Has variable composition	Has fixed composition by mass
Has properties that are the same as constituents	Has properties different from that of its constituents
No new substance is formed	New substance is formed
No energy change occurs when a mixture is formed	Energy is given off or absorbed in forming a compound
Melts at a lower temperature than pure substance and boils at higher temperature than pure substance	Melts at constant temperature and boils at constant temperature

Differences between a mixture and an element

Mixture	Element
Contains two or more elements or compounds	Contains only one kind of atom
Melts at lower temperature and boils at a higher temperature than pure substances	Has fixed melting and boiling points

Summary

1. Mixtures are made up of two or more substances physically combined
2. They melt at lower temperatures and boil at higher temperatures than pure substances
3. Mixtures are classified according to the states of their components
4. Mixtures can be classified according to the phase of the mixture – as homogenous or heterogeneous
5. Solid – liquid mixture are classified as solution, suspension or colloid
6. Solutions are also classified based on ability to dissolve more solute at a particular temperature as saturated, unsaturated and supersaturated solution

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 10.00

Flag question

A solution that cannot dissolve any more solute in a given temperature is called .....

Select one:

- Mixture
- Solute
- Solution
- Saturated

Question **2**

Not yet answered

Marked out of 10.00

Flag question

The table below shows the difference between compounds and mixtures. Pick the correct box in the table.

Property	Mixtures of element	Compounds
Can vary the amount of each element in it		

Select one:

- mixture
- compound

Question **3**

Not yet answered

Marked out of 10.00

Flag question

The table below shows the difference between compounds and mixtures. Pickin the correct box in the table.

Property	Mixtures of element	Compounds
Can be easily separated into its elements		

Select one:

- compound
- mixture

Question **4**

Not yet answered

Marked out of 10.00

Flag question

Which of the following solid – liquid mixture is not homogeneous?

Select one:

- Sulphur and iron fillings
- Bronze
- Steel
- Brass

Question **5**

Not yet answered

Marked out of 10.00

Flag question

Which of the following is not correct about a suspension?

Select one:

- Particles settle on standing
- It can be separated by filtration
- Particles scatter light
- Particles are larger than colloidal particles

Question **6**

Not yet answered

Marked out of 10.00

Flag question

The table below shows the difference between compounds and mixtures. Pick in the correct box in the table.

Property	Mixtures of element	Compounds
Properties of its constituents are similar to its properties		

Select one:

- mixture
- compund

Question **7**

Not yet answered

Marked out of 10.00

Flag question

Which of the following is a heterogeneous liquid – liquid mixture?

Select one:

- Ethanol and water
- Methanol and water
- Crude oil
- Kerosene and water

Question **8**

Not yet answered

Marked out of 10.00

Flag question

Which of the following is a mixture?

Select one:

- Bronze
- Boron
- Boron trichloride
- Borane

Question **9**

Not yet answered

Marked out of 10.00

Flag question

Which of the following does not scatter light?

Select one:

- Milk
- Milk of magnesia
- Cloud
- Ethanol

Question **10**

Not yet answered

Marked out of 10.00

Flag question

Which of the following solvents can dissolve rust stain?

Select one:

- Ethanol
- Kerosene
- Water
- Lemon

LESSON NOTE

Lesson 24

Separation of Mixtures I

Let us continue with the discussion on mixtures by looking at 'separation of mixtures.'

An ore is a mixture of impurities and a mineral. The process of getting the mineral from the ore involves the application of separation of mixtures. What then is separation of mixtures?

By the end of the lesson, you will be able to:

1. Identify some methods of separating mixtures
2. Explain the separation of a mixture of insoluble solid from a suspension
3. Explain the separation of a mixture of soluble solid from a solution
4. Name and state the functions of the parts of filtration, evaporation, centrifuging and crystallization set – up.

Methods of Separating Mixtures

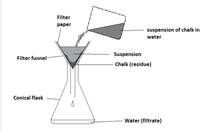
Mixtures can be separated physically into their constituent components. This process is called method of separation of mixtures. The method used in separating mixtures depends on the physical properties and the state of the components of the mixture. Some of the methods include:

1. **Separating a solid from a liquid (suspension and solution)**

- **By filtration:** A heterogeneous mixture of fine solids such as chalk and water (suspension) can be separated into its components by filtration. The separation technique is based on differences in particle sizes of the solid and the liquid and hence the ability of one to pass through the holes in a filter paper.

The filter paper traps the larger particle (solid) and allow the smaller particle (liquid) to pass through. The solid trapped in the filter paper is called the residue and the liquid that passes through the filter paper is called the filtrate.

Filtration allows both components of the mixture to be obtained in one process



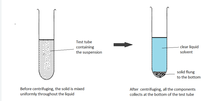
Examples of mixtures that can be separated using this method are, muddy water, milk of magnesia

NB: Practical Application

- The use of filter beds in municipal water treatment plant to purify drinking water.
- It is also used to purify Guinea worm infested water or muddy water for drinking
- It is used in brewing raw coffee for drinking
- There are various large – scale industrial application of the method eg. In the extraction of metals.

- **By Centrifuging**

It involves separating insoluble solids from a suspension by using a centrifuge. Test tubes containing the suspension are inserted in the holes of the centrifuge where they spun at high speed. A force of gravity acts on the particles of the suspension to separate out and become compact at the bottom of the centrifuge test tubes. The liquid can then be decanted off carefully from the test tube leaving the solid behind.



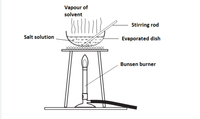
NB: Practical Application

It is used in medical or hospital laboratory to separate and examine:

- Blood cells
- Cells from urinary deposits
- Concentrate certain parasite eggs in diluted stools

- **By Evaporating the Solvent**

For homogeneous mixture or solutions, the solute particles are so small that they cannot be separated by filtration or centrifuging. One way of separating the solvent from the solute is by heating the solution gently so that the **solvent is evaporated** leaving the solute behind. This method is only applicable when the solvent is not needed.



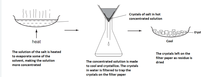
NB: Practical application

This method is used industrially in large scale production of salt from sea water at Ada, Accra and other parts of coastal Ghana.

- **By Crystallization**

It is the process of "growing" a solid out of a solution that has been evaporated to its solubility limit. It is achieved by heating the solution to get it concentrated and upon cooling crystals formed. It is used in practice to get a pure solid out of solution.

An illustration of crystallization of $CuSO_4$ salt.



Practical Application

It is applied in purification of samples in scientific research such as computer chips.

1. **Separating a Mixture of Two Solids**

- a. The suitable method for separating solid – solid mixture is based on differences in physical properties of the components.

4. **Separation by dissolving one of the component**

This separation method is based on differences in the solubility of the components in a given solvent at room temperature. For example, sand and salt mixture.

Problem 1: How can sand be separated from salt in a mixture?

Solution: Use the problem – solving approach to solve it

1. **Analyse:** Plan a problem – solving strategy

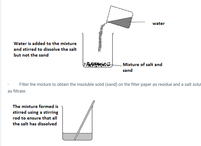
- List the properties of salt and sand and look for a physical property that would be useful to effect the separation of the mixture.

Salt	Sand
Compound	- Mixture
White in colour	- Brown in colour
Soluble in water	- Insoluble in water

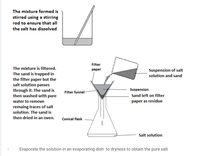
Make use of the crucial physical property that differentiates the salt from the sand, (i.e. water dissolves salt but not sand to make suspension)

2. **Solve:** Apply the problem – solving strategy

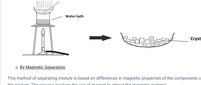
- Dissolve the mixture in water
- The salt dissolves but the sand does not



- Filter the mixture to obtain the insoluble solid (sand) on the filter paper as residue and a salt solution as filtrate.



- Evaporate the solution in an evaporating dish to dryness to obtain the pure salt



- **By Magnetic Separation**

This method of separating mixture is based on differences in magnetic properties of the components of the mixture. The process involves the use of magnet to attract the magnetic material.

-

Problem 2: How can a mixture of iron fillings and sulphur be separated?

Solution: use problem – solving strategy

Analyse: plan a problem – solving strategy: List the properties of iron fillings and sulphur and look for a crucial property that could be used to separate them.

Iron Fillings	Sulphur
- Metal	- non - metal
- Greyish	- yellow
- Insoluble in water	- insoluble in water
- Attracted by magnet	- not attracted by magnet

Solve: Apply the problem – solving strategy

Use the differences in magnetic property to separate them. Use the magnet to attract the iron fillings.

- **By Magnetic Separation**

This method of separating mixture is based on differences in magnetic properties of the components of the mixture. The process involves the use of magnet to attract the magnetic material.

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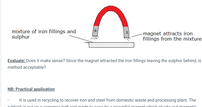


Evaluate: Does it make sense? Since the magnet attracted the iron fillings leaving the sulphur behind, is the method acceptable?

NB: Practical application

- It is used in recycling to recover iron and steel from domestic waste and processing plant. The rubbish is put on a conveyor belt and made to pass by a powerful magnet which plucks out magnetic materials.
- In metal extraction, magnetic iron ore can be separated from other minerals in their crushed or by using an electromagnet

- **By Sublimation**

This method of separation is based on differences in the ability of the components to sublime.

-

Problem 3: How can a mixture of iodine crystal and sand be separated?

Solution

1. **Analyse:** Plan a problem – solving strategy: List the properties of iodine and sand and look for a crucial property that could be used to separate them.

Sand	Iodine crystal
- Solid mixture	- solid crystal element
- Does not sublime	- sublimes
- Insoluble in water	- soluble in water

2. **Solve:** Apply the problem – solving strategy

Make use of the differences that is, iodine sublimes but sand does not and effect separation as shown below:

3. **Evaluate:** Does the result make sense? Iodine sublimes and is collected leaving the sand behind.

Summary

1. **Crystallization** involves growing a crystal out of a hot concentrated solution by evaporating to a point beyond solubility limit.
2. **Evaporation** involves removing a solvent from solution leaving behind the solid solute
3. **Centrifuging** involves separating insoluble solids from a liquid, where normal filtration does not work
4. **Filtration** is used to separate insoluble solid from a suspension. It is employed if either the solid or liquid or both are required
5. **Magnetization** involves the use of magnet to separate a magnetic material from a non – magnetic material in a mixture
6. **Sublimation** is employed to separate two or more solids in which one solid sublimes and the other does not.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which method can be used to obtain crystals from aqueous sodium chloride solution?

Select one:

- Neutralization
- Decanting
- Evaporation
- Electrolysis

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which separation method is applied in large scale production of salt from sea water?

Select one:

- Filtration
- Centrifuging
- Evaporation
- Chromatography

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following separation method is applied in concentrating parasite eggs in diluted stools in hospitals laboratories?

Select one:

- Centrifuging
- Crystallization
- Distillation
- Filtration

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following separation method is applied in brewing raw coffee for drinking?

Select one:

- Centrifuging
- Crystallization
- Filtration
- Distillation

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Consider a solid – solid mixture made up of iodine crystals and sand. Which of the following separation method can be employed to separate the two?

Select one:

- Filtration
- Distillation
- Chromatography
- Sublimation

LESSON NOTE

Lesson 25

Separation of Mixtures II

A fruit drink coloured orange contains dissolved mixture of red and yellow colouring agents. One of these colouring agents is suspected by Ghana Standard Authority of being illegal. Is it possible to detect which colouring agent is illegal? What method will you use?

At the end of the lesson, you will be able to:

1. Explain the separation of a solution by simple distillation
2. Explain the separation of a mixture of two miscible liquids using fractional distillation
3. Explain the separation of immiscible liquids using separating funnel
4. Explain the separation of soluble coloured mixtures using chromatography
5. Name and state the functions of the parts of a distillation apparatus

Separation of Solution by Simple Distillation

To separate a solution, such that both the solute and the solvent are obtained is usually carried out by simple distillation. The technique is based on differences in the relative tendency of the components to vaporize. Thus, it can be used to obtain a pure solvent from a solution. For example, pure water from salt solution. This is because the dissolved solid salt has much higher boiling point and will not evaporate. It can also be used to separate a mixture of two miscible liquids having large boiling point differences. The process involves two stages and both are physical state processes. These are vaporization and condensation.

- The solution or liquid mixture is boiled to vaporize the most volatile component of the mixture or the substance with lower boiling point, leaving the other component in the flask (**liquid** **gas**). The other component (solute) will not evaporate.

- The vapour rises into the condenser where it is cooled by cold water in the condenser. It is condensed back to a liquid and collected as a **distillate**. (**gas** **liquid**)

NB: Anti – bumping granules are added to mixture to give a smoother boiling action.

Problem 1: How can a mixture of sodium chloride and water be separated?

Solution: use problem – solving approach

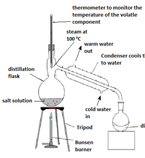
1. **Analyze:** Plan a problem – solving strategy.

List the properties of sodium chloride and water and look for something that can be used to separate the mixture.

Sodium chloride	**Water**
- Solid	- Liquid
- Colourless	- Colourless
- Water soluble solute	- Solvent
- Boils at 1 413 °C	- Boils at 100 °C

Make use of the large boiling point difference and use distillation to separate the water as the distillate while the sodium chloride remains in the flask.

2. **Solve:** Apply the problem – solving strategy.



3. **Evaluate:** does the result make sense? The water is collected as distillate at 100 °C leaving the sodium chloride in the distillation flask.

Separation of two Miscible Liquids or Complex Mixture of Liquids by Fractional Distillation

To separate solutions containing two or more miscible liquids of close boiling point differences, **fractional distillation** is required. For example, water boils at 100°C and ethanol boils at 78°C. A mixture of water and ethanol can be separated by fractional distillation.

The process also involves two main stages and both are physical state changes. These are vaporization and condensation.

- The solution or liquid mixture is boiled to vaporize the most volatile component. However, some of the other components also vaporizes so that a gaseous mixture of both components rise up the fractionating column.

- The vapour mixture condenses on the cold beads in the fractionating column making the beads heat up until the temperature is equal to the lower boiling point. Then the component with lower boiling point no longer condenses but proceeds to the condenser where it condenses into liquid.

Practical Application

This method can be used to separate industrially:

- Mixture such as alcohol from a fermented sugar or carbohydrate
- Separate the various fractions from crude oil
- Separate different gases from air

Problem 2: How can a mixture of ethanol and water be separated?

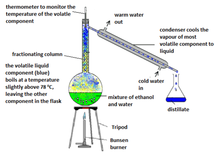
Solution: Use problem – solving strategy

1. **Analyze:** List the properties of ethanol and water and look for something that can be used to separate the mixture.

Ethanol	**Water**
- Liquid	- liquid
- Colourless	- colourless
- Miscible	- miscible
- Boils at 78°C	- boils at 100°C
- More volatile	- less volatile

Make use of the close boiling point difference and use fractional distillation to separate the ethanol as the distillate.

2. **Solve:** Apply the problem – solving strategy



3. **Evaluate:** Does the results make sense? The ethanol is collected as distillate at 78°C leaving the water in the distillation flask.

Separation of two Immiscible Liquids using Separating Funnel

Liquids that do not mix but form two separate layers are called *immiscible liquids*. Their separation is based on differences in density and their immiscibility. Example, oil and water mixture. They are separated using *separating funnel*.

Procedure

1. **The mixture of immiscible liquids settle in two layers**
2. **The tap is opened to let only the bottom layer run into the beaker**
3. **The tap is immediately closed and the beaker is changed. The tap is then opened to let the top layer liquid run out.**

Problem 3: How can a mixture of palm oil and water be separated?

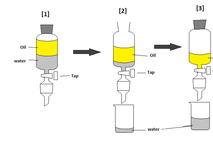
Solution: Use problem solving strategy

1. **Analyze: plan a problem – solving strategy.**

- **List the properties of palm oil and water and look for something that can be used to separate the mixture.**

Palm oil	**Water**
- Liquid	- liquid
- Red	- colourless
- Immiscible	- immiscible
- More viscous	- less viscous
- Lower density	- higher density

2. **Solve: apply the problem – solving strategy**



Practical Application

- **Panning for gold** – gold dust is denser than other substances in the river sediment.

- **Purification of zinc and copper**- the metal is less dense than the other impurities and therefore floats on the surface

- **Salting – out**- in preparation of soap

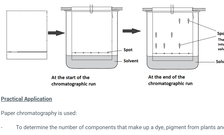
Separation of Mixtures of Coloured Substances by Chromatography

A mixture of two or more dissolved solids in solution can be separated by *chromatography*. It can also be used to separate a mixture of coloured substances in solution. There are different types of chromatography but the most common one is paper chromatography. *Paper chromatography* is a separation technique based on the relative ability or rate of the various coloured components of the mixture (dye) to move along the stationary paper.

Procedure

1. Use a pencil to draw a horizontal line on the filter paper.
2. Spot the dye on the line and allow it to dry.
3. Mount it in a beaker containing some solvent such that the tip of the filter paper just touches the paper.
4. Allow the solvent to creep upward for about 20 minutes.
5. Observe the chromatogram formed.

The total number of spot determines the number of components in the dye.



Practical Application

Paper chromatography is used:

- To determine the number of components that make up a dye, pigment from plants and ink
- To determine the number of amino acids from protein analysis
- Analyse food, fruit juice and drinking water for possible contamination
- In forensic analysis, to detect fraud and trace criminals to crime scenes or the criminal.

Summary

1. **Distillation** is used to separate a solvent and a solute from a solution. It can also be used to separate miscible liquids of large boiling point difference.
2. **Fractional distillation** involves separating a mixture of two miscible liquids of close boiling point difference. The distillation apparatus has a fractional column.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which method of separation is best for investigating the composition of plant pigment?

Select one:

- Evaporation
- Distillation
- Sublimation
- Chromatography

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which separation method is based on the relative ability of the components to move over a stationary phase?

Select one:

- Filtration
- Distillation
- Chromatography
- Use of separation funnel

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which method of separation is best to use for separating kerosene from crude oil?

Select one:

- Filtration
- Chromatography
- Evaporation
- Fractional distillation

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following methods of separation is based on the differences between the boiling points of the components?

Select one:

- Chromatography
- Sublimation
- Distillation
- Use of separating funnel

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Filtration and distillation can be used to separate substances. In which method of separation is a thermometer required to check that complete separation has occurred?

Select one:

- Filtration of two solids of different solubility
- Filtration of a suspension
- Distillation of two miscible liquids
- Distillation of two immiscible liquids

LESSON NOTE

Lesson 10

Atomic structure

How can atoms combine together to form a molecule? What makes certain atoms combine readily but others cannot? To find answers to these questions, we must first consider the structure of atoms.

At the end of today's lesson, you will be able to:

1. Name the sub – atomic particles and describe their properties
2. Describe the structure of an atom
3. Write the electron configuration of at least the first 10 elements of the periodic table

A Simple Model of the Atom

The scientific model that describes the structure of an atom states that atoms are made up of two main parts. These are:

A small dense body at the centre that contains the mass of the atom called the nucleus. The nucleus contains positively charged particles. The number of these positively charged particles is the atom's positively charged particles. Each proton has one unit positive charge (+1). The nucleus is neutral particles having zero charge. The protons and neutrons in the nucleus determine the physical properties, such as the mass of the atom. The electrons in the nucleus of an atom and neutrons also determine the stability of the atom and how it is chemically reactive.

The other part of the atom are shells. They surround the nucleus and contain a third sub – atomic particle called electrons. An electron has negligible mass. Each electron has a unit negative charge (-1). The electrons determine the chemical properties of an atom. Thus, the proton, neutron and electron are fundamental particles of the atom. These atomic particles. The table below summarizes the characteristic properties of fundamental particles.

Sub atomic particle	Symbol	Relative mass	Relative charge	Comment
Proton	P	1	+1 (positive)	Located in the nucleus and it is a nucleon
Neutron	N	1	Zero	Located in the nucleus and it is a nucleon
Electron	E	1/2000	-1 (negative)	Has arranged in orbit around the nucleus. It is not a nucleon

The atom therefore is represented diagrammatically by the model

Proton number

Through all atoms are made of the same fundamental particles, their number and arrangement vary. The table contains the first twenty elements and the number of fundamental particles contained in them.

Element	Symbol	Atomic number	Composition of nucleus		Number of electrons
			Protons	Neutrons	
Hydrogen	H	1	1	0	1
Helium	He	2	2	2	2
Lithium	Li	3	3	4	3
Beryllium	Be	4	4	5	4
Boron	B	5	5	6	5
Carbon	C	6	6	6	6
Nitrogen	N	7	7	7	7
Oxygen	O	8	8	8	8
Fluorine	F	9	9	10	9
Neon	Ne	10	10	10	10
Sodium	Na	11	11	12	11
Magnesium	Mg	12	12	12	12
Aluminium	Al	13	13	14	13
Silicon	Si	14	14	14	14
Phosphorus	P	15	15	16	15
Sulphur	S	16	16	16	16
Chlorine	Cl	17	17	18	17
Argon	Ar	18	18	22	18
Potassium	K	19	19	20	19
Calcium	Ca	20	20	20	20

It can be deduced from the table that

- The number of protons in the nucleus of an atom varies from one element to another. That is, no two elements have the same number of protons. For example, sodium and magnesium have 12 neutrons but different number of protons. Sodium has 11 protons while magnesium has 12 protons.
- The number of protons in the nucleus of an atom is equal to the atomic number. For example sodium has its atomic number and number of protons being 11.

The number of protons in the nucleus of an atom is the same as the number of electrons in the orbits outside the nucleus. An atom is therefore described as electrically neutral. For example, sodium has 11 protons and 11 electrons. Thus, the charge on the 11 protons is +11 while the 11 electrons in its shells and a charge of -11. These charges cancel out making the atom electrically neutral.

Electron Configuration

The atomic model reveals that electrons encircle the nucleus in a spherical orbits called shells or energy levels. These shells differ in energy, shape, distance from the nucleus and the number of electrons it contains.

The K – shell is the shell having the lowest energy and closest to the nucleus.

The second energy level which is further away from the nucleus and has energy greater than the K – shell is called the L – shell.

The rest of the energy levels are M – shell, N – shell, O – shell and P – shell is increasing order of average distance from the nucleus and energy.

In distributing the electrons into the various shells, certain rules must be observed. These are:

- Electrons fills the shells starting with the first shell, which is the innermost shell and the closest to the nucleus.
- When the shell is full, the next electron goes into the next highest shell.

Each shell can only hold a certain number of electrons. That is, the maximum number of electrons that can be found in the following $2n^2$, where n is the number of the shell from the nucleus and 2 takes values from 1, 2, 3, 4, 5, 6.

For the first 20 elements, the arrangement is as follows:

- The first shell can contain a maximum of 2 electrons.
- The second shell can contain a maximum of 8 electrons.
- The third shell can contain a maximum of 8 electrons for small atoms (those with up to 20 electrons). The third shell can hold a maximum of 18 electrons for the 21st to 30th elements up into the fourth shell.

The arrangement of electrons into the various shells of an atom is called electron configuration.

Drawing electron configuration

In representing the electron configuration diagrammatically, the atoms are placed in the shell one at a time and systematically until a full – filled before pairing them.

1. Filling the first shell

2. Filling the second shell

3. Filling the third shell

4. Filling the fourth shell

The outermost shell of an atom is called the **valence shell** and the number of electrons occupying the valence shell are called the **valence electrons**.

Electron structure

The electron configuration of an atom can be represented using numbers in a shorthand notation called **electron structure**. It indicates the number of electrons in each shell starting from the one closest to the nucleus. The table below shows examples of some elements.

Element	Symbol	Atomic number (Z)	Shell	2n	$2n^2$	Electron structure
Hydrogen	H	1	K	2	2	1
Helium	He	2				2
Lithium	Li	3	L	4	8	2, 1
Beryllium	Be	4				2, 2
Boron	B	5				2, 3
Carbon	C	6				2, 4
Nitrogen	N	7				2, 5
Oxygen	O	8				2, 6
Fluorine	F	9				2, 7
Neon	Ne	10				2, 8
Sodium	Na	11	M	6	18	2, 8, 1
Magnesium	Mg	12				2, 8, 2
Aluminium	Al	13				2, 8, 3
Silicon	Si	14				2, 8, 4
Phosphorus	P	15				2, 8, 5

Problem 1

- Give the electron configuration, electron structure of B and N atoms.
- Determine the number of valence electrons.
- B (atomic number 5)
- N (atomic number 7)

Solution

1. **Analyse** (Give a problem + solving strategy

Known	Unknown
Atomic number	Valence electrons

Use the relation, number of electrons = atomic number

B = 5 electrons

N = 7 electrons

- Place electrons in the shells with the lowest energy level, symmetrically until half – filled before pairing.
- Apply the rule of the maximum number of electrons allowed to occupy a shell.
- Count the number of electrons in outermost shell to determine the valence electrons.

2. **Solve.** Apply the problem – solving strategy

a. i. Boron

ii. Nitrogen

3. **Evaluate.** Does the results make sense?

The number of electrons in the various electronic shells adds up to the respective atomic numbers.

Problem 2

- Give the electron configuration and electron structure of these atoms.
- Determine the number of valence electrons in

i. Mg (atomic number 12)

ii. S (atomic number 16)

Solution

1. **Analyse** (Give a problem + solving strategy

Known	Unknown
Atomic numbers	Valence electrons

Use the relation, number of electrons = atomic number

i. Mg = 12 electrons

ii. S = 16 electrons

- Place electrons in the shells with the lowest energy level, symmetrically until half – filled before pairing.
- Apply the rule of the maximum number to occupy a shell.
- Count the number of electrons in the outermost shell to determine the valence electrons.

2. **Solve.** Apply the problem – solving strategy

a.

i. Magnesium

ii. Sulphur

b. i. Valence electrons = Mg = 2

ii. Valence electrons in S = 6

3. **Evaluate.** Does the results make sense?

The number of electrons in the various electronic shells adds up to the respective atomic numbers.

Electron configuration of ions

Recall that, ions are atoms carrying electrical charges. Ions can be formed when a neutral atom loses one or more electrons from its valence shell or accepts one or more electrons into its valence shell.

For example, lithium has the electron structure (2, 1) and electron configuration.

When one electron is removed from the atom of lithium, the electron structure and electron configuration become.

For the other hand, fluorine has the electron structure and electron configuration.

Fluorine (2, 7)

When one electron is added onto its valence shell, the electron structure and electron configuration become.

The electron configuration of the ion has its valence shell being full. Atoms that have full valence shells do not form ions and therefore do not combine to form a molecule. However, atoms whose valence shells are not full, combine readily to form a molecule.

Summary

1. Atoms of all element are made up of different combinations of sub - atomic particles – protons, electrons and neutrons.
2. The nucleus is positive and positively – charged particles in the nucleus of the atom.
3. The neutron is massive and a zero – charged particle in the nucleus of an atom.
4. The electron is negatively charged particle with negligible mass that orbits round the nucleus in shells.
5. The nucleus is small, massive central part of the atom. It contains the protons and neutrons.
6. Shells are energy levels or spherical space around the nucleus where electrons are found
7. The electron configuration of an element is the arrangement of its electrons in shells.
8. Electron configuration is the arrangement of electrons in the shell of an atom.

SHS 1 INTEGRATED SCIENCE

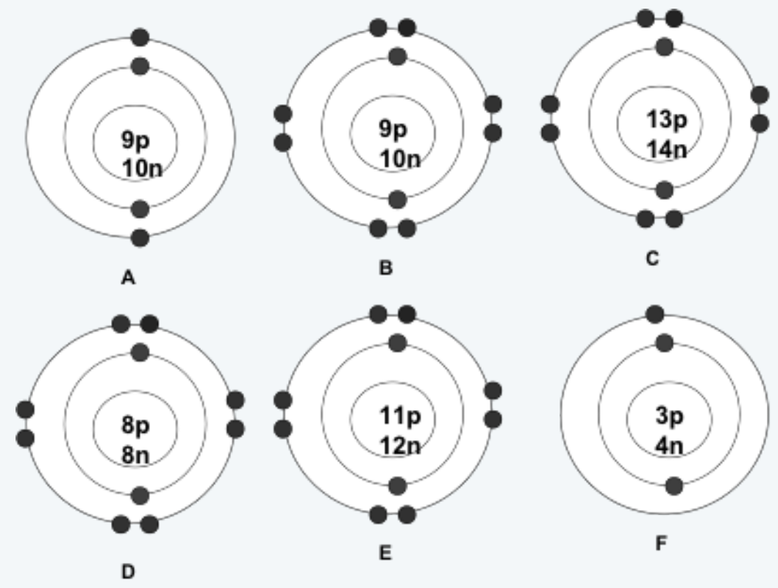
Question **1**

Not yet answered

Marked out of 20.00

Flag question

The electronic configuration of some atoms are shown below



Which of the species is/are anions?

Select one:

- A
- B
- A,B
- B,C

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following particles is found outside the nucleus of an atom in an electronic shell?

Select one:

- Neutron
- Nucleon
- Electron
- Proton

Question **3**

Not yet answered

Marked out of 20.00

Flag question

The maximum number of electrons which can be placed in the third shell of an atom is

Select one:

- 18
- 10
- 3
- 8

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The mass of the atom is concentrated in

Select one:

- Shells
- Neutrons
- Protons
- Nucleus

Question **5**

Not yet answered

Marked out of 20.00

Flag question

An atom can turn into an ion if it?

Select one:

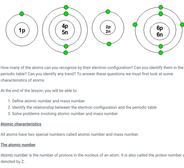
- loses an electron
- gains a proton
- gains a neutron
- loses a proton

LESSON NOTE

Lesson 27

Atomic Characteristics

Consider the following electron configurations.



How many of the atoms can you recognize by their electron configuration? Can you identify them in the periodic table? Can you identify any trend? To answer these questions we must first look at some characteristics of atoms.

At the end of the lesson, you will be able to:

1. Define atomic number and mass number
2. Identify the relationship between the electron configuration and the periodic table
3. Solve problems involving atomic number and mass number

Atomic characteristics

All atoms have two special numbers called atomic number and mass number.

The atomic number

Atomic number is the number of protons in the nucleus of an atom. It is also called the proton number and denoted by Z.

The significance of atomic number

- Every element has a unique atomic number and hence the same number of protons. Atoms of different elements have different atomic numbers. Example, all lithium atoms (Z = 3) have 3 protons, all carbon atoms (Z = 6) have 6 protons.
- Atoms are electrically neutral because the total number of protons is equal to the total number of electrons. Therefore, atomic number defines the total number of electrons in the shells of an atom. Example, nitrogen with atomic number of 7 it has 7 protons and 7 electrons.
- Atomic number determines the chemical properties of an element.
- The various elements in the periodic table are arranged in order of atomic number.

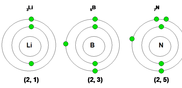
The structure of an atom and the periodic table

The periodic table is a chart that arranges elements in order of increasing atomic number and electron arrangement in their various shells.

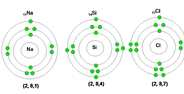
The elements are arranged in vertical columns with similar properties called groups and horizontal rows as periods. The *period of elements* are defined by the number of electronic shells contained in its electron configuration.

- Hydrogen and helium belong to period 1 because they have only one electronic shell

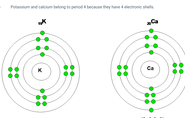
- Lithium (3), Boron (5) and Nitrogen (7) have 2 electronic shells and therefore belong to period 2.



- Sodium (11), Silicon (14) and Chlorine (17)

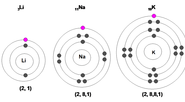


- Potassium and calcium belong to period 4 because they have 4 electronic shells



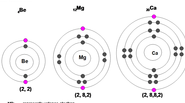
The group of elements have the same number of valence electrons.

- For example, lithium (3), Sodium (11) and potassium (19) have one electron in its valence shell and therefore belong to group 1.



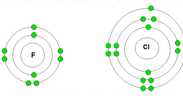
NB: represents valence electron
represent inner electron

- Beryllium (4), Magnesium (12) and Calcium (20) belong to group 2 because they have 2 electrons in their valence shell.

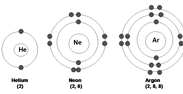


NB: represents valence electron
represents inner electron

- Fluorine (9) and Chlorine (17) belong to group 7, because they have 7 electrons in their valence shell.



- Helium (2), Neon (10) and Argon (18) have their valence shell being full. That is, they have the maximum number of valence electrons. They are termed as noble gases and belong to group 0 or 8.



Name of shell / Period	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 0
Period 1							$_{1}H$ $_{2}He$
Period 2	$_{3}Li$ 2.1	$_{4}Be$ 2.2	$_{5}B$ 2.3	$_{6}C$ 2.4	$_{7}N$ 2.5	$_{8}O$ 2.6	$_{9}F$ 2.7	$_{10}Ne$ 2.8
Period 3	$_{11}Na$ 2.8.1	$_{12}Mg$ 2.8.2	$_{13}Al$ 2.8.3	$_{14}Si$ 2.8.4	$_{15}P$ 2.8.5	$_{16}S$ 2.8.6	$_{17}Cl$ 2.8.7	$_{18}Ar$ 2.8.8
Period 4	$_{19}K$ 2.8.8.1	$_{20}Ca$ 2.8.8.2						

Mass Number

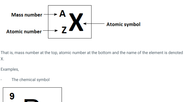
The mass number of an atom is defined as the total number of protons and neutrons contained in the nucleus of the atom. It is also known as nucleon number and denoted by A. Mathematically, the mass number is defined by the equation:

Mass number = Atomic number + Number of neutrons

$$A = Z + n$$

Chemical Symbols

The short-hand notation for representing chemical symbol, mass number and atomic number is as shown below:



That is, mass number at the top, atomic number at the bottom and the name of the element is denoted as X.

Examples,

- The chemical symbol

Shows that Beryllium atom has an atomic number 4 and mass number 13.

- The chemical symbol

Shows that nitrogen atom have atomic number 7 and mass number of 14.

- The chemical symbol

Shows that chlorine atom has atomic number 17 and mass number 35.

Problem 1

How many electrons and neutrons are in the following atoms?

	Atomic number	Mass number
a. Phosphorus	15	31
b. Aluminium	13	27

Solution: Use problem – solving strategy

1. **Analyse** List the known and unknown.

Known	Unknown
- Atomic number	- Number of protons =?
- Mass number	Number of electrons =?

Number of neutrons =?

Use the relationship between atomic number and number of protons to get the number of electrons and neutrons.

2. **Calculate:** Solve for the unknown

Number of electrons = Atomic number of neutral atom = number of protons

a. 15 electrons b. 13 electrons

Number of neutrons = mass number − atomic number

a. $n = 31 - 15 = 16$ neutrons
b. $n = 27 - 13 = 14$ neutrons

3. **Evaluate:** Does the results make sense?

a. $A = Z + n = 15 + 16 = 31$
b. $A = Z + n = 13 + 27$

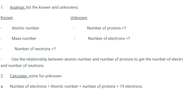
The concept has been correctly applied because the mass numbers were obtained back.

Evaluate: Does the result make sense?

$A = n + Z = 20 + 19 = 39$

The concept has been applied correctly.

Problem 2: Potassium has the chemical symbol:



a. How many electrons has potassium?

b. How many neutrons has potassium?

Solution: use problem – solving strategy

1. Analysis list the known and unknowns.

Known	Unknown
- Atomic number	- Number of protons =?
- Mass number	- Number of electrons =?
- Number of neutrons =?	

Use the relationship between atomic number and number of protons to get the number of electrons and number of neutrons.

2. Calculate: solve for unknown.

a. Number of electrons = Atomic number = number of protons = 19 electrons.

b. Number of neutrons = mass number − atomic number = 39 − 19 = 20 neutrons

3. Evaluate: Does the result make sense?

$A = n + Z = 20 + 19 = 39$

The concept has been applied correctly.

Summary

1. Atomic number also known as proton number is the number of protons.
2. Mass number also known as nucleon number is the sum of the number of protons and number of neutrons.
3. The periodic table is a chart that arranges elements in groups and periods according to their atomic numbers and structure
4. Elements with the same number of valence electrons are called group of elements
5. Elements having the same number of electronic shells are called period of elements

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

The number of protons, neutrons and electrons present in the isotope $^{37}_{17}Cl^{0}$ is

Select one:

- 17 protons, 17 electrons, 20 neutrons
- 17 protons, 37 electrons, 20 neutrons
- 17 protons, 37 electrons, 17 neutrons
- 17 protons, 17 electrons, 17 neutrons

Question **2**

Not yet answered

Marked out of 20.00

Flag question

An element Q has the proton number of 10. The next element in the periodic table is an element X. Which statement is correct?

Select one:

- Element X is in the same period of the periodic table as element Q
- Element X has one more electron in its outer shell than Q
- Element X has one more electron shell than element Q
- Element X is in the same group of the periodic Table as element Q

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Isotopes of an element can be distinguished by their

Select one:

- Valencies
- Reactions
- Masses
- Charges

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Consider the elements X and Y with atomic numbers 8 and 14 respectively. Which option gives the correct number of valence electrons of X and Y?

Select one:

- 6, 8
- 6, 4
- 2, 2
- 2, 4

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Nucleons consist of

Select one:

- Electrons and protons
- Neutrons and electrons
- Protons and neutrons
- Electrons, protons and neutrons

LESSON NOTE

Lesson 28

Isotopes and relative atomic mass

Some animals come in different species. Example is the African elephant and the Asian elephant. Do elements also have slight different variations as animals? To answer this question, we must examine other characteristics of atoms.

At the end of the lesson, you would be able to:

1. Define isotopes and give examples
2. Identify isotopes from their chemical symbols
3. Define the relative atomic mass of an atom
4. Solve problems involving isotopes and relative atomic mass

Isotopes of elements

Isotopes are atoms of the same element that have the same atomic number but different mass numbers. They have the same number of protons and electrons but different number of neutrons. For example, pure samples of hydrogen element contain atoms of different masses. Hydrogen – 1, Hydrogen – 2 and Hydrogen – 3.

Hydrogen – 1

1 proton

0 neutron

1 electron

Hydrogen – 2

1 proton

1 neutron

1 electron

Hydrogen – 3

1 proton

2 neutrons

1 electron

They can be usually represented by the following short – hand.

- The element symbol separated from its mass number by a dash. Example, H – 1, H – 2 or H – 3.
- Alternatively, the chemical symbol short – hand is represented as:

Hence, hydrogen is represented as:

The three isotopes of hydrogen have special names. Hydrogen – 1 is called hydrogen, hydrogen – 2 is called deuterium and hydrogen – 3 is called tritium.

Problem 1. Carbon has three isotopes namely, carbon – 12, carbon – 13 and carbon – 14.

a. Write the chemical symbol for each isotope using superscript and subscripts to represent the mass and atomic numbers and

b. Determine the number of neutrons in each isotope.

Solution. Use the problem – solving strategy

1. **Analyse** Plan a problem – solving strategy.

List the known and unknown

Known	Unknown
Three isotopes of carbon	Each isotope symbol +?
Atomic number	Number of neutrons +?

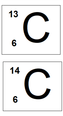
Use the symbol of carbon and place the mass number on the left hand size of the symbol as superscript. Place the atomic number on the left hand side of the symbol as subscript.

- Given the symbol, subtract the atomic number from the mass number to get the number of neutrons

2. **Solve**. Apply the problem solving strategy.

Use the periodic table to get the symbol of carbon and the atomic number.

a. The symbol for each isotope is given as:

- Carbon – 12, the symbol is
- Carbon – 13, the symbol is 
- Carbon – 14, the symbol is

b. Using the relationship:

n = A – Z

- Number of neutrons in C – 12 = 12 – 6 = 6
- Number of neutrons in C – 13 = 13 – 6 = 7
- Number of neutrons in C – 14 = 14 – 6 = 8

3. **Evaluate** Does the results make sense? The mass number and atomic number have been properly positioned by the symbol and the number of neutrons are consistent.

-

-

-

Problem 2

Boron has two most stable isotopes. If the number of neutrons and electrons of each isotope is as below:

Isotope 1	Isotope 2
Electrons = 5	electrons = 5
Neutrons = 5	neutrons = 6

Write the chemical symbol for each isotope.

Solution. Use problem – solving strategy:

1. **Analyse** plan problem – solving strategy

Known	Unknown
Electrons	Atomic number
Neutrons	Mass number

- Use the relationship between the number of electrons + number of protons
- The sum of atomic number and number of neutrons to get the mass number

2. **Calculate** solve the problem

- Number of electrons = Number of protons

Isotope 1: Number of protons = 5

Isotope 2: number of protons = 5

-

- Mass number = atomic number + neutron number

Isotope 1 = 5 + 5 = 10

Isotope 2 = 5 + 6 = 11

Chemical symbol and

3. **Evaluate** Does the result make sense? The atomic number is correctly deduced and correctly placed as left – hand subscript. The mass number is correctly calculated and correctly placed as right – hand superscript of the symbol.

Properties of isotopes

- Different isotopes of an element have the same atomic number, number of electrons and hence similar electronic arrangement.
- Different isotopes of an element have similar chemical properties because they have similar number of electrons.
- Different isotopes of an element have different physical properties such as mass, density, melting point and boiling point.

Some isotopes have unstable nuclei and therefore can emit radiations. Such isotopes are called radioisotopes. Examples are, and . Other isotopes have stable nuclei and therefore do not undergo radioactive decay. They are termed as non – radioactive isotopes. Examples are

and

Other isotopes have stable nuclei and therefore do not undergo radioactive decay. They are termed as non – radioactive isotopes. Examples are and

Uses of isotopes

Radioisotopes are used in industry and in the fields of medicine, agriculture and research.

Relative atomic mass

The sum of the number of protons and neutrons in the nucleus of an atom give the actual mass of an atom. However, the actual mass of a proton and a neutron is too small to be measured directly. To overcome this challenge, a standard reference scale is employed using carbon – 12 isotope. Carbon – 12 has 6 protons and 6 neutrons and therefore its mass is fixed at 12. Scientist arrived at a unit defined as $1/12^{th}$ of the mass of one atom of carbon – 12 and compared the mass of other atoms by this unit. For example, helium has mass that is 4 times as massive as $1/12^{th}$ the mass of one atom of Carbon – 12 isotope. This is because it has 2 protons and 2 neutrons. Phosphorus is 31 times as massive as $1/12^{th}$ the mass of Carbon – 12 isotope. This is because it has 15 protons and 16 neutrons. Relative atomic mass of an atom therefore measures the number of times an atom is heavier than $1/12^{th}$ the mass of one atom of carbon – 12 isotope.

For naturally occurring samples of an element that have a mixture isotopes, each isotope has different mass and different abundance. The mixture of isotopes of the element is unique and can be accurately described as its percentage abundance. The relative atomic mass of an element is therefore determined taking into account the different masses and different percentage abundance as a weighted average. It is therefore defined as the average mass of an atom of the element compared with one twelfth the mass of one atom of carbon – 12 isotope.

It is denoted as Ar.

Mathematically, it is expressed as:

Relative atomic mass = $\frac{\text{Average mass of an atom of the element}}{1/12^{th} \text{ of the mass of one atom of C} - 12}$

Relative atomic mass has no unit.

Relative atomic mass and isotopic masses

The relative atomic mass of an atom of an element can be determined from the isotopic masses and their percentage abundance by the relationship:

$$Ar = \frac{m_1b_1 + m_2b_2}{b_1 + b_2}$$

Where m_1 = mass of isotope 1, m_2 = mass of isotope 2, b_1 = percentage abundance of isotope 1, b_2 = percentage abundance of isotope 2.

The table below summarizes the relative atomic masses of some elements.

Element	Symbol	Relative atomic mass
Hydrogen	H	1.0
Helium	He	4.0
Lithium	Li	6.9
Beryllium	Be	9.0
Boron	B	10.8
Carbon	C	12.0
Nitrogen	N	14.0
Oxygen	O	16.0
Fluorine	F	19.0
Neon	Ne	20.2
Sodium	Na	22.9
Magnesium	Mg	24.3
Aluminium	Al	27.0
Silicon	Si	28.1
Phosphorus	P	31.0
Sulphur	S	32.1
Chlorine	Cl	35.5
Argon	Ar	39.9
Potassium	K	39.1
Calcium	Ca	40.1

Summary

1. Isotopes of an element have the same number of protons but different number of neutrons.
2. Isotopes have similar chemical properties but different physical properties.
3. Some isotopes are radioactive and others are non – radioactive.
4. Relative atomic mass of an atom of an element is the average mass of the atom compared to one twelfth the mass of one atom of C – 12 isotope.
5. Relative atomic mass has no unit.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following statement is true about isotopes?

Select one:

- They have the same mass number
- They have the same physical properties
- They have the same chemical properties
- They have the same number of neutrons

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Carbon has three isotopes:

$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

Which option gives the correct number of neutrons of each isotope?

Select one:

- 7, 7, 7
- 6, 6, 6
- 6, 7, 8
- 6, 7, 7

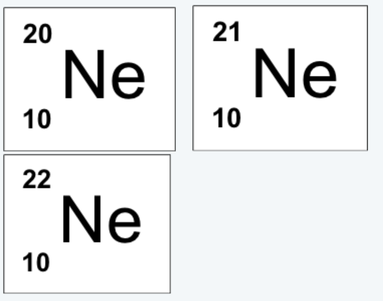
Question **3**

Not yet answered

Marked out of 20.00

Flag question

Neon has three isotopes.



Which option gives the correct number of electrons of each isotope?

Select one:

- 10, 21, 12
- 20, 21, 22
- 10, 11, 12
- 10, 10, 10

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following determines the physical properties of isotope?

Select one:

- Isotope number
- Mass number
- Neutron number
- Atomic number

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following determines the chemical properties of isotope?

Select one:

- Isotope number
- Atomic number
- Mass number
- Neutron number

LESSON NOTE

Lesson 23

Chemical bonding

Have you considered the fact that there are 26 letters of the alphabet but different combinations of these letters produce unlimited number of words? Similarly, different combinations of elements produce unlimited number of substances. How do elements combine? Why do elements combine? These and other questions would be discussed in this lesson.

By the end of the lesson, you will be able to:

1. Define the terms chemical bonding
2. Identify the type of bonding based on the component elements
3. Define ionic bonding and explain its formation
4. Define covalent bonding and explain its formation
5. Write the electronic arrangements of ions and covalent compounds

Chemical bonding

When two or more atoms of different elements combine, a compound is formed. The atoms are held together by a chemical bond. A **chemical bond** therefore, is the force of attraction that exist between **two chemical species** (that is atoms or ions).

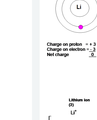
Atoms combine to form compounds so that they can achieve a **stable electron configuration of noble gases or an octet.**

There are two types of chemical bonds. These are the **ionic bond** and **covalent bond** depending on the bonding atoms.

An **ionic bond** is formed with a **non – metal**, the bond is called **ionic bond**. For example, NaCl, LiF, $CaCl_2$, $MgCl_2$, $AlCl_3$, etc.

A **covalent bond** is formed with a **non – metal**, the bond is called a **covalent bond**. Examples are CO_2, NH_3, and H_2O.

Periodic table

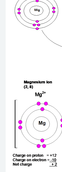


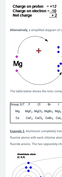
Ionic bond

It is defined as the **electronic force of attraction between oppositely charged ions** (that is, a cation and an anion). It is formed when one or more **valence electrons are completely transferred** from a **metal** to a **non – metal** resulting in the formation of a **cation and an anion.** This results in the formation of a stable electron configuration of the bonding atoms.

Example 1. Lithium atom transfers one electron from its incomplete valence shell to a fluorine atom to form oppositely charged ions (that is, Lithium cation and a fluoride anion). The ions formed are held together by electrostatic force called ionic bond. This is illustrated as follows:

a.





b. Alternatively, it could be illustrated using the electron dot structures or Lewis structures. Lewis structures use the symbol of the element and the valence electrons to represent the atom.

The table below shows the ionic compounds formed between group 1 and 7 elements.

Group 1/7	F	Cl	Br	I
Na	NaF	NaCl	NaBr	NaI
K	KF	KCl	KBr	KI

Example 2. Magnesium transfers two valence electrons to two fluorine atoms, with each fluorine atom gaining one electron to form magnesium cation and two fluoride anion.

Alternatively, a simplified diagram of ionic structure is represented as below:

The table below shows the ionic compounds formed between group 2 and 7 elements.

Group 2/7	F	Cl	Br	I
Mg	MgF_2	$MgCl_2$	$MgBr_2$	MgI_2
Ca	CaF_2	$CaCl_2$	$CaBr_2$	CaI_2

Example 3. Aluminium completely transfers three valence electrons from its outermost shell to three fluorine atoms with each fluorine atom receiving one electron to form aluminium cation and three fluoride anions. The ion oppositely charged ion are held together by electrostatic force of attraction.

Alternatively

The table below illustrates the ionic compound formed between Group 3 elements and Group 7 elements.

Group 3 / Group 7	F	Cl	Br	I
Al	AlF_3	$AlCl_3$	$AlBr_3$	AlI_3

Example 4. Two sodium atoms, each transfer one valence electron from their outermost shells to one atom of oxygen to form two sodium cations and a dioxide – charged oxide anion. All the ions self attain stable electronic configuration.

Covalent bonding

Covalent bonding is the non – metals share their unpaired valence electron making them acquire stable electron configuration. Note that only valence electrons are shared.

Example 1. Covalent bonding diagram of hydrogen molecule

Two hydrogen atoms share their unpaired electrons to have a full, stable electron configuration as below

Alternatively, using 'dot and cross' electronic diagram (Lewis structures) for the covalently bonded H_2 molecule.

Example 2. Covalent bonding diagram of fluorine molecule (F_2)

Two fluorine atoms shared their valence unpaired electrons to form a full stable electron configuration as below:

Alternatively

Example 3. Covalent bonding diagram of hydrogen fluoride (HF)

One hydrogen atom shares its unpaired electron with one fluorine atom having an unpaired electron to form a molecule of hydrogen fluoride.

Alternatively

Example 4. Covalent bonding diagram of ammonia (NH_3)

Nitrogen atom shares its three unpaired electrons with three hydrogen atoms to form a molecule of ammonia.

Properties of ionic compounds

Ionic compounds exist as hard **crystalline solids** at room temperature having alternating **positive and negative ions** held together by strong electrostatic forces of attraction.

They are **brittle** but not malleable like metals.

Ionic compounds have **high melting** and **very high boiling points.** This is due to the strong electrostatic force of attraction between the cations and anions.

Many ionic compounds are **soluble in polar solvents** such as water but **insoluble in non – polar solvents** such as organic solvents like tetrachloromethane.

Ionic compounds **conduct electricity in molten state** or in **aqueous solution** but not in the **solid state.** The solid crystals do not conduct electricity because the ions are not free to move and carry an electric charge but are held to a fixed position. When an ionic compound is melted or dissolved in water, the ions are free to move and carry charges.

Properties of covalent compounds

Covalent compounds usually exist as **liquids and gases** at room temperature. They are usually made of simple or giant **molecules.**

They have **low melting points and boiling points** due to the weak forces of attraction.

Most covalent compounds are **soluble in non - polar solvents** such as organic solvents (benzene, tetrachloromethane) but **insoluble in polar solvents** like water.

Covalent compounds **do not conduct electricity** either in molten form or in aqueous solution except diamond.

Difference between ionic compounds and covalent compounds

Ionic compounds	Covalent compounds
They are crystalline hard solids (made of ions)	They are liquids, gases or solids (made of molecules)
Have high boiling and melting points	Have low melting and boiling points
Conduct electricity when molten or in solution	Poor conductors of heat in all physical states
Many are soluble in water but insoluble in non-polar solvents	Many are soluble in non - polar solvent but insoluble in polar solvent like water

Summary

1. Covalent bond is formed by the sharing of electrons between two atoms.
2. Each of the bonding atoms contributes one electron to each bond.
3. Ionic bond is formed by the complete electron transfer from a metal to a non – metal.
4. The number of electrons lost or gained is equal to the number of charges.
5. The number of electrons lost or equal to the number of positive charge on the metal ion.
6. Non – metals except hydrogen always gain electrons to form negative ion.
7. Metals always lose electrons to form positive ions except in coordinate bond.
8. Ionic bond results from the attraction between oppositely charged ions.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Consider the following substances

a. NH_3
b. KCl
c. CO_2
d. NaCl

Answer the following questions by choosing from the compounds A, B, C and D. You can use each compound once, more than once or not at all. Which substance(s) represents

Compound made up of components held by strong forces of attraction? ……

Select one:

- B and D
- B
- A and C
- B and A

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Consider the following substances

a. NH_3
b. KCl
c. CO_2
d. NaCl

Answer the following questions by choosing from the compounds A, B, C and D. You can use each compound once, more than once or not at all. Which substance(s) represents

Which substance is a good conductor of electricity when solid?

Select one:

- A wood
- A salt
- A metal
- A plastic

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Sodium chloride is a typical ionic compound formed by combining a metal with a non – metal. Sodium chloride will …

Select one:

- Not conduct electricity when dissolved in water
- Have a low melting point
- Not conduct electricity when solid
- Consist of NaCl molecules

Question **4**

Not yet answered

Marked out of 20.00

Flag question

What changes, when an ion is made from an atom?

Select one:

- The number of neutrons only
- The number of protons and of neutrons
- The number of electrons only
- The number of protons only

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following statements about gaseous hydrogen chloride and solid sodium chloride is correct?

Select one:

- They are both ionic compounds
- Hydrogen chloride is ionic but sodium chloride is covalent
- Hydrogen chloride is covalent but sodium chloride is ionic
- They are both covalent compounds

LESSON NOTE

LESSON 30

Chemical formula

The recipe for a cake provides essential information about the type and amount of each ingredient needed to make the cake. Similarly, a chemical formula tells us the type and number of each atom that is present. Varying the type and amount of ingredients would definitely lead to a cake that has a different texture and taste. How is this related to a chemical formula? A chemical formula also provides similar information about the "ingredients" of a chemical compound. In this lesson, we shall learn how elements combine to give more than one chemical compound and how chemical formulae are used to represent millions of chemical substances.

By the end of the lesson, you would be able to:

- Define the valency of an atom
- Predict the valencies of elements from their position on the periodic table
- Define the term 'radical' and state the valencies of radicals
- Write chemical formulae of compounds, given the valencies of elements and radicals

Chemical formulae

Chemist use chemical formulae to express the different types of elements present in a chemical compound and the ratio of each in the compound. Example, water contains one oxygen atom and two hydrogen atoms and therefore has the ratio of hydrogen to oxygen being 2:1. Hence, the formula H_2O. Varying the ratio of hydrogen to oxygen to 2:2 gives the formula H_2O_2 and the compound is hydrogen peroxide.

Chemical formula is therefore defined as an expression that shows the type and number of atoms in the smallest unit of the substance. Different substances have their unique chemical formula. Some such as table salt have simple formula – NaCl. Others such as palmitic acid in palm oil has complex chemical formula. $CH_3-(CH_2)_{14}COOH$.

Valency

One may ask, why isn't the formula salt for sodium chloride $NaCl_2$ or Na_2Cl_2? The answer is that, each elements has a combining power or **valency** that determines how the element combines with other elements. For example, aluminium has a valency of 3 and chloride has a valency of 1. When they combine to form aluminium chloride, 3 chlorine atoms must combine with one aluminium atom to give the formula $AlCl_3$. How do we determine the valencies of elements? There is a close relationship between the position of an element in the periodic table and its valency. The **valency** of elements can therefore be worked out from the groups they belong in the periodic table.

where n is the group number

Deductions:

- For the elements on the left hand side of the periodic table, their valencies are equal to their group number. Example, Na = 1, Be = 2, Al = 3.
- For the elements on the right hand side of the periodic table, their valencies are obtained by subtracting the group number from 8. Example, Oxygen, in group 6, hence 8 – 6 = 2. Therefore, it has a valency of 2.

The valencies of the elements can be summarized in the table below:

Group	1	2	3	4	5	6	7	8
Valency	1	2	3	4	3	2	1	0

Radicals

Radicals are polyatomic ions. They also have valencies. The table below summarizes them:

Radicals	Valency
NO_3^-	1
OH^-	
NH_4^+	
SO_4^{2-}	2
CO_3^{2-}	
PO_4^{3-}	3

Writing chemical formulae

Rules for writing a chemical formula

The ingredients for cake making are not put together at the same time. Similarly, there are rules that determine how a chemical formulae is written. These are:

- Write the name of the compound
- Write the symbols of the elements or radicals below them
- Write the valencies below them.
- Interchange the valencies and write them as right – hand subscript
- Radicals must be put in bracket before writing the valency as subscript

- For elements having more than one valencies, the valency being used in the compound will be determined by the valency of the element written up to 2/3 from lowest valency but metals having atomic number greater than 20 have variable valency.
- For the formula to be correct, the following relation must hold:

Number of atom A x valency of atom A = number of atom B x valency of atom B

.

- For **binary compounds** (compounds made up of two different elements), the name ending (suffix) is **"ide"**. Example, sodium chloride.
- For oxo - compounds (compounds having oxygen in their radicals) the suffix is **"ate"**. Example, sodium trioxonitrate(V).

Worked example 1

Case 1: Writing the formulae of the following binary compounds:

a. Aluminium fluoride
b. Potassium nitride
c. Sodium sulphide
d. Aluminium oxide

Solution: Use the problem – solving strategy:

1. **Analyse:** Plan the problem – solving strategy:
   - Identify the suffix to determine the type of compound.
   - Write the name of compound.
   - State the symbols below the name.
   - State the valencies below the symbols.
   - Interchange the valencies as right – hand subscript.

2. **Solve:** Apply the problem – solving strategy

a. Aluminium fluoride

Since, a letter or a number multiplied by 1, gives the same letter or number, the formula is reduced to: AF_3

b. Potassium nitride

Since, a letter or a number multiplied by 1, gives the same letter or number, the formula is reduced to: K_3N

c. Sodium sulphide

Again, since, a letter or a number multiplied by 1, gives the same letter or number, the formula is reduced to: Na_2S

d. Aluminium oxide

Al_2O_3

Again, since a letter or a number multiplied by anything including a letter is that same thing, the formula is reduced to: Al_2O_3

3. **Evaluate:** Does the results make sense? Check the answers by applying an alternative approach.

Number of atom A x Valency of atom A = Number of atom B x Valency of atom B

Valency of A	Valency of B	Deduced formula of A and B
a. 1 of Al (3)	Balances 3 x 1 (1)	1 x 3 = 3 x 1 = AF_3
b. 3 of K (1)	Balances 1 x N (3)	3 x 1 = 1 x 3 K_3N
c. 2 of Na (1)	Balances 1 x S (2)	2 x 1 = 1 x 2 Na_2S
d. 2 of Al (3)	Balances 3 x O (2)	2 x 3 = 3 x 2 Al_2O_3

NB: All has a net charge of zero on the compound formed.

Case 2: Writing the chemical formulae of binary compounds having cations and anions of the same valency

NB: The ratio of the bonding atoms are divided by an integer to reduce it to 1:1.

Worked example 2

Write the chemical formulae of the following compounds:

a. Magnesium oxide
b. Aluminium nitride

Solution: Use problem solving strategy

1. Analyse: Plan problem solving strategy:
   - Write the name of compound
   - Write the symbols below them
   - Write the valencies below them.
   - Since the valencies are the same, interchanging would not be necessary. Rather, write them as right – hand subscript and divide through by an integer to get the simplest ratio.

2. **Solve:** apply the problem – solving strategy:

a. Magnesium oxide

To give MgO_2, the subscripts cancels out to give MgO.

b. Aluminium nitride

To give AlN_3, the subscripts cancel out to become AlN.

3. **Evaluate:** Does the results make sense? Apply the alternative approach:
Number of atom A x Valency of atom A = Number of atom B x Valency of atom B

Valency of A	Valency of B	Deduced formula of A and B
a. 1 of Mg (2)	Balances 2 of O (2)	1 x 2 = 2 x 1 MgO
b. 1 of Al (3)	Balances 1 of N (3)	1 x 3 = 1 x 3 AlN

Case 3: Writing chemical formula of binary compounds having metal that has more than one valency

NB: The valency of the metal is indicated in Roman numeral and in bracket.

Worked example 3

Write the chemical formula of the following compounds

a. Iron(II) oxide
b. Manganese(IV) chloride
c. Copper(I) sulphide
d. Chromium(IV) oxide

Solution: Use problem – solving strategy

1. **Analyse:** Use a problem – solving strategy

- Apply the previous rules but the valency of the cation is indicated by a number in Roman numeral and in bracket.

2. **Solve:** apply the problem – solving strategy

A. Manganese(IV) chloride

B. Copper(I) sulphide

C. Chromium(IV) oxide

Divide through by 2 to get the simplest ratio of Cr:O to be 1:2. Hence formula becomes CrO_2

1. **Evaluate:** Does the results make sense? Apply the alternative approach to check.

Number of atoms A x Valency of atom A = Number of atom B x Valency of atom B

Valency of A	Valency of B	Deduced formula of A and B
a. 2 atoms of Fe (3)	Balances 3 atoms of O (2)	2 x 3 = 3 x 2 Fe_2O_3
b. 1 atom of Mn (4)	Balances 4 atoms of Cl (1)	1 x 4 = 4 x 1 $MnCl_4$
c. 2 atoms of Cu (1)	Balances 1 atom of S (2)	2 x 1 = 1 x 2 Cu_2S
d. 1 atom of Cr (4)	Balances 2 atoms of O (2)	1 x 4 = 2 x 2 CrO_2

Case 4: writing the chemical formula of ionically (that is salts containing radicals such as NO_3^-, CO_3^{2-}, SO_4^{2-})

NB: If the valency of the cation is greater than 1, the radical is put in bracket before writing the right – subscript.

- The prefix – ps, indicates the number of oxygen atoms attached to the central atom.

Worked example 4

Write the chemical formulae of the following compounds:

a. Sodium trioxonitrate(V)
b. Aluminium tetraoxosulphate(VI)
c. Calcium tetraoxophosphate(V)

Solution: Use a problem – solving strategy

1. **Analyse** Use a problem – solving strategy
2. **Apply** the rules discussed earlier

a. Sodium trioxocarbonate(IV).

b. Aluminium tetraoxosulphate(VI)

a. Calcium tetraoxophosphate(V)

C. **Evaluate:** Does the results make sense? Apply the alternative to check the answers.

Number of atom A x Valency of atom A = Number of atom B x Valency of atom B

Valency of A	Valency of B	Deduced formula of A and B
a. 1 Na^+ cation with valency of 1	Balanced by 1 carbonate anion of valency (2)	1 x 1 = 1 x 2 Na_2CO_3
b. 2 Al^{3+} cations with valency (3)	Balanced by 3 sulphate anions of valency (2)	2 x 3 = 3 x 2 $Al_2(SO_4)_3$
c. 3 Ca^{2+} cations with valency (2)	Balanced by 2 phosphate anions of valency (3)	3 x 2 = 2 x 3 $Ca_3(PO_4)_2$

.

Summary

- Chemical formula expresses the chemical composition of a compound in terms of the different atoms and their relative ratios.
- Valency of an element is its combining power.
- Writing a chemical formula involves following specific rules.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which is the correct formula for sodium tetraoxophosphate(V)?

Select one:

- $Na(PO_4)_4$
- $NaPO_4$
- Na_3PO_4
- Na_4PO_4

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is the chemical formula for silicon(IV) oxide?

Select one:

- Si_2O
- SiO_2
- SiO
- Si_4O_2

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is the valency of sulphur?

Select one:

- 2
- 6
- 32
- 1

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The product of heating a mixture of sulphur and iron fillings is

Select one:

- Iron sulphate
- Ferric sulphur
- Sulphur ironide
- Iron(II) sulphide

Question **5**

Not yet answered

Marked out of 20.00

Flag question

For which compound is the formula correct?

	Compound	Formula
A	Copper(II) tetraoxosulphate(VI)	$CuSO_4$
B	Iron (III) oxide	Fe_3O_2
C	Potassium chloride	K_2Cl
D	Lithium fluoride	LiF_2

Select one:

- C
- A
- D
- B

LESSON NOTE

LESSON 21

IUPAC Nomenclature of inorganic compounds

Does a nickname tell us something about a person? Do you have a nickname? In the same way, different chemical compounds have different names that tell us about the chemical nature of the compound. Each one has a common name called brand. The way assigned it because it was obtained by boiling wood ashes in iron pots. Potash does not tell us much about the compound. There is the need for a more systematic name that tells us something about the chemical nature of the compound. In this lesson, we will examine a more accessible system of naming inorganic compounds.

By the end of the lesson, you will be able to

1. Calculate the oxidation state of an element
2. Name binary compounds
3. Name ternary compounds
4. Name acid – anions – acids and salts

Naming of chemical formula

Most chemical compounds have common name that uses prefixes and suffixes, and IUPAC name. The IUPAC system of naming compounds is based on some rules of the **International Union of Pure and Applied Chemistry**. The rules are based on the oxidation state of the elements in the compound. Naming depends on the type of compound involved and oxidation number of the constituent element. What is oxidation number? And how is it determined?

Oxidation number

The oxidation state of an element is the number of charges an atom of it will carry in its pure state or in a molecule if electrons were completely transferred. It is determined by a set of rules. These are

- The oxidation number of all elements in their free state or un-combined state is zero. The free state of a element is un-combined state like N, O, Na, Fe and the same true – metals, their diatomic molecules O_2, H_2, N_2, etc.
- The oxidation number of oxygen in most compounds is -2. Example, oxidation number of oxygen in CO_2, SO_2, HNO_3, SO_4^{2-} is -2
- The oxidation number of hydrogen is +1 when it is bonded to a non – metal. Example, the oxidation number of H in H_2O, NH_3, CH_4. The oxidation number of hydrogen is -1 when it is bonded to a metal. Example, the oxidation number of H in NaH, CaH_2
- The oxidation number of the halogens (F, Cl, Br and I) when it is bonded is -1
- For ions of a single atom, the oxidation number is equal to the charge on it. Example $Na^+(+1)$, $Ca^{2+}(+2)$, $O^{2-}(-2)$, $Al^{3+}(+3)$
- The sum of the oxidation states of all the elements in a neutral atom is zero and for a polyatomic ion is equal to its net charge.

Worked examples

Problem 1. Determine the oxidation number of the underlined element in the following compound

a. $\underline{Br}O_3$ b. $K\underline{Cl}O_4$ c. $Ca\underline{S}O_4$

Solution.

Let x be the oxidation number of the central atom. Apply the rule which states that the sum of all the elements in the substance is equal to zero

a. $\underline{Br}O_3$

$x + 3(+1) = 0$

$x + 3 = 0$

$x = -3$

b. $K\underline{Cl}O_4$

$1 + x + 4(-2) = 0$

$x - 7 = 0$

$x = 7$

c. $Ca\underline{S}O_4$

$2 + x + 4(-2) = 0$

$x - 6 = 0$

$x = 6$

Problem 2

Determine the oxidation number of the underlined element in the following ions

a. $\underline{Al}^{3+}$

b. $\underline{Cl}O^-$

c. $\underline{Br}O_3^-$

d. $\underline{Cr}O_4^{2-}$

Solution

- Let x be the oxidation number of the central atom.
- Apply the rule which states that the sum of the oxidation states of all the elements in the radicals is equal to the net charge

a. $\underline{Al}^{3+}$

$x = 3(+1) = +3$

$x - 3 = 3$

$x = +3$

b. $\underline{Cl}O^-$

$x + 2(-1) = -1$

$x - 2 = -1$

$x = +1$

c. $\underline{Br}O_3^-$

$x + 3(-2) = -1$

$x - 6 = -1$

$x = +5$

d. $\underline{Cr}O_4^{2-}$

$x + 4(-2) = -2$

$x - 8 = -2$

$x = +6$

Naming of Inorganic Compounds

Let us consider the various ways of naming various inorganic compounds

1. Naming of binary ionic compounds

A **binary ionic compound** is made up of two different elements one of which is a metal. Examples are NaCl, $MgCl_2$. The basic convention in naming is based on the following rules

- Name the cation first followed by the name of the anion.
- The name of the cation is usually the name of the metal.

Charge	Formula	Name
1+	H^+	Hydrogen
	Li^+	Lithium
	Na^+	Sodium
	K^+	Potassium
	Ca^+	Calcium
2+	Ba^{2+}	Barium
	Mg^{2+}	Magnesium
	Zn^{2+}	Zinc
	Cu^{2+}	Zinc
3+	Al^{3+}	Aluminium

- The name of the anion takes the root name of the non – metal plus the suffix "-ide". Example, anion from chlorine is named chloride (chlor + ide)

Charge	Formula	Name
1-	H^-	Hydride
	F^-	Fluoride
	Cl^-	Chloride
	Br^-	Bromide
	I^-	Iodide
2-	O^{2-}	Oxide
	S^{2-}	Sulphide
	Se^{2-}	Selenide
3-	P^{3-}	Phosphide
	N^{3-}	Nitride
	S^{3-}	Sulphide

Worked examples 3

i. Name the following binary ionic compounds.

a. K_2S b. MgO c. $AlBr_3$

Solution. For problem – solving strategy

- **Analysis.** Plan a problem – solving strategy
- Check to see if the formula is a binary ionic compound
- Name the compound by the rule in the order written in the chemical formula.

ii. **Solve.** Apply the problem – solving strategy

Name the cation followed by the anion

a. K_2S Potassium nitride

b. MgO Magnesium sulphide

c. $AlBr_3$ Aluminium bromide

iii. **Evaluate.** Does the results make sense?

Check to see if it is correct by trying to write a chemical formula for each. The check leads to the formulas K_2S, MgO, $AlBr_3$ respectively.

Binary ionic compounds having cations made of metals having more than one oxidation number, its oxidation number must be indicated in Roman numeral and it is bracket immediately after the name without space. These are metals having the atomic number above 20. Examples are

Metal	Oxidation number
copper	1 and 2
iron	2 and 3
Lead	2, 3 and 4
manganese	2 and 4

Worked examples 4

Name the following binary ionic compounds.

a. $FeCl_2$

b. $FeCl_3$

c. $CuCl_2$

Solution

- **Analysis.** Plan a problem – solving strategy
- Check to see if it is a binary ionic compound
- Check to see if metal is a transition element be face atomic number above 20.
- Name the cation first, followed by the anion. In naming the cation, its oxidation state must be indicated in Roman numerals and is bracket before naming the anion.

ii. **Solve.** Apply the problem – solving strategy. Use the crisscross method to determine the valency or oxidation state.

a. $FeCl_2$ Iron(II) fluoride

b. $NaCl_3$ Manganese(III) sulphide

c. $CuCl_2$ Cobalt(II) chloride

iii. **Evaluate.** Does the results make sense? Check to see if the answer is correct by trying to write the formula again. The check leads to the formula $FeCl_2$, $MnCl_3$, $CuCl_2$.

2. Naming binary molecular compound

These are compounds that contain discrete or simple covalent or molecular units made up of non – metals. There are different types.

a. **Type 1.** Binary covalent molecules having hydrogen atom covalently bonded to a non – metal. These are named as hydrogen followed by the name of the non – metal. The name of the non – metal is changed to end in hydride and therefore named from followed by the name of the non – metal. Examples.

Compound	Name
HCl	Hydrogen fluoride
HCl	Hydrogen chloride
HBr	Hydrogen bromide
HI	Hydrogen iodide
H_2S	Hydrogen sulphide

b. **Type 2.** Binary covalent molecules where a pair of non – metal and oxygen form compounds with different number of oxygen atoms. Example, NO and NO_2.

Rules

- Name the first element in the chemical formula first
- Indicate the oxidation state of the first element in Roman numerals and in bracket.
- Followed by the word oxide.

Naming oxidation. Some of first element in the oxidation number(+) Greek

Examples.

Chemical formula	IUPAC
NO	Nitrogen(II) oxide
NO_2	Nitrogen(IV) oxide
N_2O	Dinitrogen(I) oxide
CO_2	Carbon(IV) oxide
CO	Carbon(II) oxide
SO_2	Sulphur(IV) oxide

3. Naming acids

An **acid** is a hydrogen containing substance that yields hydrogen ions in solution.

4. Simple acids

These are hydrogen – containing binary compounds.

- The hydrogen is bonded directly to a non – metal which is more electronegative.
- They are named with the prefix "hydro" plus root name of the other non – metal + suffix "-ic acid".

Examples.

Acid	Name
HF	Hydrofluoric acid
HCl	Hydrochloric acid

5. Oxy – acids

These are types of acids that have hydrogen and oxygen atoms bonded directly to a non – metal. Examples are $HClO_4$, HNO_3 and H_2CO_3.

Rules

- Use the prefix ortho, meta, between to indicate the total number of oxygen atoms present in the formula. (e.g. 1, 2 and 3 respectively)
- Followed by the root name of the central non – metal with the suffix "ic" added to it.
- Indicate in Roman numeral and in brackets, the oxidation state of the central non – metal, with the word "acid" is added to the name.

Name scheme

[Prefix + Root name + "ic" (Central atom's oxidation state in Roman numeral) + Acid]

Worked Examples 5.

Name the following acids

a. H_2SO_4

b. HNO_3

Solution. For the problem – solving approach

- **Analysis.** Plan the problem – solving strategy
- Identify the type of compound it is.
- Apply the rules to find particular type of compound
- If it is an oxy – acid, work out the oxidation state of the non – metal
- Do not forget to add the word "acid" to it.

ii. **Solve.** Apply the problem – solving strategy

a. H_2SO_4

It is an oxy – acid. The oxidation state of S is worked out as follows

$2(+1) + x + 4(-2) = 0$

$x = +6$

- Number of oxygen – 4, hence the prefix is tetrakis
- Name of the central atom + suffix -sulphuric
- Applying the rule

Tetrakis(oxo)sulphuric (VI) acid

b. HNO_3

It is an oxy-acid. The oxidation state of N is worked out as follows

$1 + x + 3(-2) = 0$

$x = +5$

- Number of oxygen atoms = 3, hence the prefix trioxo
- Name of central atom + suffix -nitrate.
- Applying the rule

Trioxonitric(V) acid

iii. **Evaluate.** Does the results make sense? Check the results with the scheme

[Prefix + Root name + "ic" (Central atom's oxidation state in Roman numeral) + Acid]

Formulae	Common Name	IUPAC Name
HNO_3	Nitric acid	Trioxonitric(V) acid
H_2CO_3	Carbonic acid	Trioxocarbonic(IV) acid
H_2SO_4	Sulphuric acid	Tetraoxosulphuric(VI) acid

6. Naming oxoacids

These are salts that contain ions – anion. Examples are $NaNO_3$, $CaCO_3$ and K_2CO_3.

Rules

- Name the cation first followed by the anion.
- In naming the anion, if it has more than one oxidation state (or valency), the oxidation state being used in the formula is indicated in Roman numeral and is bracket.
- The anion is named just like the oxoacid but without the word acid.

The rule is summarized as

[Name of cation + Prefix + Root name + "ate" (Central atom's oxidation state in Roman numeral)]

Worked example 6.

Name the following compounds

a. K_2CO_3

b. $Fe_2(SO_4)_3$

Solution. For the problem solving approach

a. **Analysis.** Plan the problem – solving strategy

- Identify the type of compound it is.
- Apply the type of rule for that particular type of compound
- If it is an oxoacid, work out the oxidation state of the central atom first
- Apply the rule.

ii. **Solve.** Apply the problem – solving strategy

a. K_2CO_3

It is an oxoacid. The oxidation state of valency of K is fixed. The oxidation state of C is obtained as follows

$2 + 4(-2) = 2$

$x = +4$

- Number of oxygen atoms = 3, hence the prefix trioxo
- Apply the rule

Potassium trioxocarbonate(IV)

b. $Fe_2(SO_4)_3$

It is also an oxoacid. The oxidation state or valency of Fe is +3 or 3. The oxidation state of sulfate is obtained from its acid – anion as follows

$x + 4(-2) = -2$

$x = +6$

- Number of oxygen per ion – anion = 4, hence the prefix – tetraoxo
- Apply the rule

Iron(III) tetraoxosulfate(VI)

iii. **Evaluate.** Does the results make sense? Check the results with the scheme

[Name of cation + Prefix + Root name + "ate" (Central atom's oxidation state in Roman numeral)]

Formulae	Common name	IUPAC name
Na_2CO_3	Sodium carbonate	Sodium trioxocarbonate(IV)
KNO_3	Potassium nitrate	Potassium trioxonitrate(V)
$CaSO_4$	Gun sulphate	Calcium tetraoxosulphate(VI)
Na_3PO_4	Sodium phosphate	Sodium tetraoxophosphate(V)

Summary

1. The IUPAC system of naming depends on the type of compound involved and oxidation number of the constituent element.
2. The oxidation state of an element is the charge an atom will carry in its pure state or in a molecule if electrons were completely transferred
3. A binary ionic compound is made up of two different elements one of which is a metal.
4. An acid is a hydrogen containing substance that yields hydrogen ions in solution.
5. A ternary compound is a compound made up of three different elements.

Question **1**

Not yet answered

Marked out of 20.00

Flag question

SO_3

.....

.....

Select one:

- Sulphur(VI) oxide
- Sulphur(VII) oxide
- Sulphur oxide
- Sulphur(VIII) oxide

Question **2**

Not yet answered

Marked out of 20.00

Flag question

$Cu_3(PO_4)_2$

.....

.....

Select one:

- Copper(III) tetraoxophosphate(V)
- Copper tetraoxophosphate(V)
- Copper(II) tetraoxophosphate
- Copper(II) tetraoxophosphate(V)

Question **3**

Not yet answered

Marked out of 20.00

Flag question

H_2CO_3

.....

.....

Select one:

- Trioxocarbonate(II) acid
- Trioxocarbonate acid
- Trioxocarbonate(IV)
- Trioxocarbonate(IV) acid

Question **4**

Not yet answered

Marked out of 20.00

Flag question

P_2O_5

.....

.....

Select one:

- Phosphorous(VI) oxide
- Phosphorous(V) oxide
- Phosphorous oxide
- Phosphorous(II) oxide

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Al_2O_3

.....

Select one:

- Aluminium (II) oxide
- Aluminium (VII) oxide
- Aluminium oxide
- Aluminium (IV) oxide

LESSON NOTE

Lesson 02

The Mole Concept

How many moles are involved in **2.3** g? How many items are involved in **2.3** moles? How many moles are involved in **2.3** litres?

What all of these questions of measurement have in common with each other? Notice that they do not only used to indicate a specific number of items. What do they have in common with each other? Is the number of moles of substance the same as the number of items? Is the number of moles the same as the number of volumes?

At the end of this lesson, you will be able to:

- Define the mole and calculate number of constituents.
- Determine the relative molecular mass and formula mass of substances.
- Calculate molar mass.
- Determine the relation between the amount of substance and the number of constituent particles.
- Perform calculations involving the mole.

The Relative Molecular Mass

In our earlier lesson, we defined the relative atomic mass of an element. Similarly, the **relative molecular mass** of a compound is the average mass of one molecule of the compound compared with the mass of an atom of carbon-12. Relative molecular mass is the number of times an average mass of a molecule of the substance is heavier than 1/12 the mass of one atom of carbon-12. It is also known as molecular weight or molecular mass.

Mathematically,

Relative Molecular Mass = Average mass of an individual of substance / 1/12 the mass of an atom of carbon-12

Molecular mass of a formula unit of a compound is numerically equivalent to the relative formula mass. Relative formula mass is the number of times the formula unit of a substance is heavier than 1/12 the mass of one atom of carbon-12. The relative formula mass is the sum of the masses of the atoms in the formula. Relative Formula Mass

Worked Examples

Problem 1

Determine the relative molecular masses of the following molecules:

a. Ammonia(NH3)
b. Ammonium(NH4)

A = 14, H = 1

Ammonia = 14 + 3 = 17

Ammonium = 14 + 4 = 18

a. Ammonia

Ammonia = 1 nitrogen + 3 hydrogen

$M_r = 1 \times 14 + 3 \times 1$

$= 14 + 3$

$= 17$

b. Ammonium

Ammonium = 1 nitrogen + 4 hydrogen

$M_r = 1 \times 14 + 4 \times 1$

$= 14 + 4$

$= 18$

Problem 2

Calculate the relative molecular mass of the following molecules:

a. Sulfuric acid(H2SO4)
b. Ethanoic acid(CH3COOH)

Sulfuric acid = 2 hydrogen + 1 sulfur + 4 oxygen

$M_r = 2 \times 1 + 1 \times 32 + 4 \times 16$

$= 2 + 32 + 64$

$= 98$

a. Sulfuric acid

Ethanoic acid = 2 carbon + 4 hydrogen + 2 oxygen

$M_r = 2 \times 12 + 4 \times 1 + 2 \times 16$

$= 24 + 4 + 32$

$= 60$

b. Ethanoic acid

Problem 3

Determine the relative molecular mass of the following compounds.

a. Sodium chloride (NaCl)
b. Calcium carbonate ($CaCO_3$)

Solution: Use the problem - solving approach

1. **Problem:** Use the problem-solving strategy.

Given: Unknown:

Relative atomic masses: Relative formula Mass?

Number of atoms

Number of moles

2. **Solve:** Apply the problem - solving strategy.

a. Sodium chloride

Sodium chloride = 1 sodium + 1 chlorine

Mass of sodium = 1 x 23 = 23

Mass of chlorine = 1 x 35.5 = 35.5

b. Calcium Carbonate(CaCO3)

Calcium carbonate = 1 calcium + 1 carbon + 3 oxygen

Mass of calcium = 1 x 40 = 40

Mass of carbon = 1 x 12 = 12

Mass of oxygen = 3 x 16 = 48

3. **Evaluate:** Do the results make sense? The results reflect the sum of the relative atomic masses.

Molar Formula mass

Ionic compounds are not made of molecules but **formula units**. We use the term formula mass with molar formula mass. The relative formula mass is determined using the same approach as relative molecular mass.

Problem 4

Determine the molar mass of the following ionic compounds.

a. Sodium chloride (NaCl)
b. Calcium carbonate ($CaCO_3$)

Solution: Use the problem - solving approach

1. **Problem:** Use the problem-solving strategy.

Given: Unknown:

Relative atomic masses: Relative formula Mass?

Number of atoms

Number of moles

Relative formula mass = sum of atomic masses of elements present in a formula unit

2. **Solve:** Apply the problem - solving strategy.

a. Sodium chloride

Sodium chloride = 1 sodium + 1 chlorine

Mass of sodium = 1 x 23 = 23

Mass of chlorine = 1 x 35.5 = 35.5

b. Calcium Carbonate(CaCO3)

Calcium carbonate = 1 calcium + 1 carbon + 3 oxygen

Mass of calcium = 1 x 40 = 40

Mass of carbon = 1 x 12 = 12

Mass of oxygen = 3 x 16 = 48

3. **Evaluate:** Do the results make sense? The results reflect the sum of the relative atomic masses.

Mole

In everyday life, measurements are made. We are usually told to as "atomic" or measure. Measuring is the process of finding the number of units in a given quantity. Measurement is the process of finding the number of units in a given quantity. Scientists use a set of standard units for measurement. These units are the meter for length, the second for time, the kilogram for mass, the kelvin for temperature, the ampere for electric current, the candela for luminous intensity, and the mole for amount of substance. These units are called SI units (from Système International d'Unités, the International System of Units).

Oranges are customarily measured in three different ways:

- Oranges can be by mere fixations by count (1 or 100 1,000)

- An 8-kilogram box of persimmons, or a carton **volume** (VOLES/boxes)
- A crate of apples is a **mass** (apples are sold by mass (5.000.00kg)

Each of these different ways of measurement of oranges (by count, volume or mass) can be converted to the other two if we know the following facts:

- 1 kg of orange contains exactly 12 oranges
- 1 kg of orange occupies exactly 0.5 litres of volume
- 1 litre of orange occupies exactly 2 oranges
- 1 kg of orange = 12 dozen (orange count) oranges occupies 0.36 of a basket
- 1 basket of orange occupies 0.5 litres of volume of orange and 1 kg of orange weighs 12 dozen oranges (or 144 oranges).

Number of oranges and oranges = 1 dozen = 12 x 1 = 12

Number of oranges and volume = 1 litre = 2 x 1 = 2

Number of oranges and weight = 1 kilogram = 12 x 12 = 144

(i) By Mass

1 dozen of oranges and orange weighs 1 kg

2 litres of orange and orange weighs 1 kg = 2 kg

3 litres of orange and orange weighs 3kg x 3 = 9 kg

(ii) By volume

1 litre of oranges and orange occupies 0 basket of orange

2 litres of oranges and orange occupies 0 basket of oranges x 2 = 0.8 basket of oranges

Similarly, scientific measurements of matter and substances are made using a set called a SI units. The SI units of amount of substance is the mole (mol). The mole is the amount of substance that contains as many elementary entities as there are atoms in exactly 0.012 kilogram of carbon-12.

Mole is Determine within the Count

The number of particles in elements of substance (i.e. molecules and ions) contained in 1 mol of a substance is called the Avogadro's constant (N_A) and is denoted as L.

For example,

1 mol of magnesium atoms (1 mole = 6.02 x 10^{23}) = 6.02 x 10^{23}

1 mol of Magnesium ions (1 mol = 6.02 x 10^{23}) = 6.02 x 10^{23}

Number of Magnesium atoms (0.5 mol = 0.5 x 10^{23} = 3.01 x 10^{23}

Substance	Entity	Number of entities per mol
Carbon-12	Atoms	6.02×10^{23}
Copper (II)	Ions	12.04×10^{23}
Sodium chloride	Formula unit	6.02×10^{23}
Sodium chloride	Formula unit	6.02×10^{23}

The number of moles of substance (n) is related to the number of elementary entities (N) by the Avogadro's constant (N_A).

Number of molecule = Number of elementary entities(N) / Avogadro's constant (N_A)

$$n = \frac{N}{N_A}$$

Mole is Mass of Atoms

The mass of an atom is a sum of any substance is the same and equal to 12. But the masses of atom of oxygen are in atoms of oxygen are different. Similarly, the number of atoms in 1 mole of any substance is the same and equal to 6.02×10^{23}. But the masses of 1 mole of atoms of various differ from element to element. Therefore, one mole of any element contains

Element	Symbol	Relative atomic mass	Mass of 1 mole of atoms (Molar mass/gram)	1 Molar contained per atom
Carbon	C	12	12	6.02×10^{23} carbon atoms
Magnesium	Mg	24	24	6.02×10^{23} magnesium atoms
Iron	Fe	56	56	6.02×10^{23} iron atoms

Mathematically, the number of moles of an element (n) present in a given mass of it (m) and the relative atomic mass (M) are related by the equation:

Number of mole = Mass of substance / Molar mass

$$n = \frac{m}{M}$$

Worked Examples

Problem 5

(a) Calculating the number or amount of substance from mass

Problem 1

Calculate the number of moles contained in the following:

a. 12g of Mg atoms
b. 40g of Ca^{2+} ions

Mg, Ca = 40

Solution: Use problem – solving approach

1. **Problem:** Use the problem-solving strategy.

Given: Unknown:

Mass of atoms Moles = ?

Relative atomic masses

Formula of ions

2. **Solve:** Apply the problem-solving strategy.

a. 12g of Mg

Moles = ?

Mass = 12g

Molar mass = 24

$$n = \frac{m}{M}$$

$$= \frac{12}{24}$$

$$= 0.5 \text{ mol}$$

b. 40g of Ca^{2+} ions

Moles = ?

Mass = 40g

Molar mass = 40

$$n = \frac{m}{M}$$

$$= \frac{40}{40}$$

$$= 1 \text{ mol}$$

3. **Evaluate:** Do the results make sense? One unit of Mg and Ca and the same amount.

c. 10g of Ag

10g of Ag contains 1 mol

$$\text{1 Mg} = \frac{1 \text{ mol} \times 10 \text{ g}}{\text{Mg}}$$

$$= 0.5 \text{ mol}$$

b. 10g of Cl_2

10g of Cl_2 contains 1 mol

$$\text{1 Mg} = \frac{1 \text{ mol} \times 10 \text{ g}}{\text{Mg}}$$

$$= 0.28 \text{ mol}$$

Calculating the mass of a mole of elements

Mass = number of mole x Relative atomic mass

$$m = n \times M$$

Problem 2

Calculate the mass of the following

(a) 0.5 mol of Na atoms

(b) 0.2 mol of ammonia (NH_3) in g

Na, N, H, O = 23, 14, 1, 16 g/mol

Solution: Use the problem-solving approach

1. **Problem:** Use the problem-solving strategy.

Given: Unknown:

Relative atomic masses Relative formula Mass

Number of moles

Formula of ions

2. **Solve:** Apply the problem-solving strategy.

a. 0.5 mol of Na

$$m = n \times M$$

$$= 0.5 \times 23$$

$$= 11.5 \text{ g}$$

b. 1 mol of Al atoms

$$m = 1.5 \times 27$$

$$= 40.5 \text{ g}$$

$$m = n \times M$$

$$= 0.2 \times 17$$

$$= 3.4 \text{ g}$$

3. **Evaluate:** Do the results make sense? Using the alternative approach to validate the results.

a. 0.5 mol of Na

1 mol of Na weighs 23 g

$$0.5 \text{ mol} = \frac{0.5 \text{ mol} \times 23 \text{ g}}{1 \text{ mol}}$$

$$= 11.5 \text{ g}$$

b. 1.5 mol of Al

1 mol of Al weighs 27 g

$$1.5 \text{ mol} = \frac{1.5 \text{ mol} \times 27 \text{ g}}{1 \text{ mol}}$$

$$= 40.5 \text{ g}$$

Moles is Mass of molecules or ionic compounds

A mole of molecules or ionic compounds contains the total number of atoms of each element present in a unit of the compound.

A mole of different compounds contains Avogadro's number of entities (molecules). The mass of one mole of a substance is equal to its relative formula mass in grams. Therefore, the mass of one mole of molecules of all kinds of compounds is equal to its relative formula mass. The mass of one mole of molecules of all kinds of compounds is equal to its relative formula mass in grams. Therefore, grams is numerically equal to the relative molecular mass or relative formula mass of the ionic compound of molecule.

Substance	Formula	Relative molecular mass / Relative formula Mass	Mass of 1 mole of substance (g)	Entities contained in 1 mole
Oxygen	O_2	$2 \times 16 = 32$	32	6.02×10^{23} molecules
Ammonia	NH_3	$14 + 3(1) = 17$	17	6.02×10^{23} molecules
Water	H_2O	$2(1) + 16 = 18$	18	6.02×10^{23} molecules
Sodium chloride	NaCl	$23 + 35.5 = 58.5$	58.5	6.02×10^{23} formula units
Calcium Carbonate(CaCO3)	$CaCO_3$	$40 + 12 + 3(16) = 100$	100	6.02×10^{23} formula units

The formula that links the number of moles and mass of substances to its molar mass (relative molecular mass) is

$$n = \frac{m}{M}$$

Number of moles of substance = Mass of substance / Molar mass

Alternatively, the number of moles could be expressed in terms of relative molecular mass (Mr) as

$$n = \frac{m}{M_r}$$

Number of moles of substance = Mass of substance / Relative molecular mass

$$n = \frac{m}{M_r}$$

Using this triangle to work out the formula required.

Worked Examples

Problem 3

Calculate the number of moles of the following

- 36g of water
- 4g of $CaCO_3$

H_2O = 2, 1, 16 = 2 x 1 + 1 x 16 = 18

Solution: Use the problem – solving strategy, by listing the knowns and unknowns.

Knowns: Unknowns:

Relative Atomic Masses Relative Formula Mass

Mass of substance Moles

Number of moles?

Solution: Use the problem-solving approach. Have the students the relative molecular mass or molar mass.

- Use the formula

$$n = \frac{m}{M}$$

$$= \frac{36}{18}$$

$$= 2 \text{ mol}$$

Method 1

$M_r(CaCO_3) = 40 + 12 + 3(16) = 100$

$$n = \frac{m}{M}$$

$$= \frac{4}{100}$$

$$= 0.04 \text{ mol}$$

Method 2

$M_r(CaCO_3) = 40 + 12 + 3(16) = 100$

100g of $CaCO_3$ = 1 mol

$$4 \text{ g} = \frac{1 \text{ mol} \times 4 \text{ g}}{100 \text{ g}}$$

$$= 0.04 \text{ mol}$$

Problem 4

Calculate the mass of 0.5 mol of glucose ($C_6H_{12}O_6$) = 12 + 1 x 6 + 16 = 180

Solution: Use problem – solving approach

1. **Problem:** Use the problem – solving strategy by listing the knowns and unknowns.

Given: Unknown:

Molar of glucose = 0.5 mol Mass = ?

Relative atomic masses

Use the molar atomic masses to calculate the relative molecular mass or molar mass.

- Use the formula

$$n = \frac{m}{M}$$

$$m = n \times M$$

$$= 0.5 \times 180$$

$$= 90 \text{ g}$$

2. **Solve:** Apply the problem – solving strategy.

Method 1

$M_r(C_6H_{12}O_6) = 6(12) + 12(1) + 6(16)$

$= 72 + 12 + 96$

$= 180 \text{ g/mol}$

$$m = n \times M$$

$$= 0.5 \times 180$$

$$= 90 \text{ g}$$

Method 2

$M_r(C_6H_{12}O_6) = 6(12) + 12(1) + 6(16)$

$= 72 + 12 + 96$

$= 180 \text{ g/mol}$

180g of $C_6H_{12}O_6$ = 1 mol

$$0.5 \text{ g} = \frac{0.5 \text{ mol} \times 180 \text{ g}}{1 \text{ mol}}$$

$$= 90 \text{ g}$$

3. **Evaluate:** Does the results make sense? Use the alternate approach to verify the results.

1 mol of $C_6H_{12}O_6$ weighs 180 g

0.5 mol of $C_6H_{12}O_6$ weighs $\frac{180 \text{ g} \times 0.5 \text{ mol}}{1 \text{ mol}}$

$= 90 \text{ g}$

Summary

- The mole is the unit used to express the amount of substance contained in a substance.
- 1 mole of any substance contains the same number of elementary particles (atoms, ions, molecules etc) (6.02×10^{23}) entities.
- The mole is the SI unit of amount of substance.
- One mole of substance has the same mass as its relative atomic mass or relative molecular mass.

SHS 1 INTEGRATED SCIENCE

Question **1**
Not yet answered
Marked out of 10.00
Flag question

Which of the following statements is not correct?

Select one:
- Molar mass of sodium is numerically equal to the relative atomic mass
- 1 mol of oxygen atoms and 1 mol of oxygen molecule contain the same number of entities
- The mass of 1 mol of oxygen atom is equal to the mass of 1 mol of oxygen molecule.
- The mass of 1 mol of H_2S is greater than the mass of 1 mol of H_2O.

Question **2**
Not yet answered
Marked out of 10.00
Flag question

Calculate number molecules contained in 0.2 mol of O_2 gas administered to a patient?
[L = 6.02 x 10^{23} molecules/mol]

Select one:
- 3.10 x 10^{24} molecules
- 1.20 x 10^{23} molecules
- 3.10 x 10^{23} molecules
- 3.32 x 10^{-25} molecules

Question **3**
Not yet answered
Marked out of 10.00
Flag question

A large advertising board is to be filled with a mixture of gases, including 9.455 g neon. What is the number of moles of neon required? [Ne = 20.2]

Select one:
- 2.14 mol
- 190.99 mol
- 0.47 mol
- 0.95 mol

Question **4**
Not yet answered
Marked out of 10.00
Flag question

Which sample has the greatest mass? [H = 1, O = 16, S = 32, C = 12

Select one:
- 2.0 mol of H_2O_2
- 2.0 mol of CH_4
- 1.0 mol of H_2O
- 1.0 mol of H_2S

Question **5**
Not yet answered
Marked out of 10.00
Flag question

What amount (in moles) is present in 4,0g of CH_4? [C = 12, H= 1]

Select one:
- 25
- 0.25
- 4
- 2.5

Question **6**
Not yet answered
Marked out of 10.00
Flag question

What amount of hydrogen, H_2, (in moles) contains 1.8 x 10^{22} molecules?

Select one:
- 0.0030
- 0.30
- 0.030
- 3.0

Question **7**
Not yet answered
Marked out of 10.00
Flag question

What is the mass of 1.5 mol of $CaCO_3$ of an egg shell from the Agric farm?
Mr. ($CaCO_3$) = 100.

Select one:
- 66.7 g
- 150g
- 0.015g
- 100 g

Question **8**
Not yet answered
Marked out of 10.00
Flag question

What is the Si unit of the amount of substance

Select one:
- mol
- g
- g/mol
- mol/g

Question **9**
Not yet answered
Marked out of 10.00
Flag question

The mass of 0.25 mol of an atom X is 6.75g. What is the relative atomic mass of the element X.?

Select one:
- 27
- 13
- 12
- 2

Question **10**
Not yet answered
Marked out of 10.00
Flag question

How many ions are contained in 1 mole?

Select one:
- 6.02 ions
- 6.02 x 10^{-23} ions
- 6.02 x 10^{30} ions
- 6.02 x 10^{23} ions

LESSON NOTE

Lesson 10

Concentration and Molarity of Solutions in Solutions

Have you ever experienced being administered an *antivenin*?

Antivenin (*antivenom* in some countries) is a medication used to treat venomous bites or stings. It is produced into the patient's bloodstream, where it binds to specific toxins. The antivenin, therefore, must be given the right concentration and survey how to administer that amount of concentration. What do you understand by concentration of solutions?

By the end of this lesson, you would be able to:

- Define the term concentration and solute by mass
- Calculate the concentration of solutions in g/dm3
- Perform calculations involving concentration of solutions

Concentration of Solution

A solution is a homogeneous (uniform) mixture of a solute and a solvent. The solute and the solvent form one phase.

The **solute** is the substance that is dissolved by the solvent to form a solution. It is usually a solid but could also be a liquid or gas as well. A **solvent** is the dissolving medium. When the solvent is water, the solution is called an **aqueous solution**. Water is the most common solvent in the laboratory as it:

(a) Dilute solutions (the low small amount of solute dissolved in a solution)

(b) Concentrated solutions (It has large amount of solute dissolved in a solution.

The amount of solute present in a solution can be determined quantitatively if the volume and concentration are known. The **concentration** of a solution therefore is the quantity of solute dissolved in a unit volume of solution. Concentration is a measure of how much the solutes or solutes there are the value of expressing concentration. There are:

- Amount of substance concentration
- Mass concentration
- Molarity
- Part per million

(a). Amount of Substance Concentration

Amount of substance concentration is defined as the amount of moles dissolved in one cubic decimeter of solution. The unit of amount of substance concentration is moles per cubic decimeter (mol/dm3) or moles per liter (**molarity** as described in it is measured in moles per liter (mol/l) or moles per cubic meter (mol/m3).

Mathematically, it is defined as:

Concentration = **Amount of substance (mol)** / **Volume of solution (dm3)**

c = n / V

It can be deduced that, concentration depends on the volume of the solution as well as the amount of substance.

The molarity therefore is a measure of the number of moles of solute present in a fixed volume of solution. This is illustrated diagrammatically below:

Figure 1 : Show the number of particles in a fixed volume solution

As illustrated, the volume increases from left to right while the number of particles generally increases. The number of particles per unit volume increases the most and therefore concentration is highest.

However in diagram 2, the total number of particles remains constant

The effect of the dissolved on concentration is that, as the volume increases, the number of particles per unit volume decreases. We call it dilution and solution and volume decreases and hence concentration decreases.

Worked Example

Problem 1

Calculate the concentration of the following solutions:

a. 20 g of sodium hydroxide (NaOH) in 500 cm3 solution.

Solution: Use the known and unknown variables to solve the problem.

Known: Mass of solute = 20 g

Volume of solution = 500 cm3 = 0.5 dm3

Unknown: Concentration of solution in mol/dm3

Strategy: Plan the problem – solving strategy by listing all the known and unknown.

Known

- Mass of substance
- Molar mass of substance
- Volume of solution in dm3

Unknown

Moles of solute

Moles formula mass / ?

Number of moles of solute / ?

- Use the volume-plank reason to calculate the relative formula mass.
- Use the mass to calculate the moles.
- Use the formula to calculate the concentration.

Solve: Apply the problem – solving strategy to solve for the unknown.

Step 1: Calculate the moles of solute

n = m/ M

n = 20g/ 40 g/mol = 0.5 mol

Relative formula mass (RFM) = 23 + 16 + 1 = 40

Alternatively, Molar mass, **M** = 40 g/mol

Step 2: Calculate the concentration of solution

c = n/v

c = 0.5 mol / 0.5 dm3 = 1.0 mol/dm3

(c). 20 g of NaCl in 250 cm3

n = m/M

n = 20 g/ 58.5 g/mol = 0.34 mol

0.5 dm3 = 0.5 x 1000 cm3 = 0.5 dm3

Alternatively, Molar mass, **M** = 58.5 g/mol

Step 2: Calculate the concentration of solution

c = n/v

c = 0.34 mol / 0.25 dm3 = 1.36 mol/dm3

Evaluate: Does the results make sense?

Yes, 1.36 mol/dm3 is a reasonable answer

To validate the results of the results obtained is corrected with the answers.

Moles in a volume of a solution

The number of moles in a solution is the number of moles of solute in a given volume of a solution can be determined from the formula:

This is done by counting number of moles. The mole to the solution.

Number of moles = concentration x volume (dm3)

Problem 1: Calculate the amount of substance contained in the following solutions:

a. 50 cm3 of 0.5 mol/dm3 of HCl(aq) solution.

Solution: Use the known and unknown variables to solve the problem.

Known: Volume of solution = 50 cm3 = 0.05 dm3

Concentration of solution = 0.5 mol/dm3

Unknown: Number of moles of solute in dm3

Strategy: Use the known and unknown.

Known

- Volume of solution in dm3
- Concentration of solution

Unknown

Volume of solution in dm3 = ?

Concentration of solution

- Use the formula to solve the problem

Solve: Apply the problem – solving strategy.

a. Mass of solute needed to dry solution

n = MV/dm3 = 0.5 x 0.05 dm3 = 0.025 mol

1 dm3 = 1000 cm3

0.05 dm3 = 0.05 x 1000 cm3 = 50 cm3

b. Mass of solute needed to dry solution

n = MV/dm3 = 0.5 x 0.05 dm3 = 0.025 mol

1 dm3 = 1000 cm3

0.05 dm3 = 0.05 x 1000 cm3 = 50 cm3

c. Mass of solute needed to dry solution

n = MV/dm3 = 0.5 x 0.05 dm3 = 0.025 mol

1 dm3 = 1000 cm3

0.05 dm3 = 0.05 x 1000 cm3 = 50 cm3

Evaluate: Does the results make sense?

Yes, 0.025 mol is a reasonable answer

To validate the number of moles obtained is corrected with the answers.

Mass concentration

Another way of expressing concentration is in terms of **mass concentration** (g/l). It is defined as the amount of substance dissolved in one cubic decimeter of solution.

Mass concentration = **Mass of solute (g)** / **Volume of solution (dm3)**

Mathematically, it is defined as:

Problem 2 Calculate the mass concentration of the following solutions:

a. 5 g of sodium chloride in 200 cm3 solution

b. 5 g of aluminum in 500 cm3 solution

Solution

Strategy: Use the known and unknown.

Known

- Mass of solute
- Volume of solution in cm3
- Volume of solution in dm3

Unknown

Volume of solution in dm3 = ?

Concentration of solution

- Use the formula to solve the problem

Solve: Solve the problem – solving strategy.

a. Mass of solute in dm3

1 dm3 = 1000 cm3

0.2 dm3 = 0.2 x 1000 cm3 = 200 cm3

b. 25 g of NaCl in 250 cm3

1 dm3 = 1000 cm3

0.25 dm3 = 0.25 x 1000 cm3 = 250 cm3

Evaluate: Does the results make sense? Yes, 200 cm3 of solution contains 5 g of glucose

Therefore, 1000 cm3 of glucose solution will contain 5 g x 1000 cm3 / 200 cm3 = 25 g

c. 25 g of sodium chloride (NaCl) solution

Therefore, 1000 cm3 of sodium chloride solution 25 g x 1000 cm3 / 250 cm3 = 100 g

d. 5 g of aluminum

The results obtained are consistent.

Mass concentration and molarity

The relationship between mass concentration and molarity can be determined by the triangle.

a. Knowing molarity, equal to the mass concentration (g/dm3) and molar mass (g/mol)

molarity (mol/dm3) = mass concentration (g/dm3) / molar mass (g/mol)

b. Similarly, knowing the mass concentration would lead to molarity equal to the mass concentration (g/dm3) and molar mass (g/mol).

mass concentration (g/dm3) = molarity (mol/dm3) x molar mass (g/mol)

c. Knowing molar mass would be

molar mass (g/mol) = mass concentration (g/dm3) / molarity (mol/dm3)

Problem 1

a. To prepare the molarity of 1.000 mol/ of 1 g/dm3 NaCl solution

b. Calculate the molarity of 0.5 mol/dm3 of NaOH solution if 5 g/l was available.

Solution

Strategy: Use the known and unknown.

Known

- Mass concentration
- Molar mass of solute

Unknown

Concentration in moles? = ?

Molarity = ?

Solve: Solve the problem – solving strategy.

Step 1: Calculate the molarity

Molarity = c/ M = 5 / 40 g/mol

= 0.125 mol/dm3

Evaluate: Does the results make sense?

Yes, 0.125 mol/dm3 is a reasonable answer when the answer

Strategy: Use the known and unknown.

Known

- Concentration in mol/dm3 = 0.125 mol/dm3
- Molar mass = ?

Use the formula: c = n/ M

Unknown

Mass concentration

Solve: Solve the unknown

Molarity = c/ M = 0.125 / 40/1 = 5 g/l

Alternatively, **M** = 1,000 g/mol

c = n/M x M

c = 0.125 mol/dm3 x 40 g/mol

5g/l (g/dm3)

Evaluate: Does the results make sense?

Review the calculations to see if you would obtain the answer.

Other Types of Concentration Terms

1. Concentration expressed as a percentage by mass per volume.

The **percentage by mass per volume** is the mass of solute dissolved in any cubic decimeters of solution.

It is also known as **w/v** or **m/v**.

It is usually used in industry.

Concentration can be expressed in g/dm3, ppm and percentage.

Percentage by mass per volume = **mass of solute (g)** / **volume of solution (dm3)** x 100%

Mathematically, it is expressed as:

Concentration = mass of solute (g) / Volume of solution (dm3) x 100%

For example, if 50 g of NaCl is dissolved in 500 g of solution, then the concentration of the solution can be expressed as:

50 g x 100

500 g

= 10%

Solutions

- Concentration monitors the amount of solute dissolved in one cubic decimeters of solution.
- It is also known as molarity.
- Concentration can be expressed in g/dm3, ppm and percentage.
- Molarity is the concentration of solutions in moles per cubic decimeter of solution.

Molarity = **Amount of substance (mol)** / **Volume of solution (dm3)**

SHS 1 INTEGRATED SCIENCE

Question **1**
Not yet answered
Marked out of 10.00
Flag question

A solution contains 10.0 g of glucose ($C_6H_{12}O_6$) per dm^3. Calculate its molarity. [C = 12, H = 1, O = 16]

Select one:
- 0.06 mol/dm^3
- 1.8 mol/dm^3
- 0.6 mol/dm^3
- 18 mol/dm^3

Question **2**
Not yet answered
Marked out of 10.00
Flag question

What is the concentration a solution containing 0.5 mol in 0.1 dm^3 of solution?

Select one:
- 0.05 mol/dm^3
- 2.0 mol/dm^3
- 5.0 mol/dm^3
- 0.2 mol/dm^3

Question **3**
Not yet answered
Marked out of 10.00
Flag question

Which of the following is not a concentration unit?

Select one:
- mol/dm^3
- g/dm^3
- ppm
- g/mol

Question **4**
Not yet answered
Marked out of 10.00
Flag question

What volume of a 6 mol/dm^3 vinegar solution being used by Home Economics students to prepare salad contains 0.03 moles?

Select one:
- 20.0 dm^3
- 200 dm^3
- 0.005 dm^3
- 0.18 dm^3

Question **5**
Not yet answered
Marked out of 10.00
Flag question

The amount of substance concentration is also termed as:

Select one:
- molarity
- part per million
- mass concentration
- percentage

Question **6**
Not yet answered
Marked out of 10.00
Flag question

What is the concentration of sodium trioxocarbionate(IV) solution containing 55 g of the salt (Na_2CO_3) in 1 dm^3? M(Na_2CO_3) = 106 g/mol

Select one:
- 5.20 mol/dm^3
- 0.52 mol/dm^3
- 0.19 mol/dm^3
- 1.93 mol/dm^3

Question **7**
Not yet answered
Marked out of 10.00
Flag question

The molarity of NaOH solution is 0.5 mol/dm^3. If its molar mass is 40 g/mol, what is its mass concentration?

Select one:
- 2.66 g/dm^3
- 26.67 g/dm^3
- 20.0 g/dm^3
- 0.013 g/dm^3

Question **8**
Not yet answered
Marked out of 10.00
Flag question

An Agrochemical meant for treating a maize pest contains 5 mol of active ingredient in 250 cm^3 solution. What is its concentration?

Select one:
- 0.05 mol/dm^3
- 50 mol/dm^3
- 0.02 mol/dm^3
- 20 mol/dm^3

Question **9**
Not yet answered
Marked out of 10.00
Flag question

What is the concentration of a solution containing 4 moles in 2.5 dm^3 of solution?

Select one:
- 10.0 mol/dm^3
- 0.63 mol/dm^3
- 0.16 mol/dm^3
- 1.6 mol/dm^3

Question **10**
Not yet answered
Marked out of 10.00
Flag question

How many moles of solution are in 500 cm^3 solution of concentration 1.5 mol/dm^3?

Select one:
- 3.33 mol
- 0.003 mol
- 0.75 mol
- 333.33 mol

LESSON NOTE

Lesson 34

Preparation of Standard Solution

In our previous lesson, we discussed the concept of concentration and mole in solution.

By the end of today's lesson, you will be able to:

- define a standard solution
- calculate the mass of solute required to prepare a solution
- describe how to prepare a standard solution with a solid solute
- define dilution of solution and solve problems involving dilution

Preparing standard solutions

A **standard solution** is a solution whose concentration is accurately known. Example, 0.1 mol/dm³ NaOH solution is a standard solution because its concentration is known to be 0.1 mol/dm³. That is, it contains 0.1 mol of NaOH in one cubic decimetre of the solution.

Preparation of a standard solution with a solid solute.

To prepare a standard solution with a solid solute the following procedure is followed.

1. Use the molar mass of the solute, the volume of solution required and the concentration of the solution to be prepared to calculate the mass of the solute to be used.
   m = cMv
2. Use a chemical balance to weigh out the mass of solute calculated, in a beaker or suitable container.

3. Add some amount of distilled water to the solute in the beaker and stir to dissolve it.

4. Carefully transfer the solution into a volumetric flask (of appropriate volume) through a funnel.

5. Rinse the beaker, the stirrer, the funnel with distilled water into the content of the volumetric flask.

6. Add the distilled water until the volume of the solution is almost up to the volume mark on the volumetric flask.
7. Use dropping pipette or dropper to add the distilled water incrementally until the bottom of meniscus of the solution coincides with the mark on the volumetric flask.

8. Cork the flask and shake to ensure uniform solution. Label the solution.

Mass of solute required to prepare a solution

The mass of a solute needed to prepare a solution of specific concentration can be calculated using the relation

m = c x M x v

Where, c is the concentration of solution, M is molar mass or relative molecular mass or relative formula mass and v is volume of solution in dm³ and m is the mass of solute in g.

Problem 1
Calculate the mass of the following required to prepare 500 cm³ of 0.05 molar⁻¹ NaCl solution [Na = 23, Cl = 35.5]

Solution:
1. **Analyse:** plan problem solving strategy.

Known		**unknown**
- Volumes of solution in cm³	-	Volume in dm³
- Concentration of solution	-	Mass in g
- Molar mass of solute		

Use the formula to solve the problem (m = c x M x V)

2. **Solve:** solve for the unknowns.
   500 cm³ of 0.05 mol/dm³ NaCl
   V = 500 cm³ = 500 / 0.5 dm³
   1 000
   C = 0.05 mol/dm³
   M = RMM(NaCl) = 23 + 35.5 = 58.5

   m = c x M x v = 0.05 mol/dm³ x 58.5 g/mol x 0.5 dm³ = 1.46 g
3. **Evaluate:** Does the results make sense? Use an alternative approach to validate the results.

Preparation of 1 mol/dm³ solution of NaOH

Aim: To prepare 1 mol/dm³ solution of sodium hydroxide using 500 cm³ volumetric flask.

Materials needed:
- Sodium hydroxide pellet
- Chemical balance
- Beaker
- 500 cm³ volumetric flask
- Filter funnel
- Spatula
- Stirring rod
- Wash bottle
- Dropping pipette or dropper

Pre – lab: Let us calculate the mass of the NaOH pellets required

The molar mass of NaOH = 23 + 16 + 1 = 40 gmol⁻¹
Volume of volumetric flask being used= 500 cm³ = 0.5 dm³
Concentration of solution = 1 mol/dm³
Using the formula:

m = c x M x v
= 1 mol/dm³ x 40 g/mol x 0.5 dm³
= 20 g

Procedure: Let us follow these steps to prepare the solution]

1. Use a chemical balance, a spatula and beaker to weigh out 20 g of NaOH pellets.
2. Add distilled water from wash bottle to the solute in the beaker and stir to dissolve.
3. Put a filter funnel on the 500 cm³ volumetric flask and transfer the solution into it.
4. Add distilled water from the wash bottle into the volumetric flask and its content through the filter funnel until the meniscus almost coincides with the volume mark on the flask.
5. Swirl to ensure uniform mixture.
6. Use dropper to add the distilled water drop-wise until the meniscus coincides with the volume mark on the volumetric flask.
7. Shake and label the solution.

Dilution of solution

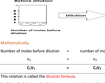
You recall that, a solution that contains less amount of solute per unit volume is described as dilute. On the other hand, a solution contains high amount of solute per unit volume is described as concentrated.

Solutions usually obtained from chemical shops or stores are usually concentrated. For example, paint products are usually sold in concentrated form.

We usually dilute them before using them to paint a house or spray a car. In this process, water is usually added to the stock solution and mixed uniformly to obtain a less concentrated form of the solution.

Dilution, therefore is the process of preparing a less concentrated solution from a more concentration one. Thus, in dilution, the concentration of the solution decreases but the volume of the solution increases.

However, the number of moles of solute before the dilution remains the same after dilution.



Mathematically,

Number of moles before dilution	=	number of moles after dilution
n_1	=	n_2
C_1V_1	=	C_2V_2

This relation is called the dilution formula.

Problem 2: Calculate the final concentration obtained from the following dilution process: 300 cm³ of water is added to 50 cm³ of 8 mol/dm³ $AlCl_3$ solution.

Solution

1. **Analyse:** Plan a problem solving strategy.

Known		**Unknown**
- Initial volume of solution	-	Final volume
- Initial concentration of solution	-	Final concentration

- Use the dilution formula to solve the problem

2. **Solve:** Solve for the unknowns

   300 cm³ of water is added to 50 cm³ of 8 mol/dm³ $AlCl_3$ solution.

   Initial volume (V_1) = 50 cm³

   Final volume (V_2) = 300 + 50 = 150 cm³
   Initial concentration (C_1) = 8 mol/dm³
   Final concentration (C_2) = ?

   $C_1V_1 = C_2V_2$

   $C_2 = \frac{C_1V_1}{V_2}$

   $= \frac{8 \times 50}{150} = 2.67 \text{ moldm}^{-3}$

3. **Evaluate:** Does the results make sense?
   The result is consistent because the concentration before dilution is greater than the concentration after dilution.

Preparation of a Standard Solution with a liquid solute

A standard solution of a liquid solute is prepared from a stock solution or concentrated form of the solution by dilution.

1. It is done by using the dilution formula to calculate the volume of the concentrated solution required (stock solution).
2. Measuring cylinder or burette is used to measure the required volume of the stock solution and transfer through a filter funnel into volumetric flask containing some distilled water.
3. The measuring cylinder, the filter funnel are washed into the volumetric flask and its content until the meniscus coincides with the mark on the volumetric flask.
4. The flask and its content is shaken to obtain a uniform mixture. It is then labelled.

Precautions required in dilution

In diluting a concentrated acid or concentrated base, water is not added directly to the concentrated acid or base. Rather, the concentrated acid is added to water. This is because water is less dense than concentrated acid. When water is added to the concentrated acid or base, the water will stay on top of the acid. The heat of dilution is localized on the surface and produces violent splashes. Rather, the concentrated acid or base is added to the water so that it sinks to the bottom of the container. The heat of dilution then becomes uniformly distributed throughout the solution.

Practical applications of Dilution

Practical applications of dilution are in:

A. Preparation of fruit drinks and beverages. Water is usually added to the fruit juice concentrate or extract.
B. Food preparation in the kitchen. For example, water is added to a thick porridge to make it light. Water can also be added to palm juice extracted to prepare palm soup to make it less concentrated.

Summary

- A standard solution is a solution of accurately known concentration.
- Concentration is the amount of substance of a solute dissolved in one cubic decimetre of a solution
- Dilution involves preparing a less concentrated solution from a more concentrated solution.
- In dilution, the number of moles of the solute remains constant, the concentration decreases but volume increases.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following apparatus is not required in preparing a standard solution of solid?

Select one:

- Chemical balance
- Beaker
- Filter funnel
- Measuring cylinder

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is true about dilution

Select one:

- The number of moles of the solute remain the same
- The number of moles of the solute decreases
- The number of moles of the solute increases
- The number of moles of solute and concentration remains the same.

Question **3**

Not yet answered

Marked out of 20.00

Flag question

In dilution of solution, the volume of diluted solution Increase

Select one:

- True
- False

Question **4**

Not yet answered

Marked out of 20.00

Flag question

In dilution of solution, the concentration of the solution increase

Select one:

- True
- False

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Dilution is required in preparing a standard solution of trioxonitrate(V) acid

Select one:

- True
- False

LESSON NOTE

Lesson 35

Rocks

What is a rock? Why do we have different types of rocks? What is inside a rock? How are rocks formed? All these questions will be answered in this lesson.

By the end of the lesson, you will be able to:

- define a rock and state different types of rocks
- describe the formation of different types of rocks
- state the characteristics of each type of rock
- state the uses of each type of rock

Rocks and their classification

The Earth's crust is made up of different types of **minerals**. (A **mineral** is a single element or a naturally occurring solid chemical compound found in the Earth's crust).

These have definite physical and chemical properties that help identify them. The minerals combine to make up a rock. For example, **silicon** and **oxygen** combine to give **compound** silicon(IV) oxide which in turn combine to make up a **mineral called quartz**. These also make up the **rock called granite**.

A **rock** is defined in different ways to give different rocks.

A **rock** therefore is defined as a **large mass of stone or mineral** material formed in the Earth's crust.

There are **three** main types of rocks depending on their **origin** and the **method** by which they were formed. These are:

1. Igneous rock
2. Sedimentary rock
3. Metamorphic rock

1. Igneous rocks

It is a **hard**, **crystalline**, **shiny** and **massive** rock having **broken joints**. It contains different minerals, randomly arranged to form interlocking crystals. Most igneous rocks consist of **quartz** and **feldspar**. The minerals in igneous rocks can be identified by their **crystal formation**, their **chemical** or **chemical composition**.

Formation of igneous rocks

Igneous rocks are formed when molten hot liquid mass called **magma** (molten lava) pushes up into the earth's surface (often through volcanoes) and is cooled and solidified.

Types of igneous rocks

There are **two** main types of igneous rocks. These are:

1. **Extrusive igneous rocks (volcanic)** Example is basalt which forms on the Earth's surface.
2. **Intrusive igneous rock (plutonic)**. Example is granite which forms within the Earth's crust.

Both rocks are formed from lava and contain crystals of minerals.

Granite is formed from **large crystals** while basalt is formed from **small crystals**.

The difference in size depends on the **rate** at which the hot magma cools down.

Basalt is exposed to air on the surface and cools down more quickly making it form small crystals.

Granite on the other hand, stays warmer for a longer period and slowly cools down, causing it to form large crystals.

basalt **granite**

General characteristics of igneous rocks

Igneous rocks:

- are hard **crystalline** solids
- have **fair density** and **shiny** appearance
- are **not stratified** (or layered)
- do not contain **fossils** (remains or imprints of ancient plants and animals preserved in rock)
- are resistant to erosion
- are composed mainly of primary minerals such as quartz, feldspars, hornblende

2. Sedimentary rocks

They are rocks formed when **layers of sediments** (of rock particles or dead matter) accumulate in lakes and hardens over a **long period of time**. They are also called **stratified rocks**. The layers are **cemented** together by **other minerals**. They are usually made up of different minerals such as dolomite, gypsum, calcite and clay.

Formation of sedimentary rocks

There are three steps in the formation of sedimentary rocks

1. **Weathering** – This is where **rocks** are broken down into **smaller rocks** settling down into **layers of sediments**. The sediments may contain fossils.
The layers of sediments **accumulate** on top of each other over a long period of time.
2. **Pressure or compression** on the layers of sediments squeezes water out of it, leaving natural mineral cement which holds the sediments together and causes them to harden to form sedimentary rocks.
It can also be formed when water evaporates leaving its dissolved solid behind. For example rock salt.

Types of sedimentary rocks

There are **three** ways in which it is formed. Sedimentary rocks can be classified into three main types. There are:

a. Mechanically formed sedimentary rocks. They are formed from the **accumulation** of rocks **fragments** that are produced by weathering and have been **cemented** together. Examples are sandstone, limestone, conglomerate, clay and breccias, shale.

limestone **sandstone**

conglomerate

b. Organically – formed sedimentary rocks. They are rocks formed from dead parts of living things. For example, shells of olden living things have formed sediments which have become rocks. Examples are limestone formed from the remains of the shells of sea animals such as mollusc; chalk is formed from shells of protozoic coat, pure and lignite.

coal **chalky limestone**

c. Chemically – formed sedimentary rocks. They are rocks that are formed from minerals which have been dissolved in water and have been carried in solution. These minerals have been washed down from rocks into the sea. When the **water evaporates** from the surface, the remaining seawater becomes **more concentrated** and **eventually crystallize** out of solution. Examples are: Rock salt, gypsum, dolomite and potash.

rock salt

General characteristics of sedimentary rocks

The general characteristics of sedimentary rocks have these common characteristics:-

- They are **stratified** (layered).
- They contain some **organic matter** (fossils).
- The layers are **cemented** together.
- They are **easily weathered**

3. Metamorphic rocks

They are rocks formed from igneous and sedimentary rocks as a result of **heat** and **increased pressure** which have been applied to them over a long period of time. **Heat** and **pressure** are the agents that cause the igneous rocks and sedimentary rocks to change or **metamorphose** into metamorphic rocks. Examples are: marble, slate, schist, quartzite, anthracite coal and gneiss.

Formation of metamorphic rocks

The type of metamorphic rock formed **resembles** the rock from which it was formed, but it also differs from it in some other ways. Generally, most metamorphic rocks have larger crystals and usually contain new minerals.

a. Marble resembles limestone which is the rock from which it was formed. It is harder and more crystalline than limestone. It also contains impurities which makes it beautifully coloured.

b. Slate resembles shale from which it was formed. It is harder than shale and does not also split like shale.

c. Schist resembles **shale**. It has parallel bands of minerals which have the tendency to cleave.

d. Quartzite is formed from **sandstone** but it is harder than it. The pores in original sandstone are filled with quartz crystals.

e. Gneiss is formed from many different rocks such as granite, sandstone and others.

Uses of rocks in everyday life

a. **Uses of igneous rocks:**
Granite and basalt are hard and are therefore used in making **building foundations** and **road surfacing**.

They are also used to make **concrete**. Concrete is a mixture of cement, sand and crushed rock.
Polished surfaces of granite have different shapes and coloured crystals that make them **attractive**. They are therefore used as **decorative stonework** on buildings.

b. **Uses of sedimentary rocks**
Limestone chippings are used for **road surfacing**

Limestone is also used to make **cement** and some **toothpastes**. Limestone also has a lot of uses in chemical industry.

Rock salt has a lot of **industrial uses**. It is also used to melt snow in temperate region. Gypsum is used in making **cement** and **plaster**.

c. **Uses of metamorphic rocks**
Slate is used for **roofs** and **sinkwells**.

Gneiss is used for **buildings** and **monuments**.

Marble is used in making **statues** and **decorative tables**.

d. **Some other economic uses of rocks in general are:**
It serves as sources of soil and plant nutrients
It serves as sources of important minerals such as gold

Summary

- Rocks are classified into 3 major groups namely: igneous, sedimentary and metamorphic rocks.
- Igneous rocks are classified as granite and basalt.
- Sedimentary rocks are classified as sandstone, shale, limestone, conglomerate and coal.
- Metamorphic rocks are classified as marble, slate, schist, quartzite, coal and gneiss.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is not a mineral found in sedimentary rock?

Select one:

- Gypsum
- Dolomite
- Calcite
- Feldspar

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following rocks is an extrusive igneous rock?

Select one:

- Sandstone
- Basalt
- Shale
- Granite

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Hardness, colour, lustre, crystal shape and cleavage are the.....used to identify minerals.

Select one:

- Rocks
- Sedimentary
- Characteristics
- Schist

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The hot liquid mass that erupts from the centre of the earth is called

Select one:

- Sediment
- Crystal
- Larva
- Precipitate

Question **5**

Not yet answered

Marked out of 20.00

Flag question

.....rock has a high tendency to be split into thin sheets?

Select one:

- Sedimentary
- Characteristics
- Rocks
- Schist

LESSON NOTE

Lesson 36

Weathering of rocks

What has weathering and erosion got in common? They are the major destructive forces that change the rocks of the Earth's crust and reshape the landscape.

By the end of the lesson, you should be able to:

- Define the term weathering.
- Explain physical weathering and list three ways in which it occurs.
- Explain the meaning of biological weathering.
- Explain chemical weathering and list three ways in which it occurs.

Weathering of rocks

Weathering is defined as the gradual process of breaking down rocks into smaller rock particles by agents such as water, changes in temperature, pressure, atmospheric oxygen, wind and root of plants. The rocks are broken without the removal of the broken pieces.

Types of weathering

There are three types of weathering namely:

- Physical weathering
- Chemical weathering
- Biological weathering

1. Physical (Mechanical) weathering)

Physical weathering is the mechanical process of breaking down rocks into small pieces without any changes in the chemical composition of the minerals that are contained in it. For example, mechanical weathering of shale involves breaking of shale into smaller pieces of shale. Similarly, large granite boulder is broken down into small granite pebbles.

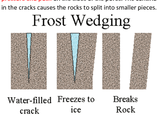
Physical weathering is caused in many ways which include: changes in temperature, effect of ice and abrasion.

a. Temperature changes

Rocks can be broken as a result of changes in temperature. During the day, the sun heats up rocks to a high temperature. The minerals in the rock expand. These minerals undergo different degree of expansion and push on each other. At night the rocks cool off causing the minerals to contract, creating spaces between them. These changes in temperature over a long period of time cause the minerals to loosen. This loosening crumbles the rocks and makes them fall apart.

b. The effect of ice (Frost action)

Rain water collects and seeps into cracks and pores of rocks. When the temperature falls below the freezing point, the water freezes and forms ice which expands. This causes the ice to exert pressure and push on the sides of the pores. The continued melting of the ice and its refreezing in the cracks causes the rocks to split into smaller pieces.



c. Abrasion

Pieces of rocks are usually carried by fast – flowing river or wind. As they move, they rub against each other, wear down and break into fragments of rocks. Example, pebbles carried by fast – flowing river rub and break down. During sandstorm, sand grains rub against rock surfaces breaking them down into smaller pieces.

Chemical weathering

Chemical weathering is the process of breaking up or decomposition of rocks into substances that have different chemical composition from the original rocks. Chemical weathering changes the minerals in the rock into new substances. This type of weathering takes place using chemical substances in the atmosphere as agents. These substances include oxygen, water and carbon dioxide. They cause chemical weathering through six processes:

i. Oxidation

Oxygen in air easily reacts with many minerals in rocks. A chemical reaction in which oxygen reacts with other substances to form their oxides is called **oxidation.** Similarly, atmospheric oxygen combines with some minerals in rocks. Many rocks contain different compounds of iron. Their oxidation produces iron rust. A rock in which iron rust has been formed falls apart easily.

ii. Hydrolysis

Some minerals in rocks react with water to form acidic solution which dissolves the rock and breaks it apart.

iii. Carbonation:

Atmospheric carbon dioxide (carbon(IV) oxide) dissolves in water to form weak carbonic acid. This weak acid dissolves some of the minerals in the rock to form new compounds called carbonates which easily breaks. For example, acid rain over limestone dissolves out the mineral calcite that constitutes the rock.

iv. Hydration

Some water molecules surround rock minerals and change it to form a new mineral by forming water of crystallization. This eventually causes the rock to crumble.

v. Solution

In this process, water on the surfaces of rocks and in cracks dissolve soluble rock minerals to form solution.

Biological weathering

It is the disintegration of rocks into smaller pieces by activities of plant roots, animals and micro – organisms. Several types of small plants can grow on rock surfaces. They force their roots into small openings causing these rocks to crumble. Trees also send their roots through cracks in rocks to cause them to split apart.

Summary

- Weathering involves breaking of rocks into smaller pieces without the removal of the broken pieces.
- Physical weathering involves mechanically breaking down rocks into small pieces with the same chemical composition as the original rock.
- Chemical weathering involves breaking up rocks into substances that have a chemical composition different from the original rocks
- Biological weathering is the disintegration of rocks into smaller pieces by activities of plant roots, animals and micro – organisms.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following factors is not responsible for mechanical weathering?

Select one:

- Changes in temperature
- Abrasion
- Activities of acid rain
- Effect of ice

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following substances does not cause chemical weathering?

Select one:

- Carbon dioxide
- Water
- Oxygen
- Nitrogen

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which is TRUE about igneous rocks?

Select one:

- formed from cooled magma
- slow cooling of lava makes small crystal grains
- soft and readily weathered
- fast cooling of lava makes big crystal grains

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The disintegration of rocks into smaller pieces by the activities of plant roots and animals is known as

Select one:

- Physical weathering
- Chemical weathering
- Biological weathering
- Mechanical weathering

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following factors is not responsible for physical weathering of rocks?

Select one:

- Effects of abrasion
- Effect of ice
- Changes in temperature
- Oxidation

LESSON NOTE

Lesson 37

Cell (Cell Organelles), Plant, Animal and Specialized Cells

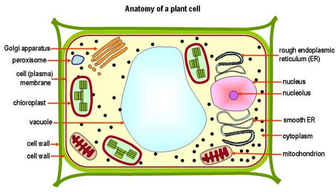
In our previous lesson, we looked at what a cell is, the types of cells and the structures (organelles) found in the cell. Today, we shall continue with the organelles and look at both plant and animal (generalized) cells and specialized cells. Before we begin, let us look at the Objectives of this lesson.

By the end of this session you should be able to

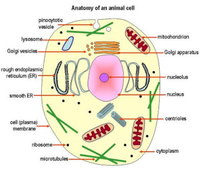
- Describe the structure and functions of Ribosome
- Identify the plant and animal cells
- State the differences and similarities between plants and animal cells
- Recognize some specialized animal cells

Plant and animal cells

Anatomy of a plant cell



Anatomy of an animal cell



Plant and animal cells are similar in the ways listed below.

Both plant and animal cells:

- **Have a cell membrane around the cell**
- **Have a jelly-like substance called cytoplasm**
- **Have a nucleus**
- **Have mitochondria and ribosomes**

There are also differences between plant and animal cells.

These are summarized in the table below:

Plant cells	Animal cells
Have cell wall which contain cellulose	Cell wall is absent
Mature cells have large vacuole which are permanent	Vacuoles, if present, are small and temporary or absent
Thin lining of cytoplasm against wall	Cytoplasm throughout the cell
Chloroplast is present	Chloroplast is absent
Have definite shape	Have no definite shape
Store carbohydrate as starch	Store carbohydrate as glycogen
Have no centrioles	Have centrioles in the cytoplasm

Specialized cells

Most organisms have bodies which are made up of many cells (multicellular organisms).

The cells within their bodies are not the same.

For example, cells in the heart are different from that of the skin.

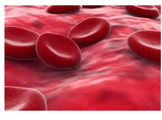
They differ in shape, size, function etc. because they are found in different parts of the organism.

The differences come as a result of the fact that during development, some cells specialize to carry out one particular function.

These specialized cells do not live in isolation but rather interact together to form tissues and organs. However a few organisms show no specialization and consist of repeated identical cells, e.g. Volvox, a colonial aglae.

Now let us look at some specialized cells in both animal and plant cells.

First the animal cells:



Red blood cells

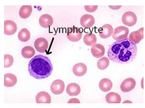
They are biconcave disc-shaped (circular with depressions on either side).

They have an elastic membrane that makes it flexible.

At maturity, they lack nucleus in the cytoplasm.
They are occupied by the red pigment called haemoglobin (an iron-carrying molecule).

During respiration, haemoglobin combines with oxygen to form oxyhaemoglobin which is used for transport. The flexibility of the cell membrane enables it to squeeze through capillary pores and tissues. The function of red blood cells is to transport oxygen from the lungs to the tissues for tissue respiration

Lymphocyte



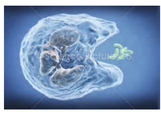
Lymphocytes are rounded and possess only a small quantity of cytoplasm. They have a nucleus at maturity and amoeboid in shape.

This allows them to squeeze through pores in capillary walls.

They are produced in the lymph, nodes and bone marrow.

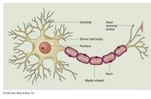
They are responsible for the production of antibodies

Phagocyte



Phagocytes are white blood cells with an indented nucleus. Their cytoplasm does not contain granules. They are produced in the bone marrow.They are called phagocytes because they engulf foreign substances and other cells such as bacteria by producing enzymes to digest the foreign materials

Nerve cell

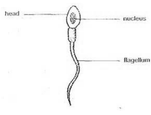


A nerve cell has a cell body, an elongated body called axon and short projections called dendrons.

The Dendrons branch to form many fine structures called dendrites.

These dendrites are placed in series for the transmission of nerve impulses from sense organs (skin) to the central nervous system and from the central nervous system to the muscles and glands.

Mammalian Sperm



The mammalian sperm is made up of the head, middle piece and the tail.

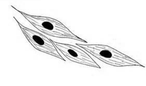
The head contains a large nucleus with acrosome at the tip.

The acrosome contains an enzyme which digest the wall of the female egg/gamete for fertilization to take place.

The middle piece contains numerous mitochondria for energy production in the form of ATP.

The energy is used to bring about the beating movement of the flagellum which is the tail.

Muscle cells



Muscle cells are elongated, flexible fibres and capable of appreciable contraction.

Their ability to contract and relax account for the overall skeletal movement in organisms

Summary

We looked at cells (plant and animal), organelles and specialized cells. We identified the similarities and differences between plants and animal cells. We looked at some specialized cells such as red blood cells, lymphocytes and phagocytes.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Who discovered the cells of living organisms?

Select one:

- Robert Hooke
- Louis Pasteur
- Robert Koch
- Antonie van Leeuwenhoek

Question **2**

Not yet answered

Marked out of 20.00

Flag question

A partially permeable membrane can best be described as one through which,

Select one:

- Only water can pass through
- No substance can pass through
- Only certain substances can pass through
- Any substance can pass through

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Organisms with nuclear material diffused in the cytoplasm belong to the kingdom

Select one:

- Prokaryotae
- Plantae
- Animalia
- Protoctista

Question **4**

Not yet answered

Marked out of 20.00

Flag question

A virus is basically composed of

Select one:

- Protein, DNA and RNA
- Protein, DNA and nucleic acid
- Protein, RNA and nucleic acid
- Protein and either DNA or RNA

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following statements about viruses is not true?

Select one:

- Able to form crystal
- Akaryotic
- Non cellular
- Prokaryotic

LESSON NOTE

LESSON 38

VIRUSES AND CELLS

In an earlier lesson, we looked at schemes of classification and taxonomy. We also considered the hierarchy of taxonomy: Kingdom, Phylum, Class, Order, Family, Genus and species. Finally, we concluded by looking at Linnaean system of classification. Today, you shall be looking at viruses and cells.

Let us look at the objectives for this session

By the end of this session, you should be able to;

- **Describe viruses.**
- **Explain why viruses do not fall into the schemes of classification**
- **Define cells and state the types of cells**

Have you had common cold of flu before?

What do you think causes it? Good! Virus!

Have you seen a virus before? I believe the answer is NO.

Why haven't you seen one before? Because they are minute or microscopic and can only be seen with an electron microscope. In fact, they are smaller than bacteria.

What then is a **Virus**?

It is a minute infectious particle consisting of a core nucleic acid (either DNA or RNA) enclosed in a protein shell called capsid.

They differ from all other forms of life in that they are not cells- they are **acellular.**

If something is described as **acellular** then it means it does not have a nucleus, cytoplasm or a cell membrane.

Another distinction between viruses and other living things is that viruses do not undergo any of the life processes (i.e. growth, nutrition, reproduction, excretion, etc.) on their own.

However, they are able to reproduce only if they invade a living cell to use the cell's system to replicate themselves. In the process, they may disrupt or change the host cell's DNA.

They use the cells they invade to make more virus particles that are then released.

Viruses are of different shapes, e.g. rods like, spiral, hexagonal and spherical.

Known diseases caused by viruses are yellow fever, measles, common cold/flu, HIV, etc. in people.

In plants we can talk about cassava mosaic and foot and mouth diseases in cattle.

Now let us look at features that classify viruses as

Living things and

Non-living things

Viruses are described as living things because they

Contain DNA or nucleic acids

Multiply or reproduce when they are in a living host cells

Viruses are described as non-living things because

1. They cannot grow
2. They lack nucleus
3. They cannot reproduce on their own
4. They cannot move
5. They can crystallize
6. They do not excrete
7. They do not respire

I believe you have a police station in your community.

At the police station, what is the name of the place where they keep suspects or criminals?.....Good! Police Cell.

Today you will be learning about cells in living things (plants and animals) and not the cell at the police station.

I believe the word "cell" is widely used in our daily lives. For example, we talk about electric or dry cells (for our torchlights, wall clocks), crystal cells, prison cell etc.

In the usage of the word "cell" one thing comes into mind: a small independent unit functioning on its own.

Now let us have a little **background** on living cells.

Cells were discovered in 1665 by the English scientist and inventor Robert Hooke.

He had designed his own compound light microscope, initially, to observe structures too small to be seen with the naked eyes.

Among the first structures to be examined was a thin piece of cork (the outer surface of bark of a tree). Hooke described the cork as being made of hundreds of little boxes, giving it the appearance of a honey comb.

He then called these little boxes as cells.

It soon became clear that virtually all living things are made of cells, and that these cells have certain features in common.

In 1858, Rudolph Virchow proposed that the cell was the basis metabolic as well as a structural unit of living organisms.

So, in summary, what can we refer to as a **Cell**?

A cell is the basic structural and functional unit of a living organism in which chemical reactions take place.

These reactions involve energy release needed to support life and to build structures.

This is to say, each cell is capable of carrying out all the life processes.

Some living things consist of only a single cell.

For example, Amoeba and paramecium are composed of one cell.

These organisms are called *unicellular organisms.*

On the other hand, some organisms are made of millions of cells and are referred to as *multicellular organisms.*

For example, fungi (mushrooms), plants and animals.

Types of Cells

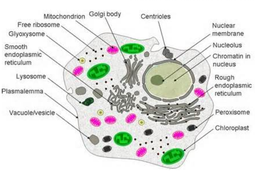
There are three types of cells according to their structure. They are:

Akaryotic – having no nucleus, no cytoplasm, e.g. virus

Prokaryotic – having no defined nucleus or cytoplasm e.g. bacteria

Eukaryotic – having well defined nucleus, with cytoplasm e.g. fungi, protoctists, plants and animals

Structure and functions of the cells



All living cells are made of cytoplasm together with some genetic materials which are usually contained within a nucleus.

The whole cell is surrounded by a surface membrane which keeps the cell together.

The cytoplasm has within it a number of very small/microscopic structures called *organelles.*

An *organelle* is a *minute* membrane-bound structure within the cytoplasm that perform specific functions in eukaryotic cells.

The organelles include the **Nucleus, Endoplasmic Reticulum, Mitochondrion, Golgi apparatus, Lysosomes, Vacuoles, Chloroplasts, Ribosomes, And Cytoplasm**.

We begin with the **Cell Membrane.**

The cell surface membrane is a thin flexible structure that surrounds the cells.

It is made up of proteins and fats and controls the movement of materials into and out of the cells.

The membrane is selective in that it only lets certain particles pass through it.

For this reason it is said to be **partially or selectively permeable.**

A partially permeable membrane is one through which certain substances can pass through and others cannot, depending on the size and nature of the molecules of which the substances are made.

Function

It serves as a barrier between the cell and its surroundings

It controls the movement of materials in and out of cells by way of its partially permeable nature.

Summary

We looked at viruses that they are infectious particles which are minute, having either DNA or RNA.

We said they are enclosed in a shell called capsid. We identified some diseases caused by viruses in animals and plants.

We then shifted our attention to cells. We identified how the word 'cell' came about and what it is in living organisms.

The types and structures were also looked at. We shall continue with the rest of the structures in the cell in our next meeting.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

In which cell would you expect to find the most lysosomes?

Select one:

- Pancreatic cell that manufacture digestive enzymes
- White blood cell that engulfs bacteria
- Ovarian cell that produces estrogen (steroid hormone)
- Muscle cell in the thigh muscle of a long-distance runner

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following organelles is associated with protein synthesis?

Select one:

- Ribosome
- Mitochondrion
- Golgi body
- Lysosome

Question **3**

Not yet answered

Marked out of 20.00

Flag question

The pores in the nuclear envelope provide for the movement of

Select one:

- Proteins into the nucleus
- ribosomal components out of the nucleus
- all of the above
- mRNA out of the nucleus

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Chromosomes are found in the

Select one:

- Nucleus
- Cytoplasm
- Ribosomes
- Gene

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following structures do all cells possess?

Select one:

- Cell wall
- Large vacuole
- Centrioles
- Nucleus

LESSON NOTE

LESSON 39

Cell Structures/Organelles.

By the end of today's session, you should be able to

Describe the structure and functions of the following organelles:

1. Cell wall
2. Cytoplasm
3. Nucleus
4. Endoplasmic reticulum
5. Golgi apparatus
6. Mitochondrion
7. Lysosome
8. Vacuole
9. Chloroplast and
10. centriole

Cell wall

This is a structure that surrounds the cell membrane.

The cell wall is found in bacteria, fungi and plants.

In bacteria, the cell wall is made up of proteins and fats.

The cell wall of fungi is made up of chitin and cellulose which is found in cells of higher plants.

Cellulose has very large molecules which form fibres.

These fibres make the walls strong and supportive, but at the same time porous.

The porous nature of the wall makes it permeable to water and dissolved particles, allowing them to pass through relatively easily.

Some plant cells have a cytoplasmic link which crosses the wall.

These links of cytoplasm are known as *plasmodesmata*.

Function

- It protect and support the cell to resist bursting during turgidity
- It provides shape to the cell especially plant cells
- It is easily permeable to gases, water and other substances.

Cytoplasm

The cytoplasm is a transparent watery fluid which is about 90% water, within which can be found various organelles.

Many ions are dissolved in it and it is the site of many chemical reactions.

- It houses the organelles
- It is the site for many chemical reactions.
- It is the site for building up materials such as proteins and carbohydrate.
- It is the site where energy is supplied for cell activities.
- It is the site where food materials such as glycogen in animals and starch in plants are stored

Nucleus

The nucleus is spherical/ovoid in shape and the largest cell organelle.

It is enclosed by a double membrane, called **nuclear envelope**.

The nuclear membrane is perforated by nuclear pores which control the exchange of materials between the nucleus and the cytoplasm.

The nucleus contains chromatin materials that form chromosome when the cell is about to divide.

Chromatin contains DNA, the molecule of inheritance which controls the activity of the cell.

The nucleus also contains one or more nucleoli which manufacture ribosomes.

The nucleus and the cytoplasm constitute the protoplasm of the cell.

The only cell without a nucleus is the red blood cell.

Function

- It controls the life activities of the cell
- Contains hereditary materials (DNA) which are passed on from parent to offspring.
- Contains nucleolus which synthesizes RNA for protein synthesis
- It initiates cell division during life processes like growth and reproduction

Endoplasmic reticulum

It is a network of minute sheets and tubes bounded by a membrane.

It is found throughout the cytoplasm and connects to the nucleus and cell membrane.

There are two types of endoplasmic reticulum – rough endoplasmic reticulum and smooth endoplasmic reticulum.

Rough endoplasmic reticulum has ribosomes on its outer surface and that gives them a rough appearance.

However the smooth endoplasmic reticulum does not have ribosomes on its outer surface.

The endoplasmic reticulum divides the internal part of the cell into compartments so that chemical reactions occurring in the cell do not interfere with one another.

Function

- The rough endoplasmic reticulum synthesize and transport proteins
- The rough endoplasmic reticulum serves as a platform that supports the ribosomes
- The smooth endoplasmic reticulum synthesize and transport lipids
- The endoplasmic reticulum provides the surface for chemical reactions

Golgi apparatus/bodies

Golgi apparatus consists of a stack of flattened membranous sacs.

This organelle (which is named after the biologist who first reported it) is present in all cells.

However, it is prominent in cells that are metabolically active.

The stacks of flattened membranous sacs have clusters of vesicles at their edges.

The vesicles are small bodies in the cell containing secretory material.

The golgi apparatus is numerous in secreting cells such as cells of salivary glands and the pancreas

Functions

- it is responsible for the production and repair of the cell membrane
- it synthesizes complex carbohydrates
- it is involved in the packaging and secretion of proteins and complex carbohydrates

Mitochondrion

It is a sausage-shaped structure bounded by a double membrane.

The number of mitochondria in a cell depends on the energy requirements of the cell or where the cell is found in the organism.

This is because mitochondrion is responsible for the synthesis of energy in the form of ATP (Adenosine Triphosphate).

For example, mitochondria are numerous in muscle cells, the middle piece of the sperm cells, cells at the bases of wings of insects and at the bases of quill feathers on the wings of birds.

All these structures require much energy for their activities.

Mitochondria contain enzymes which take part in the respiration process.

It is therefore referred to as the "power house" of the cell.

Function

- It is the site for energy production in the form of ATP (adenosine Triphosphate)

Lysosomes

Lysosomes originate either from golgi apparatus or directly from the endoplasmic reticulum.

They are bounded by a single membrane, and contain concentrated mixture of hydrolytic digestive enzymes.

If these digestive enzymes were not kept enclosed in a sac they would attack the other cell organelles. They are numerous in animal cells than in plant cells.

The enzymes they contain are used in the dissolution and digestion of redundant structures or damaged organelles from within or outside the cell.

For example, when a cell dies its own lysosomes release enzymes that digest the remains of the cell. This process is known as **autolysis.**

Functions

- **It** destroys itself when it is worn-out and therefore referred to as "suicide bag" of the cell.
- It destroys redundant structures or organelles within the cell.

Vacuoles

Vacuoles are fluid-filled cavities bounded by a single membrane called **tonoplast**.

It occupies over 80% of the cell volume.

The plant vacuole is filled with a liquid known as **cell sap**, an aqueous solution of dissolved food materials, ions, waste products and pigments.

The vacuoles of animal cells are usually very much smaller and less permanent.

Small vacuoles are often called vesicles.

They may contain engulfed solids or liquids such as **food vacuole** or **contractile vacuole** in Amoeba.

Function

- Provide support for herbaceous plants when they are turgid.
- Store food in plant cells
- Provide water balance (osmoregulation) in animal cells e.g. amoeba.

Chloroplast

A large disc-shaped organelle bounded by a double membrane.

They are found only in the green parts in plants.

They contain the green pigment, chlorophyll, which absorbs light energy from sunlight for photosynthesis.

Function

- It is the site for photosynthesis due to the presence of chlorophyll

Ribosomes

Ribosomes are minute structures which are composed of RNA and protein in roughly equal numbers. Some are free in the cytoplasm, while others are bound to the outer surface of the rough endoplasmic reticulum.

Function

They are the site of protein synthesis

Centrioles

Centrioles are two hollow cylindrical bodies, lying at right angles to each other besides the nucleus.

They occur in animal cells and not in plant cells.

They separate and move to opposite poles at early stages of cell division.

It is also believed to be responsible for the formation of spindle fibres.

Summary

We looked at the various cell organelles in both plants and animal cells and their functions.

Hope you have enjoyed today's lesson.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following specialized cells lacks nucleus?

Select one:

- Nerve cell
- Sperm cell
- Red blood cell
- Epidermal cell

Question **2**

Not yet answered

Marked out of 20.00

Flag question

The following specialized cells have nucleus except,

Select one:

- Sperm cell
- Muscle cell
- Red blood cell
- White blood cell

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following specialized cells is responsible for the responses of both external and internal stimuli?

Select one:

- Muscle cell
- Nerve cell
- Sperm cell
- Red blood cell

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following structures in a plant cell is concerned with the manufacture of organic food?

Select one:

- Chloroplast
- Chromosome
- Ribosome
- Vacuole

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following specialized cells contain haemoglobin?

Select one:

- Neutrophil
- Epithelial cell
- Palisade cell

LESSON NOTE

Lesson 40

REPRODUCTION AND GROWTH IN FLOWERING PLANTS

Reproduction occurs in all living organisms. It is the process by which living things produce new individuals of their own kind. This is to enable them continue to exist.

There are two types of reproduction: **sexual** and **asexual.**

Sexual reproduction involves **fertilization**- a process in which the nuclei of male and female gametes or sex cells fuse to form a **zygote**. The zygote develops into a new individual of the same kind.

In Asexual reproduction there is no fusion of male and female gametes. A common example of asexual reproduction found in some plants is vegetative reproduction. It involves the development of a new plant from a vegetative part (root, stem and leaves) of a plant. In cultivating cassava for example, a piece of stem is cut. This piece of stem then develops into a new plant. The new plant is **genetically** identical to the plant from which the vegetative structure was taken.

Today we shall be looking at the structure of the flower. But before that, let us look at the objectives of the lesson.

By the end of today's session we should be able to

- Identify parts of a flower and variation in flower structure
- State the functions of the parts of the flower
- Explain some terminologies associated with flowers

Structure of the flower

Flowers are the main reproductive organs of flowering plants. A flower consists of a cluster of modified leaves which are borne on a shortened stem, the flower stalk or **pedicel**. A flower without a flower stalk is referred to as **sessile**. Flowers bear the sex organs that produce male and female gametes. A flower develops from a flower bud. Depending on the location of the flower on the plant, it may be described as **axillary flower** when it is found in the axil of a leaf, or **terminal flower** when it is located at the tip or apex of the stem or **cauline** when it is directly borne on the stem as in **cocoa**. Flowers may be solitary (single) as in **hibiscus** or in clusters (groups). A collection of flowers borne on a single stalk, the **peduncle,** is referred to as **inflorescence** as in *sunflower*

A flower is made up of four floral parts. These floral parts are usually arranged in concentric rings, one above the other, on the swollen tip of the pedicel called **receptacle** or **thalamus.** The floral parts are arranged in four different whorls on the receptacle. The floral parts are the **calyx, corolla, androecium and gynoecium.**

Calyx

The calyx is the outermost whorl of floral parts on the receptacle. It consists of sepals which are usually green in colour and serve to protect the inner parts of the flower during the bud stage. They may remain completely free from one another (e.g. *morning glory).* The free state of the sepals is called **polysepalous**. The sepals may be fused together to form a cup-like structure as in *Crotalaria*. When the sepals are fused it is referred to as **gamosepalous.**

The sepals of some flowers, instead of being small and green, are large, brightly coloured and attractive. An examples of a plant with such flowers is *Caesalpinia* in which the sepal colours are orange and white. In such flowers the sepals are said to be **petaloid**.

Corolla

The corolla is usually the most conspicuous part of the flower and includes all the petals. It serves, in most cases, to attract insects to the flower for pollination. It also protects the stamens and the carpels, especially when the petals are united as in *morning glory*.

Petals are usually conspicuous because of their large size, brightly coloured (e.g. *flamboyant*) and scented. Petals may be free from one another as in *Hibiscus*. Such petals are described as **polypetalous**. When the petals are fused, they are said to be **gamopetalous** (e.g. *Allamanda*). A group of glandular cells situated at the base of the corolla forms the **nectary**. These cells produce a sugary solution called **nectar.**

In some flowers the sepals and petals look alike such that both cannot be distinguished from one another. In such a situation it is described as **perianth** (e.g. *Gloriosa*).

Androecium

This is the whorl immediately inside the corolla. It is a collection of stamens-the male sex organs. Each stamen is made up of a long stalk known as the **filament** and a bean-shaped or elongated yellow body known as **anthe**r attached to it. The anther is a four-lobed structure which produces **pollen grains which are yellowish and powdery.** The filament is a structure which supports the anther for effective dispersal of pollen grains. Stamens may be either free or fused in various ways.

Gynaecium

The gynoecium is the innermost whorl and constitutes the female reproductive organs of a flower. A gynoecium or pistil consists of **carpels**. Each carpel consist of an **ovary, a style and a stigma**. The ovary is the enlarged base of the carpel. It contains one or more ovules. When the ovary is completely embedded in a fleshy receptacle such that the other floral parts (namely, calyx, corolla, and stamens) arise from a position higher than it, it is described as inferior ovary and the flower is referred to as **epigynous** (e.g. guava). The tissues of receptacle may offer protection for the ovary against mechanical injury. When the ovary is above the receptacle and other floral parts, it is described as superior ovary and the flower is referred to as **hypogynous** (e.g. Hibiscus). Each ovule, in the ovary, is attached to the inner wall of the ovary at a point called the **placenta.**

The **style** is a long stalk that connects the stigma to the ovary. The **stigma** is a sticky, hairy or feathery apex of the style that receives pollen grains during pollination. A pistil with only one carpel is described as **monocarpous** (e.g. flamboyant), while one with two or more carpels is known as **polycarpous** (e.g. Hibiscus). When the carpels are free from one another, the pistil is said to be **apocarpous** (e.g. rose). However when the carpels are fused together it is known as **syncarpous** (e.g. Hibiscus).

A flower is described as **radially symmetrical** (actinomorphic) when two mirror halves can be obtained by cutting a longitudinal section through many vertical planes. In such a flower the floral leaves in each whorl are similar in shape and size (e.g. *hibiscus*). **A bilaterally symmetrical** (zygomorphic) flower is one when cut through, two mirror halves can be obtained by cutting the flower longitudinally through only one particular vertical plane (e.g. *flamboyant*).

Now let us look at some terminologies used to describe flowers

Terms used in describing flowers

Unisexual flower: a flower type that has either stamens or carpels as its sexual part. A flower that has only carpels is a female flower and such a flower is described as pistillate, e.g. maize and pawpaw. On the other hand, any flower that has only stamens is a male flower hence it is described as staminate, e.g. pawpaw and maize

Bisexual flower: A flower type, also called hermaphrodite, which has both the carpels (female) and stamens (male) on it. Example is pride of Barbados or Hibiscus.

Perfect flower: A flower that has both carpels and stamens in it, e.g. pride of Barbados

Imperfect flower: A flower in which either carpel or stamens are naturally missing, e.g. maize

Complete flower: A complete flower is the type that has naturally all the four floral parts namely, calyx, corolla, androecium and gynoecium. Example, Hibiscus, pride of Barbados.

Incomplete flower: An incomplete flower is the type which lacks one or more of the floral parts, e.g. maize and pawpaw flowers

Regular flower: A flower is regular if it has all members of a whorl on it, i.e., petals identical in shape and size, and are evenly arranged on the receptacle. Such a flower can be cut vertically into two similar halves through any one of several vertical places (radial symmetry) and is described as **actinomorphic flower**, e.g. Hibiscus

Irregular flower: An irregular flower is one in which the members of a whorl, e.g. petals, are not similar either because some parts are fused, some are smaller than others or because one or more parts are missing. The flower can be cut vertically into two similar halves through only one plane (bilateral symmetry) and is described as zygomorphic flower, e.g. pride of Barbados and Delonix.

Essential parts of a flower: The stamens and carpels are regarded as the essential parts of the flower because they produce the gametes required for fertilization to take place resulting in the formation of seeds or fruits

Non-essential of a flower. The petals and the sepals are regarded as the non-essential parts of a flower because they are not required for gamete production in flowers

SUMMARY

The flower is the structure/organ for sexual reproduction in a flowering plant.

A complete flower has four (4) floral parts that is Calyx, Corolla, Androecium and Gynaecium.

Each of the floral parts performs specific functions.

Flowers are described as unisexual, bisexual, perfect, complete, regular flower etc.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

The ovary, stigma and style are known as the

Select one:

- Pistil
- Fruit
- Stamen
- Reproductive organ

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following parts of a flower forms the innermost whorl?

Select one:

- Androecium
- Gynaecium
- Corolla
- Calyx

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Nitrogen from the atmosphere gets into the soil by the action of

Select one:

- Rain
- Burning
- Microbes
- Fungi

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Stamen
- Pollen grain
- Sepal
- Pistil

Question **5**

Not yet answered

Marked out of 20.00

Flag question

An inferior ovary of a flower is situated

Select one:

- Below the floral parts
- At the centre of the floral parts
- Above the floral parts
- At the same level with all the floral parts

LESSON NOTE

LESSON 41

SOME TERMS USED IN DESCRIBING FLOWERS AND POLLINATION

In our previous lesson we looked at the structure of a flower.

We said a flower is the reproductive organ of a flowering plant.

We identified the various floral parts of the flower and their functions.

We also looked at some terms associated with flowers.

Today we shall continue with the terms used in describing flowers, pollination and the various types of pollination.

But before that, let us look at the objectives for this lesson.

By the end of this session, you should be able to

- **Explain the term pollination**
- **Explain the types of pollination**
- **Identify the characteristics of wind and insect-pollinated flowers**
- **Recognize the adaptations for either self or cross-pollination**

Some terms used in flowering plants to describe flower:

- **Monoecious plant**: a plant with both the male and female flowers borne on the same plant such that the flowers are at different positions on the plant, e.g. maize, oil palm etc.
- **Dioecious plant**: a plant in which the female and male flowers occur on separate plants, e.g. pawpaw

Pollination

Pollination is the transfer of matured pollen grains from the anther to the stigma of the same flower or, the stigma of another flower on the same plant or another of flower on a different plant of the same species.

Transfer of pollen grains is carried out or aided by a pollinating agent such as birds, water, insects and wind.

Pollination is important because it ensures that the male sex cell in the pollen grain reaches the female sex cell in the ovary leading to fertilization

Types of Pollination

There are two types of pollination. These are **self-pollination and cross-pollination**.

Self-pollination

Self-pollination is the transfer of matured pollen grains from the anther of a flower to the stigma of the same flower or to another flower on the same plant, e.g. pea, cotton, tomato etc.

For self-pollination, only one parent plant is involved.

Cross-pollination

Cross-pollination is the transfer of matured pollen grains from the anther of a flower to the stigma of another flower on a different plant of the same or closely related species, e.g. morning glory, Hibiscus, pride of Barbados. For cross-pollination to occur, two parent plants are involved.

Self-pollination	Cross-pollination
1. It takes place only in bisexual plant 2. Only one parent plant is involved 3. Pollination may occur without an external agent 4. It does not ensure new varieties 5. Pollen grains are effectively utilized	1. It takes place in both unisexual and bisexual plants 2. Two parent plants are involved 3. This requires external agents, e.g. insects and winds 4. It results in the formation of new varieties 5. Much of the pollen grains are wasted

Now let us look at the various adaptations of flowers/plants that make self-pollination and cross-pollination possible. We begin with self-pollination

Adaptation of flowers that undergo self-pollination

- The flower must be **bisexual** (hermaphrodite), e.g. wild marigold
- The flower must be **homogamous**, i.e. the anther and the stigma mature at the same time, e.g. tomato
- The flower must be **cleistogamous,** i.e. the flower does not open until self-pollination has taken place.
- The flowers are concealed in the ground, e.g. some species of Commelina

Adaptation of flowers that undergo cross-pollination

- The plants must be **monoecious**, i.e. separate male and female flowers occur on the same plant, e.g. maize and coconut
- The plant must be **dioecious**, i.e. male and female flowers occur on separate plants, e.g. pawpaw
- The flower must be **protandrous**, i.e. when the androecium matures first before the stigma, e.g. cowpea
- The flower must be **protogynous,** i.e. when the stigma matures first before the androecium, e.g. tridax and sunflower

Flower must exhibit **self-sterility**, i.e. the pollen grains cannot germinate on the stigma of the same flower and even if germination takes place, fertilization cannot occur, e.g. passion flower

Flower must show **heterostyly**, i.e. male and female parts are of different length in flowers of the same species, i.e. long style and short stamen and vice versa. This is to prevent pollen grains reaching the stigma of the same flower

The flower must be **unisexua**l, i.e. only the male or female part is present in each flower

Adaptation of flowers for pollination

Flowers are adapted in specific ways for the various agents of pollination. The two major agents of pollination are wind and insects. Other agents include birds, snails, water and other animals. Insect-pollinated flowers are described as **entomophilous** flowers (e.g. Hibiscus, Crotalaria, Pride of Barbados, Delonix etc.) and wind-pollinated flowers are referred to **anemophilous** flowers (e.g. maize, guinea grass, rice, millet, wheat etc.)

Now let us look at the characteristics of insects and wind-pollinated flowers. We begin with insect-pollinated flowers.

Characteristics of insect-pollinated flowers

- They have large, conspicuous petals or sepals
- Flowers are usually brightly coloured
- They possess scent
- Nectar is also present
- Pollen grains are rough, sticky and relatively few
- The stigma is flat with a sticky surface to enable it receive pollen grains

Characteristics of wind-pollinated flowers

- They have small, inconspicuous petals or sepals
- Flowers are usually dull coloured
- There is absence of scent
- There is absence of nectar
- Large quantity of pollen grains are produced
- Pollen grains are small, smooth, light and not sticky.
- Stigma is elongated and sticky with large surface area
- Anthers are attached to the flower in such a way that they readily swing in the air and release the pollen grains.

SUMMARY

1. We looked at the definition of pollination and the two types of pollination
2. We looked at the fact that different flowers are adapted for either self or cross-pollination
3. We also learnt that pollination is carried out by some agents such as wind, insects, bird, water etc
4. Lastly, we also looked at the differences between insect-pollinated flower and wind-pollinated flower.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

A flower with both stamens and carpels is said to be

Select one:

- Irregular
- Monecious
- Dioecious
- A hermaphrodite

Question **2**

Not yet answered

Marked out of 20.00

Flag question

A pistillate flower is best described as a flower

Select one:

- With the petals arranged in whorls
- With the sepals coloured like petal
- In which all the floral parts are present
- In which the male part in absent

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following conditions in flowering plants enhances self pollination?

Select one:

- herkogamy
- Cleistogamy
- Heterostyly
- Protandry

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Dioecious
- Cleistogamous
- Monoecious
- Herkogamous

Question **5**

Not yet answered

Marked out of 20.00

Flag question

A complete flower is one that have

Select one:

- The floral parts are fused in each whorl
- All the whorls well developed
- Only the vegetative parts present
- Both androecium and gynaecium present

LESSON NOTE

Lesson 42

Fertilization, seeds and fruits development

In our previous lesson, we looked at pollination by defining it and the types of pollination.

We considered also plants/flowers adapted for self and cross pollination.

Today, we shall be looking at fertilization, seeds and fruits formation.

But before that let us look at the Objectives.

By the end of this session you should be able to,

1. Define fertilization and describe fertilization in flowering plants
2. Describe

- Seed development
- Fruit development

Fertilization

Sexual reproduction is the production of offspring by the fusion of two gametes to form a diploid zygote which develops into the mature organism.

The act of fusion is called fertilization.

Therefore, **fertilization** is the fusion of the nuclei of the male and female gametes to form a diploid zygote.

The fusion of the nuclei of the gametes brings together two sets of chromosomes, one set from each parent.

The presence of two sets of chromosomes is referred to as the diploid condition.

Pollination precedes fertilization.

It occurs in the ovule, which contains a female gamete called the ovum or egg cell.

When a matured pollen grain lands on a matured stigma it absorbs nutrient (sucrose solution) secreted by the epidermal cells of the stigma and swells.

The nucleus of the pollen grain divides into two nuclei of unequal size.

The larger one is known as a generative nucleus and the smaller one, pollen tube nucleus.

A pollen tube emerges from one of the pores in the wall of the pollen grain and grows down the style.

The growth of the pollen tube is controlled by the pollen tube nucleus of the pollen grain, which is found at the growing tip of the tube followed by the generative nucleus.

The tube then grows through the tissues of the style towards the **ovary**.

As the pollen tube gets closer to the ovary, the generative nucleus divides into two male nuclei.

The ovary contains one or more **ovules**.

The main body of the ovule is called the nucellus and is enclosed and protected by two sheaths or integuments.

A small pore is left in the integument at one of the ovule called the **micropyle.**

The end of the ovule opposite the micropyle is called the chalaza.

The embryo sac contains one ovum or egg surrounded by two cells called synergids, all of which are situated near the micropyle.

There are also three cells at the chalazal end called antipodal cells in the embryo sac. At the centre of the embryo sac are two nuclei called polar nuclei.

The synergids and the antipodal cells have no useful function and degenerate after fertilization.

The pollen tube enters the ovary and grows towards the ovule.

The pollen tube enters the ovule through the micropyle, the tube nucleus degenerates and the tip of the tube bursts, releasing the male nuclei near the embryo sac, which they enter.

One of the male nucleus fuses with the female egg or ovum to form a diploid zygote.

The other male nucleus fuses with the polar nucleus to form a triploid nucleus known as the primary endosperm nucleus.

This is called double fertilization which is unique to flowering plants.

It leads eventually to two structures found in the seed, namely the embryo and the endosperm.

Immediately after fertilization, the ovule becomes known as the seed and the ovary, the fruit.

The other floral parts wither: that is the sepals, petals, stamens, stigma and style, leaving only the ovary behind.

Seed Formation

Immediately after fertilization, the triploid primary endosperm cell divides to form a mass of food tissue called the **endosperm**.

The endosperm stores food.

The zygote grows by division to become a multicellular embryo which consist of an embryonic shoot, the **plumule**, an embryonic root, the **radicle**, and either one or two seed-leaves called **cotyledons**.

The number of cotyledons forms the basis for the two major divisions of the angiosperms: the dicotyledons and the monocotyledons.

In dicotyledonous plants, most of the food is usually transferred from the endosperm to both cotyledons before the seed is mature.

They are referred to as **non-endospermous seeds**.

In contrast, seeds of monocotyledonous plants are endospermic.

That is the bulk of the seed is made of the endosperm which stores food.

As these changes occur within the seed. The integuments of the ovule develop into a protective coat called **testa** or seed coat.

The seed coat protects the seeds from bacteria, fungi and insects.

The testa has a thin membranous **tegmen** within it.

Only the micropyle perforates this seed coat.

During the final stages of seed formation, the water content of the seed falls from about 85% to 90% of fresh weight and the seed becomes dormant.

The seed is attached to the pod by a stalk called **funicle**.

A scar, known as the **hilum**, marks the point of attachment of the seed to the funicle.

Fruit Formation

The result of pollination and fertilization in flowers is the formation of fruits and seeds.

A **fruit** is usually described as a fertilized ovary containing seeds.

However, in some plants such as banana and pineapple, fertilization is not necessary for fruit formation.

Fruits which develop without fertilization are known as **parthenocarpic fruits** and they are often seedless.

During fruit formation, the wall of the ovary becomes the **pericarp**, or fruit wall.

The pericarp is usually made up of three layer, an outer **epicarp**, a middle **mesocarp** and an inner **endocarp**.

When a fruit has developed solely from the ovary, it is known as a **true fruit** (e.g. beans).

If it develops not only from the ovary but also from other parts such as the sepals, petals and the receptacle it is called **false fruit** (e.g. apple, cashew nut etc.). Fruits developing from whole inflorescence (e.g. pineapple, fig, etc.) are also regarded as *false fruits.*

Importance of fruits

1. Fruits protect the seeds and aid their dispersal
2. They contain nutrients for immediate germination of the embryo

Differences between a fruit and a seed

Fruit	Seed
It is a fertilized ovary containing seeds	It is a fertilized ovule
It has two scars	It has only one scar

SUMMARY

1. Fertilisation is the fusion of the nuclei of the male and female gametes to form a zygote.
2. A zygote develops into an embryo.
3. The ovule develops to become the seed whiles ovary becomes the fruits.
4. Fruits are classified into true fruits and false fruits depending on the part of the flower involved in their formation.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Egg cell
- Cotyledon
- Plumule
- Pollen grain

Question **2**

Not yet answered

Marked out of 20.00

Flag question

After fertilization in a flower, the ovary develops to form the

Select one:

- Seed
- Receptacle
- Embryo
- Fruit

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following statements is always true of a fruit? It

Select one:

- Is soft in texture but contains hard seeds
- Contains one or more seeds
- Develops from an ovule
- Has a micropyle at one end

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The part of a seed where food is stored for germination is called the

.

Select one:

- Plumule
- Cotyledon
- Testa
- Integument

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following statements about a seed is not correct? It

Select one:

- Is developed from a fertilized ovule
- Has two scars
- Has either one or two cotyledons
- Has an embryo

LESSON NOTE

Lesson 43

Classification of Fruits

By the end of this lesson you should be able to:

1. Identify true and false fruits giving examples each
2. Identify simple, aggregate and composite or compound fruits giving examples each
3. Explain and give examples of dry and succulent/fleshy fruits.

Fruits are classified into different groups depending on their origin and structure.

The following are the common ways of grouping fruits:

1. True and false fruits
2. Simple, aggregate and composite fruits
3. Fleshy and dry fruits
4. Dehiscent and indehiscent fruits

True and False Fruits

True fruits: type of fruits that develop only from fertilized ovaries consisting of pericarp and seed(s). Examples are mango, orange, cowpea and tomato.

False fruits: type of fruits formed from the ovaries and other floral parts as well.

Examples include apples, pineapple and cashew

Simple fruits: these are fruits that develop from a single or syncarpus ovary.

Examples are okra, cowpea, maize, tomato and pawpaw.

Aggregate fruits: these are fruits which develop from a single flower with many ovaries.

Such flowers have pistils where the carpels are separated and therefore have several ovaries.

Each ovary then develops into a *fruitlet.*

Examples include strawberry, raspberry, etc.

Multiple fruits: these are fruits developed from inflorescence or flowers positioned very close to one another.

Here, all the fruitlets and the floral parts are fused together to form a single large fruit.

An example is pineapple.

Dry and Succulent/fleshy fruits

Fruits are classified as dry or fleshy according to the nature of their pericarp.

A. Dry Fruits

A fruit is described as dry when the pericarp becomes dry, hard and woody or fibrous as soon as it ripens.

Dry fruits may be grouped into **dehiscent** or **indehiscent** depending on whether their pericarp split open when ripe or not.

Types of dehiscent fruits are follicle, legume/pod, capsule and schizocarp.

I. *Follicle*: It is a simple fruit formed from a superior monocarpous pistil.

The fruit when ripe dehisces meaning it split longitudinally **on one side only**.

Examples include kola and silk cotton

II. *Legume*: it is a simple fruit formed from a superior monocarpous pistil.

It is usually long and flattened sideways.

When the fruit is ripe the pericarp dehisces longitudinally along both **sutures** to release the seeds in it.

Examples are crotalaria, cowpea, soya beans, flamboyant and pride of Barbados

III. *Capsule*: it is a simple fruit formed from a single ovary divided into many independent compartments called carpels.

It dehisces along many sides along the points of contact of the carpels.

Examples of capsule are cotton, okra and castor oil

IV. *Schizocarp*: A simple fruit formed from an ovary made up of one carpel.

The dry fruit has several seeds in l**ocules** and break transversally, with each seed enclosed in a locule.

Examples of schizocarp are Desmodium and Cassia

B. Dry Indehiscent

These are fruits which do not split open when mature or ripe but usually fall to the ground where the pericarp eventually decays to release the seeds.

Such fruits are produced in large numbers and are very small in size.

Types of dry indehiscent fruits are achene, caryopsis, cypsela, nut and samara.

I. *Achene*: it is a small, simple, one-seeded fruit formed from an apocarpous pistil.

The pericarp develops from the seed coat.

Examples include strawberry and sunflower

II. *Caryopsis*: it a small simple fruit developed from a single pistil with a single ovary.

The seed coat and the pericarp are fused together to form a covering over the entire grain. Examples are rice grain, maize grain, millet, guinea corn etc.

III. *Cypsela*: it is a small simple fruit formed from a superior monocarpous ovary and contains only one seed.

Here the pericarp is free from the seed coat.

At maturity, the corolla drops off and the calyx persist and form a prominent parachute-like structure called pappus.

The seed coat is hard and does not split open on drying.

An example is the Tridax fruit

IV. *Nut*: it is a simple true fruit with a hard woody pericarp which develops from a superior polycarpous ovary.

It has one seed chamber with a seed.

An example of nut is the cashew nut which is on a fleshy edible receptacle.

V. *Samara*: it is a simple true fruit in which the pericarp is extended to form one or more wing-like structure(s).

Samara fruits develop from superior ovaries with more than one carpel. Usually they contain one or more seeds.

An example is Cumbretum.

Succulent/Fleshy Fruits

A succulent fruit is a type of fruit in which the entire pericarp or at least one of its layers is thick, soft and fleshy when ripe.

Types of succulent fruit are drupe, berry, pome and sorosis.

1. *Drupe:* it is a true, simple fruit with well-developed pericarp.The epicarp is thin, the mesocarp is fleshy or fibrous and the endocarp is hard and stony, e.g. Mango, Coconut and Palm nut.
2. *Berry:* it is a true, simple fruit with well-developed pericarp. However, the endocarp is not stony as in a drupe. The epicarp is usually a thin membranous covering, which is closely attached to a fleshy mass, made up of the mesocarp and endocarp. Within this mass lie one or many seeds. e.g. tomato, guava, banana, watermelon, orange
3. *Pome:* it is a simple false fruit in which the skin and the fleshy edible part are derived from the receptacle and only the core enclosing the seeds are from the ovary.Examples are apples and pear
4. *Sorosis*: it is a composite false fruit formed from a dense of inflorescence. Every part of each flower forms part of the fruit while the stalk or axis of the inflorescence swells to form the core or mass.Examples of Sorosis are breadfruits and pineapple

Summary

We looked at fruits, types of fruits (true and false fruits, simple, aggregate and composite fruits, dry and succulent fruits). Finally, you looked at types of dry (dehiscent and indehiscent fruits) and succulent fruits in detail.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of these is not a true fruit?

Select one:

- Tomato
- Guava
- Mango
- Apple

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of these is not a true fruit?

Select one:

- Pineapple
- orange
- Quava
- Mango

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following fruits is a false fruit?

Select one:

- Pawpaw
- Cashew
- Pineapple
- Mango

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Pawpaw
- Tomato
- Banana
- Palm fruit

Question **5**

Not yet answered

Marked out of 20.00

Flag question

A false fruit like the apple develops from the ovary and the

Select one:

- Pedicel as well
- Petals as well
- Receptacle as well
- Stamen as well

LESSON NOTE

LESSON 44

Dispersal of Fruits, Seeds and Germination

In our previous lesson, we looked at seeds and fruits structures and fruit types.

Remember, we are looking at reproduction in flowering plants.

As part of the reproduction cycle of flowering plant, a process called dispersal is involved.

Before that let us look at the aims of this session

By the end of this session you should be able to

1. Explain what dispersal is
2. Identify the importance of dispersal
3. Recognize the agents of dispersal
4. Deduce the adaptive features that enable fruits and seeds to be dispersed by a particular agent
5. Explain germination and its conditions

Dispersal of fruits and seeds

When the flowering season is over and the fruits and seeds ripen, they fall from the parent plant to the ground.

The number of fruits and seeds produced by a plant is often very large.

However, most of them perish, some are eaten by animals, while others may fall on ground already occupied or unfavourable to the particular plant.

If conditions are favourable, the seeds germinate and grow.

If the seedlings develop close to the parent plant, they soon become overcrowded.

Hence, they compete among themselves and with the parent and other plants for light, water, mineral salts and other essential soil constituents so that only the strongest seedlings finally survive.

To overcome such difficulties, the fruits and seeds of most plants are variously adapted so that they can be scattered far away from the parent and this is referred to as *dispersal*!

So what is dispersal?

Dispersal is defined as the transfer or scattering of seeds and fruits from the parent plant to other places where the seeds may germinate.

Importance of Dispersal

Dispersal of fruits and seeds have the following importance or advantages:

1. If the seedlings develop close to the parent plant, they soon become overcrowded. Hence the rationale behind dispersal is to prevent overcrowding
2. When the seedlings and parent plant become overcrowded they compete among themselves for water, light, mineral salts and other essential soil constituents. Therefore the purpose of dispersal is to prevent undesirable competition for space, light, water and nutrients.
3. It prevents diseases from spreading among plant species.
4. It results in colonization of new areas with new plants
5. It ensures the survival of a good number of seedlings under favourable conditions.
6. It prevents herbivorous animals from having easy access to the plants.

Agents of Dispersal

The common agents that bring about dispersal are wind, water, animals, and 'explosive' mechanisms within the fruits themselves.

Agents of dispersal of seeds and fruits are the means by which seeds and fruits are removed from the parent plant to other places.

Animal Dispersal

The fruits are seeds dispersed by animals and have special features that facilitate their dispersal. These are

- **Adhesive fruits**: fruits and seeds with hooks and hairs (e.g. love-grass or spear grass) can be caught in the fur of animals e.g. dog, cat cattle or on the clothing of people and may be dropped at distances away from the parent plant e.g. hooks on *Desmodium*, sticky drops on *Boerhavia*.
- The fruits and seeds are **edible** and are **sticky** (e.g. *mistletoe*). Such fruits and seeds stick to the beak of birds. These birds may clean their beaks on tree trunks and leaves the seeds there.
- Other fruits and seeds have **sharp, rigid spines** by means of which they are trapped in the hooves of animals, or between the digits of their feet
- Some fruits and seeds are **fleshy** and **brightly coloured** (e.g. *mango, pawpaw, orange* and *guava*). They may be eaten by bats, birds, squirrels or other animals.The hard seeds are thrown away or swallowed.
- Some edible fruits have digestive-enzyme resistant seeds. Meaning, after the fruits are eaten and the seeds swallowed, they are able to withstand the activities of the digestive enzymes. This is because the seeds have a slimy impermeable layer or tough woody seed coat. Therefore they are able to pass through the alimentary canal unharmed. As birds usually cover great distances during flight, these seeds get deposited in several different places.

Dispersal by Wind

Fruits and seeds dispersed by wind have certain adaptive features that aid their dispersal:

- Fruits or seeds are **small, light and dry**.

Therefore they are easily carried away by the wind from the parent plant to other places. Examples are *Orchids* and *some grasses*

- Some may have **wings** and **hairs** which enable them to float easily and allow them to be carried around by the wind. An example is *the cornbretum*.
- Others have **parachute-like tuft** or **pappus** to enable them to float in the air for a long time before landing on the ground. Example is *tridax*.
- Fruits and seeds of cotton may have **floss** (*cotton seeds*) which makes them be easily carried by the wind.

Dispersal by Water

Features or adaptations of fruits and seeds dispersed by water include the following:

- The fruits or seeds may be **light** and can float on water
- The fruits have **water-proof epicarp,** such as coconut fruit, which prevents it from imbibing water so that they can remain afloat
- The fruits have **fibrous mesocarp** (e.g. coconut fruits) containing lots of air spaces enabling it to float
- The endocarp is **stony** or **hard** (e.g. coconut fruits), preventing it from soaking water thereby remaining afloat for a long time before they are washed ashore.

Then, germination starts

Explosive Mechanism

Features that aid fruits or seeds dispersal by explosive mechanism has one or more lines of sutures.

When the pericarp dries up, it contracts.

Then pressure and tension build up within the fruit as a result of uneven drying up of the pericarp.

This causes the pericarp to split along the lines of sutures.

The splitting of such a fruit is called explosive mechanism.

The splitting and thrusting of the pericarp disperse the seeds from the parent plant. Examples of fruits dispersed by this method are *Acacia, Oil bean, Caesalpinia* etc.

Germination

The seed occupies a unique position in the life cycle of a flowering plant.

In its dehydrated and inactive state, it is able to tolerate conditions so extreme that viable seeds can be found on the surface of sun-baked desert sand.

The embryo is enclosed in a tough impermeable seed coat in a miniature new plant. Equipped with a food store and all the necessary genetic information, it has the potential to become an independent member of the next generation of plants.

However, this potential remains unfulfilled until it breaks out of its state of dormancy. When dormancy is broken and conditions are favorable, seed germination begins

So what then is germination?

It is the onset of growth of a seed, often following a period of dormancy, in response to suitable environmental conditions

Dormancy is the period where there is very little or minimum cell activity or metabolism in the embryo of a seed.

The length of the dormant period varies with different species of plants; from a few days to several months.

Conditions Necessary for Seed Germination

A. External conditions

- **Moisture/water**
- **Oxygen**
- **Suitable temperature**

B. Internal conditions

- **Enzymes**
- **Seed viability**
- **Energy**

Summary

We looked at fruits and seeds dispersal by defining it as the scattering of fruits and seeds from the parent plant. Again we looked at agents that promote dispersal and features of fruits and seeds which facilitate their dispersal. Finally, we looked at germination and conditions (external and internal) which are necessary for germination.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

A seed imbibes water through the

Select one:

- Micropyle
- Integument
- Testa
- Hilum

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Cowpea fruit
- Pride of Barbados fruit
- Banana fruit
- Flamboyant fruit

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following fruits can be dispersed by water?

Select one:

- Desmodium
- Coconut
- Tridax
- Mango

Question **4**

Not yet answered

Marked out of 20.00

Flag question

A fruit which the pappus has been modified into a parachute is likely to be dispersed by

Select one:

- Wind
- Explosion
- Water
- Mammals

Question **5**

Not yet answered

Marked out of 20.00

Flag question

A fruit with sticky covering is likely to be dispersed by

Select one:

- Mammals
- Explosion
- Wind
- Water

LESSON NOTE

LESSoN 45

Germination and Asexual Reproduction

Today, we shall be looking at the process of germination, types of germination and asexual reproduction (considering the natural and artificial vegetative propagations).

But before that let us consider the aims of this session.

By the end of this session, you should be able to

- Describe the process of germination
- Demonstrate the conditions necessary for germination through an experiment
- Explain asexual reproduction and the forms/types of natural and artificial vegetative propagation

Process of Germination

The process of germination is similar in different types of seeds.

The seed first absorbs water through the micropyle and the testa, to soften the testa.

In addition, the water also dissolves the complex food nutrients to enable digestive enzymes breakdown the complex food into simple soluble food substance. Thus;

- Carbohydrate is broken down into glucose by the enzyme, **Carbohydrase**
- Fats/lipids are converted into fatty acids and glycerol by the enzyme, **Lipase**
- Proteins are broken down into amino acids by the enzyme, **Protease**

The soluble food substance (glucose, amino acids, fatty acids and glycerol) are transported to the plumule and radicle.

The simple sugars are broken down (oxidized) through tissue respiration to produce energy for the synthesis of new protoplasm or cells, cell division and over growth.

The radicle grows downwards into the soil by splitting the testa.

The plumule also elongates and grow upwards out of the soil.

The **radicle** grows into the **root system**.

The **plumule** also develops into the **shoot system**.

The stored food is eventually used up by the embryo for growth.

An Experiment to Demonstrate the Conditions Necessary for Germination

Materials

- **Stoppers**
- **Four conical flasks labelled A, B, C and D**
- **Test tubes**
- **Cooton wool**
- **Oil**
- **Refrigerator**
- **Water**
- **Some viable seeds, (e.g. bean or maize)**

Method

- Some bean seedlings are placed on a piece of wet cotton in **flask A**. suitable warmth (30°C) and oxygen are also present in the flask
- The same number of seeds are placed on dry cotton wool in **flask B**. suitable warmth and oxygen are present. However, moisture is absent.
- In **flask C**, the same number of seeds are placed on wet cotton wool. Moisture and oxygen are present here. However, the flask is placed in a refrigerator at temperature of about 4°C so that suitable temperature would be absent.
- In flask D, the same number of seeds are placed in the flask, with cooled boiled water added and sealed with a layer of oil. Here, warmth and moisture are present but oxygen is absent.All the flasks are set aside for a week while the progress of germination of the seeds are absorbed daily.

Observation after a week

No germination occurs in **flasks B, C** and **D**. The seeds in **flask A** only germinated.

Conclusion

Suitable temperature, oxygen and water are necessary conditions for seeds to germinate

Types of Germination

There are two types of germination namely,

1. Epigeal germination
2. Hypogeal germination

Epigeal Germination

Epigeal germination occurs when the cotyledons are brought above the soil surface due to rapid elongation of the hypocotyl.

Examples of seeds that experience epigeal germination are castor oil, flamboyant, cowpea seeds and most Dicotyledonous seeds

Hypogeal Germination

Germination is hypogeal when the cotyledons remain below the ground as a result of rapid elongation of the epicotyl.

Examples are maize seeds and most Monocotyledonous seeds.

Asexual Reproduction in Plants

In flowering plants, asexual reproduction takes the form of vegetative reproduction.

Vegetative reproduction is a type of reproduction in which part of the vegetative plant (root, stem and leaves) gives rise to a new plant.

Plants which normally reproduce vegetatively are herbaceous perennials.

They are non-woody plants which grow from year to year, surviving the dry unfavourable season as an underground storage organ.

In the dry season, the aerial shoots of each plant wither and die leaving the storage organs.

These remain dormant until the rainy season when the buds on each storage organ grow to make new aerial shoots and new plants.

The main types of herbaceous perennials are bulbs, rhizomes, corms, suckers, runners, stolons and setts.

Parts of these perennials, for instance, the stem, leaves, etc, can also give rise to a whole new plant.

This is called **natural vegetative propagation**.

Vegetative reproduction can also be achieved artificially through budding, grafting, cutting, layering and marcotting.

Natural Vegetative Propagation

1. Rhizome
2. Bulbs
3. Corms
4. Suckers
5. Runners
6. Stolon
7. Setts

Rhizomes

Rhizomes are thick, fleshy, elongated stems which grow horizontally below the soil.

Characteristics

1. They have nodes, internodes and scale leaves
2. They have axillary and terminal buds. Axillary buds on nodes give rise to new rhizomes whereas the terminal bud gives rise to aerial foliage.
3. They have adventitious roots growing from the nodes
4. They store form in the form of water, mineral salts and glucose
5. Examples are cana lily, ginger, runner grass, lotus and water lily

Bulbs

A bulb is an underground modified shoot consisting of a shortened convex or conical stem.

Characteristics

1. It has thick, whitish, fleshy leaves which store food
2. The fleshy leaves are covered by dry, brown pappery scale leaves
3. It possesses tiny axillary buds in the axil of some of the leaves
4. It possesses terminal bud which produces aerial shoot

An example is an onion

Corms

A corm is a short vertical stem swollen and store food.

The stored food is used for the development of a new shoot.

Characteristics

- the **pre**sence of brown scale leaves
- presence of lateral buds along the nodes
- Presence of adventitious roots at the base new corms are formed on top of the previous year's corm.

Examples are cocoyam, taro, Gladiolus etc.

Suckers

These are lateral branches with terminal buds, which grow from the base of underground stem of certain plants,

Characteristics

- They have large terminal buds
- They have underground stems and leaf bases
- They have scale leaves
- They have adventitious roots
- They do not store food

Runners

Runners have slender, prostrate branches with long or short internodes, creeping on the ground and rooting at nodes.

Runners arise from axillary buds and creep some distance away from the mother plant.

They then develop adventitious roots and grow into new plants.

Examples are **Oxalis, Desmodium, sweet potato, strawberry** etc.

Stolon

It is a slender lateral branch originating from the base of the stem. It grows, first, obliquely upwards to some extent and then bends down to the ground, developing roots at the tip and producing bud. The bud soon grows into a daughter plant. Examples are gooseberry and blackberry

Setts

A sett is a cut from the head portion of a tuber for planting. At least one 'eye' must be found on each sett. The 'eye' on the sett is capable of spouting and establishing as a new plant. Example are yam and Irish potato

Summary

We looked the process of germination which as to do with absorption of water, softening the seed coat to enable the radicle and plumule to emerge. We studied the conditions necessary for germination and demonstrated an experiment to prove that oxygen, moisture and suitable temperature are needed for germination. We then looked at epigeal and hypogeal germinations as types of germination. Finally, we saw the types of asexual reproduction as in natural and artificial vegetative propagation.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Rhizomes are used in vegetative propagation because they

Select one:

- Have buds
- Are protected by scale leaves
- Contain food reserves
- Have adventitious roots

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Parts of plants used for vegetative propagation include

I. Bulbs
II. Rhizomes
III. Leaves

Select one:

- I and III only
- I and II only
- I, II and III
- II and III only

Question **3**

Not yet answered

Marked out of 20.00

Flag question

The part of the banana plant used for its propagation is the

Select one:

- Scion
- Sucker
- Runner
- Bud

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Cocoa is propagated mainly through

Select one:

- Seedlings
- Stem cutting
- Layering
- Grafting

Question **5**

Not yet answered

Marked out of 20.00

Flag question

In which part of a rhizome is food stored?

Select one:

- Lateral bud
- Terminal bulb
- Lateral stem
- Adventitious roots

LESSON NOTE

LESSON 46

Nitrogen Cycle

Most plants cannot absorb free atmospheric nitrogen.

All the nitrogen which they need for their metabolism is obtained from nitrogenous compounds in the soil such as the nitrates of several elements, as well as ammonium compounds.

Soil nitrogen is continuously being lost from the soil through both artificial and natural means such as

- Crop removal
- Soil erosion
- Leaching action by rain and
- Denitrification

Also, large quantities of nitrogen are lost each year from cultivated soils as constituents of crops are harvested.

In this lesson, you are going to look at the Nitrogen Cycle.

By the end of the lesson you should be able to:

- Explain what nitrogen cycle is
- Describe the main processes of nitrogen cycle such as
    - Nitrogen fixation
    - Ammonification
    - Nitrification
    - Denitrification
- Explain the importance of Nitrogen Cycle
- Identify ways through which farmers replenish soils which have lost their nitrogenous compounds

Since nitrogen is essential to plant life and is continually being lost from the soil, there must be means by which Nature replenishes the soil with nitrogen compounds.

The series of reactions in which these nitrogenous compound are involved, under natural conditions, make up a cycle known as the **Nitrogen Cycle.**

Nitrogen is a vital component of every living organism. It forms part of all proteins, nucleic acids (such as DNA) and their products.

Nitrogen cycle consists of four main processes:

- Nitrogen fixation
- Ammonification
- Nitrification
- Denitrification

1. Nitrogen fixation

Most organisms cannot use atmospheric nitrogen, or nitrogen dissolved in water, because nitrogen gas is chemically inert or unreactive. Why?

This is because each molecule consists of two nitrogen atoms linked by a triple bond.

Therefore, before plants and animals can use nitrogen, it must first be converted to absorbable nitrogen compounds.

This conversion is called **nitrogen fixation.**

Nitrogen fixation has been put into two types namely, **nitrogen fixation by non-living processes** and **nitrogen fixation by living organisms**.

Let us now consider nitrogen fixation by non-living processes

Nitrogen fixation by non-living processes

This normally occurs during **thunderstorms (non-living)**.

Sometimes during thunderstorms nitrogen combine with oxygen to form gaseous oxides of nitrogen such as nitrous oxide, nitric oxides and nitrogen peroxides.

These form *nitrous acid* and *nitric acid* with rain water.

When these acids go into the soil they combine with mineral salts to produce nitrates eventually. The nitrate so formed dissolve in soil water and are absorbed by the roots of plants.

Nitrogen fixation is also carried out artificially by industries in the production of nitrogen fertilizers. One major industrial process, the *Haber process*, synthesizes ammonia from atmospheric nitrogen and hydrogen by passing the gases under high temperature and pressure through an inorganic catalyst.

This process requires a large amount of energy, usually from burning fossil fuel.

Nitrogen fixation by living organisms

The nitrogen-fixing micro-organisms include

- certain bacteria living in the soil, e.g. *Azotobacter* and *Clostridium*
- certain blue-green algae living in the soil, e.g. *Nostic* and
- Bacteria which live symbiotically in the root nodules of leguminous plants (such as cowpea and sweet pea), e.g. *Rhizobium.*

These micro-organisms are capable of absorbing atmospheric nitrogen and converting it to organic nitrogenous compounds, namely proteins within their bodies.

Nitrogen-fixing bacteria possess *nitrogenase*, an enzyme that enables them to reduce nitrogen to ammonia or ammonium compounds

$$\text{Nitrogen} + \text{Hydrogen} \xrightarrow{\text{Nitrogenase}} \text{Ammonia}$$

$$N_2 + 3H_2 \xrightarrow{\text{Nitrogenase}} 2NH_3$$

- **Ammonification (ammonia from organic compounds)**

Living plants and animals add nitrogen to the soil by constantly giving out nitrogenous compounds as excretory products.

Furthermore, dead plants and animal tissues, which occur in the soil as **humus**, also add nitrogen to the soil.

Two groups of soil organisms, the **putrefying bacteria and fungi,** are responsible for the decay, or **putrefaction,** of dead plant and animal tissues, as well as their excretory products.

These organisms convert organic nitrogenous compounds in the soil to simple substances like carbon dioxide, water and ammonia.

The process by which these compounds are converted to ammonia is called **ammonification.**

The energy released during the conversion is used by these organisms for their life processes.

The carbon dioxide is given back to the atmosphere for plants use and ammonia is converted by other micro-organisms to nitrates.

- **Nitrification (ammonium ions to nitrites and nitrates)**

The conversion of ammonia to nitrates is called **nitrification.**

The micro-organisms which are responsible for the conversion of ammonia to nitrates are known as **nitrifying bacteria**.

There are two groups of nitrifying bacteria: those which convert *ammonia* to *nitrites* (NO_2^-), e.g. *Nitrosomonas,* and others which convert **nitrites** to **nitrates** (NO_3^-), e.g. *Nitrobacter.*

Nitrification occurs only when there is sufficient air in the soil and also when the soil is not too acidic.

Nitrates in the soil can be absorbed directly by plant roots.

Within the plant they are converted to plant proteins.

Some plants are eaten by herbivorous animals and are finally converted to animal proteins.

When these animals are eaten by carnivorous animals, more animal proteins are formed.

Hence, nitrates in the soil are ultimately incorporated into the bodies of plants and animals

- **Denitrification (nitrates back to nitrogen)**

The nitrogen cycle is completed by denitrifying bacteria such as *Pseudomonas denitrificans* and *Thiobacillus denitificans.*

These bacteria live in conditions of low oxygen and reverse the nitrifying process, converting *nitrates* into *nitrites,* and *nitrites* to *nitrogen gas*.

The energy liberated in the process is used for their life processes.

The nitrogen so formed escapes into the air where it becomes atmospheric nitrogen, leading to loss of nitrogen from the biotic component of an ecosystem to the atmosphere.

Now how do farmers help to replenish the lost nitrogenous compounds in the soil?

- Providing additional nitrate by spreading artificial fertilizers such as N.P.K.
- Growing leguminous crops, e.g. cowpea in crop rotation as part of crop rotation practice
- Ploughing back plant remains, or turf, to provide green manure for decay.
- Sowing 'dressed seeds', coated with a culture of the symbiotic bacteria.

Importance of nitrogen

1. It provides plants (leguminous plants) with absorbable nitrogen compounds which enable them to manufacture plant proteins for their life processes
2. Herbivorous animals feed on plants (leguminous plants) to obtain plant proteins for the repair of worn-out tissues
3. When leguminous plant and animals die they decompose to release nitrogen compound back into the soil, improving its fertility.It serves as a food source for some micro-organisms such as *Pseudomonas* and *Thiobacillus* during the process of denitrification

Summary

We looked at nitrogen cycle under four main processes: Nitrogen fixation, Ammonification, Nitrification and Denitrification. **Nitrogen fixation** has to do with the conversion of atmospheric nitrogen into nitrogenous compounds by enzymes such as *Nitrogenase and a bacterium Rhizobium*. **Ammonificatio**n is the conversion of the nitrogenous compounds into simple ammonia, carbon dioxide and water. **Nitrification** on the other hand, is the conversion of ammonia into nitrates by bacteria like *Nitrobacter* and *Nitrosomonas*. Finally, **Denitrificatio**n is the conversion of nitrates into nitrogen gas by enzymes such as *Pseudomonas.*

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is a denitrifying bacteria?

Select one:

- Nitrobacillus
- Nitrosomonas
- Azotobacter
- Pseudosomonas

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following agricultural practices replenishes the lost nitrogen in the soil?

Select one:

- mixing human wastes with soil
- Adding inorganic fertilizers
- practicing shifting cultivation
- Burning weeds before sowing seeds

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following bacteria converts ammonia to nitrite?

Select one:

- Pseudosomonas
- Nitrobactor
- Azotobacter
- Nitrosomonas

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following agricultural practices replenishes the lost nitrogen in the soil?

Select one:

- practicing shifting cultivation
- mixing human wastes with soil
- Adding inorganic fertilizers
- Burning weeds before sowing seeds

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following bacteria is responsible for ammonification?

Select one:

- Nitrobacter
- Petrifying bacteria
- Azotobacter
- Nitrifying bacteria

LESSON NOTE

LESSON 47

SKELETAL SYSTEM

If you build a model car, you usually begin with the body framework.

Then you add coving or paint.

Finally, you add engine, wheels, and other parts.

But the strength of the entire structure depends on the basic framework.

Like the model car, vertebrates have a strong supporting structure.

This is their internal skeleton, or endoskeleton.

Today, we shall be looking at the skeletal system.

Now the objectives

By the end of this session you should be able to

- Explain what the mammalian skeleton is
- Identify the various parts of the mammalian skeleton and

State the functions of the parts of the mammalian skeleton

Mammalian Skeleton

The mammalian skeleton is the bony framework of the body which provides support, shape and protection to the soft tissues and organs in animals.

Without the skeleton, animals may not be able to move or carry out other life processes.

The skeleton of animals enable them to move from one place to another.

In mammals and other vertebrates the skeleton is covered by flesh and muscles, i.e. the bone or cartilage occurs internal to the muscles.

Such a skeleton is called **endoskeleton**. Examples of animals with endoskeletons are fish, toad, lizards, birds and mammals like human, monkeys, rats etc.

Other types of skeleton are **exoskeleton** (such as those found in arthropods, molluscs etc.) and **hydrostatic skeleton** (such as those found in soft-bodied organisms like worms and maggot)

Parts of the Mammalian Skeleton

The skeletal system or bones in mammals are grouped into two major parts namely

the axial skeleton, which consist of the skull, vertebral column or backbone and the ribcage (comprising of the ribs, sternum or breastbone)

appendicular skeleton, which consist of limb girdles (pectoral and pelvic girdles) and the limbs (fore limbs and hind limbs)

Functions of the mammalian skeleton

The mammalian skeleton has the following functions:

Support

The vertebral column, the pectoral girdle and the pelvic girdle form a framework by which the skeletal muscles can be supported.

The pectoral girdle also supports the shoulders and the skeleton of the fore limbs, while the pelvic girdle supports the back of the body and the skeleton of the hind limbs.

The vertebral column forms a pillar-like structure to which both girdles and ribs are attached.

The structure and position of the girdles allow the body to resist deformation due to its weight.

Movement

The whole skeleton, including the fore and hind limbs, is made up of several pieces of bones joined to one another.

This allows free movement of the body and the limbs, and gives them the ability to bend, turn and twist in any desired direction.

Furthermore, the skeleton serves as a base for the attachment of muscles responsible for movement.

Protection

The skull forms a protective covering for the delicate tissues of the brain.

It also houses the complicated structures of the inner ear and the eyeball.

The vertebral column protects the spinal cord.

The rib cage in the thoracic region protects all the important organs of the thorax such as the heart, the thoracic blood vessels and the lungs.

Finally, the pelvic girdle protects the abdominal organs, particularly the urinary bladder and the reproductive organs of the female.

Respiration

The skeleton also plays an important part in respiration: the rib cage contributes to the breathing mechanism by continuously increasing and decreasing the volume of the thoracic cavity.

Other functions include,

Red blood cells are manufactured in the bone marrow

It gives shape and form to the body

It provides a rigid framework and support for the body.

Now let us discuss the major parts of the mammalian skeleton. We begin with the axial skeleton.

Axial skeleton

Skull

The mammalian skull is made up of several flat bones which are joined together by means of joints called sutures. The three major parts of the skull are

The cranium or brain box which holds or contains the brain

The facial skeleton which supports the nose, eyes and the muscles of the cheek

The jaws which are made up of the upper jaw (maxilla) and lower jaw (mandible) which contain the teeth.

Functions of the skull

It protects the brain

It gives shape to the head

It protects vital organs in the head, e.g. eyes, nose, ears etc.

It bears the teeth which aid grinding of food.

Vertebral Column

The vertebral column, also known as the **backbone** or spinal column, is the central supporting structure of the skeleton. The vertebral column protects the **spinal cord**. It is made up of five groups of bones called the **vertebrae** (singular: vertebra) in mammals. In humans, it consist of 33 vertebrae. They are,

Cervical vertebrae - found in the neck region

Thoracic vertebrae - found in the chest region

Lumbar vertebrae - found in the upper abdominal region

Sacral vertebrae - found in the lower abdominal region

Caudal vertebrae - found in the tail region

Each vertebra is separated from the one above and the one below by a compressible pad of cartilage known as an intervertebral disc. The vertebrae can only move slightly in relation to each other. They are held together by sheets of tough, fibrous material called **ligaments**

Functions

Supports the skull, pectoral and pelvic girdles

Protects the spinal cord which runs through it from the skull to the sacrum

Gives rigidity to the body

Bridges the gap between fore and hind limbs

Ribs

The ribs are long semi-circular rods connecting the thoracic vertebrae to the breastbone (sternum). It is found in the chest region of mammals. There are twelve pairs of ribs in humans. The ribs, the vertebral column and the sternum together form the **ribcage** of the thorax.

Functions of the ribs:

Protects the heart and lungs against mechanical injury

It assists in breathing

Summary

The mammalian skeleton is the bony framework of the body which provides support, shape and protection to the soft tissues and organs in animals.

Skeletons are for production of red blood cells, for movements, respiration, protection etc.

The two major parts of the mammalian skeleton are the axial and appendicular skeleton

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

The bones at the joints are held together by

Select one:

- Cartilage
- Tendons
- Ligaments
- Mesentery

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following vertebrae has the odontoid process?

Select one:

- Atlas
- Axis
- Thoracic
- Lumbar

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is not a function of the mammalian skeleton?

Select one:

- It gives support
- It helps in excretion
- It helps in respiration
- It gives protection

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Muscles are usually attached to bones by

Select one:

- Ligaments
- Membrane
- Tendons
- Cartilage

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Humerus
- Femur
- Ulna
- Coccyx

LESSON NOTE

LESSON 48

Mammalian Skeleton

Appendicular skeleton/Joint

In our previous session, we looked at the mammalian skeleton.

We studied the axial skeleton (which comprises of the skull, vertebral column and rib cage).

In this lesson, we would be looking at the other parts of the mammalian skeleton (which is the appendicular skeleton), comprising of the pectoral, pelvic girdles and the limbs (fore and hind limbs).

Before that, let us look at the objectives.

By the end of this session you should be able to:

- Describe the following parts of the appendicular skeleton and their functions:
  - Pectoral girdle
  - Pelvic girdle and the
  - limbs
- Explain what joints are
- Mention types of joints and give examples

Appendicular Skeleton

The appendicular skeleton is made up of the girdles, i.e., pectoral and pelvic girdles as the bones of the limbs, i.e., forelimbs and hind limbs.

The Pectoral Girdle

The pectoral girdle is found around the shoulder in man.

It is made up of two halves which are held by muscles.

Each half of the girdle is made up of three bones. These bones are:

- Scapula or shoulder bone
- Clavicle or collar bone and
- Coracoid

In mammals, the scapula and the coracoid are fused to form what is called **scapula-coracoid.**

The Pelvic Girdle

The pelvic girdle is found around the waist in man. It consists of two halves which are joined to each other ventrally and to the sacrum dorsally.

The line of fusion of the two halves is called **pubis symphysis**.

Each half, called an *innominate bone*, is made of three fused bones namely

- **Ilium**
- **Ischium and**
- **pubis**

Limbs

The fore and hind limbs of all vertebrates are built on a basic pattern.

This basic pattern is known as the **pentadactyl pattern.**

Therefore limbs of this pattern are known as **pentadactyl limbs.**

The evolution of pentadactyl limbs was one of the major adaptations that arose in connection with life on land.

This type of limb consist of a proximal long bone, followed by a pair of long bones placed side by side, a set of nine small bones in three rows, five thin long bones and finally, five digits (‘**penta**’ meaning ‘five’ and ‘**dactyl**’ meaning ‘digits’).

Each digit is made up of a few small bones.

In the fore limbs, the first bone is the **humerus** which fits into the **glenoid cavity** of the **scapula.**

In the hind limbs, the first bone is the **femur** which fits into the **acetabulum** of the pelvic girdle.

In the pentadactyl plan two bones articulate (communicate) with the first bone.

In the fore limbs are the **radius** and **ulna**, while in the hind limbs are the **tibia** and **fibula**.

These are followed by a number of small bones, arranged to form the wrist or ankle bones, the hand or foot bones and the bones of the finger and toes respectively

Joints

A joint is described as the point where two or more bones meet to bring about movement.

Bones of the mammalian skeleton are joined to one another in different parts of the body.

These arrangements are to allow movement of the body parts.

There are various types of joints which permit varying degree of movement.

However, in some parts of the body such as the s**kull** and the **pelvic girdle,** the bones are firmly attached to one another such that movement of these bones are impossible.

Such joints are known as **immovable joints.**

Those immovable joints in the skull are known as **sutures.**

Most of the bones in the body are held by movable joints.

The vertebrae are joined by ligaments and the intervertebral discs allow very little movement between them.

However, the bones of the limbs have freely articulating movable joints.

Types of joints

There are four main kinds of movable joints namely

- ball-and-socket joints
- hinge joints
- gliding/sliding joints
- pivot joints

Ball-and-socket joints

This type of joint allows movement in all directions. That is it allows freedom of movement in all planes. The hip joint and shoulder joint are ball-and-socket joints. The head of the humerus is a ball-like structure which fits into the cup-like glenoid cavity of the pectoral girdle. This allows movement in several planes. Again, the round head of the femur fits into the hollow acetabulum to form a freely articulating joint

Hinge joints

This a type of joint allows movement in only one direction or plane.

Hinge joints occur at the elbow and knee. As the name implies, each set of bones making up the joint functions like one half of a hinge

Gliding/sliding joints

This type of joint allows the sliding of bones over one another.

It occurs at the wrist and ankle allowing the hand and the foot to be moved up and down or rotated only slightly.

Pivot joint

This type of joint allows rotation of one part of the body on another.

It is found between the atlas and axis vertebrae. The peg-like structure of the axis acts as a pivot which allows the rotation of the head on the vertebral column.

Structure of a typical joint

The bones meeting at a joint are always held together by strong **ligaments,** the presence of which prevents dislocation during movement. Sometimes the whole joint is enclosed by a tube of ligament known as the **capsular ligament**. The articulating surfaces of the bones are covered by **cartilage**. The cartilage prevents the surfaces of bones from being worn out with the **friction** due to movement.

Friction must be exerted between the sole of the feet or paws of the animal and the floor so that the animal can move. The toes dig into the soil to increase the static friction: hence the shape of the hoofs of horses and cattle.

Between the surfaces of the cartilage is a sac known as the **synovial membrane**. The space in the sac is filled with a thick, viscous fluid called the **synovial fluid**. This fluid serves as a lubricant during movement.

SUMMARY

1. The appendicular skeleton is made up of the limbs, pectoral and pelvic girdles
2. The pectoral girdle is made up of the scapular coracoid and clavicle
3. The pelvic girdle is made up of two (2) halves
4. Each half is referred to as the innominate bone
5. We also looked at joint, their types and typical movable joints

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is a second order of lever in a mammalian joint?

Select one:

- Hydrostatic skeleton of earthworms
- Chitinous exoskeleton of arthropods
- Raising of the body on the toes
- The extension of the leg bending it

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Pick the odd one out

Select one:

- Suture
- Ball and socket
- Hinge
- Gliding

Question **3**

Not yet answered

Marked out of 20.00

Flag question

The strong cords which attach one bone to another at a joint is called……..

Select one:

- Myosin
- Tendon
- Glands
- Ligaments

Question **4**

Not yet answered

Marked out of 20.00

Flag question

The correct sequential arrangement of the vertebrae along the vertebral column of a mammal is

Select one:

- Cervical, thoracic, lumbar, sacral and caudal
- Thoracic, lumbar, caudal, cervical and sacral
- Sacral, cervical, thoracic, lumbar and caudal
- Cervical, lumbar, thoracic, sacral and caudal

Question **5**

Not yet answered

Marked out of 20.00

Flag question

The atlas constitutes part of the

Select one:

- Caudal vertebrae
- Thoracic vertebrae
- Cervical vertebrae
- Lumbar vertebrae

LESSON NOTE

Lesson 49

Topic: **Infections and Diseases**

Sub-Topic **Diseases: Pathogenic and Non- Pathogenic Diseases**

Have you ever fallen sick or seen somebody sick? What are the things that you saw or felt that informed you of sickness? I believe you wondered what caused the sickness.

In this unit we will be discussing answers to these questions

Objectives:

By the end of the lesson you should be able to:

- *state the definition for diseases*
- *explain how diseases occur*
- *mention and distinguish between the types of diseases, i.e., pathogenic diseases and non-pathogenic diseases*
- *state the causes and prevention of non-pathogenic diseases*

A. Diseases

A disease is a condition that occurs in the body of organisms – humans, animals and plants, which changes the normal functioning or activities of the cells or tissues.

- A disease condition is accompanied by (comes with) *signs and symptoms*. Examples of diseases are malaria, cholera and scurvy (gum bleeding).
- It is important to note that headache, fever (high body temperature), etc. are only symptoms of a number of diseases.

B. General Causes of diseases

- Eating/drinking food and water contaminated with disease-causing organisms (pathogens); breathing-in air contaminated with pathogens.
- Lack of one or more nutrients in the diet or eating *food poor in nutrition* can also cause diseases.
- A disease may also be caused by a *genetic disorder* or abnormality in inherited genes
- *Stress* (tension or pressure) is another cause of some diseases.
- Poor personal hygiene
- Poor environmental sanitation
- Lack of regular exercise

Types of Diseases

Diseases can be broadly grouped into two – pathogenic disease and non-pathogenic disease.

i. Pathogenic Diseases – Infectious diseases

- Microorganisms that cause diseases are described as *pathogens*.
- Therefore, a *pathogenic disease* is a disease that is caused by microorganisms. When pathogens enter the body, they feed on nutrients and other materials and may release toxins/poisons into the body. The individual becomes ill as a result.
- Pathogens or pathogenic organisms are usually grouped (classified) under bacteria, viruses, protozoa and fungi.
- More often pathogenic diseases can be transmitted (passed on) from an infected person to another person who may also suffer from the disease. A disease that can be transmitted from an infected person to another person is called an *infectious disease*. Examples are cholera, malaria, tuberculosis, chicken pox, measles, etc.

Class of pathogens

Microorganisms that cause diseases can be grouped into:

i. *bacteria*,

ii. viruses

iii. fungi

iv. protozoa

Diseases caused by bacteria are described as bacterial diseases. Similarly, we have viral diseases, protozoan diseases and fungal diseases. We shall look at the details in the next lesson.

ii. Non-pathogenic Diseases / Non-infectious diseases

- A non-pathogenic disease is a disease that is not caused by pathogens but may arise due mainly to

i. lack of one or more nutrients in the diet, i.e., poor nutrition

ii. genetic disorder.

iii. stress condition

- Diseases that are caused by lack of one or more nutrients in one's diet are called *nutritional deficiency diseases*. Typical examples of nutritional deficiency diseases are:

i. scurvy (lack of vitamin C)

ii. beriberi (lack of vitamin B_1) and

iii. night-blindness (lack of vitamin A).

- A *genetic disease* is a disease that arises as a result of changes or mutation or abnormality in one's DNA or sequence of genes. A genetic disease can occur suddenly in an individual.
- More often, a parent may transfer a defective gene to an offspring (the child), who may express the genetic disease.
- The offspring is said to have inherited that genetic disease. Examples of genetic diseases include

i. haemophilia

ii. red-green colour blindness

iii. sickle cell anaemia. (*show a picture of a patient*)

- Stress condition occurs when one has some tasks to perform feels, anxious about meeting deadline or some set standards. The anxiety that arises puts the person under pressure/tension and may suffer some stress condition.
- Diseases that are experienced from stress conditions are

i. high blood pressure

ii. heart attack

iii. peptic ulcers

iv. alcoholism

How to control Non-pathogenic diseases

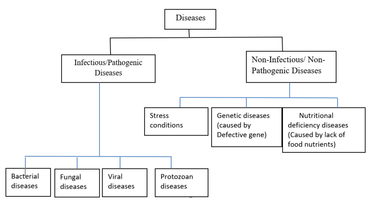
i. Eating balanced diet, i.e., diets that contains all the six food nutrients in the right amounts and proportions. (*Show a picture of balanced diet*)

ii. two persons who are carriers of defect genes should be advised not marry. For example, two adults – a man and a woman may each carry one of the genes causes the gene sickle cell disease. If the two should marry, chances are that each of them would contribute one of sickle cell gene in the offspring in the offspring. The offspring would then suffer from the sickle cell disease. When they are advised through genetic counseling and do not marry, a person with the sickle cell disease would not be borne.

iii. Stress conditions are usually managed. For example, one should not do too many things at the same time which will make him exert too much energy and feel too anxious of meeting dead lines

SUMMARY

Drawing a scheme on classification of diseases



NB: Signs of a disease is what one (or the doctor) observes in a sick person and by which he diagnoses or establishes the type of disease the person is suffering from. Examples are vomiting, rashes, swellings and fever (high body temperature). Symptoms of a disease are what the sick person describes of his/her condition. Examples are pains, headache, etc.

SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following diseases is non-pathogenic?

Select one:

- beriberi
- chicken pox
- scurvy
- sickle anaemia

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following diseases is inherited?

Select one:

- malaria
- dysentery
- cholera
- sickle cell anaemia

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Which of the following is a cause of stress related diseases?

Select one:

- having enough rest at night
  having enough rest at night
- having a regular exercise schedule
- being involved in recreational activities
- having too many to do things at the same time

Question **4**

Not yet answered

Marked out of 20.00

Flag question

Which of the following diseases is not a pathogenic disease?

Select one:

- athlete foot
- hypertension
- tuberculosis
- cholera

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Causative organisms for infectious diseases are prevalent mostly in

Select one:

- scarcely populated environment
- dry, windy environment
- dry well ventilated environment
- moist, crowded and dirty environment

LESSON NOTE

Topic: **Infections and Diseases**

Sub-Topic: **Mode of Transmission Pathogenic Diseases**

Dear student, after going through the previous lesson, I believe you can now state the definition of diseases and state their causes. I also believe that you can distinguish between pathogenic and non-pathogenic diseases

In this lesson we shall discuss the various modes of transmission of pathogenic diseases.

Objectives:

By the end of the lesson you should be able to:

1. explain the 'expression infectious diseases'
2. name the specific microorganisms that cause infectious diseases
3. state the various modes of transmission of infectious diseases
4. state some specific examples of pathogenic diseases and their mode of transmission

Spread of Infectious/contagious/communicable diseases

- Infectious diseases are diseases that spread from a person who has the disease to a healthy person or from an animal to a person through a medium or by contact with body fluid (e.g., blood).
- A disease spreads when the pathogen is transmitted from an infected person to another person
- Pathogen are transmitted through the mediums food, water, air, direct contact with an infected person or vector organisms
- Examples of vector organisms are mosquito, housefly, blackfly, cockroach, etc.
- The terms communicable and contagious can be used in place of infectious diseases.

Types of Infectious Diseases

- Diseases that are transmitted through water are called water-borne diseases.
- Similarly, we have air-borne diseases and food-borne diseases.

In this unit we shall focus on water and air-borne diseases

a. *Air-borne diseases*

- Air-borne diseases are infectious diseases that are transmitted through air
- When infected person coughs, talks, sneezes or spits, the pathogen are released as droplets and float or become air-borne. Thus air-borne diseases are also referred to as *droplet infections.*
- Droplet infections spread fast in poorly ventilated area (in enclosed area)
- Air-borne pathogens enter the body during breathing, i.e., through the nose and the mouth.
- Air-borne diseases affect the nose, throat, trachea, bronchi and ultimately, the lungs

Typical examples of air-borne diseases are tuberculosis (TB), influenza (flu), pneumonia, and mumps.

Tuberculosis (TB)

- Tuberculosis is an infectious disease caused by a *bacterium* called *Mycobacterium* tuberculosis. It mainly affects the lungs.
- It is transmitted from person to person through droplet infection (which contains the mycobacterium tubercle) from the infected person.
- The *symptoms* include coughing, chest pains, weight loss, night sweat and body weakness.

Treatment and Control of TB

- TB is controlled by vaccination with BCG (BCG is a vaccine; full name is Baccille, Calmette, Guerin).
- A vaccine
- TB is treated using antibiotics.

Influenza

Influenza, or flu, is a respiratory disease that is caused by a virus. Flu is highly infectious and is often spread by the coughs and sneezes of infected persons.

b. *Water-borne diseases*

- They are diseases spread by drinking contaminated water, i.e., water that contains pathogens
- Pathogens are contained in faeces; improper disposal of human excreta and may lead to the contamination of drinking water from various sources including treated water, streams, wells, etc.
- Water-borne diseases affect the intestines which usually results in diarrhoea and vomiting.
- Diarrhoea is a condition in which a sick person frequently and rapidly discharges watery stool from the intestines.
- Diarrhoea results in dehydration, i.e., loss of fluid from the body
- Typical examples of water-borne diseases are cholera, dysentery and typhoid.

Cholera

The causative organism (pathogen) is a bacterium called *Vibrio cholerae*. Cholera outbreak occurs mainly as result poor sanitation including choked gutters, defecating in the open, etc. Cholera can also be spread through contaminated food.

Control and treatment: practicing good sanitation; victims or sufferers should be given oral rehydration salt (ORS).

c. *Food-borne diseases*

- These are diseases caused by eating contaminated food and as such affect the intestines.

Source of contamination

- through improper handling by infected persons or carriers.
- using contaminated water for cooking
- when animal vector carrying the pathogen settle on cooked food and uncooked food normally eaten in the raw state.

Most foods contain enough nutrients that support microbial growth. Typical examples are milk and products and house-holds foods. Examples of food borne diseases are *Salmonella* food poisoning, cholera, typhoid, etc.

d. *diseases that spread through direct skin contact*

Direct skin contacts during sports activities, kissing and sexual intercourse. Infectious diseases can also be transmitted when a person uses items such as spoon, shaving blades, clothing, etc. already used by infected persons. Examples of diseases that spread through contact are ringworm and leprosy. Others are gonorrhea, syphilis and HIV/AIDS, which are venereal or sexually transmitted. Venereal diseases affect the reproductive organs and the urinary tract. Venereal diseases are transmitted through sexual intercourse.

e. *Spread by vectors*

A vector organism is an organism that transmits pathogen from an infected person to another person who may become infected. The table below shows some examples of diseases transmitted by vectors

Vector organism	*Pathogen transmitted*	*Diseases*
1. Female *Anopheles* mosquito	*Plasmodium sp.* (parasite)	Malaria
2. Blackfly	*Trypanosome* (a protozoan)	River blindness (onchocerciasis)
3. Tsetse fly	A protozoan	Sleeping sickness (trypanosomiasis)
4. Housefly	*Vibrio cholera*	Cholera

Exercises

1. List the various means by which infectious diseases are transmitted

Answers

Eating/ingesting contaminated food,

Drinking contaminated water,

Inhaling air laden with pathogens,

Coming into contact with an infected person and

Been beaten by vector organism carrying the pathogens

2. Fill in the empty spaces in table A with expressions in table B

Table A

Disease	**Causative organism**	**Mode of transmission**	**Type of infectious disease**
Cholera		Contaminated Water, food	Water-borne, food-borne
Typhoid fever			Water-borne, food-borne
Tuberculosis	*Mycobacterium tuberculosis*	Inhaling air laden with pathogens	
	Neisseria gonnrhoea		Venereal disease
Malaria		Bite of infected mosquito	-

Table B

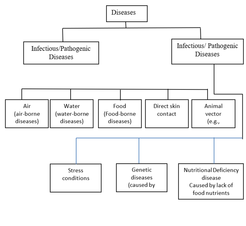
Air-borne, *Plasmodium* sp., *Vibrio cholera*, Gonnorhoea, Contaminated Water, food, Direct contact through sexual intercourse, *Salmonella typhi*

Complete table

Disease	**Causative organism**	**Mode of transmission**	**Type of infectious disease**
Cholera	*Vibrio cholera*,	Contaminated Water, food	Water-borne, food-borne
Typhoid fever	*Salmonella typhi*	Contaminated Water, food	Water-borne, food-borne
Tuberculosis	*Mycobacterium tuberculosis*	Inhaling air laden with pathogens	Air-borne
Gonnorhoea	*Neisseria gonnrhoea*	Direct contact through sexual intercourse	Venereal disease
Malaria	*Plasmodium* sp.	Bite of infected mosquito	-

SUMMARY

1. We have explained the expression infectious diseases
2. We also named the specific micro-organism that causes infectious diseases
3. We stated the modes of transmission of infectious diseases
4. We also looked at some specific examples of pathogenic diseases and their modes of transmission



SHS 1 INTEGRATED SCIENCE

Question **1**

Not yet answered

Marked out of 20.00

Flag question

Which of the following food materials is the mostly likely to be contaminated

Select one:

- a ball of kenkey
- opened tin of milk
- roasted plantain
- dried fish

Question **2**

Not yet answered

Marked out of 20.00

Flag question

Which of the following symptoms is characteristic of diarrhoea?

Select one:

- loss of appetite
- loss of fluid from the body
- loss of blood
- high blood pressure

Question **3**

Not yet answered

Marked out of 20.00

Flag question

Venereal are transmitted through

Select one:

- mosquito bite
- eating contaminated food
- drinking contaminated food
- sexual intercourse

Question **4**

Not yet answered

Marked out of 20.00

Flag question

All of the following can transmit droplet infections except

Select one:

- contact
- sneezing
- talking
- coughing

Question **5**

Not yet answered

Marked out of 20.00

Flag question

Which of the following about is not true about a vector organism?

Select one:

- It transmits pathogens from animals to humans
- It is usually an insect
- It transmits pathogens from one person to another
- It is pathogen