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Authors

Ms. A. Subhabarathi, M.Sc., M.Ed. M.Phil., Chennai

Mr. P. Charles Xavier, M.Sc, M.Ed. PGT-Physics, Chennai

Edited by

Mr. S. Murugan, M.Sc., B.Ed., Chennai

Reviewed by

Dr. B. Rajendran M.Sc., M.Phil., Ph.D.

Head of the Department

Chennai

Head Office:

1620, 'J' Block, 16th Main Road,
Anna Nagar, **Chennai - 600 040.**
Phones : 044-26161088, 26161099.
Mobile : 96001 75757 / 81242 01000 / 81243 01000
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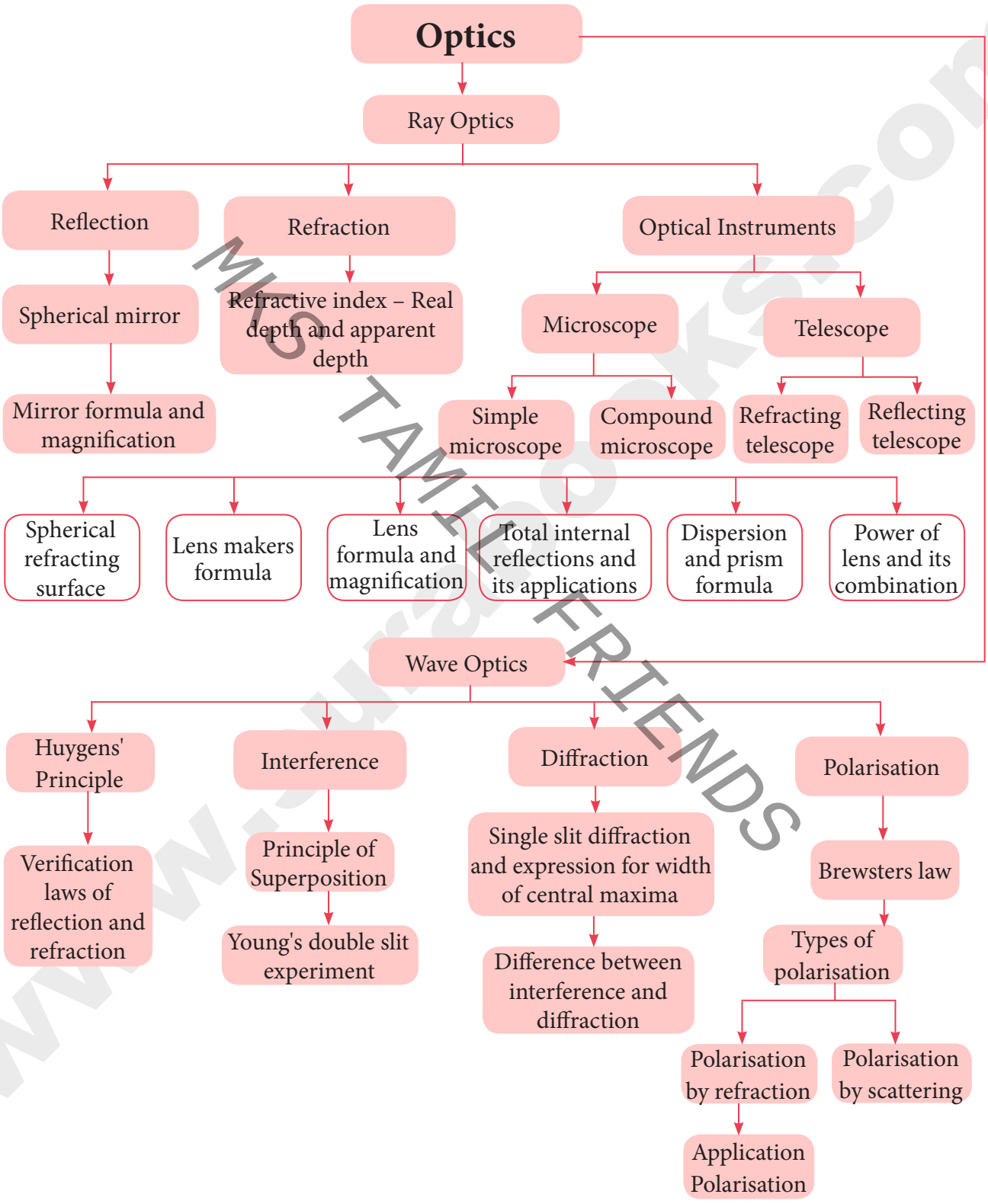
CONTENTS

UNIT 6

OPTICS

CHAPTER SNAPSHOT

CONCEPT MAP



MUST KNOW DEFINITIONS

Reflection of light : The bouncing back of light into the same medium when it encounters a reflecting surface is called **reflection of light**.

Angle of deviation : The angle between the incident and deviated light ray is called **angle of deviation of the light ray**.

Virtual image : Type of image which cannot be formed on the screen but can only be seen with the eyes is called **virtual image**.

Real image : Type of image which can be formed on a screen and can also be seen with the eyes is called **real image**.

Convex mirror : If the reflection takes place at the convex surface, it is called a **convex mirror**

Concave mirror : If the reflection takes place at the concave surface, it is called a **concave mirror**.

Center of curvature : The centre of the sphere of which the mirror is a part is called the **center of curvature** (C) **of the mirror**.

Radius of curvature : The radius of the sphere of which the spherical mirror is a part is called the **radius of curvature** (R) **of the mirror**.

Pole : The middle point on the spherical surface of the mirror (or) the geometrical center of the mirror is called **pole** (P) **of the mirror**.

Principal axis : The line joining the pole and the centre of curvature is called the **principal axis of the mirror**.

Focus or focal point : Light rays travelling parallel and close to the principal axis when incident on a spherical mirror, converge at a point for concave mirror or appear to diverge from a point for convex mirror on the principal axis. This point is called the **focus** or **focal point** (F) **of the mirror**.

Focal length : The distance between the pole and the focus is called the **focal length (f) of the mirror**.

Focal plane : The plane through the focus and perpendicular to the principal axis is called the **focal plane of the mirror**.

Paraxial rays : The rays travelling very close to the principal axis and make small angles with it are called **paraxial rays**.

Marginal rays : The rays travelling far away from the principal axis and fall on the mirror far away from the pole are called as **marginal rays**.

Refractive index : Refractive index of a transparent medium is defined as the ratio of speed of light in vacuum (or air) to the speed of light in that medium.

Optical path : Optical path of a medium is defined as the distance d' light travels in vacuum in the same time it travels a distance d in the medium.

Snell's law : The incident ray, refracted ray and normal to the refracting surface are all coplanar (ie. lie in the same plane).

EVALUATION

CHOOSE THE CORRECT ANSWER:

1. **The speed of light in an isotropic medium depends on,**

(a) its intensity (b) its wavelength
(c) the nature of propagation
(d) the motion of the source w.r. to medium

[Ans. (b) its wavelength]

2. **A rod of length 10 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that its end closer to the pole is 20 cm away from the mirror. The length of the image is,** *(AIPMT Main 2012)*

(a) 2.5 cm (b) 5 cm
(c) 10 cm (d) 15 cm

[Ans. (b) 5cm]

3. **An object is placed in front of a convex mirror of focal length of f and the maximum and minimum distance of an object from the mirror such that the image formed is real and magnified.** *(IEE Main 2009)]*

(a) $2f$ and c (b) c and ∞
(c) f and O (d) None of these

[Ans. (d) None of these]

4. **For light incident from air onto a slab of refractive index 2. Maximum possible angle of refraction is,**

(a) 30° (b) 45°
(c) 60° (d) 90°

[Ans. (a) 30°]

5. **If the velocity and wavelength of light in air is V_a and λ_a and that in water is V_w and λ_w, then the refractive index of water is,**

(a) $\frac{V_w}{V_a}$ (b) $\frac{V_a}{V_w}$
(c) $\frac{\lambda_w}{\lambda_a}$ (d) $\frac{V_a\lambda_a}{V_w\lambda_w}$

[Ans. (b) $\frac{V_a}{V_w}$]

6. **Stars twinkle due to,**

(a) reflection
(b) total internal reflection
(c) refraction (d) polarisation

[Ans. (c) refraction]

7. **When a biconvex lens of glass having refractive index 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index,**

(a) less than one
(b) less than that of glass
(c) greater than that of glass
(d) equal to that of glass

[Ans. (d) equal to that of glass]

8. **The radius of curvature of curved surface at a thin planoconvex lens is 10 cm and the refractive index is 1.5. If the plane surface is silvered, then the focal length will be,**

(a) 5 cm (b) 10 cm
(c) 15 cm (d) 20 cm

[Ans. (b) 10 cm]

9. **An air bubble in glass slab of refractive index 1.5 (near normal incidence) is 5 cm deep when viewed from one surface and 3 cm deep when viewed from the opposite face. The thickness of the slab is,**

(a) 8 cm (b) 10 cm
(c) 12 cm (d) 16 cm

[Ans. (c) 12 cm]

10. **A ray of light travelling in a transparent medium of refractive index n falls, on a surface separating the medium from air at an angle of incidents of 45°. The ray can undergo total internal reflection for the following n,**

(a) $n = 1.25$ (b) $n = 1.33$
(c) $n = 1.4$ (d) $n = 1.5$

[Ans. (d) $n = 1.5$]

Disadvantages :

(i) The objective mirror would focus the light inside the telescope tube.

(ii) One must have an eye piece inside obstructing some light.

(iii) This problem could also be overcome by introducing a secondary mirror which would take the light outside the tube for view.

74. What is the use of an erecting lens in a terrestrial telescope?

Ans. (i) A terrestrial telescope is used to see object at long distance on the surface of earth. Hence, image should be erect.

(ii) A terrestrial telescope has an additional erecting lens is used to make the final image erect.

75. What is the use of collimator?

Ans. The collimator is an arrangement to produce a parallel beam of light.

76. What are the uses of spectrometer?

Ans. The spectrometer is an optical instrument used

(i) to study the spectra of different sources of light and

(ii) to measure the refractive indices of materials.

77. What is myopia? What is its remedy?

Ans. A person suffering from nearsightedness or myopia cannot see distant objects clearly. This may result because the lens has too short focal length due to thickening of the lens or larger diameter of the eyeball than usual.

78. What is hypermetropia? What is its remedy?

Ans. (i) A person suffering from farsightedness or hypermetropia or hyperopia cannot clearly see objects close to the eye.

(ii) It occurs when the eye lens has too long focal length due to thining of eye lens or shortening of the eyeball than normal.

79. What is presbyopia?

Ans. Farsightedness arising due to aging is called **presbyopia** as the aged people cannot strain their eye more to reduce the focal length of the eye lens.

80. What is astigmatism?

Ans. Astigmatism is the defect arising due to different curvatures along different planes in the eye lens. Astigmatic person cannot see all the directions equally well.

Long Answer Questions :

1. Derive the mirror equation and the equation for lateral magnification.

Ans. The mirror equation establishes a relation among object distance u, image distance v and focal length f for a spherical mirror.

(i) An object AB is considered on the principal axis of a concave mirror beyond the center of curvature C.

(ii) Consider three paraxial rays from point B on the object.

(iii) The first paraxial ray BD travelling parallel to principal axis is incident on the concave mirror at D, close to the pole P.

(iv) After reflection, the ray passes through the focus F. The second paraxial ray BP incident at the pole P is reflected along PB′.

(v) The third paraxial ray BC passing through centre of curvature C, falls normally on the mirror at E is reflected back along the same path. The three reflected rays intersect at the point B′.

(vi) A perpendicular drawn as A′ B′ to the principal axis is the real, inverted image of the object AB.

(vii) As per law of reflection, the angle of incidence ∠BPA is equal to the angle of reflection ∠B′PA′.

(viii) The triangles ΔBPA and ΔB′PA′ are similar. Thus, from the rule of similar triangles,

$$\frac{A'B'}{AB} = \frac{PA'}{PA} \quad ...(1)$$

(ix) The other set of similar triangles are, ΔDPF and ΔB′A′ F. (PD is almost a straight vertical line)

$$\frac{A'B'}{PD} = \frac{A'F}{PF}$$

As, the distances PD = AB the above equation becomes,

$$\frac{A'B'}{AB} = \frac{PA'}{PA} \quad ...(2)$$

6. Two independent monochromatic sources cannot act as coherent sources, why?

Ans. (i) Two independent sources of light can't emit waves continuously.

(ii) The waves emitted by two sources do not have same phase or a constant phase difference.

7. Does diffraction take place at the Young's double slit?

Ans. (i) Yes. Diffraction occur in the double slit experiment.

(ii) The wavefront is diffracted as it passes through each of the slits.

(iii) The diffraction causes the wavefronts to spread out as if they are coming from light sources located at the slits.

(iv) These two wavefronts overlap and interference occurs.

8. Is there any difference between coloured light obtained from prism and colours of soap bubble?

Ans. (i) Colours are seen in a soap bubble which arises due to interference of light.

(ii) Interference occurs due to light reflection off the front of the thin soap film and back surface of thin soap films.

(iii) When beam of light passes through the prism, light is splitted into colours called dispersion. Colours of soap bubble is due to interference colours of light in prism is due to dispersion.

9. A small disc is placed in the path of the light from distance source. Will the center of the shadow be bright or dark?

Ans. (i) Wave diffracted from the edge of circular obstacle interfere constructive at the center of the shadow resulting in the formation of bright spot.

(ii) Centre of the shadow is bright due to diffraction

10. When a wave undergoes reflection at a denser medium, what happens to its phase?

Ans. When a wave undergoes a reflection at a denser medium then its rest reflected as through and vice versa. So its phase changes at 180°.

Numerical Problems:

1. An object is placed at a certain distance from a convex lens of focal length 20 cm. Find the distance of the object if the image obtained is magnified 4 times.

Solution :

Given data :

Focal length of convex lens = 20 cm = f

To find : Magnification $m = 4 = \frac{v}{u}$

Lens formula : $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{4u} - \frac{1}{u} = \frac{1}{20} \qquad \frac{1-4}{4u} = \frac{-3}{4u}$$

$$\frac{-3}{4u} = \frac{1}{20}$$

$$\Rightarrow \quad 4u = -60$$

$$\Rightarrow \quad u = \frac{-60}{4}$$

$$u = -15 \text{ cm}$$

2. A compound microscope has a magnification of 30. The focal length of eye piece is 5 cm. Assuming the final image to be at least distance of distinct vision, find the magnification produced by the objective.

Solution :

Given data :

Magnification of compound microscope $m = 30$

Focal length of eye piece f_e = 5 cm

Image distance D = 25 cm

To find :

Magnification of objective m_o = ?

Formula : Magnification $m = m_o m_e$

$$m = m_o\left(1 + \frac{D}{f_e}\right)$$

$$30 = m_o\left(1 + \frac{25}{5}\right)$$

$$\Rightarrow \quad m_o = 5$$

$$m_o = 5$$

OPTICS

ADDITIONAL QUESTIONS AND ANSWERS

CHOOSE THE CORRECT ANSWER 1 MARK

1. A light bulb is placed between two mirrors (plane) inclined at an angle of 60°. Number of images formed are

(a) 2 (b) 4
(c) 5 (d) 6 **[Ans. (c) 5]**

2. Two plane mirror are inclined at an angle of 72°.The number of images of a point object placed between them will be

(a) 2 (b) 3
(c) 4 (d) 5 **[Ans. (c) 4]**

3. To get three images of a single object, one should have two plane mirror at an angle of

(a) 30° (b) 60°
(c) 90° (d) 120°
[Ans. (c) 90°]

4. A man of length h requires a mirror of length at least equal to, to see his own complete image

(a) $\frac{h}{4}$ (b) $\frac{h}{3}$
(c) $\frac{h}{2}$ (d) h
[Ans. (c) $\frac{h}{2}$]

5. Two plane mirrors are at 45° to each other. If an object is placed between them than the number of images will be

(a) 5 (b) 9
(c) 7 (d) 8 **[Ans. (c) 7]**

6. An object is at a distance of 0.5 in front of a plane mirror. Distance between the object and image is

(a) 0.5 m (b) 1 m
(c) 7 (d) 8 **[Ans. (b) 1 m]**

7. A man runs towards a mirror at a speed 15 m/s. The speed of the image relative to the man is

(a) 15 ms^{-1} (b) 30 ms^{-1}
(c) 35 ms^{-1} (d) 20 ms^{-1}
[Ans. (b) 30 ms^{-1}]

8. The light reflected by plane mirror may form a real images.

(a) If the rays incident on the mirror are diverging
(b) If the rays incident on the mirror are converging
(c) If the object is placed very close to mirror
(d) Under no circumstance
[Ans. (b) If the rays incident on the mirror are converging]

9. A man is 180 cm tall and his eyes are 10 cm below the top of his head. In order to see his entire height right from toe to head, he uses a plane mirror kept at a distance of 1 m from him. The minimum length of the plane mirror required is

(a) 180 cm (b) 90 cm
(c) 85 cm (d) 170 cm
[Ans. (b) 90 cm]

10. A small object is placed 10 cm infront of a plane mirror. If you stand behind the object 30 cm from the object and look at its image, the distance foursed for your eye will be

(a) 60 cm (b) 20 cm
(c) 40 cm (d) 80 cm
[Ans. (c) 40 cm]

11. Two plane mirror are at right angles to each other. A man stands between them and combs hair with his right hand. In how many of the images will he be seen using his right hand.

(a) None (b) 1
(c) 2 (d) 3 **[Ans. (b) 1]**

12. A ray of light is incidenting normally on a plane mirror. The angle of reflection will be

(a) 0°
(b) 90°
(c) will not be reflected
(d) None of these **[Ans. (a) 0°]**

Assertion - Reason

Direction:

(a) Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) Assertion and Reason are true but Reason is the false explanation of the Assertion.

(c) Assertion is true but Reason is false.

(d) Assertion is false but Reason is true.

1. **Assertion :** Nicol prism is used to produce and analyse plane polarised light.

Reason : Nicol prism reduces the intensity of light to zero.

[*Ans.* (c) Assertion is true but Reason is false]

2. **Assertion :** The unpolarised light and polarised light can be distinguished from each other by using polaroid.

Reason : A polaroid is capable of producing plane polarised beams of light.

[*Ans.* (a) Assertion and Reason are correct and Reason is the correct explanation of Assertion]

Choose the correct statements

1. (I) The fringe width is inversely proportional to the distance between the two slits.

(II) In Young's experiment, the fringe width for dark fringes is different from that for white fringes.

(III) In Young's experiment, the width of each slit is about 0.05 mm.

(IV) In Young's experiment, the double slit S_1 and S_2 are separated by a distance of about 0.3 mm.

(a) I and II only (b) I and IV only

(c) I, II and III only (d) I, II, III and IV

[*Ans.* (b) I and IV only]

2. (I) Wavefront division used to produce two coherent sources.

(II) Destructive interference occurs at the centre of the shadow.

(III) Newton used a prism to produce dispersion.

(IV) Atmospheric particles changes the direction of the sunlight.

(a) I and II only (b) I, II and IV only

(c) I, II and III only (d) I, III and IV only

[*Ans.* (d) I, III and IV only]

Choose the incorrect statements

1. (a) Angular dispersion produced by a prism depends upon angle of the prism.

(b) Dispersive power is the ability of the material of the prism to cause dispersion.

(c) Dispersive power is a dimensionless quality.

(d) Dispersive power is always negative.

[*Ans.* (d) Dispersive power is always negative.]

2. (a) Blue colour of sky appears due to scattering of blue colour.

(b) Blue colour has shortest wave length in visible spectrum.

(c) A red colour scatters least.

(d) A red object appears dark in the yellow light.

[*Ans.* (c) A red colour scatters least.]

Very Short Answer 2 marks

1. What is reflection?

Ans. The bouncing back of light into the same medium when it encounters a reflecting surface is called **reflection of light**.

49. Images formed by totally reflected light are brighter than the images formed by ordinary reflected light. Why?

Ans. This is because, in total internal reflection, 100% of incident light gets reflected. On the other hand, in ordinary reflection. 20%-30% of incident light is lost. So, images formed in the first case are brighter than the images formed in the second case.

50. How does focal length of a lens change when red light is replaced by blue light?

Ans. $\frac{1}{f} = (\mu_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$. As $\mu_b > \mu_r$

51. A lens whose radii of curvature are different is forming the image of an object placed on its axis. If the surfaces of the lens facing the object and image are interchanged will the position of the image change?

Solution : No, we know that

$$\frac{1}{f} = (\mu_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

When we interchange R_1 and R_2 the value of f does not change except for the sign. So, the image will be formed at the same position.

SHORT ANSWER — 3 MARKS

1. Write the conditions for nature of objects and images.

Ans.

	Nature of object / image	Condition
1.	Real Image	Rays actually converge at the image.
2.	Virtual Image	Rays appear to diverge from the image.
3.	Real Object	Rays actually diverge from the object.
4.	Virtual Object	Rays appear to converge at the object.

2. What is principal axis of the mirror?

Ans. (i) The line joining the pole and the centre of curvature is called the **principal axis of the mirror**.

(ii) The light ray travelling along the principal axis towards the mirror after reflection travels back along the same principal axis. It is also called **optical axis**.

3. What is focus (or) focal point of a mirror?

Ans. (i) Light rays travelling parallel and close to the principal axis when incident on a spherical mirror, converge at a point for concave mirror or appear to diverge from a point for convex mirror on the principal axis.

(ii) This point is called the **focus** or **focal point** (F) of the mirror.

4. Write the difference between paraxial rays and marginal rays.

Ans.

Paraxial Rays	Marginal Rays
The rays travelling very close to the principal axis and make small angles with it are called **paraxial rays**.	the rays travelling far away from the principal axis and fall on the mirror far away from the pole are called as **marginal rays**.

5. Define refractive index of a medium.

Ans. Refractive index of a transparent medium is defined as the ratio of speed of light in vacuum (or air) to the speed of light in that medium.

refractive index n of a medium

$$= \frac{\text{speed of light in vacuum } (c)}{\text{speed of light in medium } (v)}$$

$$n = \frac{c}{v}$$

6. Write the conditions for obtaining clear and broad interference bands.

Ans. (i) The screen should be as far away from the source as possible.

(ii) The wavelength of light used must be larger.

(iii) The two coherent sources (here S_1 and S_2) must be as close as possible.

7. Discuss difraction at single slit and obtain the condition for n^{th} maxima.

Ans. (i) For points of maxima, the slit is to be divided in to odd number of equal parts so that one part remains un-cancelled making the point P appear bright.

The condition for first maximum is,

$$\frac{a}{3}\sin\theta = \frac{\lambda}{2} \text{ (or) } a\sin\theta = \frac{3\lambda}{2}$$

For $0 < |u| < f$

$\frac{1}{v} = \frac{1}{f} - \frac{1}{|u|} < 0$ i.e. $u < 0$

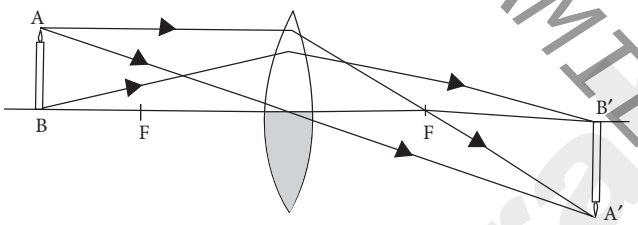
(image on left ; virtual)

Also for this case, $\frac{1}{|v|} < \frac{1}{|u|}$ i.e. $|u| < |v|$

(image enlarged)

13. The image of a candle is formed by a convex lens on a screen. The lower half of the lens is painted black to make it completely opaque. Draw the ray diagram to show the image formation. How will this image be different from the one obtained when the lens is not painted black?

Ans. The full size of the image will be obtained. But the intensity of image will be reduced. This is because the number of rays of light refracted through different parts of the lens will be reduced.

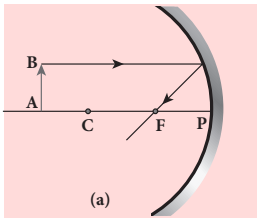


Long Answer 5 marks

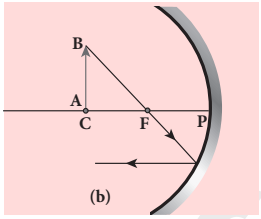
1. Draw and explain the image formation in spherical mirrors.

Ans. The image can be located by graphical construction. To locate the point of an image, a minimum of two rays must meet at that point.

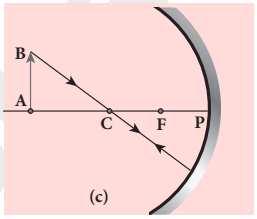
(i) A ray parallel to the principal axis after reflection will pass through or appear to pass through the principle focus. (Figure(a))



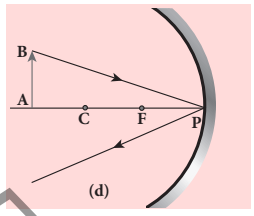
(ii) A ray passing through or appear to pass through the principal focus, after reflection will travel parallel to the principal axis. (Figure(b))



(iii) A ray passing through the centre of curvature retraces its path after reflection as it is a case of normal incidence. (Figure(c))



(iv) A ray falling on the pole will get reflected as per law of reflection keeping principal axis as the normal. (Figure(d))



2. Derive the equation for lateral magnification in spherical mirrors.

Ans. (i) The lateral or transverse magnification is defined as the ratio of the height of the image to the height of the object.

(ii) The height of the object and image are measured perpendicular to the principal axis.

$$\text{magnification } (m) = \frac{\text{height of the image } (h')}{\text{heigh of the object } (h)}$$

$$m = \frac{h'}{h}$$

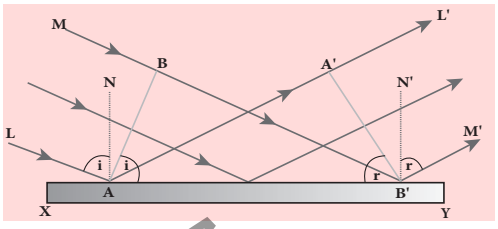
Applying proper sign conventions for equation (1),

$$\frac{A'B'}{AB} = \frac{PA'}{PA} \quad \ldots(1)$$

$A'B' = -h$, $AB = h$, $PA' = -v$, $PA = -u$

5. Prove the laws of reflection using Huygen's principle.

Ans. **(i)** Consider a parallel beam of light, incident on a reflecting plane surface such as a plane mirror XY as shown in Figure.



Laws of reflection

(ii) The incident wavefront is AB and the reflected wavefront is A′B′ in the same medium. These wavefronts are perpendicular to the incident rays L, M and reflected rays L′, M′ respectively.

(iii) By the time point A of the incident wavefront touches the reflecting surface, the point B is yet to travel a distance BB′ to touch the reflecting surface a B′.

(iv) When the point B falls on the reflecting surface at B′, the point A would have reached A′.

(v) This is applicable to all the points on the wavefront. Thus, the reflected wavefront A′B′ emanates as a plane wavefront. The two normals N and N′ are considered at the points where the rays L and M fall on the reflecting surface.

(vi) As reflection happens in the same medium, the speed of light is same before and after the reflection.

(vii) Hence, the time taken for the ray to travel from B to B′ is the same as the time taken for the ray to travel from A to A′.

(viii) Thus, the distance BB′ is equal to the distance AA′; (AA′ = BB′).

(a) The incident rays, the reflected rays and the normal are in the same plane.

(b) Angle of incidence, $\angle i = \angle NAL = 90^o - \angle NAB = \angle BAB'$

Angle of reflection,

$\angle r = \angle N' B' M' = 90^o - \angle N' B' A' = A' B' A'$

(ix) For the two right angle triangles, ΔABB′ and ΔB′ A′ A′, the right angles, ∠B and ∠A′ are equal, (∠B and ∠A = 90°); the two sides, AA′ and BB′ are equal, (AA′= BB′); the side AB′ is the common.

(x) Thus, the two triangles are congruent. As per the property of congruency, the two angles, ∠BAB′ and A′ B′ A′ must also be equal.

$$i = r$$

Hence, the laws of reflection are proved.

Numerical Problems

1. The focal length of an equiconvex lens is equal to the radius of curvature of either face. What is the value of refractive index of the material of the lens?

Solution :

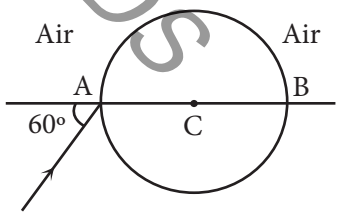
$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (\mu - 1)\left(\frac{2}{f}\right) \qquad \therefore f = R$$

$$\frac{1}{2} = (\mu - 1)$$

$$\mu = 1.5$$

2. A ray of light falls on a transparent sphere with centre C as shown in the figure. The ray emerges from the sphere paralled to the line AB. Find the angle of refraction at A if refraction index of the material of the sphere is $\sqrt{3}$.



Solution :

Formula : Refractive index, $\mu = \frac{\sin i}{\sin r}$

$$\sqrt{3} = \frac{\sin 60^o}{\sin r}$$

$$\sin r = \frac{\sqrt{3}}{2} \times \frac{1}{\sqrt{3}} = \frac{1}{2}$$

$$\sin r = \sin 30^o$$

$$\Rightarrow \quad r = 30^o$$

Angle of refraction = 30°.

If y be the vertical fall in time t, then

$$y = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \left(\frac{1}{3\times10^5}\right)^2 \quad m = 5.5 \times 10^{-11}\text{m}$$

This result is independent of the mass of the particle. As it is clear from the above result, the downward distance covered by the corpuscle is only 5.5×10^{-11} m for 103 m of horizontal distance covered by the corpuscle. So, we can neglect the effect of earth's gravitation and safely assume that the corpuscles travels along a straight line.

40. Light of wavelength 5000 Å falls on a plane reflecting surface. What are the wavelength and frequency of reflected light? For what angle of incidence is the reflected ray normal to the incident ray?

Ans. Reflection does not change wavelength.

Frequency remains unchanged both in reflection and refraction.

$$\therefore \lambda = 5000 \text{ Å} \text{ . Again, } \nu = \frac{c}{\lambda} = \frac{3\times10^8}{5000\times10^{-10}} \text{ Hz}$$

$$= 6 \times 1014 \text{ Hz}$$

Again $i = r$ and $i + r = 90^\circ$.

$\therefore i = 45^\circ$.

41. A telescope has an objective of diameter 60 cm. The focal lengths of the objective and eyepiece are 2.0 m and 1.0 cm respectively. The telescope is directed to view two distant almost point sources of light, (e.g., two stars of a binary). The sources are roughly at the same distance = (=10^4 light year) along the line of sight but are separated transverse to the line of sight by a distance of 1010 m. Will the telescope resolve the two objects i.e. will it see two distant stars?

Solution :

Data on focal lengths is not required. The limit of resolution of the telescope is given by

$$\theta = \frac{1.22\lambda}{D} = \frac{1.22 \times 6 \times 10^{-7}}{0.60} \text{ rad} = 1.22 \times 10^{-6} \text{ rad}$$

Here, the value of chosen corresponds roughly to the wavelength of yellow light.

The transverse separation between the two sources subtends an angle equal to

$$\frac{10^{10}\ m}{9.46\times10^{19}\ m} \approx 10^{-10} \text{ red.}$$

Here, we have used 1 light year = 9.46×10^{15} m

This angle is much too small compared to θ above. The two stars of the binary cannot be resolved by the given telescope.

☆☆☆

UNIT 7

DUAL NATURE OF RADIATION AND MATTER

CHAPTER SNAPSHOT

CONCEPT MAP

Dual nature of radiation and matter

- Electron emission
  - Thermionic emission
  - Field emission
  - Photoelectric emission
  - Secondary emission
- Photoelectric effect
  - Observations of Hertz, Hallwachs and Lenard
  - Effect of intensity
  - Effect of potential difference
  - Effect of frequency
  - Quantisation of energy
  - Einstein's photoelectric equation
  - Photocells and uses
- Matter waves
  - De Broglie hypothesis
  - De Broglie equation
  - De Broglie wavelength of election
  - Davission-Germer Experiment
  - Electron microscope
- X-rays
  - Introduction
  - Production of X-rays
  - X-ray spectra
  - Continuous X-ray spectra
  - Characteristic X-ray spectra
  - Applications

MUST KNOW DEFINITIONS

Particle	:	**Particle** is a material object which is considered as a tiny concentration of matter (localized in space and time) whereas wave is a broad distribution of energy (not localized in space and time).
Electron emission	:	The liberation of electrons from any surface of a substance is called **electron emission**.
Work function	:	The minimum energy needed for an electron to escape from the metal surface is called **work function** of that metal.
Thermionic emission	:	The emission of electrons by supplying thermal energy is known as **thermionic emission**.
Electric field emission	:	**Electric field emission** occurs when a very strong electric field is applied across the metal.
Photoelectric emission	:	The emission of electrons due to irradiation of light is called **photoelectric emission**.
Secondary emission	:	**Secondary emission** is the process in which electrons are emitted due to the bombardment of fast moving electrons.
Stopping potential	:	**Stopping potential** is that the value of the negative (retarding) potential given to the collecting electrode A which is just sufficient to stop the most energetic photoelectrons emitted and make the photocurrent zero.
Threshold frequency	:	For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called the **threshold frequency**.
Matter	:	According to Planck, a **matter** is composed of a large number of oscillating particles (atoms) which vibrate with different frequencies.
Photon	:	The individual light quantum of definite energy and momentum can be associated with a particle. This particle is named **photon**.
de Broglie waves	:	According to de Broglie hypothesis, all matter particles like electrons, protons, neutrons in motion are associated with waves. These waves are called **de Broglie waves** or matter waves.
Electron microscope	:	Wave nature of the electron is used in the construction of microscope called **electron microscope**.
x-ray	:	Whenever fast moving electrons fall on the materials, a highly penetrating radiation, **x-rays**, is emitted.
Continuous x-ray spectrum	:	**Continuous x-ray spectrum** consists of radiations of all possible wavelengths with a certain minimum wavelength λ_0.
Characteristic x-ray spectra	:	**Characteristic x-ray spectra** show some narrow peaks at some well – defined wavelengths when the target is hit by fast electrons.

EVALUATION

I. MULTIPLE CHOICE QUESTIONS:

1. The wavelength λ_e of an electron and λ_p of a photon of same energy E are related by *(NEET 2013)*

(a) $\lambda_p \propto \lambda_e$ (b) $\lambda_p \propto \sqrt{\lambda_e}$

(c) $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$ (d) $\lambda_p \propto \lambda_e^2$

[Ans. (d) $\lambda_p \propto \lambda_e^2$]

2. In an electron microscope, the electrons are accelerated by a voltage of 14 kV. If the voltage is changed to 224 kV, then the de Broglie wavelength associated with the electrons would

(a) increase by 2 times
(b) decrease by 2 times
(c) decrease by 4 times
(d) increase by 4 times

[Ans. (c) decrease by 4 times]

3. A particle of mass 3×10^{-6} g has the same wavelength as an electron moving with a velocity 6×10^6 ms^{-1}. The velocity of the particle is

(a) 1.82×10^{-18} ms^{-1} (b) 9×10^{-2} ms^{-1}
(c) 3×10^{-31} ms^{-1} (d) 1.82×10^{-15} ms^{-1}

[Ans. (d) 1.82×10^{-15} ms^{-1}]

4. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is *(NEET 2016)*

(a) 4λ (b) 5λ
(c) $\frac{5}{2}\lambda$ (d) 3λ

[Ans. (d) 3λ]

5. If a light of wavelength 330 nm is incident on a metal with work function 3.55 *e*V, the electrons are emitted. Then the wavelength of the emitted electron is (Take $h = 6.6 \times 10^{-34}$ Js)

(a) $< 2.75 \times 10^{-9}$m (b) $\geq 2.75 \times 10^{-9}$m
(c) $\leq 2.75 \times 10^{-12}$m (d) $< 2.5 \times 10^{-10}$m

[Ans. (b) $\geq 2.75 \times 10^{-9}$m]

6. A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and $\frac{\lambda}{2}$. If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function at the surface of material is *(NEET 2015)*

(a) $\frac{hc}{\lambda}$ (b) $\frac{2hc}{\lambda}$
(c) $\frac{hc}{3\lambda}$ (d) $\frac{hc}{2\lambda}$

[Ans. (d) $\frac{hc}{2\lambda}$]

7. In photoelectric emission, a radiation whose frequency is 4 times threshold frequency of a certain metal is incident on the metal. Then the maximum possible velocity of the emitted electron will be

(a) $\sqrt{\frac{hv_0}{m}}$ (b) $\sqrt{\frac{6hv_0}{m}}$
(c) $2\sqrt{\frac{hv_0}{m}}$ (d) $\sqrt{\frac{hv_0}{2m}}$

[Ans. (b) $\sqrt{\frac{6hv_0}{m}}$]

8. Two radiations with photon energies 0.9 eV and 3.3 eV respectively are falling on a metallic surface successively. If the work function of the metal is 0.6 eV, then the ratio of maximum speeds of emitted electrons will be

(a) 1:4 (b) 1:3
(c) 1:1 (d) 1:9

[Ans. (b) 1:3]

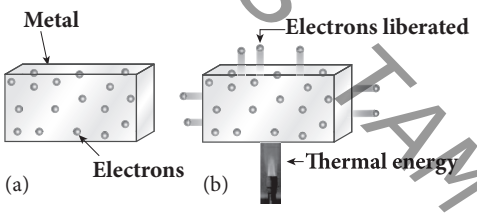
III. Long Answer Questions :

1. What do you mean by electron emission? Explain briefly various methods of electron emission.

Ans. The liberation of electrons from any surface of a substance is called **electron emission**.

(a) Thermionic emission :

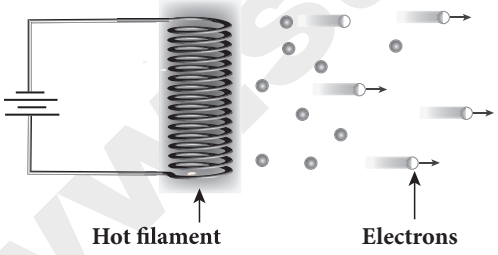
(i) When a metal is heated to a high temperature, the free electrons on the surface of the metal get sufficient energy in the form of thermal energy so that they are emitted from the metallic surface. This type of emission is known as **thermionic emission**.



Electrons in the (a) metal
(b) heated metal

(ii) The intensity of the thermionic emission (the number of electrons emitted) depends on the metal used and its temperature.

(iii) Examples: cathode ray tubes, electron microscopes, X-ray tubes etc.



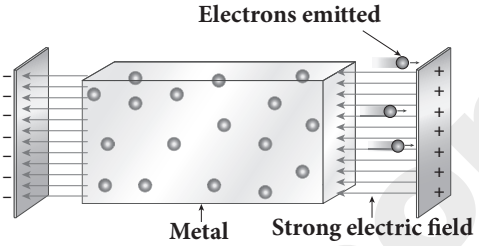
Thermionic emission from hot filament of cathode ray tube or X-ray tube

(b) Field emission :

(i) Electric field emission occurs when a very strong electric field is applied across the metal.

(ii) This strong field pulls the free electrons and helps them to overcome the surface barrier of the metal.

(iii) Ex.: Field emission scanning electron microscopes, Field-emission display etc.



Field emission

(c) Photo electric emission :

(i) When an electromagnetic radiation of suitable frequency is incident on the surface of the metal, the energy is transferred from the radiation to the free electrons.

(ii) Hence, the free electrons get sufficient energy to cross the surface barrier and the photo electric emission takes place.

(iii) The number of electrons emitted depends on the intensity of the incident radiation.

(iv) Examples: Photo diodes, photo electric cells etc.

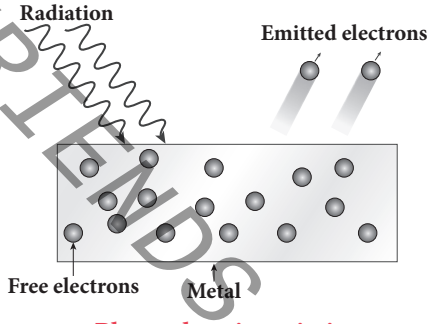


Photo electric emission

(d) Secondary emission :

(i) When a beam of fast moving electrons strikes the surface of the metal, the kinetic energy of the striking electrons is transferred to the free electrons on the metal surface.

(ii) Thus the free electrons get sufficient kinetic energy so that the secondary emission of electron occurs.

(iii) Examples: Image intensifiers, photo multiplier tubes etc.

(viii) Figure shows the variation of intensity of the scattered electrons with the angle θ for the accelerating voltage of 54V. For a given accelerating voltage V, the scattered wave shows a peak or maximum at an angle of 50° to the incident electron beam.

(ix) This peak in intensity is attributed to the constructive interference of electrons diffracted from various atomic layers of the target material.

(x) From the known value of interplanar spacing of Nickel, the wavelength of the electron wave has been experimentally calculated as 1.65Å.

(xi) The wavelength can also be calculated from de Broglie relation for V = 54 V from equation as

$$\lambda = \frac{12.27}{\sqrt{V}}\text{ Å} = \frac{12.27}{\sqrt{54}}$$

$$\lambda = 1.67\text{ Å}$$

(xii) This value agrees well with the experimentally observed wavelength of 1.65Å. Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles.

IV. Numerical Problems:

1. How many photons per second emanate from a 50 mW laser of 640 nm?

Solution :

Given data:

Wavelength of the laser = 640 nm

$\lambda = 640 \times 10^{-9}$ m

Power of laser P = 50 mw $= 50 \times 10^{-3}$ w

To find :

No. of photons emitted per second N = ?

The energy of a photon E $= h\nu = \frac{hc}{\lambda}$

c - velocity of light $= 3 \times 10^8$ ms^{-1}

h - planck constant = 6.626×10^{-34} Js.

P = no. of photons emitted per second × energy of one photon.

$P = NE$

$$N = \frac{P}{E}$$

$$= \frac{50\times10^{-3}\times640\times10^{-9}}{6.626\times10^{-34}\times3\times10^{8}} = \frac{32000\times10^{-12}}{19.878\times10^{-26}}$$

$$N = 1609.8 \times 10^{14}\ s^{-1}$$

No. of protons emitted per second = **1.61×10^{17} s^{-1}**

2. Calculate the maximum kinetic energy and maximum velocity of the photoelectrons emitted when the stopping potential is 81V for the photoelectric emission experiment.

Solution :

Given data:

Stopping potential $V_0 = 81$ V

To find :

Maximum Kinetic Energy = ?

Maximum velocity of photoelectrons emitted V_{max} = ?

(i) $eV_0 = \frac{1}{2} m v^2_{max}$ = Kinetic Energy$_{max}$

e - charge of the electron = 1.6×10^{-19} C

K.E.$_{max} = eV_0 = 1.6 \times 10^{-19} \times 81$

$= 129.6 \times 10^{-19}$ J

Kinetic Energy$_{max}$ = **1.3×10^{-17} J**

(ii) Maximum velocity $v^2_{max} = \frac{2eV_0}{m}$

$$\therefore v_{max} = \sqrt{\frac{2eV_0}{m}}$$

m - mass of the e$^-$ = 9.1×10^{-31}

$$v_{max} = \sqrt{\frac{2\times1.3\times10^{-17}}{9.1\times10^{-31}}} = \sqrt{0.2857\times10^{14}}$$

$$= \sqrt{28.57\times10^{12}}$$

v_{max} = **5.3×10^6 ms^{-1}**

3. Calculate the energies of the photons associated with the following radiation: (i) violet light of 413 nm (ii) X-rays of 0.1 nm (iii) radio waves of 10 m.

Solution :

Given data :

(i) Wavelength of violet light $\lambda_v = 413$ nm $= 413 \times 10^{-9}$ m

(ii) Wavelength of X-rays $\lambda_x = 0.1$ nm $= 0.1 \times 10^{-9}$ m

(iii) Wavelength of radio waves $\lambda_r = 10$ m

Energy of the photons associated with the radiation E = ?

ADDITIONAL QUESTIONS AND ANSWERS

CHOOSE THE CORRECT ANSWER 1 MARK

1. **P and E denote the linear momentum and energy of a photon. If the wavelength is decreased.**

(a) Both P and E increase
(b) P increases and E decreases
(c) P decreases and E increases
(d) both P & E decrease

[Ans. (a) Both P and E increase]

2. **The work function of a metal is hv_0. Light of frequency v falls on this metal. The photoelectric effect will take place only if**

(a) $v < v_0$ (b) $v > 2v_0$
(c) $v < v_0$ (d) $v > v_0/2$

[Ans. (a) $v > v_0$]

3. **When stopping potential is applied in an experiment on photoelectric effect, no photocurrent is observed. This means that,**

(a) The emission of photoelectrons is stopped
(b) The photoelectrons are emitted but are reabsorbed by the emitter metal
(c) The photo electrons are accumulated near the collector plate
(d) The photoelectrons are dispersed from the sides of the apparatus.

[Ans. (b) The photoelectrons are emitted but are reabsorbed by the emitter metal]

4. **If the frequency of light in a photoelectron experiment is doubled the stopping potential will**

(a) be doubled (b) be halved
(c) become more than double
(d) become less than double.

[Ans. (c) become more than double]

5. **Light of wavelength falls on a metal having work function $\frac{h_c}{\lambda_0}$. Photoelectric effect will place only if**

(a) $\lambda \geq \lambda_0$ (b) $\lambda \geq 2\lambda_0$
(c) $\lambda \leq \lambda_0$ (d) $\lambda < \lambda_0/2$.

[Ans. (c) $\lambda \leq \lambda_0$]

6. **When the intensity of a light source is increased**

(a) the number of photons emitted by the source in unit time increases
(b) more energetic photons are emitted
(c) faster photons are emitted
(d) total energy of the photons emitted per unit time decreases.

[Ans. (a) the number of photons emitted by the source in unit time increases]

7. **Photoelectron effect supports quantum nature of light because**

(a) there is a minimum frequency which no photo electrons are emitted
(b) the maximum kinetic energy of photo electrons depends only one the frequency of light and not in intensity
(c) even when the metal surface is faintly illuminated the photoelectrons leave the surface immedietly
(d) All the above. **[Ans. (d) All the above]**

8. **A photon of energy hv is absorbed by a free electrons of a metal having work function $\phi < hv$**

(a) The electron is sure to come out
(b) The electron is sure to come out with a kinetic energy $\phi < hv$
(c) Either the electron does not come out or it comes out with kinetic energy $h\nu - \phi$
(d) It may come out with a kinetic energy less than $h\nu - \phi$ **[Ans. (d) It may come out with a kinetic energy less than $hv - \phi$]**

9. **If the wavelength of light in an expt on photoelectric effect is doubled**

(a) the photoelectric emission will not take place
(b) the photoelectric emission may not take place
(c) the stopping potential will increase
(d) the stopping potential will decrease

[Ans. (d) the stopping potential will decrease]

Assertion - Reason

Direction:

(a) Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) Assertion and Reason are true but Reason is the false explanation of the Assertion.

(c) Assertion is true but Reason is false.

(d) Assertion is false but Reason is true.

1. **Assertion :** Electromagnetic radiations are regarded as waves.

Reason : Because they exhibit interference, diffraction and polarization under some suitable circumstances.

[*Ans.* (a) Assertion and Reason are correct and Reason is the correct explanation of Assertion]

2. **Assertion :** Thermionic emission occurs in metals when they are heated to a very high temperature.

Reason : Electrons emitted due to the electromagnetic radiation.

[*Ans.* (c) Assertion is true but Reason is false]

Choose the correct statements

1. (I) Cadmium show photoelectric emission for ultraviolet light.

(II) Photosensitive materials eject photo electrons

(III) The photocurrent becomes zero at a particular negative potential

(IV) The liberation of electrons from any surface of a substance is electron emission.

(a) I, II, III and IV (b) I and II only

(c) I and III only (d) I, II and III only

[*Ans.* (a) I, II, III and IV]

2. (I) Metal selected for electron emission should have low work function.

(II) Potential barrier presents leaving free electron from the metallic surface

(III) Potential barrier created by the positive nuclei of the metal

(IV) Electron in the outermost shells are tightly pound to the nucleus.

(a) I and II only (b) II and III only

(c) I, II and III only (d) I, II, III and IV

[*Ans.* (c) I, II and III only]

Choose the Incorrect statements

1. (a) Photo cells are used for reproduction of sound in motion picture.

(b) Photo cells used as times to measure the speeds of athletes during a race.

(c) Photo cell converts light energy into thermal energy

(d) Photo cells used to measure the interncity of the light in photography.

[*Ans.* (c) Photo cell converts light energy into thermal energy]

2. (a) The threshold frequency of photoelectric effect supports the particle nature of sunlight.

(b) The specific charge of positive rays is constant.

(c) Photosensitive of a metal is high of its work function is small

(d) The stopping potential is independent of intensity of the incident light.

[*Ans.* (b) The specific charge of positive rays is constant.]

Very Short Answer — 2 marks

1. What is meant by surface barrier?

Ans. **(i)** To leave the metallic surface, the free electrons must cross a potential barrier created by the positive nuclei of the metal.

(ii) The potential barrier which prevents free electrons from leaving the metallic surface is called **surface barrier**.

2. Give example for photosensitive materials. Why is called so?

Ans. **(i)** Metals like cadmium, zinc, magnesium, alkali metals lithium, sodium, caesium respond to visible light.

(ii) The materials which eject photoelectrons upon irradiation of electromagnetic wave of suitable wavelength are called **photosensitive materials**.

18. Does the stopping potential in photoelectric emission depend upon

(i) the intensity of the incident radiation in a photocell?

(ii) the frequency of the incident radiation?

Ans. (i) No,

(ii) Yes, stopping potential increases with increases of frequency.

19. Ultraviolet light is incident on two photosensitive materials having work functions W_1 and W_2 ($W_1 > W_2$). In which case will the kinetic energy of the emitted electrons be greater? Why?

Ans. From Einstein's photoelectric equation hv = W + Ek

$$E_k = h\nu - W$$

Clearly, smaller the work function, greater is the K.E. As $W_1 > W_2$, K.E for metal of work function W_2 will be greater.

20. With what purpose was famous Davisson-Germer experiment with electrons performed?

Ans. Davisson-Germer experiment was performed to verify wave nature of electrons. It is the first experimental evidence for wave nature of matter.

21. If the potential difference used to accelerate electrons is tripled, by what factor does de Broglie wavelength of electrons beam change?

Ans. de Broglie wavelength of electrons accelerated through a potential difference of V volts is

$$\lambda = \frac{h}{\sqrt{2mqV}}$$

When accelerating voltage V is tripled, the de Broglie wavelength becomes $\frac{1}{\sqrt{3}}$ times.

22. Which of the two :

(i) light or

(ii) moving material particle is concerned with de-Broglie hypothesis?

Ans. Moving material particle is concerned with de Broglie hypothesis.

23. A proton and a deuteron have the same velocity, what is the ratio of their de Broglie wavelengths?

Ans. de Broglie wavelength $\lambda = \frac{P}{m} \propto \frac{1}{m}$ for the same velocity v.

$$\frac{\lambda_p}{\lambda_d} = \frac{m_d}{m_p} = \frac{2m_p}{m_p} = \frac{2}{1} = 2.1.$$

24. If the intensity of light falling on a metal plate is doubled, what will be the effect on photocurrent and maximum kinetic energy of emitted photoelectrons?

Ans. As photocurrent is proportional to intensity of incident light, the photocurrent will be doubled; but the maximum kinetic energy of emitted photoelectrons does not depend upon the intensity of incident light; hence the maximum kinetic energy remains unchanged.

25. If the potential difference used to accelerate electrons is tripled, by what factor does the de Broglie wavelength of the electron beam change?

Ans. $\lambda = \frac{h}{\sqrt{2mqV}}$; $\lambda' = \frac{h}{\sqrt{3 \times 2meV}}$;

$\frac{\lambda'}{\lambda} = \frac{1}{\sqrt{3}}$ or $\frac{\lambda}{\sqrt{3}}$

26. The de Broglie wavelength associated with an electron accelerated through a potential difference V is λ. What will be its wavelength when the accelerating potential is increased to 4V?

Ans. $\lambda = \frac{h}{\sqrt{2mqV}}$; $\lambda' = \frac{h}{\sqrt{2me(4V)}} = \frac{\lambda}{2}$

SHORT ANSWER — 3 MARKS

1. Derive an expression for De Broglie wave length.

Ans. (i) The momentum of photon of frequency ν is given by

$$p = \frac{h\nu}{c} = \frac{h}{\lambda}$$

(ii) The wavelength of a photon in terms of its momentum is

$$\lambda = \frac{h}{p}$$

Reason : de Broglie wavelength associated with electron is

$$\lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{V}}$$

Obviously when accelerating potential becomes 4 V, the de-Broglie wavelength reduces to half.

14. Red light however bright it is, cannot produce the emission of electrons from a clean zinc surface, but even weak ultraviolet radiation can do so; why?

Ans. (i) The photoemission of electrons does not depend on the intensity but it depends on the frequency and hence on the energy of photon of incident light.

(ii) If the energy of photon is greater than the work function, the photoemission of electrons results however weak the incident radiation may be.

(iii) The energy of photon of red light is less than the work function of zinc, so red light cannot emit photoelectrons.

(iv) The energy of photon of ultraviolet light is greater than the work function of zinc, so ultraviolet light can emit photoelectrons.

LONG ANSWER 5 MARKS

1. Write the characteristics of photons.

Ans. (i) The photons of light of frequency ν and wavelength λ will have energy, given by

$$E = h\nu = \frac{hc}{\lambda}$$

(ii) The energy of a photon is determined by the frequency of the radiation and not by its intensity and the intensity has no relation with the energy of the individual photons in the beam.

(iii) The photons travel with the velocity of light and its momentum is given by

$$p = \frac{h}{\lambda} = \frac{h\nu}{c}$$

(iv) Since photons are electrically neutral, they are unaffected by electric and magnetic fields.

(v) When a photon interacts with matter (photon-electron collision), the total energy, total linear momentum and angular momentum are conserved. Since photon may be absorbed or a new photon may be produced in such interactions, the number of photons may not be conserved.

2. Write the application of photo cells.

Ans. (i) Photo cells are used as switches and sensors.

(ii) Automatic lights that turn on when it gets dark use photocells.

(iii) Street lights that switch on and off according to whether it is night or day.

(iv) Photo cells are used for reproduction of sound in motion pictures.

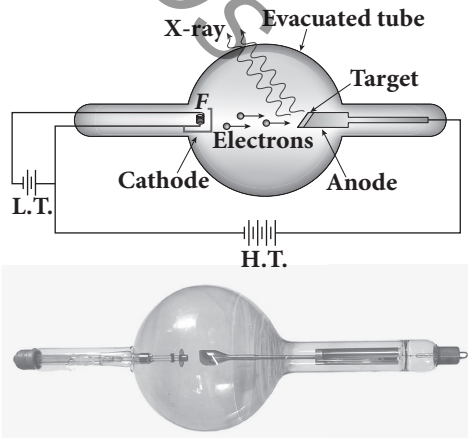
(v) Used as timers to measure the speeds of athletes during a race.

(vi) Photo cells of exposure meters in photography are used to measure the intensity of the given light and to calculate the exact time of exposure.

3. Explain the production of x-rays.

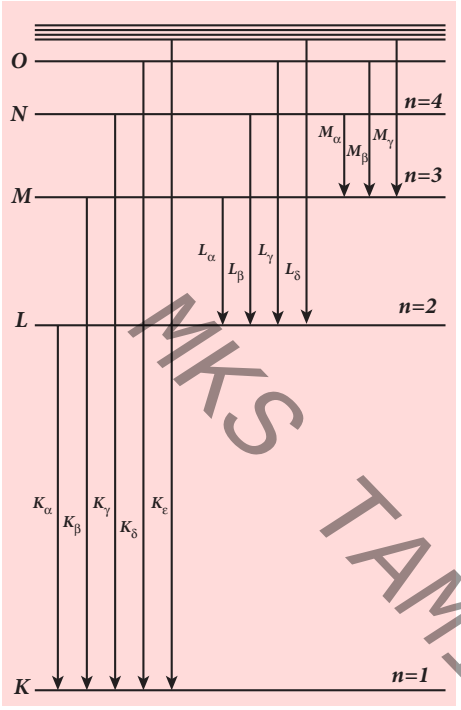
Ans. (i) X-rays are produced in x-ray tube which is essentially a discharge tube.

(ii) A tungsten filament F is heated to incandescence by a battery. As a result, electrons are emitted from it by thermionic emission.



Production of x-rays

(v) During the downward transition, the energy difference between the levels is given out in the form of x– ray photon of definite wavelength.



Origin of characteristic x-ray spectra

(vi) Such wavelengths, characteristic of the target, constitute the line spectrum.

(vii) It is evident that K-series of lines in the x-ray spectrum of an element arises due to the electronic transitions from L, M, N, . . levels to the K-level. Similarly, the longer wavelength L-series originates when an L-electron is knocked out of the atom and the corresponding vacancy is filled by the electronic transitions from M, N, O,... and so on.

(viii) The K_α and K_β of the K-series of molybdenum are shown by the two peaks in its x-ray spectrum.

6. Write the application of x-rays

Ans. X-rays are being used in many fields. Let us list a few of them.

(i) **Medical diagnosis** X-rays can pass through flesh more easily than through bones. Thus an x-ray radiograph containing a deep shadow of the bones and a light shadow of the flesh may be obtained. X-ray radiographs are used to detect fractures, foreign bodies, diseased organs etc.

(ii) **Medical therapy** Since x-rays can kill diseased tissues, they are employed to cure skin diseases, malignant tumours etc.

(iii) **Industry** X-rays are used to check for flaws in welded joints, motor tyres, tennis balls and wood. At the custom post, they are used for detection of contraband goods.

(iv) **Scientific research** X-ray diffraction is important tool to study the structure of the crystalline materials – that is, the arrangement of atoms and molecules in crystals.

Numerical Problems

1. Determine the distance of closed approach when an alpha particle of kinetic energy 4.5MeV strikes a nucleus of Z = 80, stops and reverses its direction.

Solution :

Let r be the center to centre distance between the alpha particle and the nucleus (Z = 80). When the alpha particle is at the stopping point, then

$$K = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(2e)}{r}$$

$$(\text{or}) \; r = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2Ze^2}{K}$$

$$= \frac{9\times10^9\times2\times80e^2}{4.5\text{ MeV}}$$

$$= \frac{9\times10^9\times2\times80\times\left(1.6\times10^{-19}\right)^2}{4.5\times10^6\times1.6\times10^{-19}\text{ J}}$$

$$= \frac{9\times160\times16}{4.5}\times10^{-16} = 512\times10^{-16}\text{m}$$

$$= 5.12\times10^{-14}\text{ m.}$$

2. A 12.3 eV electron beam is used to bombard gaseous hydrogen at room temperature. Upto which energy level the hydrogen atoms would be excited?

Calculate the wavelengths of the second member of Lyman series and second member of Balmer series.

Solution :

The energy of electron in the n^{th} orbit of hydrogen atom is

$$E_n = -\frac{13.6}{n^2}\text{ eV}$$

40. **(a) Define the term 'intensity of radiation' in terms of photon picture of light.**

(b) Two monochromatic beams, one red and the other blue, have the same intensity. In which case (i) the number of photons per unit area per second is larger, (ii) the maximum kinetic energy of the photoelectrons is more? Justify you answer.

Ans. **(a)** The number of photons incident normally per unit area per unit time in determined the intensity of radiations.

(b) **(i)** Red light, because the energy of red light is less than that of blue light $(h\nu)_R < (h\nu)_B$

(ii) Blue light, because the energy of blue light is greater than the of red light $(h\nu)_B > (h\nu)_R$

41. **When an electron in hydrogen atom jumps from the third excited state to the ground state how would the de Broglie wavelength associated with the electron change? Justify your answer.**

Solution :

de Broglie wavelength associated with a moving charge particle having a KE. 'K can be given as

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} \qquad ...(1)$$

$$\left[K = \frac{1}{2}m\nu^2 = \frac{p^2}{2m}\right]$$

The kinetic energy of the electron in any orbit of hydrogen atom can be given as

$$K = -E = -\left(\frac{13.6}{n^2}eV\right) = \frac{13.6}{n^2} \qquad ...(2)$$

Let K_1 and K_4 be the KE of the electron in ground state and third excited state, where $n_1 = 1$ show ground state and $n_2 = 4$ shows third excited state.

Using the concept of equation (1) & (2), we have

$$\frac{\lambda_1}{\lambda_4} = \sqrt{\frac{K_4}{K_1}} = \sqrt{\frac{n_1^2}{n_2^2}}$$

$$\frac{\lambda_1}{\lambda_4} = \sqrt{\frac{1^2}{4^2}} = \frac{1}{4} \qquad \Rightarrow \lambda_1 = \frac{\lambda_4}{4}$$

i.e. the wavelength in the ground state will decrease.

42. **An electron and a proton, each have de Broglie wavelength of 1.00 nm.**

(a) Find the ratio of their momenta.

(b) Compare the kinetic energy of the proton with that of the electron.

Solution :

(a) $\lambda_e = \frac{h}{p_e}$ and $\lambda_p = \frac{h}{p_p}$, $\lambda_e = \lambda_p = 1.00$ nm

So, $\frac{\lambda_e}{\lambda_p} = \frac{p_p}{p_e} = \frac{1}{1} \Rightarrow \frac{p_p}{p_e} = \frac{1}{1} = \mathbf{1 : 1}$

(b) From relation $K = \frac{1}{2}m\upsilon^2 = \frac{p^2}{2m}$

$$K_e = \frac{p_e^2}{2m_e} \text{ and } K_p = \frac{p_p^2}{2m_p}$$

$$\frac{K_p}{K_e} = \frac{p_p^2}{2m_p} \times \frac{2m_e}{p_e^2} = \frac{m_e}{m_p}$$

Since $m_e <<< m_p$, So $K_p <<< K_e$.

$$\frac{K_p}{K_e} = \frac{9.1\times10^{-31}}{1.67\times10^{-27}}$$

$$= \mathbf{5.4 \times 10^{-4}}$$

43. **Write briefly the underlying principle used in Davision - Germer experiment to verify wave nature of electrons experimentally. What is the de-Broglie wavelength of an electron with kinetic energy (KE) 120 eV?**

Solution :

Diffraction effects are observed for beams of electrons scattered by the crystals.

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}} = \frac{h}{\sqrt{2meV}}$$

$$= \frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times120}}$$

$$\lambda = \mathbf{0.112 \text{ nm}}$$

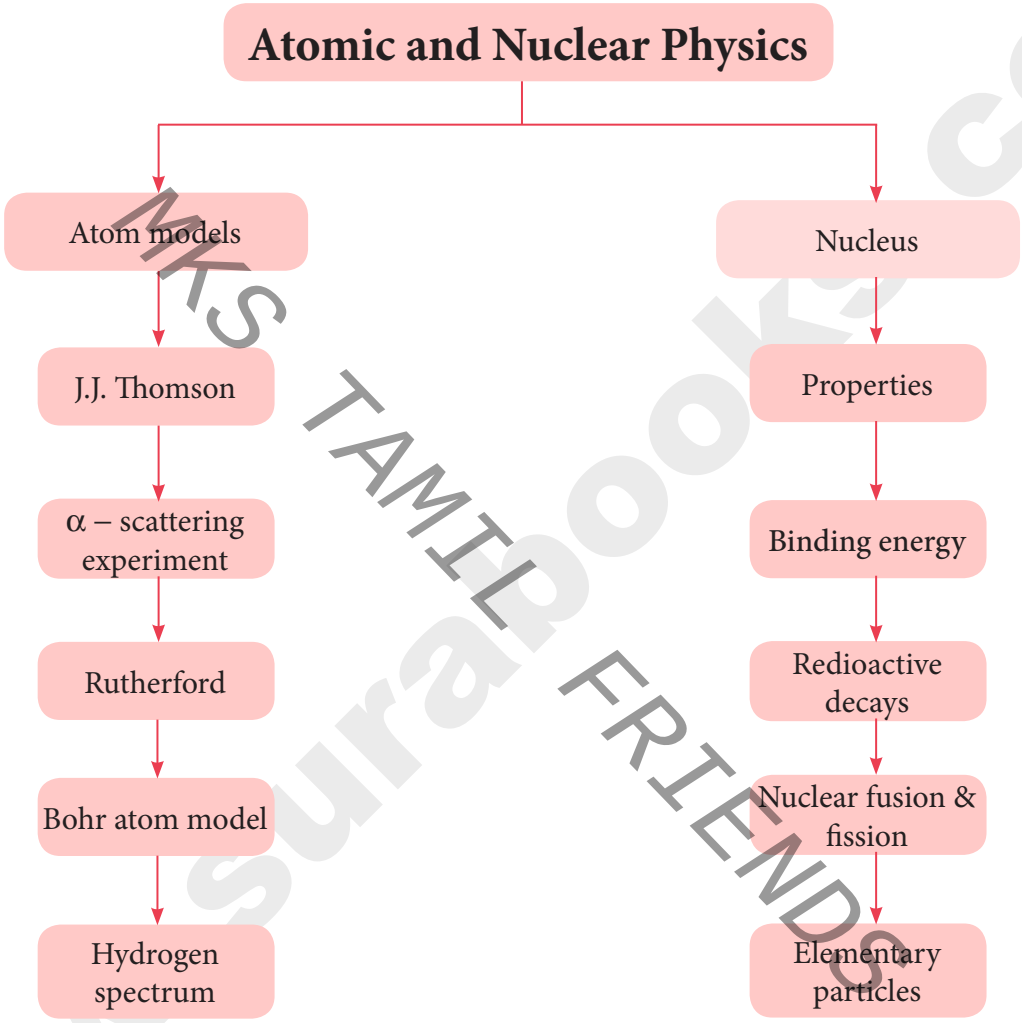
☆☆☆

UNIT 8

ATOMIC AND NUCLEAR PHYSICS

CHAPTER SNAPSHOT

CONCEPT MAP



MUST KNOW DEFINITIONS

Gas discharge tube : A device used to study the conduction of electricity through gases is known as **gas discharge tube**.

Normalized charge : Charge per unit mass is known as **specific charge** or **normalized charge**.

Large distance : The impact parameter is defined as the perpendicular distance between the centre of the gold nucleus and the direction of velocity vector of alpha particle when it is at a large distance.

Excitation potential : The energy required to excite an electron from the lower energy state to any higher energy state is known as **excitation energy** and corresponding potential supplied is known as **excitation potential**.

Ionization potential : The potential difference through which an electron should be accelerated to get ionization energy is known as **ionization potential**.

Ionization Energy : The minimum energy required to remove an electron from an atom which is in ground state is known as **ionization energy**.

Nuclear fission : If a heavier nucleus decays into lighter nuclei, it is called **nuclear fission**.

Nuclear fusion : If two lighter nuclei fuse to heavier nuclei, it is called **nuclear fusion**.

EVALUATION

I. MULTIPLE CHOICE QUESTIONS :

1. Suppose an alpha particle accelerated by a potential of V volt is allowed to collide with a nucleus whose atomic number is Z, then the distance of closest approach of alpha particle to the nucleus is

(a) $14.4 \frac{Z}{V}$ Å (b) $14.4 \frac{V}{Z}$ Å

(c) $1.44 \frac{Z}{V}$ Å (d) $1.44 \frac{V}{Z}$ Å

[**Ans.** (c) $1.44 \frac{Z}{V}$ Å]

2. In a hydrogen atom, the electron revolving in the fourth orbit, has angular momentum equal to

(a) h (b) $\frac{h}{\pi}$

(c) $\frac{4h}{\pi}$ (d) $\frac{2h}{\pi}$

[**Ans.** (d) $\frac{2h}{\pi}$]

3. Atomic number of H-like atom with ionization potential 122.4 V for $n = 1$ is

(a) 1 (b) 2

(c) 3 (d) 4 [**Ans.** (c) 3]

4. The ratio between the first three orbits of hydrogen atom is

(a) 1:2:3 (b) 2:4:6

(c) 1:4:9 (d) 1:3:5

[**Ans.** (c) 1:4:9]

5. The charge of cathode rays is

(a) positive (b) negative

(c) neutral (d) not defined

[**Ans.** (b) negative]

II. Short Answer Questions :

1. What are cathode rays?

Ans. A cathode ray is a beam of electrons in a discharge tube travelling from cathode to anode at a present of 0.01 mm of Hg across a voltage difference between the electrodes.

2. Write the properties of cathode rays.

Ans. (i) Cathode rays possess energy and momentum and travel in a straight line with high speed of the order of 10^7m s^{-1}. It can be deflected by application of electric and magnetic fields. The direction of deflection indicates that they are negatively charged particles.

(ii) When the cathode rays are allowed to fall on matter, they produce heat. They affect the photographic plates and also produce fluorescence when they fall on certain crystals and minerals.

(iii) When the cathode rays fall on a material of high atomic weight, x-rays are produced.

(iv) Cathode rays ionize the gas through which they pass.

(v) The speed of cathode rays is up to $\left(\frac{1}{10}\right)^{th}$ of the speed of light.

3. Give the results of Rutherford alpha scattering experiment.

Ans. (i) An atom has a lot of empty space and contains a tiny matter known as nucleus whose size is of the order of 10^{-14}m.

(ii) The nucleus is positively charged and most of the mass of the atom is concentrated in nucleus.

(iii) The nucleus is surrounded by negatively charged electrons.

(iv) The electrons are not at rest and they revolve around the nucleus in circular orbits.

4. Write down the postulates of Bohr atom model.

Ans. (i) The electron in an atom moves around nucleus in circular orbits under the influence of Coulomb electrostatic force of attraction. This Coulomb force gives necessary centripetal force for the electron to undergo circular motion.

(ii) Electrons in an atom revolve around the nucleus only in certain discrete orbits called **stationary orbits** where it does not radiate electromagnetic energy. Only those discrete orbits allowed are stable orbits.

5. What is meant by excitation energy?

Ans. The energy required to excite an electron from lower energy state to any higher energy state is known as **excitation energy**.

6. Define the ionization energy and ionization potential.

Ans. (i) **Ionization energy :** The minimum energy required to remove an electron from an atom in the ground state is known as **binding energy** or ionization energy.

(ii) **Ionization potential :** The potential difference through which an electron should be accelerated to get ionization energy is known as ionization potential.

7. Write down the draw backs of Bohr atom model.

Ans. (i) Bohr atom model is valid only for hydrogen atom or hydrogen like-atoms but not for complex atoms.

(ii) When the spectral lines are closely examined, individual lines of hydrogen spectrum is accompanied by a number of faint lines. These are often called **fine structure.** This is not explained by Bohr atom model.

(iii) Bohr atom model fails to explain the intensity variations in the spectral lines.

(iv) The distribution of electrons in atoms is not completely explained by Bohr atom model.

8. What is distance of closest approach?

Ans. The minimum distance between the centre of the nucleus and the alpha particle just before it gets reflected back through 180° is defined as the **distance of closest approach** r_0 (also known as **contact distance**).

(ii) β - decay is represented by :

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + e^{-} + \bar{\nu}$$

It implies that the element X becomes Y by giving out an electron and antineutrino.

(iii) The gamma decay is given by :

$${}^{A}_{Z}X^{*} \rightarrow {}^{A}_{Z}X + \text{gamma } (\gamma) \text{ rays}$$

In gamma decay, there is no change in the mass number or atomic number of the nucleus.

22. In alpha decay, why the unstable nucleus emits ${}^{4}_{2}He$ nucleus? Why it does not emit four separate nucleons?

Ans. **(i)** The unstable nucleus is composed of many neutrons (no charge) and protons (possitive charge).

(ii) According to electromagnetic forces, like charges repelect unstable nuclei will loose neutrons and protons when α-particle is emitted, reducing the size of the nucleus.

(iii) In this decay, the change in B.E. appears as the kinetic energy of the α - particle and the daughter nucleus.

(iv) Therefore this energy must be shared between these two particles and therefore the particle and daughter nucleus must have equal and opposite momenta, the emitted α - particle and recoiling nucleus will each have a well defined energy after the decay.

(v) Because of its smaller mass, most of the kinetic energy goes to the α - particle.

23. What is mean life of nucleus? Give the expression.

Ans. The mean life time of the nucleus is the ratio of sum or integration of life times of all nuclei to the total number nuclei present initially.

$$\tau = \frac{1}{\lambda}$$

24. What is half-life of nucleus? Give the expression.

Ans. The half-life $T_{1/2}$ is the time required for the number of atoms initially present to reduce to one half of the initial amount.

$$T_{1/2} = \frac{1n2}{\lambda} = \frac{0.6931}{\lambda}$$

25. What is meant by activity or decay rate? Give its unit.

Ans. **(i)** **Activity (R)** or **decay rate** which is defined as the number of nuclei decayed per second and it is denoted as

$$R = \left|\frac{dN}{dt}\right|$$

(ii) The SI unit of activity R is Becquerel and one Becquerel (Bq) is equal to one decay per second. Another standard unit for the activity called Curie(Ci). 1 Curie =1 Ci $=3.7 \times 10^{10}$ decays per second

1 Ci $= 3.7 \times 10^{10}$ Bq.

26. Define curie.

Ans. One curie was defined as number of decays per second in 1 g of radium and it is equal to 3.7×10^{10} decays/s.

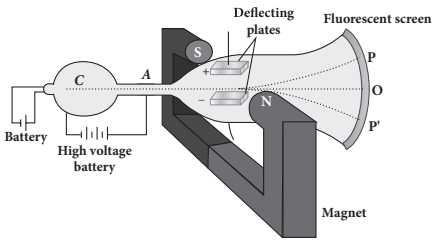
27. What are the constituent particles of neutron and proton?

Ans. Neutrons and protons are made up of quarks. Proton is made up of two up quarks and one down quark and neutron is made up of one up quark and two down quarks

III. Long Answer Questions :

1. Explain the J.J. Thomson experiment to determine the specific charge of electron.

Ans. **Principle :** In the presence of electric and magnetic fields, the cathode rays are deflected. By the variation of electric and magnetic fields, mass normalized charge or the specific charge (charge per unit mass) of the cathode rays is measured.



Arrangement of J.J. Thomson experiment to determine the specific charge of an electron

EXERCISES:

1. Consider two hydrogen atoms H_A and H_B in ground state. Assume that hydrogen atom H_A is at rest and hydrogen atom H_B is moving with a speed and make head-on collide on the stationary hydrogen atom H_A. After the strike, both of them move together. What is minimum value of the kinetic energy of the moving hydrogen atom H_B, such that any one of the hydrogen atoms reaches one of the excitation state.

Solution :

H_A - rest. $u_2 = 0$

H_B - moving with a speed u_1

After the strike, velocity of H_A & H_B is same

i.e. $v_1 = v_2 = v$

Mass of H_A = mass of H_B = m

Total Kinetic energy before collission

$$\text{Kinetic energy} = \frac{1}{2}mu_1^2 + \frac{1}{2}mu_2^2 = \frac{1}{2}mu_1^2 \quad (u_2 = 0)$$

Total kinetic energy after collission

$$\text{Kinetic energy}_f = \frac{1}{2}(m+m)\,v^2$$

$$= \frac{1}{2}.\,2m\,V^2 = m\,v^2$$

$$\text{Less in kinetic energy} = K.E_f - K.E_i$$

$$= mv^2 - \frac{1}{2}mu_1^2 \quad ...(1)$$

$$\Delta E = \frac{1}{2}\left(\frac{m^2}{2m}\right)u_1^2$$

[substitute $v = \frac{mu_1}{2m}$] in equation (1)

$$\Delta E = \frac{1}{4}mu_1^2$$

$$2\Delta E = \frac{1}{2}mu_1^2$$

The minimum energy that can be absorbed by the H_2 alom in ground state to go to an excited state is 10.2 eV.

Thus minimum kinetic energy the moving H_2 atom H_B.

$$\frac{1}{2}mu^2_{min} = 2 \times 10.2 = \mathbf{20.4\ eV}.$$

2. In the Bohr atom model, the frequency of transitions is given by the following expression $v = Rc\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$, where n < m, Consider the following transitions:

Transitions	$m \to n$
1	$3 \to 2$
2	$2 \to 1$
3	$3 \to 1$

Show that the frequency of these transitions obey sum rule (which is known as Ritz combination principle)

Solution :

Ritz combination principle states that the spectral lines of any element include frequencies that are sum of the frequencies of two other lines.

An atom can make transition from 3 to 1 (first state) either directly (i.e. 3→1) or in two steps 3 →2 and 2 → 1. Energy is conserved so the two frequencies (wave number) of later add to the frequency of the first way (3 → 1)

According to Bohr

$$\upsilon = RC\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$

$$\upsilon_{3\to2} = RC\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5}{36}$$

$$\upsilon_{2\to1} = RC\left(\frac{1}{1^2}\frac{1}{2^2}\right) = \frac{3}{4}$$

$$\upsilon_{3\to1} = RC\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = \frac{8}{9}$$

Hence,

$$\upsilon_{3\to1} = \upsilon_{3\to2} + \upsilon_{2\to1} \Rightarrow \frac{8}{9} = \frac{5}{36} + \frac{3}{4} = \frac{32}{36} = \frac{8}{9}$$

3. (a) A hydrogen atom is excited by radiation of wavelength 97.5 nm. Find the principal quantum number of the excited state.

(b) Show that the total number of lines in emission spectrum is $\frac{n(n-1)}{2}$ and compute the total number of possible lines in emission spectrum.

Solution :

(a) Wave length of radiation λ = 97.5 nm (or) 975Å = 975×10^{-10} m

ADDITIONAL QUESTIONS AND ANSWERS

CHOOSE THE CORRECT ANSWER 1 MARK

1. **Bohr's postulate is based on**

(a) conservation of linear momentum
(b) quantisation of angular momentum
(c) conservation of quantum frequency
(d) none of these

[Ans. (b) quantisation of angular momentum]

2. **The circumference of an electron's orbit of radius *r* must be an integral multiple of de Broglie wavelength that is**

(a) 0.529 nl (b) $\sqrt{n}\lambda$
(c) 13.6 l (d) $2\pi r = n\lambda$

[Ans. (d) $2\pi r = n\lambda$]

3. **The ground state energy of hydrogen atom is 13.6 eV. The energy needed to ionize H_2 atom from its second excited state.**

(a) 1.51 eV (b) 3.4 eV
(c) 13.6 eV (d) none

[Ans. (a) 1.51 eV]

4. **In terms of Bohr radius a_0, the radius of the third Bohr orbit of a hydrogen atom is given by**

(a) $8a_0$ (b) $9a_0$
(c) $6a_0$ (d) $\sqrt{3}\,a_0$

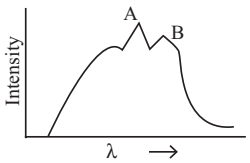
[Ans. (b) $9a_0$]

5. **The ionization energy of hydrogen atom is –13.6eV. The energy corresponding to a transition between 3rd and 4th orbit is**

(a) 3.40 eV (b) 1.51 eV
(c) 0.85 eV (d) 0.66 eV

[Ans. (d) 0.66 eV]

6. **The fig. represents the observed intensity of X-rays emitted by an X-ray tube as a function of wavelength. The sharp peaks A and B denote**



(a) continuous spectrum
(b) band spectrum
(c) characteristic spectrum
(d) white radiations

[Ans. (c) characteristic spectrum]

7. **The minimum wavelength of the X-rays produced by electrons accelerated through a potential difference of V volts is directly proportional to**

(a) $\frac{1}{\sqrt{V}}$ (b) $\frac{1}{V}$
(c) $\sqrt{V}$ (d) V^2

[Ans. (b) $\frac{1}{V}$]

8. **According to to Bohr, the relation between principal quantum number (n) and radius of the orbit (r) is**

(a) $r \alpha \frac{1}{n}$ (b) $r \alpha \frac{1}{n^2}$
(c) $r \alpha n$ (d) $r \alpha n^2$

[Ans. (d) $r \alpha n^2$]

9. **The energy of the ground state of hydrogen is –13.6 eV. The energy of the first excited state is**

(a) –27.2 eV (b) –52.4 eV
(c) –3.4 eV (d) –6.8 eV

[Ans. (c) –3.4 eV]

10. **When hydrogen atom is in its first excited level, its radius is _____ of the Bohr radius.**

(a) twice (b) same
(c) half (d) four times

[Ans. (d) four times]

11. **The total energy of electrons in the ground state of hydrogen atom is –13.6 eV. The k.E of an electron in the first excited state is**

(a) 6.8 eV (b) 13.6 eV
(c) 1.7 eV (d) 3.4 eV

[Ans. (d) 3.4 eV]

Match the following

1.

1.	J.J. Thomson	(a)	Atomic model for hydrogen atom
2.	Rutherford	(b)	Theoretical atom model
3.	Geiger and Marsden	(c)	Nucleus
4.	Neils Bohr	(d)	Scattering of alpha particles

	(1)	(2)	(3)	(4)
(a)	b	c	d	a
(b)	b	c	d	a
(c)	c	d	b	a
(d)	b	a	d	c

[Ans. (b) b c d a]

2.

1.	1 Bohr	(a)	Water melon model
2.	J.J. Thomson	(b)	0.53 Å
3.	1 Curie	(c)	Neutrons
4.	James Chadwick	(d)	3.7×10^{10} Bq

	(1)	(2)	(3)	(4)
(a)	d	c	a	b
(b)	c	d	b	a
(c)	d	c	b	a
(d)	b	a	d	c

[Ans. (d) b a d c]

Choose Incorrect pair

1.

(a)	Breaking nucleus	-	Nuclear fission
(b)	Slow neutrons	-	0 - 1000 eV
(c)	Fast neutrons	-	0.5 MeV - 10 MeV
(d)	Nuclear fusion	-	1.5×10^7 K

[Ans. (d) Nuclear fusion - 1.5×10^7 K]

2.

(a)	Half life of radioactive nuclei	-	$0.693 / \lambda$
(b)	Nucleus	-	Electrons and neutrons
(c)	Density of nucleus	-	$\rho = 2.3 \times 10^{17}$ kg m^{-3}
(d)	Control rods	-	Cadmium

[Ans. (b) nucleus - Electrons and neutrons]

Assertion - Reason

Direction:

(a) Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) Assertion and Reason are true but Reason is the false explanation of the Assertion.

(c) Assertion is true but Reason is false.

(d) Assertion is false but Reason is true.

1. **Assertion :** Electrons in the atom are held due to coulomb forces.

Reason : The atom is stable only because the centripetal force due to coulomb's law is balanced by the centrifugal force.

[Ans. (c) Assertion is true but Reason is false.]

2. **Assertion :** Electron capture occurs more often than positron emission in heavy elements..

Reason : Heavy elements exhibit radio activity.

[Ans. (b) Assertion and Reason are true but Reason is the false explanation of the Assertion]

Choose the correct statements

1. (I) Cathode rays produce heat, when allowed to fall on matter.

(II) Cathode rays produce X-ray, when allowed to fall on material of high atomic weight.

(III) Cathode rays are positively charged particles

(IV) Cathode rays ionize the gas.

(a) I, II and III only (b) I, II and IV only

(c) I and II only (d) II, III and IV only

[Ans. (b) I, II and IV only]

2. (I) Density of all the nuclei is same.

(II) Heavy elements exhibit radioactivity.

(III) Amongst alpha, beta and gamma rays, α–particle has maximum penetrating power.

(IV) Isobars are the atoms of same elements having the different mass number.

(a) I, II and III only (b) I, II and IV only

(c) I and III only (d) I and II only

[Ans. (a) I, II and III only]

VERY SHORT ANSWER 2 MARKS

1. Which ray has high ionising power? Why?

Ans. **(i)** Alpha ray has high ionising power.

(ii) α - particle has large mass and large nuclear cross section. So it has high ionising power.

2. What is meant by fissile material? Give an example for fissile material?

Ans. The material which can undergo nuclear fission easily is called **fissile material**. Example: ${}_{92}U^{235}$.

3. What is nuclear chain reaction?

Ans. A nuclear reaction in which the neutron used to carry out the nuclear fission reaction gets multiplied as more and more such fission reaction take place is called a nuclear chain reaction.

4. State the reasons. Why a chain reaction stops?

Ans. **(i)** A nuclear chain reaction dies out, when the neutrons produced so fast they escape from the uranium without interacting.

(ii) When the neutrons are lost due to the extremely small size of uranium (i.e. smaller than critical size).

5. What are the essential parts of a nuclear reactor?

Ans. Nuclear fuel, neutron source, moderator control roads, coolant and shielding.

6. A fusion reaction is more energetic than a fission reaction. Why?

Ans. In nuclear fusion reaction, the energy liberated per unit mass of the nuclei taking part in the reaction is many times larger than the energy liberated in a fission reaction.

7. Define Roentgen.

Ans. It is defined as the quantity of radiation which produces 1.6×10^{12} pair of ions in 1 gram of air.

8. What is meant by nuclear fission?

Ans. The process of breaking up of the nucleus of a heavy atom into two fragments with the release of large amount of energy is known as nuclear fission.

9. What is the reason for using lighter nuclei as moderators?

Ans. The moderator is a material used to convert fast neutrons into slow neutrons.

(i) A billiard ball striking a stationary billiard ball of equal mass would itself be stopped but the same billiard ball bounces off almost with same speed when it strikes a heavier mass.

(ii) This is the reason for using lighter nuclei as moderators.

10. Why neutrons in the nucleus are stable?

Ans. Neutrons are stable inside the nucleus. But outside the nucleus they are unstable. If the neutron comes out of the nucleus (free neutron), it decays with emission of proton, electron, and antineutrino with the half life of 13 minutes.

11. Classify the neutrons according to their kinetic energy.

Ans. Neutrons are classified according to their kinetic energy as (i) slow neutrons (0 to 1000 eV) (ii) fast neutrons (0.5 MeV to 10 MeV).

12. What causes the sun to expand?

Ans. When the hydrogen is burnt out, the sun will enter into new phase called red giant where helium will fuse to become carbon. During this stage, sun will expand greatly in size and all its planets will be engulfed in it.

13. How does thermonuclear fusion reaction occurs?

Ans. When the surrounding temperature reaches around 10^7K, lighter nuclei start fusing to form heavier nuclei and this resulting reaction is called thermonuclear fusion reaction.

14. The ground state energy of hydrogen atom is –13.6 eV. What are k.E & P.E of the electron in this state?

Ans. K.E of the electron = 13.6 eV

P.E is equal to twice its K.E

P.E of the electron = $-13.6 \times 2 = -27.2$ eV

15. Name the series of hydrogen spectrum which has least wavelength and where it lies in the spectral region.

Ans. (i) Lyman series has least wavelength.

(ii) Lyman series lies in ultraviolet region.

16. What are thermal neutrons? Why are neutrons considered as ideal particles for nuclear fission?

Ans. Thermal neutrons are low-energy neutrons having an approximate energy of 0.025 eV. Neutrons are consider as ideal particles for nuclear fission because they are uncharged.

17. Comment on the statement - "A nucleus contains to electrons and can eject them"

Ans. It is true that a nucleus contains no electrons as such. However, in the process of -decay, a neutron breaks up as follows.

$${}^{1}_{0}n \rightarrow {}^{1}_{1}H + {}^{0}_{-1}e + \bar{\nu}$$

18. Give the mass number and atomic number of elements on the right-hand side of the decay process $^{220}_{86}Rn \rightarrow$ Po + He.

Ans. $^{220}_{86}Rn \rightarrow {}^{216}_{84}Po + {}^{4}_{2}He$

Mass number of Po = 216

Atomic number of Po = 84

Mass number of He = 4

Atomic number of He = 2

19. Why are heavy nuclei unstable?

Ans. Heavy nuclei, for example, $_{92}U^{238}$ contains 92 protons and 146 neutrons. The wide difference between the number of protons and neutrons makes the heavy nuclei unstable.

20. What is a reactor core?

Ans. The fuel bundles which consist of tiny pellets of uranium oxide, are placed in calandria reactor vessel. The part of the reactor vessel which contains the fuel rod is known as **reactor core**.

SHORT ANSWER 3 MARKS

1. What does a neutron moderator do?

Ans. (i) **Moderators:** The moderator is a material used to convert fast neutrons into slow neutrons. Usually the moderators are chosen in such a way that it must be very light nucleus having mass comparable to that of neutrons.

(ii) Hence, these light nuclei undergo collision with fast neutrons and the speed of the neutron is reduced.

(iii) A billiard ball striking a stationary billiard ball of equal mass would itself be stopped but the same billiard ball bounces off almost with same speed when it strikes a heavier mass.

(iv) This is the reason for using lighter nuclei as moderators.

2. Write the properties of neutrino?

Ans. The neutrino has the following properties

(i) It has zero charge

(ii) It has an antiparticle called anti-neutrino.

(iii) Recent experiments showed that the neutrino has very tiny mass.

(iv) It interacts very weakly with the matter. Therefore, it is very difficult to detect. In fact, in every second, trillions of neutrinos coming from the sun are passing through our body without any interaction.

3. What is the diameter of H_2 atom?

Ans. Radius of the nth orbit

$$r_n = \frac{n^2h^2\varepsilon_0}{\pi m Z e^2}$$

$$r_1 = 0.53\text{Å}$$

$\therefore$ The diameter of $H_2 = 2 \times r_1$

$= 0.53 \times 2 = 1.06$ Å

4. Show that the decay rate 'R' of a sample of a radionuclide is related to the number of radioactive nuclei 'N' at the same instant by the expression R = λN.

Ans. Rate of disintegration of a radioactive sample,

$$R = \frac{dN}{dt}$$

According to radioactive decay law,

$$-\frac{dN}{dt} \propto N$$

$$-\frac{dN}{dt} = \lambda N \text{ or } R = \lambda N.$$

5. Define atomic mass unit. Find its energy equivalent in MeV.

Ans. Atomic mass unit is defined as $\frac{1}{12}$ th of the mass of one $^{12}_{6}C$ atom.

$E = mc^2$

$= 1.66 \times 10^{-27} \times 3 \times 10^8 \times 3 \times 10^8$ J

$= 1.66 \times 9 \times 10^{-11}$ J

$= \frac{1.66 \times 9 \times 10^{-11}}{1.6 \times 10^{-13}}$ MeV = 931 MeV.

6. If the total number of neutrons and protons in a nuclear reaction is conserved how than is the energy absorbed or evolved in the reaction? Explain.

Ans. (i) Since proton number and neutron number are conserved in a nuclear reaction, the total rest mass of neutrons and protons is the same on either side of a reaction.

(ii) But the total binding energy of nuclei on the left side need not be the same as that on the right hand side.

(iii) The difference in these binding energies appears as energy released or obsorbed in nuclear reaction.

7. Energy released per fission of a nucleus is of the order of 200 MeV whereas that per fusion is of the order of 10 MeV. But a fusion bomb (Hydrogen bomb) is said to be more powerful than a fission bomb. Explain why?

Ans. (i) Energy produced per fusion is less but the number of nuclei per unit mass is larger on account of smaller mass number.

(ii) So, energy released per unit mass is greater. On the other hand, the fissionable materials have high atomic weight.

(iii) The number of fission nuclei per unit mass is less. So, energy released is less.

8. With respect to power generation, what are the relative advantages and disadvantages of fusion type and Fission type reactors?

Ans. (i) Fusion requires high temperature. controlled reaction is not yet obtained. Highly sophisticated technology will be required.

(ii) However, the fuel is easily available, cheap and causes very less pollution.

(iii) There is no problem of waste management.

(iv) Fission controlled chain reaction is possible. The technology is well developed and established.

(v) There also exists the problem of waste management.

9. What are radioactive elements? What are the factors that affect radio activity?

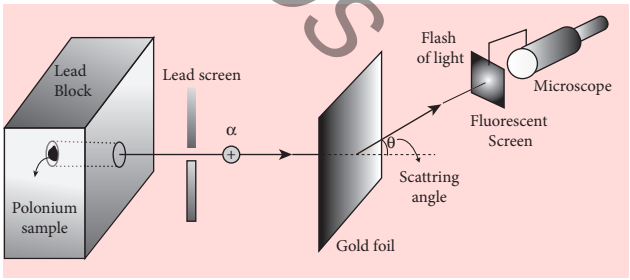
Ans. (i) The phenomenon of spontaneous emission of highly penetrating radiations such as α, β, γ rays by heavy elements having atomic number greater than 82 is called radioactivity and the substances which emit these radiations are called **radioactive elements**.

(ii) The radioactive phenomenon is spontaneous and is unaffected by any external agent like temperature, pressure, and magnetic fields.

LONG ANSWER — 5 MARKS

1. Explain the results of Rutherford α-particle scattering experiment.

Ans. (i) In 1911, Geiger and Marsden did a remarkable experiment based on the advice of their teacher Rutherford, which is known as scattering of alpha particles by gold foil.



Schematic diagram for scattering of alpha particles experiment by Rutherford

(ii) The experimental arrangement. A source of alpha particles (radioactive material, example polonium) is kept inside a thick lead box with a fine hole.

(ii) This radioactive source is placed between two oppositely charged metal plates and α radiations from $^{241}_{95}Am$ continuously ionize the nitrogen, oxygen molecules in the air space between the plates.

(iii) As a result, there will be a continuous flow of small steady current in the circuit.

(iv) If smoke enters, the radiation is being absorbed by the smoke particles rather than air molecules.

(v) As a result, the ionization and along with it the current is reduced. This drop in current is detected by the circuit and alarm starts.

(vi) The radiation dosage emitted by americium is very much less than safe level, so it can be considered harmless.

4. What is chain reaction? Classify the chain reaction.

Ans. Chain reaction: When one $^{235}_{92}U$ nucleus undergoes fission, the energy released might be small. But from each fission reaction, three neutrons are released. These three neutrons cause further fission in another three $^{235}_{92}U$ nuclei which in turn produce nine neutrons. These nine neutrons initiate fission in another 27 $^{235}_{92}U$ nuclei and so on. This is called a chain reaction and the number of neutrons goes on increasing almost in geometric progression.

There are two kinds of chain reactions:

(i) uncontrolled chain reaction

(ii) controlled chain reaction.

(i) **uncontrolled chain reaction :** In an uncontrolled chain reaction, the number of neutrons multiply indefinitely and the entire amount of energy released in a fraction of second.

(ii) The atom bomb is an example of nuclear fission in which uncontrolled chain reaction occurs. Atom bombs produce massive destruction for mankind.

(iii) During World War II, in the year 1946 August 6 and 9, USA dropped two atom bombs in two places of Japan, Hiroshima and Nagasaki. As a result, lakhs of people were killed and the two cities were completely destroyed.

(iv) Even now the people who are living in those places have side effects caused by the explosion of atom bombs.

(v) It is possible to calculate the typical energy released in a chain reaction.

(vi) In the first step, one neutron initiates the fission of one nucleus by producing three neutrons and energy of about 200 MeV.

(vii) In the second step, three nuclei undergo fission, in third step nine nuclei undergo fission, in fourth step 27 nucleus undergo fission and so on. In the 100^{th} step, the number of nuclei which undergoes fission is around 2.5×10^{40}.

(viii) The total energy released after 100^{th} step is $2.5 \times 10^{40} \times 200$ MeV $= 8 \times 10^{29}$ J. It is really an enormous amount of energy which is equivalent to electrical energy required in Tamilnadu for several years.

(i) **controlled chain reaction :** If the chain reaction is controllable, then we can harvest an enormous amount of energy for our needs.

(ii) It is achieved in a controlled chain reaction. In the controlled chain reaction, the average number of neutron released in each stage is kept as one such that it is possible to store the released energy.

(iii) In nuclear reactors, the controlled chain reaction is achieved and the produced energy is used for power generation or for research purpose.

Numerical Problems

1. The half-life of $^{90}_{38}Sr$ is 28 years. What is the disintegration rate of 15 mg of this isotope?

Solution :

$$N = \frac{6.023 \times 10^{23}}{90} \times 15 \times 10^{-3}$$

$$\frac{dN}{dt} = \lambda N = \frac{0.693}{T_{1/2}} N$$

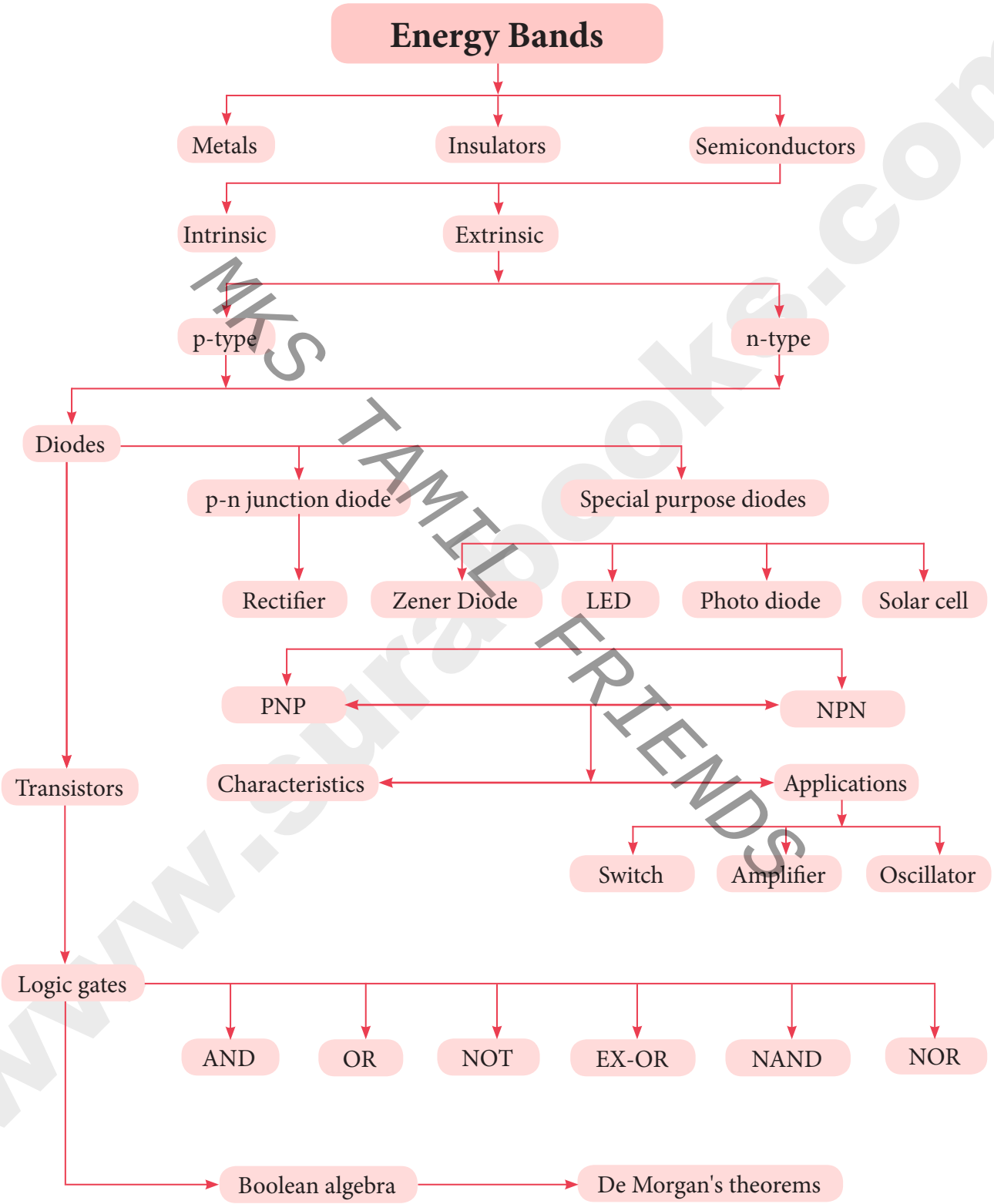
$$= \frac{0.693}{28 \times 365 \times 24 \times 60 \times 60} \times \frac{6.023 \times 10^{23}}{90} \times 15 \times 10^{-3} \text{ Bq}$$

$$= 7.878 \times 10^{10} \text{ Bq.}$$

UNIT 9 SEMICONDUCTOR ELECTRONICS

CHAPTER SNAPSHOT

CONCEPT MAP



MUST KNOW DEFINITIONS

Electronics : **Electronics** is the branch of physics incorporated with technology towards the design of circuits using transistors and microchips.

Passive Components : Components that cannot generate power in a circuit.

Active components : Components that can generate power in a circuit.

Energy band : Band of very large number of closely spaced energy levels in a very small energy range is known as energy band.

Conduction band : The energy band formed due to the valence orbitals is called valence band and that formed due to the unoccupied orbitals is called the **conduction band**.

Forbidden energy gap : The energy gap between the valence band and the conduction band is called **forbidden energy gap**.

Insulators : The electrical conduction is not possible as the free electrons are almost nil and hence these materials are called **insulators**. Its resistivity is in the range of 10^{11}–10^{19} Ωm.

Intrinsic semiconductor : A semiconductor in its pure form without impurity is called an **intrinsic semiconductor.**

Holes : The vacancies produced in the valence band are called **holes**.

Intrinsic carrier concentration : The **intrinsic carrier concentration** is the number of electron in the conduction band or the number of holes in the valence band in an **intrinsic semiconductor.**

Doping : The process of adding impurities to the intrinsic semiconductor is called **doping**.

Dopants : The impurity atoms are called dopants and its order is approximately 100 ppm (parts per million).

Donor energy level : The energy level of the loosely attached fifth electron from the dopant is found just below the conduction band edge and is called the **donor energy level**.

Donor impurities : The group V pentavalent impurity atoms donate electrons to the conduction band and are called **donor impurities**.

n-type semiconductor : The majority carriers of current in an n-type semiconductor are electrons and the minority carriers are holes. Such a semiconductor doped with a pentavlent impurity is called an **n-type semiconductor**.

Acceptor impurity : To make complete covalent bonding with all four neighbouring atoms, the dopant is in need of one more electron. These dopants can accept electrons from the neighbouring atoms. Therefore, this impurity is called an **acceptor impurity**.

Acceptor energy level : The energy level of the hole created by each impurity atom is just above the valence band and is called the **acceptor energy level**.

Barrier potential : The internal repulsion of the depletion layer stops further diffusion of free electrons across the junction. This difference in potential across the depletion layer is called the **barrier potential**.

EVALUATION

CHOOSE THE CORRECT ANSWER:

1. The barrier potential of a silicon diode is approximately,

(a) 0.7 V (b) 0.3V
(c) 2.0 V (d) 2.2V

[*Ans.* (a) 0.7 V]

2. Doping a semiconductor results in

(a) The decrease in mobile charge carriers
(b) The change in chemical properties
(c) The change in the crystal structure
(d) The breaking of the covalent bond

[*Ans.* (c) The change in the crystal structure]

3. A forward biased diode is treated as

(a) An open switch with infinite resistance
(b) A closed switch with a voltage drop of 0V
(c) A closed switch in series with a battery voltage of 0.7V
(d) A closed switch in series with a small resistance and a battery

[*Ans.* (d) A closed switch in series with a small resistance and a battery]

4. If a half –wave rectified voltage is fed to a load resistor, which part of a cycle the load current will fl ow?

(a) 0^o - 90^o (b) 90^o - 180^o
(c) 0^o - 180^o (d) 0^o - 360^o

[*Ans.* (c) 0^o - 180^o]

5. The primary use of a zener diode is

(a) Rectifier (b) Amplifier
(c) Oscillator (d) Voltage regulator

[*Ans.* (d) Voltage regulator]

6. The principle in which a solar cell operates

(a) Diffusion
(b) Recombination
(c) Photovoltaic action
(d) Carrier flow

[*Ans.* (c) Photovoltaic action]

7. The light emitted in an LED is due to

(a) Recombination of charge carriers
(b) Reflection of light due to lens action
(c) Amplification of light falling at the junction
(d) Large current capacity

[*Ans.* (a) Recombination of charge carriers]

8. When a transistor is fully switched on, it is said to be

(a) Shorted (b) Saturated
(c) Cut-off (d) Open

[*Ans.* (b) Saturated]

9. The specific characteristic of a common emitter amplifier is

(a) High input resistance
(b) Low power gain
(c) Signal phase reversal
(d) Low current gain

[*Ans.* (c) Signal phase reversal]

10. To obtain sustained oscillation in an oscillator,

(a) Feedback should be positive
(b) Feedback factor must be unity
(c) Phase shift must be 0 or 2π
(d) All the above

[*Ans.* (d) All the above]

11. If the input to the NOT gate is A = 1011, its output is

(a) 0100 (b) 1000
(c) 1100 (d) 0011

[*Ans.* (a) 0100]

12. The electrical series circuit in digital form is

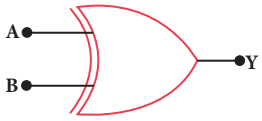
(a) AND (b) OR
(c) NOR (d) NAND

[*Ans.* (a) AND]

Ex-OR gate

Circuit Symbol :

A and B are inputs and Y is the output.



Ex-OR gate

Inputs		Output (Ex-OR)
A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

Truth table

Boolean equation:

$Y = A.\overline{B} + \overline{A}.B$

$Y = A \oplus B$

Logic operation :

The output is high only when either of the two inputs is high. In the case of an Ex-OR gate with more than two inputs, the output will be high when odd number of inputs are high.

14. State De Morgan's first and second theorems.

Ans. **(i)** De Morgan's First theorem states that the complement of the sum of two inputs is equal to the product of its complements.

(i) The second theorem states that the complement of the product of two inputs is equal to the sum of its complements.

III. Long Answer Questions :

1. Elucidate the formation of a N-type and P-type semiconductors.

Ans. **n-type semiconductor :**

(i) A n-type semiconductor is obtained by doping a pure Germanium (or Silicon) crystal with a dopant from group V pentavalent elements like Phosphorus, Arsenic, and Antimony.

(ii) The dopant has five valence electrons while the Germanium atom has four valence electrons.

(iii) During the process of doping, a few of the Germanium atoms are replaced by the group V dopants.

(iv) Four of the five valence electrons of the impurity atom are bound with the 4 valence electrons of the neighbouring replaced Germanium atom.

(v) The fifth valence electron of the impurity atom will be loosely attached with the nucleus as it has not formed the covalent bond.

(vi) The energy level of the loosely attached fifth electron from the dopant is found just below the conduction band edge and is called the **donor energy level**.

(vii) At room temperature, these electrons can easily move to the conduction band with the absorption of thermal energy.

(viii) Besides, an external electric field also can set free the loosely bound electrons and lead to conduction.

(ix) It is important to note that the energy required for an electron to jump from the valence band to the conduction band (E_g) in an intrinsic semiconductor is 0.7 eV for Ge and 1.1 eV for Si, while the energy required to set free a donor electron is only 0.01 eV for Ge and 0.05 eV for Si.

(x) The group V pentavalent impurity atoms donate electrons to the conduction band and are called **donor impurities**. Therefore, each impurity atom provides one extra electron to the conduction band in addition to the thermally generated electrons.

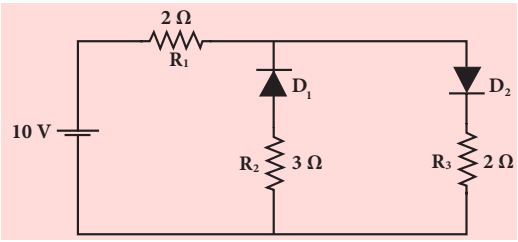
(xi) These electrons leave holes in valence band. Hence, the majority carriers of current in an *n*-type semiconductor are electrons and the minority carriers are holes. Such a semiconductor doped with a pentavalent impurity is called an **n-type semiconductor**.

p-type semiconductor :

(i) A trivalent atom from group III elements such as Boron, Aluminium, Gallium and Indium is added to the Germanium or Silicon substrate. The dopant with three valence electrons are bound with the neighbouring Germanium atom.

IV. Numerical Problems

1. The given circuit has two ideal diodes connected as shown in figure below. Calculate the current flowing through the resistance R_1



Solution :

Given Date :

Applied voltage V = 10 V

$R_1 = 2\Omega$; $R_2 = 3\Omega$; $R_3 = 2\Omega$;

Effective resistance $= R_1 + R_2$

$= 2 + 2 = 4\ \Omega$

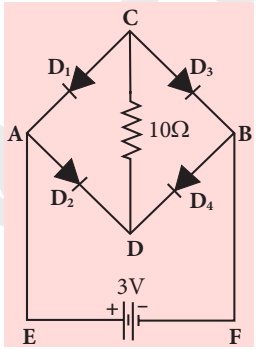
D_1 is reverse biased. So no current flows in the branch of diode D_1.(Block the current)

D_2 is forward biased and effects no resistance in the circuit. (pass the current)

$\therefore$ Current $I = \frac{V}{R} = \frac{10}{4}$

$$\boxed{I = 2.5\ A}$$

2. Four silicon diodes and a 10 Ω resistor are connected as shown in figure below. Each diode has a resistance of 1Ω. Find the current flows through the 10Ω resistor.



Solution :

Given data :

Four silicon diodes $= 1 \times 4 = 4\ \Omega$

Connected resistor $= 10\ \Omega$

To find :

Current flows through the 10 Ω resistor = ?

Each of diode $= 1 \times 4 = 4$

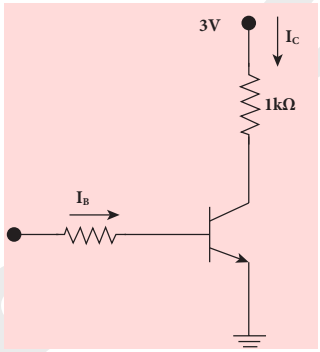
Given resistor $= 10\ \Omega = \frac{10}{4} = 2.5$

Current flows through the resistor

$$I = \frac{V}{R} = \frac{2.5}{10}$$

$$I = 0.25\ A$$

3. Assuming V_{CEsat} = 0.2 V and β = 50, find the minimum base current (I_B) required to drive the transistor given in the figure to saturation.



Solution:

Given data :

$V_{CEsat} = 0.2\ V$

$\beta = 50$

$V_{CC} = 3\ V$

$R_C = 1\ k\Omega$ (or) $10^3\ \Omega$

I_C = collector current

I_B = base current

To find :

$I_B = ?$

$V_{CE} = V_{CC} - I_C R_C$

$Ic_{sat} = \frac{V_{CC} - V_{CEsat}}{R_C}$

$\therefore Rc = 1\ k$

$Ic_{sat} = \frac{3 - 0.2}{1k\Omega} = 2.8\ mA$

$I_{B\ Min} = \frac{I_C}{\beta}$

$= \frac{2.8\,mA}{50} = 56\ \mu A$

$$\boxed{I_B = 56\ \mu A}$$

ADDITIONAL QUESTIONS AND ANSWERS

CHOOSE THE CORRECT ANSWER 1 MARK

1. **C, Si and Ge have same no. of valence electrons. C is an insulator because energy required to take one electron out from**

(a) Si is more (b) C is more

(c) Ge is more (d) C is less

[***Ans.*** **(B) C is more]**

2. **By adding _____ impurity in intrinsic semi conductor, p type semiconductor is made. Charge of these p-type semiconductor is _____**

(a) Trivalent, neutral

(b) Pentaralent, neutral

(c) Pentavalent, positive

(d) Trivalent, negative

[***Ans.*** **(a) Trivalent, neutral]**

3. **Why can't we physically join p-type and n-type semiconductor directly to form a p-n junction?**

(a) Inter-atomic spacing become less than 1 A^o

(b) p -type will repet N-type

(c) There will be discontinuity for the flowing charge carriers

(d) Semi-conducting properties will be lost

[***Ans.*** **(c) There will be discontinuity for the flowing charge carriers]**

4. **Which statement is incorrect regarding for p-n junction.**

(a) Donor atoms are depleted of their holes in junction

(b) No net charge exists far from junction

(c) Barrier potential V_B is generated

(d) Energy V_B is to be surmounted before any charge can flow across junction

[***Ans.*** **(d) Energy V_B is to be surmounted before any charge com flow across junction]**

5. **The intrinsic semi-conductor has :**

(a) A finite resistance which does not change with temperature

(b) Infinite resistance which decreases with temperature

(c) Finite resistance which decreases with temperature

(d) Finite resistance which does not change with temperature

[***Ans.*** **(c) Finite resistance which decreases with temperature]**

6. **The behaviour of Ge as semi-conductor is due to width of :**

(a) conduction band being large

(b) forbidden band being small

(c) conduction band being small

(d) forbidden band being small and narrow

[***Ans.*** **(d) forbidden band being small and narrow]**

7. **Which of the following is not the advantage of PN junction diode over tube value?**

(a) Unlimited life

(b) No warming-up time after switching

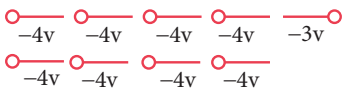
(c) Large efficiency

(d) Low consumption of power

[***Ans.*** **(a) Unlimited life]**

8. **The forward based diode is**

(a) 

(b) 

(c) 

(d) 

[***Ans.*** **(a)** 

]

2. **Assertion :** Higher the value of α better is the transistor.
Reason : The α of a transistor is a measure of the quality of a transistor.

[Ans. (a) Assertion and Reason are correct and Reason is the correct explanation of Assertion]

CHOOSE THE CORRECT STATEMENTS

1. **(I) Transistor can be operated efficiently in an operating point**
(II) Variations of I_C and V_{CE} takes place in this point.
(III) Q - points determine the working point of a transistor.
(IV) Transistor is a semiconductor device used to amplify or switch electronic signals.
(a) I and II only (b) II and III only
(c) I, II and III only
(d) I, II, III and IV only

[Ans. (d) I, II, III and IV only]

2. **(I) Germanium atom has 32 orbiting electrons.**
(II) Diode has 2 terminals.
(III) mA is the unit used to represent the level of a diode forward current I_F.
(IV) The diffused impurities with 3 valence electrons are called donor atoms.
(a) I, II and III only (b) III and IV only
(c) I, II and IV only (d) I, III and IV only

[Ans. (a) I, II and III only]

CHOOSE THE INCORRECT STATEMENTS

1. (a) Amplification is the process of increasing the signal strength.
(b) A logic gate is an electronic circuit.
(c) Logic gate functions based on digital signals.
(d) Logic gates having one or more than and one or more than outputs inputs.

[Ans. (d) Logic gates having one or more than and one or more than outputs inputs]

2. (a) A and B are inputs and Y is the output for OR gate.
(b) A is the input and Y is the output for NOT gate.
(c) A and B are outputs and Y is the input for NOR gate.
(d) A and B are inputs and Y is the output for Ex-OR gate.

[Ans. (c) A and B are outputs and Y is the input for NOR gate.]

VERY SHORT ANSWER — 2 MARKS

1. Define energy band.

Ans. Band of very large number of closely spaced energy levels in a very small energy range is known as **energy band**.

2. Define conduction band.

Ans. The energy band formed due to the valence orbitals is called **valance band** and that formed due to unoccupied orbital is called **conduction band**.

3. What is forbidden energy gap?

Ans. The energy gap between the valance band and conduction band is called forbidden energy gap.

4. What is barrier potential?

Ans. The internal repulsion of the depletion layer stops further diffusion of free electrons across the junction. This difference in potential across the depletion layer is called **barrier potential**.

5. Define bias voltage.

Ans. The external voltage applied to the p-n junction is called **bias voltage**.

6. Define forward bias.

Ans. If the positive terminal of the external voltage source is connected to the p-side and the negative terminal to the n-side, it is called forward bias.

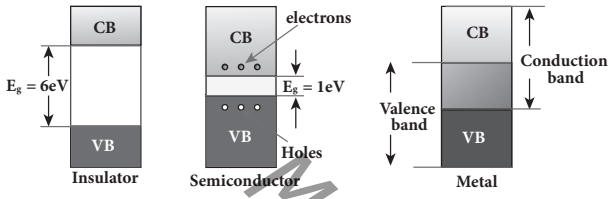
7. Define Reverse bias.

Ans. If the positive terminal battery is connected to the n-side and the negative potential to the p-side, the junction is said to be **reverse biased**.

Short Answer 3 marks

1. Give the Schematic representation of valence band, conduction band, and forbidden energy gap. and draw energy band structure of (a) Insulators (b) Semiconductors (c) Metals?

Ans.



2. What is electronics?

Ans. (i) It is the branch of physics incorporated with technology towards the design of circuits using transistors and microchips.

(ii) It depicts the behaviour and movement of electrons in a semiconductor, vacuum, or gas.

(iii) Electronics deals with electrical circuits that involve active components such as transistors, diodes, integrated circuits, and sensors, associated with the passive components like resistors, inductors, capacitors, and transformers.

Long Answer 5 marks

1. How does the change in temperature and application of electric field affect the behavior of materials and write the range of resistivity for each materials.

Ans. **Insulators**

(i) The gap is very large that electrons from valence band cannot move into conduction band even on the application of strong external electric field or the increase in temperature.

(ii) The electrical conduction is not possible as the free electrons are almost nil.

(iii) Its resistivity is in the range of 10^{11}–10^{19} Ωm.

Metals

(i) Conduction becomes possible even at low temperatures.

(ii) The application of electric field provides sufficient energy to the electrons to drift in a particular direction to constitute a current.

(iii) The resistivity value lies between 10^{-2} and 10^{-8} Ωm.

Semiconductors

(i) At a finite temperature, thermal agitations in the solid can break the covalent bond between the atoms.

(ii) This releases some electrons from valence band to conduction band.

(iii) The resistivity value of semiconductors is from 10^{-5} to 10^{6} Ωm

(iv) When the temperature is increased further, more number of electrons is promoted to the conduction band and increases the conduction.

(v) Thus, electrical conduction increases with the increase in temperature.

2. Explain and classify transistor as an oscillator.

Ans. (i) An oscillator basically converts dc energy into ac energy of high frequency ranging from a few Hz to several MHz.

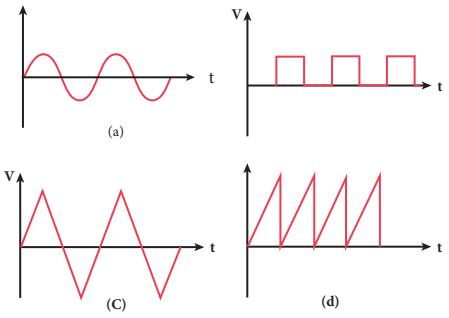
(ii) There are **two types of oscillators**:

a) Sinusoidal

b) Non-sinusoidal.

(iii) Sinusoidal oscillators generate oscillations in the form of sine wave at constant amplitude and frequency.

(iv) Non-sinusoidal oscillators generate complex non-sinusoidal waveforms like square wave, Triangular - wave or Sawtooth - wave



Numerical Problems

1. For a BJT, the common - base current gain $\alpha = 0.98$ and the collector base junction reverse bias saturation $I_{Cu} = 0.6\ \mu A$. This BJT is connected in the common emitter mode and operated in the active region with a base drive current $I_D = 20\ \mu A$. The collector current I_C for this mode of operating is

Solution :

$$\alpha = 0.98$$

$$I_{Cu} = 0.6\ \mu A$$

$$\alpha = \frac{\beta}{1+\beta}$$

(or)

$$0.98 = \frac{1}{\frac{1}{\beta}+1}$$

$$\beta = 49$$

$$I_{CEO} = (1+\beta)I_{CBO}$$

$$= (1+49) \times 0.6\ \mu A$$

$$I_{CEO} = 30\ \mu A$$

$$I_C = \beta I_B + I_{CEO}$$

$$= 49 \times 20\ \mu A + 30\ \mu A = 1010\ \mu A$$

$$\boxed{I_C = 1.01\ mA}$$

2. For a BJT circuit shown, assume that the 'β' of the transistor is very large and $V_{BE} = 0.7$ V. The mode of operation.

Solution :

$V_{BE} = 0.7$ V

Input junction is a forward biased.

Since,

$$V_{BE} = 0.7\ V$$

$$V_{CE} = V_{BE} + V_{CB}$$

$$V_{CB} = V_{CE} - V_{BE}$$

To determine V_{CB} we find I_C

$$I_C \cong I_C = \frac{2 - V_{BE}}{R_2} = \frac{2 - 0.7}{1k\Omega}$$

$$I_C = 1.3\ mA$$

$$V_{CE} = V_{CC} - I_C (R_1 + R_2)$$

$$= 10 - 1.3\ mA\ (10K + 1K)$$

$$V_{CE} = -4.3\ V$$

$$V_{CE} = -4.3\ V - 0.7$$

$$V_{CB} = -5V$$

☆☆☆

UNIT 10 COMMUNICATION SYSTEMS

CHAPTER SNAPSHOT

EVALUATION

CHOOSE THE CORRECT ANSWER:

1. The output transducer of the communication system converts the radio signal into _____

(a) Sound
(b) Mechanical energy (c) Kinetic energy
(d) None of the above

[*Ans.* (a) Sound]

2. The signal is affected by noise in a communication system

(a) At the transmitter (b) At the modulator
(c) In the channel (d) At the receiver

[*Ans.* (c) In the channel]

3. The variation of frequency of carrier wave with respect to the amplitude of the modulating signal is called _____

(a) Amplitude modulation
(b) Frequency modulation
(c) Phase modulation
(d) Pulse width modulation

[*Ans.* (b) Frequency modulation]

4. The internationally accepted frequency deviation for the purpose of FM broadcasts.

(a) 75 kHz (b) 68 kHz
(c) 80 kHz (d) 70 kHz

[*Ans.* (a) 75 kHz]

5. The frequency range of 3 MHz to 30 MHz is used for

(a) Ground wave propagation
(b) Space wave propagation
(c) Sky wave propagation
(d) Satellite communication

[*Ans.* (c) Sky wave propagation]

II. SHORT ANSWERS :

1. Give the factors that are responsible for transmission impairments.

Ans. (i) **Noise :** It is the undesirable electrical signal that interfaces with the transmitted signal.

(ii) **Attenuation :** The loss of strength of a signal while propagating through a medium.

2. Distinguish between wireline and wireless communication? Specify the range of electromagnetic waves in which it is used.

Ans.

Wireline	Wireless
Wireline communication (point-point communication) uses mediums like wires, cables and optical fibers.	Wireless communication uses free space as a communication medium.
These systems cannot be used for long distance transmission as they are connected physically.	The signals are transmitted in the form of electro magnetic waves with the help of a transmitting antenna. Hence wireless communication is used for long distance transmission.
Examples are telephone, intercom and cable TV.	Examples are mobile, radio or TV broadcasting, and satellite communication.
Range of electro magnetic waves	
Wireline upto 100 meters	Wireless upto several thousand kilometers

It is the maximum distance between the source and the destination up to which the signal is received with sufficient strength.

3. Explain centre frequency or resting frequency in frequency modulation.

Ans. When the frequency of the baseband signal is zero (no input signal), there is no change in the frequency of the carrier wave. It is at its normal frequency and is called as **centre frequency** or **resting frequency**.

4. What does RADAR stand for?

Ans. RADAR basically stands for Radio Detection and Ranging System. It is one of the important applications of communication systems and is mainly used to sense, detect, and locate distant objects like aircraft, ships, spacecraft, etc.

ADDITIONAL QUESTIONS AND ANSWERS

CHOOSE THE CORRECT ANSWER 1 MARK

1. **Essential elements of a communication system are**

(a) transmitter & receiver
(b) receiver & communication chennal
(c) transmitter and communication channel
(d) transmitter communication channal & receiver

[*Ans.* (d) transmitter communication chennal & receiver]

2. **The loss of strengh of a signal while propagating through a medium is known as_____**

(a) modulation (b) absorption
(c) transmission (d) Attenuation

[*Ans.* (d) Attenuation]

3. **The process of increasing the strength of a signal using an electric circuit is called**

(a) amplification (b) modulation
(c) demodulation (d) transmission

[*Ans.* (a) amplitreation]

4. **Modulation is the process of superposing**

(a) low frequency audio signal on high frequency radio waves
(b) low frequency radio signal on low frequency audio waves
(c) high frequency radio signal on low frequency audio
(d) high frequency audio signal on low frequency radio waves

[*Ans.* (a) low frequency audio signal on high frequency rodio waves]

5. **The device which is a combination of a receiver and a transmitter is**

(a) Amplifier (b) Repeater
(c) Transducer (d) Modulator

[*Ans.* (b) Repeater]

6. **Large band width for higher data is achieved by using**

(a) high frequency carrier wave
(b) high frequency audio wave
(c) low frequency carrier wave
(d) low frequency audio wave

[*Ans.* (a) high frequency carrier wave]

7. **In a video signal for transmission of picture what value of bandwidth is used in communication system?**

(a) 2.4 MHz (b) 4.2 MHz
(c) 24 MHz (d) 42 MHz

[*Ans.* (b) 4.2 MHz]

8. **Which of the following is an example of breadcast made of communication?**

(a) Radio (b) Television
(c) Mobile (d) both (a) & (b)

[*Ans.* (d) both (a) & (b)]

9. **The radio waves of frequency 30 MHz to 300 MHz belong to**

(a) high frequency band
(b) very high frequency band
(c) ultra high frequency band
(d) super high frequency band

[*Ans.* (b) very high frequency band]

10. **For base station to mobile communication, the required frequency band is**

(a) 540 - 1600 KHz (b) 200 - 32 MHz
(c) 840 - 935 MHz (d) 5.9 - 6.42 GHz

[*Ans.* (c) 840 - 935 MHz]

11. **Ground wave have wavelength**

(a) less than that of sky waves
(b) greater than that of sky wave
(c) less than that of space waves
(d) equal to that of space waves

[*Ans.* (b) greater than that of sky wave]

2. **Assertion :** Short wave bands are used for transmission of radio waves to a large distance.
Reason : Short waves are reflected by ionosphere.

[***Ans.*** **(a) Assertion and Reason are correct and Reason is the correct explanation of Assertion.]**

3. **Assertion :** A dish antenna is highly directional.
Reason : This is because a dipole antenna is omni directional.

[***Ans.*** **(b) Assertion and Reason are true but Reason is the false explanation of the Assertion.]**

Choose the correct statements

1. (I) Carrier signal does not have information.
(II) Carrier wave usually have a much higher frequency.
(III) Carrier signal is used ot carry the baseband signal.
(IV) Carrier signal cannot be transmuted to long distance with less attenuation.
(a) I, II and III only (b) I and II only
(c) I and III only
(d) I, II, III and IV [***Ans.*** **(a) I, II and III only]**

2. (I) Amplitude modulation is used in radio and TV brad casting.
(II) Phase of the carrier signal remain constant in amptitude modulation.
(III) Noise level is low in AM.
(IV) Baseband signal carries information.
(a) I, II and III only (b) I, II and IV only
(c) I and II only
(d) I, II, III and IV [***Ans.*** **(b) I, II and IV only]**

Choose the Incorrect statements

1. (a) PM wave is similar to AM wave.
(b) PM generally uses a smaller bandwidth than FM.
(c) FM signal produced from PM signal is very stable.
(d) FM and PM waves are completely different for square wave modulating signal.

[***Ans.*** **(a) PM wave is similar to AM wave]**

2. (a) Input transducer converts variations in physical quantity.
(b) The electrical equivalent of the original information is called the baseband signal.
(c) Transducer converts electrical energy into sound energy.
(d) Microphone is an example of transducer.

[***Ans.*** **(c) Transducer converts electrical energy into sound energy.]**

Choose the incorrect pair

1. (a) Ground wave propagation - Surface waves
(b) Sky wave propagation - Antenna
(c) Space wave propagation - 50 MHz
(d) Skip distance - No reception

[***Ans.*** **(c) Space wave propagation - 50 MHz]**

2. (a) Fibre optic cables - Date speed of 1 Gbps
(b) Satellite communication - Radio repeater in sky
(c) Oscillator - Sinusoidal wave
(d) Transmitting antenna - 5×10^8 ms^{-1}

[***Ans.*** **(d) Transmitting antenna - 5×10^8 ms^{-1}]**

Very Short Answer — 2 marksm

1. Write the advantages of PM ?

Ans. **(i)** FM signal produced from PM signal is very stable.
(ii) The centre frequency called **resting frequency** is extremely stable.

2. Define Bandwidth.

Ans. The frequency range over which the baseband signals or the information signals such as voice, music, picture, etc. is transmitted is known as **bandwidth**.

3. Define Bandwidth of transmission system.

Ans. The range of frequencies required to transmit a piece of specified information in a particular channel is called **channel bandwidth** or the bandwidth of the transmission system.

4. What is meant by skip distance?

Ans. The shortest distance between the transmitter and the point of reception of the sky wave along the surface is called as the **skip distance**.

LONG ANSWER **5 MARKS**

1. Write a note on RADAR and its applications.

Ans. **(i)** Radar basically stands for Radio Detection and Ranging System.

(i) It is one of the important applications of communication systems and is mainly used to sense, detect, and locate distant objects like aircraft, ships, spacecraft, etc.

(ii) The angle, range, or velocity of the objects that are invisible to the human eye can be determined.

(iii) Radar uses electromagnetic waves for communication. The electromagnetic signal is initially radiated into space by an antenna in all directions.

(iv) When this signal strikes the targeted object, it gets reflected or reradiated in many directions.

(v) This reflected (echo) signal is received by the radar antenna which in turn is delivered to the receiver.

(vi) Then, it is processed and amplified to determine the geographical statistics of the object. The range is determined by calculating the time taken by the signal to travel from RADAR to the target and back.

Radars find extensive applications in almost all fields.

(i) In military, it is used for locating and detecting the targets.

(ii) It is used in navigation systems such as ship borne surface search, air search and weapons guidance systems..

(iii) To measure precipitation rate and wind speed in meteorological observations, Radars are used.

(iv) It is employed to locate and rescue people in emergency situations.

2. Write the applications of mobile communication.

Ans. **(i)** It is used for personal communication and cellular phones offer voice and data connectivity with high speed.

(ii) Transmission of news across the globe is done within a few seconds.

(iii) Using Internet of Things (IoT), it is made possible to control various devices from a single device. Example: home automation using a mobile phone.

(iv) It enables smart classrooms, online availability of notes, monitoring student activities etc. in the field of education.

3. Explain about satellite communication in detail.

Ans. **(i)** The satellite communication is a mode of communication of signal between transmitter and receiver via satellite.

(ii) The message signal from the Earth station is transmitted to the satellite on board via an uplink (frequency band 6 GHz), amplified by a transponder and then retransmitted to another earth station via a downlink (frequency band 4 GHz)

(iii) The high-frequency radio wave signals travel in a straight line (line of sight) may come across tall buildings or mountains or even encounter the curvature of the earth.

(iv) A communication satellite relays and amplifies such radio signals via transponder to reach distant and far off places using uplinks and downlinks. It is also called as a radio repeater in sky.

Applications:

(i) **Weather Satellites:** They are used to monitor the weather and climate of Earth. By measuring cloud mass, these satellites enable us to predict rain and dangerous storms like hurricanes, cyclones etc.

(ii) **Communication satellites:** They are used to transmit television, radio, internet signals etc. Multiple satellites are used for long distances.

(iii) Navigation satellites: These are employed to determine the geographic location of ships, aircrafts or any other object.

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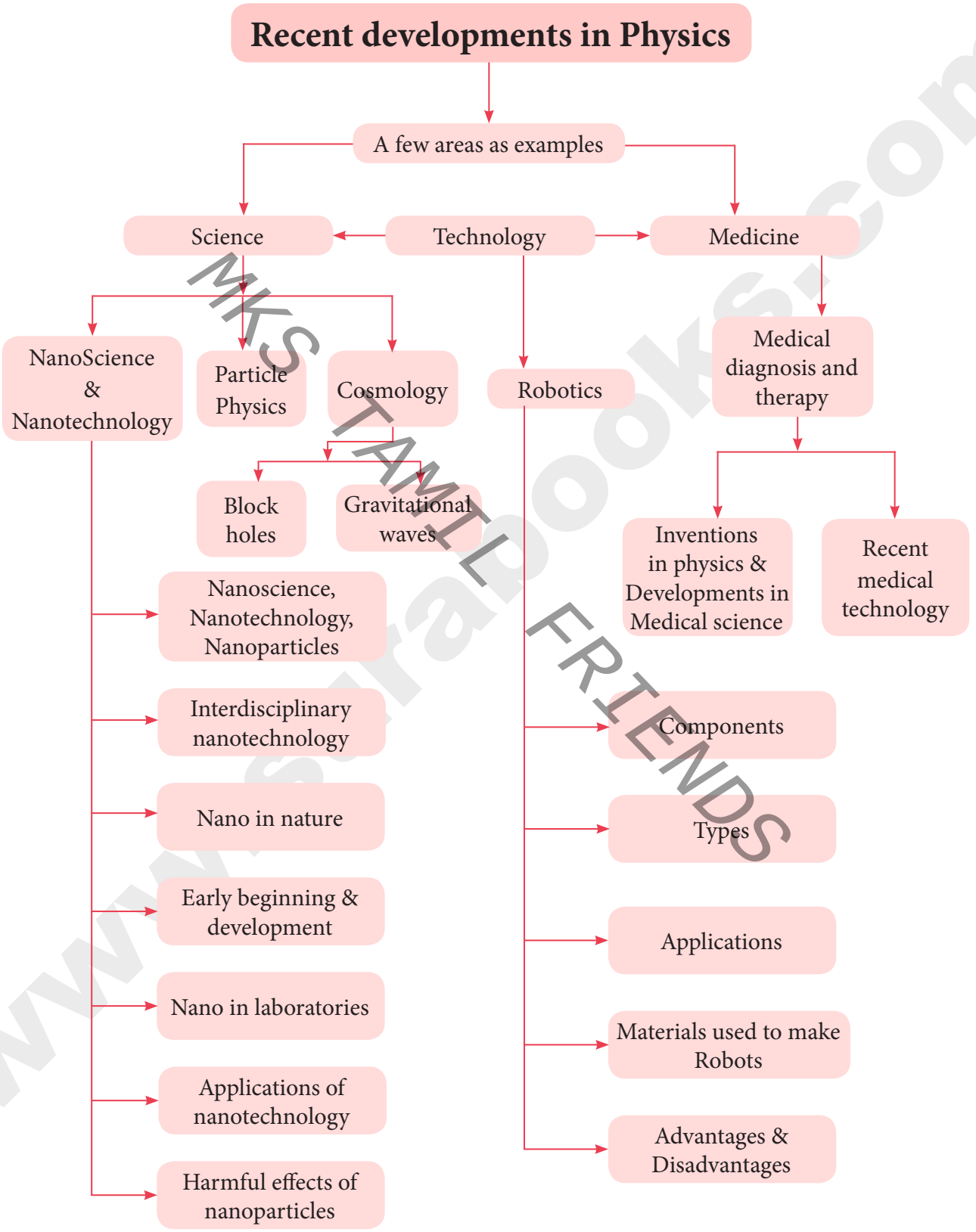
UNIT 11 RECENT DEVELOPMENTS IN PHYSICS

CHAPTER SNAPSHOT

CONCEPT MAP



EVALUATION

I. MULTIPLE CHOICE QUESTIONS:

1. The particle size of ZnO material is 30 nm. Based on the dimension it is classified as

(a) Bulk material (b) Nanomaterial
(c) Soft material
(d) Magnetic material

[*Ans.* (b) Nanomaterial]

2. Which one of the following is the natural nanomaterial.

(a) Peacock feather (b) Peacock beak
(c) Grain of sand (d) Skin of the Whale

[*Ans.* (a) Peacock feather]

3. The blue print for making ultra durable synthetic material is mimicked from

(a) Lotus leaf (b) Morpho butterfly
(c) Parrot fish (d) Peacock feather

[*Ans.* (c) Parrot fish]

4. The method of making nanomaterial by assembling the atoms is called

(a) Top down approach
(b) Bottom up approach
(c) Cross down approach
(d) Diagonal approach

[*Ans.* (b) Bottom up approach]

5. "Sky wax" is an application of nano product in the field of

(a) Medicine
(b) Textile
(c) Sports
(d) Automotive industry [*Ans.* (c) Sports]

6. The materials used in Robotics are

(a) Aluminium and silver
(b) Silver and gold (c) Copper and gold
(d) Steel and aluminum

[*Ans.* (d) Steel and aluminum]

7. The alloys used for muscle wires in Robots are

(a) Shape memory alloys
(b) Gold copper alloys
(c) Gold silver alloys
(d) Two dimensional alloys

[*Ans.* (a) Shape memory alloys]

8. The technology used for stopping the brain from processing pain is

(a) Precision medicine
(b) Wireless brain sensor
(c) Virtual reality
(d) Radiology [*Ans.* (c) Virtual reality]

9. The particle which gives mass to protons and neutrons are

(a) Higgs particle (b) Einstein particle
(c) Nanoparticle (d) Bulk particle

[*Ans.* (a) Higgs particle]

10. The gravitational waves were theoretically proposed by

(a) Conrad Rontgen
(b) Marie Curie
(c) Albert Einstein
(d) Edward Purcell [*Ans.* (c) Albert Einstein]

II. SHORT ANSWERS :

1. Distinguish between Nanoscience and Nanotechnology.

Ans.

Nanoscience	Nanotechnology
Nanoscience is the science of objects with typical sizes of 1- 100 nm. Nano means one-billionth of a metre that is 10^{-9} m.	Nenotechnology is a technology is a involving the design, production, characterization and applications of nano structured materials

(v) Advanced 3D printer systems and materials assist physicians in a range of operations in the medical field from audiology, dentistry, orthopedics and other applications.

(vi) Wireless brain sensors monitor intracranial pressure and temperature and then are absorbed by the body. Hence there is no need for surgery to remove these devices.

(vii) Robotic surgery is robotically-assisted surgery helps to overcome the limitations of pre-existing minimally-invasive surgical procedures and to enhance the capabilities of surgeons performing open surgery.

(viii) Smart inhalers are the main treatment option for asthma. Smart inhalers use bluetooth technology to detect inhaler use, remind patients when to take their medication and gather data to help guide care.

ADDITIONAL QUESTIONS AND ANSWERS

CHOOSE THE CORRECT ANSWER **1 MARK**

1. Nanoscience is the science of object with typical sizes of _____

(a) 1 - 100 μm (b) 1 - 100 nm
(c) 1 - 100 cm (d) 1 - 100 m

[Ans. (b) 1 - 100 nm]

2. If the particle of a solid is of size less than 100 nm, it is said to be a _____

(a) Nano particle (b) Nano bytes
(c) Nano solid (d) Nano technology

[Ans. (c) Nano soild]

3. _____ Scanning Electron Micrograph (SEM) showing the nano structures on the surface of a leaf from a lotus plant.

(a) Parrot fish
(b) Morpho butterfly
(c) Lotus leaf surface
(d) Peacock feathers

[Ans. (c) Lotus leaf surface]

4. _____ is synthesized top down approach

(a) Ball milling (b) Plasma etching
(c) lithography
(d) Vapour deposition

[Ans. (d) Ball milling and lithography]

5. Best example for applications of nano technology

(a) Chemical industry (b) Engineering
(c) medicine (d) all of these

[Ans. (d) all of these]

6. George Devol invented the first digitally operated programmable robot called

(a) Unimate (b) Robotics
(c) Motors (d) Generators

[Ans. (a) Unimate]

7. Muscle wires can contract by _____ when electric current is passed through them

(a) 5% (b) 7 %
(c) 25% (d) 50%

[Ans. (a) 5%]

8. The size of the Nano robots is reduced to _____ level to perform a task in very small space.

(a) Macroscopic (b) Robots DNA
(c) Microscopic (d) Bacteria

[Ans. (c) Microscopic]

9. Chinese scientists have created the world's first autonomous _____ to combat caner tumours.

(a) RNA Robot (b) DNA Robot
(c) m RNA Robot (d) r RNA Robot

[Ans. (b) DNA Robot]

10. In _____ it was established that atoms are made up of electrons, protons and neutrons

(a) 1945 (b) 1923
(c) 1930 (d) 1927

[Ans. (c) 1930]

11. What are God particles?

Ans. (i) Higgs particles' also known as "God" particles were discovered and for this, Peter Higgs and Englert received noble prize in physics.

(ii) It is the 'Higgs particle' which gives mass to many particles like protons, neutrons etc.

12. What is Cosmology?

Ans. Cosmology is the branch that involves the origin and evolution of the universe. It deals with formation of stars, galaxy etc.

13. Write the key components of robot.

Ans. The key components of a robot are Power conversion unit, Actuators, Electric motors, Pneumatic Air Muscles, Muscle wires, Piezo Motors and Ultrasonic Motors, Sensors, and Robot locomotion.

14. What is the use of household robots?

Ans. Household robots are used as vacuum cleaners, floor cleaners, gutter cleaners, lawn mowing, pool cleaning, and to open and close doors.

15. What is the use of industrial robots?

Ans. Industrial robots are used for welding, cutting, robotic water jet cutting, robotic laser cutting, lifting, sorting, bending, manufacturing, assembling, packing, transport, handling hazardous materials like nuclear waste, weaponry, laboratory research, mass production of consumer and industrial goods.

16. Define nano science.

Ans. Nano science is the science of objects with typical sizes of 1-100 nm. Nano means One - billionth of a meter that is 10^{-9} m.

17. Define nano solid.

Ans. The particle of solid is of size less than 100 nm, it is said to be a **nano solid.** Ex. : ZnO.

18. What is the two ways of preparing nano particle?

Ans. (i) Top - down approach.

(ii) Bottom - up approach.

19. What is use of robotics?

Ans. (i) Defusing Bomb.

(ii) Finding survivors in unstable rains, and exploring mines and shipwrecks.

SHORT ANSWER 3 MARKS

1. Write the application of nano robots in medical field?

Ans. (i) Nano-robots in blood stream to perform small surgical procedures, to fight against bacteria, repairing individual cell in the body.

(ii) It can travel into the body and once after the job is performed it can find its way out. Chinese scientists have created the world's first autonomous DNA robots to combat cancer tumours.

2. What is particle physics?

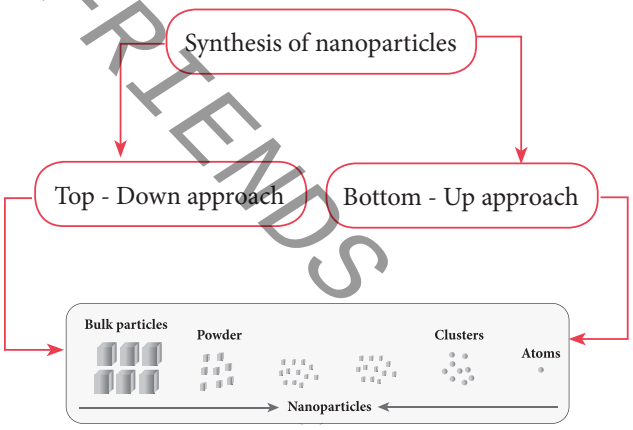
Ans. (i) Particle physics deals with the theory of fundamental particles of nature and it is one of the active research areas in physics.

(ii) Initially it was thought that atom is the fundamental entity of matter.

(iii) In 1930s and it was established that atoms are made up of electrons, protons and neutrons.

3. Write the two ways of preparing the nano materials.

Ans. There are two ways of preparing the nanomateials, **top down** and **bottom up approaches**.



4. Write the aim of artificial intelligence in robots.

Ans. (i) Face recognition.

(ii) Providing response to player's actions in computer games.

(iii) Taking decisions based on previous actions.

(iv) To regulate the traffic by analyzing the density of traffic on roads.

(v) Translate words from one language to another.

5. What is robotics?

Ans. **(i)** Robotics is an integrated study of mechanical engineering, electronic engineering, computer engineering, and science.

(ii) Robot is a mechanical device designed with electronic circuitry and programmed to perform a specific task.

(iii) These automated machines are highly significant in this robotic era where they can take up the role of humans in certain dangerous environments that are hazardous to people like defusing bombs, finding survivors in unstable ruins, and exploring mines and shipwrecks.

6. Write a note on Gravitational waves.

Ans. **(i)** Gravitational waves are the disturbances in the curvature of space-time and it travels with speed of light.

(ii) Any accelerated charge emits electromagnetic wave.

(iii) Similarly any accelerated mass emits gravitational waves but these waves are very weak even for masses like earth.

(iv) The strongest source of gravitational waves are black holes. The discovery of gravitational waves made it possible to study the structure of black holes since it is the strongest source of gravitational waves.

(v) In fact, the recent discoveries of gravitational waves are emitted by two black holes when they merge to a single black hole.

(vi) In fact, Albert Einstein theoretically proposed the existence of 'gravitational waves' in the year 1915. After 100 years, it is experimentally proved that his predictions are correct.

LONG ANSWER — 5 MARKS

1. Write the advantages and disadvantages of robotic.

Ans. **Advantages of robotic :**

(i) The robots are much cheaper than humans.

(ii) Robots never get tired like humans. It can work for 24 × 7. Hence absenteeism in work place can be reduced.

(iii) Robots are more precise and error free in performing the task.

(iv) Stronger and faster than humans.

(v) Robots can work in extreme environmental conditions: extreme hot or cold, space or underwater. In dangerous situations like bomb detection and bomb deactivation.

(vi) In warfare, robots can save human lives.

(vii) Robots are significantly used in handling materials in chemical industries especially in nuclear plants which can lead to health hazards in humans.

Disadvantages of Robotics :

(i) Robots have no sense of emotions or conscience.

(ii) They lack empathy and hence create an emotionless workplace.

(iii) If ultimately robots would do all the work, and the humans will just sit and monitor them, health hazards will increase rapidly.

(iv) Unemployment problem will increase.

(v) Robots can perform defined tasks and cannot handle unexpected situations.

(vi) The robots are well programmed to do a job and if a small thing goes wrong it ends up in a big loss to the company.

(vii) If a robot malfunctions, it takes time to identify the problem, rectify it, and even reprogram if necessary. This process requires signi cant time.

(viii) Humans cannot be replaced by robots in decision making.

(ix) Till the robot reaches the level of human intelligence, the humans in work place will exit.

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12th STD.

GOVT. MODEL QUESTION PAPER 2019-20

TIME ALLOWED : 15 min + 2.30 Hours **PHYSICS** MAXIMUM MARKS : 70

Instructions : **(1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately.**

(2) Use Blue or Black ink to write and underline and pencil to draw diagrams.

PART - I

Note : **(i) Answer all the questions: (15 × 1 = 15)**

(ii) Choose the most appropriate answer from the four given alternatives and write the option code with the corresponding answer .

1. When the current changes from +2 A to –2 A in 0.05 s, an emf of 8 V is induced in a coil. The coefficient of self-induction of the coil is:
   (a) 0.2 H (b) 0.4 H
   (c) 0.8 H (d) 0.1 H

2. If λ_v, λ_x, and λ_m represent the wavelengths of visible light, X-rays and microwaves respectively, then:
   (a) $\lambda_m > \lambda_x > \lambda_v$ (b) $\lambda_v > \lambda_m > \lambda_x$
   (c) $\lambda_m > \lambda_v > \lambda_x$ (d) $\lambda_v > \lambda_x > \lambda_m$

3. The materials used in Robotics are:
   (a) aluminum and silver
   (b) silver and gold
   (c) copper and gold
   (d) steel and aluminum

4. Two wires of A and B with circular cross-section are made up of the same materials with equal lengths. If $R_A = 3\ R_B$, then what is the ratio of radius of wire A to that of B?
   (a) 3 (b) $\sqrt{3}$ (c) $\frac{1}{\sqrt{3}}$ (d) $\frac{1}{3}$

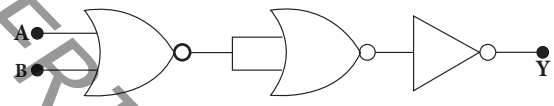
5. The frequency range of 3 MHz to 30 MHz is used for:
   (a) Ground wave propagation
   (b) Space wave propagation
   (c) Sky wave propagation
   (d) Satellite communication

6. A ray of light strikes a glass plate at an angle 60°. If the reflected and refracted rays are perpendicular to each other, the refractive index of the glass is:
   (a) $\sqrt{3}$ (b) $\frac{3}{2}$ (c) $\frac{1}{\sqrt{3}}$ (d) $\frac{1}{3}$

7. If voltage applied on a capacitor is increased from V to 2V:
   (a) Q remains the same, C is doubled
   (b) Q is doubled, C doubled
   (c) C remains same, Q doubled
   (d) Both Q and C remains same

8. The nucleus is approximately spherical in shape. Then the surface area of the nucleus having mass number having mass number A varies as :
   (a) $A^{\frac{2}{3}}$ (b) $A^{\frac{4}{3}}$ (c) $A^{\frac{1}{3}}$ (d) $A^{\frac{5}{3}}$

9. The given electrical network is equivalent to:



   (a) AND gate (b) OR gate
   (c) NOR gate (d) NOT gate

10. A wire to length l carriers a current I along the Y direction and magnetic field is given by $\vec{B} = \frac{\beta}{\sqrt{3}}\left(\vec{i} - \vec{j} + \vec{k}\right)$ T. The magnitude of Lorentz force acting on the wire is :
    (a) $\sqrt{\frac{2}{3}}\ \beta I l$ (b) $\sqrt{\frac{1}{\sqrt{3}}}\ \beta I l$
    (c) $\sqrt{2}\ \beta I l$ (d) $\sqrt{\frac{1}{2}}$

11. When a point charge of 6 μC is moved between two points in an electric field, the work done is 1.8×10^{-5} J. The potential difference between the two points is :
    (a) 1.08 V (b) 1.08 μV
    (c) 3 V (d) 30 V

(vi) Substituting the values of the R, l_1 and l_2, the internal resistance of the cell is determined. The experiment can be repeated for different values of R. It is found that the internal resistance of the cell is not constant but increases with increase of external resistance connected across its terminals.

38.(b)

(ii) **Given :** Cell supplies a circuit I_1 = 0.9 A

Cell supplies to resistor R_1 = 1

Cell supplies to circuit I_2 = 0.3 A

Cell supplies to resistor R_2 = 2 Ω

To find :

Internal resistor of the cell r = ?

Formula :

$$I_1 = \frac{\xi}{R_1 + r}$$

$$\xi = I_1 (R_1 + r) \quad ...(1)$$

$$I_2 = \frac{\xi}{R_2 + r}$$

$$\xi = I_2 (R_2 + r) \quad ...(2)$$

From (1) and (2)

$$I_1 (R_1 + r) = I_2 (R_2 + r)$$

$$r = \frac{I_1R_1 - I_2R_2}{I_2 - I_1} = \frac{0.9\times1 - 0.3\times2}{0.3 - 0.9}$$

$$= \frac{0.9 - 0.6}{0.3 - 0.9} = \frac{0.3}{-0.6} = -\frac{1}{2}$$

$$r = -0.5\ \Omega$$

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12th STD.

SURA'S MODEL QUESTION PAPER - 1

TIME ALLOWED : 15 min + 2.30 Hours **PHYSICS** MAXIMUM MARKS : 70

Instructions : (1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately.

(2) Use Blue or Black ink to write and underline and pencil to draw diagrams.

Part - I

Note : (i) Answer all the questions: **(15 × 1 = 15)**

(ii) Choose the most suitable answer from the given four alternatives and write the option code and the corresponding answer.

1. Which charge configuration produces a uniform electric field?
   (a) point Charge
   (b) infinite uniform line charge
   (c) uniformly charged infinite plane
   (d) uniformly charged spherical shell

2. A piece of copper and another of germanium are cooled from room temperature to 80 K. The resistance of
   (a) each of them increases
   (b) each of them decreases
   (c) copper increases and germanium decreases
   (d) copper decreases and germanium increases

3. A circular coil of radius 5 cm and has 50 turns carries a current of 3 ampere. The magnetic dipole moment of the coil is
   (a) 1.0 amp - m^2 (b) 1.2 amp - m^2
   (c) 0.5 amp - m^2 (d) 0.8 amp - m^2

4. A long straight conductor carrying a current lies along the axis of a ring. The conductor will exert a force on the ring, if the ring
   (a) carries a current
   (b) has uniformly distributed charge
   (c) has non-uniformly distributed
   (d) none of the above

5. A circular coil with a cross-sectional area of 4 cm^2 has 10 turns. It is placed at the center of a long solenoid that has 15 turns/cm and a cross-sectional area of 10 cm^2. The axis of the coil coincides with the axis of the solenoid. What is their mutual inductance?
   (a) 7.54 μH (b) 8.54 μH
   (c) 9.54 μH (d) 10.54 μH

6. What is the value of resistance of the following resistor?

   (a) 100 k Ω (b) 10 k Ω
   (c) 1k Ω (d) 1000 k Ω

7. Which of the following are false for electromagnetic waves
   (a) transverse
   (b) mechanical waves
   (c) longitudina
   (d) produced by accelerating charges

8. The speed of light in an isotropic medium depends on,
   (a) its intensity
   (b) its wavelength
   (c) the nature of propagation
   (d) the motion of the source w.r. to medium

9. In an electron microscope, the electrons are accelerated by a voltage of 14 kV. If the voltage is changed to 224 kV, then the de Broglie wavelength associated with the electrons would
   (a) increase by 2 times
   (b) decrease by 2 times
   (c) decrease by 4 times
   (d) increase by 4 times

38.b)

i) (i) Internet is a fast growing technology in the field of communication system with multifaceted tools.

(ii) It provides new ways and means to interact and connect with people.

(iii) Internet is the largest computer network recognized globally that connects millions of people through computers.

(iv) It finds extensive applications in all walks of life.

ii) **Possible harmful effects of nanoparticles :**

(i) The nanoparticles have same dimensions same as that of the biological molecules such as proteins. They may easily get absorbed onto the surface of living organisms and they might enter the tissues and fluids of the body.

(ii) The adsorbing nature depends on the surface of the nanoparticle. Indeed, it is possible to deliver a drug directly to a specific cell in the body by designing the surface of a nanoparticle so that it adsorbs specifically onto the surface of the target cell.

(iii) The interaction with living systems is also affected by the dimensions of the nanoparticles. For instance, nanoparticles of a few nanometers size may reach well inside biomolecules, which is not possible for larger nanoparticles.

(iv) Nanoparticles can also cross cell membranes. It is also possible for the inhaled nanoparticles to reach the blood, to reach other sites such as the liver, heart or blood cells.

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12th STD.

SURA'S MODEL QUESTION PAPER - 2

PHYSICS

TIME ALLOWED : 15 min + 2.30 Hours | MAXIMUM MARKS : 70

Instructions : (1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately.

(2) Use Blue or Black ink to write and underline and pencil to draw diagrams.

Part - I

Note : (i) Answer all the questions: **(15 × 1 = 15)**

(ii) Choose the most suitable answer from the given four alternatives and write the option code and the corresponding answer.

1. Two identical conducting balls having positive charges q1 and q2 are separated by a center to center distance r. If they are made to touch each other and then separated to the same distance, the force between them will be
   (a) less than before
   (b) same as before
   (c) more than before
   (d) zero

2. A carbon resistor of (47 ± 4.7) k Ω to be marked with rings of different colours for its identification. The colour code sequence will be
   (a) Yellow – Green – Violet – Gold
   (b) Yellow – Violet – Orange – Silver
   (c) Violet – Yellow – Orange – Silver
   (d) Green – Orange – Violet - Gold

3. Three wires of equal lengths are bent in the form of loops. One of the loops is circle, another is a semi-circle and the third one is a square. They are placed in a uniform magnetic field and same electric current is passed through them. Which of the following loop configuration will experience greater torque?
   (a) circle (b) semi-circle
   (c) square (d) all of them

4. Lorentz force generally refers to force experienced by a charge due to combined action of
   (a) magnetic fields
   (b) electric fields
   (c) electric, magnetic & gravitational fields
   (d) electric and magnetic fields

5. In a transformer, the number of turns in the primary and the secondary are 410 and 1230 respectively. If the current in primary is 6A, then that in the secondary coil is
   (a) 2 A (b) 18 A
   (c) 12 A (d) 1 A

6. Lenz's law is in accordance with the law of
   (a) conservation of charges
   (b) conservation of flux
   (c) conservation of momentum
   (d) conservation of energy

7. During the propagation of electromagnetic waves in a medium:
   (a) electric energy density is double the magnetic energy density
   (b) electric energy density is half of the magnetic energy density
   (c) electric energy density is equal to the magnetic energy density
   (d) both electric and magnetic energy densities are zero

8. When a biconvex lens of glass having refractive index 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index,
   (a) less than one
   (b) less than that of glass
   (c) greater than that of glass
   (d) equal to that of glass

ANSWERS

Part - I

1. (c) more than before
2. (b) Yellow – Violet – Orange – Silver
3. (a) circle
4. (d) electric and magnetic fields
5. (a) 2 A
6. (d) conservation of energy
7. (c) electric energy density is equal to the magnetic energy density
8. (d) equal to that of glass
9. (b) 1 : 3
10. (c) $M(N, Z) = NM_n + ZM_p - B/c^2$
11. (a) Recombination of charge carriers
12. (c) diffusion of charge carriers
13. (b) very high frequency band
14. (a) Sound
15. (d) Steel and aluminum

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