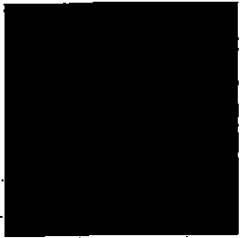# Form C01

## (July 2020)

The **ACT**®

2019|2020

In response to your request for Test Information Release materials, this booklet contains the test questions, scoring keys, and conversion tables used in determining your ACT scores. Enclosed with this booklet is a report that lists each of your answers, shows whether your answer was correct, and, if your answer was not correct, gives the correct answer.

If you wish to order a photocopy of your scanned answer document—including, if you took the writing test, a copy of your written essay—please use the order form on the inside back cover of this booklet.

*01129 2 2 00*

## ENGLISH TEST

### 45 Minutes—75 Questions

**DIRECTIONS:** In the five passages that follow, certain words and phrases are underlined and numbered. In the right-hand column, you will find alternatives for the underlined part. In most cases, you are to choose the one that best expresses the idea, makes the statement appropriate for standard written English, or is worded most consistently with the style and tone of the passage as a whole. If you think the original version is best, choose "NO CHANGE." In some cases, you will find in the right-hand column a question about the underlined part. You are to choose the best answer to the question.

You will also find questions about a section of the passage, or about the passage as a whole. These questions do not refer to an underlined portion of the passage, but rather are identified by a number or numbers in a box.

For each question, choose the alternative you consider best and fill in the corresponding oval on your answer document. Read each passage through once before you begin to answer the questions that accompany it. For many of the questions, you must read several sentences beyond the question to determine the answer. Be sure that you have read far enough ahead each time you choose an alternative.

**PASSAGE I**

### A Mouthful of Music

*Mouth music* is the name given in English to the many ways by imitating the sounds of musical instruments with
1
the human voice. Forms of mouth music are performed

around the world, but the genre being particularly popular
2
in England, Ireland, and Scotland. In this Celtic region,

*lilting* and *jigging* are two of the lively names used to

refer to this musical form.

Celtic mouth music exists to accompany

dancing, so the rhythms and sounds are ·

first-class and the words take a back seat.
3
Instead of using traditional lyrics, singers often

produce nonsense syllables, called vocables to
4
represent specific instrumental sounds, such as

those of bagpipes or violins. The results are songs

that rarely make literal sense but nevertheless flow

in a way easier to dance to. ·
5

1. A. NO CHANGE
   B. with
   C. of
   D. at

2. F. NO CHANGE
   G. was being
   H. is
   J. DELETE the underlined portion.

3. A. NO CHANGE
   B. more important than the lyrics.
   C. a bigger deal than the words.
   D. way more vital than verse.

4. F. NO CHANGE
   G. syllables called vocables,
   H. syllables, called vocables,
   J. syllables called, vocables,

5. A. NO CHANGE
   B. easily
   C. that is easy
   D. DELETE the underlined portion.

One Scottish form of mouth music, *puirt-a-beul*, is performed entirely in the Gaelic language and accompanies traditional dance steps. The often tongue-twisting lyrics require much practice to perfect. The greater challenge for
<u>6</u>

many puirt-a-beul singers, <u>though, is learning when to</u>
<u>7</u>
breathe. A poorly timed breath might break a song's

flow, interrupting the steady beat <u>it relies</u> on to help
<u>8</u>
time their steps.

<u>9</u> Instruments were prohibitively expensive and

thus scarce in isolated Scottish <u>villages in order to fill</u>
<u>10</u>
the void, mouth music emerged and provided residents

with the music they wanted for dancing. Additionally,

puirt-a-beul gave anyone <u>whomever</u> didn't read music
<u>11</u>
a way to learn and pass on traditional songs.

The continuing popularity of Celtic

mouth music is testament to the vitality of <u>them.</u>
<u>12</u>
In the 1990s, groups like Mouth Music from Scotland

and The Cranberries from Ireland rose to fame,

<u>exposing with audiences Celtic mouth music worldwide.</u>
<u>13</u>

6. If the writer were to delete the underlined portion, the sentence would primarily lose:
   F. a description that emphasizes the difficulty of puirt-a-beul.
   G. information about writing lyrics for puirt-a-beul music.
   H. an indication of how often puirt-a-beul is performed in the Celtic culture.
   J. an example of a training exercise puirt-a-beul singers use to practice lyrics.

7. A. NO CHANGE
   B. at the same time,
   C. this time,
   D. still,

8. F. NO CHANGE
   G. dancers rely
   H. they rely
   J. relied

9. Given that all the following statements are true, which one, if added here, would most effectively introduce the subject of the paragraph?
   A. Puirt-a-beul was most likely invented out of necessity.
   B. Mouth music singers must have a good sense of rhythm.
   C. Celtic mouth music, including puirt-a-beul, has influenced jazz scat singing.
   D. Another form of mouth music that originated in Scotland is the waulking song.

10. F. NO CHANGE
    G. villages and in
    H. villages. In
    J. villages, in

11. A. NO CHANGE
    B. which
    C. whom
    D. who

12. F. NO CHANGE
    G. this musical form.
    H. itself.
    J. one.

13. A. NO CHANGE
    B. exposing audiences worldwide to Celtic mouth music.
    C. for audiences worldwide exposing Celtic mouth music.
    D. worldwide exposing Celtic mouth music to audiences.

The bands' celebrity continually survives as they
<u>                                            </u>
14

combine traditional mouth music with modern rhythms.
<u>                                                    </u>
15

**14.** F. NO CHANGE
G. still remains and carries on
H. stays sticking around
J. endures

**15.** Given that all the choices are accurate, which one most effectively expresses the idea that the bands incorporate both classic Celtic music and current influences into their music?

A. NO CHANGE
B. continue to produce new music and release new albums.
C. put on concerts around the world.
D. sing and dance on stage.

## Making the Desert Bloom

More than two thousand years ago, a people the

Romans, called the Garamantes, created a complex
<u>                                        </u>
16
civilization in one of the world's driest places—the Sahara

Desert. Beginning around 500 BCE, they built towns and

villages, cloth was manufactured there and jewelry, and
<u>                                        </u>
17
traded throughout North Africa and the Mediterranean.

They also grew a variety of crops, including wheat,

dates, palms, grapes, figs, and melons. [18]

The survival of their civilization depended on

hundreds of miles of underground tunnels. These tunnels

carried water to desert settlements from an aquifer, an

underground water source, in the distant mountains.
<u>                                        </u>
19

The water ran through sloping, hand-dug tunnels
<u>        </u>
20
called foggaras, which could be as deep as one hundred

thirty feet below ground. These tunnels were connected

to the surface by ventilation shafts every thirty feet or so.

**16.** F. NO CHANGE
G. Romans called the Garamantes,
H. Romans called: the Garamantes
J. Romans called the Garamantes

**17.** A. NO CHANGE
B. the manufacture of cloth took place
C. manufactured cloth
D. cloth

**18.** If the writer were to delete the preceding sentence, the paragraph would primarily lose a concluding statement that:

F. suggests the Garamantes were successful farmers in that they grew a variety of crops.
G. summarizes the information presented about the Garamantes.
H. indicates the products that the Garamantes exported to Rome.
J. takes the focus off the Garamantes and places it on the products they imported.

**19.** Which choice provides new information to the essay?
A. NO CHANGE
B. upon which they depended.
C. used by the Garamantes.
D. a key to their survival.

**20.** Which choice best indicates the method used to build the tunnels?
F. NO CHANGE
G. underground
H. dimly lit
J. desert

When the tunnels reached a town or field, the water flowed

into more easy accessible surface canals or reservoirs.
___
21

Having left no clues, archaeologists don't know how
___
22

the Garamantes learned to build foggaras. Other such

tunnels exist in Iran, Algeria, Tunisia, and elsewhere.

Because the canals were underground, the water they

carried stayed clean and didn't evaporate. And because the

water came from an aquifer rather then from its rainfall,
___
23

the supply was unaffected by drought. The Garamantes

could of relied on a constant supply of water for drinking,
___
24

washing, and irrigation. Moreover, the cold, damp air of
___
25

the foggaras lowered the temperature inside the homes

that were built over them, resulting in an ancient form

of air-conditioning.

The Garamantes who thrived until about 500 CE,
___
26

when some archaeologists believe they began to deplete

the aquifer. As the foggaras supplied less and less water,
___
27

the Garamantes' population declined, their civilization
___
28

eventually collapsed. However, at least six hundred of

the ancient foggaras survive. The stone mounds that mark

their ventilation shafts are still visible in what is now

southwestern Libya, where they can be seen even now.
___
29

**21.** A. NO CHANGE
   B. more easily
   C. easier and
   D. easy and

**22.** F. NO CHANGE
   G. A genuine puzzle to scientists, archaeologists
   H. Giving no indication, archaeologists
   J. Archaeologists

**23.** A. NO CHANGE
   B. than from
   C. then
   D. by

**24.** F. NO CHANGE
   G. had to of relied
   H. could rely
   J. relies

**25.** A. NO CHANGE
   B. Nevertheless,
   C. In contrast,
   D. Even so,

**26.** F. NO CHANGE
   G. many of whom
   H. having
   J. DELETE the underlined portion.

**27.** A. NO CHANGE
   B. As to when
   C. Whereas
   D. Though

**28.** F. NO CHANGE
   G. declined the Garamantes'
   H. declined. Their
   J. declined their

**29.** A. NO CHANGE
   B. a place where visitors can see these amazing signs of an ancient civilization.
   C. the location that continues to present visitors with a view of these remnants of a time gone by.
   D. DELETE the underlined portion and end the sentence with a period.

Question 30 asks about the preceding passage as a whole.

30. Suppose the writer's primary purpose had been to present information about a civilization's efforts to overcome a natural obstacle in order to survive. Would this essay accomplish that purpose?
  F. Yes, because it explains that the Garamantes traded throughout North Africa and the Mediterranean.
  G. Yes, because it describes the Garamantes' method of bringing water to an otherwise dry area, allowing the Garamantes to thrive there.
  H. No, because the foggaras were not naturally occurring tunnels.
  J. No, because the foggaras ultimately led to the downfall of the Garamantes' civilization.

**PASSAGE III**

### Neutrinos on Ice

At the IceCube Neutrino Observatory in Antarctica, eighty-six cables descend 2,500 meters down into the glacial terrain. Each cable is equipped with sixty digital optical modules (DOMs), which, are programmed, to detect a faint blue flash known as Cherenkov radiation.

This radiation: a veritable shock wave of photonic energy—is emitted when subatomic particles called neutrinos collide with electrons in the molecules of ice.

Although there are countless neutrinos in the universe (fifty trillion neutrinos pass through your body every second), actually detecting them is a formidable task. Neutrinos carry no electrical charge, are practically weightless, and travel at nearly the speed of light. Neutrinos are rarely affected by matter or electromagnetic fields. For this purpose, many neutrinos have been traveling through space unimpeded for billions of years.

31. A. NO CHANGE
    B. down below
    C. downwards
    D. DELETE the underlined portion.

32. F. NO CHANGE
    G. (DOMs), which are programmed
    H. (DOMs): which are programmed
    J. (DOMs); which are programmed

33. A. NO CHANGE
    B. radiation—
    C. radiation;
    D. radiation

34. If the writer were to delete the underlined portion (adjusting the punctuation as needed), the essay would primarily lose information that:
    F. specifies why neutrinos are practically weightless.
    G. explains how neutrinos pass through matter.
    H. indicates why there are so many neutrinos.
    J. emphasizes how numerous neutrinos are.

35. A. NO CHANGE
    B. In contrast,
    C. Besides,
    D. In fact,

On some occasions however; neutrinos do collide
36

with other particles. [37] Scientists specifically selected

the site of the IceCube Neutrino Observatory to facilitate
38

the detection of such a collision. Not only is the Antarctic

subterranean ice exceptionally clear, it is also less

pressurized due to it's subzero altitude. These factors
39

increase the chance of DOMs detecting the blue flash

that signifies a neutrino collision. Once this detection

occurs, data is gathered and transferred to laboratories

at the University of Wisconsin. Here, the origin of each

of these neutrinos is determined by analyzing the direction
40

and intensity of the flash.

Determining neutrinos' origins could provide
41

scientists with new insights into the universe. For instance,
41

some neutrinos are produced during supernovae (the

collapsing of stars). The origins of these neutrinos could
42

**36. F.** NO CHANGE
**G.** occasions, however,
**H.** occasions, however;
**J.** occasions, however

**37.** At this point, the writer is considering adding the following true sentence:

In 1956, during the Cowan-Reines neutrino experiment, a neutrino was detected for the first time.

Should the writer make this addition?

**A.** Yes, because the information is relevant to the history of neutrino detection outlined in the paragraph.
**B.** Yes, because the information indicates that subzero altitude is essential to the detection of neutrinos.
**C.** No, because the information is unrelated to the discussion of why scientists selected the location of the IceCube Neutrino Observatory.
**D.** No, because the information is unrelated to why the detection of neutrinos is facilitated by zero-gravity conditions.

**38. F.** NO CHANGE
**G.** Observatory, and to
**H.** Observatory. To
**J.** Observatory; to

**39. A.** NO CHANGE
**B.** their
**C.** its
**D.** its'

**40. F.** NO CHANGE
**G.** have been
**H.** are being
**J.** are

**41.** Which of the following true sentences best introduces the main idea of the paragraph?

**A.** NO CHANGE
**B.** For decades, scientists have been trying to learn more about gamma rays through the study of supernovae.
**C.** Recently, at IceCube, scientists discovered two neutrinos, which they now refer to as Bert and Ernie.
**D.** Neutrinos can now be created in laboratories, using a particle accelerator called a Super Proton Synchrotron.

**42. F.** NO CHANGE
**G.** stars) and the
**H.** stars), the
**J.** stars) the

**GO ON TO THE NEXT PAGE.**

give us opulent information about how, when, and why
‾‾
43

stars collapse. Scientists are optimistic that the neutrinos

detected at IceCube could lead to new ways of looking

at our galaxy—and galaxies beyond.
‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾
44

43. A. NO CHANGE
    B. invaluable
    C. upscale
    D. lavish

44. The writer wants to emphasize that information gar-
    nered from the detected neutrinos at IceCube could
    have dramatic effects on how scientists study the uni-
    verse. Which choice best accomplishes that goal?
    F. NO CHANGE
    G. phenomena that have puzzled scientists over the
       last decade.
    H. common occurrences in space.
    J. the world around us.

---

Question 45 asks about the preceding passage
as a whole.

---

45. Suppose the writer's primary purpose had been to out-
    line a scientific theory concerning the origins of a par-
    ticle in nature. Would this essay accomplish that goal?
    A. Yes, because it explains how scientists are discov-
       ering new reasons why neutrinos emit a blue flash
       known as Cherenkov radiation.
    B. Yes, because it summarizes how DOMs at the
       IceCube Neutrino Observatory track neutrinos to
       their origins despite neutrinos' numerous colli-
       sions with matter and electromagnetic forces.
    C. No, because it describes instead how neutrinos are
       detected at an observatory and how these detec-
       tions could benefit future scientific research.
    D. No, because it details instead how new research on
       neutrinos could potentially contradict a commonly
       held theory about supernovae.

---

**PASSAGE IV**

### Clinton Hill's Found Artist

[1]

At the Urban Vintage, my favorite café here in

Clinton Hill, Brooklyn, I found a table by the window

and checked the day's news on my laptop. On the

*New York Times* home page, I noticed an article about

Rafael Leonardo Black, a 64-year-old Clinton Hill

artist who had just been discovered. [A]
‾‾‾‾
46

46. F. NO CHANGE
    G. of whom
    H. which
    J. whom

[2]

Black, a native of Aruba, has been creating art in his
47
New York City studio apartment for over three decades.

Until recently, few people had seen his work. I wondered

why—and learned he simply never cared to share it. Black

has worked as a typist, a salesperson, and a receptionist.

He never expected (or tried) to make a living as an artist.

However, in May of 2013, art dealer Francis Naumann,

directed to Black's art by one of Black's longtime friends,

displayed sixteen of the artist's drawings in a solo show.
48

Within days, ten of Black's pieces sold for, prices ranging
49
from $16,000 to $28,000. [B]

[3]

Black draws collages in black No. 2

pencil on white board and they're packed with
50

depictions, in the form of drawings, of ancient myths,
51
historical events, and popular culture. I found a collage

titled *Seven Lamps* in a quick search online. [C] It

features a representation of a British psychedelic poster,

a portrayal of Danish surrealist painter, Wilhelm Freddie,
52
at work, and a tiny figure of Los Angeles architect Simon

Rodia. The images are stacked, forming a surreal tower.

47. **A.** NO CHANGE
    **B.** originally from Aruba, for more than half his life
    **C.** living in Clinton Hill but a native of Aruba,
    **D.** a newly found artist originally from Aruba,

48. Given that all the choices are accurate, which one provides the best transition to the information in the following sentence?
    **F.** NO CHANGE
    **G.** was taking down an artist's long-running exhibition at his Manhattan gallery.
    **H.** became aware that Black had never shown his drawings, formally or otherwise.
    **J.** recognized that no one in the New York City art world had heard of Black.

49. **A.** NO CHANGE
    **B.** sold—for
    **C.** sold; for
    **D.** sold for:

50. **F.** NO CHANGE
    **G.** board. They're
    **H.** board, they're
    **J.** board they're

51. **A.** NO CHANGE
    **B.** black pencil drawings that depict
    **C.** drawings that create collages of
    **D.** depictions of

52. **F.** NO CHANGE
    **G.** painter Wilhelm Freddie,
    **H.** painter, Wilhelm Freddie
    **J.** painter Wilhelm Freddie

I wasn't sure how the drawings in *Seven Lamps*—so

detailed that I could see the folds in Rodia's clothing—fit
$\overline{\text{53}}$

together logically, but I liked that there was so much for
$\overline{\phantom{xxxxxxxxxxxx}\text{54}\phantom{xx}}$

me to puzzle over. Maybe this complexity
$\overline{\text{54}}$

in May helps explain why Black's work created such a stir.
$\overline{\text{55}}$

[4]

I read that Black observes the sudden interest
$\overline{\text{56}}$
in his drawings. [D] He says he's always been an artist,

regardless of who knew it. Given that I know the city, I'll
$\overline{\phantom{xxxxxxxxxxxxx}\text{57}\phantom{xxx}}$
keep checking the *Times* for word of his next show. When

I walk home from the Urban Vintage, its décor often being
$\overline{\phantom{xxxxxxxxxxx}\text{58}}$
updated with restored antiques and vintage housewares, I
$\overline{\phantom{xxxxx}\text{58}}$

wonder if I'll pass the brownstone building where, Black,
$\overline{\phantom{xxxxxxxxxxxxx}\text{59}}$
creates his fascinating, newly found art.

**53. A.** NO CHANGE
**B.** has fit
**C.** is fit
**D.** fits

**54.** If the writer were to delete the underlined portion (adjusting the punctuation as needed), the essay would primarily lose a:
**F.** claim arguing that the reason Naumann chose to show Black's art is that the art offers so much for a viewer to reflect upon and analyze.
**G.** detail indicating that the narrator appreciated Black's collage even though he or she might not have understood its overall intent.
**H.** comment suggesting that though the narrator enjoys only some of Black's art, he or she is glad that Black has been discovered.
**J.** statement revealing the narrator's belief that the best modern art is understood only by the artist who created it.

**55.** The best placement for the underlined portion would be:
**A.** where it is now.
**B.** after the word *Maybe*.
**C.** after the word *explain*.
**D.** after the word *stir* (and before the period).

**56.** The writer wants to clearly establish that the newspaper article claims Black is unmoved by the sudden interest in his art. Which choice best accomplishes that goal?
**F.** NO CHANGE
**G.** is nearly a celebrity in Clinton Hill due to
**H.** has benefited financially from
**J.** gives little thought to

**57.** Which choice provides the most effective transition from the preceding sentence to this sentence?
**A.** NO CHANGE
**B.** Since I'm knowledgeable about art and books,
**C.** Now that I know about him,
**D.** Knowing that I like news,

**58. F.** NO CHANGE
**G.** Vintage, easily carrying my lightweight laptop in my old, navy blue messenger bag,
**H.** Vintage this evening—I can't be late to meet a friend exactly at eight—
**J.** Vintage tonight,

**59. A.** NO CHANGE
**B.** building where Black
**C.** building, where Black
**D.** building: where Black

> Question 60 asks about the preceding passage as a whole.

**60.** The writer is considering adding the following sentence to the essay:

> Fortunately, the web page included a key that identified the people, places, and events—most of which I had never even heard of—that Black portrays in this piece.

If the writer were to add this sentence, it would most logically be placed at:

F. Point A in Paragraph 1.
G. Point B in Paragraph 2.
H. Point C in Paragraph 3.
J. Point D in Paragraph 4.

---

**PASSAGE V**

**Cher Ami, Pigeon Hero**

Pigeons have a fairly poor reputation. In many

urban areas, they are considered little more than,
                                              ―――
                                               61

"rats with wings," blamed for spreading disease and
                         ―――――
                          62

despoiling statues. For example, one species, the homing
                    ―――――――――
                        63

pigeon, which is among the best navigators of the natural
―――――――
   64

world. There navigational ability has earned the homely
       ――――
        65
pigeon an undeniable place in history.

**61.** A. NO CHANGE
    B. than—
    C. than;
    D. than

**62.** F. NO CHANGE
    G. wings" and they are blamed
    H. wings," they are blamed
    J. wings." Blamed

**63.** A. NO CHANGE
    B. Similarly,
    C. However,
    D. Thus,

**64.** F. NO CHANGE
    G. pigeon that
    H. pigeon,
    J. pigeon

**65.** A. NO CHANGE
    B. They're
    C. It's
    D. Its

Former modern technologies like the radio or
66
telephone, commanders on the battlefield often faced

challenges in communicating, depending on their location.
67
One solution was to use homing pigeons to carry messages

from the front lines back to headquarters. The pigeon was

a particularly good soldier in such endeavors: It flew fast.

It flew high. And it always quickly returned and came back
68
to its home roost.

The most famous avian war hero is perhaps Cher Ami,

whose name means *dear friend*. One of six hundred birds

used by the US Army Signal Corps in France during

World War I, all twelve of Cher Ami's missions were
69
deemed successful. His last was instrumental in saving
69
hundreds of lives.

Near Verdun, France, the 77th Infantry Division

became separated from US forces. The men were

surrounded by German troops and were rapidly running

out of rations. They were separated from other US forces.
70

They had but one link to headquarters homing pigeons.
71

It was becoming clear that the Americans were unaware
72
of the 77th's whereabouts, the situation grew dire.

66. F. NO CHANGE
G. Before
H. Earlier
J. Prior

67. The writer is considering revising the underlined portion to the following:

especially across long distances and difficult terrain.

Should the writer make this revision?

A. Yes, because it offers a better indication of the circumstances that made communication difficult.
B. Yes, because it more clearly identifies the locations of and distances between troops.
C. No, because it adds information that is irrelevant to the paragraph's discussion of pigeons.
D. No, because it suggests that homing pigeons are unnecessary today.

68. F. NO CHANGE
G. speedily returned, coming home
H. returned home
J. returned

69. A. NO CHANGE
B. the twelve missions Cher Ami flew were successful.
C. successful missions by Cher Ami numbered twelve.
D. Cher Ami flew twelve successful missions.

70. F. NO CHANGE
G. German troops were all around them.
H. They would soon be out of rations.
J. DELETE the underlined portion.

71. A. NO CHANGE
B. headquarters:
C. headquarters;
D. headquarters,

72. F. NO CHANGE
G. Having become
H. As it became
J. It became

Major Whittlesey wrote a note about the 77th's location, placed it in a canister attached to the pigeon's leg, and watched as the bird flew out in the midst of battle. Despite being wounded in flight, Cher Ami managed to deliver the message to headquarters; the unit known as "the Lost Battalion" would be rescued.

News reports around the world touted the bird's heroism. The French military awarded Cher Ami a medal, the War Cross. Although one might question
73

the extent in which Cher Ami understood his mission,
74

his story proves that pigeons are unique.
75

**73. A.** NO CHANGE
  **B.** medal, it was the
  **C.** medal, that was
  **D.** medal. The

**74. F.** NO CHANGE
  **G.** of
  **H.** to
  **J.** DELETE the underlined portion.

**75.** Which choice best concludes the sentence and essay by connecting Cher Ami's story to a specific idea raised in the first paragraph of the essay?
  **A.** NO CHANGE
  **B.** is testimony to the homing pigeon's navigational skill and instinct.
  **C.** has made people reconsider the definition of heroism.
  **D.** suggests that even birds can be brave.

**END OF TEST 1**

**STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.**

## MATHEMATICS TEST

*60 Minutes—60 Questions*

**DIRECTIONS:** Solve each problem, choose the correct answer, and then fill in the corresponding oval on your answer document.

Do not linger over problems that take too much time. Solve as many as you can; then return to the others in the time you have left for this test.

You are permitted to use a calculator on this test. You may use your calculator for any problems you choose,

but some of the problems may best be done without using a calculator.

Note: Unless otherwise stated, all of the following should be assumed.

1. Illustrative figures are NOT necessarily drawn to scale.
2. Geometric figures lie in a plane.
3. The word *line* indicates a straight line.
4. The word *average* indicates arithmetic mean.

---

1. The parallelogram below has consecutive angles with measures $x°$ and $25°$. What is the value of $x$ ?
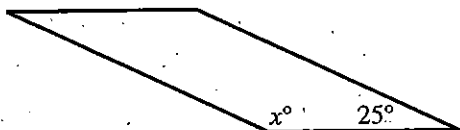


   A. 100
   B. 115
   C. 130
   D. 140
   E. 155

2. A retail sales associate's daily commission during 1 week was $30 on Monday and Tuesday and $70 on Wednesday, Thursday, and Friday. What was the associate's average daily commission for these 5 days?

   F. $50
   G. $51
   H. $54
   J. $55
   K. $56

3. What is the greatest common factor of 45, 50, and 84 ?

   A. 0
   B. 1
   C. 2
   D. 3
   E. 5

4. For what value of $x$ is the equation $2(x - 12) + x = 36$ true?

   F. 4
   G. 8
   H. 16
   J. 20
   K. 30

**DO YOUR FIGURING HERE.**

**DO YOUR FIGURING HERE.**

5. A bag contains exactly 22 solid-colored buttons: 4 red, 6 blue, and 12 white. What is the probability of randomly selecting 1 button that is NOT white?

A. $\frac{5}{11}$

B. $\frac{5}{6}$

C. $\frac{2}{3}$

D. $\frac{1}{22}$

E. $\frac{1}{10}$

6. On a map, $\frac{1}{2}$ inch represents 12 actual miles. Two towns that are 5 inches apart on this map are how many actual miles apart?

F. 120
G. 60
H. 30
J. 24
K. 12

7. Caden had exactly 45 plants to sell. After Day 1 of his sale, he had exactly 42 plants left. After Day 2, Caden had exactly 39 plants left. After Day 3, he has exactly 36 plants left. Assuming Caden will continue to sell plants at that daily rate, how many of these plants will he have left at the end of Day 6 ?

A. 33
B. 27
C. 24
D. 6
E. 3

8. An on-demand movie service charges $5 per month, plus $2 for each movie rented. Which of the following equations models the relationship between $M$, the number of movies rented per month, and $T$, the total monthly cost, in dollars, for the service?

F. $M = 5 + 2T$
G. $M = 2 + 5T$
H. $T = 5 + 2M$
J. $T = 2 + 5M$
K. $T = (5 + 2)M$

9. What are the solutions to the quadratic equation $(2x + 5)(3x - 4) = 0$ ?

A. $-5$ and $4$

B. $-\frac{5}{2}$ and $-\frac{4}{3}$

C. $-\frac{5}{2}$ and $\frac{4}{3}$

D. $\frac{5}{2}$ and $-\frac{4}{3}$

E. $\frac{5}{2}$ and $\frac{4}{3}$

**GO ON TO THE NEXT PAGE.**

**10.** An 8-inch-by-6-inch rectangle is cut along a diagonal to form 2 triangles. What is the area, in square inches, of each triangle?

F. 7
G. 12
H. 14
J. 24
K. 48

**DO YOUR FIGURING HERE.**

**11.** In a class of tenth graders, no student participated in more than 1 of the following extracurricular activities: $\frac{2}{3}$ the class played in the band; $\frac{1}{6}$ sang in the chorus; $\frac{1}{10}$ played football; and $\frac{1}{60}$ played basketball. What fraction of the class did not participate in any 1 of these 4 activities?

A. 0

B. $\frac{1}{5,400}$

C. $\frac{1}{20}$

D. $\frac{74}{79}$

E. $\frac{57}{60}$

**12.** What is the smallest integer greater than $\sqrt{61}$ ?

F. 4
G. 7
H. 8
J. 10
K. 31

**13.** In $\triangle ABC$ shown below, $\sin C = \frac{2}{3}$ and the length of $\overline{AB}$ is 6 inches. What is the length, in inches, of $\overline{AC}$ ?



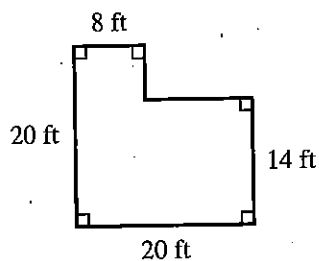A. $\sqrt{5}$
B. $\sqrt{13}$
C. 4
D. 5
E. 9
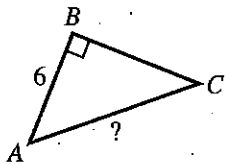
14. The table below shows the first 5 terms of an arithmetic sequence. Which of the following is a general expression for the $n$th term?

| Term position ($n$) | $n$th term |
|---|---|
| 1 | 1 |
| 2 | 5 |
| 3 | 9 |
| 4 | 13 |
| 5 | 17 |

F. $2n - 1$
G. $3n - 2$
H. $4n - 3$
J. $5n - 4$
K. $6n - 5$

15. What is the perimeter, in feet, of the figure shown below?

8 ft

20 ft

14 ft

20 ft

A. 60
B. 62
C. 70
D. 80
E. 84

16. Manuel estimates that $\frac{2}{3}$ of a pizza is left. Stephen estimates that $\frac{3}{4}$ is left. They are going to compromise for a joint estimate by using the number halfway between their 2 estimates. What is their joint estimate?

F. $\frac{17}{24}$

G. $\frac{5}{12}$

H. $\frac{5}{8}$

J. $\frac{5}{7}$

K. $\frac{1}{2}$

17. So far this basketball season, Sherita made 46 of her first 60 free throws, giving her a free-throw average of about 76.7%. What is the minimum number of free throws she would need to make from now on in order to have a free-throw average of at least 80% ?

A. 2
B. 3
C. 10
D. 14
E. 20

18. Two functions are defined as $f(x) = 2x - 1$ and $g(x) = x^2 + 1$. Which of the following expressions represents $f(g(x))$ ?

F. $x^2 + 2x$

G. $2x^2 + 1$

H. $2x^2 + 2$

J. $4x^2$

K. $4x^2 - 4x + 2$

19. Data Set A consists of the 8 numbers listed below. Data Set B consists of the 8 numbers in A and a 9th number, which is greater than 90. How will the mean and the median of B compare to the mean and the median of A ?

$$62, 76, 76, 80, 82, 87, 94, 96$$

A. The mean and the median of B will each be greater than the mean and the median of A.

B. The mean and the median of B will each be less than the mean and the median of A.

C. The mean and the median of B will each be the same as the mean and the median of A.

D. The mean of B will be the same as the mean of A, and the median of B will be greater than the median of A.

E. The mean of B will be greater than the mean of A, and the median of B will be the same as the median of A.

20. A truck traveling at 35 mph has a leaky radiator that is losing 4 fluid ounces per minute. How many *miles* will the truck travel before the radiator, which held 480 fluid ounces when it began to leak, is empty?

F. 13.7

G. 17.5

H. 35.0

J. 70.0

K. 120.0

21. In the standard $(x,y)$ coordinate plane, what is the midpoint of the line segment that has endpoints $(-5,8)$ and $(3,-1)$ ?

A. $(-2, -9)$

B. $\left(-1, \frac{7}{2}\right)$

C. $\left(\frac{3}{2}, 1\right)$

D. $\left(4, -\frac{9}{2}\right)$

E. $(8, -9)$

**DO YOUR FIGURING HERE.**

**GO ON TO THE NEXT PAGE.**

**22.** The ordered pairs $(x,y)$ in one of the following tables belong to a linear function. Which one?

**F.**

| x | y |
|---|---|
| 0 | 1 |
| 1 | 0 |
| 2 | 1 |
| 3 | 0 |

**J.**

| x | y |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | 0 |
| 3 | 1 |

**G.**

| x | y |
|---|---|
| 0 | 2 |
| 1 | 1 |
| 2 | 1 |
| 3 | 0 |

**K.**

| x | y |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | 4 |
| 3 | 9 |

**H.**

| x | y |
|---|---|
| 0 | 3 |
| 1 | 2 |
| 2 | 1 |
| 3 | 0 |

**23.** In $\triangle ABC$ shown below, $m\angle A = x°$, $m\angle B = (2x)°$, $m\angle C = (3x)°$, $AB = c$ inches, $AC = b$ inches, and $BC = a$ inches. Which of the following inequalities correctly relates the side lengths of $\triangle ABC$ ?

(Note: $m\angle A$ denotes the measure of $\angle A$, and $AB$ denotes the length of $\overline{AB}$. The triangle is NOT drawn to scale.)
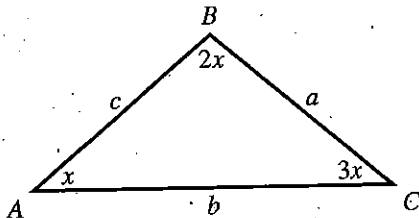


- **A.** $a < b < c$
- **B.** $a < c < b$
- **C.** $b < a < c$
- **D.** $c < a < b$
- **E.** $c < b < a$

**24.** What is the slope of the line that passes through $(1,5)$ and $(17,7)$ in the standard $(x,y)$ coordinate plane?

- **F.** $\frac{1}{8}$
- **G.** $\frac{2}{3}$
- **H.** $\frac{3}{2}$
- **J.** $\frac{5}{2}$
- **K.** $8$

19

ACT-C01

**25.** The perimeter of a particular rectangle is 36 centimeters. The longer sides of the rectangle are each 2 centimeters longer than each of the shorter sides of the rectangle. What is the length, in centimeters, of one of the longer sides of this rectangle?

A. 8
B. 9
C. 10
D. 18
E. 32

**DO YOUR FIGURING HERE.**

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Use the following information to answer questions 26–28.

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Winter Fun Ski Resort sells only 2 types of tickets—adult and student. On Monday, the resort sold 200 tickets, 1 ticket to each skier. Of those tickets, 25 were sold to first-time skiers. When Alyssa skis the resort's main run, her elevation, $E$ feet, at any point on the run is modeled by the equation $E = \dfrac{300{,}000}{t + 100}$ where $t$ is the number of seconds after she begins skiing at the start of the main run.

**26.** The resort collected a total of $6,000 in ticket sales on Monday. The price of an adult ticket is $50 and the price of a student ticket is $25. How many adult and student tickets were sold on Monday?

|    | adult | student |
|----|-------|---------|
| F. | 40    | 160     |
| G. | 80    | 120     |
| H. | 100   | 100     |
| J. | 120   | 80      |
| K. | 160   | 40      |

**27.** On Monday, the resort sold 1 ticket to each of the 8 members of the Herzog family. Assume this family is a representative sample of all of the skiers at the resort on Monday. How many of the 8 members of the Herzog family are NOT first-time skiers?

A. 1
B. 2
C. 4
D. 6
E. 7

**28.** What is Alyssa's elevation, in feet, at the start of the main run?

F. 30
G. 300
H. 3,000
J. 30,000
K. 300,000

---

**DO YOUR FIGURING HERE.**

29. One side of square *ABCD* has a length of 18 meters. A certain rectangle whose area is equal to the area of *ABCD* has a width of 6 meters. What is the length, in meters, of the certain rectangle?

    A. 18
    B. 24
    C. 27
    D. 30
    E. 54

30. The $2 \times 2$ matrices *A* and *B* below are related to matrix *C* by the equation $C = 2A - 3B$. What is matrix *C* ?

    $$A = \begin{bmatrix} 3 & 5 \\ -2 & 1 \end{bmatrix} \quad B = \begin{bmatrix} -4 & 5 \\ 2 & 1 \end{bmatrix}$$

    F. $\begin{bmatrix} 18 & -5 \\ -10 & -1 \end{bmatrix}$

    G. $\begin{bmatrix} 13 & -10 \\ -8 & -2 \end{bmatrix}$

    H. $\begin{bmatrix} 10 & 5 \\ -6 & 1 \end{bmatrix}$

    J. $\begin{bmatrix} 6 & -1 \\ -5 & -1 \end{bmatrix}$

    K. $\begin{bmatrix} -6 & 25 \\ 2 & 5 \end{bmatrix}$

31. Jen is doing an experiment to determine whether a high-protein food affects the ability of white mice to find their way through a maze. The mice in the experimental group were given the high-protein food; the mice in the control group were given regular food. Jen then timed the mice as they found their way through the maze. The table below shows the results.

| Mouse number | Experimental group | Control group |
|---|---|---|
| 1 | 1 min 46 sec | 2 min 13 sec |
| 2 | 2 min 2 sec | 1 min 49 sec |
| 3 | 2 min 20 sec | 2 min 28 sec |
| 4 | 1 min 51 sec | 2 min 7 sec |
| 5 | 1 min 41 sec | 1 min 58 sec |

The average time the mice in the experimental group took to find their way through the maze was how many seconds less than the average time taken by the mice in the control group?

    A. 8
    B. 11
    C. 13
    D. 16
    E. 19

**GO ON TO THE NEXT PAGE.**

**32.** In the United States, phone numbers begin with a 3-digit area code. Now, there are restrictions on some of the digits, but in the future, as more and more area codes are needed, the restrictions may need to be lifted. If, and when, there are no restrictions and each of the 3 digits can be any integer from 0 through 9, how many area codes will be possible?

F. 27
G. 30
H. 720
J. 729
K. 1,000

**DO YOUR FIGURING HERE.**

**33.** The function $y = 2 \sin(8\pi x)$ is graphed in the standard $(x,y)$ coordinate plane below. How many $x$-intercepts does the graph of this function have on the interval $0 < x < 1$?
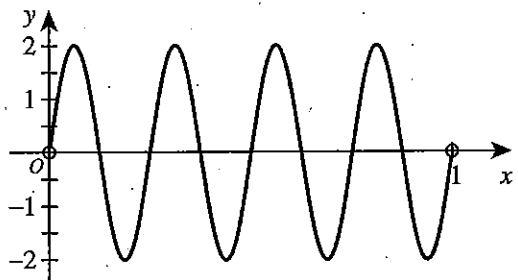


A. 2
B. 4
C. 7
D. 8
E. 9

**34.** If both $x$ and $\left(\frac{x}{3} + \frac{x}{7} + \frac{x}{9}\right)$ are positive integers, what is the least possible value of $x$?
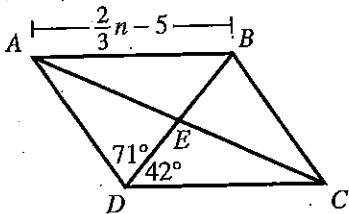
F. 21
G. 27
H. 36
J. 63
K. 189

**DO YOUR FIGURING HERE.**

Use the following information to answer questions 35–38.

In parallelogram $ABCD$ shown below, the diagonals intersect at $E$, $m\angle BDC = 42°$, $m\angle BDA = 71°$, and $AB = \left(\frac{2}{3}n - 5\right)$ inches.

(Note: The figure is NOT drawn to scale; $m\angle PQR$ denotes the measure of $\angle PQR$.)



**35.** What is $m\angle BAD$ ?

- **A.** 23°
- **B.** 42°
- **C.** 48°
- **D.** 67°
- **E.** 71°

**36.** Given that $DC = \left(\frac{1}{3}n + 7\right)$ inches, what is the value of $n$ ?

- **F.** 2
- **G.** 4
- **H.** 6
- **J.** 12
- **K.** 36

**37.** Suppose $A$ and $C$ are located at $(2,10)$ and $(30,3)$, respectively, in the standard $(x,y)$ coordinate plane. What are the coordinates of $E$ ?

- **A.** $\left(-\frac{7}{2}, 14\right)$
- **B.** $\left(\frac{13}{2}, 16\right)$
- **C.** $\left(14, -\frac{7}{2}\right)$
- **D.** $\left(14, \frac{7}{2}\right)$
- **E.** $\left(16, \frac{13}{2}\right)$

**38.** Which of the following triangles is congruent to $\triangle ABE$ ?

- **F.** $\triangle ADC$
- **G.** $\triangle AED$
- **H.** $\triangle BCE$
- **J.** $\triangle BCD$
- **K.** $\triangle CDE$

ACT-C01

23

**GO ON TO THE NEXT PAGE.**

**DO YOUR FIGURING HERE.**

**39.** Which of the following expressions is equal to $(a + \sqrt{b})(a - 2\sqrt{b})$ for all positive real numbers $a$ and $b$ ?

A. $a^2 - 3a\sqrt{b}$

B. $a^2 - a\sqrt{b} - 2b$

C. $a^2 - a\sqrt{b} - 2\sqrt{2b}$

D. $a^2 - 3a\sqrt{b} - 2b$

E. $a^2 + 3a\sqrt{b} - 2b$

**40.** The track for a model railroad display is set up as 2 circles that are tangent to one another and have diameters of 30 feet and 50 feet, respectively, as shown below. The engine of the train travels at a constant rate of 75 feet per minute. To the nearest minute, how many minutes does the engine take to go in a figure 8 pattern around the entire track exactly 1 time?

F. 1
G. 2
H. 3
J. 4
K. 7



30 feet

50 feet
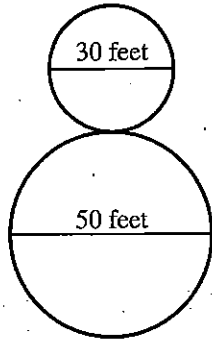
**41.** $\left(\dfrac{4}{5}\right)^{-\frac{3}{2}} = ?$

A. $\dfrac{5}{2}$

B. $\dfrac{5\sqrt{5}}{8}$

C. $\dfrac{4\sqrt{2}}{5}$

D. $\dfrac{\sqrt{5}}{2}$

E. $-\dfrac{6}{5}$

**42.** What is the value of the positive real number $x$ such that $\log_x\left(\dfrac{1}{25}\right) = -2$ ?

F. 5

G. 50

H. $\dfrac{1}{50}$

J. $\dfrac{1}{5}$

K. $\dfrac{25}{2}$

43. The points $(-4,-5)$, $(0,-3)$, and $(6,0)$ lie on a line in the standard $(x,y)$ coordinate plane. Which of the following points also lies on that line?

   A. $(-3,-4)$
   B. $(-1,-4)$
   C. $(1,-2)$
   D. $(4,-1)$
   E. $(9, 1)$

44. Rya and Sampath start running laps from the same starting line at the same time and in the same direction on a certain indoor track. Rya completes one lap in 16 seconds, and Sampath completes the same lap in 28 seconds. Both continue running at their same respective rates and in the same direction for 10 minutes. What is the fewest number of seconds after starting that Rya and Sampath will again be at their starting line at the same time?

   F. 88
   G. 112
   H. 120
   J. 220
   K. 448

45. The CFO of Math King Enterprises estimates that if the company sets a price of $c$ cents for each unit of their new product, then the weekly profit from selling the product will be modeled by $p(c) = 1{,}600c - 4c^2$, where $0 \le c \le 400$. According to this model, for which of the following values of $c$ will the weekly profit for this product be the largest?

   A. 20
   B. 40
   C. 100
   D. 200
   E. 400

46. Given consecutive positive integers $a$, $b$, $c$, and $d$ such that $a < b < c < d$, which of the following expressions has the greatest value?

   F. $\dfrac{a}{b}$

   G. $\dfrac{b}{c}$

   H. $\dfrac{c}{d}$

   J. $\dfrac{a+b}{b+c}$

   K. $\dfrac{b+c}{c+d}$

47. The ratio of the perimeters of two squares is 2:3. If the area of the larger square is 324 square feet, what is the length, in feet, of the side of the smaller square?

   A. 12
   B. 18
   C. 24
   D. 27
   E. 36

**DO YOUR FIGURING HERE.**

48. What is the set of all integer solutions for the inequality $-1 \leq x - \sqrt{5} < 4$ ?

    F. $\{3, 4, 5\}$
    G. $\{2, 3, 4, 5, 6\}$
    H. $\{2, 3, 4, 5\}$
    J. $\{1, 2, 3, 4, 5, 6\}$
    K. $\{1, 2, 3, 4, 5\}$

49. Wind blowing against a flat surface exerts a maximum force equal to $kSv^2$, where $S$ is the area of the surface, $v$ is the wind's velocity, and $k$ is a constant. If a 40 mile-per-hour (mph) wind can exert a maximum force of 50 pounds on a 1-square-foot flat surface, what is the maximum force, in pounds, that an 80 mph wind can exert on a 2-square-foot flat surface?

    A. 100
    B. 128
    C. 200
    D. 400
    E. 1,600

50. Roger will pour concrete to make a sidewalk with the dimensions, in feet, shown in the figure below. He will pour the concrete to a depth of 4 *inches*. One bag of concrete mix makes 0.6 cubic feet of concrete. What is the least whole number of bags of concrete mix that Roger needs in order to make the sidewalk?
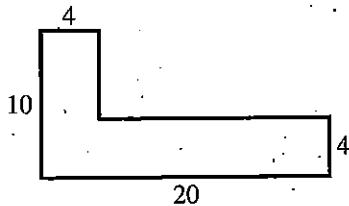
    F. 16
    G. 44
    H. 50
    J. 58
    K. 67



51. Radius $\overline{OA}$ of the circle shown below is perpendicular to $\overline{AP}$. The circle intersects $\overline{OP}$ at $B$. The length of $\overline{AP}$ is 12 centimeters, and the measure of $\angle APO$ is 20°. Which of the following values is closest to the length, in centimeters, of $\overline{BP}$ ?
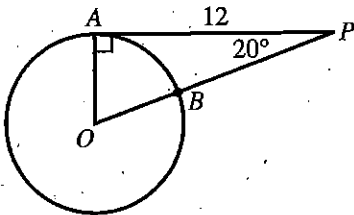


(Note: sin 20° ≈ 0.342, cos 20° ≈ 0.940, and tan 20° ≈ 0.364)

    A. 2.1
    B. 4.4
    C. 6.9
    D. 7.6
    E. 8.4

**DO YOUR FIGURING HERE.**

**52.** The average of 10 test scores is $x$. When the highest score and lowest score are removed from the 10 scores, the average is $y$. Which of the following is an expression for the average of the highest score and lowest score?

F.  $10x - 8y$

G.  $\dfrac{x+y}{2}$

H.  $\dfrac{10x + 8y}{2}$

J.  $\dfrac{10x - 8y}{2}$

K.  $\dfrac{10x + 8y}{18}$

**53.** Which of the following is the solution set of $27^{n^2} = 9^{5n-4}$ ?

A.  $\left\{-4, \dfrac{2}{3}\right\}$

B.  $\left\{-1, \dfrac{8}{3}\right\}$

C.  $\left\{-\dfrac{2}{3}, 4\right\}$

D.  $\{1, 4\}$

E.  $\left\{\dfrac{4}{3}, 2\right\}$

**54.** Each face of 2 cubes with faces numbered from 1 through 6 has a $\dfrac{1}{6}$ chance of landing up when the 2 cubes are tossed. What is the probability that the sum of the numbers on the faces landing up will be less than 6 ?

F.  $\dfrac{5}{36}$

G.  $\dfrac{5}{18}$

H.  $\dfrac{5}{13}$

J.  $\dfrac{5}{12}$

K.  $\dfrac{13}{36}$

**GO ON TO THE NEXT PAGE.**

**DO YOUR FIGURING HERE.**

55. At 2:00 p.m., Louisa leaves Kansas City in her car traveling east on I-70 toward St. Louis at an average speed of 68 mph. At precisely the same time, Antonio leaves St. Louis in his car traveling west on I-70 toward Kansas City at an average speed of 57 mph. The driving distance from St. Louis to Kansas City is 240 miles. At what time, to the nearest minute, will they drive past each other on I-70 ?

   A. 3:46 p.m.
   B. 3:50 p.m.
   C. 3:53 p.m.
   D. 3:55 p.m.
   E. 4:06 p.m.

56. There are 10 points in a plane, and no 3 of the points are collinear. These 10 points, taken 2 points at a time, determine how many distinct lines?

   F. 10
   G. 20
   H. 35
   J. 45
   K. 90

57. The expression $n!$ (read as $n$ *factorial*) is defined as the product of all positive integers up to and including $n$, whenever $n$ is a positive integer. For example, $4! = 1 \cdot 2 \cdot 3 \cdot 4$. Whenever $n$ is a positive integer, which of the following is equivalent to $\dfrac{(n+1)!6!}{n!3!}$ ?

   A. $120(n+1)$

   B. $120$

   C. $2$

   D. $\dfrac{2(n+1)}{n}$

   E. $\dfrac{(6n+6)!}{(3n)!}$

58. Which of the following *must* be true for each set of 4 consecutive positive integers?

   I. At least 1 of the 4 integers is prime.
   II. At least 2 of the 4 integers have a common prime factor.
   III. At least 1 of the 4 integers is a factor of at least 1 of the 3 other integers.

   F. I only
   G. II only
   H. I and III only
   J. II and III only
   K. I, II, and III

    **GO ON TO THE NEXT PAGE.**

**59.** When $(x + 1)^4$ is expanded and like terms are combined, what is the coefficient of $x^2$ ?

A. 0
B. 1
C. 2
D. 4
E. 6

**DO YOUR FIGURING HERE.**

**60.** A hill makes an angle of 20° with the horizontal, $\overrightarrow{AD}$, as shown below. A taut guy wire, $\overline{AB}$, extends from the base of the hill, point $A$, to point $B$ on a vertical pole. Point $B$ is 25 ft directly above where the pole is inserted into the ground at point $C$. Given that the length of $\overline{AC}$ is 60 ft, which of the following expressions represents the length, in feet, of the guy wire?

(Note: For a triangle with sides of length $a$, $b$, and $c$ that are opposite angles $\angle A$, $\angle B$, and $\angle C$, respectively, $\dfrac{\sin \angle A}{a} = \dfrac{\sin \angle B}{b} = \dfrac{\sin \angle C}{c}$ and $c^2 = a^2 + b^2 - 2ab \cos \angle C$.)
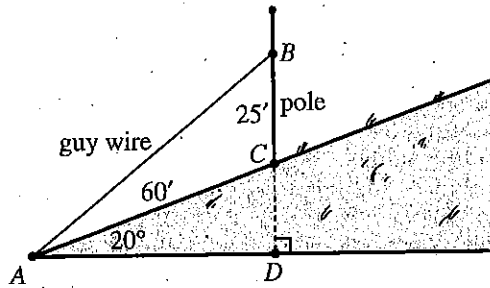


F. $\dfrac{25 \sin 60°}{\sin 20°}$

G. $\dfrac{25 \sin 70°}{\sin 20°}$

H. $\dfrac{25 \sin 110°}{\sin 20°}$

J. $\sqrt{60^2 + 25^2 - 2(60)(25) \cos 70°}$

K. $\sqrt{60^2 + 25^2 - 2(60)(25) \cos 110°}$

**END OF TEST 2**

**STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.**

**DO NOT RETURN TO THE PREVIOUS TEST.**

# READING TEST

*35 Minutes—40 Questions*

**DIRECTIONS:** There are several passages in this test. Each passage is accompanied by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

## Passage I

**LITERARY NARRATIVE:** Passage A is adapted from the essay "Touring Home" by Susan Power (©1996 by Susan Power). Passage B is adapted from the memoir *Beyond the Narrow Gate: The Journey of Four Chinese Women from the Middle Kingdom to Middle America* by Leslie Chang (©1999 by Leslie Chang).

### Passage A by Susan Power

My mother tells me stories every day: while she cleans, while she cooks, on our way to the library, standing in the checkout line at the supermarket. I like to share her stories with other people and chatter away
5 when I am able to command adult attention.

"She left the reservation when she was sixteen years old," I tell my audience. Sixteen sounds very old to me, but I always state the number because it seems integral to my recitation. "She had never been on a train
10 before or used a telephone. She left Standing Rock to take a job in Chicago so she could help out the family during the War. She was so petrified of the new surroundings, she stayed in her seat all the way from McLaughlin, South Dakota, to Chicago, Illinois, and
15 didn't move once."

I usually laugh after saying this because I cannot imagine my mother being afraid of anything. She is so tall, a true Dakota woman; she rises against the sun like a skyscraper, and when I draw her picture in my note-
20 book, she takes up the entire page. She talks politics and attends sit-ins and says what's on her mind.

I am her small shadow and witness. I am the timid daughter who can rage only on paper.

We don't have much money, but Mom takes me
25 from one end of the city to the other, on foot, on buses. I will grow up believing that Chicago belongs to me, because it was given to me by my mother.

Some days we haunt the Art Institute, and my mother pauses before a Picasso. "He did this during his
30 blue period," she tells me.

I squint at the blue man holding a blue guitar. "Was he very sad?" I ask.

"Yes, I think he was." My mother takes my hand and looks away from the painting. I can see a story
35 developing behind her eyes, and I tug on her arm to release the words. She will tell me why Picasso was blue, what his thoughts were as he painted this canvas. She relates anecdotes I will never find in books, never see footnoted in a biography of the master artist. I don't
40 even bother to check these references because I like my mother's version best.

### Passage B by Leslie Chang

Water belongs to everyone and to no one. For this reason, I have always had a particular affinity for it, which may strike some as mysterious. Westerners ask
45 me where my parents were born, as though the answer will enable them to glean some knowledge. The answer is Beijing and Luoyang. The truth is that this response signifies nothing. The meaningful question would be to ask where my ancestors lived. The answer to that is
50 inland. My father's people came from Wuhan, birthplace of the Chinese republic and the capital of Hubei, that sweltering province sandwiched between Sichuan and Anhui. My mother's father was from Inner Mongolia, land of desert and grassy plains.

55 Yet water calls to me. I remain convinced that I would find peace if I could only have a house by the ocean. I insisted on being married near the sea. This bond, I know, comes from my mother.

She longs for a view more than anything else.
60 Once, staying at a hotel in San Francisco, she insisted on seeing three different rooms before she found one with which she was satisfied. It was on a floor so high it made me dizzy, with a corner window overlooking the bay. Even so, my mother spent most of her time on
65 the bridge linking the elevator bank to our wing. The bridge consisted almost entirely of windows. It offered a view in either direction that was brilliant and blinding. If there had been a chair, she could have sat forever, letting the gold sun and blue sea overwhelm her
70 through the glass.

My mother may have descended from inland people, but they were also nomads. Her father once rode his horse practically the length of China, from Inner Mongolia to Guangzhou, a distance of some
75 twelve hundred miles. My mother could only become a

nomad herself—forever moving, changing and going, yet always retaining some essential part of her being, recognizable and intact in spite of all the places she has been. In this, she is like water, not dead water but fear-
80 somely alive. When she gazes out on its shimmering expanse, she sees her own reflection. When I gaze out, I see her, my mother, always pulling away, returning and pulling away again. I drink from her, and she slips between my fingertips. She has borne me all this way. I
85 cannot decide whether I want her to stay or go. When she is here, I wish she would leave. When she is gone, I wish she would return. She pulls away again, a force as elemental as the ebbing tide. I remain a child on the shore, eagerly collecting the sea glass and driftwood
90 she has left behind.

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### Questions 1–3 ask about Passage A.

**1.** In Passage A, the narrator directly compares her mother to a:

A. Picasso painting.
B. shadow and witness.
C. story behind someone's eyes.
D. skyscraper against the sun.

**2.** The narrator of Passage A most strongly suggests that the reason she began to believe Chicago belongs to her is that she:

F. could eventually take several different routes to travel from one end of the city to the other without getting lost.
G. had watched her mother directly influence the politics of the city.
H. felt she could move about the city almost unseen, like a small shadow.
J. initially explored the city with her mother as her affirming guide, so her connection to the city seemed familial.

**3.** It can most reasonably be inferred from Passage A that the narrator doesn't bother to verify that her mother's ideas about Picasso and his work are accurate primarily because the narrator:

A. doesn't know which references would be best for her to consult.
B. is confident that what her mother says about the artist is accurate and feels that checking references would be a waste of time.
C. doesn't care whether her mother is accurate given how much the narrator likes what her mother says about the artist.
D. wants to hold to her own ideas about the artist, regardless of what her mother says about him.

---

### Questions 4–7 ask about Passage B.

**4.** In Passage B, the narrator most strongly suggests that she believes her answer to which of the following questions does not provide significant information about her background?

F. How is your mother like your other ancestors?
G. Where did your ancestors live?
H. Where were your parents born?
J. Why does water call to you?

**5.** As they are used in Passage B, the word *blinding* (line 68) and the word *overwhelm* (line 69) both have a connotation that most strongly suggests a feeling of:

A. fright.
B. awe.
C. regret.
D. quietness.

**6.** In line 79, the word *dead* is most nearly used to describe water that is:

F. colorless.
G. obsolete.
H. stagnant.
J. frozen.

**7.** The last sentence of Passage B can best be described as a:

A. metaphor for the narrator's feelings as her mother goes away from her.
B. memory of childhood and of her mother that the narrator holds dear.
C. literal explanation of the way the narrator reacts to her mother's actions.
D. reference to a set of objects that the narrator as a child often found on the shore.

---

### Questions 8–10 ask about both passages.

**8.** Which of the following actions do the narrators of both passages closely connect with their mothers?

F. Traveling and moving
G. Exploring Chicago streets
H. Speaking openly and boldly
J. Staying at hotels in cities

**9.** The narrator of Passage B would be more likely than the narrator of Passage A to describe her relationship with her mother as being marked by:

A. moments of lively conversation and pure joy.
B. years of fierce competition and debate.
C. displays of physical affection and warmth.
D. feelings of distance and tension.

10. In both Passage A and Passage B, the narrator of the passage shares information about her mother's:

F. personal history.
G. physical appearance.
H. academic interests.
J. relationship to the narrator's father.

## Passage II

SOCIAL SCIENCE: This passage is adapted from *The Frozen Water Trade: A True Story* by Gavin Weightman (©2003 by Gavin Weightman).

When the first comprehensive report on the ice industry of the United States was commissioned in 1879 as part of a national census, it was estimated that about eight million tons were harvested annually,
5 though the business was so extensive and production so poorly documented that this was, at best, a well-informed guess. The figures were put together by one Henry Hall, who signed himself "special agent" and gave an account of the great growth of the industry in
10 the preceding ten years. Of the eight million tons of ice harvested, about five million reached the consumer— the rest melted during shipment and storage. By far the biggest market was in New York, and none of its ice was manufactured artificially: it was all cut in winter
15 and stored in hundreds of timber warehouses that lined the lakes and rivers and had a capacity of up to fifty thousand tons each. Between New York and Albany, 150 miles up the Hudson River, there were 135 ice-houses, but even this was not enough to supply the
20 metropolis, which relied heavily on imports. In fact, in the year of the great ice census, New York and Philadel-phia suffered one of their recurrent ice "famines," when unseasonably warm weather destroyed the harvest on the Hudson and local lakes, and the price of ice rose
25 from $4 to $5 a ton. That year the ice was fifteen to twenty inches thick in Maine, a top-quality crop, and it could be shipped down to New York at an estimated cost of $1.50 a ton. This produced a frenzy of harvest-ing on the Kennebec, Penobscot, and Sheepscot Rivers,
30 and two thousand cargoes of ice packed in hay and saw-dust were shipped south to New York, Philadelphia, and other more southern cities, where they were sold for a total of around $1.5 million.

Though the demand for ice rose annually, the New
35 York suppliers did not explore the use of artificial refrigeration. Instead, they began to buy up sections of the Kennebec River shoreline and to erect great wooden warehouses there, transforming the landscape of the river for many miles. It was the same farther inland,
40 where ice companies bought up shoreline along the lakes and put up storehouses to supply the meat indus-try of Chicago and the brewers of Milwaukee, as well as millions of domestic consumers.

The first real crisis in the natural-ice trade was
45 caused not by competition from artificial manufacture, but by pollution. As the cities grew, they encroached on the rivers and lakes from which the ice was cut, and soon there were health scares. This produced a search for cleaner supplies away from towns, and stimulated
50 the search for a means of manufacturing ice with pure water. The realization that the bacteria that cause dis-eases such as typhoid were not killed off in frozen water added to the urgency of finding safer forms of refrigeration.

55 The natural-ice trade began to decline from the early decades of the twentieth century, though in more remote areas of North America where electric power was not available but lake ice was abundant in winter, it survived as late as the 1950s. As ice harvesting died
60 out, the evidence of its former vast scale rapidly disap-peared. There was no alternative use for the great ice-houses, many of which simply burned down, often set alight by a spark from a steam train—they were surpris-ingly flammable, as most were made of wood and kept
65 as dry as possible to better preserve the blocks of ice they housed. But the majority were demolished or simply rotted away.

Over a wide area of the northern states, young diving enthusiasts with no knowledge of the former ice
70 trade still emerge from lakes and rivers clutching an impressive variety of odd implements—plows and chis-els and scrapers that fell through the ice during the har-vesting. One or two museums keep small displays of these tools, and collectors have preserved manufactur-
75 ers' catalogs that proudly present their versions of the ice plow, the ice saw, the grapple, the Jack grapple, the breaking-off bar, the caulk bar, the packing chisel, the house bar, the fork bar, the float hook, the line marker, and many other specialist implements the use
80 of which has long been forgotten.

The inner-city icehouses have also gone, and the ice wagon and the iceman are rapidly fading memories. All that is left in America of this once-great industry is the water itself, which provided a continuously renew-
85 able supply of ice each winter. There are few memorials on the banks of the rivers and lakes that once produced such a vital crop.

11. Which of the following events referred to in the pas-sage occurred last chronologically?

A. The first comprehensive report on the ice industry of the United States was commissioned.
B. Divers emerged from lakes and rivers clutching ice industry implements.
C. Two thousand cargoes of ice were sold for around $1.5 million.
D. The price of ice rose from $4 to $5 a ton.

12. The passage states that, in terms of the natural-ice industry, the decade from 1869 to 1879 was characterized by:

F. significant growth.
G. damaging publicity.
H. high shipping prices.
J. mildly declining demand.

13. As it is used in lines 19–20, the phrase *the metropolis* most likely refers to:

A. Albany.
B. New York City.
C. Philadelphia.
D. the average US city of the 1870s.

14. Based on the passage, the 1879 Maine ice that was fifteen to twenty inches thick can best be described as:

F. a top-quality crop that was shipped to New York City, Philadelphia, and destinations further south.
G. sufficient for local demand but not a solution to the problem of the ice "famine" in the South.
H. typical of Maine crops of ice until the ice "famine" struck.
J. remarkable but surpassed in size and quality by crops the following year.

15. The main idea of the fourth paragraph (lines 55–67) is that:

A. the natural-ice industry declined over several decades, leaving few traces of its magnitude.
B. the arrival of the steam train signaled the demise of ice harvesting.
C. icehouses were extremely flammable and therefore few remain.
D. in the 1950s, the natural-ice industry experienced a short-lived revival.

16. The author most clearly indicates that the contents of the manufacturers' catalogs referred to in the fifth paragraph (lines 68–80) typify the natural-ice industry's:

F. rapid response to market changes.
G. ability to erect icehouses quickly.
H. wide array of tools.
J. simple work.

17. On which of the following points does the author contradict himself elsewhere in the passage?

A. "Of the eight million tons of ice harvested, about five million reached the consumer" (lines 10–11).
B. "The New York suppliers did not explore the use of artificial refrigeration" (lines 34–36).
C. "There was no alternative use for the great icehouses" (lines 61–62).
D. "All that is left in America of this once-great industry is the water itself" (lines 83–84).

18. According to the passage, in the time period referred to in the first paragraph, how much of New York City's ice was made artificially?

F. The vast majority
G. About half
H. About ten percent
J. None

19. The passage states that for shipping purposes, natural ice was sometimes packed in:

A. refrigerated boxcars.
B. waterproof tarps.
C. sawdust and hay.
D. paper and cloth.

20. The passage indicates that the first real crisis in the natural-ice industry can be attributed to:

F. the Great Depression.
G. weather pattern changes.
H. the advent of refrigeration.
J. polluted water.

## Passage III

**HUMANITIES:** This passage is adapted from the article "Read My Lips" by Chiara Barzini (©2012 by the Harper's Magazine Foundation).

*In the passage, dubbing primarily refers to providing a film with a new sound track, especially dialogue, in a different language.*

Filmmakers have debated the respective merits of subtitles and dubbing since the earliest sound films. In "The Impossible Life of Clark Costa," published in 1940 in the film journal *Cinema*, director Michelangelo
5 Antonioni wrote that Romolo Costa, the person who dubbed all of actor Clark Gable's performances, was a "hybrid individual born out of a chemical combination." This "half Clark, half Costa" was unbearable to Antonioni, who considered dubbing to be a mere
10 "acoustic surrogate" of acting. To him, dubbing compromised the intention of the director, leading to an artificial product that lacked artistic unity. Director Pier Paolo Pasolini, who called both dubbing and subtitles "evils," said that, between the two, dubbing was the less
15 harmful, since it allowed you to see the picture in full. Director Jean Renoir called dubbing a "monstrosity, a challenge to human and divine laws."

Director Federico Fellini didn't agree with any of them. Dubbing was an extension of his shoots, a tech-
20 nique he would use to retouch and rewrite. He mercilessly dubbed over his actors, changing dialogue in postproduction, sometimes having worked without a script. (He reportedly instructed his actors to count aloud in front of the camera so that he could insert new
25 dialogue afterward.) Renato Cortesi, a veteran Fellini dubber, told me that, during the filming of *Amarcord* (1973), he witnessed Fellini ask an old Neapolitan lady to tell him a sad story. Over footage of this woman recounting a tragic tale about her grandson, Fellini
30 added a new sound track about war and hunger recorded by an actor from Emilia-Romagna, combining the vivid expressiveness of the South with his favorite northern accent.

If you visit a dubbing studio, the over-the-top zest
35 of the actors is evident in everything from their melodramatic speech to their movements; standing in front of the microphone, they coil and twitch. I asked Cortesi whether this was a consequence of having to focus one's lifelong talent into the few centimeters between
40 mouth and microphone, a kind of bodily rebellion to the condition of being heard but not seen, and he laughed. "Of course it isn't easy to spend a life in the darkness, but this is hardly the reason why they twitch and turn! Dubbers are used to reciting while trying to re-create
45 the bodily sensations of what they see on the screen before them. If there is running in the film, they will run on their feet. The moving," he explained, "is the result of re-creating large movements in small spaces."

There are still few options for those seeking to
50 watch subtitled, original-language films at a movie house in Italy. The Metropolitan cinema on Via del Corso closed recently after a long battle involving intel-
lectuals, show-business people, and American and British expats in Rome, to be replaced with a clothing
55 store. Italians remain hooked on dubbing—perhaps because of simple affection. Familiar voices yield emotional attachment.

Francesco Vairano, a dubber and dubbing director known for adapting foreign films considered to be
60 "undubbable," such as the French box office hit *Bienvenue chez les Ch'tis* ("Welcome to the Sticks," 2008), which relies on linguistic misunderstandings for much of its comedy, explained that actors become just as attached to their parts as audiences do. Vairano has
65 been one of the few directors to break the habit of matching the same Italian dubber to a foreign actor for all his films, preferring instead to select the dubber according to the requirements of the role, and, he admits, he was hated by all the prima donna dubbers for
70 this. "If you take that actor away from them," he told me, "they will insult you."

In 2007, I met dubber Luca Ward, who provided the voice of the narrator for a romantic comedy I co-wrote, *Scusa ma Ti Chiamo Amore* ("Sorry but I Love
75 You"). What I didn't then know was that everyone Ward met wanted him to recite actor Samuel L. Jackson's Ezekiel 25:17 passage from the film *Pulp Fiction*, and that I should consider it an honor that he would offer a performance to a stranger. When he finally did recite
80 the monologue, it was astonishing, every dramatic pause carefully timed and every word perfectly enunciated. I understood that, if anybody took Samuel L. Jackson away from Ward, it would have meant taking away a part of his soul; he was, as Antonioni would say,
85 half Ward, half Jackson. Leaving the day's recording session, Ward told me he was off to have dinner with actress Meg Ryan, before raising an eyebrow and clarifying, "With Meg Ryan's *dubber* . . . I am having dinner with Meg Ryan's voice."

21. The last sentence of the passage primarily serves to illustrate the passage author's central claim that:

A. a dubber wants others in the film industry to respect the actor he or she usually dubs.
B. the work of Ryan's dubber is as effective as that of Jackson's dubber.
C. a dubber begins to seem almost like a hybrid of him- or herself and the actor he or she dubs.
D. Ward is unlike most dubbers in that he prefers to dub many different actors.

22. It can reasonably be inferred from the passage that regarding whether dubbing is useful or valuable, Vairano would most strongly sympathize with the views of:

F. Antonioni.
G. Fellini.
H. Pasolini.
J. Renoir.

23. The main function of the second paragraph (lines 18–33) is for the passage author to present:

   A. her own ideas as an example of a contemporary perspective on the merits of dubbing.
   B. a perspective on dubbing that bluntly counters those outlined in the first paragraph.
   C. Fellini's personal, direct response to Renoir's criticism of his work.
   D. a claim, centered on Fellini's work, that strengthens the argument she makes in the first paragraph.

24. The anecdote about Fellini's footage of a woman recounting a tragic tale (lines 25–33) primarily serves to:

   F. explain why Fellini preferred to feature voices with northern accents in his films.
   G. provide a famous example of Fellini closely following scripted dialogue.
   H. illustrate the extent to which dubbing was a part of Fellini's craft.
   J. show why Fellini preferred his actors to follow a script rather than tell their own stories.

25. As Cortesi is presented in the passage, does he agree with the passage author's assumptions about the reason for dubbers' "over-the-top zest" (line 34)?

   A. Yes, and he thinks that she should visit his dubbing studio to see how he works.
   B. Yes, and he suggests that the reason is the dubber's condition of being heard but not seen.
   C. No, and he gruffly makes clear his belief that she does not at all understand a dubber's work.
   D. No, and he corrects her misinterpretation with an explanation of his own.

26. It can most reasonably be inferred from the passage that the Metropolitan cinema on Via del Corso was known for showing films that had been:

   F. dubbed only.
   G. subtitled only.
   H. both dubbed and subtitled.
   J. neither dubbed nor subtitled.

27. The passage most strongly suggests that at movie houses in Italy today, compared to subtitled, original-language films, dubbed films can be found:

   A. much more easily.
   B. about as easily.
   C. slightly less easily.
   D. much less easily.

28. The passage indicates that a foreign film with which of the following characteristics is particularly difficult to dub?

   F. Linguistic misunderstanding that creates comedy
   G. Dramatic action that advances plot
   H. Reverse chronology that provides context
   J. Extensive monologues that further characterization

29. According to the passage, the work of dubbing director Vairano differs from that of most other Italian directors in that Vairano:

   A. focuses on dubbing French films into Italian.
   B. does not necessarily match the same Italian dubber to the same foreign actor for all his films.
   C. works mostly with "prima donna" dubbers.
   D. does not believe that dialogue should be rewritten during a dubbing session.

30. As it is used in lines 16–17, the phrase *a challenge to* most nearly means:

   F. an assault on.
   G. a declaration of.
   H. a question for.
   J. an offer to.

## Passage IV

NATURAL SCIENCE: This passage is adapted from the essay "Making Stuff: From Bacon to Bakelite" by Philip Ball (©2010 by Philip Ball).

During the Industrial Revolution, the high price of steel meant that many large engineering projects were carried out that used instead cast iron, which is brittle and prone to failure. This was why Henry Bessemer's
5 new process for making steel was greeted with jubilation: the details, announced at a meeting of the British Association in 1856, were published in full in *The Times*. Bessemer himself was lauded not just as an engineer but as a scientist, being elected a Fellow of the
10 Royal Society in 1879.

Bessemer's process controlled the amount of carbon mixed with iron to make steel. That the proportion of carbon governs the hardness was first noted in 1774 by the Swedish metallurgist Torbern Bergmann,
15 who was by any standards a scientist, teaching chemistry, physics and mathematics at Uppsala. Bergmann made an extensive study of the propensity of different chemical elements to combine with one another—a property known as elective affinity, central to the
20 eighteenth-century notion of chemical reactivity. He was a mentor and sponsor of Carl Wilhelm Scheele, the greatest Swedish chemist of the age and co-discoverer of oxygen.

Oxygen, as a component of air, was the key to the
25 Bessemer process. It offered a way of removing impurities from pig iron and adjusting its carbon content during conversion to steel. A blast of air through the molten metal turned impurities such as silicon into light silica slag (a collection of compounds removed from
30 metal in the smelting process), and removed carbon in the form of volatile carbon dioxide. Pig iron contains as much as 4 per cent carbon; steels have only around 0.3–2 per cent. Meanwhile, the heat produced in these reactions with oxygen kept the iron molten without the
35 need for extra fuel.

It was long known that steel can be improved with a spice of other elements. A dash of the metal manganese helps to remove oxygen and sulphur from the iron, and most of the manganese currently produced
40 globally is used for this purpose. Manganese also makes steel stronger, while nickel and chromium improve its hardness. And chromium is the key additive in stainless steel—in a proportion of more than about 11 per cent, it makes the metal rust-resistant. Most
45 modern steels are therefore alloys blended to give the desired properties.

But is this science? Some of the early innovations in steel alloys were chance discoveries, often due to impurities incorporated by accident. In this respect,
50 metallurgy has long retained the air of an artisan craft, akin to the trial-and-error explorations of dyers, glassmakers and potters. But the reason for this empiricism is not that the science of metallurgy is trivial; it is because it is so difficult. According to Rodney

55 Cotterill, a remarkable British physicist whose expertise stretched from the sciences of materials to that of the brain, 'metallurgy is one of our most ancient arts, but is often referred to as one of the youngest sciences'.

One of the principal difficulties in understanding
60 the behaviour of materials such as steel is that this depends on its structure over a wide range of length scales, from the packing of individual atoms to the size and shape of grains micrometres or even millimetres in size. Science has trouble dealing with such a span of
65 scales. One might regard this difficulty as akin to that in the social sciences, where social behaviour is governed by how individuals behave but also how we interact on the scale of families and neighbourhoods, within entire cities, and at a national level. (That's why the
70 social sciences are arguably among the hardest of sciences too.)

The mechanical properties of metals depend on how flaws in the crystal structure, called defects, move and interact. These defects are produced by almost
75 inevitable imperfections in the regular stacking of atoms in the crystalline material. The most common type of stacking fault is called a dislocation. Metals bend, rather than shattering like porcelain, because dislocations can shift around and accommodate the defor-
80 mation. But if dislocations accumulate and get entangled, restricting their ability to move, the metal becomes brittle. This is what happens after repeated deformation, causing the cracking known as metal fatigue. Dislocations can also get trapped at the bound-
85 aries between the fine, microscopic grains that divide a metal into mosaics of crystallites. The arrest of dislocations at grain edges means that metals may be made harder by reducing the size of their grains, a useful trick for modifying their mechanical behaviour.

31. The main purpose of the passage is to:
A. explain in detail the various experiments Bessemer conducted in order to develop a better steel.
B. provide an overview of some of the scientific principles that apply to the creation and behavior of steel.
C. describe some of the philosophical questions concerning metallurgy.
D. illustrate the differences between pig iron and cast iron.

32. The author most likely includes details about the initial response to Bessemer's new steel-making process in order to:
F. emphasize that Bessemer's new process was a significant achievement for industry.
G. provide support for the author's opinion that Bessemer's new process was prone to failure.
H. describe Bessemer's qualifications as an engineer.
J. provide specific examples of the criticism that Bessemer's new process received.

33. It can reasonably be inferred that the author includes the information that Bergmann was a mentor and sponsor of Scheele's mainly to:

A. introduce the fact that Bergmann was a teacher as well as a scientist.
B. suggest that Bergmann was a more successful scientist than Scheele was.
C. give an example of the eighteenth-century notion of scientific communities.
D. reinforce Bergmann's credibility as a scientist.

34. According to the passage, which of the following conversions is a direct result of adding oxygen to molten pig iron?

F. Light silica slag is converted into carbon dioxide.
G. Carbon dioxide is converted into carbon.
H. Silicon is converted into light silica slag.
J. Impurities in the metal are converted into silicon.

35. In the context of the passage, the main effect of the word "spice" (line 37) is to emphasize that:

A. elements must be gradually mixed into steel in order to produce the desired effect.
B. adding certain elements to steel can enrich the steel's quality.
C. manganese, chromium, and nickel are used sparingly in steel because of their expense.
D. blending elements is a trial-and-error process that has not yet yielded positive results.

36. Based on the passage, with which of the following statements would the author most likely agree?

F. Metallurgy is not an art because it requires too much scientific knowledge.
G. Metallurgy is too difficult to be considered a science.
H. Metallurgy is a science as well as an art.
J. Metallurgy is a trivial science.

37. The passage most strongly suggests that the study of the behavior of materials and the study of the social sciences are similar because they:

A. require analyses that span a wide range of scales.
B. are based on trial-and-error experimentation.
C. involve examination of the size and shape of individual atoms.
D. produce results that must be interpreted by both scientists and artists.

38. The main idea of the last paragraph is that:

F. defects in the crystal structure of a metal determine that metal's mechanical properties.
G. dislocations are the most common type of stacking fault in a metal.
H. the mechanical behavior of a metal can be modified by increasing the size of a metal's grains.
J. microscopic grains divide a metal into mosaics of crystallites.

39. As it is used in line 56, the word *stretched* most nearly means:

A. strained.
B. exaggerated.
C. extended.
D. amplified.

40. According to the passage, reducing the size of a metal's grains can make the metal:

F. more rust-resistant.
G. more brittle.
H. finer.
J. harder.

**END OF TEST 3**

**STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.**

**DO NOT RETURN TO A PREVIOUS TEST.**

# SCIENCE TEST

## 35 Minutes—40 Questions

**DIRECTIONS:** There are several passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

You are NOT permitted to use a calculator on this test.

## Passage I

The termite *Reticulitermes flavipes* consumes wood and bark. A study examined whether the consumption of wood or bark mulch by *R. flavipes* varies with the type of mulch or the age of the mulch. Separate portions of each of 5 types of mulch were aged (allowed to decay) for 1, 24, and 48 weeks. Then, 2 g of each type of 1-week-old mulch were put into a box, 2 g of each type of 24-week-old mulch were put into a second box, and 2 g of each type of 48-week-old mulch were put into a third box. Next, 1 g of *R. flavipes* was added to each box. After 15 days, the mass of mulch consumed, in milligrams (mg), was determined for each type and age of mulch (see figure).
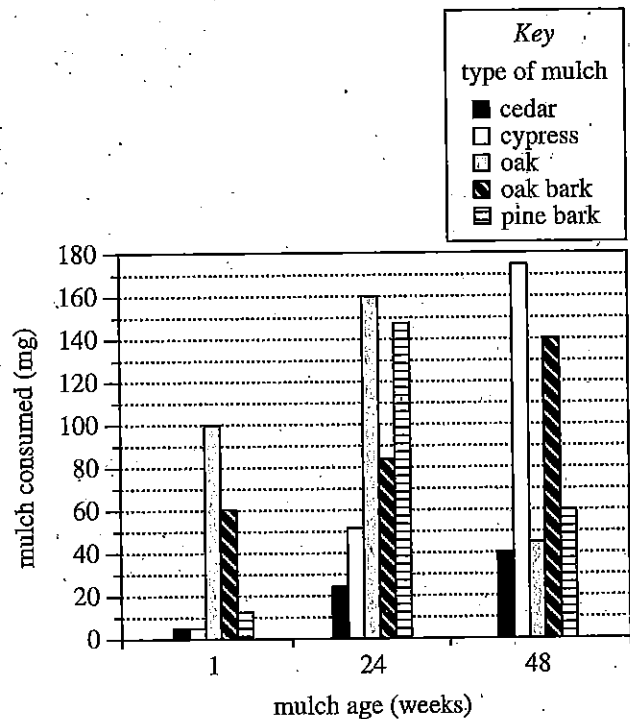


Figure adapted from O. P. Pinzon, R. M. Houseman, and C. J. Starbuck, "Feeding, Weight Change, Survival, and Aggregation of *Reticulitermes flavipes* (Kollar) (Isoptera: Rhinotermitidae) in Seven Varieties of Differentially-Aged Mulch." ©2006 by the Horticultural Research Institute.

**GO ON TO THE NEXT PAGE.**

1. Of the following combinations of type of mulch and mulch age, which combination resulted in the greatest mass of mulch consumed by *R. flavipes* ?

| | type of mulch | mulch age |
|---|---|---|
| A. | oak | 24 weeks |
| B. | pine bark | 24 weeks |
| C. | oak | 48 weeks |
| D. | pine bark | 48 weeks |

2. Which of the following statements about the effect of mulch age on the consumption of mulch by *R. flavipes* is consistent with the figure? As mulch age increased from 1 week through 48 weeks, the mass of mulch consumed by *R. flavipes*:

F. decreased for all 5 types of mulch.
G. increased for all 5 types of mulch.
H. initially decreased for all 5 types of mulch, but then increased for some of the 5 types of mulch.
J. initially increased for all 5 types of mulch, but then decreased for some of the 5 types of mulch.

3. Based on the passage, would *R. flavipes* be classified as an autotroph or as a detritivore, and why?

A. Autotroph, because *R. flavipes* produces its own energy without consuming organic material.
B. Autotroph, because *R. flavipes* obtains its energy by consuming decaying organic material.
C. Detritivore, because *R. flavipes* produces its own energy without consuming organic material.
D. Detritivore, because *R. flavipes* obtains its energy by consuming decaying organic material.

4. Based on the passage, is the primary food source of *R. flavipes* more likely cellulose or cholesterol?

F. Cellulose; *R. flavipes* consumes the cell membranes of animal cells, and the cell membranes of animal cells contain cellulose.
G. Cellulose; *R. flavipes* consumes the cell walls of plant cells, and the cell walls of plant cells consist primarily of cellulose.
H. Cholesterol; *R. flavipes* consumes the cell membranes of animal cells, and the cell membranes of animal cells contain cholesterol.
J. Cholesterol; *R. flavipes* consumes the cell walls of plant cells, and the cell walls of plant cells consist primarily of cholesterol.

5. Which of the following statements comparing the consumption by *R. flavipes* of 1-week-old oak mulch, 24-week-old oak mulch, and 48-week-old oak mulch is supported by the figure?

A. More 1-week-old mulch was consumed than 24-week-old mulch, and more 24-week-old mulch was consumed than 48-week-old mulch.
B. Less 1-week-old mulch was consumed than 24-week-old mulch, and less 24-week-old mulch was consumed than 48-week-old mulch.
C. More 1-week-old mulch was consumed than 24-week-old mulch, and less 24-week-old mulch was consumed than 48-week-old mulch.
D. Less 1-week-old mulch was consumed than 24-week-old mulch, and more 24-week-old mulch was consumed than 48-week-old mulch.

6. What mass, in *grams* (NOT milligrams), of the 48-week-old oak bark mulch was consumed by *R. flavipes* ?

F. 0.06 g
G. 0.14 g
H. 0.6 g
J. 1.4 g

## Passage II

Samples of Species C bacteria must often be transported from the areas in which they are collected. During transport, the samples are typically packed in ice to keep them alive. However, ice is not always available where the samples are collected.

Scientists studied how *lyophilization* (a freeze-drying process that doesn't require ice) followed by incubation affects the survival of 2 strains (Strain E and Strain V2) of Species C bacteria.

*Experiment 1*

The scientists placed a 100 µL (1 µL = $10^{-3}$ mL) sample of a nutrient medium containing $4 \times 10^6$ Strain E elementary bodies into each of 8 sterile test tubes. An *elementary body* is the infective form of Species C. The sample in each of the tubes was then lyophilized, and each tube was sealed. Two of the tubes were incubated at 4°C, 2 were incubated at 20°C, 2 were incubated at 30°C, and 2 were incubated at 37°C.

One week after the start of incubation, the *percent survival* (the percent of the elementary bodies that survived) was determined for the sample in 1 of the 2 tubes at each temperature. Then, 1 month after the start of incubation, the percent survival was determined for the sample in the remaining tube at each temperature. The results are shown in Table 1.

| Table 1 | | | |
|---|---|---|---|
| Strain | Incubation temperature (°C) | Percent (%) survival at: | |
| | | 1 week | 1 month |
| E | 4 | 52 | 51 |
| | 20 | 69 | 42 |
| | 30 | 5 | 4 |
| | 37 | 0 | 0 |

*Experiment 2*

The scientists repeated Experiment 1, except with Strain V2 instead of Strain E. The results are shown in Table 2.

| Table 2 | | | |
|---|---|---|---|
| Strain | Incubation temperature (°C) | Percent (%) survival at: | |
| | | 1 week | 1 month |
| V2 | 4 | 59 | 6 |
| | 20 | 29 | 4 |
| | 30 | 2 | 2 |
| | 37 | 0 | 0 |

Tables adapted from Adrian Eley et al., "Effect of Storage Temperature on Survival of *Chlamydia trachomatis* after Lyophilization." ©2006 by American Society for Microbiology.

**GO ON TO THE NEXT PAGE.**

7. Which of the following statements describes a difference between Experiment 1 and Experiment 2 ?

A. A different incubation temperature was tested in Experiment 1 than in Experiment 2.
B. A different strain of Species C was tested in Experiment 1 than in Experiment 2.
C. Samples in Experiment 1 were lyophilized before being transported, whereas samples in Experiment 2 were transported on ice.
D. Samples in Experiment 1 were incubated for 1 week before being transported, whereas samples in Experiment 2 were incubated for 1 month before being transported.

8. Suppose that in Experiment 2 the scientists had determined the percent survival for a sample incubated at 25°C for 1 week. The percent survival of the Strain V2 elementary bodies in the sample would most likely have been:

F. 0%.
G. between 2% and 29%.
H. between 29% and 59%.
J. greater than 59%.

9. At which 2 temperatures was the percent survival of Strain V2 elementary bodies less for the longer incubation time than for the shorter incubation time?

A. 4°C and 20°C
B. 4°C and 37°C
C. 20°C and 30°C
D. 20°C and 37°C

10. Which of the following questions was NOT addressed by the experiments?

F. Does incubation time affect the percent survival of Strain E and Strain V2 elementary bodies after lyophilization?
G. Does temperature affect the percent survival of Strain E and Strain V2 elementary bodies after lyophilization?
H. Does the number of Strain E or Strain V2 elementary bodies present in a sample before lyophilization affect their percent survival?
J. Do Strain E elementary bodies have a greater percent survival than Strain V2 elementary bodies after lyophilization and incubation?

11. One week after the start of incubation, which of the 4 samples of Strain V2 elementary bodies would have been *least* likely to infect another organism that came into contact with the samples?

A. The sample that had been incubated at 4°C
B. The sample that had been incubated at 10°C
C. The sample that had been incubated at 20°C
D. The sample that had been incubated at 37°C

12. Suppose that a scientist wants to transport a lyophilized sample of Strain E elementary bodies. Based on the results of Experiment 1, which of the following combinations of temperature and transportation time would most likely ensure the greatest percent survival of the elementary bodies?

F. 4°C and 1 week
G. 4°C and 1 month
H. 20°C and 1 week
J. 20°C and 1 month

13. Consider the rating system in the table below for the percent survival of elementary bodies after lyophilization.

| Rating | Percent survival |
|---|---|
| Excellent | > 90% |
| Good | ≥ 30% and ≤ 90% |
| Poor | < 30% |

Based on this table, what is the total number of tubes in Experiment 1 that contained samples having a poor percent survival?

A. 2
B. 4
C. 6
D. 8

## Passage III

When an object is submerged in a fluid, the object displaces a volume of fluid equal to the object's submerged volume. The fluid exerts an upward *buoyant force* on the object that is equal in magnitude to the weight of the displaced fluid. The object floats if the buoyant force equals the object's weight.

A group of students conducted 2 studies on buoyant forces using 3 fluids—water, Fluid A, and Fluid B—having densities of 1.0 g/cm$^3$, 1.25 g/cm$^3$, and 1.50 g/cm$^3$, respectively.

*Study 1*

The students placed a 10 cm long cylinder in a container of water and measured the length of the portion of the cylinder that was submerged. They then repeated this procedure with a container of Fluid A and a container of Fluid B (see Figure 1).
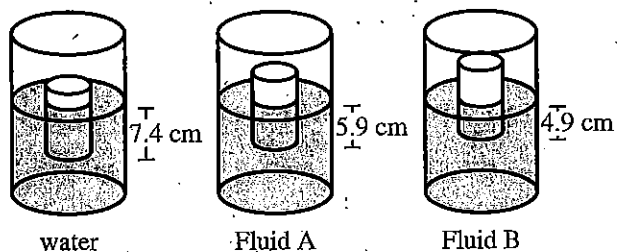


water          Fluid A          Fluid B

Figure 1

*Study 2*

The students placed a stone—either Stone X, Stone Y, or Stone Z—in a net that was tied to a spring balance. They recorded the force measured by the balance as the stone's weight, $W$. They then submerged the stone in water and again recorded the force measured by the balance (see Figure 2).
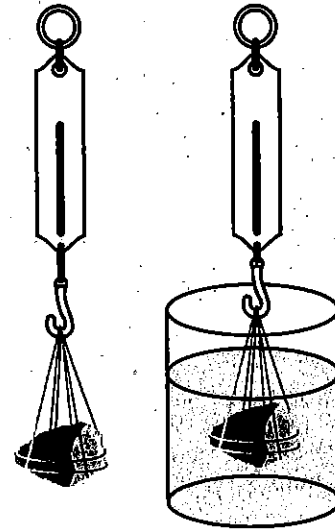


Figure 2

The students calculated the buoyant force on the stone in water as $W$ minus the force that was measured when the stone was submerged. They repeated this procedure to test all 3 stones in all 3 fluids. Table 1 lists each stone's volume, in cm$^3$, and $W$, in newtons (N), as well as the buoyant force, in N, on each stone in the fluid.

| Table 1 | | | | | |
|---|---|---|---|---|---|
| | | | Buoyant force (N) in: | | |
| Stone | Volume (cm$^3$) | $W$ (N) | water | Fluid A | Fluid B |
| X | 48 | 1.50 | 0.47 | 0.59 | 0.70 |
| Y | 96 | 1.50 | 0.94 | 1.18 | 1.41 |
| Z | 96 | 3.00 | 0.94 | 1.18 | 1.41 |

14. Based on the results of Study 2, as the density of the fluid in which Stone X was submerged increased, the buoyant force on Stone X:

F. decreased only.
G. increased only.
H. decreased and then increased.
J. varied with no general trend.

15. Based on the results of Study 2, for Stone Y, what was the difference between the buoyant force in Fluid A and the buoyant force in Fluid B ?

A. 0.11 N
B. 0.23 N
C. 0.47 N
D. 0.71 N

16. Suppose the students decide to study whether a cylinder's volume determines the submerged length of the cylinder in a given fluid. Which of the following procedural changes should the students make to Study 1 ? The students should test:

F. a single cylinder with multiple fluids; the fluids should each have the same density as the cylinder.
G. a single cylinder with multiple fluids; the fluids should have different densities.
H. multiple cylinders with a single fluid; the cylinders should have different volumes but the same density.
J. multiple cylinders with a single fluid; the cylinders should have different weights but the same volume.

17. In Study 1, did the cylinder displace a greater volume of water or a greater volume of Fluid A ?

A. Water, because the cylinder's submerged length was greater in water than in Fluid A.
B. Water, because the cylinder's submerged length was greater in Fluid A than in water.
C. Fluid A, because the cylinder's submerged length was greater in water than in Fluid A.
D. Fluid A, because the cylinder's submerged length was greater in Fluid A than in water.

18. Suppose that in Study 1 the students had placed the cylinder in a container of fluid having a density of 1.60 g/cm$^3$. The submerged length of the cylinder would most likely have been:

F. less than 4.9 cm.
G. between 4.9 cm and 5.9 cm.
H. between 5.9 cm and 7.4 cm.
J. greater than 7.4 cm.

19. Suppose that in Study 2 the students had tested a stone having the same weight as Stone Z but a larger volume than Stone Z. Which of the following statements about the buoyant force on this submerged stone would be correct? The buoyant force on this stone in:

A. water would have been less than 0.94 N.
B. Fluid A would have been less than 1.18 N.
C. Fluid B would have been greater than 1.41 N.
D. water would have been greater than the buoyant force on this stone in Fluid A.

20. Assume that Atlantic Ocean water has a density of 1.01 g/cm$^3$ and that Pacific Ocean water has a density of 1.03 g/cm$^3$. Based on the results of Study 1, in which ocean would a given iceberg more likely have the greater submerged volume?

F. The Atlantic Ocean, because the results of Study 1 indicate that submerged volume increases as fluid density decreases.
G. The Atlantic Ocean, because the results of Study 1 indicate that submerged volume decreases as fluid density decreases.
H. The Pacific Ocean, because the results of Study 1 indicate that submerged volume increases as fluid density decreases.
J. The Pacific Ocean, because the results of Study 1 indicate that submerged volume decreases as fluid density decreases.

## Passage IV

: Chemical reactions that release heat are *exothermic* reactions. The amount of heat released depends on the number of moles of reactants consumed in the reaction. A *mole* of any substance is $6 \times 10^{23}$ molecules or formula units of the substance.

When sodium hypochlorite (NaClO) and sodium iodide (NaI) are dissolved in acidic $H_2O$, an exothermic reaction occurs:

$$NaClO + NaI \rightarrow products + heat$$
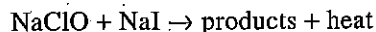
Students did an experiment to study this reaction.

### Experiment

In each of 8 trials, the students performed Steps 1–5:

1. A known volume of a 0.2 mole/L aqueous NaClO solution was poured into a foam coffee cup. A lid was placed on the cup.

2. A thermometer was placed into the solution through a hole in the lid. The solution's initial temperature, $T_i$, of 22.0°C was recorded.

3. The lid was lifted, and a known volume of a 0.2 mole/L aqueous NaI solution, also at a $T_i$ of 22.0°C, was poured into the cup. The lid was put back on the cup, and the solution was swirled.

4. The solution's final (maximum) temperature, $T_f$, was measured.

5. The change in temperature, $\Delta T$, was calculated:

$$\Delta T = T_f - T_i$$

The data for each trial are shown in Table 1.

| Table 1 | | | | |
|---|---|---|---|---|
| Trial | Volume of NaClO solution (mL) | Volume of NaI solution (mL) | $T_f$ (°C) | $\Delta T$ (°C) |
| 1 | 0 | 100 | 22.0 | 0.0 |
| 2 | 25 | 75 | 25.5 | 3.5 |
| 3 | 50 | 50 | 29.0 | 7.0 |
| 4 | 70 | 30 | 31.7 | 9.7 |
| 5 | 75 | 25 | 32.5 | 10.5 |
| 6 | 80 | 20 | 30.6 | 8.6 |
| 7 | 90 | 10 | 26.2 | 4.2 |
| 8 | 100 | 0 | 22.0 | 0.0 |

The students plotted $\Delta T$ versus the volume of NaClO solution for each trial (see Figure 1).
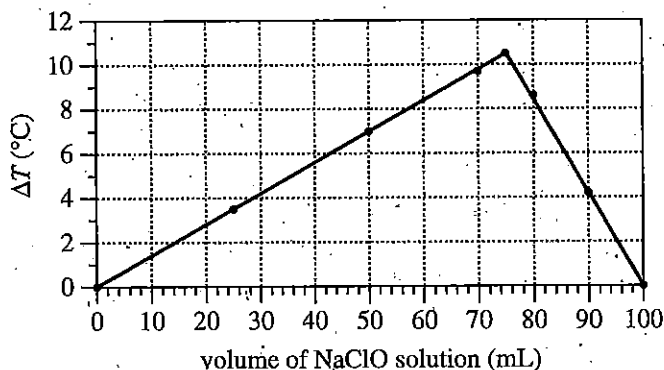


Figure 1

Table and figure adapted from M. Jerome Bigelow, "Thermochemistry of Hypochlorite Oxidations." ©1969 by Division of Chemical Education, Inc., American Chemical Society.

Then they identified the trial for which $\Delta T$ had its greatest value. The ratio of the volume of the NaClO solution to the volume of the NaI solution for this trial is the *mole ratio* for the reaction.

21. If a trial had been performed with 60 mL of NaClO solution and 40 mL of NaI solution, $T_f$ would most likely have been:

    A. less than 25.5°C.
    B. between 25.5°C and 29.0°C.
    C. between 29.0°C and 31.7°C.
    D. greater than 31.7°C.

22. Before the experiment, a student predicted that $\Delta T$ for Trial 2 would be greater than $\Delta T$ for Trial 6. Do the results shown in Table 1 support this prediction?

    F. No; $\Delta T$ for Trial 2 was 5.1°C less than $\Delta T$ for Trial 6.
    G. No; $\Delta T$ for Trial 2 was 8.6°C less than $\Delta T$ for Trial 6.
    H. Yes; $\Delta T$ for Trial 2 was 5.1°C greater than $\Delta T$ for Trial 6.
    J. Yes; $\Delta T$ for Trial 2 was 8.6°C greater than $\Delta T$ for Trial 6.

23. In each trial, the *total* volume of solution poured into the cup was:

    A. 25 mL.
    B. 50 mL.
    C. 75 mL.
    D. 100 mL.

24. Consider the trial for which the volume of NaClO was 4 times as great as the volume of NaI. For this trial, $T_f$ was:

    F. 25.5°C.
    G. 26.2°C.
    H. 30.6°C.
    J. 32.5°C.

25. Suppose a trial had been performed with 20 mL of NaClO solution and 80 mL of NaI solution. Based on Figure 1, $\Delta T$ for this new trial would most likely have been closest to which of the following?

    A. 1°C
    B. 3°C
    C. 5°C
    D. 7°C

26. Which of the following statements best explains why $\Delta T$ was 0.0°C for Trial 8 ? The volume of solution added was 0 mL for one of the:

    F. products, NaClO, so no reaction had occurred.
    G. products, NaI, so no reaction had occurred.
    H. reactants, NaClO, so no reaction had occurred.
    J. reactants, NaI, so no reaction had occurred.

27. Suppose that the reaction studied had been *endothermic*. As the endothermic reaction progressed, would the solution temperature more likely have decreased or increased?

    A. Decreased, because the reaction would have released heat.
    B. Decreased, because the reaction would have absorbed heat.
    C. Increased, because the reaction would have released heat.
    D. Increased, because the reaction would have absorbed heat.

## Passage V

When rocks are melted at very high temperatures beneath Earth's surface, *magma* (molten rock) is formed. The gases $CO_2$ and $H_2O$ can dissolve in magma. Figure 1 shows, for 4 different magmas (leucitite, basanite, rhyolite, and tholeiitic basalt), how the solubility of $CO_2$ in the magma at 1,150°C varies with pressure (in megapascals, MPa).
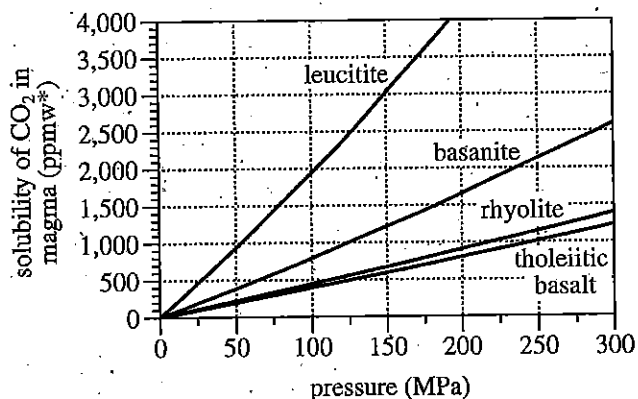


*parts per million by weight

Figure 1

Figure 2 shows, at 3 different pressures, how the solubility of $CO_2$ in rhyolite magma varies with temperature.
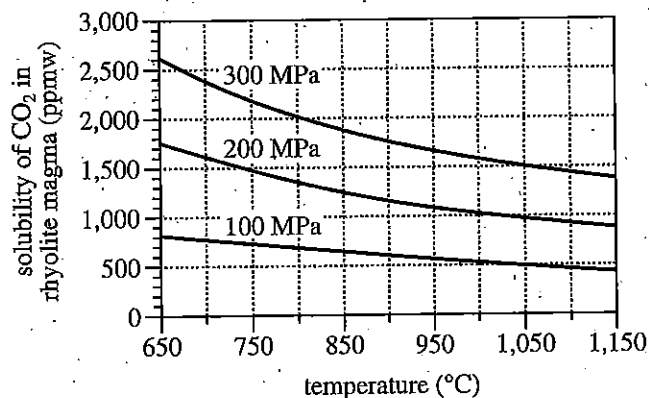


Figure 2

Figure 2 adapted from Robert A. Fogel and Malcolm J. Rutherford, "The Solubility of Carbon Dioxide in Rhyolitic Melts: A Quantitative FTIR Study." ©1990 by the Mineralogical Society of America.

Figure 3 shows, at 4 different pressures, how the solubility of $CO_2$ in rhyolite magma at 750°C varies with the weight percent of $H_2O$ in the magma.
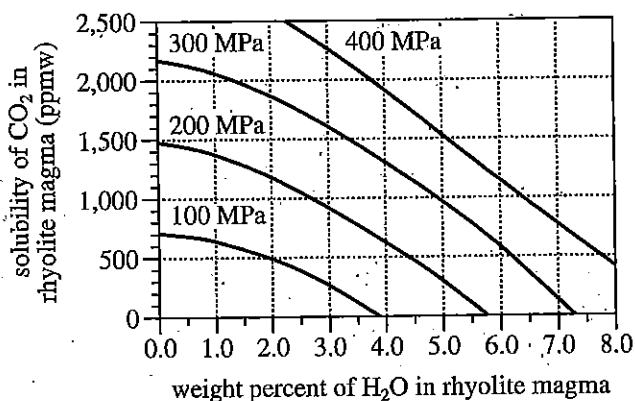


Figure 3

Figures 1 and 3 adapted from Jacob B. Lowenstern, "Carbon Dioxide in Magmas and Implications for Hydrothermal Systems." ©2001 by Springer-Verlag.

28. According to Figure 2, at 300 MPa, the solubility of $CO_2$ in rhyolite magma is closest to 2,000 ppmw at which of the following temperatures?

   F. 700°C
   G. 750°C
   H. 800°C
   J. 850°C

29. Based on Figure 3, at 750°C and 350 MPa, rhyolite magma having a solubility of $CO_2$ equal to 1,250 ppmw would most likely have a weight percent of $H_2O$ that is:

   A. less than 2.0%.
   B. between 2.0% and 4.0%.
   C. between 4.0% and 6.0%.
   D. greater than 6.0%.

30. According to Figure 1, at 1,150°C, the solubility of $CO_2$ in basanite magma and the solubility of $CO_2$ in tholeiitic basalt magma are closest in value at which of the following pairs of pressures?

| | basanite magma | tholeiitic basalt magma |
|---|---|---|
| F. | 50 MPa | 200 MPa |
| G. | 50 MPa | 250 MPa |
| H. | 125 MPa | 200 MPa |
| J. | 125 MPa | 250 MPa |

31. Based on Figure 1, at 1,150°C and 150 MPa, the solubility of $CO_2$ in leucitite magma is approximately how much greater than or less than the solubility of $CO_2$ in rhyolite magma?

A. 1,750 ppmw greater
B. 2,300 ppmw greater
C. 1,750 ppmw less
D. 2,300 ppmw less

32. According to Figure 2, increasing the temperature from 650°C to 1,150°C has the *lesser* effect on the solubility of $CO_2$ in rhyolite magma at which pressure, 100 MPa or 300 MPa ?

F. 100 MPa; the solubility of $CO_2$ decreases by about 400 ppmw.
G. 100 MPa; the solubility of $CO_2$ decreases by about 1,300 ppmw.
H. 300 MPa; the solubility of $CO_2$ decreases by about 400 ppmw.
J. 300 MPa; the solubility of $CO_2$ decreases by about 1,300 ppmw.

33. Consider the solubility of $CO_2$ in rhyolite magma at 750°C and 200 MPa, as shown in Figure 2. According to Figure 3, this rhyolite magma has a weight percent of $H_2O$ closest to which of the following?

A. 0.0%
B. 2.0%
C. 4.0%
D. 6.0%

## Passage VI

When viewed from Earth, the other planets in the solar system usually appear to move *prograde* (eastward relative to the stars). Occasionally, however, each planet appears to briefly move *retrograde* (westward relative to the stars). For example, Figure 1 shows Mars's position relative to the stars on 9 dates between July 24, 2005, and February 26, 2006.
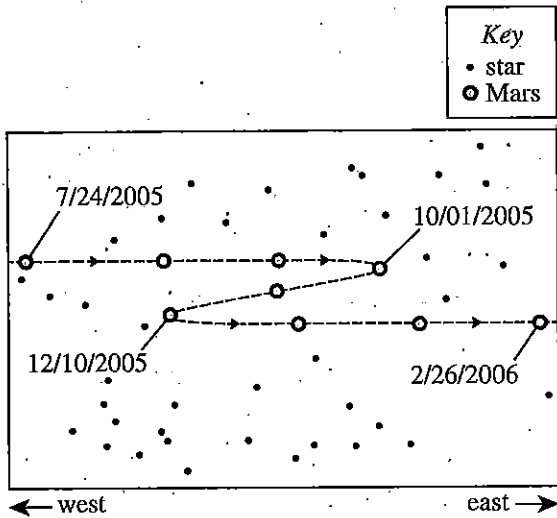
Figure 1

Two hypotheses were proposed to explain why the planets occasionally appear to move retrograde.

### Hypothesis 1

Earth is the solar system's central body, and the other bodies move around Earth in looped orbits. Each body (except Earth) has 2 circles associated with it: a *deferent* and an *epicycle*. Both circles rotate counterclockwise, and their combined motions result in a body following a looped orbit. In Figure 2, the left panel shows Mars's deferent and epicycle, and the right panel shows Mars's orbit.
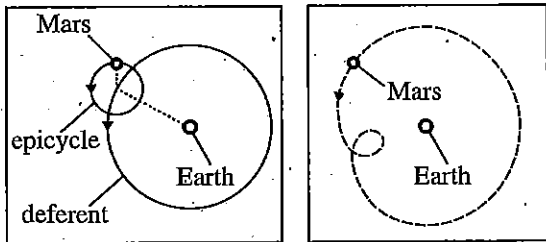
Figure 2

As a body passes through a loop, the body's motion changes from prograde to retrograde and back. The larger a body's deferent, the more loops in the body's orbit, and the more often that body passes through a loop.

### Hypothesis 2

The Sun is the solar system's central body, and the planets move counterclockwise around the Sun in elliptical orbits. The larger a planet's orbit, the more time the planet takes to complete a revolution around the Sun. As a result, the line of sight from Earth to a given planet drifts over time. Figure 3 shows the orbits of Earth and Mars, and the positions of Earth and Mars, on each of the 4 dates labeled in Figure 1. For each date, the line of sight from Earth to Mars is projected onto a view of the sky.

There are 2 rules for apparent retrograde motion:

- A planet with an orbit larger than Earth's appears to move retrograde whenever Earth passes between the Sun and that planet. The larger that planet's orbit, the more often a pass occurs.

- A planet with an orbit smaller than Earth's appears to move retrograde whenever that planet passes between the Sun and Earth. The *smaller* that planet's orbit, the more often a pass occurs.
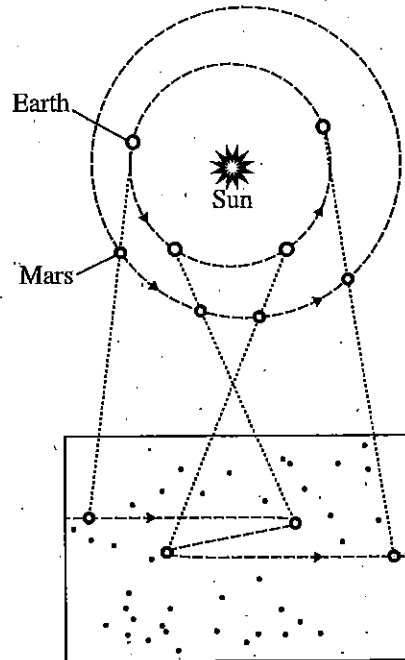
Figure 3

34. Which of the following statements best describes a primary difference between the two hypotheses? Hypothesis 1 claims that all planets follow:

    F. looped orbits around Earth, whereas Hypothesis 2 claims that all planets follow elliptical orbits around the Sun.
    G. looped orbits around Earth, whereas Hypothesis 2 claims that all planets follow elliptical orbits around Earth.
    H. elliptical orbits around the Sun, whereas Hypothesis 2 claims that all planets follow looped orbits around the Sun.
    J. elliptical orbits around the Sun, whereas Hypothesis 2 claims that all planets follow looped orbits around Earth.

35. Assume that Figures 2 and 3 are drawn to scale. Which of the figures, if either, implies that the distance between Earth and Mars varies with time?

    A. Figure 2 only
    B. Figure 3 only
    C. Both Figure 2 and Figure 3
    D. Neither Figure 2 nor Figure 3

36. Consider both the interval of time represented in Figures 1 and 3 and the reason that, according to Hypothesis 2, the line of sight from Earth to Mars drifts over time. Is the top portion of Figure 3 consistent with that reason?

    F. Yes; Earth is shown as having the smaller orbit and as having completed a greater percentage of its revolution around the Sun than is Mars.
    G. Yes; Earth is shown as having the larger orbit and as having completed a greater percentage of its revolution around the Sun than is Mars.
    H. No; Earth is shown as having the smaller orbit and as having completed a greater percentage of its revolution around the Sun than is Mars.
    J. No; Earth is shown as having the larger orbit and as having completed a greater percentage of its revolution around the Sun than is Mars.

37. Based on Figure 1, as viewed from Earth, for approximately how many days between July 2005 and February 2006 did Mars move retrograde?

    A. 30
    B. 70
    C. 150
    D. 220

38. A supporter of Hypothesis 1 and a supporter of Hypothesis 2 would both be likely to agree with which of the following statements? When viewed from Earth, if a planet appears to be moving prograde, that planet is actually moving:

    F. clockwise around Earth.
    G. clockwise around the central body in the solar system.
    H. counterclockwise around the Sun.
    J. counterclockwise around the central body in the solar system.

39. Based on Figures 1 and 3, if Hypothesis 2 is correct, which of the following figures most likely shows the positions of Earth and Mars on November 7, 2005 ?
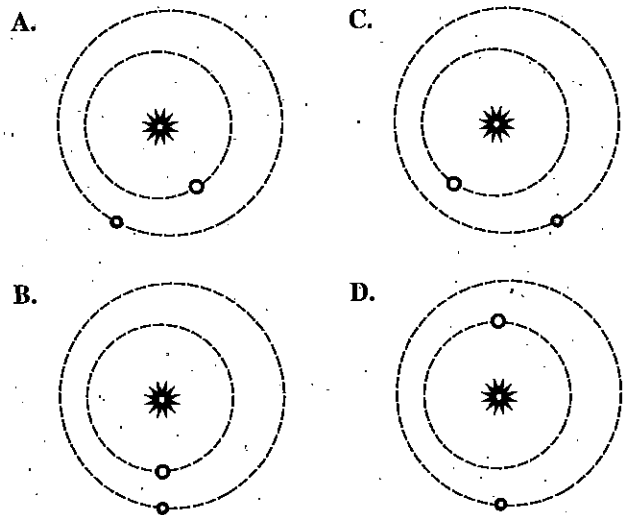


40. Can Hypothesis 2 explain why Venus occasionally appears to move retrograde?

    F. Yes; Hypothesis 2 accounts for the motion of planets that are closer to the Sun than Earth is.
    G. Yes; Hypothesis 2 accounts for the motion of planets that are farther from the Sun than Earth is.
    H. No; Hypothesis 2 does not account for the motion of planets that are closer to the Sun than Earth is.
    J. No; Hypothesis 2 does not account for the motion of planets that are farther from the Sun than Earth is.

**END OF TEST 4**

**STOP! DO NOT RETURN TO ANY OTHER TEST.**

## Scoring Keys for Form C01

Use the scoring key for each test to score your answer document for the multiple-choice tests. Mark a "1" in the blank for each question you answered correctly. Add up the numbers in each reporting category and enter the total number correct for each reporting category in the blanks provided. Also enter the total number correct for each test in the blanks provided. The total number correct for each test is the sum of the number correct in each reporting category.

### Test 1: English—Scoring Key

| | | Reporting Category* | | |
|---|---|---|---|---|
| | Key | POW | KLA | CSE |
| 1. | C | | | __ |
| 2. | H | | | __ |
| 3. | B | | __ | |
| 4. | H | | | __ |
| 5. | C | | | __ |
| 6. | F | __ | | |
| 7. | A | __ | | |
| 8. | G | | | __ |
| 9. | A | __ | | |
| 10. | H | | | __ |
| 11. | D | | | __ |
| 12. | G | | | __ |
| 13. | B | | | __ |
| 14. | J | | __ | |
| 15. | A | __ | | |
| 16. | J | | | __ |
| 17. | C | | | __ |
| 18. | F | __ | | |
| 19. | A | | __ | |
| 20. | F | __ | | |
| 21. | B | | | __ |
| 22. | J | | | __ |
| 23. | B | | | __ |
| 24. | H | | | __ |
| 25. | A | __ | | |
| 26. | J | | | __ |
| 27. | A | | __ | |
| 28. | H | | | __ |
| 29. | D | | __ | |
| 30. | G | __ | | |
| 31. | D | | __ | |
| 32. | G | | | __ |
| 33. | B | | | __ |
| 34. | J | __ | | |
| 35. | D | __ | | |
| 36. | G | | | __ |
| 37. | C | __ | | |
| 38. | F | | | __ |

| | | Reporting Category* | | |
|---|---|---|---|---|
| | Key | POW | KLA | CSE |
| 39. | C | | | __ |
| 40. | F | | | __ |
| 41. | A | __ | | |
| 42. | F | | | __ |
| 43. | B | | __ | |
| 44. | F | __ | | |
| 45. | C | __ | | |
| 46. | F | | | __ |
| 47. | A | | __ | |
| 48. | F | __ | | |
| 49. | B | | | __ |
| 50. | G | | | __ |
| 51. | D | | | __ |
| 52. | J | | | __ |
| 53. | A | | | __ |
| 54. | G | __ | | |
| 55. | D | | | __ |
| 56. | J | __ | | |
| 57. | C | __ | | |
| 58. | J | __ | | |
| 59. | B | | | __ |
| 60. | H | __ | | |
| 61. | D | | | __ |
| 62. | F | | | __ |
| 63. | C | __ | | |
| 64. | H | | | __ |
| 65. | D | | | __ |
| 66. | G | | | __ |
| 67. | A | __ | | |
| 68. | J | | | __ |
| 69. | D | | | __ |
| 70. | J | | | __ |
| 71. | B | | | __ |
| 72. | H | | | __ |
| 73. | A | | | __ |
| 74. | H | | | __ |
| 75. | B | __ | | |

**\*Reporting Categories**
POW = Production of Writing
KLA = Knowledge of Language
CSE = Conventions of Standard English

| Number Correct (Raw Score) for: | |
|---|---|
| Production of Writing (POW) | ____ (23) |
| Knowledge of Language (KLA) | ____ (12) |
| Conventions of Standard English (CSE) | ____ (40) |
| Total Number Correct for English Test (POW + KLA + CSE) | ____ (75) |

# Test 2: Mathematics—Scoring Key

| Key | N | A | F | G | S | IES | MDL |
|---|---|---|---|---|---|---|---|
| 1. E | | | | — | | | |
| 2. H | | | | | | — | — |
| 3. B | | | | | | — | |
| 4. J | | — | | | | | |
| 5. A | | | | | | — | — |
| 6. F | | | | | | — | — |
| 7. B | | | | | | — | |
| 8. H | | | | | | | — |
| 9. C | | — | | | | | · |
| 10. J | | | | | | — | |
| 11. C | | | | | | — | |
| 12. H | — | | | | | | |
| 13. E | | | | — | | | |
| 14. H | | | — | | | | |
| 15. D | | | | | | — | |
| 16. F | | | | | | — | |
| 17. C | | | | | — | | |
| 18. G | | | — | | | | |
| 19. A | | | | — | | | |
| 20. J | | | | | | — | — |
| 21. B | | | | — | | | |
| 22. H | | — | — | | | | |
| 23. A | | | | | | — | |
| 24. F | | | — | | | | |
| 25. C | | | | | | — | |
| 26. F | | — | | | | | — |
| 27. E | | | | | | — | · |
| 28. H | | | | | | — | — |
| 29. E | | | | | | — | |
| 30. F | — | | | | | | |

| Key | N | A | F | G | S | IES | MDL |
|---|---|---|---|---|---|---|---|
| 31. B | | | | | — | | — |
| 32. K | | | | | — | | — |
| 33. C | | | — | | | | |
| 34. J | — | | | | | | — |
| 35. D | | | | — | | | |
| 36. K | | — | | | | | |
| 37. E | | | — | | | | |
| 38. K | | | | — | | | |
| 39. B | — | | | | | | |
| 40. H | | | | | | — | — |
| 41. B | — | | | | | | |
| 42. F | | | — | | | | |
| 43. D | | | — | | | | — |
| 44. G | | | | | | — | — |
| 45. D | | | — | | | | |
| 46. H | | | | | | — | — |
| 47. A | | | | | | — | |
| 48. G | — | | | | | — | |
| 49. D | | | | | | — | |
| 50. J | | | | | | — | — |
| 51. E | | | | — | | | |
| 52. J | | | | | — | | — |
| 53. E | | — | | | | | |
| 54. G | | | — | | | | — |
| 55. D | | | | | | — | |
| 56. J | | | | | — | | — |
| 57. A | | | | | | — | |
| 58. G | | | | | | — | |
| 59. E | | | — | | | | |
| 60. K | | | | — | | | — |

Combine the totals of these columns and put in the blank for PHM in the box below.

**\*Reporting Categories**
**PHM** = Preparing for Higher Math
  N = Number & Quantity
  A = Algebra
  F = Functions
  G = Geometry
  S = Statistics & Probability
**IES** = Integrating Essential Skills
**MDL** = Modeling

| Number Correct (Raw Score) for: | |
|---|---|
| Preparing for Higher Math (PHM) | |
| (N + A + F + G + S) | (35) |
| Integrating Essential Skills (IES) | |
| | (25) |
| Total Number Correct for Mathematics Test | |
| (PHM + IES) | (60) |
| Modeling (MDL) | |
| (Not included in total number correct for mathematics test raw score) | (24) |

# Test 3: Reading—Scoring Key

| | Key | KID | CS | IKI |
|---|---|---|---|---|
| 1. | D | — | | |
| 2. | J | — | | |
| 3. | C | — | | |
| 4. | H | — | | |
| 5. | B | | — | |
| 6. | H | | — | |
| 7. | A | | — | |
| 8. | F | | | — |
| 9. | D | | | — |
| 10. | F | | | — |
| 11. | B | — | | |
| 12. | F | — | | |
| 13. | B | — | | |
| 14. | F | — | | |
| 15. | A | — | | |
| 16. | H | — | | |
| 17. | D | | | — |
| 18. | J | — | | |
| 19. | C | — | | |
| 20. | J | — | | |

| | Key | KID | CS | IKI |
|---|---|---|---|---|
| 21. | C | | | — |
| 22. | G | | — | |
| 23. | B | | — | |
| 24. | H | | — | |
| 25. | D | — | | |
| 26. | G | — | | |
| 27. | A | — | | |
| 28. | F | — | | |
| 29. | B | — | | |
| 30. | F | | — | |
| 31. | B | | — | |
| 32. | F | | | — |
| 33. | D | | — | |
| 34. | H | — | | |
| 35. | B | | — | |
| 36. | H | — | | |
| 37. | A | — | | |
| 38. | F | — | | |
| 39. | C | | — | |
| 40. | J | — | | |

| Number Correct (Raw Score) for: | |
|---|---|
| Key Ideas & Details (KID) | ___ (23) |
| Craft & Structure (CS) | ___ (11) |
| Integration of Knowledge & Ideas (IKI) | ___ (6) |
| Total Number Correct for Reading Test (KID + CS + IKI) | ___ (40) |

# Test 4: Science—Scoring Key

| | Key | IOD | SIN | EMI |
|---|---|---|---|---|
| 1. | A | — | | |
| 2. | J | — | | |
| 3. | D | — | | |
| 4. | G | — | | |
| 5. | D | | | — |
| 6. | G | — | | |
| 7. | B | | — | |
| 8. | G | | — | |
| 9. | A | | — | |
| 10. | H | | — | |
| 11. | D | | | — |
| 12. | H | | | — |
| 13. | B | — | | |
| 14. | G | — | | |
| 15. | B | — | | |
| 16. | H | | — | |
| 17. | A | | | — |
| 18. | F | — | | |
| 19. | C | | — | |
| 20. | F | | | — |

| | Key | IOD | SIN | EMI |
|---|---|---|---|---|
| 21. | C | | — | |
| 22. | F | | | — |
| 23. | D | | — | |
| 24. | H | — | | |
| 25. | B | | — | |
| 26. | J | | — | |
| 27. | B | | | — |
| 28. | H | — | | |
| 29. | C | — | | |
| 30. | J | — | | |
| 31. | B | — | | |
| 32. | F | — | | |
| 33. | A | — | | |
| 34. | F | | | — |
| 35. | C | | | — |
| 36. | F | | | — |
| 37. | B | | | — |
| 38. | J | | | — |
| 39. | B | | | — |
| 40. | F | | | — |

| Number Correct (Raw Score) for: | |
|---|---|
| Interpretation of Data (IOD) | ___ (16) |
| Scientific Investigation (SIN) | ___ (10) |
| Evaluation of Models, Inferences & Experimental Results (EMI) | ___ (14) |
| Total Number Correct for Science Test (IOD + SIN + EMI) | ___ (40) |

# Explanation of Procedures Used to Obtain
# Scale Scores from Raw Scores

On each of the four tests on which you marked any responses, the total number of correct responses yields a raw score. Use the table below to convert your raw scores to scale scores. For each test, locate and circle your raw score or the range of raw scores that includes it in the table below. Then, read across to either outside column of the table and circle the scale score that corresponds to that raw score. As you determine your scale scores, enter them in the blanks provided on the right. The highest possible scale score for each test is 36. The lowest possible scale score for any test on which you marked any responses is 1.

Next, compute the Composite score by averaging the four scale scores. To do this, add your four scale scores and divide the sum by 4. If the resulting number ends in a fraction, round it off to the nearest whole number. (Round down any fraction less than one-half; round up any fraction that is one-half or more.) Enter this number in the blank. This is your Composite score. The highest possible Composite score is 36. The lowest possible Composite score is 1.

**ACT Test C01**                                     **Your Scale Score**

English _____

Mathematics _____

Reading _____

Science _____

**Sum of scores** _____

**Composite score (sum ÷ 4)** _____

NOTE: If you left a test completely blank and marked no items, do not list a scale score for that test. If any test was completely blank, do not calculate a Composite score.

| Scale Score | Raw Scores | | | | Scale Score |
| --- | --- | --- | --- | --- | --- |
| | Test 1 English | Test 2 Mathematics | Test 3 Reading | Test 4 Science | |
| 36 | 73-75 | 58-60 | 39-40 | 39-40 | 36 |
| 35 | 70-72 | 56-57 | 38 | 38 | 35 |
| 34 | 69 | 54-55 | 37 | — | 34 |
| 33 | 68 | 52-53 | 36 | 37 | 33 |
| 32 | 67 | 51 | 35 | 36 | 32 |
| 31 | 66 | 50 | — | — | 31 |
| 30 | 65 | 48-49 | 34 | 35 | 30 |
| 29 | 64 | 46-47 | 33 | 34 | 29 |
| 28 | 62-63 | 44-45 | 32 | 33 | 28 |
| 27 | 61 | 41-43 | 31 | 32 | 27 |
| 26 | 59-60 | 38-40 | 30 | 31 | 26 |
| 25 | 57-58 | 36-37 | 29 | 29-30 | 25 |
| 24 | 54-56 | 34-35 | 28 | 27-28 | 24 |
| 23 | 51-53 | 32-33 | 26-27 | 25-26 | 23 |
| 22 | 49-50 | 30-31 | 25 | 23-24 | 22 |
| 21 | 46-48 | 29 | 24 | 21-22 | 21 |
| 20 | 43-45 | 28 | 22-23 | 19-20 | 20 |
| 19 | 41-42 | 26-27 | 21 | 18 | 19 |
| 18 | 40 | 24-25 | 20 | 16-17 | 18 |
| 17 | 38-39 | 21-23 | 18-19 | 14-15 | 17 |
| 16 | 35-37 | 18-20 | 17 | 13 | 16 |
| 15 | 31-34 | 14-17 | 15-16 | 12 | 15 |
| 14 | 29-30 | 11-13 | 14 | 10-11 | 14 |
| 13 | 27-28 | 9-10 | 12-13 | 9 | 13 |
| 12 | 24-26 | 7-8 | 11 | 8 | 12 |
| 11 | 21-23 | 6 | 9-10 | 7 | 11 |
| 10 | 18-20 | 5 | 8 | 6 | 10 |
| 9 | 16-17 | 4 | 7 | 5 | 9 |
| 8 | 13-15 | 3 | 6 | 4 | 8 |
| 7 | 11-12 | — | 5 | — | 7 |
| 6 | 9-10 | 2 | 4 | 3 | 6 |
| 5 | 7-8 | — | 3 | 2 | 5 |
| 4 | 5-6 | 1 | — | — | 4 |
| 3 | 4 | — | 2 | 1 | 3 |
| 2 | 2-3 | — | 1 | — | 2 |
| 1 | 0-1 | 0 | 0 | 0 | 1 |

# ACT® Test Information Release Answer Document Copy Order Form 2019–2020

(July 18, 2020)

**Now that you have received the List Report,** you may request a photocopy of your scanned answer document for a $24 fee. If you took the writing test, you will also receive a copy of your written essay.

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(    )

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LEGAL SIGNATURE of person whose test information is requested

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# Directions

This booklet contains tests in English, mathematics, reading, and science. These tests measure skills and abilities highly related to high school course work and success in college. **Calculators may be used on the mathematics test only.**

The questions in each test are numbered, and the suggested answers for each question are lettered. On the answer document, the rows of ovals are numbered to match the questions, and the ovals in each row are lettered to correspond to the suggested answers.

For each question, first decide which answer is best. Next, locate on the answer document the row of ovals numbered the same as the question. Then, locate the oval in that row lettered the same as your answer. Finally, fill in the oval completely. Use a soft lead pencil and make your marks heavy and black. **Do not use ink or a mechanical pencil.**

Mark only one answer to each question. If you change your mind about an answer, erase your first mark thoroughly before marking your new answer. For each question, make certain that you mark in the row of ovals with the same number as the question.

Only responses marked on your answer document will be scored. Your score on each test will be based only on the number of questions you answer correctly during the time allowed for that test. You will **not** be penalized for guessing. **It is to your advantage to answer every question even if you must guess.**

You may work on each test **only** when the testing staff tells you to do so. If you finish a test before time is called for that test, you should use the time remaining to reconsider questions you are uncertain about in that test. You may **not** look back to a test on which time has already been called, and you may **not** go ahead to another test. To do so will disqualify you from the examination.

Lay your pencil down immediately when time is called at the end of each test. You may **not** for any reason fill in or alter ovals for a test after time is called for that test. To do so will disqualify you from the examination.

Do not fold or tear the pages of your test booklet.

**DO NOT OPEN THIS BOOKLET
UNTIL TOLD TO DO SO.**

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