Form C03

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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.

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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

Double the Manta Rays

There are thousands of new animal species[1] identified each year, the vast majority are small or geographically isolated. So as graduate student Andrea Marshall studied manta rays, which are neither small nor isolated, she didn't expect to identify a new species. Mantas, which are[2] plankton-eating relatives of stingrays that look like pairs of enormous black wings—up to twenty-five feet wide—[3] flying slowly through the water. Encompassing wide swaths of both temperate and tropical oceans, the manta's range abuts every continent but Antarctica.

During Marshall's research off the coast of Mozambique, she observed intriguing physical variations, in the mantas[4] she swam amongst.

1. **A.** NO CHANGE
   B. Scientists say thousands of new animal species are
   C. Of the thousands of new animal species
   D. Thousands of new animal species are

2. **F.** NO CHANGE
   G. Mantas are
   H. Mantas,
   J. DELETE the underlined portion (adjusting the capitalization as needed).

3. **A.** NO CHANGE
   B. wings: up to twenty-five feet wide—
   C. wings, up to twenty-five feet wide—
   D. wings, up to twenty-five feet wide:

4. **F.** NO CHANGE
   G. variations—in the mantas
   H. variations, in the mantas,
   J. variations in the mantas

Her beachside lodgings in Mozambique now house the Marine Megafauna Research Center. She began to suspect that the one recognized species of manta might in fact be two species.

[1] To investigate, Marshall began collecting data. [2] Other data required a closer look. [3] The skin of all mantas, for example, is embedded with tiny, toothlike "denticles." [4] Marshall found that denticles on some mantas were randomly spaced and occasionally overlapped, whereas denticles on other mantas were evenly spaced and never overlapped. [5] Another discovery was: that some mantas had egg-shaped masses at the base of their tail fins. [6] Each mass contained a bony spine about an inch long—the vestige of a stinging barb from the manta's ancestors. [8]

In 2009, Marshall announced, with two other scientists, that indeed there is two manta species. The reef manta, *Manta alfredi*, is the smaller and more common of the two. Thriving in shallow water, it kind of sticks around one area. In contrast, the giant manta, *Manta birostris*, favors deep water and migrates thousands of miles a year.

5. The writer is considering deleting the underlined sentence. Should the writer make this deletion?

- **A.** Yes, because the sentence interrupts the account of how Marshall came to investigate the possibility that there were two manta ray species.
- **B.** Yes, because the sentence fails to clarify why Marshall did her research in Mozambique.
- **C.** No, because the sentence explains how Marshall created a large scientific institution even though she started as a lone researcher.
- **D.** No, because the sentence clarifies Marshall's role at the Marine Megafauna Center.

6.

- **F.** NO CHANGE
- **G.** happen to be
- **H.** were
- **J.** are

7.

- **A.** NO CHANGE
- **B.** was, that,
- **C.** was that
- **D.** was, that

8. The writer wants to add the following sentence to this paragraph:

> Some of the data were basic, such as manta coloration and size.

The sentence would most logically be placed:

- **F.** after Sentence 1.
- **G.** after Sentence 2.
- **H.** after Sentence 3.
- **J.** after Sentence 4.

9. Which choice best conveys that Marshall's announcement was backed by scientific data?

- **A.** NO CHANGE
- **B.** surprised many scientists by announcing
- **C.** had the evidence to announce
- **D.** at long last announced

10.

- **F.** NO CHANGE
- **G.** exists
- **H.** was
- **J.** are

11.

- **A.** NO CHANGE
- **B.** rarely ventures far from its home territory.
- **C.** doesn't delight in slogging long distances.
- **D.** loves hanging around its neighborhood.

The fact that such large animals went undifferentiated
12

highlights how little scientists know for so long about
13

these gentle giants. At the moment, manta ray populations
14

face an array of threats worldwide.
14

12. F. NO CHANGE
G. whether
H. which
J. how

13. A. NO CHANGE
B. for so long highlights how little scientists know
C. highlights for so long how little scientists know
D. highlights how for so long little scientists know

14. Which of the following true statements best concludes this paragraph and the essay by suggesting that the scientific study of manta rays will continue?
F. NO CHANGE
G. A 2009 documentary film about Dr. Marshall related the story of her manta-species discovery.
H. Dr. Marshall once described the manta ray as "like the largest, most beautiful underwater bird."
J. Fortunately, mantas have a devoted and expert researcher in Dr. Marshall.

Question 15 asks about the preceding passage as a whole.

15. Suppose that the writer's purpose had been to survey the scientific community's response to the identification of the two manta species. Would this essay accomplish that purpose?
A. Yes, because it explains that the scientific community enthusiastically accepted the identification of the two manta species.
B. Yes, because it relates that Marshall's research was thorough and well documented.
C. No, because it presents only one scientist's response to the identification of the two manta species.
D. No, because it focuses on how Marshall's research led to the discovery of the two manta species.

PASSAGE II

Origins of Aspirin

When a plant is attacked by bacteria, fungi, or insects, it produces chemicals, called salicylates, that help the plant produce enzymes or toxins capable of destroying the plant's attackers. Salicylates may also play a role in the plant's ability to regulate its temperature; in effect, helping
16

the plant tolerate heat and cold. Humans have used the

salicylic acids found in plants, particularly in the bark
17

of the willow tree, to fight disease and to reduce fevers.
17

16. F. NO CHANGE
G. temperature, helping
H. temperature, this helps
J. temperature. As a result, helping

17. A. NO CHANGE
B. plants—particularly in the bark—of the willow tree,
C. plants; particularly in the bark of the willow tree,
D. plants particularly, in the bark of the willow tree,

The first known references to willow bark's medicinal use date from ancient Egypt and Sumeria. On a Sumerian stone tablet from 3000 BCE, lists willow among (18) dozens of plants used to treat illnesses. An Egyptian papyrus from approximately about (19) 1534 BCE refers to willow's use as an all-purpose medicine.

Though willow trees are often found near water (20) and have become religious symbols in many cultures, (20) its medicinal use gradually fell out of favor in Europe.

Apothecaries increasingly preferred (21) the imported bark of South American cinchona trees as a fever reducer, even though willow grew abundantly throughout Europe.

The high cost of importing (22) cinchona bark however, (23) was expensive.

Consequently, (24) in the mid-1700s, English minister Edward Stone had began (25) to seek a substitute. He noted that the bitter taste of willow bark was reminiscent of the bitter taste of cinchona bark.

18. **F.** NO CHANGE
G. willow is listed among
H. willow is listed on
J. lists willow on

19. **A.** NO CHANGE
B. an estimation of
C. in the region of
D. about

20. Given that all the choices are true, which one would provide the most logical transition to the new subject of this paragraph?

F. NO CHANGE
G. While the use of willow bark remained a commonplace method to reduce aches, pains, and fevers around the world,
H. Though the ancient Egyptian physician Imhotep was worshipped as a god of healing and thought to have used willow bark,
J. Despite the fact that possible side effects to using willow bark could sometimes include stomach aches and dizziness,

21. **A.** NO CHANGE
B. would of preferred
C. will prefer
D. prefer

22. **F.** NO CHANGE
G. Importing the high price tag of
H. The high importation cost of
J. Importing

23. **A.** NO CHANGE
B. bark; however,
C. bark, however,
D. bark, however

24. **F.** NO CHANGE
G. Nevertheless,
H. Furthermore,
J. Likewise,

25. **A.** NO CHANGE
B. would have began
C. begun
D. began

Known also for his interest in astronomy, Stone
26

pulverized some willow bark and adds its powder
27

to a liquid. He administered the medicine to people
28

suffering from fevers, he then noted that it worked.
29

As the field of medicine evolved, so did the use of willow bark. Searching for a way to make the salicylic acid in willow bark less abrasive to the stomach, in 1853 French chemist Charles von Gerhardt created a synthetic version. Decades later, German chemist Felix Hoffmann combined synthetic salicylic acid with acetic acid, inventing a consumer-friendly powdered formula that would come to be known as aspirin.

26. Given that all the choices are accurate, which one provides the most logical transition from the preceding sentence?

- **F.** NO CHANGE
- **G.** Assuming diseases and their cures derive from the same environments,
- **H.** Believing that the two plants must share similar qualities,
- **J.** Living on the outskirts of the town of Chipping Norton,

27.
- **A.** NO CHANGE
- **B.** then added it's
- **C.** added its
- **D.** adds it's

28. Which choice best emphasizes the experimental nature of the liquid Stone created?

- **F.** NO CHANGE
- **G.** He tested his new concoction on
- **H.** The liquid was given to benefit
- **J.** He decided to give the drink to

29.
- **A.** NO CHANGE
- **B.** fevers, he was elated to find that
- **C.** fevers which
- **D.** fevers. It

Question 30 asks about the preceding passage as a whole.

30. Suppose the writer's primary purpose had been to outline the development of a common medicine. Would this essay accomplish that purpose?

- **F.** Yes, because the essay describes how Egyptians used to administer willow bark and how this process evolved from ancient Sumerian practices.
- **G.** Yes, because the essay documents the historical use of willow bark as a medicine and traces its gradual refinement into modern aspirin.
- **H.** No, because the essay primarily explains the function of salicylates in willow bark and how aspirin affects the human body.
- **J.** No, because the essay primarily compares the use of willow bark to the use of cinchona bark in eighteenth-century European medicine.

PASSAGE III

Good Vibrations

In his studio in Dusseldorf, Germany, paint is what photographer Martin Klimas carefully pours onto a rubber membrane placed on top of an audio speaker. The paint collects in a puddle of colors; rich oranges and powder blues, hot pinks and electric yellows. Klimas attaches his camera to a tripod and positions the camera so it is level with the paint puddle. He then sets a sound trigger (a device that automatically snaps a photo when a given sound level is reached) on his camera. Finally, he inserts Daft Punk's *Homework* CD into a stereo, cranks up the volume to ten, and pushes Play.

The result is what Klimas calls a "sonic sculpture." The vibrations produced by Daft Punk's dance anthem "Around the World" has caused the paint to rise and fall, to string and swirl, to splatter and stretch. It is this image that Klimas's camera captures—sound visually rendered by the effects of the vibrations on the paint. Although Klimas's photographs only capture an instant of the paint erupting in arcs of color, each of the photographs is unique to a given song.

31. **A.** NO CHANGE
B. there is paint carefully being poured by photographer Martin Klimas
C. paint is carefully poured by Martin Klimas, a photographer,
D. photographer Martin Klimas carefully pours paint

32. **F.** NO CHANGE
G. colors: rich oranges and powder blues,
H. colors: rich oranges; and powder blues
J. colors; rich oranges and powder blues;

33. Which of the following alternatives to the underlined portion would NOT be acceptable?
A. tripod, and he
B. tripod and he
C. tripod. He
D. tripod; he

34. **F.** NO CHANGE
G. eye-to-eye with
H. the same as
J. equal to

35. Which choice provides the most dramatic description of Klimas's action?
A. NO CHANGE
B. turns the volume knob a bit higher,
C. increases the volume of the output,
D. adjusts the speaker's output level,

36. **F.** NO CHANGE
G. cause
H. is causing
J. causes

37. **A.** NO CHANGE
B. pic, frozen in time's embrace that Klimas's camera has snapped—
C. picture that Klimas's photographic paraphernalia has managed to catch—
D. snapshot that Klimas's photographic machine snares—

"I leave the creation of the picture to the sound itself," Klimas says.

Klimas's idea for his sonic sculptures were sparked by the experiments, of Swiss scientist, Hans Jenny. In the 1960s, Jenny's study on the effects of sound vibrations on various materials. For example, Jenny discovered that low sonic tones caused powdery substances to form into uniform lines, while deeper tones caused the same powder to form into more nuanced patterns. [42] Klimas relies on similar principles, only with a more compelling component: music. Klimas has photographed sonic sculptures of classical music by Wagner and Bach; jazz by Miles Davis, Charlie Parker, and John Coltrane; and psychedelic rock by Pink Floyd and Jimi Hendrix. While he acknowledges that all forms of music can generate sonic sculptures. Klimas says, "I typically select something dynamic and percussive."

That would certainly impress Jenny. After all, to create his art, Klimas needs his paint to get up and dance.

38. Which of the following quotations from Klimas provides the most relevant information at this point in the essay?

- **F.** NO CHANGE
- **G.** "The most annoying thing was cleaning up the set thoroughly after every single shot,"
- **H.** "In general, I use normal photographic equipment and common music stuff,"
- **J.** "The shooting is mostly about repeating the process again and again."

39.
- **A.** NO CHANGE
- **B.** have been
- **C.** was
- **D.** are

40.
- **F.** NO CHANGE
- **G.** experiments, of Swiss scientist
- **H.** experiments of Swiss, scientist
- **J.** experiments of Swiss scientist

41.
- **A.** NO CHANGE
- **B.** while Jenny studied
- **C.** Jenny, to study
- **D.** Jenny studied

42. At this point, the writer is considering dividing the paragraph into two. Should the writer begin or not begin a new paragraph here, and why?

- **F.** Begin a new paragraph because the essay shifts here from an explanation of the harmonics of music to a discussion of Klimas's taste in music.
- **G.** Begin a new paragraph because the essay shifts here from a discussion of Jenny's experiments to a discussion of the music Klimas uses for his artwork.
- **H.** DO NOT begin a new paragraph because doing so would interrupt the analysis of Jenny's experiments.
- **J.** DO NOT begin a new paragraph because doing so would interrupt a description of Klimas's scientific background.

43.
- **A.** NO CHANGE
- **B.** sculptures, and
- **C.** sculptures,
- **D.** sculptures;

44. Which sentence most effectively leads the reader from the Klimas quotation to the concluding sentence of the essay?

- **F.** NO CHANGE
- **G.** That's simply a matter of taste.
- **H.** That seems unwise.
- **J.** That makes sense.

Question 45 asks about the preceding passage as a whole.

45. Suppose the writer's primary purpose had been to document the process of an artist. Would this essay accomplish that purpose?

- **A.** Yes, because the essay focuses on how Jenny used an artistic process similar to Klimas's process.
- **B.** Yes, because the essay describes how Klimas photographs the effects of vibrations created by music on paint.
- **C.** No, because the essay focuses on the cultural significance of Klimas's artwork.
- **D.** No, because the essay provides a general overview of how Jenny's experiments have inspired visual artists like Klimas.

PASSAGE IV

Building and Rebuilding "the King of Roads"

[1]

Separating Oregon from Washington, the Columbia River Gorge is eighty-five miles of flowing water, there are tree-covered bluffs, and roaring waterfalls. [46]

These striking features daunted would-be road builders [47] until 1913. That year, Samuel Hill and Samuel Lancaster, a businessman and an engineer, respectively, began constructing a road through the gorge to connect the towns along the river. [A] Their design went beyond practicalities [48] it showcased the scenic grandeur of the gorge where the Columbia River is located. [49]

46. **F.** NO CHANGE
- **G.** tree-covered bluffs flank the river,
- **H.** featuring tree-covered bluffs,
- **J.** tree-covered bluffs,

47. Which choice most clearly indicates that the features of the Columbia River Gorge intimidated road builders and kept them from constructing the highway?

- **A.** NO CHANGE
- **B.** posed problems for
- **C.** slowed potential
- **D.** challenged

48. **F.** NO CHANGE
- **G.** practicalities: and
- **H.** practicalities:
- **J.** practicalities,

49. **A.** NO CHANGE
- **B.** gorge, which is over eighty miles long.
- **C.** gorge and its scenery.
- **D.** gorge.

[2]

Featuring seven viaducts and eighteen bridges, the Columbia River Highway was a marvel. [B] Roadside overlooks with benches for sitting by the road offered travelers the chance to take in a view of the river or a waterfall. Guardrails made of local rock lined the route and blurred the distinction between that and environment. [C] Engineers created [53] openings in the side of one tunnel; enabling motorists surrounded by rock to glimpse the river below. Completed in 1922, the highway earned the local nickname "the King of Roads."

[3]

Impressive as it was, the highway was soon outmoded because of increased traffic and larger vehicles. In time, Oregon built a new road along the Columbia, much of the highway was destroyed to make room; other stretches were abandoned. By 1954, only the western third of the original road was still in use, mainly by tourists seeking waterfalls. [D]

50. **F.** NO CHANGE
G. alongside the road
H. for travelers
J. DELETE the underlined portion.

51. **A.** NO CHANGE
B. up
C. on
D. DELETE the underlined portion.

52. **F.** NO CHANGE
G. this and the
H. road and
J. it and it's

53. At this point, the writer is considering adding the following accurate phrase:

an unprecedented five

Should the writer make this addition here?

A. Yes, because it adds a detail that highlights the impressive design of the highway.
B. Yes, because it hints at how the engineers were able to make openings in the tunnel.
C. No, because it provides information that is unrelated to the sentence.
D. No, because it suggests that creating intricate tunnels was easy for road engineers.

54. **F.** NO CHANGE
G. tunnel; an achievement that enabled
H. tunnel, this enabled
J. tunnel, enabling

55. **A.** NO CHANGE
B. When
C. Soon
D. DELETE the underlined portion.

56. **F.** NO CHANGE
G. road that first existed continued in a functional capacity,
H. highway that was completed in 1922 continued to be utilized,
J. original highway was still being utilized by the driving populace,

[4]

In the 1980s, however, local people's interest in the original highway abounded[57]. In 1981, the National Park Service offered suggestions for restoring parts of the road and repurposing unused sections of it as a trail. Since then, crumbling stone guardrails along the roadside have been repaired. Damaged bridges and viaducts have been rebuilt. Tunnels, now empty and strong, had rubble removed from them[58]. Today, hikers and bikers on the Historic Columbia River Highway Trail experience a site that became a National Historic Landmark in 2000[59].

57. Which choice most clearly conveys that people's interest in the original Columbia River Highway was not a new phenomenon?

A. NO CHANGE
B. took hold.
C. rekindled.
D. set in.

58. Which choice most closely maintains the sentence pattern the writer has established in the previous two sentences?

F. NO CHANGE
G. Rubble-filled tunnels have been emptied and strengthened.
H. The tunnels have had the rubble removed from them, and people have strengthened them.
J. Once filled with rubble, tunnels have been emptied and strengthened.

59. Given that all the choices are accurate, which one best concludes the essay by referring back to the first paragraph?

A. NO CHANGE
B. the gorge on sections of the road where it wasn't feasible to restore motor vehicle traffic.
C. the splendor of the highway that Hill and Lancaster envisioned over one hundred years ago.
D. a beautiful path that has become a popular tourist destination.

Question 60 asks about the preceding passage as a whole.

60. The writer wants to add the following sentence to the essay:

The rest of the highway fell into disrepair.

The sentence would most logically be placed at:

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

PASSAGE V

Selling Hip-Hop

One night in the late seventies, at a popular club in New York City, singer and music producer Sylvia Robinson had a revelation. At the time, hip-hop subculture—based on the graffiti, breakdancing, deejaying, and rapping art forms—were emerging as a phenomenon. Robinson watched as DJ Lovebug Starski spun records for the crowd and rapped over the instrumental breaks in the music. Every time the DJ chanted, "Throw your hands in the air," everyone obeyed. Robinson could hear the enthusiasm shared between the hip-hop performer and his audience. She knew she had to capture that excitement on record.

Robinson wasted no time in recruiting three aspiring rappers: Big Bank Hank, Master Gee, and Wonder Mike— to record on her label as the Sugarhill Gang. [65] Wanting to re-create the feel-good vibe of the music she'd heard, an upbeat disco record provided the background that the rappers rhymed over. The resulting track, "Rapper's Delight," sold fourteen million copies; Robinson had produced the first rap record to break into the charts.

61. **A.** NO CHANGE
B. singer, and music producer, Sylvia Robinson,
C. singer and music producer, Sylvia Robinson,
D. singer, and music producer Sylvia Robinson

62. **F.** NO CHANGE
G. have emerged
H. was emerging
J. are emerging

63. **A.** NO CHANGE
B. obeyed by throwing their hands in the air.
C. heeded the DJ's call and obeyed him.
D. did what he said and obeyed.

64. **F.** NO CHANGE
G. rappers—
H. rappers;
J. rappers,

65. At this point, the writer is considering adding the following true statement:

> Robinson and her husband would go on to form other record labels as well.

Should the writer make this addition here?

A. Yes, because it suggests that the Sugarhill Gang was able to choose where they wanted to record "Rapper's Delight."
B. Yes, because it helps explain why Big Bank Hank, Master Gee, and Wonder Mike decided to record with Robinson.
C. No, because it interrupts the paragraph's discussion of how "Rapper's Delight" was created.
D. No, because it fails to specify the time period in which Robinson and her husband started their labels.

66. **F.** NO CHANGE
G. an upbeat disco record provided by Robinson was rhymed over by the rappers.
H. rhymes were created by the rappers over an upbeat disco record.
J. Robinson had the rappers rhyme over an upbeat disco record.

Nevertheless, Robinson's musical
67

instincts, and business savvy had served her well
68
with the Sugarhill Gang. However, there was more to

hip-hop music than party-ready club anthems. She hoped
69
to capitalize on her success by expanding the genre,
Robinson signed Grandmaster Flash and the Furious Five,
a group that already had a following, to her label.

Robinson allowed the group to record a track that
70
studio musician Edward Fletcher had written. The track,

titled "The Message," encountered new commercial
71
hip-hop ground by addressing harsh realities of inner-city
life. It was a far cry from the more digestible singles the
group had previously released because the rappers were
72
hesitant to record it. But Robinson believed it was a

surefire hit. In the opposite fashion, Fletcher and
73
Melle Mel (one of the Furious Five) recorded the
track, which became the group's biggest hit.
Its socially conscious rhymes helped usher in a
74

new generation of artists and secured Robinson's
75
legacy in the landscape of commercial hip-hop.

67. **A.** NO CHANGE
B. On the other hand,
C. As a result,
D. DELETE the underlined portion.

68. **F.** NO CHANGE
G. instincts, and, business savvy
H. instincts and business savvy
J. instincts and business savvy,

69. **A.** NO CHANGE
B. She was hoping
C. The hope was
D. Hoping

70. Which choice most effectively indicates that Robinson had to convince Grandmaster Flash and the Furious Five to record "The Message"?

F. NO CHANGE
G. pressured
H. helped
J. asked

71. **A.** NO CHANGE
B. protected
C. covered
D. filled

72. **F.** NO CHANGE
G. released although
H. released, so
J. released, for

73. **A.** NO CHANGE
B. first place,
C. same way,
D. end,

74. **F.** NO CHANGE
G. Its socially conscience
H. It's socially conscious
J. It's socially conscience

75. Which of the following alternatives to the underlined portion would NOT be acceptable?

A. artists, and it secured
B. artists and securing
C. artists and secure
D. artists, securing

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.

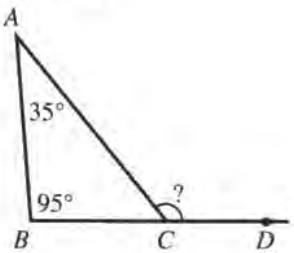
1. Illustrative figures are NOT necessarily drawn to scale.
2. Geometric figures lie in a plane.
3. The word *line* indicates a straight line.
4. The word *average* indicates arithmetic mean.

DO YOUR FIGURING HERE.

1. A function, f, is defined by $f(x,y) = 3x^2 - 4y$. What is the value of $f(3,2)$?

A. 0
B. 10
C. 19
D. 24
E. 28

2. In the figure below, $\angle BAC$ measures 35°, $\angle ABC$ measures 95°, and points B, C, and D are collinear. What is the measure of $\angle ACD$?



F. 95°
G. 125°
H. 130°
J. 140°
K. 145°

3. For all nonzero values of x and y, which of the following expressions is equivalent to $-\frac{36x^4y^3}{4xy}$?

A. $-40x^3y^2$
B. $-32x^3y^2$
C. $-9x^5y^4$
D. $-9x^4y^3$
E. $-9x^3y^2$

4. At a certain airline company, the cost to transfer mileage points from one person's account to another person's account is \$0.75 for every 100 mileage points transferred plus a onetime \$20 processing fee. What is the cost to transfer 7,000 mileage points from one account to another at that airline company?

F. \$25.25
G. \$67.50
H. \$72.50
J. \$75.00
K. \$95.00

DO YOUR FIGURING HERE.

5. For $x = -5$, what is the value of $4x^2 - 11x$?

   A. −155
   B. −84
   C. −45
   D. 84
   E. 155

6. Taho earns his regular pay of \$11 per hour for up to 40 hours of work per week. For each hour over 40 hours of work per week, Taho earns $1\frac{1}{2}$ times his regular pay. How much does Taho earn in a week in which he works 50 hours?

   F. \$550
   G. \$605
   H. \$625
   J. \$750
   K. \$825

7. A science class has 8 juniors and 4 seniors. The teacher will randomly select 2 students, one at a time, to represent the class in a committee at the school. Given that the first student selected is a junior, what is the probability that the second student selected will be a senior?

   A. $\frac{1}{11}$
   B. $\frac{1}{4}$
   C. $\frac{3}{11}$
   D. $\frac{1}{3}$
   E. $\frac{4}{11}$

8. When Tyrone fell asleep one night, the temperature was 24°F. When Tyrone awoke the next morning, the temperature was −12°F. Letting + denote a rise in temperature and − denote a drop in temperature, what was the change in temperature from the time Tyrone fell asleep until the time he awoke?

   F. −36°F
   G. −12°F
   H. +6°F
   J. +12°F
   K. +36°F

9. The total cost of renting a car is \$35.00 for each day the car is rented plus 42.5¢ for each mile the car is driven. What is the total cost of renting the car for 6 days and driving 350 miles?

   (Note: No sales tax is involved.)

   A. \$ 154.75
   B. \$ 224.88
   C. \$ 358.75
   D. \$ 420.00
   E. \$1,697.50

DO YOUR FIGURING HERE.

10. In the standard (x,y) coordinate plane, what is the slope of the line through $(-6,4)$ and $(1,3)$?

F. $-\frac{7}{5}$

G. $-\frac{1}{5}$

H. $-\frac{1}{7}$

J. $\frac{1}{7}$

K. $\frac{1}{5}$

11. One morning at a coffee shop, each customer ordered either decaf or regular coffee, and each ordered it either with milk or without milk. The number of customers who ordered each type of coffee with or without milk is listed in the table below.

Order	Decaf	Regular	Total
With milk	12	8	20
Without milk	6	10	16
Total	18	18	36

A customer will be randomly selected from all 36 customers for a prize. What is the probability that the selected customer will have ordered a regular coffee without milk?

A. $\frac{1}{6}$

B. $\frac{5}{18}$

C. $\frac{5}{13}$

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

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

12. Which of the following inequalities describes the solution set for $3x - 5 < 2x + 1$?

F. $x < -4$

G. $x > -\frac{4}{5}$

H. $x < \frac{6}{5}$

J. $x < 6$

K. $x > 6$

13. Which of the following expressions is equivalent to $4(x + 2) + 3(2x - 1)$?

A. $3x + 8$
B. $5(2x + 1)$
C. $10(x + 1)$
D. $10x + 11$
E. $15x$

14. What is 4% of 1.36×10^4 ?

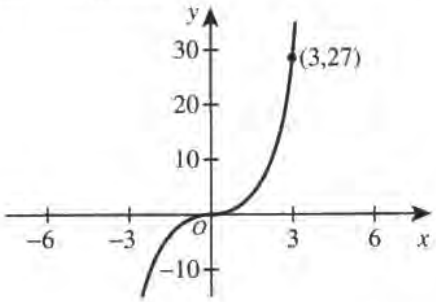
F. 340
G. 544
H. 3,400
J. 5,440
K. 54,400

DO YOUR FIGURING HERE.

15. What is the least common denominator of the fractions $\frac{4}{35}$, $\frac{1}{77}$, and $\frac{3}{22}$?

A. 110
B. 770
C. 2,695
D. 8,470
E. 59,290

16. The point (3,27) is labeled on the graph of $f(x) = x^3$ in the standard (x,y) coordinate plane below. The graph of $f(x)$ will be translated 3 coordinate units to the left. Which of the following points will be on the image of the graph after the translation?



F. (0,27)
G. (3,24)
H. (3,27)
J. (3,30)
K. (6,27)

17. In the standard (x,y) coordinate plane, what is the midpoint of the line segment that has endpoints (−6,9) and (2,5) ?

A. (−4,−4)

B. (−2, 7)

C. $\left(\frac{3}{2}, \frac{7}{2}\right)$

D. (4,−2)

E. (8,−4)

18. What value of x satisfies the equation $\frac{x^2+2x}{x+2} = 2$?

F. −4
G. −3
H. −2
J. 1
K. 2

DO YOUR FIGURING HERE.

Use the following information to answer questions 19–21.

A large theater complex surveyed 5,000 adults. The results of the survey are shown in the tables below.

Age groups	Number
21–30	2,750
31–40	1,225
41–50	625
51 or older	400

Moviegoer category	Number
Very often	830
Often	1,650
Sometimes	2,320
Rarely	200

Tickets are $9.50 for all regular showings and $7.00 for matinees.

19. Based on the survey results, what was the average number of moviegoers for each of the 4 categories?

A. 610
B. 1,060
C. 1,240
D. 1,250
E. 1,985

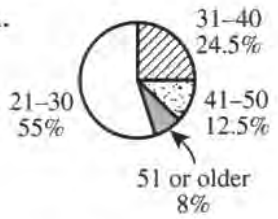
20. Suppose all the adults surveyed happened to attend 1 movie each in one particular week. The total amount spent on tickets by those surveyed in that week was $44,000.00. How many adults attended matinees that week?

F. 500
G. 1,400
H. 2,500
J. 3,600
K. 4,500

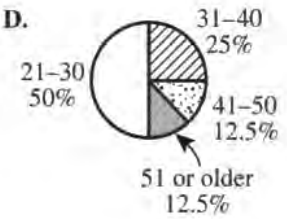
DO YOUR FIGURING HERE.

21. One of the following circle graphs represents the proportion by age group of the adults surveyed. Which one?

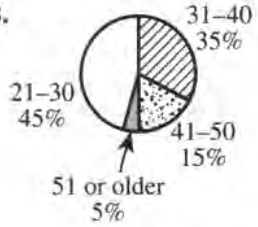
A.



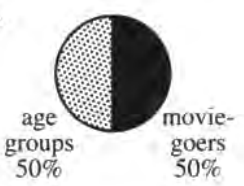
D.



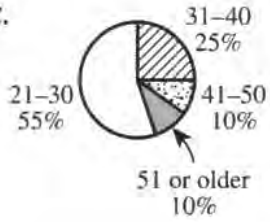
B.



E.



C.



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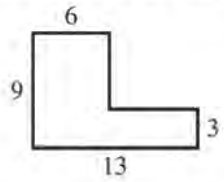
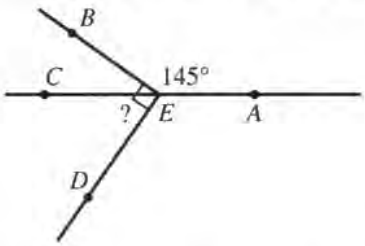
22. In the figure shown below, all angles are right angles, and the side lengths given are in centimeters. What is the area, in square centimeters, of the figure?

F. 42
G. 75
H. 93
J. 99
K. 117



23. In the figure below, E is on $\overline{CA}$, and the measures of $\angle BED$ and $\angle AEB$ are 90° and 145°, respectively. If it can be determined, what is the measure of $\angle CED$?



A. 35°
B. 45°
C. 55°
D. 80°
E. Cannot be determined from the given information

DO YOUR FIGURING HERE.

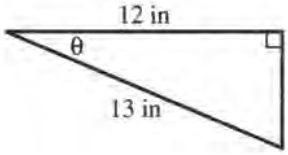
24. In the standard (x,y) coordinate plane, the graph of the function $y = 5\sin(x) - 7$ undergoes a single translation such that the equation of its image is $y = 5\sin(x) - 14$. Which of the following describes this translation?

F. Up 7 coordinate units
G. Down 7 coordinate units
H. Left 7 coordinate units
J. Right 7 coordinate units
K. Right 14 coordinate units

25. What is the value of $\left(9^{\frac{1}{2}} + 16^{\frac{1}{2}}\right)^2$?

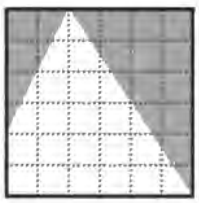
A. 7
B. 25
C. 49
D. 337
E. 625

26. A right triangle is shown in the figure below. What is the value of $\sin\theta$?



F. $\frac{5}{13}$
G. $\frac{5}{12}$
H. $\frac{12}{13}$
J. $\frac{13}{12}$
K. $\frac{13}{5}$

27. A 6-inch-by-6-inch square grid shown below is divided into 36 squares, each with a side length of 1 inch. Each vertex of the 2 shaded triangles lies at an intersection of 2 grid lines. What fractional part of the 6-inch-by-6-inch square is shaded?



A. $\frac{2}{3}$
B. $\frac{4}{5}$
C. $\frac{4}{9}$
D. $\frac{5}{9}$
E. $\frac{8}{9}$

28. All the values in the equation below are exact. What value of c makes the equation true?

$$(4.25 \times 10^{2c+4})(6 \times 10^{7}) = 255$$

F. −7
G. −6.5
H. −5
J. −4.5
K. −4

DO YOUR FIGURING HERE.

29. Which of the following inequalities is true for all positive integers m ?

A. $m \leq \frac{1}{m}$

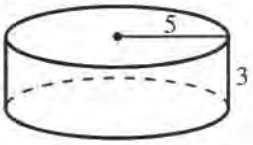
B. $m \leq \sqrt{m}$

C. $m \geq m^2$

D. $m \leq m + 1$

E. $m \geq \sqrt{m+1}$

30. A formula for the volume, V, of a right circular cylinder is $V = \pi r^2 h$, where r is the radius and h is the height. The cylindrical tank shown below has radius 5 meters and height 3 meters and is filled with water.

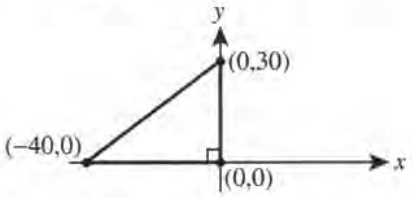


Given that the weight of 1 cubic meter of water is approximately 2,205 pounds, the weight, in pounds, of the water in the tank is:

F. less than 200,000.
G. between 200,000 and 300,000.
H. between 300,000 and 500,000.
J. between 500,000 and 1,000,000.
K. more than 1,000,000.

31. Graphed in the standard (x,y) coordinate plane below is a right triangle with vertices (0,0), (−40,0), and (0,30). What is the length, in coordinate units, of the hypotenuse of the triangle?

A. 30
B. 35
C. 40
D. 50
E. 70



32. Every graph in one of the following categories has a vertical line of symmetry regardless of how it is oriented in the standard (x,y) coordinate plane. Which one?

F. Circles
G. Squares
H. Ellipses
J. Triangles
K. Rectangles

DO YOUR FIGURING HERE.

33. In the standard (x,y) coordinate plane, the graph of $y = 30(x + 17)^2 - 42$ is a parabola. What are the coordinates of the vertex of the parabola?

A. (−30,−42)
B. (−17,−42)
C. (17,−42)
D. (17, 42)
E. (30, 42)

34. One side of square *ABCD* has a length of 15 meters. A certain rectangle whose area is equal to the area of *ABCD* has a width of 10 meters. What is the length, in meters, of the rectangle?

F. 15
G. 20
H. 22.5
J. 25
K. 37.5

35. The average weight of 10 boys is 77.0 pounds. If the youngest boy is excluded, the average weight of the 9 remaining boys is 78.0 pounds. What is the weight, in pounds, of the youngest boy?

A. 62
B. 68
C. 70
D. 78
E. 87

36. The total amount of a certain substance present in a laboratory experiment is given by the formula $A = A_0\left(2^{\frac{h}{5}}\right)$, where A is the total amount of the substance h hours after an initial amount (A_0) of the substance began accumulating. Which of the following expressions gives the number of hours it will take an initial amount of 10 grams of this substance to accumulate to 100 grams?

F. 5
G. 25
H. $\log_2(50)$
J. $5 \log_2(10)$
K. $5 \log_{20}(100)$

DO YOUR FIGURING HERE.

37. For all values of x greater than 3, which of the following expressions is equivalent to $\frac{x^2-x-6}{x^2-9}$?

A. $\frac{-x-6}{-9}$

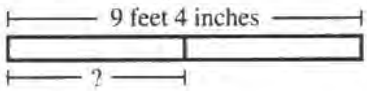
B. $\frac{x-2}{x-3}$

C. $\frac{x-2}{x+3}$

D. $\frac{x+2}{x-3}$

E. $\frac{x+2}{x+3}$

38. Shown below, a board 9 feet 4 inches long is cut into 2 equal parts. What is the length, to the nearest inch, of each part?



F. 4 feet 5 inches
G. 4 feet 7 inches
H. 4 feet 8 inches
J. 5 feet 4 inches
K. 5 feet 5 inches

39. If the positive integers x and y are relatively prime (their greatest common factor is 1) and $\frac{1}{2}+\frac{1}{3}\cdot\frac{1}{4}\div\frac{1}{5}=\frac{x}{y}$, then $x+y=$?

A. 23
B. 25
C. 49
D. 91
E. 132

40. What is the 358th digit after the decimal point in the repeating decimal $0.\overline{3178}$?

F. 0
G. 3
H. 1
J. 7
K. 8

41. To promote a new brand of shoes, a shoe store will run a promotion using a jar containing 3 red balls marked "10% off," 2 white balls marked "30% off," and 1 green ball marked "60% off." Each customer will randomly select 1 ball from the jar to determine the discount that the customer will receive on any single pair of the new brand of shoes. Given that the new brand of shoes regularly costs \$60 per pair, what is the average discount amount, in dollars, that the store can expect to give each customer due to this promotion?

A. \$ 6
B. \$10
C. \$15
D. \$20
E. \$25

DO YOUR FIGURING HERE.

Use the following information to answer questions 42–44.

A 500-square-mile national park in Kenya has large and small protected animals. The number of *large* protected animals at the beginning of 2014 is given in the table below.

Large animal	Number
Elephant	600
Rhinoceros	100
Lion	200
Leopard	300
Zebra	400
Giraffe	800
Total	2,400

At the beginning of 2014, the number of *all* protected animals in the park was 10,000. Zoologists predict that for each year from 2015 to 2019, the total number of protected animals in the park at the beginning of the year will be 2% more than the number of protected animals in the park at the beginning of the previous year.

42. At the beginning of 2014, the number of lions in the park was p percent of the total number of *large* animals. Which of the following is closest to the value of p ?

F. 2
G. 8
H. 9
J. 11
K. 12

43. In this park, the average number of gallons of water consumed per day by each elephant, lion, and giraffe is 50, 5, and 10, respectively. Which of the following matrix products yields the average total number of gallons of water consumed per day by all the elephants, lions, and giraffes in the park?

A. $[600\ 200\ 800]\begin{bmatrix}50\\5\\10\end{bmatrix}$

B. $[600\ 800\ 200]\begin{bmatrix}50\\5\\10\end{bmatrix}$

C. $\begin{bmatrix}600\\200\\800\end{bmatrix}[50\ 5\ 10]$

D. $\begin{bmatrix}600\\800\\200\end{bmatrix}[50\ 5\ 10]$

E. $\begin{bmatrix}600\\800\\200\end{bmatrix}\begin{bmatrix}50\\5\\10\end{bmatrix}$

DO YOUR FIGURING HERE.

44. Let t be a positive integer less than 6. Based on the zoologists' prediction, which of the following expressions represents the number of protected animals in the park t years after the beginning of 2014 ?

F. $10{,}000 + 0.02t$
G. $10{,}000 + 0.2t$
H. $10{,}000(1 + 0.02^t)$
J. $10{,}000(1 + 0.02)^t$
K. $10{,}000(1 + 0.2)^t$

---

45. Anela and Jacob plan to attend a concert in Brady. Anela will drive 375 km to Brady at a constant speed of 75 km/hr, stopping one time for a 30-minute break. Jacob will start 600 km from Brady and will drive at a constant speed of 90 km/hr for 2 hours. He will take a 1-hour break and then drive to Brady at a constant speed of 70 km/hr. To the nearest 0.1 hour, Jacob must leave how much earlier than Anela in order for them to arrive in Brady at the same time?

A. 2.2
B. 2.5
C. 3.1
D. 3.5
E. 4.0

46. Which of the following is equal to $\frac{3x+5}{2x} - \frac{7x-3}{2x}$, for all $x \neq 0$?

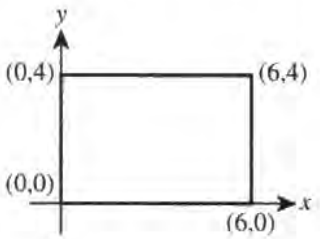
F. $-4x + 8$
G. $-4x + 2$
H. $-2x + 1$
J. $\frac{-2x+4}{x}$
K. 2

47. A rectangular stage is 90 feet long and 30 feet wide. What is the area, in square *yards*, of this stage?

A. $30\sqrt{3}$
B. 300
C. 675
D. 900
E. 2,700

DO YOUR FIGURING HERE.

48. A rectangle, with its vertex coordinates labeled, is graphed in the standard (x,y) coordinate plane below. A *lattice point* is a point with coordinates that are both integers. A lattice point inside but NOT on the rectangle will be chosen at random. What is the probability that the sum of the x-coordinate and the y-coordinate of the chosen lattice point will be odd?



F. $\frac{1}{5}$

G. $\frac{2}{5}$

H. $\frac{7}{15}$

J. $\frac{17}{35}$

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

49. The nth term of an arithmetic progression is given by the formula $a_n = a_1 + (n-1)d$, where d is the common difference and a_1 is the first term. If the third term of an arithmetic progression is $\frac{5}{2}$ and the sixth term is $\frac{1}{4}$, what is the seventh term?

A. $-\frac{1}{2}$

B. 0

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

D. $\frac{3}{4}$

E. 1

50. The probability of Jamie being chosen to bat first in the lineup for his baseball team is $\frac{1}{9}$. What are the odds in favor of Jamie being chosen to bat first?

(Note: The *odds* in favor of an event are defined as the ratio of the probability that the event will happen to the probability that the event will NOT happen.)

F. $\frac{1}{8}$

G. $\frac{1}{9}$

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

J. $\frac{8}{1}$

K. $\frac{9}{1}$

DO YOUR FIGURING HERE.

51. A 120-liter solution that is 5% salt is mixed with an 80-liter solution that is 15% salt. The combined solution is what percent salt?

A. 8%
B. 9%
C. 10%
D. 11%
E. 12%

52. A 50-foot-long rectangular swimming pool with vertical sides is 3 feet deep at the shallow end and 10 feet deep at the deep end. The bottom of the pool slopes downward at a constant angle from horizontal along the length of the pool. Which of the following expressions gives this constant angle?

(Note: For $-\frac{\pi}{2} < x < \frac{\pi}{2}$, $y = \tan x$ if and only if $x = \tan^{-1} y$.)

F. $\tan^{-1}\left(\frac{7}{50}\right)$

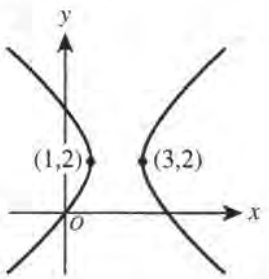
G. $\tan^{-1}\left(\frac{13}{50}\right)$

H. $\tan^{-1}\left(\frac{7}{10}\right)$

J. $\tan^{-1}\left(\frac{50}{13}\right)$

K. $\tan^{-1}\left(\frac{50}{7}\right)$

53. A hyperbola that has vertices (1,2) and (3,2) and that passes through the origin is shown below in the standard (x,y) coordinate plane. The hyperbola has which of the following equations?



A. $\frac{(x-2)^2}{1} - \frac{3(y-2)^2}{4} = 1$

B. $\frac{(x-2)^2}{1} - \frac{4(y-2)^2}{3} = 1$

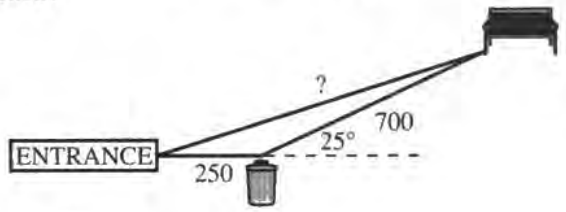
C. $\frac{(x+2)^2}{1} - \frac{3(y+2)^2}{4} = 1$

D. $\frac{(x-2)^2}{1} + \frac{3(y-2)^2}{4} = 1$

E. $\frac{(x+2)^2}{1} + \frac{4(y+2)^2}{3} = 1$

DO YOUR FIGURING HERE.

54. As shown below, Alli walked her dog 250 feet due east from the entrance of a dog park to a trash can and then walked 700 feet in a straight line 25° north of east to a bench. Which of the following expressions is equal to the distance, in feet, between the entrance and the bench?



F. $\frac{950}{\cos 25°}$

G. $\frac{250}{\cos 25°} + 700$

H. $\frac{250}{\sin 155°} + 700$

J. $\sqrt{700^2 + 250^2 - 2(700)(250)\cos 25°}$

K. $\sqrt{700^2 + 250^2 - 2(700)(250)\cos 155°}$

55. For real numbers a, b, and c such that $a > b > c$ and $b > 0$, which of the statements below is(are) *always* true?

I. $|a| > |b|$
II. $|a| > |c|$
III. $|b| > |c|$

A. I only
B. II only
C. I and II only
D. II and III only
E. I, II, and III

56. Kenji and Mary are members of a school committee that will be meeting this afternoon. The 6 members of the committee will be seated randomly around a circular table. What is the probability that Kenji and Mary will NOT sit next to each other at the meeting?

F. $\frac{1}{5}$

G. $\frac{1}{3}$

H. $\frac{2}{5}$

J. $\frac{3}{5}$

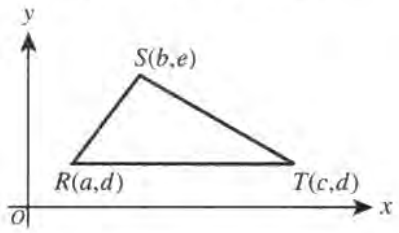
K. $\frac{4}{5}$

57. The digit in the ones place of 2^{88} is 6. What is the digit in the ones place of 2^{90} ?

A. 0
B. 2
C. 4
D. 6
E. 8

DO YOUR FIGURING HERE.

58. Which of the following expressions represents the area, in square coordinate units, of $\triangle RST$ shown in the standard (x,y) coordinate plane below?



F. $\frac{1}{2}(c-a)(e-d)$

G. $\frac{1}{2}c(e-b)$

H. $\frac{1}{2}e(c-a)$

J. $\frac{1}{2}\left[(e-d)^2+(b-a)^2\right]\left[(e-d)^2+(b-c)^2\right]$

K. $\frac{1}{2}\left(\sqrt{(e-d)^2+(b-a)^2}\right)\left(\sqrt{(e-d)^2+(b-c)^2}\right)$

59. In the complex numbers, where $i^2=-1$, what complex number x is a solution to the equation $x(2+3i)=1$?

A. $\frac{2}{13}-\frac{3}{13}i$

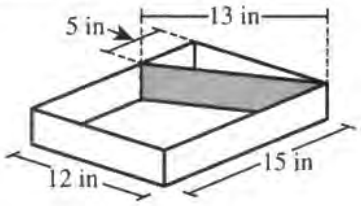
B. $\frac{2}{5}+\frac{3}{5}i$

C. 1

D. -1

E. $-\frac{i}{13}$

60. The rectangular container shown below has a small compartment for water created by a rectangular dividing wall of negligible width. One face of the dividing wall, shown shaded, has an area of 39 square inches. What is the volume, in cubic inches, of the larger compartment?



F. 180
G. 195
H. 390
J. 450
K. 540

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: This passage is adapted from the novel *Love Marriage* by V. V. Ganeshananthan (©2008 by Vasugi Ganeshananthan).

He met her, my mother, in New York City, and the Heart said plaintively: *Thump thump thump*. That was not the sound of illness. Theirs was an auspicious meeting, although no one had troubled to check the alignment of the stars; the young woman was twenty-seven—old for a prospective bride?—but she did not look it. She had a generous face, he said to himself.

He liked her glossy sheaf of dark hair, her sparse brows, her pronounced chin, her full lower lip. She smiled with her mouth closed because she did not like her teeth. He could already see within the structure of her face how she would become thinner, that her bones would give her older face a certain elegance, a chiseled and austere severity. He liked her precision in even the smallest of tasks, like arranging hibiscus in a vase. Her reserve, her inability to say anything truly personal in public. He thought she might be full of secrets and wanted to know them. She never raised her voice, but she did not speak softly. *How are you? That's a beautiful sari. How are the children? I like this rice.* She liked her food steaming and spicy, as he did. She made her own clothes, staying up late into the night, her foot on the pedal of a sewing machine that had belonged to her mother and had crossed the ocean with her. Her hemlines suited both the times and her young pale slimness, which reminded him of a flowering tree by his home in Jaffna. He never caught her admitting she was wrong; her words clambered around that impossibility, but so sheepishly that he found it endearing. In a noisy room he learned to tell the clear bell sound of her bangles apart from the rest.

Suddenly, he was no longer thinking about widows or about repeating his own father's collapse. It was as though an invisible conductor was directing the pulling of strings to draw them together. Whether it was Murali who managed to get introduced to Vani or the other way around, no one else really remembers. And they will never admit which one of them was responsible. And yet, it was this simple: a friend of his noticed that they were staying near each other. Perhaps Murali could give Vani a ride home? Yes, yes, two heads nodded. They left the party they were at too quickly to say all their good-byes. After the door closed behind them the space where they had been was filled with the laughter of friends.

He took her home. She boarded with a family in Brooklyn. During the car ride they were silent. It was a strange and comfortable silence for two people who had waited for so long to be alone. The thrum of the motor was loud because the car was old. When they turned around the corner he pulled over and turned the engine off and there was a quiet as loud as the motor had been. He walked her to her door and she thanked him. She did not ask him in for a cup of coffee; it was not her house. But it was out of his way and both of them knew it. She forgot that she did not like her teeth and bared them at him. Her smile, for once, was not self-conscious. She watched him drive away, waving from the window.

The Sri Lankan elders of New York City were all too eager to play parents to the couple. She was Proper: smart and polite and a good cook and lovely. Vani had a job, and more important than any of these things, she had grace, which was something that could not be taught. Murali, of course, was the Beloved Parentless Boy; their favorite bachelor-doctor whom they took into their homes and bosoms and tried to smother with welcome and curry. Occasions were arranged; even the very rooms seemed to conspire to make the two end up next to each other. And then one day something was suggested by one of those elders. And somehow the pair of them were *talking* about it. To each other. Directly.

Which was a faux pas. But neither of them minded.

Oceans away, families exploded. True to form, his family's discord faded quickly. But her family almost did not consent: afraid of the Improper, they questioned his intentions, his failure to observe certain formalities, his ancestry, his habits and his character. He heard about what they had said and turned to her, his eyes full of questions.

They may not know these things about you, she said, but I do.

Are you sure? he asked her. The unsaid: they may not forgive you for this.

Positive, she answered. Countries away, Vani's brother crashed into Murali's brother's house, yelling: *Who* is this doctor who wants to marry my *sister*? *Who* is this doctor who is *in love with my sister*?

The nerve of Murali, they thought. In Love? These were not words they were used to saying.

1. The third paragraph (lines 33–46) marks a shift from the second paragraph's focus on Murali's impressions of Vani to the rest of the passage's focus on:
   - **A.** Murali's life as a married man.
   - **B.** Murali's concerns about marriage.
   - **C.** Murali and Vani's courtship and its effects on others.
   - **D.** Murali's characteristics and his family conflicts.

2. Details in the second paragraph (lines 9–32) primarily characterize Vani as:
   - **F.** reserved but self-assured.
   - **G.** severe and impolite.
   - **H.** intelligent and apologetic.
   - **J.** beautiful but unkempt.

3. Which of the following events mentioned in the passage occurred first chronologically?
   - **A.** The elders organized occasions in which Vani and Murali would be together.
   - **B.** A friend suggested that Murali drive Vani home.
   - **C.** Vani smiled at Murali without thinking about her teeth.
   - **D.** Vani's brother burst into Murali's brother's home.

4. As it is presented in the passage, the italicized portion "*How are you? That's a beautiful sari. How are the children? I like this rice*" (lines 20–21) most likely indicates:
   - **F.** the types of pleasantries that Murali would prepare in his head before meeting someone new.
   - **G.** parts of a conversation between Murali and Vani when they were first introduced.
   - **H.** comments typical of the kind that Vani would make when in public.
   - **J.** secret thoughts that Murali imagined Vani to be thinking.

5. According to the passage, one similarity between Murali and Vani is that both:
   - **A.** enjoyed eating spicy food.
   - **B.** were born in New York City.
   - **C.** had a passion for cooking.
   - **D.** worked at a medical clinic.

6. In the context of the passage, the statement "And they will never admit which one of them was responsible" (lines 38–39) most strongly suggests that:
   - **F.** neither Murali nor Vani remembers who first sought to be introduced to the other.
   - **G.** each of Murali and Vani's friends claims to have been the one who introduced the two of them.
   - **H.** Murali initiated contact with Vani, though he would stubbornly deny that he did so.
   - **J.** both Murali and Vani refuse to confess to initiating their introduction to each other.

7. In the passage, the narrator makes clear that Vani didn't ask Murali in for coffee because Vani:
   - **A.** felt extremely self-conscious in Murali's presence.
   - **B.** did not want to invite Murali into someone else's house.
   - **C.** assumed that Murali wanted to get home at a reasonable hour.
   - **D.** did not want to further burden Murali with her requests.

8. The passage indicates that the description of Vani in lines 61–65 most closely reflects the perspective of:
   - **F.** Murali.
   - **G.** Vani's family in Sri Lanka.
   - **H.** Murali's friends in New York City.
   - **J.** the Sri Lankan elders in New York City.

9. It can reasonably be inferred from the passage that, by traditional standards, the Sri Lankan community would have considered Murali and Vani's direct discussion of marriage to be:
   - **A.** proper.
   - **B.** sensible.
   - **C.** superficial.
   - **D.** unconventional.

10. As it is used in line 79, the word *observe* most nearly means:
    - **F.** study.
    - **G.** follow.
    - **H.** express.
    - **J.** perceive.

Passage II

SOCIAL SCIENCE: Passage A is adapted from the article "Our Vanishing Night" by Verlyn Klinkenborg (©2008 by National Geographic Society, Inc.). Passage B is adapted from the book *The End of Night: Searching for Natural Darkness in an Age of Artificial Light* by Paul Bogard (©2013 by Paul Bogard).

Passage A by Verlyn Klinkenborg

For most of human history, the phrase "light pollution" would have made no sense. Imagine walking toward London on a moonlit night around 1800, when it was Earth's most populous city. Nearly a million people lived there, making do, as they always had, with candles and rushlights and torches and lanterns. Only a few houses were lit by gas, and there would be no public gaslights in the streets or squares for another seven years. From a few miles away, you would have been as likely to *smell* London as to see its dim collective glow.

Now most of humanity lives under intersecting domes of reflected, refracted light, of scattering rays from overlit cities and suburbs, from light-flooded highways and factories. Nearly all of nighttime Europe is a nebula of light, as is most of the United States and all of Japan. In the south Atlantic the glow from a single fishing fleet—squid fishermen luring their prey with metal halide lamps—can be seen from space, burning brighter, in fact, than Buenos Aires or Rio de Janeiro.

In most cities the sky looks as though it has been emptied of stars, leaving behind a vacant haze that mirrors our fear of the dark. We've grown so used to this pervasive orange haze that the original glory of an unlit night—dark enough for the planet Venus to throw shadows on Earth—is wholly beyond our experience. And yet above the city's pale ceiling lies the rest of the universe, utterly undiminished by the light we waste—a bright shoal of stars and planets and galaxies, shining in seemingly infinite darkness.

We've lit up the night as if it were an unoccupied country, when nothing could be further from the truth. Among mammals alone, the number of nocturnal species is astonishing. Light is a powerful biological force, and on many species it acts as a magnet, a process being studied by researchers such as Travis Longcore and Catherine Rich. The effect is so powerful that scientists speak of songbirds and seabirds being "captured" by searchlights on land or by the light from gas flares on marine oil platforms, circling and circling in the thousands.

Passage B by Paul Bogard

Unless Vincent Van Gogh's *The Starry Night* from 1889 is traveling as part of an exhibition, it hangs at home on its wall at the Museum of Modern Art (MoMA) in Manhattan as fifty million people pass by every year. On a Saturday morning I stand near Van Gogh's scene of stars and moon and sleeping town, talking with its guardian for the day, Joseph, as he repeats, "No flash, no flash," "Two feet away," and "Too close, too close" again and again as people from around the world crowd near. "What's the appeal of this painting?" I ask. "It's beautiful," he says. "What more can you say than that?"

You could rightly leave it at that. But I love the story this painting tells, of a small dark town, a few yellow-orange gaslights in house windows, under a giant swirling and waving blue-green sky. This is a painting of our world from before night had been pushed back to the forest and the seas, from back when sleepy towns slept without streetlights. People are too quick, I think, to imagine the story of this painting—and especially this sky—is simply that of "a werewolf of energy," as Joachim Pissarro, curator at the MoMA exhibition Van Gogh and the Colors of the Night, would tell me. While Van Gogh certainly had his troubles, this painting looks as it does in part because it's of a time that no longer exists, a time when the night sky would have looked a lot more like this. Does Van Gogh use his imagination? Of course, but this is an imagined sky inspired by a real sky of a kind few of the fifty million MoMA visitors have ever seen. It's an imagined sky inspired by the real sky over a town much darker than the towns we live in today. So a painting of a night imagined? Sure. But unreal?

In our age, yes. But Van Gogh lived in a time before electric light. In a letter from the summer of 1888, he described what he'd seen while walking a southern French beach:

> The deep blue sky was flecked with clouds of a blue deeper than the fundamental blue of intense cobalt, and others of a clearer blue, like the blue whiteness of the Milky Way. In the blue depth the stars were sparkling, greenish, yellow, white, pink, more brilliant, more sparkling gemlike than at home—even in Paris: opals you might call them, emeralds, lapis lazuli, rubies, sapphires.

It's remarkable to modern eyes, first of all, that Van Gogh would reference the stars over Paris—no one has seen a sky remotely close to this over Paris for at least fifty years. But stars of different colors? It's true.

Questions 11–13 ask about Passage A.

11. The main idea of the first paragraph of Passage A is that:

- **A.** before electricity, it was difficult to travel to London at night.
- **B.** gas lighting existed long before it was widely used.
- **C.** light pollution is a relatively recent phenomenon in human history.
- **D.** because of its large population, London has had light pollution for centuries.

12. In the third paragraph of Passage A (lines 21–30), the author makes a contrast between the:
    - **F.** hazy night sky over cities today and the bright stars and planets that exist above it.
    - **G.** gray night sky over cities and the various colors of the stars.
    - **H.** brightness of the planet Venus on an unlit night and the comparative dimness of the stars.
    - **J.** appreciation that people once had for stars and the apathy that is pervasive today.

13. It can reasonably be inferred from Passage A that an animal "captured" by light is most nearly one that:
    - **A.** has lost the ability to search for food in dark areas.
    - **B.** is irresistibly drawn to artificial light at night.
    - **C.** is confined to limited dark areas at night.
    - **D.** has lost its natural habitat to urban expansion.

Questions 14–17 ask about Passage B.

14. Compared to what Joseph appreciates about *The Starry Night*, the author of Passage B is more appreciative of the:
    - **F.** painting's vivid colors.
    - **G.** beauty of the painting.
    - **H.** story the painting tells.
    - **J.** technique used in the painting.

15. The main purpose of the first paragraph of Passage B (lines 42–53) is to introduce the passage by:
    - **A.** describing *The Starry Night* and providing an idea of the painting's popularity.
    - **B.** conveying the passage author's excitement when he first saw *The Starry Night*.
    - **C.** showing examples of people's expectations about *The Starry Night* and their reactions to it.
    - **D.** establishing when and why Van Gogh painted *The Starry Night*.

16. Based on Passage B, which of the following statements best summarizes the passage author's point about Van Gogh's use of imagination while painting *The Starry Night*?
    - **F.** Van Gogh had to rely heavily on his imagination because he usually painted during the daytime.
    - **G.** Van Gogh's work is almost entirely imagined because the painting's stars have colors that are unlike actual stars.
    - **H.** Van Gogh used his imagination in part, but his painting was also inspired by the real night sky he observed.
    - **J.** Van Gogh barely used his imagination at all; he tried to depict the vivid night sky exactly as it was.

17. As it is used in line 90, the phrase *remotely close to* most nearly means:
    - **A.** exactly similar to.
    - **B.** anything like.
    - **C.** anywhere nearby.
    - **D.** somewhat adjacent to.

Questions 18–20 ask about both passages.

18. Which of the following statements best captures the main difference in the information presented in the two passages?
    - **F.** Passage A summarizes the process by which light at night became common, whereas Passage B explores one person's reaction to Van Gogh's *The Starry Night*.
    - **G.** Passage A offers suggestions for restoring darkness to today's night, whereas Passage B compares the night skies of several Van Gogh paintings.
    - **H.** Passage A discusses the problems of today's bright night sky, whereas Passage B explains how people in Van Gogh's time used light at night.
    - **J.** Passage A gives an overview of the issue of light at night, whereas Passage B examines the matter of light at night through a discussion of Van Gogh's *The Starry Night*.

19. One similarity between the passages is that, in order to make a point about light at night, both authors discuss:
    - **A.** how dark large cities once were.
    - **B.** the opinions of scientific researchers.
    - **C.** well-known works of art.
    - **D.** personal memories of when night was darker.

20. Compared to Passage B, Passage A offers more information about the:
    - **F.** effects lighting up the night sky can have on animals.
    - **G.** colorful appearance stars had prior to electric lights.
    - **H.** interaction between nature and the imagination.
    - **J.** places where night's original darkness remains.

Passage III

HUMANITIES: This passage is adapted from the essay "On Places, Photographs, and Memory" by Chris Engman (©2012 by Chris Engman).

Recently I visited a place that I knew intimately in childhood, a waterfall with cliffs on both sides and a pool of cold water below. We used to jump from those cliffs despite our parents' concerns. I loved this place, and revisiting it I am amazed by all that I can remember. Bends in trails, sap stains on bark, crooks in branches, the intricate web of root structures, the shape of trees—all are startlingly unchanged and I remember them precisely. A small tree is in the middle of the trail. I put my hand on it for support and drops of moisture fall on my back from above, and I realize: I have done this before. I remember the sensation precisely, the sound of rustling leaves above, the freshness of the smell, the temperature of the droplets, the mixture of apprehension and pleasure. Standing on a rock ledge getting ready to jump, I reach for a handhold so I can lean over the edge and prepare myself for what I am about to do. The shape of the rock where my hand touches it is known to me: I have performed this ritual.

Places hold memories better than people and better than photographs. Family, or people from our past who may remind us of events in our lives and with whom we may reminisce, are themselves constantly changing, as is their version of events. Conversations with others about shared experiences of the past can seem to augment memory but quite often, more often than we probably realize, they operate in the opposite way: they alter or even replace our own memories with those of another. Whatever the event, one's memory of it is inevitably altered through conversation; recalling the same event at a later date, it becomes difficult or impossible to distinguish an original memory from the altered version that emerged.

Photographs act on us in a similar fashion. Whatever their apparent precision or correctness, photographs inaccurately reflect experience from the start. They convert the three dimensions of space into two and eliminate the third spatial dimension and time. Also sacrificed are smell, touch, sound, and context. In a word, a photograph is an abstraction of experience. Yet we take them compulsively. We fill scrapbooks and hard drives with family outings, vacations, ballgames—Scotty in front of Niagara Falls, Dad and Grandma smiling in front of the famous restaurant—in the hope of freezing time, making experience tangible for future reference, preserving memory. I do it, too. But it is well to realize that photographs do not preserve memory, they replace memory. Just as photographs are an abstraction of experience, they are even more so an abstraction of memory—a dangerously compelling abstraction. Memories are fragile and impressionable. They cannot hold up against the seemingly irrefutable factuality of a photograph. It isn't that what is in a photograph is false: a photograph's version of events did happen, what is in a picture did indeed pass before the lens. The problem is that photographs only tell such a small part of any story. And while they may be technically correct, nonetheless they deceive. Does a smile in a photograph mean that a person is happy? Or does it mean that a photographer prodded, "look up and smile"? Was the fish I caught really bigger than my uncle's, or did I cleverly, intentionally hold mine closer to the lens? Photographs deceive in another respect. Whatever the event one wishes to preserve, snapshots are most commonly a break from that event. The moment that a photograph is taken is experienced as a moment taking a photograph, not as a moment engaged in the activity implied by the resulting image. Time taken to make photographs is time subtracted from the experience of the thing being photographed. What photographs most accurately record, ultimately, is nothing more than the act of photography, itself.

To be sure, photographs can form a record of our lives that has value, and I cherish my old snapshots as much as the next person. But as image-makers and consumers, which all of us are these days, there is also value to be had in a recognition of the limits of photography to the facility of memory—in an understanding of what images can and cannot offer us in this regard. Moreover it is precisely the deceitfulness of photography as it pertains to memory that gives the medium its unique platform to address the nature of memory itself: its malleability, its unreliability, its elusiveness. It seems to me that no conversation or photograph can make memory so vivid or recognizable, so physically palpable, as the return to a place.

21. The passage as a whole can best be described as:

- **A.** a summary of a childhood incident followed by reflections on how the memory of that incident has changed.
- **B.** a description of an experience followed by consideration of a topic raised by that experience.
- **C.** an account of the author's lifelong interest in a hobby.
- **D.** an explanation of why the author's opinions on a topic have changed.

22. Which of the following statements best represents the passage's central claim?

- **F.** The accuracy of most memories is improved by viewing photographs related to the memories.
- **G.** Revisiting a place evokes clearer and more accurate memories than conversations or photographs.
- **H.** The truth represented by a photograph is only as accurate as your memory of the event in the photograph.
- **J.** Memories are sustained over time only through a combination of conversations, photographs, and visits to places.

23. The author's tone when recounting his visit to the waterfall can best be described as:

A. joking.
B. gloomy.
C. pleading.
D. reverent.

24. The main idea of the second paragraph (lines 20–33) is that:

F. over time, some memories fade.
G. frequently, reminiscing with other people changes one's memories.
H. reminiscing with other people helps preserve one's memories.
J. family members better evoke one's memories than nonfamily members.

25. When the author states "What photographs most accurately record, ultimately, is nothing more than the act of photography, itself" (lines 70–72), he most nearly means that:

A. the quality of a photograph reflects the skill of the photographer.
B. when viewing a photograph, people forget that the photographer is an unseen participant in the scene.
C. photographs by nature are records of brief moments.
D. photographs tend to depict people stopping an activity and posing for the photographer.

26. It can most reasonably be inferred that immediately after the events described in the first paragraph, the author:

F. hikes back down the cliffs.
G. sits on the rock ledge.
H. jumps into the water below.
J. takes a photograph of the scene.

27. Which of the following details does the author use to support his claim that photographs don't accurately reflect experiences?

A. Photographs are usually only taken by adults.
B. People take photographs without considering the best way to photograph an event.
C. Photographs don't record the passage of time.
D. The human eye can discern more detail than a photograph can capture.

28. The information between the dashes in lines 43–44 primarily serves to:

F. highlight the difference between trivial pictures and meaningful pictures.
G. exemplify the kind of commonplace pictures that people take.
H. point out the usefulness of photographs in capturing moments in our lives.
J. list events from the author's life that he wishes he had pictures of.

29. The phrase "seemingly irrefutable factuality" (lines 52–53) mainly serves to emphasize that photographs:

A. convey an impression of objective truth.
B. help clarify the events being photographed.
C. record details that can't be proven.
D. imply a story beyond what they actually depict.

30. As it is used in line 82, the word *nature* most nearly means:

F. temperament.
G. essence.
H. scenery.
J. environment.

Passage IV

NATURAL SCIENCE: This passage is adapted from the article "Reinventing the Leaf" by Antonio Regalado (©2010 by Scientific American, a division of Nature America, Inc.).

Nathan S. Lewis has been giving a lecture on the energy crisis that is both terrifying and exhilarating. To avoid potentially debilitating global warming, the chemist says civilization must be able to generate more than 10 trillion watts of clean, carbon-free energy by 2050. That level is three times the U.S.'s average energy demand of 3.2 trillion watts.

Before Lewis's crowds get too depressed, he tells them there is one source of salvation: the sun pours more energy onto the earth every hour than humankind uses in a year. But to be saved, humankind needs a radical breakthrough in solar-fuel technology: artificial leaves that will capture solar rays and churn out chemical fuel on the spot, much as plants do. We can burn the fuel, as we do oil or natural gas, to power cars, create heat or generate electricity, and we can store the fuel for use when the sun is down.

Lewis's lab is one of several that are crafting prototype leaves, not much larger than computer chips, designed to produce hydrogen fuel from water, rather than the glucose fuel that natural leaves create. Unlike fossil fuels, hydrogen burns clean. Other researchers are working on competing ideas for capturing the sun's energy, such as algae that has been genetically altered to pump out biofuels, or on new biological organisms engineered to excrete oil. All these approaches are intended to turn sunlight into chemical energy that can be stored, shipped and easily consumed. Lewis argues, however, that the man-made leaf option is the most likely to scale up to the industrial levels needed to power civilization.

Although a few lab prototypes have produced small amounts of direct solar fuel—or electrofuel, as the chemicals are sometimes called—the technology has to be improved so the fuel can be manufactured on a massive scale, very inexpensively. To power the U.S., Lewis estimates the country would need to manufacture thin, flexible solar-fuel films, instead of discrete chip-like devices, that roll off high-speed production lines the way newsprint does. The films would have to be as cheap as wall-to-wall carpeting and eventually cover an area the size of South Carolina.

Far from being a wild dream, direct solar-fuel technology has been advancing in fits and starts ever since President Jimmy Carter's push for alternative energy sources during the 1970s oil shocks. Now, with a new energy and climate crunch looming, solar fuel is suddenly gaining attention.

In photosynthesis, green leaves use the energy in sunlight to rearrange the chemical bonds of water and carbon dioxide, producing and storing fuel in the form of sugars. "We want to make something as close to a leaf as possible," Lewis says, meaning devices that work as simply, albeit producing a different chemical output. The artificial leaf Lewis is designing requires two principal elements: a collector that converts solar energy (photons) into electrical energy (electrons) and an electrolyzer that uses the electron energy to split water into oxygen and hydrogen. A catalyst—a chemical or metal—is added to help achieve the splitting. Existing photovoltaic cells already create electricity from sunlight, and electrolyzers are used in various commercial processes, so the trick is marrying the two into cheap, efficient solar films.

Bulky prototypes have been developed just to demonstrate how the marriage would work. Engineers at a Japanese automaker, for example, have built a box that stands taller than a refrigerator and is covered with photovoltaic cells. An electrolyzer, inside, uses the solar electricity to break water molecules. The box releases the resulting oxygen to the ambient air and compresses and stores the remaining hydrogen, which the automaker would like to use to recharge fuel-cell cars.

In principle, the scheme could solve global warming: only sunlight and water are needed to create energy, the by-product is oxygen, and the exhaust from burning the hydrogen later in a fuel cell is water. The problem is that commercial solar cells contain expensive silicon crystals. And electrolyzers are packed with platinum, to date the best material for catalyzing the water-splitting reaction, but it costs $1,500 an ounce.

Lewis calculates that to meet global energy demand, future solar-fuel devices would have to cost less than $1 per square foot of sun-collecting surface and be able to convert 10 percent of that light energy into chemical fuel. Fundamentally new, massively scalable technology such as films or carpets made from inexpensive materials are needed.

31. The main function of the seventh and eighth paragraphs (lines 65–82) is to:

- **A.** suggest that solar technology has advanced but still faces problems that prevent it from being a viable power source on a large scale.
- **B.** introduce the information that under specific laboratory conditions electrolyzers can be used to release energy from water molecules.
- **C.** establish that the United States and Japan are collaborating on research on new energy sources.
- **D.** question whether the auto industry will be a leader in the race to develop new sources of energy.

32. Based on the passage, whose opinion is it that there is a need for "more than 10 trillion watts of clean, carbon-free energy by 2050" (lines 4–6)?

F. Researchers in South Carolina who are developing a form of artificial algae
G. An unidentified chemist whom Lewis challenges in his lectures
H. Lewis as expressed in lectures he gives on the subject of world energy needs
J. The author before attending a lecture by Lewis that changed the author's mind

33. Based on the passage, what is the relationship between the "radical breakthrough" referred to in line 12 and the capabilities described in lines 14–17?

A. Both were made possible as a result of Lewis's work in his lab.
B. Both serve as examples for Lewis of the energy industry's misguided focus on consumption.
C. The breakthrough will make the capabilities possible.
D. The breakthrough has been made based on the capabilities.

34. According to the passage, one challenge facing Lewis in developing his energy solution is the:

F. high price of the silicon crystals and platinum that are integral to the process.
G. lack of technology to split water into hydrogen and oxygen.
H. diminishing availability of federal funding for his research.
J. public's reluctance to embrace new technology.

35. According to Lewis, compared to the amount of energy the sun pours onto the earth in one hour, what amount of energy does humankind use in one year?

A. A smaller amount
B. The same amount
C. Twice the amount
D. Ten times the amount

36. According to the passage, what size are the prototype leaves being developed in Lewis's lab?

F. About the size of a human hand
G. About the size of a maple leaf
H. Not much larger than a carpet square
J. Not much larger than a computer chip

37. As it is used in line 25, the phrase *pump out* most nearly means:

A. remove.
B. drain.
C. produce.
D. siphon.

38. According to the passage, what physical form does Lewis imagine his artificial leaves will ideally take?

F. Chiplike devices
G. Thin, flexible films
H. Rigid miniature solar panels
J. Refrigerated photovoltaic cells

39. The passage states that the two principal elements of Lewis's artificial leaf technology are:

A. a fuel cell and ambient air.
B. solar electricity and a catalyst.
C. platinum and silicon.
D. a collector and an electrolyzer.

40. According to the passage, what is one outcome of the process of burning hydrogen in a fuel cell?

F. The electron energy splits silicon crystals.
G. The hydrogen bonds with oxygen.
H. The fuel cell's lining deteriorates.
J. The exhaust produced is water.

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 *molar volume* of a gas is the volume occupied by 1 mole (mol; 6×10^{23} atoms or molecules) of that gas at a given pressure and temperature.

Table 1 shows how the molar volume, in L, of each of 6 gases—helium (He), neon (Ne), argon (Ar), hydrogen (H_2), nitrogen (N_2), and oxygen (O_2)—varies with pressure, in atmospheres (atm), at a temperature of 273 kelvins (K).

Table 1

Pressure (atm)	Molar volume (L) at 273 K of:					
	He	Ne	Ar	H_2	N_2	O_2
0.500	44.825	44.810	44.774	44.818	44.781	44.773
1.00	22.424	22.409	22.374	22.417	22.380	22.372
5.00	4.503	4.488	4.453	4.496	4.459	4.451
10.0	2.262	2.248	2.213	2.256	2.219	2.211
50.0	0.471	0.456	0.421	0.465	0.430	0.420
100.0	0.247	0.233	0.200	0.242	0.210	0.198

Table 2 shows how the molar volume of each of the 6 gases varies with temperature at a pressure of 1.00 atm.

Table 2

Temperature (K)	Molar volume (L) at 1.00 atm of:					
	He	Ne	Ar	H_2	N_2	O_2
223	18.321	18.304	18.257	18.312	18.263	18.256
323	26.504	26.513	26.486	26.521	26.492	26.485
373	30.670	30.617	30.595	30.625	30.601	30.594
573	47.041	47.031	47.022	47.040	47.028	47.021
773	63.453	63.443	63.440	63.452	63.446	63.440

1. Based on Table 1, for H_2 at 273 K, the absolute value of the difference between the molar volume at 5.00 atm and the molar volume at 10.0 atm is approximately:

   A. 1.8 L.
   B. 2.2 L.
   C. 4.0 L.
   D. 5.0 L.

2. Consider the molar volumes of He, Ar, H_2, and N_2 listed in Table 2 at 323 K. What is the order of these gases from the gas having the smallest molar volume to the gas having the largest molar volume?

   F. Ar, He, N_2, H_2
   G. Ar, N_2, He, H_2
   H. H_2, He, N_2, Ar
   J. H_2, N_2, He, Ar

3. Based on Tables 1 and 2, at any given temperature and pressure, the molar volume of which other gas is most similar to the molar volume of O_2 ?

   A. He
   B. Ar
   C. H_2
   D. N_2

4. An *ideal gas* has a molar volume of 63.429 L at 1.00 atm and 773 K. At 1.00 atm and 773 K, how many of the gases listed in Table 2 have a *smaller* molar volume than that of an ideal gas?

   F. 0
   G. 2
   H. 4
   J. 6

5. In a gas sample, collisions between gas particles are common. The average time a gas particle spends between one collision and the next is called the *mean free time*. In general, mean free time decreases as a sample's volume decreases. Based on Table 1, the mean free time would be *least* for a 1 mol sample of which gas at which pressure?

   A. He at 0.500 atm
   B. O_2 at 0.500 atm
   C. He at 100.0 atm
   D. O_2 at 100.0 atm

6. Consider 2 separate 1 mol samples of O_2, each at a pressure of 1 atm. One sample has a volume of about 18 L, and the other has a volume of about 63 L. Based on Table 2, the average kinetic energy of the O_2 molecules is more likely greater in which sample?

   F. The 18 L sample, because it's at the lower temperature.
   G. The 18 L sample, because it's at the higher temperature.
   H. The 63 L sample, because it's at the lower temperature.
   J. The 63 L sample, because it's at the higher temperature.

Passage II

Scientists conducted 3 experiments to study the transfer of bacteria from one surface to another by 2 species of flies: *Musca domestica* and *Sarcophaga carnaria*.

Experiment 1

A group of 10 *M. domestica* was tested using this procedure:

1. Each fly was placed in a separate enclosure containing *Escherichia coli* (a type of bacteria) and allowed to walk on the *E. coli* for 5 min.
2. Each fly was then immediately placed in a separate petri dish containing sterile nutrient agar. Five minutes later, the flies were removed from the dishes.
3. The dishes were incubated at 37°C for 24 hr so that each *E. coli* cell on the dish divided to form a separate colony, and then the number of *E. coli* colonies on each dish was counted.
4. The average number of colonies per dish was calculated.

This procedure was also used to test a group of 10 *S. carnaria*. The results are shown in Figure 1.

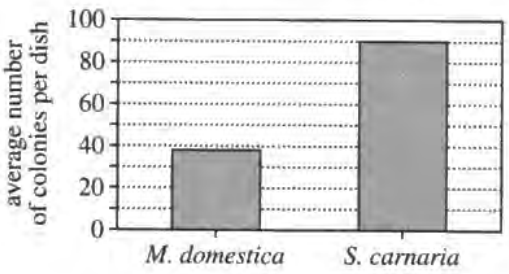


Figure 1

Experiment 2

The procedure from Experiment 1 was repeated with each of 3 groups of 10 *S. carnaria* except that the flies in each group were allowed to walk on the *E. coli* for a different period of time—5 min, 30 min, or 60 min—before each fly was placed in a separate petri dish containing nutrient agar. The results are shown in Figure 2.

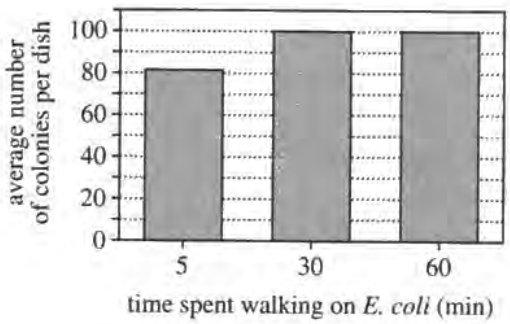


Figure 2

Experiment 3

The procedure from Experiment 1 was repeated with each of 3 groups of 10 *S. carnaria* except that, after Step 1, the flies in each group were allowed a different period of time—0 min, 30 min, or 60 min—to clean themselves before each fly was placed in a separate petri dish containing sterile nutrient agar. The results are shown in Figure 3.

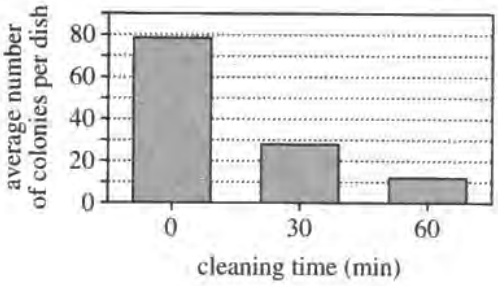


Figure 3

Figures adapted from Julie J. Shaffer, Kasey Jo Warner, and W. Wyatt Hoback, "Filthy Flies? Experiments to Test Flies as Vectors of Bacterial Disease." ©2007 by National Association of Biology Teachers.

7. As the amount of cleaning time increased, the average number of colonies per dish:
   - **A.** increased only.
   - **B.** decreased only.
   - **C.** increased and then decreased.
   - **D.** decreased and then increased.

8. What was the total number of flies tested in Experiment 3 ?
   - **F.** 5
   - **G.** 10
   - **H.** 24
   - **J.** 30

9. A scientist claimed that some species of flies spread bacterial diseases. Are the results of Experiment 1 consistent with this claim?
   - **A.** Yes; based on Figure 1, the flies transferred bacteria from one surface to another.
   - **B.** Yes; based on Figure 1, *M. domestica* transferred bacteria to *S. carnaria*.
   - **C.** No; based on Figure 1, the flies did not transfer bacteria from one surface to another.
   - **D.** No; based on Figure 1, *M. domestica* did not transfer bacteria to *S. carnaria*.

10. In the experiments, why was it necessary for the nutrient agar in the petri dishes to be sterile until the flies were placed in the dishes?

- **F.** To ensure that any colonies that formed came from bacteria present in the nutrient agar before the flies were placed in the dishes
- **G.** To ensure that any colonies that formed came from bacteria transferred to the nutrient agar by the flies
- **H.** To ensure that the nutrient agar contained all the nutrients necessary for the flies to reproduce
- **J.** To ensure that the nutrient agar contained all the nutrients necessary for the bacteria to reproduce

11. A student claimed that Species X flies would transfer more *E. coli* cells to a petri dish containing nutrient agar than would either *M. domestica* or *S. carnaria*. Which of the following experiments would best test the student's claim?

- **A.** Repeat Experiment 1 except include a group of 10 Species X flies.
- **B.** Repeat Experiment 1 except with a different species of bacteria.
- **C.** Repeat Experiment 2 except include a group of 10 Species X flies.
- **D.** Repeat Experiment 2 except with a different species of bacteria.

12. Which of the following statements gives the most likely hypothesis for Experiment 3 ?

- **F.** *S. carnaria* remove bacteria when they clean themselves.
- **G.** The longer *S. carnaria* are exposed to bacteria, the more bacteria they transfer between surfaces.
- **H.** *M. domestica* transfer more bacteria between surfaces than do *S. carnaria*.
- **J.** *M. domestica* are better at removing bacteria during cleaning than are *S. carnaria*.

13. Which of the following is the most likely reason that the average number of colonies per dish for *S. carnaria* shown in Figure 1 was different from the average number of colonies per dish for the flies that spent 5 min walking on the *E. coli* in Experiment 2 ?

- **A.** By chance, the *M. domestica* in Experiment 2 transferred, on average, fewer *E. coli* than did the *S. carnaria* in Experiment 1.
- **B.** By chance, the *S. carnaria* in Experiment 2 transferred, on average, fewer *E. coli* than did the *S. carnaria* in Experiment 1.
- **C.** The *M. domestica* in Experiment 2 walked on the *E. coli* for a shorter period of time than did the *S. carnaria* in Experiment 1.
- **D.** The *S. carnaria* in Experiment 2 walked on the *E. coli* for a shorter period of time than did the *S. carnaria* in Experiment 1.

Passage III

Forest fires require oxygen (O_2) to burn. Figure 1 shows the number of *paleowildfires* (large forest fires known from the rock record) for each 10-million-year interval of the *Mesozoic era* (250–65 million years ago, mya). Figure 1 also shows a model of the percent O_2 by volume ($\%O_2$) in Earth's atmosphere from 250 mya to 70 mya.

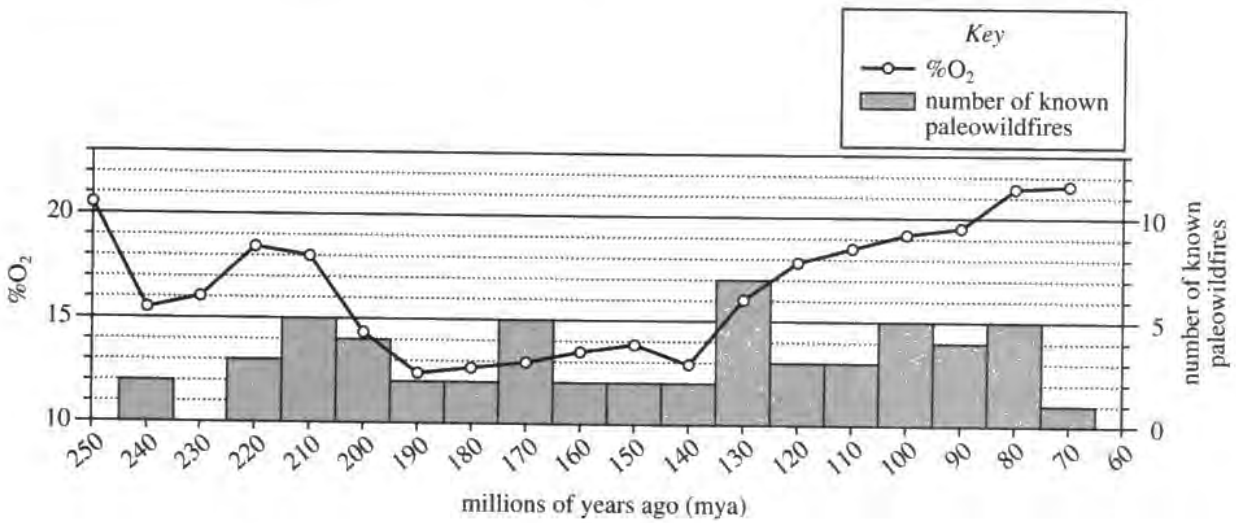
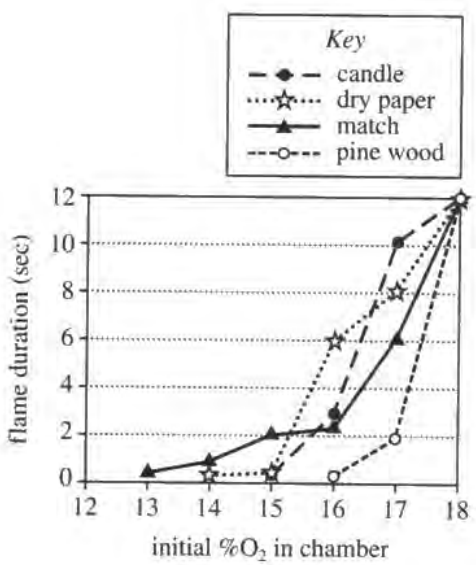


Figure 1

To study how $\%O_2$ affects burning, scientists attempted to ignite 7 samples of each of 4 different materials, 1 sample at a time, in a chamber. For each set of samples of the same material, the initial $\%O_2$ in the chamber ranged from 12% to 18%. Figure 2 shows, for each sample that ignited, the duration of the sample's flame.



Note: At an initial $\%O_2$ of 18, all samples burned to ash in 12 seconds.

Figure 2

Figures adapted from C. M. Belcher and J. C. McElwain, "Limits for Combustion in Low O_2 Redefine Paleoatmospheric Predictions for the Mesozoic." ©2008 by American Association for the Advancement of Science.

14. The $\%O_2$ in Earth's atmosphere today is about 21. According to Figure 1, at which of the following times during the Mesozoic era was the $\%O_2$ in Earth's atmosphere closest to the $\%O_2$ in Earth's atmosphere today?

F. 250 mya
G. 200 mya
H. 150 mya
J. 100 mya

15. According to Figure 2, at an initial $\%O_2$ of 17, approximately how many seconds greater was the flame duration for dry paper than the flame duration for pine wood?

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

16. A scientist claimed that paleowildfires could only have occurred when the $\%O_2$ was higher than 15. For which of the following time intervals during the Mesozoic era are the data in Figure 1 *inconsistent* with this claim?

F. 250–230 mya
G. 180–160 mya
H. 120–100 mya
J. 90–70 mya

17. According to Figure 2, what is the order of the 4 materials tested, from the material that required the highest initial $\%O_2$ to ignite to the material that required the lowest initial $\%O_2$ to ignite?

A. Match, pine wood, dry paper, candle
B. Match, dry paper, pine wood, candle
C. Pine wood, candle, dry paper, match
D. Pine wood, dry paper, candle, match

18. According to Figure 1, how many paleowildfires are known from the rock record between 95 mya and 85 mya ?

F. 4
G. 9
H. 14
J. 19

19. According to Figure 2, at an initial $\%O_2$ of 16, which of the 4 materials sustained a flame the longest?

A. Candle
B. Dry paper
C. Match
D. Pine wood

Passage IV

Four students observed that in a population of land plants, Population A, a plant could have a green stem or a purple stem. Each student proposed an explanation for this observation.

Student 1

All plants in Population A produce the green pigment chlorophyll. If a plant receives 8 hr or more of sunlight each day, it also produces a purple pigment, causing its stem to be purple. If a plant receives less than 8 hr of sunlight each day, it does not produce this purple pigment, so its stem is green. All plants in Population A are genetically identical, so they all have the ability to produce both pigments.

Student 2

All plants in Population A produce the green pigment chlorophyll. If a plant receives too little *phosphorus* (a nutrient), it also produces a purple pigment, causing its stem to be purple. If a plant receives enough phosphorus, it does not produce this purple pigment, so its stem is green. All plants in Population A are genetically identical, so they all have the ability to produce both pigments. The amount of sunlight received by a plant does not affect stem color.

Student 3

All plants in Population A produce the green pigment chlorophyll. The production of purple pigment is determined by Gene Q, which has 2 alleles (Q and q) and 3 possible genotypes (QQ, Qq, and qq). A plant with either the Gene Q genotype QQ or the Gene Q genotype Qq produces the purple pigment, causing its stem to be purple. A plant with the Gene Q genotype qq does not produce this purple pigment, so its stem is green. The amount of sunlight or nutrients received by a plant does not affect stem color.

Student 4

All plants in Population A produce the green pigment chlorophyll. The production of purple pigment is determined by Gene Q, which has 2 alleles (Q and q) and 3 possible genotypes (QQ, Qq, and qq). A plant with the Gene Q genotype qq produces the purple pigment, causing its stem to be purple. A plant with either the Gene Q genotype QQ or the Gene Q genotype Qq does not produce this purple pigment, so its stem is green. The amount of sunlight or nutrients received by a plant does not affect stem color.

20. Which student would be the most likely to agree that the soil in which a Population A plant is grown will influence its stem color?

F. Student 1
G. Student 2
H. Student 3
J. Student 4

21. Suppose it were found that the presence of the purple pigment in some plant tissues protects those tissues from being damaged by sunlight. Would this finding better support the explanation of Student 1 or the explanation of Student 2 ?

A. Student 1, because Student 1 indicated that the plants receiving the most sunlight will have purple stems.
B. Student 1, because Student 1 indicated that the plants receiving the most sunlight will have green stems.
C. Student 2, because Student 2 indicated that the plants receiving the most sunlight will have purple stems.
D. Student 2, because Student 2 indicated that the plants receiving the most sunlight will have green stems.

22. All 4 of the students' explanations are consistent with which of the following statements? In Population A:

F. both green-stemmed plants and purple-stemmed plants produce a pigment that can be used for photosynthesis.
G. only green-stemmed plants produce a pigment that can be used for photosynthesis.
H. only purple-stemmed plants produce a pigment that can be used for photosynthesis.
J. neither green-stemmed plants nor purple-stemmed plants produce a pigment that can be used for photosynthesis.

23. Which of the students, if any, would be likely to agree that providing a purple-stemmed plant from Population A with additional sunlight will cause its stem to become green?

A. Student 1 only
B. Students 1 and 3 only
C. Students 3 and 4 only
D. None of the students

24. Suppose 2 of the purple-stemmed plants in the population were crossed and 52 purple-stemmed and 15 green-stemmed offspring were produced. If all the parents and offspring in the cross were grown under the same conditions, these results would best support the explanation of which student?

F. Student 1
G. Student 2
H. Student 3
J. Student 4

25. Based on Student 4's explanation, if a purple-stemmed plant and a green-stemmed plant from Population A are crossed and they produce both purple-stemmed offspring and green-stemmed offspring, the Gene Q genotype of the parent with the:

A. purple stem must be QQ.
B. purple stem must be Qq.
C. green stem must be QQ.
D. green stem must be Qq.

26. Which of the students would be likely to agree that a plant receiving 9 hr of sunlight each day could have either a purple stem or a green stem?

F. Student 1 only
G. Student 2 only
H. Students 3 and 4 only
J. Students 2, 3, and 4 only

Passage V

Liquid H_2O can be broken down into hydrogen gas (H_2) and oxygen gas (O_2) by *electrolysis* according to the following chemical equation:

$$2H_2O \rightarrow 2H_2 + O_2$$

A scientist performed an experiment to study the electrolysis of H_2O using electricity generated from sunlight.

Experiment

Steps 1–5 were performed daily for 12 months:

1. A tank fitted with 2 electrodes—an *anode* (where O_2 would be produced) and a *cathode* (where H_2 would be produced)—was assembled. Each electrode was suspended in an inverted plastic tube, and each tube was marked to allow gas volume to be measured.

2. Four liters (4.0 L) of a 25% by mass aqueous solution of sodium hydroxide (NaOH) was added to the tank. As a result, the tubes were completely filled with the solution.

3. At 8:00 a.m., a rectangular solar cell was attached to the electrodes and placed next to a particular south-facing window for 8 hr. (Figure 1 shows the apparatus at the initiation of electrolysis.)

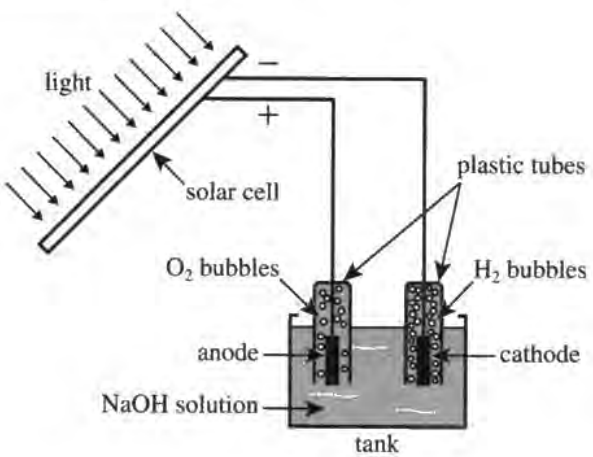


Figure 1

4. Eight hours later, the solar cell was detached from the electrodes, and the amount of H_2 that had been produced was measured.

5. The tank, tubes, and electrodes were cleaned and dried for reuse.

Figure 2 shows the total volume of H_2 produced (in L) in each month of the experiment. Table 1 shows the average *solar irradiance* (power per unit area), in watts per square meter (W/m^2), at the location of the solar cell during each month of the experiment.

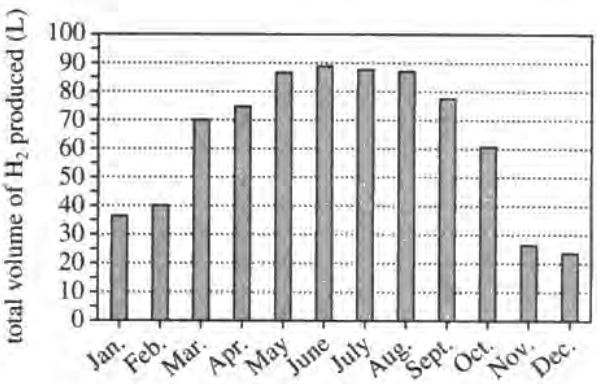


Figure 2

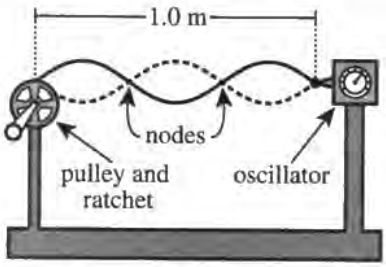
Table 1

Month	Average solar irradiance (W/m^2)
January	77.8
February	106.4
March	153.8
April	170.7
May	197.5
June	213.1
July	206.4
August	198.7
September	183.1
October	137.1
November	59.9
December	52.3

Figures and table adapted from Sergii Bespalko, "Hydrogen Production by Water Electrochemical Photolysis Using PV-Module." ©2011 by Sergii Bespalko.

Passage VI

A *standing wave* on a taut string is a wave that appears to vibrate without traveling along the string. Such waves are called the string's *harmonics*. Each harmonic has a characteristic number of *nodes*: locations between the ends of the string that do not move (the ends of the string do not count as nodes). Figure 1 illustrates a harmonic and also the apparatus that a student used to perform 2 experiments on standing waves.



Note: Figure not drawn to scale.

Figure 1

A string having a mass per unit length of μ was attached on one end to an *oscillator* (a motor that vibrates) and on the other end to a pulley and ratchet. The student could select the frequency, f (the number of cycles per second), of the oscillator's vibration. By cranking the ratchet, the student could vary the force of tension, T, in the string.

Experiment 1

With 0.10 newtons (N) of tension in String X ($\mu = 0.02$ g/cm), the student varied f. She noted that standing waves occurred only at certain values of f. The student sketched the first 5 harmonics and recorded f (in hertz, Hz) for each. She repeated this procedure for String Y ($\mu = 0.08$ g/cm) and for String Z ($\mu = 0.16$ g/cm). See Table 1.

Table 1

Harmonic	Sketch	f (Hz) for String: X	Y	Z
1st		11.2	5.59	3.95
2nd		22.4	11.2	7.91
3rd		33.5	16.8	11.9
4th		44.7	22.4	15.8
5th		55.9	28.0	19.8

Experiment 2

Beginning again with String X, the student set the oscillator to vibrate at $f = 25.0$ Hz. She then varied T, and noted that standing waves occurred only at certain values of T. The student recorded T for the first 5 harmonics. She repeated this procedure for Strings Y and Z. See Table 2.

Table 2

Harmonic	T (N) in String: X	Y	Z
1st	0.50	2.00	4.00
2nd	0.13	0.50	1.00
3rd	0.06	0.22	0.44
4th	0.03	0.13	0.25
5th	0.02	0.08	0.16

27. Based on Figure 2 and Table 1, during the month in which a total of 70 L of H_2 was produced, the average solar irradiance was:

A. 77.8 W/m^2.
B. 153.8 W/m^2.
C. 197.5 W/m^2.
D. 206.4 W/m^2.

28. Based on the description of the experiment, at 4:00 p.m. on each day, did the scientist measure the amount of gas produced at the anode or the cathode?

F. The anode, because the anode is where H_2 was produced.
G. The anode, because the anode is where O_2 was produced.
H. The cathode, because the cathode is where H_2 was produced.
J. The cathode, because the cathode is where O_2 was produced.

29. Consider the percent by mass of NaOH in the solution added to the tank in Step 2. Approximately what mass of NaOH was in 200 g of this solution?

A. 25 g
B. 50 g
C. 200 g
D. 225 g

30. Based on the chemical equation and Figure 2, approximately how many liters of O_2 (NOT H_2) were produced in February?

F. 20 L
G. 40 L
H. 80 L
J. 100 L

31. Based on the description of the experiment, in the month of June how many total liters of NaOH solution were added to the tank?

A. 4.0 L, because Step 2 was performed once in June, on June 1.
B. 8.0 L, because Step 2 was performed twice in June, once on June 1 and once on June 30.
C. 120 L, because Step 2 was performed 30 times in June, once each day.
D. 240 L, because Step 2 was performed 60 times in June, twice each day.

32. Based on Table 1, on May 11, was the solar irradiance of the solar cell less than, equal to, or greater than 197.5 W/m^2 ?

F. Less
G. Equal
H. Greater
J. Cannot be determined from the given information

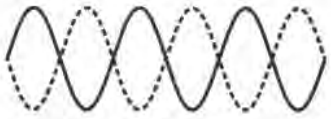
33. Suppose the experiment was repeated, except that the scientist added only pure liquid H_2O to the tank in Step 2. Based on the description of the experiment, would this change have more likely resulted in more H_2 being produced or less H_2 being produced?

A. More H_2; pure liquid H_2O has more ions and thus higher electrical conductivity than does an aqueous NaOH solution.
B. More H_2; pure liquid H_2O has fewer ions and thus lower electrical conductivity than does an aqueous NaOH solution.
C. Less H_2; pure liquid H_2O has more ions and thus higher electrical conductivity than does an aqueous NaOH solution.
D. Less H_2; pure liquid H_2O has fewer ions and thus lower electrical conductivity than does an aqueous NaOH solution.

34. Based on the sketches made in Experiment 1, the string shown in Figure 1 is vibrating in which harmonic?

F. 1st
G. 2nd
H. 3rd
J. 4th

35. In a new trial, the student made the following sketch of a standing wave on String Z.



Based on the results of Experiments 1 and 2, this standing wave occurred at which approximate values of f and T ?

A. $f = 0.10$ Hz and $T = 0.11$ N
B. $f = 0.10$ Hz and $T = 23.7$ N
C. $f = 25.0$ Hz and $T = 0.11$ N
D. $f = 25.0$ Hz and $T = 23.7$ N

36. A piece of String Y that is 1 cm in length would have the same mass as a piece of:

F. String X that is 1 cm in length.
G. String X that is 4 cm in length.
H. String Z that is 1 cm in length.
J. String Z that is 4 cm in length.

37. The student reported the data in Table 1 with how many *significant digits* ?

A. Some data were reported with 1 significant digit, and some were reported with 2 significant digits.
B. Some data were reported with 2 significant digits, and some were reported with 3 significant digits.
C. All data were reported with 2 significant digits.
D. All data were reported with 3 significant digits.

38. For a string at constant tension, let f_n represent the frequency of the nth harmonic (f_1 is the frequency of the 1st harmonic, f_2 is the frequency of the 2nd harmonic, f_3 is the frequency of the 3rd harmonic, and so on). Which of the following equations for f_n is consistent with the results of Experiment 1 for String X ?

F. $f_n = n + f_1$
G. $f_n = n - f_1$
H. $f_n = n \times f_1$
J. $f_n = n + f_1$

39. Suppose that a string having a mass per unit length of 0.32 g/cm had been tested in Experiment 2. The 4th harmonic of this string would most likely have occurred at a tension:

A. less than 0.03 N.
B. between 0.03 N and 0.13 N.
C. between 0.13 N and 0.25 N.
D. greater than 0.25 N.

40. Based on the results of Experiments 1 and 2, for a given harmonic, as μ increased, did f increase or decrease, and did T increase or decrease?

	f	T
F.	increased	increased
G.	increased	decreased
H.	decreased	increased
J.	decreased	decreased

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.