

# Form Z15

(April 2019)



The **ACT**<sup>®</sup>

2019

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

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

## The Cable Car Lady's San Francisco Feat

San Francisco is famous for its cable cars. In operation since 1873, passengers travel through town on cable cars, moving and gripping a cable that is constantly<sup>1</sup> in motion just below the street. Their old-fashioned look

and open-air seating have made them a tourist favorite. 2

They likely would have ceased operating, however, if it<sup>3</sup> hadn't been for Friedel Klusmann.

1. A. NO CHANGE  
B. a person can travel through town on cable cars, which move by  
C. passengers travel through town on cable cars, which move by  
D. cable cars transport passengers through town, moving by
2. If the writer were to delete the preceding sentence, the paragraph would primarily lose:  
E. an indication of how long cable cars have been in use.  
G. details that show the appeal of cable cars.  
H. information about how cable cars move.  
J. a brief overview of the cable car system.
3. A. NO CHANGE  
B. operating; however, if  
C. operating. However, if  
D. operating, however. If

In January 1947, San Francisco mayor Roger Lapham proposed a plan to rid the city of cable cars. The cars, he argued, posed a safety threat because the cables were old and might snap, resulting in a runaway car. [A] They were also a financial burden on the city. [B] He proposed replacing the cable cars with buses that would operate reliably, on the steep streets of San Francisco, and be profitable. [C] Klussmann, the president of the

San Francisco Federation of the Arts, and she was a fan of cable cars, was unconvinced. In March 1947, Klussmann called a meeting of the leaders of twenty-seven women's civic groups, forming the Citizens Committee to Save the Cable Cars. [D] Led by Klussmann, a fan of cable cars, the group rebutted the mayor's arguments in a press release. Cable cars were safe, they argued; in fact, cable cars caused fewer accidents than did buses. Additionally, cable

cars made money for the city by commending

tourism. 9

4. F. NO CHANGE  
G. buses that would operate reliably on the steep streets of San Francisco  
H. buses, that would operate reliably, on the steep streets of San Francisco,  
J. buses, that would operate reliably on the steep streets of San Francisco
5. A. NO CHANGE  
B. Arts; Klussmann was  
C. Arts, she was  
D. Arts and
6. F. NO CHANGE  
G. Klussmann, who was unconvinced by the mayor's plan,  
H. Klussmann, the group's leader,  
J. Klussmann,
7. A. NO CHANGE  
B. fewer accidents than  
C. a few accidents than  
D. less accidents then
8. F. NO CHANGE  
G. encouraging  
H. sanctioning  
J. reassuring
9. The writer wants to divide this paragraph into two in order to separate Lapham's arguments from Klussmann's response to them. The best place to begin the new paragraph would be at:  
A. Point A.  
B. Point B.  
C. Point C.  
D. Point D.

1 [1] With the signatures over 50,000 supporters, the committee's amendment was granted a spot on the ballot that November. [2] Still, the mayor wanted to scrap the cable cars. [3] Klusmann realized that the best way to protect the cable cars would be to pass an amendment to the city charter and the city would be required to retain them. [12]

Two days before the election, Klusmann put signs from a previously eliminated cable car route on a cable car, which she (Klusmann) then paraded through town to remind San Franciscans of what was at stake. On election day, her efforts paid off. Many voters supported the amendment to save the cable cars. "The Cable Car Lady" (as Klusmann came to be known), had won.

10. F. NO CHANGE  
G. around  
H. of  
J. as

11. A. NO CHANGE  
B. charter and the amendment would require the city  
C. charter that would require the city  
D. charter, it would require the city

12. Which sequence of sentences makes this paragraph most logical?

- F. NO CHANGE  
G. 2, 3, 1  
H. 2, 1, 3  
J. 1, 3, 2

13. A. NO CHANGE  
B. then paraded through the town of San Francisco  
C. then paraded through the town after that  
D. then paraded through town

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

Seventy-seven percent of

Given that the information is accurate, should the writer make this revision?

- F. Yes, because it specifically shows how much support the amendment received.  
G. Yes, because it emphasizes that Klusmann's campaign had to overcome a lot of opposition.  
H. No, because the sentence indicates the outcome of the election without this revision.  
J. No, because it underscores the fact that Klusmann's campaign wasn't entirely successful.

15. A. NO CHANGE  
B. Lady," (as Klusmann came to be known),  
C. Lady," as Klusmann came to be known,  
D. Lady," as Klusmann came to be known

## PASSAGE II

### Ringin' in Harmony

Barbershop music—four voices singing in perfect harmony, without instrumental, accompaniment—can be traced back to late nineteenth-century African American barbershops. While waiting for a haircut, a patron might

16. F. NO CHANGE  
G. harmony without instrumental accompaniment—  
H. harmony—without instrumental accompaniment,  
J. harmony, without instrumental accompaniment



have improvised a melody. Two or three other customers would then harmonize higher or lower than the melody to<sup>17</sup> create a song. [A] This pastime eventually became a widely known genre of music that's traditionally characterized by four men singing in red-and-white-striped suits and straw hats. [B] The songs usually have simple melodies and honeyed titles like "Let Me Call You Sweetheart"<sup>18</sup> and "Sweet Adeline."<sup>18</sup> [C] Barbershop music has many distinctive qualities; however, enthusiasts say the

music's true thrill,<sup>19</sup> all in the acoustical effect called the ringing chord,<sup>20</sup> or overtone. [D] Produced when all four voices perfectly combine to create the impression (hence the term "overtone")<sup>20</sup> of a fifth note rising above the rest, the ringing chord is an acoustic phenomenon. Highly coveted, the ringing chord elicits what barbershoppers describe as emotional responses that are hair raising, skin prickling, and a tingling of the spine.<sup>21</sup> 22

17. A. NO CHANGE  
B. higher or lowest than  
C. higher or lower then  
D. high or low then
18. The writer is considering deleting the underlined portion (adjusting the punctuation as needed). Should the underlined portion be kept or deleted?  
F. Kept, because it provides examples of song titles that help illustrate the style of the genre.  
G. Kept, because the song titles help explain why barbershop music is traditionally unaccompanied.  
H. Deleted, because it offers information that is redundant and not necessary for comprehension.  
J. Deleted, because it detracts from the discussion of the historical origins of barbershop quartets.
19. A. NO CHANGE  
B. thrill, which is  
C. thrill, it is  
D. thrill is
20. Which of the following placements for the underlined portion would most clearly support the definition of a ringing chord?  
F. Where it is now  
G. After the word *combine*  
H. After the word *rest* (and before the comma)  
J. After the word *chord*
21. Which choice best maintains the descriptive pattern established in the list of emotional responses?  
A. NO CHANGE  
B. and spine tingling.  
C. and spinal tingles.  
D. etc.
22. The writer wants to divide this paragraph into two in order to separate the description of barbershop music in general from a focus on one specific characteristic of the genre. The best place to begin a new paragraph would be at:  
F. Point A.  
G. Point B.  
H. Point C.  
J. Point D.

Quartets can only achieve this “angel’s  
voice,” nevertheless, with proper breath support  
and precise vocal technique. Collaboration is

also crucial; each participant must listen to the

others to sing flawlessly, tuned notes. When the  
singers each hold a different pitch-perfect note at the  
correct harmonic interval, the variations in frequencies  
in their voices overlaps. These audible frequencies

above and below the four voices create the illusion  
of a fifth voice.

Few modern instruments can create this effect because  
of slight tuning imperfections. Keyboards, for example, are  
tuned such that a piece of music sounds equally good in  
any key, though this prevents frequencies from interacting  
and overlapping (necessary to “ring a chord”). Beyond  
honoring tradition, then: barbershoppers would be

wary of adding instruments that might compromise  
the beloved ringing chord.

23. A. NO CHANGE  
B. voice,” regardless,  
C. voice,” besides,  
D. voice”
24. F. NO CHANGE  
G. crucial. As  
H. crucial,  
J. crucial
25. A. NO CHANGE  
B. sing flawlessly tuned  
C. sing: flawlessly tuned  
D. sing, flawlessly tuned,
26. F. NO CHANGE  
G. has overlaps.  
H. overlapping.  
J. overlap.
27. A. NO CHANGE  
B. delusion  
C. allusion  
D. elusion
28. F. NO CHANGE  
G. tradition—then  
H. tradition, then,  
J. tradition; then
29. A. NO CHANGE  
B. petrified about  
C. suspecting of  
D. frugal with

Question 30 asks about the preceding passage as a whole.

30. Suppose the writer's main purpose had been to describe the various stages in the development of a genre of music. Would this essay accomplish that purpose?
- F. Yes, because the writer discusses the origins of barbershop music along with present-day reactions to the genre.
  - G. Yes, because the writer describes how a defining characteristic of barbershop music has evolved over time.
  - H. No, because while the writer mentions the origins of barbershop music, the main focus is on a characteristic of the genre.
  - J. No, because the writer focuses on the emotional rather than historical features of barbershop music.

### PASSAGE III

#### Master Paper Portrait Cutter

In crowded New York City subway stations, violinists rarely turn heads, dance troupes spin by unnoticed, and singers often serenade only themselves. But subway artist, Ming Liang Lu, who in 2012 is creating his delicate work at the foot of a Union Square staircase, attracts attention. He's a self-described "master paper portrait cutter," transforming the centuries-old traditional Chinese art of paper cutting <sup>31</sup> by focusing on an

untraditional subject, it's the human face.

31. A. NO CHANGE  
B. artist Ming Liang Lu,  
C. artist, Ming Liang Lu  
D. artist Ming Liang Lu
32. Given that all the following parenthetical phrases are accurate, which one, if added here, would provide the most relevant information at this point in the essay?
- F. (though he also teaches calligraphy at the New York Chinese Cultural Center on the weekends)
  - G. (he claims that the noise of the subway doesn't bother him)
  - H. (which usually depicts animals and flowers)
  - J. (an art that requires few tools)
33. A. NO CHANGE  
B. subject:  
C. subject;  
D. subject

[1] Lu flags down a passerby who has an intriguing face offering to create a tiny silhouette portrait, needing just a small piece of black paper, razor-sharp scissors, and

a few minutes. [2] The model often buys the portrait with

a small fee. [3] Many commuters, so taken by the art, and have missed morning trains to have their own likenesses

cut. [4] If not, Lu pins it to a white foam board, which has become an eye-catching gallery of dozens of distinct faces

whose outlines pop out crisply in black. [38]

Lu begins a portrait by folding a four-by-six-inch rectangle of paper in half and asking them to stand still

facing him. He first cuts into the folded edge, carving paper away to shape the model's main facial features, including eyes, nose, and lips. Lu doesn't move the scissors as he works. Instead, he maneuvers the paper along the slightly open scissor blades. [A] He then unfolds his creation, working with scissors to cut out eyebrows, wrinkles, and other details. [B] To finish, he shapes the outer contours of the face, such as the hair and jawline, letting the paper's border fall to the floor.

[C] Lu often exaggerates a model's facial features for whimsical effect, but it's not as if his intentions are cruel.

34. F. NO CHANGE  
G. having offered  
H. that offers  
J. and offers

35. A. NO CHANGE  
B. using  
C. given  
D. for

36. F. NO CHANGE  
G. art, and they  
H. art that they  
J. art,

37. A. NO CHANGE  
B. board, placing it among the many faces on the board that  
C. board, attaching it to this display that  
D. board—a gallery of his work—which

38. For the sake of logic and cohesion, Sentence 4 should be placed:

- F. where it is now.  
G. before Sentence 1.  
H. after Sentence 1.  
J. after Sentence 2.

39. A. NO CHANGE  
B. their model  
C. his model  
D. DELETE the underlined portion.

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

- F. edge, proceeding to carve  
G. edge and begins to carve  
H. edge, and carving  
J. edge and carves

41. The writer wants to clearly reinforce and build upon the explanation of Lu's paper-cutting technique provided in the preceding two sentences. Which choice best accomplishes that goal?

- A. NO CHANGE  
B. chopping into the paper rapidly with his scissors  
C. twisting and turning his scissors in his hand  
D. swiveling the paper around the blades

42. Given that all the choices are true, which one most effectively leads the reader into the next sentence?

- F. NO CHANGE  
G. but each portrait bears an unmistakable resemblance to the model.  
H. which is not surprising given that there is so much he is able to capture.  
J. but his models, after having seen his portrait gallery, know what to expect.



Passersby, seeing Lu's board, sometimes even

recognize people from their commute. [D] A bald

43

man in sunglasses, a woman with dreadlocks, a girl

wearing hoop earrings, a young boy smiling. One of Lu's

admirers claimed that collectively Lu's paper cuttings

44

arranged together create "a New York portrait." 45

43. A. NO CHANGE

B. recognize that a person

C. recognizes a person

D. recognizes people

44. F. NO CHANGE

G. assembled as a gallery

H. as a group

J. DELETE the underlined portion.

45. The writer wants to divide this paragraph into two in order to separate the explanation of Lu's process as he works on a paper portrait from the general discussion of highlights and notable characteristics of Lu's work. The best place to begin the new paragraph would be at:

A. Point A.

B. Point B.

C. Point C.

D. Point D.

#### PASSAGE IV

##### Quick-Change Artist

Cephalopods are smart creatures in general. But

*Thaumoctopus mimicus*—the mimic octopus discovered

46

in the estuaries of Indonesia and Malaysia in 1998,

exhibits an almost eerie level of intelligence. It appears to

be the first known animal who's repertoire of sophisticated

47

deceptive behaviors enables it to imitate multiple animals.

The mimic octopus's habitat, a largely

featureless expanse rich in worms, echinoderms,

crustaceans, and fishes, is equally rich in predators.

48

With few places to hide, the mimic, like many other

cephalopods are dependent on deception for survival.

49

46. F. NO CHANGE

G. *mimicus*,

H. *mimicus*;

J. *mimicus*

47. A. NO CHANGE

B. whom a

C. whose

D. that's

48. F. NO CHANGE

G. fishes, which is

H. fishes, and

J. fishes

49. A. NO CHANGE

B. cephalopods which depend

C. cephalopods, dependent

D. cephalopods, depends

Its lack of a skeleton allows it to change shape, while  
50

chromatophores, tiny sacs of yellow, brown, red, or black  
51  
pigment located just under the skin, allow it to change  
51  
color and pattern in less than a second. Unlike most  
cephalopods, though, this octopus imitates the behavior of  
other animals as well.

When slowly foraging along the seafloor, probing  
holes with its arms, trapping prey in its flared web. The  
52  
mimic typically avoids notice. It assumes a drab,

brown color, blending in with the silt and sand.  
53

But as speed increases, it morphs into the teardrop  
54  
shape of a flatfish, arms trailing behind. Scientists debate

whether, in the end, the octopus's final, ultimate goal is  
55  
to mimic the toxic sole or the unpalatable flounder.

Additionally, the octopus's intentions appear more  
56  
certain: when a territorial damselfish is present, for

example, the octopus imitates the fish's predator, a  
57  
venomous banded sea snake. It plunges six arms and its

body into the sand, displays a banded black-and-white  
58  
color pattern, and waves the two free arms in opposite  
directions. The gesture appears quite effective in warding  
off an attack.

50. F. NO CHANGE  
G. Its lacking of a  
H. It's lack in  
J. Its lack in

51. If the writer were to delete the underlined portion  
(adjusting the punctuation as needed), the paragraph  
would primarily lose:

- A. a definition of chromatophores and an indication  
of their location.  
B. an explanation of particular features that permit  
dramatic changes in shape.  
C. a visual description of the texture of the mimic  
octopus's skin.  
D. an indication of the rapidity with which the chro-  
matophores can change the octopus's color.

52. F. NO CHANGE  
G. web, which the  
H. web, the  
J. web the

53. A. NO CHANGE  
B. with similar brown hues of the sandy seafloor's  
C. to appear much like the color of the  
D. by displaying the brown color of

54. F. NO CHANGE  
G. as the acceleration of the octopus increases,  
H. when the rate of movement increases,  
J. as the octopus picks up speed,

55. A. NO CHANGE  
B. with much discussion as to if the octopus's intent  
C. if the octopus's intentional aim  
D. whether the octopus's aim

56. F. NO CHANGE  
G. Sometimes, the  
H. However, the  
J. The

57. A. NO CHANGE  
B. predator. A  
C. predator; a  
D. predator a

58. Which choice most clearly indicates that the octopus  
uses the black-and-white color pattern to appear  
threatening?

- F. NO CHANGE  
G. brandishes  
H. shifts to  
J. adopts



As yet, scientists have minimal video footage of the mimic octopus, and the momentary glimpses afforded by still photos <sup>59</sup>offered inconclusive evidence for claims about the extent of the octopus's capabilities. Some argue it can mimic up to fifteen species. Others remain unconvinced. Nearly all, however, are awed by its ingenuity.

59. A. NO CHANGE  
B. has offered  
C. offers  
D. offer

Question 60 asks about the preceding passage as a whole.

60. Suppose the writer's primary purpose had been to focus on a particular animal's use of deception for predatory purposes. Would this essay accomplish that purpose?
- F. Yes, because it asserts that although there is some debate about the octopus's intentions, most scientists agree that it is an ingenious predator.  
G. Yes, because it explains how the mimic octopus uses imitation while foraging.  
H. No, because it describes the mimic octopus's deception more as a general tool for survival than as a means of pursuing prey.  
J. No, because it focuses primarily on how the mimic octopus's deceptive strategies compare to those of other cephalopods.

#### PASSAGE V

##### As Light as Pavlova

In the 1920s, Anna Pavlova, Russia's premier ballerina, toured Australia and New Zealand, firing the imaginations of dancers, patrons of ballet, and chefs who found inspiration. Few doubt that the meringue <sup>61</sup>

dessert known as the *pavlova*, was created to honor the world-famous dancer. Both Australia and New Zealand, <sup>62</sup>

likewise, lay claim to being first to celebrate <sup>63</sup>

their luminous costumes and light-footed dancing with puffy clouds of meringue. <sup>64</sup>

61. A. NO CHANGE  
B. chefs were inspired by her.  
C. as were chefs.  
D. even chefs.
62. F. NO CHANGE  
G. dessert, and known as the *pavlova*,  
H. dessert, known as the *pavlova*  
J. dessert known as the *pavlova*
63. A. NO CHANGE  
B. granted nevertheless,  
C. therefore,  
D. though,
64. F. NO CHANGE  
G. those  
H. her  
J. its

In 1935, Chef Herbert Sachse of the Hotel Esplanade in Perth, Australia, commemorated Pavlova's tour with a dessert he hoped would be as ethereal and delicate as her movements onstage. He started by making a

marshmallow-like base of fluffy meringue, it's a blend of whipped egg whites and sugar. He filled the sunken center of the baked meringue with mounds of whipped cream, swirled to suggest a spinning ballerina. Because Pavlova's tutu had been speckled with green

silk roses, he covered the cream with sliced kiwifruit. To the hotel guests to whom Sachse

first served this delicacy, he went, "It is as light

as Pavlova." 70

New Zealanders, however, believe that a dessert was served, very similar to Sachse's confection also in honor of Anna Pavlova, at a hotel in Wellington, New Zealand, as early as 1926. Sachse himself said that his own meringue dessert was a fanciful adaptation of a recipe for "meringue cake" that he had found in a

65. Which word choice most clearly connotes that Sachse created his dessert for the purpose of honoring Pavlova's tour?

- A. NO CHANGE
- B. authenticated
- C. emblazoned
- D. initiated

66. E. NO CHANGE  
G. meringue, a  
H. meringue; a  
J. meringue. A

67. Which choice most clearly emphasizes that Sachse deliberately shaped his dessert to mimic the form and movement of Pavlova as a dancer?

- A. NO CHANGE
- B. twirled within the meringue base.
- C. almost reminiscent of a ballerina.
- D. made fresh for the dessert.

68. Which choice best conveys that Sachse's placement of kiwifruit on his dessert mimicked the arrangement of green silk roses on Pavlova's tutu?

- F. NO CHANGE
- G. wrapped
- H. dotted
- J. lined

69. A. NO CHANGE  
B. proclaimed,  
C. procured,  
D. told,

70. Which of the following true sentences would most effectively lead the reader from this paragraph to the next paragraph?

- F. And about Pavlova one commentator wrote, "She does not dance; she soars as though on wings."
- G. And so the dessert was invented and named, according to many Australians.
- H. But the heart of the pavlova dessert, of course, is its baked meringue shell.
- J. But before the dessert was served, the guests applauded Sachse.

71. The best placement for the underlined portion would be:

- A. where it is now.
- B. after the word *that*.
- C. after the word *dessert*.
- D. after the year 1926 (and before the period).

magazine. That recipe had been contributed by “Rewa,  
a woman from New Zealand.” 72

The many variations of the dessert have allowed  
both countries to call one of their own early recipes as  
“the original pavlova.” But there were dozens of recipes  
for pavlova in New Zealand cookbooks by 1940, the year  
a pavlova recipe *first* appeared in an Australian cookbook.  
Most culinary historians—and even the authoritative  
Oxford English Dictionary—attribute the original  
pavlova to New Zealand. Consequently, this artistic  
dessert generously adorns the national cuisine  
of both countries.

72. If the writer were to delete the preceding sentence, the essay would primarily lose information that:
- F. strongly supports New Zealand’s claim to the original pavlova recipe.
  - G. argues that “Rewa, a woman from New Zealand” created a “meringue cake” that was even more decadent than Sachse’s meringue dessert.
  - H. harshly criticizes Sachse’s decision to adapt a recipe he had found in a magazine.
  - J. provides facts about how Sachse typically found inspiration for new recipes for hotel guests.
73. A. NO CHANGE  
B. make for  
C. point to  
D. refer
74. F. NO CHANGE  
G. For the sake of clarity,  
H. In addition,  
J. Even so,
75. A. NO CHANGE  
B. of both countries, those being Australia and New Zealand.  
C. in Australia and New Zealand, those two countries.  
D. DELETE the underlined portion and end the sentence with a period.

**END OF TEST 1**

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



## MATHEMATICS TEST

60 Minutes—60 Questions

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

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

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

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

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

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

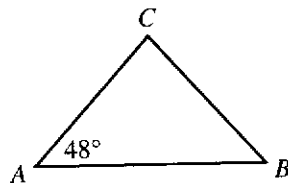
1. Given  $r = 4$ ,  $b = 2$ , and  $g = -5$ ,  $(r + b - g)(b + g) = ?$

A. -33  
B. -3  
C. 3  
D. 7  
E. 8

2. Jeralyn purchases 1 box of granola bars and 6 boxes of chocolate bars for a total price of \$22.00. The price of each box of granola bars is \$2.50, and the price of each box of chocolate bars is  $n$  dollars. Which of the following equations models Jeralyn's purchase?

F.  $2.50 + 22.00 = 6n$   
G.  $2.50n + 22.00 = 6n$   
H.  $2.50(6n) = 22.00$   
J.  $2.50 + 6n = 22.00$   
K.  $2.50n + 6n = 22.00$

3. In  $\triangle ABC$  shown below,  $\overline{AC} \cong \overline{BC}$  and the measure of  $\angle A$  is  $48^\circ$ . What is the measure of  $\angle C$ ?



A.  $48^\circ$   
B.  $84^\circ$   
C.  $90^\circ$   
D.  $96^\circ$   
E.  $132^\circ$

4. A square has a perimeter of 20 feet. What is the area, in square feet, of the square?

F. 5  
G. 10  
H. 25  
J. 40  
K. 80

DO YOUR FIGURING HERE.



5. A bag contains exactly 21 solid-colored buttons: 3 red, 6 blue, and 12 white. What is the probability of randomly selecting 1 button that is NOT white?

**DO YOUR FIGURING HERE.**

- A.  $\frac{1}{21}$   
 B.  $\frac{1}{9}$   
 C.  $\frac{3}{7}$   
 D.  $\frac{2}{3}$   
 E.  $\frac{3}{4}$
6. What is the value of  $|-7| - |7 - 29|$  ?
- F. -29  
 G. -15  
 H. 15  
 J. 29  
 K. 43
7. A store's revenue is the amount of money received for goods sold. A store's cost is the amount of money the store pays for the goods plus all the store's operating costs like rent, utilities, wages, etc. A store's net profit is the difference between revenue and cost. During 1 month, a grocery store paid \$30,000 for goods that were sold for \$39,500. With operating costs as shown below, what was the store's net profit for that month?

Operating costs	Amount
Rent, utilities, and telephone	\$2,500
Taxes and insurance	\$ 370
Interest on business loan	\$ 400
Grocer's own wages	\$4,500
Wages for part-time help	\$ 630
Miscellaneous	\$ 400

- A. \$ 700  
 B. \$ 800  
 C. \$ 900  
 D. \$1,000  
 E. \$1,100
8. When Jorge began a driving trip, his car's odometer read 42 miles. After Jorge drove for 3 hours, the odometer read 165 miles. Which of the following values is closest to Jorge's average driving speed, in miles per hour, during those 3 hours?
- F. 36  
 G. 41  
 H. 54  
 J. 55  
 K. 62



DO YOUR FIGURING HERE.

9. Melinda and Jericho are painting a room in the city recreation center. They started with 5 gallons of paint.

On the first day, Melinda used  $\frac{3}{4}$  gallon of paint and Jericho used  $2\frac{1}{2}$  gallons of paint. How many gallons of paint were left after the first day?

- A.  $1\frac{3}{4}$
- B.  $2\frac{1}{2}$
- C.  $2\frac{3}{4}$
- D.  $3\frac{1}{4}$
- E.  $4\frac{1}{4}$

10. What value of  $x$  makes the equation below true?

$$\frac{25^x}{5^2} = 5^4$$

- F. 3
- G. 6
- H. 8
- J. 25
- K. 625

11. For functions  $f(x) = 5 \cdot 2^x$  and  $g(x) = 10x$ , the value of  $f(3) - g(3)$  is:

- A. 0
- B. 10
- C. 70
- D. 970
- E. 1,030

12. Tanisha, a manager at a state park, counted the money in the cash register at the end of her shift, and then she deposited the money in the bank. When she went back to her office, she accidentally shredded the deposit slip. She remembered that there were only \$5 and \$10 bills. She also recalled that there were 27 bills totaling \$205. How many \$5 bills were in Tanisha's cash register at the end of her shift?

- F. 13
- G. 14
- H. 16
- J. 23
- K. 32





13. In the standard  $(x,y)$  coordinate plane, a line intersects the  $y$ -axis at  $(0,2)$  and contains the point  $(8,3)$ . What is the slope of the line?

DO YOUR FIGURING HERE.

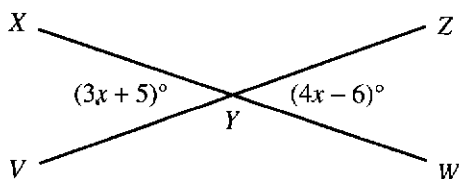
- A.  $\frac{1}{8}$   
 B.  $\frac{2}{5}$   
 C.  $\frac{1}{2}$   
 D. 2  
 E. 8
14. For an angle with measure  $\alpha$  in a right triangle,  
 $\sin \alpha = \frac{15}{17}$  and  $\tan \alpha = \frac{15}{8}$ . What is the value of  $\cos \alpha$ ?

- F.  $\frac{17}{8}$   
 G.  $\frac{8}{15}$   
 H.  $\frac{8}{17}$   
 J.  $\frac{8}{\sqrt{161}}$   
 K.  $\frac{8}{\sqrt{514}}$

15. The expression  $\frac{6\sqrt{28}}{3\sqrt{7}}$  is equal to:

- A. 4  
 B. 6  
 C. 8  
 D. 12  
 E.  $3\sqrt{21}$

16. In the figure below,  $\overline{XW}$  intersects  $\overline{VZ}$  at  $Y$ , the measure of  $\angle XYV$  is  $(3x + 5)^\circ$ , and the measure of  $\angle ZYW$  is  $(4x - 6)^\circ$ . What is the measure of  $\angle XYZ$ ?



- F.  $83^\circ$   
 G.  $97^\circ$   
 H.  $104^\circ$   
 J.  $142^\circ$   
 K.  $169^\circ$



DO YOUR FIGURING HERE.

17. The table below shows the letter grades 60 students earned on the final exam in American Literature. The highest possible grade is A; the lowest possible grade is F.

Final exam grade	Number of students
A	10
B	26
C	18
D	4
F	2

A student from this group will be chosen at random. What is the probability that the student's final exam grade is C or higher?

- A. 0.3  
B. 0.4  
C. 0.6  
D. 0.7  
E. 0.9
18. For what value of  $n$  does the quadratic equation  $x^2 - 2x + n = 0$  have solutions of  $x = 4$  and  $x = -2$  ?
- F. -8  
G. -2  
H. 2  
J. 6  
K. 8
19. The circumference of a circle is  $12\pi$  inches. What is the area of the circle, in square inches?
- A.  $4\pi$   
B.  $9\pi$   
C.  $12\pi$   
D.  $16\pi$   
E.  $36\pi$
20. The application for a license plate states that the license plate number has 3 letters followed by a 3-digit number, for example, AEE123. The letters O and I and the digit 0 cannot be part of the license plate number. Any of the other letters and digits may be used up to 3 times. Which of the following expressions represents how many different license plate numbers are possible?
- F.  $24(23)(22)(9)(8)(7)$   
G.  $24(23)(22)(10)(10)(10)$   
H.  $24(24)(24)(9)(9)(9)$   
J.  $26(25)(24)(10)(9)(8)$   
K.  $26(26)(26)(10)(10)(10)$
21. Which of the following expressions is equivalent to  $3(a + b) - 2(a - 5b)$  ?
- A.  $a - 9b$   
B.  $a - 7b$   
C.  $a - 4b$   
D.  $a + 8b$   
E.  $a + 13b$



22. In the figure below, all of the small squares are equal in area, and the area of rectangle  $ABCD$  is 1 square unit. Which of the following expressions represents the area, in square units, of the shaded region?

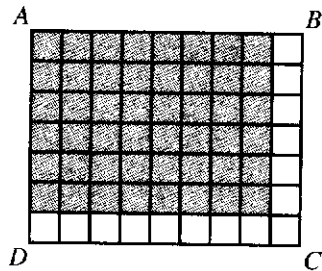
F.  $\frac{1}{9} \cdot \frac{1}{7}$

G.  $\frac{1}{9} \cdot \frac{6}{7}$

H.  $\frac{1}{9} \cdot \frac{8}{9}$

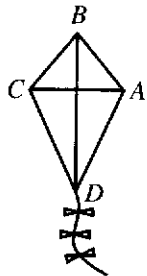
J.  $\frac{8}{9} \cdot \frac{1}{7}$

K.  $\frac{8}{9} \cdot \frac{6}{7}$



DO YOUR FIGURING HERE.

23. Marie is building a kite. In a drawing of her kite, shown below,  $AB = BC$ ,  $AD = DC$ , the measure of  $\angle ABC$  is  $80^\circ$ , and the measure of  $\angle ADC$  is  $50^\circ$ . What is the measure of  $\angle BAD$ ?



- A.  $50^\circ$   
 B.  $65^\circ$   
 C.  $90^\circ$   
 D.  $115^\circ$   
 E.  $130^\circ$

24. The triangles below are similar ( $\triangle ABC \sim \triangle DEF$ ). Which of the following is an expression for the area of  $\triangle ABC$ , in square inches?

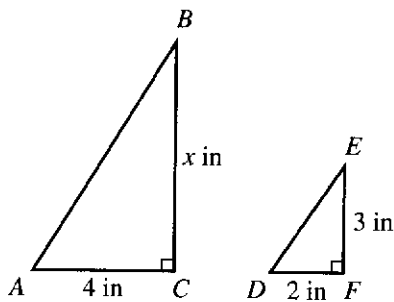
F.  $\frac{1}{2}(2+4)(3+x)$

G.  $\frac{1}{2}(2)(3)$

H.  $\frac{1}{2}(2)(3)(2)$

J.  $\frac{1}{2}\left(\frac{x}{3}\right)(2)$

K.  $\frac{1}{2}(4)(6)$



25. The interior of a rectangular shipping crate has dimensions 2 ft by 3 ft by 6 ft. The crate will be filled with cube-shaped boxes whose exteriors have dimensions 12 in by 12 in by 12 in. Given that no box can extend beyond the dimensions of the crate's interior, what is the maximum number of boxes the crate can hold?

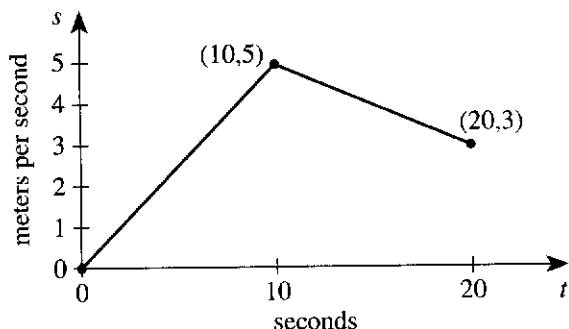
- A. 3  
 B. 12  
 C. 36  
 D. 48  
 E. 72



Use the following information to answer questions 26–29.

DO YOUR FIGURING HERE.

Shasta is participating in a bike ride for charity. The graph of speed ( $s$ ) versus time ( $t$ ) for the first 20 seconds of her bike ride is shown in the coordinate plane below. The graph is composed of 2 line segments for which the endpoints are at  $(0,0)$ ,  $(10,5)$ , and  $(20,3)$ . Shasta traveled 25 meters in the first 10 seconds.



Beginning at  $t = 20$  seconds, Shasta slows down as she approaches a familiar group of riders ahead of her and then travels at a constant speed with the group after joining them.

26. What is Shasta's speed, in meters per second, at  $t = 3$  seconds?

F. 1.5  
G. 2.0  
H. 2.5  
J. 3.0  
K. 6.0

27. Shasta's acceleration,  $a$ , over the interval from  $t = 10$  seconds to  $t = 20$  seconds, is equal to the slope of the graph over that interval, measured in meters per second per second. What is the value of  $a$ ?

A.  $-5$   
B.  $-\frac{1}{5}$   
C.  $\frac{1}{5}$   
D.  $2$   
E.  $5$



28. Calen started his bike ride earlier than Shasta. During the first 15 seconds of Shasta's ride, Calen was traveling at a constant speed equal to  $\frac{1}{2}$  of Shasta's maximum speed during that same time period. How far, in meters, did Calen travel during the first 15 seconds of Shasta's ride?

F.  $22\frac{1}{2}$

G. 25

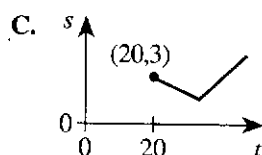
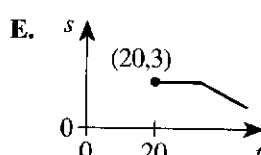
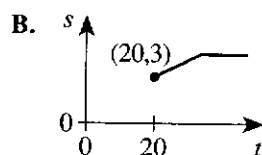
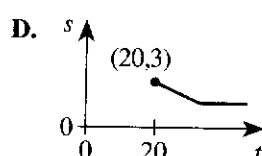
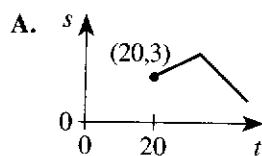
H.  $37\frac{1}{2}$

J. 45

K. 75

DO YOUR FIGURING HERE.

29. Which of the following graphs best represents the portion of Shasta's ride beginning at  $t = 20$  seconds?



30.  $\frac{2}{3} - \frac{5}{6} \left( \frac{2}{5} + \frac{1}{10} \right) = ?$

F.  $-\frac{1}{3}$

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

H.  $-\frac{1}{12}$

J.  $\frac{1}{4}$

K.  $\frac{13}{30}$



DO YOUR FIGURING HERE.

31. The lengths of 2 adjacent sides of a rectangle are represented by  $x + 2$  feet and  $2x + 7$  feet. In terms of  $x$ , what is the area, in square feet, of the rectangle?
- A.  $6x + 18$   
B.  $2x^2 + 14$   
C.  $2x^2 + 9x + 14$   
D.  $2x^2 + 11x + 9$   
E.  $2x^2 + 11x + 14$
32. Which one of the following inequalities is true?
- F.  $2 < \sqrt{3} < 4$   
G.  $\frac{1}{2} < \sqrt{\frac{1}{3}} < \frac{1}{4}$   
H.  $4 < 2(\sqrt{5}) < 5$   
J.  $\sqrt{3} < 4 < \sqrt{5}$   
K.  $\sqrt{2} < 2(\sqrt{2}) < \sqrt{3}$
33. Two fair coins are repeatedly tossed simultaneously. What is the probability that both coins land heads up on the 36th toss?
- A.  $\frac{1}{144}$   
B.  $\frac{1}{108}$   
C.  $\frac{1}{36}$   
D.  $\frac{1}{9}$   
E.  $\frac{1}{4}$
34. Suppose a student's course grade is determined solely by that student's scores on 8 tests, which are worth 100 points each. If Bane has an average of exactly 88 points on the first 6 tests, how many points must he average on the last 2 tests to earn exactly a 90-point course grade?
- F. 99  
G. 96  
H. 95  
J. 94  
K. 92
35. Which of the following operations will produce the largest result when substituted for the blank in the expression  $62 \text{ } \left(-\frac{1}{65}\right)$ ?
- A. Averaged with  
B. Divided by  
C. Minus  
D. Plus  
E. Multiplied by



36. Given the sets  $A = \{0, 1, 2, 3\}$  and  $B = \{1, 3, 5, 7\}$ , which of the following defines a function  $f$  from  $A$  onto  $B$ ?

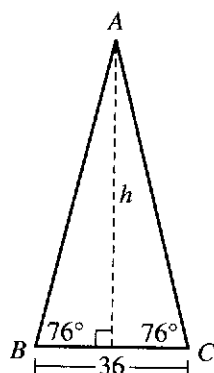
F.  $f(x) = 2x + 1$   
 G.  $f(x) = 2x - 1$   
 H.  $f(x) = 3x - 1$   
 J.  $f(x) = 3x - 2$   
 K.  $f(x) = x + 1$

DO YOUR FIGURING HERE.

37. If  $x = \frac{3}{4} + \frac{4}{3}$ ,  $y = \frac{2}{3} + \frac{3}{2}$ , and  $z = 1 + 1$ , which of the following orders  $x$ ,  $y$ , and  $z$  from least to greatest?

A.  $x < y < z$   
 B.  $y < x < z$   
 C.  $y < z < x$   
 D.  $z < x < y$   
 E.  $z < y < x$

38. Isosceles triangle  $\triangle ABC$  has an altitude of  $h$  inches, a base of 36 inches, and 2 base angles measuring  $76^\circ$  each, as shown in the figure below. What is the value of  $h$ ?



F.  $18 \sin 76^\circ$   
 G.  $18 \tan 76^\circ$   
 H.  $36 \cot 76^\circ$   
 J.  $36 \sin 76^\circ$   
 K.  $36 \tan 76^\circ$

39. The least common multiple (LCM) of 2 numbers is 216. The larger of the 2 numbers is 108. What is the greatest value the other number can have?

A. 2  
 B. 6  
 C. 36  
 D. 54  
 E. 72

40. In the standard  $(x, y)$  coordinate plane, given Parabola A with equation  $y = 3x^2$ , Parabola B is the image of Parabola A after a shift of 7 coordinate units to the left and 4 coordinate units down. Parabola B has which of the following equations?

F.  $y = 3(x - 4)^2 - 7$   
 G.  $y = 3(x - 7)^2 - 4$   
 H.  $y = 3(x - 7)^2 + 4$   
 J.  $y = 3(x + 7)^2 - 4$   
 K.  $y = 3(x + 7)^2 + 4$



DO YOUR FIGURING HERE.

Use the following information to answer questions 41–43.

In 2012, pollsters for the Gallup Organization asked a random sample of 1,014 adults, “On the average, about how much does your family spend on food each week?” The table below lists the percent of the sample that gave each response. For example, approximately 21% of adults in the sample responded that, on average, they spend no less than \$200 but no more than \$299 on food each week.

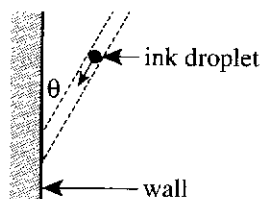
Average amount spent	Percent of sample
Less than \$50	8%
\$50 to \$99	17%
\$100 to \$124	22%
\$125 to \$149	4%
\$150 to \$199	15%
\$200 to \$299	21%
\$300 or more	10%
Did not give an amount	3%

41. Which of the following expressions is equal to the approximate number of adults from the sample that said they spend an average of less than \$100 each week on food?
- A.  $1,014(22)$   
 B.  $1,014(25)$   
 C.  $1,014(47)$   
 D.  $1,014(0.22)$   
 E.  $1,014(0.25)$
42. What percent of adults in the sample responded that they spend, on average, at least \$150 each week on food?
- F. 15%  
 G. 46%  
 H. 49%  
 J. 51%  
 K. 66%
43. A pollster will create a circle graph using the information in the table. One sector of the circle graph will represent the percent of adults in the sample who said they spend an average of \$300 or more on food each week. What will be the measure of the central angle for that sector?
- A.  $10^\circ$   
 B.  $13^\circ$   
 C.  $36^\circ$   
 D.  $45^\circ$   
 E.  $47^\circ$

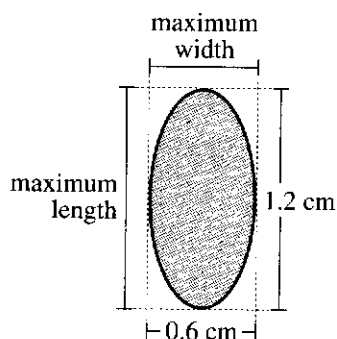




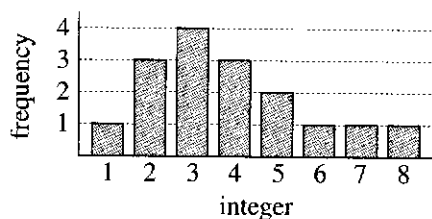
44. A spherical droplet of ink strikes a vertical wall, as modeled in the figure below. The angle of impact is indicated by  $\theta$  in the figure.



The stain the droplet leaves on the wall is oval-shaped. Scientists can measure the maximum length and maximum width of the stain to determine the angle of impact according to the formula  $\sin \theta = \frac{\text{maximum width}}{\text{maximum length}}$ . The figure below models such a stain. What was the impact angle of the droplet that left this stain?



- F.  $30^\circ$   
 G.  $45^\circ$   
 H.  $60^\circ$   
 J.  $90^\circ$   
 K.  $120^\circ$
45. The graph below shows the distribution of a data set consisting of 16 positive integers. Which of the following statements about the mean, median, and mode of the data set is true?



- A. The mode is less than the median, and the median is less than the mean.  
 B. The mode is less than the mean, and the mean is equal to the median.  
 C. The mode is equal to the mean, and the mean is less than the median.  
 D. The mean is less than the median, and the median is less than the mode.  
 E. The mean is equal to the median, and the median is equal to the mode.



DO YOUR FIGURING HERE.

46. Yolanda collects trading cards, and she has started her younger brothers, Xavier and Zach, collecting cards as well. As of today, Zach owns 5 more cards than Xavier, and Yolanda owns twice as many cards as Xavier and Zach combined. Which of the following equations expresses the relationship between  $y$ , the number of cards Yolanda owns, and  $x$ , the number of cards Xavier owns?
- F.  $y = x - 5$   
G.  $y = x + 5$   
H.  $y = 2x$   
J.  $y = 4x - 10$   
K.  $y = 4x + 10$
47. What is the distance, in coordinate units, between the points  $(-2,1)$  and  $(1,10)$  in the standard  $(x,y)$  coordinate plane?
- A.  $\sqrt{72}$   
B.  $\sqrt{80}$   
C.  $\sqrt{82}$   
D.  $\sqrt{90}$   
E. 12
48. A rectangular solid has a volume of 100 cubic units. If the length, width, and height of the solid are each doubled, what will the volume, in cubic units, of the new solid be?
- F. 200  
G. 400  
H. 600  
J. 800  
K. 2,700
49. The set of all values of  $x$  that satisfies  $|x - 2| < 7$  is the same as the set of all values of  $x$  that satisfies:
- A.  $0 < x < 5$   
B.  $0 < x < 9$   
C.  $-5 < x < 5$   
D.  $-5 < x < 9$   
E.  $-9 < x < 9$
50. The fifth power of a number is 380,204,032. The number is between:
- F. 1 and 10.  
G. 10 and 100.  
H. 100 and 1,000.  
J. 1,000 and 100,000.  
K. 100,000 and 100,000,000.



51. Given  $A = \begin{bmatrix} 2 & 0 & 3 \\ -1 & 5 & -2 \end{bmatrix}$ ,  $B = \begin{bmatrix} -3 & 1 \\ 4 & 1 \\ 1 & 2 \end{bmatrix}$ , and  $C = \begin{bmatrix} 0 & -2 \\ 1 & -4 \end{bmatrix}$ , if it is possible to calculate  $C + AB$ , which of the following matrices is the result?

DO YOUR FIGURING HERE.

A.  $\begin{bmatrix} -6 & -3 \\ 1 & 1 \end{bmatrix}$

B.  $\begin{bmatrix} -3 & 6 \\ 22 & -4 \end{bmatrix}$

C.  $\begin{bmatrix} 11 & 6 \\ 2 & -3 \end{bmatrix}$

D.  $\begin{bmatrix} -6 & 0 \\ -8 & 1 \\ 3 & -4 \end{bmatrix}$

- E. It is not possible to calculate  $C + AB$ .

52. Given  $0 \leq x \leq 8$  and  $y \geq 18$ , what is the greatest value of  $\frac{x+y}{y}$ , if it can be determined?

F. 0

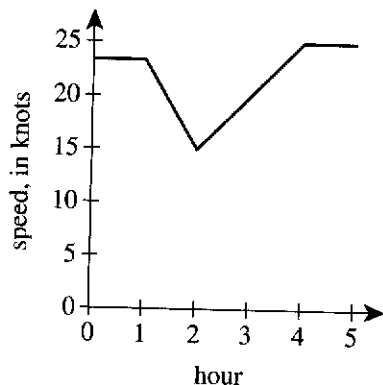
G. 1

H.  $\frac{13}{9}$

J.  $\frac{13}{4}$

- K. Cannot be determined from the given information

53. The graph below gives the speed, in *knots* (nautical miles per hour), of a cruise ship during a 5-hour period. Which of the following values is closest to the rate of change, in knots per hour, of the speed of the ship between hours 2 and 4?



- A. 2  
B. 3  
C. 5  
D. 10  
E. 25

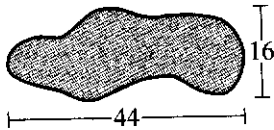


DO YOUR FIGURING HERE.

54. A fair spinner with 4 equally sized regions and an arrow has regions numbered 1, 2, 3, and 4, respectively, and a second fair spinner with 5 equally sized regions and an arrow has regions numbered 1, 2, 3, 4, and 5, respectively. The arrows are both spun at the same time, and the numbers the 2 arrows land on are multiplied together. What is the probability that this product is an odd number?

- F.  $\frac{1}{2}$   
 G.  $\frac{4}{5}$   
 H.  $\frac{4}{9}$   
 J.  $\frac{5}{9}$   
 K.  $\frac{3}{10}$

55. The bottom of a swimming pool, shown below, has an area of 630 square feet and a perimeter of 114 ft. The swimming pool has a uniform depth of 5 ft of water, and the given lengths are in feet. If it can be determined, what is the volume of water, in cubic feet, that the pool contains?



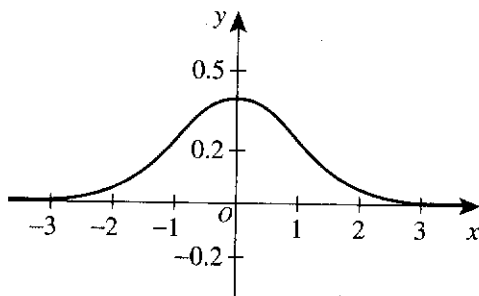
- A. 3,150  
 B. 3,335  
 C. 3,520  
 D. 3,720  
 E. Cannot be determined from the given information
56. For all positive integers  $a$  and  $b$ , the expression  $(a!)^b$  is equivalent to one of the following expressions. Which one?
- F.  $(a^b)!$   
 G.  $(ab)!$   
 H.  $b(a!)$   
 J.  $a^b(-1 + -2 + -3 + \dots)$   
 K.  $[a(a-1)(a-2) \dots (1)]^b$



57. The standard normal probability distribution function ( $\mu = 0$  and  $\sigma = 1$ ) is graphed in the standard  $(x,y)$  coordinate plane below. Which of the following percentages is closest to the percent of the data points that are within 2 standard deviations of the mean in any normal distribution?

DO YOUR FIGURING HERE.

- A. 50%  
B. 68%  
C. 90%  
D. 95%  
E. 99%



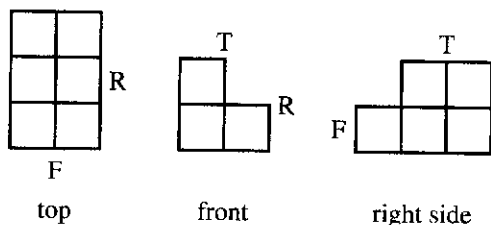
58. For what value of  $b$  will the determinant of the matrix  $\begin{bmatrix} 4 & b \\ 2 & 3 \end{bmatrix}$  have a value of 18?

- F.  $-\frac{10}{3}$   
G.  $-3$   
H.  $3$   
J.  $6$   
K.  $15$

59. What are the solutions to  $x^2 - 2x + 17 = 0$ ?

- A.  $-3$  and  $5$   
B.  $1 \pm (3\sqrt{2})i$   
C.  $1 \pm 4i$   
D.  $1 \pm 8i$   
E.  $2 \pm 8i$

60. Shown below are the top, front, and right side views of a stack of 1-centimeter cubes. The labels T, F, and R specify where the top, front, and right sides are located with respect to the view. What is the volume, in cubic centimeters, of the stack of cubes?



- F. 6  
G. 8  
H. 9  
J. 12  
K. 14

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 1

**LITERARY NARRATIVE:** This passage is adapted from the essay "The Public Father" by Daphne Merkin (©2000 by The New York Times Company).

The narrator's father was Hermann Merkin, a widely known New York City philanthropist, who died in 1999.

I rarely visited my father at his office, where he worked as an investment banker, but I knew that its ongoing affairs were more crucial to him, in many ways, than the life he led at home—just as I knew that his public face as a philanthropist was easier to read than his private face as a father or husband. My father was an Orthodox Jew who had grown up in Leipzig, Germany; he remained committed to Jewish causes until his death, and his knowledge of the dizzying intricacies of Israeli politics was impressive. Throughout his life my father supported Jewish scholarship; he also helped endow the kosher kitchen at Mount Sinai, as well as the Merkin Concert Hall on West 67th Street (which is silent from Friday at sundown to Saturday at sundown, in observance of the Sabbath).

I consider him to have been something of an enigma—to himself, and certainly to his children. He was constitutionally secretive, and it would have been nice to be let in on the secret, to know what was going on in his busy, obsessive mind.

He wasn't the kind of father I would have ideally wished for, an image cobbled together from the paternal figures I warmed to on television or in the movies, attentive and playful and full of wise counsel. He wasn't invested in the homely details of my existence or those of my five siblings: I don't think he ever knew the name of any of my teachers, and he couldn't tell my friends apart. He didn't teach me to ride a bike (he couldn't ride one himself) or drive a car (he couldn't drive one himself). He didn't, in other words, lend himself to helping me master the world, the role often attributed to fathers in the developmental histories of daughters. He hadn't much use for feelings, which were what interested me the most, then as now. I couldn't go to him with my problems or my passions, partly because he spoke the language of businesslike resolution while I specialized in the articulation of finely honed conflict. On those infrequent times when I would

officially meet with him in his study—a room that bordered on the sacrosanct—to discuss some girlhood difficulty, I would invariably find myself cut off at the pass by his decisiveness. My habit of questioning everything wilted before his focus on the bottom line. Later I would find some of my relationship with him expressed in writer Franz Kafka's famous, importuning letter to his father, with its futile wish for a communion that doesn't exist.

These days I find myself looking for my father, as though now that he is gone I might still get to know him better. There are superficial associations: I saw a movie in which the Savoy Hotel in London was briefly featured, and I was immediately reminded of my father's fondness for it when he traveled on business. And there are deeper ones, as well: When I'm around people—especially men—who seem too obvious in their thought processes, I think with affection of my father's utterly idiosyncratic, curvy mind. I keep wondering what has happened to all the bits of information he stored in his head, the phrases he wrote down—in English, or Hebrew, or German, or French—with his ubiquitous, freshly sharpened No. 2 pencils on little white notepads. I found the combinations of things he scribbled in his vertical, almost mathematical handwriting—practical reminders mixed in with cerebral notations, isolated vocabulary words mixed in with stock quotes and dollar signs—invariably intriguing. Language meant a lot to him, and though I never shared his fondness for punsters or a certain kind of briskly witty columnist, I could see that he liked words to crackle on the page.

Since he wasn't given to communicating his emotions, I had to guess at them much of the time. In the end, I think he was genuinely different from other people, put together from strange and incongruous parts. I know he took pride in my being a writer, and I always enjoyed it when he came to literary gatherings, where he greeted everyone with relish, acting perfectly oblivious to anything ungenerous about him or my family that I might have written. He didn't, in fact, much care what other people thought of him—which struck me as both annoying and admirable, but made him socially unembarrassable. I miss his impersonal yet oddly reassuring presence in the world, sitting in a chair in his study filled with his scholarly books, his round bald head covered with a flat black crocheted

yarmulke. Write about me, he said, shortly before he died, squeezing my hand, which was his version of a hug. Did he mean it? And would he have recognized himself on the page?

1. A main theme of the passage is:
  - A. resignation; the narrator has long ago accepted the fact that her father was utterly indifferent to her.
  - B. resentment; the narrator explains that having a more supportive father would have aided her career.
  - C. longing; the narrator often yearned for connections with her father that were difficult for her to make.
  - D. redemption; the narrator has finally realized her father's deep sadness regarding their distant relationship.
2. The narrator's statement that she rarely visited her father at the office most strongly suggests:
  - F. her father's refusal to allow his children to play while he was working.
  - G. the tender, unspoken bond between the narrator and her father regardless of their differences.
  - H. the fundamental separation between her father's public life and his private life.
  - J. her father's comfort in private life as compared to discomfort in public life.
3. The narrator indicates that when she tried to discuss her life's difficulties with her father, she found his focus on which of the following to be particularly frustrating?
  - A. Seeking conflict
  - B. Examining emotions
  - C. Asking questions
  - D. Finding resolution
4. When the narrator states, "These days I find myself looking for my father" (line 48), she is most nearly referring to the fact that she has been:
  - F. relating certain places she sees or certain people she communicates with to her father.
  - G. deliberately searching for memories of her father through long discussions with his closest former colleagues.
  - H. trying to uncover her father's handwritten notes that analyze her work as a writer.
  - J. writing a series of articles and a short story about her feelings about her father.
5. The narrator most clearly illustrates her father's "utterly idiosyncratic, curvy mind" (lines 56–57) by providing details about which of the following?
  - A. The hotels where he stayed while traveling on business
  - B. The regulations he placed on his endowments
  - C. The scribbles on his white notepads
  - D. The decor of his study
6. The narrator offers which of the following details as support for her claim that she knew her father took pride in her career as a writer?
  - F. Her father repeatedly told her that he was proud of her.
  - G. Her father recorded notes about her essays and articles in his notepads.
  - H. Her father encouraged her to commit herself to Jewish causes as a writer.
  - J. Her father happily attended the literary gatherings that were a part of her career.
7. In the last paragraph, the narrator characterizes her father most nearly as a:
  - A. famous banker who ultimately chose to focus on his private life instead of on his public life.
  - B. philanthropist who was as generous to his family with his time as he was to the public with his money.
  - C. businessman who was more difficult for his colleagues to understand than he was for his family to understand.
  - D. truly unique person who brought her comfort despite the often impersonal nature of their interactions.
8. The narrator describes which of the following as being "cobbled together" (line 22)?
  - F. Her feelings for her father
  - G. Her childhood image of an ideal father
  - H. Her self-identity when she was a young woman
  - J. Her understanding of her father's thought processes
9. The narrator makes clear that compared to her interest in exploring feelings when she was a girl, her interest in exploring feelings at the time the passage was written was:
  - A. much stronger.
  - B. slightly stronger.
  - C. about the same.
  - D. slightly weaker.
10. The narrator characterizes the talks she and her father had in his study about her life problems as:
  - F. impromptu chats that were infrequent but deeply fulfilling.
  - G. weekly appointments that were lighthearted and casual.
  - H. once-a-year events that were emotionally difficult.
  - J. occasional, prearranged meetings that had a serious tone.

## Passage II

**SOCIAL SCIENCE:** This passage is adapted from the article "Raiders or Traders?" by Andrew Curry (©2008 by the Smithsonian Institution).

Norsemen have traditionally been seen as intrepid seafarers and fierce warriors. They traveled thousands of miles to the east and south: across the Baltic, onto the rivers of modern-day Russia and across the Black Sea to menace Constantinople.

All that wandering would have been impossible without ships. For most of the 20th century, archaeologists assumed that all Viking ships resembled a vessel excavated in Norway in 1880. Known as the Gokstad ship, for the farm on which it was found, it dated to the year 900. A replica was sailed across the Atlantic, from Norway to Chicago, for the 1893 World's Fair. But a discovery in 1962 forced researchers to abandon the idea that the Vikings had only one kind of ship.

At the bottom of a fjord near the Danish town of Roskilde, archaeologists found remnants of five Viking ships piled one atop the other. Dubbed the Skuldelev ships, for a nearby town, each had had a specialized role. One had been a fishing boat; two were cargo ships, so easy to handle that a crew of eight could move 20-ton loads; and one was a warship that could carry about 30 people. The fifth ship, a raider known as Skuldelev 2, was the biggest.

It was 98 feet long but 12 feet wide. Its keel reached just three feet below the surface, and its masts and sail could be lowered to approach fortifications and settlements with stealth.

Because only 20 percent of the Skuldelev 2 could be recovered, the only way to determine its capabilities for certain was to somehow resurrect and sail it. In 2000, researchers at the Viking Ship Museum in Roskilde began working with scientists to build an accurate replica. They used thousand-year-old methods and replicas of Viking tools, which meant carving each of the ship's 90 oak planks with axes, wedges, and hammers. After four years, the eight builders had their replica. They called it *Sea Stallion from Glendalough* for the Irish village where Vikings used to find oak for their ships. With its narrow beam (width) and shallow draft (the depth a ship extends below the waterline), the *Sea Stallion* could have navigated nearly any river in Europe. But how would it fare on the open sea?

In the summer of 2006, the *Sea Stallion* sailed under sunny skies and gentle winds from Roskilde to Norway and back in four weeks—a virtual pleasure cruise. A test sail in May 2007 around the Roskilde fjord enjoyed similar conditions. A tougher, six-week test was planned for July 2007, with the crew sailing from Roskilde north to Norway, west to Scotland and south to Dublin. Fully loaded, the ship weighed 24 tons—eight of ship, eight of rock for ballast (the weight used to steady a ship) and eight of crew and

gear. In ideal conditions, the *Sea Stallion* could travel 160 nautical miles a day; it could sprint at 13 knots, or almost 15 miles an hour. (A high-tech America's Cup racer might hit 20 knots.) "It ranks as one of the fastest warships in history," says Anton Englert, an archaeologist at the ship museum.

The ship set sail for Dublin on July 1, 2007, under dark skies that presaged Northern Europe's coldest and wettest summer in decades. Nighttime temperatures plunged below freezing. Three days into the voyage, two crew members had been treated for hypothermia; weak winds forced the *Sea Stallion* to take a 24-hour tow across part of the North Sea to stay on schedule.

After the six-week test, archaeologists at the ship museum in Roskilde began analyzing data generated during the voyage. High speeds over long distances pushed the ship to its limits—and challenged some assumptions about how the Skuldelev 2 had been put together. "The sails are very stable and can take a lot of wind, but problems with the rudder come up again and again, and haven't been solved yet," Englert says.

Information from the crew proved as valuable as technical data. Exhausted sailors told researchers that the close quarters made sleeping nearly impossible. Between the rough water, constant rain and their nautical duties, it was all crew members could do to nap for an hour or two during their rest periods. "That indicates the ship must have had an amphibious behavior—they had to land often just to get some rest," Englert says. Crossing the North Sea in a narrow ship like this one would have stretched a Viking crew almost to the breaking point, and crossing the Atlantic would have been inconceivable. A ship like this would have been used for coastal raiding.

11. Which of the following statements best summarizes the passage?

- A. The discovery of Viking ship remnants provided learning opportunities for researchers and scientists, particularly as they constructed a replica vessel and sailed it on test voyages.
- B. European researchers studied Viking ships and, with the help of a crew of scientists, built a replica of one using a mix of modern and ancient construction methods.
- C. After studying five ancient Viking ships, archaeologists learned that Norsemen were not as aggressive as had previously been believed.
- D. Historians and sailors have attempted to re-create the Vikings' Atlantic crossing by repairing and rebuilding a recently discovered ship.



12. Which of the following conclusions about the Vikings' knowledge of ship construction is best supported by the passage?
- F. They learned most of their shipbuilding skills from the Irish.
  - G. They could adapt a ship's size, design, and weight depending on its intended use.
  - H. They could build ships that didn't require rocks for ballast.
  - J. They could build ships strong enough to withstand powerful storms, but the ships were slow.
13. Based on the passage, the author would most likely agree with which of the following statements about the *Sea Stallion*?
- A. Post-trip analysis of the *Sea Stallion*'s damage proved to be more valuable than interviews with its crew.
  - B. Building the *Sea Stallion* provided researchers with more technical data than sailing it had.
  - C. Difficulties with the *Sea Stallion*'s rudder meant that the majority of the ship's design was flawed.
  - D. Questions about how Viking ships were used were partly answered by sailing the *Sea Stallion*.
14. The author compares the *Sea Stallion* to a high-tech racer most nearly to:
- F. explain how fast the replica could sail under poor conditions.
  - G. detail the different factors that contributed to the speed of most Viking ships.
  - H. emphasize the remarkable speed the replica could achieve.
  - J. identify in precise terms how fast most Viking ships could sail.
15. The passage indicates that until a discovery in 1962, researchers had mistakenly believed that Norsemen had:
- A. been known only for their sailing abilities.
  - B. sailed in only one kind of ship.
  - C. been aggressive fighters and conquerors.
  - D. crossed the Atlantic before any other explorers.
16. It can reasonably be inferred from the passage that one reason researchers constructed a replica of Skuldelev 2 was that:
- F. the salvaged ship was too incomplete for an accurate understanding of how it was used.
  - G. they hoped to sail the ship in a race against more modern vessels.
  - H. they were determined to prove that they could build a better ship than could the Vikings.
  - J. scientists and researchers were unable to agree on the exact dimensions of the original ship.
17. According to the passage, the *Sea Stallion* from *Glendalough* was named after:
- A. a river in Europe that was difficult for Vikings to navigate.
  - B. a village where Vikings had found oak to build ships.
  - C. the location where Skuldelev 2 had been discovered.
  - D. the fjord in which the crew of the replica would sail.
18. Compared to the *Sea Stallion*'s trip in July 2007, the vessel's expedition in the summer of 2006 is described as a "virtual pleasure cruise" (lines 45–46) because that earlier voyage:
- F. took place during better weather and was shorter in duration.
  - G. allowed the crew more time to learn to appreciate the ship.
  - H. gave the sailors a better idea of what life was like for the Vikings.
  - J. traveled through calmer waters that allowed repairs to be made while sailing.
19. When Englert uses the phrase *amphibious behavior* (line 80), he is most nearly referring to the ship's:
- A. steady speed.
  - B. frequent landings.
  - C. ability to navigate rivers.
  - D. maneuverability in heavy rain.
20. According to the passage, a ship similar to the *Sea Stallion* would have been used by the Vikings for:
- F. crossing the Atlantic Ocean.
  - G. fishing in nearby fjords.
  - H. raiding coastal settlements.
  - J. training new sailing crews.

### Passage III

**HUMANITIES:** Passage A is adapted from the article "The Animated Worlds of Basil Twist" by Eileen Blumenthal (©2005 by Theatre Communications Group). Passage B is adapted from the article "Dancing 'Like a Fish' in Underwater Puppet Theater" by Robert Greskovic (©2003 by Dow Jones and Company, Inc.).

#### Passage A by Eileen Blumenthal

"I feel like I'm a little old-fashioned," says master puppeteer Basil Twist.

Old-fashioned? Twist staged *Symphonie Fantastique* (1998) in a 1,000-gallon tank of water. For *Red Beads* (2005), he animated the scenery with electric fans, while live actors played the human characters. His puppets for both *Symphonie Fantastique* and *Petrushka* (2001) included unadorned lengths of fabric.

Actually, the contradiction is only skin-deep. Whatever techniques Twist uses for a particular show, the core for him is the age-old basis of puppetry: as he puts it, "animating—giving breath and soul—to something inanimate."

Thinking back to a festival he attended on the theme "music and puppetry," Twist recalls, "There was a lot of Baroque music played on strange instruments, but it wasn't a puppet show."

Twist decided he would create a visual equivalent of a musical work using totally abstract puppets—pieces of fabric, feathers, tinsel, poles, non-figurative cutouts. Light of varying color and intensity, sometimes smooth, sometimes in bursts, would underscore the emotion in the music. And—the clincher—he would get a sense of otherworldliness and (literal) fluidity by staging the show *underwater* in a giant tank. To animate this world, hidden puppeteers would work from the sides of the tank and suspended above it in harnesses.

Twist did temper the abstraction, in a way, by choosing Hector Berlioz's programmatic *Symphonie Fantastique*, which tells in music a story of an artist's obsession with a woman. But Twist chose the work despite rather than for its story. He liked the music's emotional richness and dramatic structure. And even for viewers who knew the "plot" (not mentioned in Twist's program), objects refused to have clear identities. The silk that swirled and swooped to a violin melody could be an image of the protagonist's beloved, or it could be his mood, or it could be a breeze. Or all of them. The rigid vertical forms could be a vision of prison bars, or a feeling of being pursued, or of being doomed. Or all of them.

#### Passage B by Robert Greskovic

In an attempt to define music-inspired choreography, George Balanchine suggested that "it was like an aquarium: music was all around and the dancer was like a fish." *Symphonie Fantastique*, Basil Twist's enchant-

ing, underwater presentation of puppet theater to Hector Berlioz's famed composition of the same name, takes such a thought at face value and swims to glory with it.

It's hard to suggest with words just what Twist's *Symphonie* does with the music and within the 1,000-gallon tank. Connections to Disney's 1940 animated film *Fantasia* come readily to mind, but the one-for-one, note-for-note Mickey Mouse emphasis favored by Disney's gifted animators isn't Twist's way; he works for a less literal, more free-spirited vision.

The cast of floating and swirling "characters" ranges from geometric, flat shapes to anthropomorphic figures, in the form of whisked lengths of fabric, unfurled sheets of cloth, and a variety of fringed pieces reminiscent of feathers, cheerleader pompons or angel-hair-like curtains of filament.

Berlioz's 1830 symphonic composition comes down to us shot through with impetuous passion. Its five movements each have poetic headings, "A Ball" and "Dream of a Witches' Sabbath," for example, and were further elaborated by the composer with specific program notes. Berlioz didn't insist on publishing the individual episodes he imagined, but he did want his movement titles printed whenever his symphony was played. Twist uses Berlioz's titles, but not the program notes. His fantastical symphony is storyless but by no means lacking in character, or even characters. Whenever the music's recurring theme is heard, suggesting the compelling beloved of the original narrative, Twist brings in his most gracefully swimming swath of white fabric, which variously takes the shape of an eel, a stingray or a wisp of smoke potent enough to cut through watery depths.

The aquatic world through which *Symphonie's* recurrent white figure winds, slips and streaks is rich with musically motivated activity. Sometimes, especially in the little pauses between movements, you can hear some sloshing from puppeteers readying their labors. Rather than distracting from the dreamlike nature of the silken proceedings, these signs of human activity help give the show an added gravity. If Twist's symphonic achievement were created by carefully edited animation it would be remarkable enough, but the fact that it's done live, by unseen manipulators working through water, makes his theatrical marvels all the more amazing.

Questions 21–23 ask about Passage A.

21. In Passage A, the author refers to *Red Beads* and *Petrushka* primarily to:
- A. indicate that Twist produced other puppet shows inspired by Berlioz.
  - B. provide examples of Twist's nontraditional approach to puppetry.
  - C. emphasize the differences between Twist's *Symphonie Fantastique* and his earlier work.
  - D. explain how prolific Twist has been as a puppeteer.
22. According to Passage A, which of the following items were used as puppets in Twist's *Symphonie Fantastique*?
- I. Poles
  - II. Tinsel
  - III. Electric fans
  - IV. Lengths of fabric
- F. I, II, and III only
  - G. I, II, and IV only
  - H. II, III, and IV only
  - J. IV only
23. As it is used in line 35, the word *clear* most nearly means:
- A. luminous.
  - B. innocent.
  - C. definite.
  - D. legible.

Questions 24–27 ask about Passage B.

24. The author of Passage B regards Twist's *Symphonie Fantastique* with what could best be described as:
- F. distanced objectivity.
  - G. mild criticism.
  - H. open appreciation.
  - J. strong disappointment.
25. The author puts quotation marks around the word *characters* in line 57 most likely to:
- A. reveal the author's doubt that puppets can play realistic roles in theatrical performances.
  - B. highlight the eccentric personalities of Twist's puppets.
  - C. emphasize that Twist pushes the limits on what can be considered a character.
  - D. indicate that the term is taken directly from Balanchine.

26. According to Passage B, which of the following requirements, if any, did Berlioz specify regarding the use of his *Symphonie Fantastique*?
- F. Berlioz's story line should be featured whenever *Symphonie Fantastique* is played.
  - G. Berlioz's movement titles should be printed whenever *Symphonie Fantastique* is played.
  - H. Any adaptation of Berlioz's music should maintain the original title.
  - J. Berlioz made no specific requirements regarding the use of his compositions.
27. In lines 86–87, the phrase "signs of human activity" most nearly refers to:
- A. pulsating light.
  - B. sloshing sounds.
  - C. individual notes of music.
  - D. the human gracefulness of silk in water.

Questions 28–30 ask about both passages.

28. Which of the following statements best captures the main difference in the scope of information presented in the two passages?
- F. Passage A is a profile of Twist with particular attention to his *Symphonie*, while Passage B is a review of Twist's *Symphonie* itself.
  - G. Passage A is a critique of Twist's work as a whole, while Passage B is a persuasive piece on the importance of live theater.
  - H. Passage A is a biography discussing Twist's life and education, while Passage B is an argumentative piece about Twist's place among leading puppeteers.
  - J. Passage A is a historical overview of the uses of Berlioz's *Symphonie*, while Passage B is a comparison of Disney's *Fantasia* and Twist's *Symphonie*.
29. Compared to Passage A, Passage B includes more information about:
- A. Twist's aspirations as a puppeteer.
  - B. the development of Twist's career.
  - C. the dimensions of the water tank.
  - D. Berlioz's original symphony.
30. The authors of Passages A and B would most likely agree that the overall feeling Twist created in his *Symphonie* could best be described as:
- F. dreamlike.
  - G. tranquil.
  - H. confused.
  - J. melancholy.

### Passage IV

**NATURAL SCIENCE:** This passage is adapted from the article "The Magic Forest: Where Poplars Are Purifying the Planet" by Dava Sobel (©2009 by Discover Media LLC).

A legacy of the Argonne National Laboratory's early foray into atomic energy lies buried here on its campus, about 25 miles southwest of Chicago. Although solid wastes from all sorts of experiments have been sealed in a landfill, certain liquids, mostly chlorinated solvents like trichloroethane, still taint the water that runs under the site. The ongoing attempt to remove these contaminants occupies an enormous experimental facility that covers four acres and looks like a forest.

"I like to brag that I have the biggest lab at Argonne," says agronomist Cristina Negri, indicating an expanse of 900 poplars and willows growing in rows. The trees stand about 30 feet high. More important, their roots extend 30 feet down, where they tap the contaminated aquifer and literally pull pollutants out of the ground.

Under normal circumstances, tree roots prefer to sip water from sources as close as possible to the surface. But these trees don't have that option. They are set into plastic-lined pits that force their roots to tunnel deep for drink. The roots lift the contaminated water into the tree trunks, where transport tissues conduct it on up to the branches and leaves. From there, as droplets transpire through leaf pores, the water evaporates and sunlight breaks down the dissolved solvent molecules, rendering them harmless.

Before the willows and poplars took over the job of wastewater management, Argonne was using extraction wells to pump contaminated water to a treatment plant. But the static mechanical pumps could not chase after groundwater that continually changed course through the complex terrain. The natural pump of a willow or poplar, on the other hand, is not only self-sustaining but so water-loving that it will snake down or fan out as far as need be to reach moisture.

Negri's trees each pump as much as 26 gallons of water per day at their summer peak. She measures the daily flow through the trunks by inserting probes that transmit data to solar-powered recorders mounted on tripods nearby.

In summer, trichloroethane levels generally run high (several thousand parts per billion), but in winter, after the leaves fall, the roots stop pumping and the bare branches bear no sign of contamination. Since the trees don't accumulate any permanent residue of pollution, they can eventually be chopped down and chipped, their remains distributed around other plantings for soil enrichment.

The technical term for this green, and increasingly prevalent, form of environmental cleanup is phytoremediation. At Argonne it will give way, over the next 20 to 30 years, to ecological restoration, as the pollutants are removed and the worker trees replaced by bur oaks and other hardwoods native to the Great Lakes region.

A second experimental forest, in Murdock, Nebraska, is helping the U.S. Department of Agriculture address the mess that it made in corn-belt communities during the 1960s, when storage drums full of grain were routinely fumigated with carbon tetrachloride to control pests. The colorless liquid seeped into the ground and continues even now to foul the local water supply.

When members of the Argonne team arrived at Murdock in 2004 for an initial assessment, they found trace levels of "carbon tet" in the resident vegetation. Their solution, implemented the next year, was to create an instant forest. Most of the 2,000 planted saplings were poplars and willows, the same types that had demonstrated their effectiveness in Illinois.

By 2007, two years after planting, the exact location of the underground plume of contamination could be mapped from the surface by examining the trees. Even in summer, trees in some areas tested clean while those in others were steadily bringing up carbon tetrachloride. Meanwhile, all the trees seemed to have enjoyed unusually rapid growth thanks to another pollutant in the Murdock soil: nitrate, possibly from fertilizers applied in the surrounding cornfields.

The compatibility of the forest and the fields conjures another poplar dream of combining remediation with energy production. Negri's colleagues have looked to the poplars as a possible source of ethanol for biofuel. The trees' need for plentiful water seemed at first to make them a poor choice, since water itself is likely to become scarce. But if the trees can slake their thirst with polluted water, and if they can grow on marginal land ill-suited for crops, then their promise as an alternate energy source grows doubly green.

31. The primary purpose of the passage is to:

- A. call attention to certain irresponsible waste disposal practices.
- B. spotlight an environmentally friendly way to clean up contaminated water.
- C. identify and describe several diverse uses for poplar and willow trees.
- D. explain how vegetation becomes contaminated by leaking landfills.

32. The main purpose of the first paragraph is to:
- F. illustrate how the Argonne National Laboratory generated waste from experiments.
  - G. explain why there is experimental work being done to remove contaminants at Argonne.
  - H. prove that the chlorinated solvents used at Argonne are harmful to the environment.
  - J. describe how contaminants leaked from a sealed landfill at Argonne.
33. According to the passage, the poplars and willows at Argonne are more efficient than extraction wells at removing contaminated water because the trees can:
- A. remove a greater variety of contaminants.
  - B. be planted on complex terrain.
  - C. pump more water by the hour.
  - D. seek out the contaminated water.
34. The main idea of the last paragraph is that poplars may eventually:
- F. grow on land ill suited for crops.
  - G. subsist purely on polluted water.
  - H. become resistant to pollutants.
  - J. become a viable source of energy.
35. According to the passage, the poplars and willows at Argonne are placed in plastic-lined pits in order to:
- A. prevent any pollutants absorbed by the trees from seeping into the surrounding soil.
  - B. stop other species of trees from growing in the Argonne forest.
  - C. force the trees' roots to tunnel deep for water.
  - D. make it easier for scientists to monitor the trees.
36. According to the passage, what ultimately happens to the contaminants in the trees at Argonne?
- F. They transpire through the trees' leaves and then break down in sunlight.
  - G. They are funneled to the trees' leaves, where they stay until the leaves fall to the ground in winter.
  - H. They leak out through the trees' branches, which bear no signs of contamination.
  - J. They remain in the trees until the trees are chopped down and chipped.
37. The passage states that contamination levels at Argonne generally run high during which season?
- A. Spring
  - B. Summer
  - C. Fall
  - D. Winter
38. According to the passage, what effect, if any, does Argonne's contaminated water have on the poplar and willow trees that absorb it?
- F. The trees must eventually be destroyed because they become contaminated.
  - G. The trees grow more rapidly than other trees in the area.
  - H. The trees show no permanent signs of pollution.
  - J. The trees develop tangled root systems.
39. Based on the passage, phytoremediation can best be described as:
- A. the practice of using trees to remove contaminants from the environment.
  - B. the practice of replanting native species in a formerly polluted area.
  - C. a process by which harmful contaminants leak into soil and groundwater.
  - D. a method of replacing poplar and willow trees in polluted areas with hardier trees.
40. The passage most strongly suggests that nitrate:
- F. can act as both a contaminant and a nutrient.
  - G. is difficult to clean up once it has entered soil.
  - H. has no effect on poplar and willow trees.
  - J. aids in the rapid growth of corn without damaging surrounding soil.

**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

A *mineral hydrate* (MH) is an ionic compound that has associated  $\text{H}_2\text{O}$  molecules. *Dehydration* (removal of all  $\text{H}_2\text{O}$ ) of an MH produces its *anhydrous salt* (an ionic compound that has no associated  $\text{H}_2\text{O}$  molecules), which may differ in color from the MH. Table 1 shows, for each of 4 MHs, the chemical formula of one formula unit of the MH, its color, and the color of its anhydrous salt.

Table 1			
MH	Chemical formula	Color	Color of anhydrous salt
Bieberite	$\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$	pink	red
Chalcanthite	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	blue	pale green
Melanterite	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	blue-green	white
Retgersite	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$	blue-green	yellow

Figure 1 shows the mass of a sample that was converted from chalcanthite to  $\text{CuSO}_4$  as its temperature was increased from  $0^\circ\text{C}$  to  $350^\circ\text{C}$ .

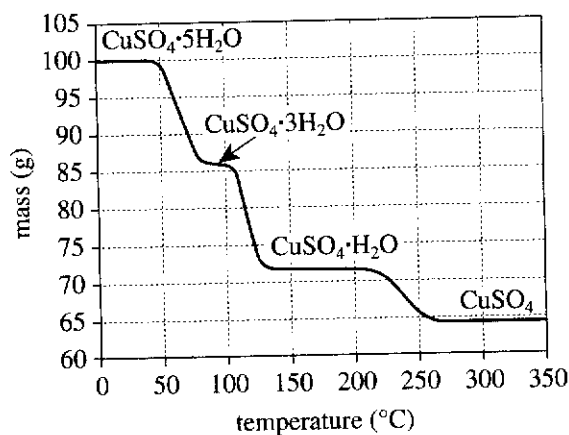


Figure 1

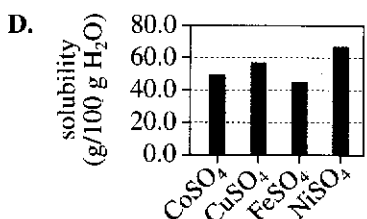
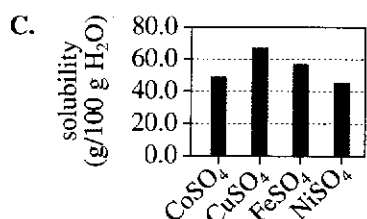
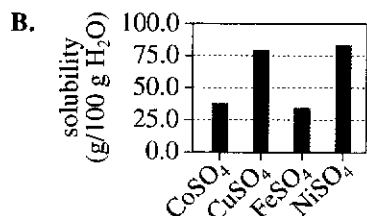
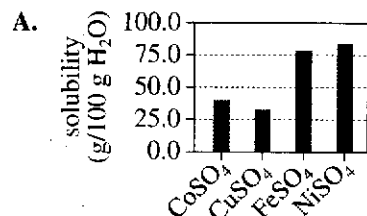
Figure 1 adapted from Jack Cazes, ed., *Ewing's Analytical Instrumentation Handbook*, 3rd ed. ©2005 by Marcel Dekker, Inc.

Table 2 shows the solubility in  $\text{H}_2\text{O}$  of each anhydrous salt at  $20^\circ\text{C}$ ,  $40^\circ\text{C}$ ,  $60^\circ\text{C}$ , and  $80^\circ\text{C}$ .

Table 2				
Temperature ( $^\circ\text{C}$ )	Solubility (g/100 g $\text{H}_2\text{O}^*$ ) of:			
	$\text{CoSO}_4$	$\text{CuSO}_4$	$\text{FeSO}_4$	$\text{NiSO}_4$
20	35.3	20.0	26.3	37.7
40	47.7	28.5	40.4	47.1
60	56.0	40.4	55.0	55.8
80	49.7	57.0	43.7	66.4
*grams of anhydrous salt per 100 grams of $\text{H}_2\text{O}$				

Tables 1 and 2 adapted from W. M. Haynes, ed., *CRC Handbook of Chemistry and Physics on CD-ROM*, Version 2011. ©2011 by CRC Press, LLC.

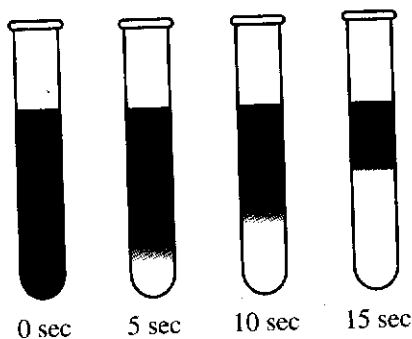
1. According to Table 2, which of the following graphs best shows, for each of the 4 anhydrous salts, the solubility in  $\text{H}_2\text{O}$  at  $80^\circ\text{C}$ ?



2. According to Table 2, as temperature increases from  $20^\circ\text{C}$  through  $80^\circ\text{C}$ , the solubility in  $\text{H}_2\text{O}$  of  $\text{CoSO}_4$  and the solubility in  $\text{H}_2\text{O}$  of  $\text{FeSO}_4$ :
- F. increase only.  
 G. decrease only.  
 H. increase, then decrease.  
 J. decrease, then increase.
3. Based on Table 1 and Figure 1, the color of the sample at  $30^\circ\text{C}$  was:
- A. blue.  
 B. pale green.  
 C. red.  
 D. yellow.
4. Based on Figure 1, as the sample was heated from  $0^\circ\text{C}$  to  $100^\circ\text{C}$ , the mass of the sample decreased by approximately:
- F. 7 g.  
 G. 14 g.  
 H. 21 g.  
 J. 28 g.
5. Based on Figure 1, the change that occurred in the sample as it was heated from  $175^\circ\text{C}$  to  $300^\circ\text{C}$  would be best represented by which of the following chemical equations?
- A.  $\text{CuSO}_4 \cdot \text{H}_2\text{O} \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$   
 B.  $\text{CuSO}_4 \cdot 3\text{H}_2\text{O} \rightarrow \text{CuSO}_4 \cdot \text{H}_2\text{O} + 2\text{H}_2\text{O}$   
 C.  $\text{CuSO}_4 + \text{H}_2\text{O} \rightarrow \text{CuSO}_4 \cdot \text{H}_2\text{O}$   
 D.  $\text{CuSO}_4 \cdot \text{H}_2\text{O} + 2\text{H}_2\text{O} \rightarrow \text{CuSO}_4 \cdot 3\text{H}_2\text{O}$
6. A student claimed that 50 g of  $\text{CuSO}_4$  will dissolve in 300 g of  $\text{H}_2\text{O}$  at  $20^\circ\text{C}$ . Does Table 2 support this claim?
- F. No; only 20 g of  $\text{CuSO}_4$  will dissolve.  
 G. No; only 40 g of  $\text{CuSO}_4$  will dissolve.  
 H. Yes; up to 60 g of  $\text{CuSO}_4$  will dissolve.  
 J. Yes; up to 80 g of  $\text{CuSO}_4$  will dissolve.

### Passage II

During a demonstration, a teacher placed 20 mL of water, 10 mL of *isopropyl alcohol* (IPA), and 1 drop of blue food coloring into a test tube, capped the test tube, and inverted it 6 times. Next, she added 7 g of *ammonium sulfate* (AS), an ionic solid, to the test tube, capped the test tube, and vigorously shook it for 10 sec. Then, over the 15 sec period immediately following the shaking, the mixture in the test tube completely separated into 2 distinct liquid layers (see figure).



Note: The darker liquid was blue, and the lighter liquid was colorless.

Figure adapted from Eric C. Person, Donnie R. Golden, and Brenda R. Royce, "Salting Effects as an Illustration of the Relative Strength of Intermolecular Forces." ©2010 by Division of Chemical Education, Inc., American Chemical Society.

The teacher asked each of 4 students to provide an explanation for what occurred in the test tube over the 15 sec period.

#### Student 1

Over the 15 sec, the mixture separated into 2 layers because IPA is denser than water. The water layer was on top, and the IPA layer was on the bottom. The AS dissolved in the IPA only, because AS breaks apart into neutral molecules when dissolved in IPA. Blue food coloring is polar, so it dissolved in the water only.

#### Student 2

Over the 15 sec, the mixture separated into 2 layers because water is denser than IPA. The IPA layer was on top, and the water layer was on the bottom. The AS dissolved in the water only, because AS breaks apart into neutral molecules when dissolved in water. Blue food coloring is polar, so it dissolved in the IPA only.

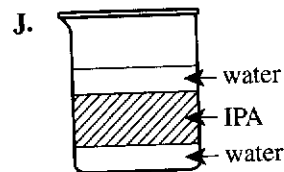
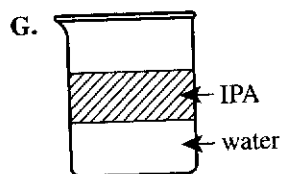
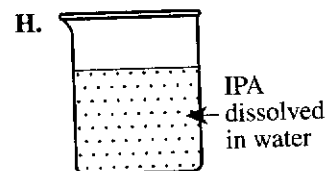
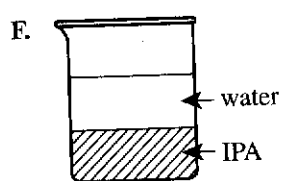
#### Student 3

Over the 15 sec, the mixture separated into 2 layers because the AS dissolved in the IPA only, causing the density of the IPA layer to increase. The water layer was on top, and the IPA layer was on the bottom. The AS dissolved in the IPA only, because AS breaks apart into ions when dissolved in IPA. Blue food coloring is polar, so it dissolved in the water only.

#### Student 4

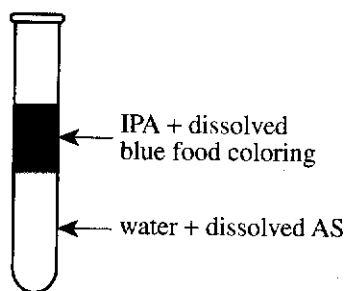
Over the 15 sec, the mixture separated into 2 layers because the AS dissolved in the water only, causing the density of the water layer to increase. The IPA layer was on top, and the water layer was on the bottom. The AS dissolved in the water only, because AS breaks apart into ions when dissolved in water. Blue food coloring is polar, so it dissolved in the IPA only.

7. Which of Students 1 and 2, if either, claimed that water is denser than IPA?
- A. Student 1 only  
B. Student 2 only  
C. Both Student 1 and Student 2  
D. Neither Student 1 nor Student 2
8. Suppose that 20 mL of water and 20 mL of IPA are poured into a beaker, mixed, and then allowed to settle. Based on Student 2's explanation, the resulting contents of the beaker would best be represented by which of the following diagrams?





9. Consider the diagram below.



The locations of the water, IPA, dissolved blue food coloring, and dissolved AS shown in the diagram are consistent with the explanation(s) given by which of the students?

- A. Student 1 only
  - B. Student 4 only
  - C. Students 1 and 3 only
  - D. Students 2 and 4 only
10. Which students, if any, would be likely to agree that after the 2 layers completely separated, the blue food coloring and the AS were both dissolved in the same layer?
- F. Students 1 and 3 only
  - G. Students 1, 2, and 4 only
  - H. Students 2, 3, and 4 only
  - J. None of the students

11. Based on the figure, 5 sec after the shaking, would the contents of the test tube have been better classified as a heterogeneous mixture or a homogeneous mixture?

- A. Heterogeneous, because the contents of the test tube varied in composition from one region to another.
  - B. Heterogeneous, because the contents of the test tube were uniform in composition throughout.
  - C. Homogeneous, because the contents of the test tube varied in composition from one region to another.
  - D. Homogeneous, because the contents of the test tube were uniform in composition throughout.
12. The statement "When AS dissolves in a liquid, the density of the resulting solution is greater than the density of the liquid alone" is consistent with the explanation(s) given by which of Students 3 and 4, if either?
- F. Student 3 only
  - G. Student 4 only
  - H. Both Student 3 and Student 4
  - J. Neither Student 3 nor Student 4
13. The chemical formula of AS is  $(\text{NH}_4)_2\text{SO}_4$ . Based on Student 3's explanation, which of the following chemical equations best represents a process that only occurred in the IPA?

- A.  $(\text{NH}_4)_2\text{SO}_4 \rightarrow 2\text{NH}_4^+ + \text{SO}_4^{2-}$
- B.  $(\text{NH}_4)_2\text{SO}_4 \rightarrow 2\text{NH}_4 + \text{SO}_4$
- C.  $(\text{NH}_4)_2\text{SO}_4 \rightarrow 2\text{NH}_4\text{SO}_4^{2+}$
- D.  $(\text{NH}_4)_2\text{SO}_4 \rightarrow 2\text{NH}_4\text{SO}_4$

### Passage III

A consumer safety laboratory conducted 3 studies of vehicle braking performance under various conditions.

#### Study 1

Each of 3 identical vehicles was equipped with a different braking system (System X, System Y, or System Z). Each vehicle was subjected to 10 trials on a dry road and 10 trials on a wet road. In each trial, the following steps were performed:

1. The vehicle was accelerated to 30 m/sec.
2. The braking system was fully engaged, and the vehicle's *stopping distance*,  $S$  (the distance required for the vehicle to come to a stop), was measured.
3. The vehicle's *braking deceleration*,  $B$  (the average rate at which the vehicle's speed decreased while the braking system was engaged), was calculated using the equation

$$B = \frac{(30 \text{ m/sec})^2}{2 \times S}$$

The results of each set of 10 trials were then averaged to obtain an average  $S$  (in m) and an average  $B$  (in  $\text{m/sec}^2$ ) for each braking system on each type of road. Table 1 shows the results.

Table 1			
System	Road type	Average $S$ (m)	Average $B$ ( $\text{m/sec}^2$ )
X	dry	43.1	10.4
	wet	45.8	9.8
Y	dry	57.5	7.7
	wet	62.6	7.2
Z	dry	45.1	10.0
	wet	52.3	8.6

#### Study 2

Three hundred kilograms of cargo was placed into each of the vehicles that were tested in Study 1, and the procedures of Study 1 were repeated. Table 2 shows the results.

Table 2			
System	Road type	Average $S$ (m)	Average $B$ ( $\text{m/sec}^2$ )
X	dry	46.9	9.6
	wet	49.9	9.0
Y	dry	60.7	7.4
	wet	63.9	7.0
Z	dry	46.3	9.7
	wet	58.0	7.6

#### Study 3

System X was installed in a compact car, a sedan, a minivan, and a truck. The procedures for determining average  $S$  in Study 1 were then repeated for each vehicle, without cargo, on both the dry and wet roads (see Figure 1).

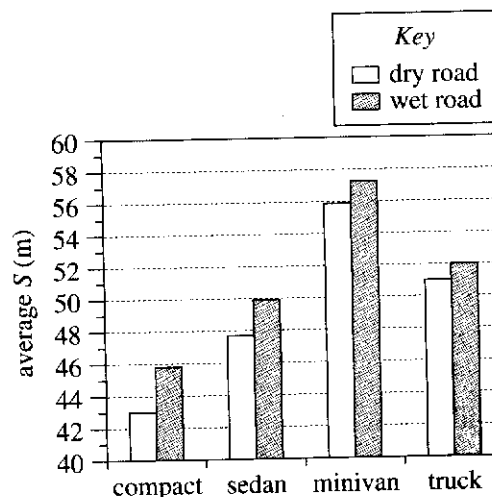


Figure 1

Tables and figure adapted from United States Department of Transportation, *Final Report for the Methodology Study of the Consumer Braking Information Initiative*. 1999.

14. Which of the following statements about the design of the 3 studies is consistent with their descriptions?

F. Study 1 was the only study in which more than 3 vehicles were involved.  
 G. Study 2 was the only study in which cargo was involved.  
 H. Studies 1 and 3 were the only 2 studies in which vehicles were tested on both road types.  
 J. Studies 2 and 3 were the only 2 studies in which System Z was not tested.

15. Any braking system that resulted in an average  $S$  that was *greater* than 50.0 m was designated as “unsafe” by the researchers at the laboratory. Based on the results of Studies 1 and 2, which system(s) was(were) most likely designated as “unsafe” under at least 1 set of conditions?

A. System Y only  
 B. Systems X and Y only  
 C. Systems Y and Z only  
 D. Systems X, Y, and Z

16. The table below gives the masses of the vehicles tested in Study 3.

Vehicle	Mass (kg)
Compact	1,302
Sedan	1,732
Minivan	3,039
Truck	2,342

For a given road type, as vehicle mass increased, the average  $S$ :

F. increased only.  
 G. decreased only.  
 H. did not vary.  
 J. varied, but with no general trend.

17. Consider the set of 10 trials in Study 2 in which the vehicle equipped with System Y was tested on the dry road. Which of the following statements about the vehicle’s 10 stopping distances is most likely correct?

A. All 10 distances were less than 60.7 m.  
 B. All 10 distances were equal to 60.7 m.  
 C. All 10 distances were greater than 60.7 m.  
 D. Some of the distances were less than 60.7 m, and some of the distances were greater than 60.7 m.

18. Suppose that in Study 3, a fifth vehicle had been tested on the dry road, and its average  $B$  was determined to be  $7.7 \text{ m/sec}^2$ . Based on the results of Study 1, the average  $S$  for this vehicle on the dry road would most likely have been closest to the average  $S$  in Study 3 for which other type of vehicle on the dry road?

F. Compact  
 G. Sedan  
 H. Minivan  
 J. Truck

19. According to the results of Studies 1 and 2, compared with the trials performed on the dry road, the trials performed on the wet road resulted in:

A. greater average stopping distances and greater average braking decelerations.  
 B. greater average stopping distances and lesser average braking decelerations.  
 C. lesser average stopping distances and greater average braking decelerations.  
 D. lesser average stopping distances and lesser average braking decelerations.

20. In a new set of 10 trials performed on the dry road, the vehicle with System Z was accelerated to  $60 \text{ m/sec}$  with no cargo. To calculate  $B$ , the following equation was used:

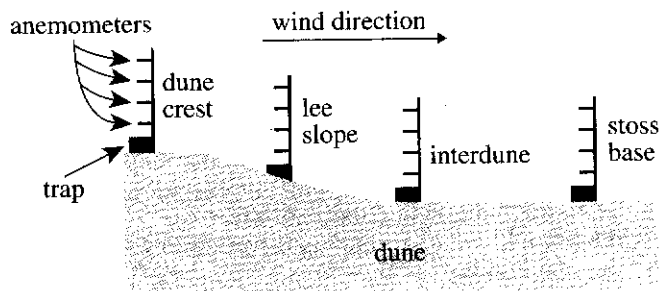
$$B = \frac{(60 \text{ m/sec})^2}{2 \times S}$$

The average  $B$  for this set of trials was  $10.0 \text{ m/sec}^2$ . Was the average  $S$  more likely less than 45.1 m or greater than 45.1 m?

F. Less; a vehicle decelerating at the same rate from a lower speed requires less distance to come to a stop.  
 G. Less; a vehicle decelerating at the same rate from a higher speed requires less distance to come to a stop.  
 H. Greater; a vehicle decelerating at the same rate from a lower speed requires more distance to come to a stop.  
 J. Greater; a vehicle decelerating at the same rate from a higher speed requires more distance to come to a stop.

### Passage IV

Scientists studied the speed of the wind and the size of sand grains at 4 sites on a sand dune (see diagram). At each site, 4 *anemometers* (devices for measuring wind speed) were attached to a vertical pole at different heights above the ground, and a sand trap was placed at the base of the pole. Each trap could collect only windblown sand grains having diameters from 0.0625 mm to 0.5 mm.



Note: Diagram is not to scale.

diagram of sites

### Study

Over a particular 45 min period, wind speed was measured multiple times by each anemometer and sand was collected at all 4 sites.

The average wind speed at each anemometer for the 45 min period was calculated. Then each average wind speed was converted to a *relative wind speed*. (The relative wind speed at an anemometer equaled the average wind speed at the anemometer divided by the average wind speed 12.0 m above the ground at the dune crest site for the same period.) The results are shown in Figure 1.

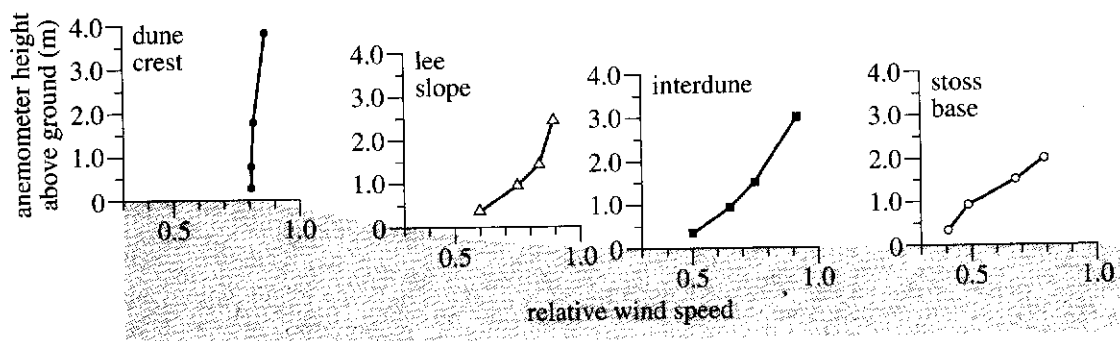
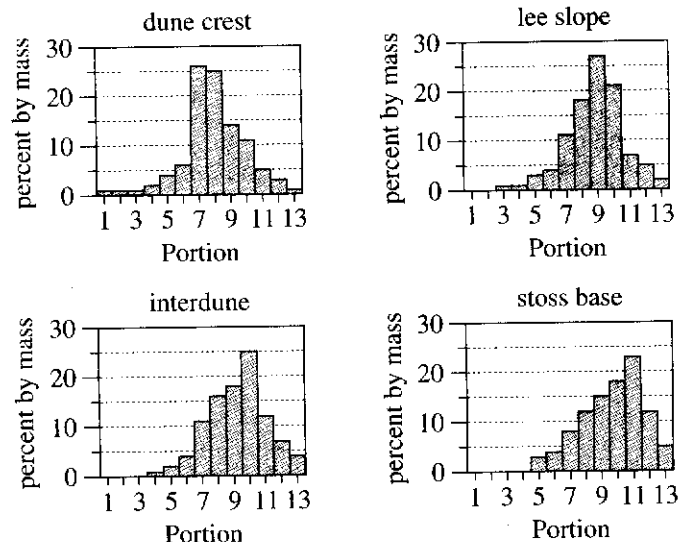


Figure 1

The mass of the sand collected at each site was measured. Then the sand from each site was sifted through a stack of 12 screens to separate the grains into 13 portions according to diameter. (Each screen had uniform openings of a smaller diameter than the openings in the screen above.) The percent of the sand's mass from grains making up each of the 13 portions was determined (see Figure 2).



Note: The average diameter of the sand grains in a portion decreases to the right along the x-axis.

Figure 2

Figures adapted from Ian Walker, "Secondary Airflow and Sediment Transport in the Lee of a Reversing Dune." ©1999 by John Wiley and Sons, Ltd.



21. According to Figure 1, at the interdune site, as anemometer height above the ground increased, relative wind speed:
- increased only.
  - decreased only.
  - increased, then decreased.
  - decreased, then increased.
22. According to Figure 2, sand grains making up which 2 adjacent portions accounted for more than half of the total mass of the collected sand from the dune crest site?
- Portions 5 and 6
  - Portions 6 and 7
  - Portions 7 and 8
  - Portions 8 and 9
23. If in the study an anemometer had been attached to the pole at the dune crest site at a height of 4.1 m above the ground, the relative wind speed at that anemometer would most likely have been closest to which of the following?
- 0.2
  - 0.4
  - 0.6
  - 0.8
24. What was the average wind speed 12.0 m above the ground at the dune crest site for the 45 min period?
- 0.5 m/sec
  - 1.0 m/sec
  - 5.0 m/sec
  - Cannot be determined from the given information
25. The *best-sorted* sand in the study was the sand made up of grains having the smallest range of diameters. Based on Figure 2, the collected sand from which site was the best sorted?
- Dune crest
  - Lee slope
  - Interdune
  - Stoss base
26. Suppose that the collected sand from the stoss base site had a total mass of 200 g. Based on Figure 2, the sand grains making up Portion 9 would have had a mass closest to which of the following?
- 10 g
  - 20 g
  - 30 g
  - 40 g
27. The *medium* sand grains collected in the study were those that made up Portions 1–4, and the *very fine* sand grains collected in the study were those that made up Portions 10–13. According to Figure 2, from site to site downwind, how did the total percent by mass of the medium sand grains change, and how did the total percent by mass of the very fine sand grains change?
- |    | <u>medium sand grains</u> | <u>very fine sand grains</u> |
|----|---------------------------|------------------------------|
| A. | decreased                 | increased                    |
| B. | increased                 | decreased                    |
| C. | increased                 | increased                    |
| D. | decreased                 | decreased                    |

### Passage V

As a person ages, the levels of *antioxidants*—compounds that reduce the number of cell-damaging *reactive oxygen molecules* (ROM)—may decrease in the body. Tea extracts are a dietary source of antioxidants.

Table 1 shows the percent by mass of each of the 4 major antioxidants (A1–A4) present in 5 tea extracts (T1–T5).

Table 1				
Tea extract	Antioxidant (percent by mass)			
	A1	A2	A3	A4
T1	1	1	8	14
T2	5	4	1	7
T3	1	1	10	21
T4	13	8	1	1
T5	1	1	2	12

Researchers studied the ability of A1–A4 and of T1–T5 to reduce the number of ROM.

#### Study 1

Solutions having the same concentration of ROM and various concentrations of A1, A2, A3, or A4 were incubated, each in a separate test tube at 25°C for 30 min. The compound NBT was then added to each tube, where it reacted with all the remaining ROM to form the blue dye *formazan*. Figure 1 shows, for A1–A4, how the formazan concentration varied with the initial antioxidant concentration.

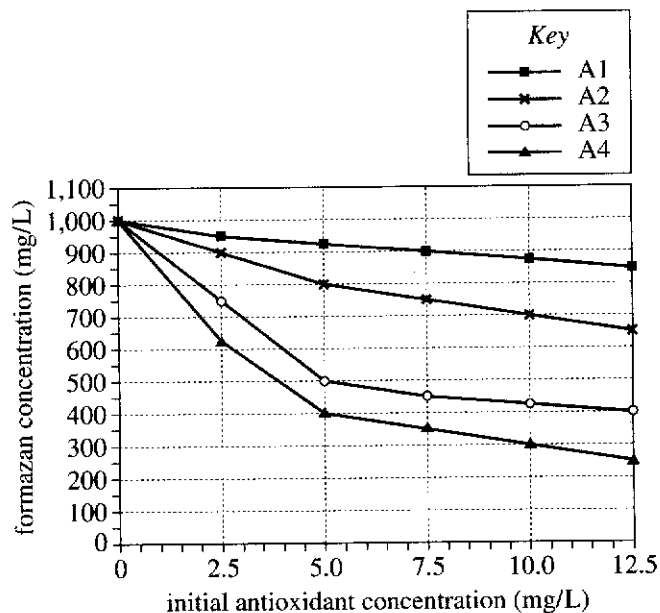


Figure 1

Figure 1 adapted from T. Nakagawa and T. Yokozawa, "Direct Scavenging of Nitric Oxide and Superoxide by Green Tea." ©2002 by Elsevier Inc.

#### Study 2

Elderly male rats received the same daily dose of T1, T2, T3, T4, or T5, or water only, for 4 weeks. A 1 mg sample of heart tissue was then collected from each rat.

Each sample was placed in a separate test tube containing 10 mL of a solution of the compound TBA. Each tube was incubated at 100°C for 1 hr to allow the TBA to react with all the *malondialdehyde* (a product of ROM cell damage) in the sample to form a pink dye. The concentration of pink dye was measured to determine the malondialdehyde concentration and, thus, the extent of ROM cell damage in the sample.



Figure 2 shows the average malondialdehyde concentration of the solutions resulting from each treatment.

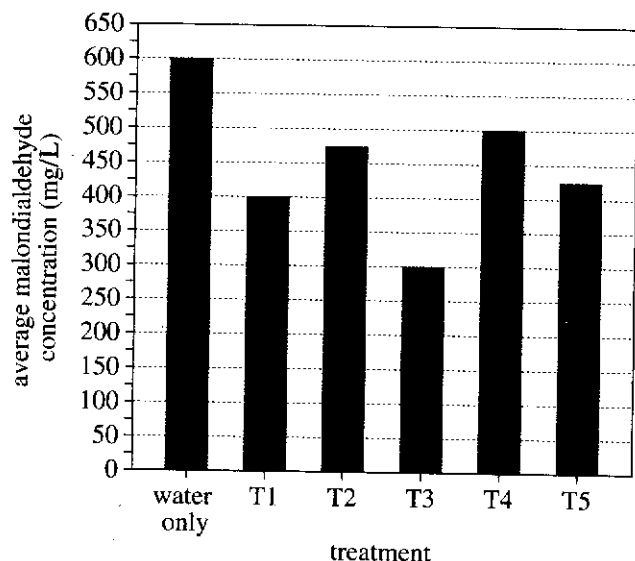


Figure 2

Figure 2 adapted from Vadivel S. Kumaran, Karpagavinayagam Arulmathi, and Periandavan Kalaiselvi, "Senescence Mediated Redox Imbalance in Cardiac Tissue: Antioxidant Rejuvenating Potential of Green Tea Extract." ©2009 by Elsevier Inc.

28. Based on the results of Study 1, at an initial antioxidant concentration of 5.0 mg/L, the solution containing which antioxidant had the *lowest* dye concentration?

F. A1  
G. A2  
H. A3  
J. A4

29. If a trial had been done in Study 1 at an initial A3 concentration of 4.0 mg/L, the formazan concentration would most likely have been closest to which of the following?

A. 500 mg/L  
B. 600 mg/L  
C. 850 mg/L  
D. 950 mg/L

30. Based on the results of Study 2, which tea extract was most effective at reducing the number of ROM in rat heart tissue?

F. T1  
G. T2  
H. T3  
J. T4

31. Consider the results of the trials in Study 1 for the 4 antioxidants at any given initial antioxidant concentration. For which of the following reasons could these results be validly compared? The solutions in the test tubes had:

A. the same initial concentration of malondialdehyde.  
B. different initial concentrations of malondialdehyde.  
C. the same initial concentration of ROM.  
D. different initial concentrations of ROM.

32. In which study was the incubation temperature of the solutions higher, and in which study was the incubation time for the solutions longer?

	temperature	time
F.	Study 1	Study 1
G.	Study 1	Study 2
H.	Study 2	Study 1
J.	Study 2	Study 2

33. Suppose that in a new study the procedures of Study 2 are repeated except that the rats receive only 50% of the daily dose of each tea extract that the rats received in Study 2. Would the malondialdehyde concentration measured for T1 more likely be higher or lower than the value for T1 shown in Figure 2?

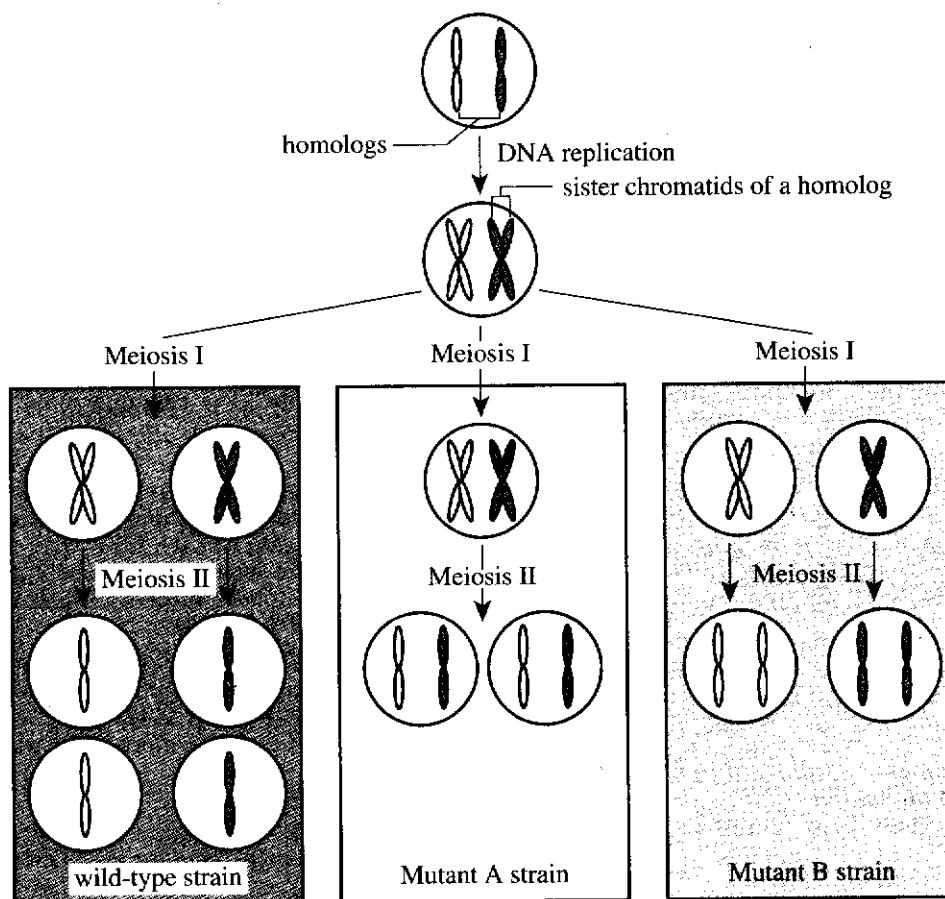
A. Higher, because fewer ROM would be eliminated.  
B. Higher, because more ROM would be eliminated.  
C. Lower, because fewer ROM would be eliminated.  
D. Lower, because more ROM would be eliminated.

34. In Study 1, each test tube was incubated for 30 min to allow sufficient time for the ROM to react with the:

F. antioxidant.  
G. formazan.  
H. NBT.  
J. tea extract.

### Passage VI

In the yeast *Saccharomyces cerevisiae*, the function of meiosis is to divide a diploid cell into 4 haploid cells called *spores*. During meiosis, the 2 copies of a chromosome, or *homologs*, undergo DNA replication (when each homolog becomes a linked pair of sister chromatids) followed by 2 rounds of chromosome *segregation* (separation into different cells) called Meiosis I and Meiosis II. The figure shows the homologs of a particular chromosome during meiosis in a wild-type *S. cerevisiae* strain and also in 2 mutant *S. cerevisiae* strains (Mutant A and Mutant B) each having a different mutation that affects meiosis.



Note: Each cell shown after Meiosis II is an *S. cerevisiae* spore, although the genetic content of the cells may vary.

Figure adapted from Andrew Murray and Tim Hunt, *The Cell Cycle*. ©1993 by W. H. Freeman and Company.





35. According to the figure, how many cells are directly produced by Meiosis I in the Mutant A *S. cerevisiae* strain, and how many cells are directly produced by Meiosis I in the Mutant B *S. cerevisiae* strain?

	Mutant A strain	Mutant B strain
A.	1	1
B.	1	2
C.	2	1
D.	4	2

36. According to the figure, does meiosis in the Mutant B *S. cerevisiae* strain produce as many spores as does meiosis in a wild-type *S. cerevisiae* strain?

- F. No; 2 Mutant B *S. cerevisiae* spores are produced.  
 G. No; 4 Mutant B *S. cerevisiae* spores are produced.  
 H. Yes; 2 Mutant B *S. cerevisiae* spores are produced.  
 J. Yes; 4 Mutant B *S. cerevisiae* spores are produced.

37. Suppose that 10 chromosomes were found in each of the spores of another species of yeast, Species X. Assuming that there were no mutations that affected the formation of the spores, what is the diploid number of chromosomes of Species X?

- A. 2  
 B. 5  
 C. 20  
 D. 40

38. Based on the figure, which of the 2 mutant *S. cerevisiae* strains, if either, has(have) a mutation that affects Meiosis I?

- F. The Mutant A strain only  
 G. The Mutant B strain only  
 H. Both the Mutant A strain and the Mutant B strain  
 J. Neither the Mutant A strain nor the Mutant B strain

39. The depiction of meiosis in the figure for which of the three *S. cerevisiae* strains, if any, is consistent with the statement "DNA replication occurs between Meiosis I and Meiosis II"?

- A. The wild-type strain  
 B. The Mutant A strain  
 C. The Mutant B strain  
 D. None of the strains; DNA replication occurs before Meiosis I.

40. Based on the figure, for a wild-type *S. cerevisiae* strain, the total mass of DNA per cell is greatest at a time between the:

- F. end of interphase and the start of DNA replication.  
 G. end of DNA replication and the start of Meiosis I.  
 H. end of Meiosis I and the start of Meiosis II.  
 J. end of Meiosis II and the start of interphase.

**END OF TEST 4**

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



A.C.T. ANSWER KEY  
April 2019 (EXT)

Section 1		Section 2		Section 3		Section 4	
<u>ENGLISH</u>		<u>MATH</u>		<u>READING</u>		<u>SCIENCE</u>	
1. D	41. D	1. A	41. E	1. C		1. D	
2. G	42. G	2. J	42. G	2. H		2. H	
3. A	43. A	3. B	43. C	3. D		3. A	
4. G	44. J	4. H	44. F	4. F		4. G	
5. D	45. C	5. C	45. A	5. C		5. A	
6. J	46. G	6. G	46. K	6. J		6. H	
7. B	47. C	7. A	47. D	7. D		7. B	
8. G	48. F	8. G	48. J	8. G		8. G	
9. C	49. D	9. A	49. D	9. C		9. D	
10. H	50. F	10. F	50. G	10. J		10. J	
11. C	51. A	11. B	51. B	11. A		11. A	
12. G	52. H	12. F	52. H	12. G		12. H	
13. D	53. A	13. A	53. C	13. D		13. A	
14. F	54. J	14. H	54. K	14. H		14. G	
15. C	55. D	15. A	55. A	15. B		15. C	
16. G	56. G	16. J	56. K	16. F		16. F	
17. A	57. A	17. E	57. D	17. B		17. D	
18. F	58. G	18. F	58. G	18. F		18. H	
19. D	59. D	19. E	59. C	19. B		19. B	
20. H	60. H	20. H	60. G	20. H		20. J	
21. B	61. D	21. E		21. B		21. A	
22. H	62. J	22. K		22. G		22. H	
23. D	63. D	23. D		23. C		23. D	
24. F	64. H	24. K		24. H		24. J	
25. B	65. A	25. C		25. C		25. D	
26. J	66. G	26. F		26. G		26. H	
27. A	67. A	27. B		27. B		27. A	
28. H	68. H	28. H		28. F		28. J	
29. A	69. B	29. D		29. D		29. B	
30. H	70. G	30. J		30. F		30. H	
31. B	71. C	31. E		31. B		31. C	
32. H	72. F	32. H		32. G		32. J	
33. B	73. C	33. E		33. D		33. A	
34. J	74. J	34. G		34. J		34. F	
35. D	75. A	35. C		35. C		35. B	
36. J		36. F		36. F		36. F	
37. A		37. D		37. B		37. C	
38. J		38. G		38. H		38. F	
39. C		39. E		39. A		39. D	
40. H		40. J		40. F		40. G	

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

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

**ACT Test Z15** **Your Scale Score**

English \_\_\_\_\_

Mathematics \_\_\_\_\_

Reading \_\_\_\_\_

Science \_\_\_\_\_

**Sum of scores** \_\_\_\_\_

**Composite score (sum ÷ 4)** \_\_\_\_\_

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

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

Scale Score	Raw Scores				Scale Score
	Test 1 English	Test 2 Mathematics	Test 3 Reading	Test 4 Science	
36	74-75	59-60	40	39-40	36
35	71-73	57-58	39	38	35
34	70	56	38	37	34
33	68-69	55	37	36	33
32	67	54	36	35	32
31	66	53	35	34	31
30	65	52	34	—	30
29	63-64	50-51	33	33	29
28	62	47-49	32	32	28
27	60-61	44-46	31	31	27
26	58-59	41-43	30	30	26
25	56-57	39-40	29	28-29	25
24	53-55	36-38	28	26-27	24
23	50-52	34-35	26-27	25	23
22	47-49	32-33	24-25	23-24	22
21	44-46	30-31	23	21-22	21
20	41-43	29	21-22	19-20	20
19	39-40	26-28	20	18	19
18	37-38	23-25	19	16-17	18
17	34-36	20-22	17-18	15	17
16	32-33	16-19	16	13-14	16
15	28-31	12-15	14-15	12	15
14	26-27	10-11	13	11	14
13	24-25	8-9	12	9-10	13
12	22-23	6-7	10-11	8	12
11	19-21	5	9	7	11
10	16-18	4	8	6	10
9	14-15	—	7	5	9
8	12-13	3	6	4	8
7	10-11	2	5	—	7
6	8-9	—	4	3	6
5	6-7	—	3	2	5
4	5	1	—	—	4
3	3-4	—	2	1	3
2	2	—	1	—	2
1	0-1	0	0	0	1