

# Form E25

(April 2022)



The **ACT**<sup>®</sup>

2021 | 2022

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.

## Directions

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

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

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

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

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

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

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

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

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

## 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

## Deborah Sampson: A Revolutionary Hero

[1]

US history books have traditionally chronicled the actions of male Revolutionary War heroes such as<sup>1</sup> George Washington, Paul Revere, and John Paul Jones. Increasingly, such books include accounts of the many brave women which<sup>2</sup> also contributed—as spies and soldiers—to the effort to gain independence from British rule.

[2]

Deborah Sampson of Plympton, Massachusetts, was one of these women.<sup>3</sup> In 1782,

despite the fact that<sup>4</sup> women weren’t allowed to serve in the military, twenty-one-year-old Sampson joined the colonial army. She disguised herself as a man and enlisted under the name of Robert Shurtliff.

1. A. NO CHANGE  
B. heroes, such as,  
C. heroes: such as  
D. heroes such as,
2. F. NO CHANGE  
G. whom  
H. who  
J. DELETE the underlined portion.

3. Given that all the choices are accurate, which one most clearly signals that the paragraph will focus on Sampson’s Revolutionary War experience?  
A. NO CHANGE  
B. a house servant for many years.  
C. tall for a woman of her time.  
D. a capable young woman.
4. F. NO CHANGE  
G. given that  
H. because  
J. and

[3]

For fourteen months Sampson served in the army,  
<sup>5</sup>  
 she acted with exceptional bravery and fortitude. Her  
 commanding officers quickly recognized these traits and  
 sent her on several special missions. On one such mission  
<sup>6</sup>  
 near West Point, New York, Sampson was part of a  
 scouting party whose assignment to track and capture  
<sup>7</sup>  
 a British convoy. While pursuing several British soldiers  
 into a swamp, Sampson was shot in the leg. Fearing that  
 her true identity would be discovered, she did not report  
 to the hospital. Instead, Sampson removed the musket ball  
 by herself.

[4]

On another scouting mission, Sampsons' party,  
<sup>8</sup>  
 was ambushed by British soldiers. To escape the scouts  
<sup>9</sup>  
 had to wade across a river. A fierce current swept  
<sup>10</sup>  
 Sampson into deep waters. It was the weight of  
<sup>11</sup>  
 her heavy backpack and musket, Sampson struggled.  
 For instance, a colonial soldier standing on a sandbar  
<sup>12</sup>  
 threw her a rope. Summoning her strength, Sampson  
 plucked from the air that which was to save her and  
<sup>13</sup>  
 made it to shore. [A]

5. A. NO CHANGE  
 B. In the fourteen months that Sampson served in the army,  
 C. Sampson served in the army for fourteen months,  
 D. Her fourteen months of service in the army,
6. F. NO CHANGE  
 G. one of such  
 H. such a one  
 J. such
7. A. NO CHANGE  
 B. their assignment was  
 C. who's been assigned  
 D. assigned
8. F. NO CHANGE  
 G. Sampson's party  
 H. Sampsons' party  
 J. Sampsons party
9. A. NO CHANGE  
 B. escape, the scouts,  
 C. escape the scouts,  
 D. escape, the scouts
10. Given that all the choices are accurate, which one most effectively advances the narration of events in the paragraph?  
 F. NO CHANGE  
 G. demonstrate courage.  
 H. help one another.  
 J. act quickly.
11. A. NO CHANGE  
 B. She felt weighted down by  
 C. Weighted down by  
 D. The weight of
12. F. NO CHANGE  
 G. Moreover, a  
 H. Instead, a  
 J. A
13. A. NO CHANGE  
 B. reached up from the deep water and took hold of the rope thrown by the colonial soldier  
 C. relied on assistance from a colonial soldier  
 D. caught the rope

[5]

Sampson survived the winter and spring with her secret undiscovered. [B] In July 1783, however, she was found out. [C] While this meant that she could no longer serve in the army, her exemplary record as a soldier was officially recognized. [D] Later, she was awarded a military pension as a sign of gratitude from the young nation she had helped found.<sup>14</sup>

14. Which of the following alternatives to the underlined portion would NOT be acceptable?
- F. pension, which was
  - G. pension, for which
  - H. pension. It was
  - J. pension,

Question 15 asks about the preceding passage as a whole.

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

When she was hospitalized for a severe fever, authorities discovered that she was a woman.

The sentence would most logically be placed at:

- A. Point A in Paragraph 4.
- B. Point B in Paragraph 5.
- C. Point C in Paragraph 5.
- D. Point D in Paragraph 5.

## PASSAGE II

### Senator Fong's Plantation and Gardens

[1]

With a full career in both politics and business, Hiram Fong never set out to develop one of Oahu's most spectacularly horticulture attractions. [A] Fong, whose political career<sup>16</sup> spanned over thirty years, was one of the first two senators from Hawaii to become a state in 1959 and the first Asian American to serve in the US Senate.<sup>17</sup>

16. F. NO CHANGE  
 G. spectacular horticulturally  
 H. spectacular horticultural  
 J. spectacle horticultural
17. A. NO CHANGE  
 B. when it became  
 C. that became  
 D. becoming

Prior to working in politics, Fong paid his own way through Harvard Law School and, upon graduating, was a part of a law firm. [B] All the while, gardening <sup>18</sup> was his escape.

[2]

19 Wanting

to experiment with growing <sup>20</sup> fruit, he planted bananas, then papaya, lemon, jackfruit, and avocado. [C] By also choosing to plant crops such as bamboo, coconut, betel nut, and turmeric, he broadened the types of plants in his garden. <sup>21</sup> He cultivated slopes covered with ti and pili grasses and forests of trees such as kukui, hala, and koa, vegetation

previously an abundance on Oahu. <sup>22</sup>

[3]

After he retired from politics in 1977, Fong continued to oversee his companies, but he focused on gardening, personally importing and planting countless species of plants. Eventually, he divided his land into five gardens, each one named for a US president whom had served while <sup>23</sup> Fong was a senator. The Eisenhower Plateau is dedicated

18. Which choice most clearly suggests that Fong had a primary role in the start-up and development of the law firm referred to in the sentence?

- F. NO CHANGE
- G. assisted in the business of
- H. helped found and run
- J. became employed at

19. Which of the following true statements, if added here, would most logically lead into the information that follows in the paragraph?

- A. Today, Fong's family maintains his gardens and visitors' center—one of his sons is the head gardener, and his daughter-in-law leads classes and tours.
- B. By 1950, Fong was in the market to purchase a large plot of land, an acreage that would provide room for his horses.
- C. In 1950, Fong purchased more than 700 acres of land on Oahu, above Kaneohe Bay.
- D. The acreage once operated as a banana plantation.

20. F. NO CHANGE

- G. to try and to experiment with
- H. the experimentation of
- J. and experimenting

21. Given that all the choices are accurate, which one provides the most clear and direct purpose, related to Hawaii's natural history, for Fong's planting crops such as bamboo, coconut, betel nut, and turmeric?

- A. NO CHANGE
- B. not only grew cash crops, such as fruit, but additionally crops that have other purposes.
- C. developed a landscape reminiscent of Hawaii hundreds of years ago.
- D. began to create a garden unlike any other on Hawaii today.

22. F. NO CHANGE

- G. that are once plenty
- H. formerly many
- J. once common

23. A. NO CHANGE

- B. being one who
- C. of whom
- D. who

to native Chinese plants, such as the Hong Kong

orchid tree and the Java plum. The Johnson

Plateau features exotic fruits. 24 Kennedy

Valley, with its rain forest canopy,  
25

recommends ginger and palms from  
26

all over the world. Nixon Valley will abound with  
27  
flowers—plumeria, crown flower, and bougainvillea  
are just a few—while the Ford Plateau highlights  
hillsides of pili grasses.

[4]

The preserve, bearing his name, is now named  
28  
Senator Fong's Plantation and Gardens, complete with  
a visitors' center and guided tours. [D] Until his death in  
2004 at ninety-seven, Fong spent every weekend tending  
to his flowers and trees and a moment to mingle with  
29  
visitors. He credited gardening for his long, healthy life.

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

In 1989, the State Department of Agriculture commemorated the bicentennial of Chinese immigrants' arrival to Hawaii by giving one hundred rare sandalwood trees to Fong to plant on his land.

Should the writer make this addition here?

- F. Yes, because it suggests that the State Department of Agriculture was supportive of Fong's endeavor and the expansion of his gardens.  
G. Yes, because it provides information about a type of tree in Fong's gardens that has not yet been mentioned in the essay.  
H. No, because it interrupts the paragraph's focus on providing an overview of the plants in each of the five presidential gardens.  
J. No, because it provides scientific information about sandalwood trees that is inconsistent with the tone of the essay.
25. A. NO CHANGE  
B. their  
C. it's  
D. its'
26. F. NO CHANGE  
G. subsidizes  
H. supports  
J. endures
27. A. NO CHANGE  
B. had abounded  
C. abounding  
D. abounds
28. F. NO CHANGE  
G. preserve, which includes a visitors' center,  
H. preserve, having been named after Fong,  
J. preserve
29. A. NO CHANGE  
B. having mingled  
C. then mingles  
D. mingling



Question 30 asks about the preceding passage as a whole.

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

Fong eventually led several companies.

The sentence would most logically be placed at:

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

### PASSAGE III

#### Rescuing the Lord Howe Stick Insect

[1]

Two men ascend the face of Ball’s Pyramid—a rocky island in the Tasman Sea that looks like a mountain jutting

up from the waves. The men, Nicholas Carlile and Dean<sup>31</sup> Hiscox, have cameras and flashlights; it is dark. They are

heading for a specific melaleuca bush that is hanging<sup>32</sup> 225 feet above the ocean. When they reach it, they find twenty-four enormous black insects. Wingless and up to fifteen inches long, the men see *Dryococelus australis*—a<sup>33</sup> nocturnal species that had been believed to be extinct for over eighty years.

[2]

*Dryococelus australis*, also known as the Lord Howe stick insect, is native to Lord Howe Island, located less

than fifteen miles to Ball’s Pyramid. [A] The insects<sup>34</sup> are so large that 1800s European sailors called them

“tree lobsters.” The animals thrived on Lord Howe

Island until 1918, when a British supply ship ran

aground while the ship was being repaired, rats escaped<sup>35</sup> onto the island and quickly wiped out the stick insects.

- 31. A. NO CHANGE  
B. men, Nicholas Carlile,  
C. men: Nicholas Carlile  
D. men Nicholas Carlile,
- 32. F. NO CHANGE  
G. bush, that is, hanging  
H. bush, that is hanging,  
J. bush that is hanging,
- 33. A. NO CHANGE  
B. the men have found  
C. the insects are  
D. DELETE the underlined portion.

- 34. F. NO CHANGE  
G. than fifteen miles from  
H. then fifteen miles from  
J. then fifteen miles to
- 35. A. NO CHANGE  
B. aground and while the ship was being repaired,  
C. aground. While the ship was being repaired,  
D. aground, while the ship was being repaired



[3]

By 1920, the insects were presumed to be extinct. 36

For decades, though the island's remote location and <sup>37</sup>dangerous waters made a thorough search difficult, so the insects' <sup>37</sup>survival wasn't confirmed until 2001. [B]

[4]

Carlile and Hiscox's find raised a question—what should be done with the <sup>38</sup>rare insects? In 2003, the Australian government permitted the removal of four insects from the island in order to bring the species back in <sup>39</sup>the brink of extinction. [C] Two of the insects were transported to the Melbourne Zoo, where invertebrate conservation expert Patrick Honan, <sup>40</sup>

took charge of it. <sup>41</sup>Starting with only thirty

eggs, Honan <sup>42</sup>was able to

activate <sup>43</sup>the population of these rare insects. [D]

36. Which of the following true statements, if added here, would provide the most effective transition to the information in the rest of the paragraph?

- F. Ball's Pyramid is named for Lieutenant Henry Ball, who spotted it in 1788.
- G. Then, in the 1960s, climbers on Ball's Pyramid reported sighting a large insect.
- H. Ball's Pyramid is the tip of an enormous volcano.
- J. There are thousands of stick insect species.

37. A. NO CHANGE

- B. though, the island's remote location and dangerous waters made
- C. though, the island's remote location and dangerous waters making
- D. though the island's remote location, and dangerous waters making

38. F. NO CHANGE

- G. question; what should be done,
- H. question, what should be done,
- J. question, what should be done

39. A. NO CHANGE

- B. over from
- C. back from
- D. against

40. F. NO CHANGE

- G. expert, Patrick Honan,
- H. expert, Patrick Honan
- J. expert Patrick Honan

41. A. NO CHANGE

- B. them.
- C. that.
- D. this.

42. F. NO CHANGE

- G. Honan, working at the Melbourne Zoo,
- H. Honan, who works with insects,
- J. Honan, an expert,

43. A. NO CHANGE

- B. retrieve
- C. revive
- D. rouse

[5]

Though the species is now safe, the insects' fame is spreading. Some stick insects will remain at the zoo as an "insurance population," but the ultimate goal is to reintroduce the insects to their native habitat on Lord Howe Island.

44. Given that all the choices are accurate, which one offers the most logical contrast to the first part of the sentence?
- F. NO CHANGE
  - G. prospects continue to improve.
  - H. future remains uncertain.
  - J. recovery is noteworthy.

Question 45 asks about the preceding passage as a whole.

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

By 2012, the zoo had bred over nine thousand stick insects.

The sentence would most logically be placed at:

- A. Point A in Paragraph 2.
- B. Point B in Paragraph 3.
- C. Point C in Paragraph 4.
- D. Point D in Paragraph 4.

#### PASSAGE IV

##### Morse Code in the Modern Age

[1]

Before texting, e-mail, and even the telephone call, there was Morse code. Transmitted over telegraph wire or radio waves via pulses of electric current, Morse code, which was used for over a century, the standard for rapid long-distance communication, especially for those at sea. [A] In 1995, however, the US Coast Guard suspended its usage of Morse code, including the

international distress signal SOS. Despite the speed and precision of technologies such as global positioning satellites, decoding signals in Morse code had become inefficient.

46. F. NO CHANGE  
G. code, used  
H. code was,  
J. code,
47. A. NO CHANGE  
B. its' usage  
C. it's use  
D. its use
48. F. NO CHANGE  
G. Notwithstanding  
H. Given  
J. Like



[2]

To some, the decision signaled the end of Morse

49

code. <sup>50</sup> Morse code's enduring utility, they argue,

lays in the fact that it functions less like a technology than  
a language—one that can reliably transmit a message  
under almost any conditions. [B]

[3]

In Morse code, each letter of the unique  
Roman alphabet consists of a pattern of short  
and long signals called dots and dashes. [C] Though

Morse code was used longer than any electrical coding  
system, spelling out and translating messages in Morse  
code does not require specialized machines. Messages  
can be transmitted by clicking a flashlight on and off,

by flashing a mirror in the sun, or simply blinking. [D] The  
code can also be spoken aloud, with the words *dit* and *dah*  
substituted for dots and dashes, or rendered rhythmically,  
allowing people to communicate via handheld buzzers.

[4]

Because of its versatility, Morse code can prove  
valuable in ensuring public safety when more sophisticated  
equipment fails. Air traffic controllers can revert to Morse  
www.crackab.com

49. A. NO CHANGE  
B. closed the book on the final chapter  
C. portended the ill-fated demise  
D. manifested the cessation
50. Which of the following true statements, if added here, would best serve as a transition between the preceding sentence and the next sentence?  
F. They wistfully recalled hearing new call signs, or code names, buzzing over their radios—proof that people were still learning and using the code.  
G. Many modern users of the code, though, assert that it will persist alongside new technologies.  
H. E-mail, in contrast to Morse code, enables us to send messages almost instantaneously.  
J. Today, for most of the public, Morse code is familiar only from historical films.
51. A. NO CHANGE  
B. lies in the fact that it functions less like a technology than  
C. lies in the fact that it functions less like a technology than  
D. lays in the fact that it functions less like a technology than
52. Which of the following placements for the underlined portion would most clearly indicate that each letter in Morse code is composed of its own distinct combination of signals?  
F. Where it is now  
G. After the word *each*  
H. After the word *a*  
J. After the phrase *pattern of*
53. Given that all the choices are accurate, which one sets up the clearest, most logical contrast with the claim made in the next part of the sentence?  
A. NO CHANGE  
B. telegraphs once recorded literal dots and dashes on punched tape,  
C. dashes are less commonly occurring in Morse code than dots,  
D. few changes have been made to the code over time,
54. F. NO CHANGE  
G. flashing a mirror in the sun can work,  
H. a mirror can be flashed in the sun,  
J. flashing a mirror in the sun,
55. Which choice most effectively leads into the new subject of this paragraph while summarizing a main idea of the preceding paragraph?  
A. NO CHANGE  
B. Thanks to the efforts of enthusiasts,  
C. Though it has fallen from use,  
D. Easy to learn and fun to use,

**GO ON TO THE NEXT PAGE.**

code if radar or satellite signals are interrupted. Similarly, amateur radio operators can use the code during weather emergencies to solicit information from outside the affected area. The news is relayed by them, by which they

56

can keep people safe and informed. 57 New communication technologies will continue to emerge,

meanwhile Morse code, with its lack of sophistication,

58

could remain just as effective an asset.

56. F. NO CHANGE

G. news, which, by relaying it, they

H. news, by relaying which they

J. news they relay

57. The writer is considering deleting the preceding sentence. Should the sentence be kept or deleted?

A. Kept, because it identifies the types of safety instructions that are most common in Morse code.

B. Kept, because it explains the important role Morse code can play in an emergency.

C. Deleted, because it contradicts a claim made earlier by implying that specialized machines are required to relay messages in Morse code.

D. Deleted, because it distracts the reader from the paragraph's focus on how advanced technologies have replaced Morse code.

58. F. NO CHANGE

G. however,

H. but

J. DELETE the underlined portion.

Questions 59 and 60 ask about the preceding passage as a whole.

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

Even laundry hung on a clothesline can relay a message, with thin and wide pieces of clothing representing dots and dashes.

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

A. Point A in Paragraph 1.

B. Point B in Paragraph 2.

C. Point C in Paragraph 3.

D. Point D in Paragraph 3.

60. Suppose the writer's primary purpose had been to discuss how a new technology revolutionized communication around the world. Would this essay accomplish that purpose?

F. Yes, because it explains how Morse code changed the way people sent messages over long distances.

G. Yes, because it describes how the advent of new technologies rendered Morse code obsolete.

H. No, because it indicates that Morse code today is pursued primarily as a hobby.

J. No, because it focuses instead on the advantages of and continuing uses for Morse code.

## PASSAGE V

### Urban Legend

On a concrete pillar just a few meters from the

61

Eiffel Tower, painted letters spell out, "This is not a

61

photo opportunity." On the sands of the Bristol Channel,

a large, spray-painted, "X" promises buried treasure.

62

61. A. NO CHANGE

B. pillar, just a few meters from, the Eiffel Tower

C. pillar, just a few meters from the Eiffel Tower

D. pillar just a few meters from the Eiffel Tower

62. F. NO CHANGE

G. large, spray-painted "X,"

H. large spray-painted "X,"

J. large, spray-painted "X"

On the side of a building in London, a stenciled image  
 depicts a pair of uniformed soldiers painting a vibrant red  
 peace sign. Although nearly no one knows what this artist

looks like, there are many who know his work. Blending  
 sharp-tongued social commentary with humor and

whimsy British-born artist, Banksy, has made a name  
 for himself by challenging people's perceptions of the  
 relevance of street art.

In the beginning, Banksy's fame originated on the  
 streets of Bristol, England, in the early 1990s. Under  
 the cover of the night sky, Banksy worked quickly and  
 steadily, sometimes painting freehand, sometimes  
 spray-painting elaborately detailed stencils.

Concerned residents argued that Banksy's work was  
 simply graffiti that encouraged vandalism. Others praised

it as art done by and for the people and debated for more.  
 England's strict anti-graffiti policy meant that most of

Banksy's pieces were destroyed within mere hours of there

63. Which choice best completes the rhetorical pattern established in the preceding sentences?

- A. NO CHANGE
- B. Found in London on the side of a building, a stenciled image depicts a pair of uniformed soldiers
- C. The side of a building in London depicts a stenciled image of uniformed soldiers,
- D. A stenciled image on the side of a building in London depicts uniformed soldiers

64. F. NO CHANGE

- G. like. There
- H. like; there
- J. like there

65. A. NO CHANGE

- B. whimsy, British-born artist, Banksy,
- C. whimsy, British-born artist Banksy
- D. whimsy British-born artist, Banksy

66. F. NO CHANGE

- G. Initially,
- H. At first,
- J. DELETE the underlined portion.

67. Given that all the following statements are true, which one, if added here, would best conclude this paragraph and introduce the subject of the next paragraph?

- A. Banksy's stenciled message "Sorry! The lifestyle you ordered is currently out of stock" captures his disapproval of consumerism.
- B. Daylight would reveal his creations to a simultaneously outraged and admiring public.
- C. This technique was featured in the street art documentary *Exit Through the Gift Shop*.
- D. It is hard to believe that no one has ever been able to get a photograph of Banksy's face.

68. F. NO CHANGE

- G. the kind that
- H. and that
- J. while it

69. Which choice most clearly indicates the enthusiasm people had for Banksy's art?

- A. NO CHANGE
- B. clamored
- C. blustered
- D. asked

70. F. NO CHANGE

- G. of their
- H. for its
- J. of its

completion. 71

By the end of the decade, Banksy had expanded his influence, painting his messages in places well beyond the British border. Seemingly he is everywhere and nowhere at once, Banksy had the full attention of the art world. Museum directors organized Banksy exhibitions, and auctioneers sold actual pieces of buildings that bore Banksy's artistry.

Despite his popularity, Banksy has not given in to the hype. He does not reproduce and sell prints of his images for profit. He also continues to communicate with the public through his street art, which is possible in part because he has managed to keep his identity secret. In Banksy's own words, "Art is not like other culture because its success is not made by its audience."

71. Given that all the following statements are true, which one, if added here, would provide the most effective transition between this paragraph and the next paragraph?
- A. Afterward, only a blank wall stood where Banksy's art had been.
  - B. Even in Los Angeles, some of Banksy's art was washed away.
  - C. Banksy had assumed that his art would eventually disappear.
  - D. Still, people had begun to take notice.
72. F. NO CHANGE  
G. whether he is  
H. to be  
J. DELETE the underlined portion.
73. A. NO CHANGE  
B. actual pieces of buildings were sold by auctioneers  
C. actual pieces, sold by auctioneers, were of buildings  
D. selling actual pieces of buildings were auctioneers
74. Which of the following quotations attributed to Banksy best suggests why Banksy has not revealed his identity to the public?
- F. NO CHANGE
  - G. "If you want to say something and have people listen, then you have to wear a mask."
  - H. "Graffiti is one of the few tools you have if you have almost nothing."
  - J. "Speak softly, but carry a big can of paint."

Question 75 asks about the preceding passage as a whole.

75. Suppose the writer's primary purpose had been to explain a common debate about the definition of art. Would this essay accomplish that purpose?
- A. Yes, because it demonstrates that characteristics of street art are similar to those found in other types of art.
  - B. Yes, because it explains why street art is controversial.
  - C. No, because it focuses on why the work of one street artist has gained popularity.
  - D. No, because it explains Banksy's reasons for choosing to create street art.

**END OF TEST 1**

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

**MATHEMATICS TEST***60 Minutes—60 Questions*

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

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

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

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

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

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

1. The table below gives the exact probability of randomly drawing a marble of a particular color from a bag of solid-colored marbles.

Color of marble	Probability
Red	0.2
Blue	0.3
Yellow	0.2
Green	0.1
Orange	0.1
Purple	0.1

What is the probability of randomly drawing a marble that is NOT green and is NOT blue?

- A. 0.60  
 B. 0.63  
 C. 0.67  
 D. 0.70  
 E. 0.90
2. What is the value of  $x$  in the equation  $\frac{3}{4} = x + \frac{1}{3}$  ?
- F.  $\frac{1}{4}$   
 G.  $\frac{5}{12}$   
 H.  $\frac{4}{7}$   
 J.  $1\frac{1}{12}$   
 K. 2
3.  $(3a^6b)(7a^3b^9)$  is equivalent to:
- A.  $10a^9b^{10}$   
 B.  $10a^{18}b^9$   
 C.  $21a^9b^9$   
 D.  $21a^9b^{10}$   
 E.  $21a^{18}b^9$

**DO YOUR FIGURING HERE.**



4. During the month of July, Garth's Video tracked the number of videos rented for each transaction. A total of 600 transactions were made during the month of July. The results are shown in the table below. How many transactions of exactly 3 video rentals were made during the month of July?

Number of videos rented	Percent of transactions
1	20%
2	36%
3	26%
4	8%
5 or more	10%

- F. 48  
G. 120  
H. 156  
J. 216  
K. 336
5. The total price for the pizza Jana and her friends bought was \$15.60. The pizza was cut into 8 equal slices, and Jana ate 3 of the slices. Jana paid a portion of the total price that was the same as the portion of the pizza she ate. What portion of the total price did Jana pay?
- A. \$1.95  
B. \$4.68  
C. \$5.20  
D. \$5.85  
E. \$7.80
6. If  $f(x) = (5x + 3)^2$ , then  $f(1) = ?$
- F. 8  
G. 16  
H. 28  
J. 34  
K. 64
7. The mean of 4 numbers is 6. Given that 3 of the numbers are 3, 6, and 7, what is the remaining number?
- A. 2  
B.  $\frac{8}{3}$   
C. 4  
D. 8  
E. 16

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DO YOUR FIGURING HERE.

GO ON TO THE NEXT PAGE.





8. The midpoint of  $\overline{NQ}$  is located at  $M(3,5)$  in the standard  $(x,y)$  coordinate plane. Given that the coordinates of  $Q$  are  $(1,2)$ , what are the coordinates of  $N$ ?

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

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

H.  $(5, 8)$

J.  $(5,12)$

K.  $(7,12)$

**DO YOUR FIGURING HERE.**

9. What is the value of  $|-3| - |7 - 49|$ ?

A.  $-45$

B.  $-39$

C.  $39$

D.  $45$

E.  $59$

10. Australia's Sydney Opera House covers a rectangular region that has a length of 605 feet and a width of 388 feet. Which of the following values is closest to the area, in acres, of the rectangular region?

(Note: 1 acre = 43,560 square feet)

F.  $5$

G.  $70$

H.  $110$

J.  $68,000$

K.  $230,000$

11.  $5^2x^{-2}y^47^{-1}$  is equivalent to:

A.  $\frac{10y^4}{7x^2}$

B.  $\frac{25y^4}{7x^2}$

C.  $\frac{70y^4}{x^2}$

D.  $-175x^2y^4$

E.  $175x^2y^4$

12. The lengths of the 2 shorter sides of a right triangle are 2 cm and 3 cm, respectively. Which of the following values is closest to the length, in centimeters, of the longest side of the triangle?

F.  $2.2$

G.  $2.3$

H.  $3.6$

J.  $5.0$

K.  $6.5$



13. When  $y = x$  and  $x + y = 10$  are graphed in the standard  $(x,y)$  coordinate plane, at what point do they intersect?

A.  $(-5, 5)$   
 B.  $(0, 10)$   
 C.  $(5, -5)$   
 D.  $(5, 5)$   
 E.  $(10, 0)$

**DO YOUR FIGURING HERE.**

14. The first 4 terms of a geometric sequence are listed in order below. What is the seventh term of the sequence?

24, 12, 6, 3, ...

F.  $-6$   
 G.  $0$   
 H.  $0.1875$   
 J.  $0.375$   
 K.  $0.75$

15. Let  $s$  be any real number such that  $4 < \sqrt{s} < 9$ . Which of the following is a possible value of  $s$ ?

A.  $2.5$   
 B.  $7.6$   
 C.  $12.7$   
 D.  $39.3$   
 E.  $82.4$

16. In the standard  $(x,y)$  coordinate plane, which of the following lines goes through  $(0,2)$  and is parallel to  $y = -5x + 7$ ?

F.  $y = -5x - 2$   
 G.  $y = -5x + 2$   
 H.  $y = \frac{1}{5}x - 2$   
 J.  $y = \frac{1}{5}x + 2$   
 K.  $y = 2x + 7$

17. What is the slope of the line in the standard  $(x,y)$  coordinate plane that contains the points  $(6,-1)$  and  $(4,3)$ ?

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



18. If  $8y = 3x - 5$ , then  $x = ?$

DO YOUR FIGURING HERE.

F.  $y + 5$

G.  $\frac{8}{3}y - 5$

H.  $\frac{8}{3}y + 5$

J.  $\frac{8y - 5}{3}$

K.  $\frac{8y + 5}{3}$

19. A tank has a capacity of 30 gallons and is  $\frac{5}{6}$  full of water. Jamal then removes  $\frac{1}{8}$  of the water in the tank.

How many gallons of water are left in the tank?

A.  $3\frac{1}{8}$

B. 5

C.  $17\frac{1}{7}$

D.  $21\frac{7}{8}$

E.  $26\frac{7}{8}$

20. Which of the following expressions is equivalent to  $3(a + b) - 5(a - 2b)$ ?

F.  $-2a - 9b$

G.  $-2a - 7b$

H.  $-2a - b$

J.  $-2a + 5b$

K.  $-2a + 13b$

21. An English teacher decided to give a second test over the same material as a first test. To reward those students who did well and to provide an incentive to students to improve their score, he announced that he would calculate the combined test score by starting with the first test score and adding  $\frac{2}{3}$  of the increase in test score from their first test to their second test. Trish scored 57 points on her first test and 72 points on her second test. What is her combined test score?

A. 62

B. 67

C. 72

D. 82

E. 95



22. Which of the following expressions is equal to  $\sqrt[3]{24}$  ?

- F. 2
- G. 8
- H.  $2\sqrt[3]{3}$
- J.  $2\sqrt[3]{6}$
- K.  $2\sqrt{2}$

DO YOUR FIGURING HERE.

23. On a rectangular sheet of paper, Aiko drew a triangle whose base length is the same as the length of the sheet and whose height is the same as the width of the sheet. What is the ratio of the area of the triangle to the area of the rectangular sheet of paper?

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

24. Norah invited 4 friends to a table tennis party. Each of the 5 people at the party played every other person exactly 1 time. The table below shows the number of games won by each player except Norah. There were no ties. How many games did Norah win?

Player	Games won
Collier	2
Evangeline	1
Gabe	1
Norah	?
Maria	3

- F. 0
- G. 1
- H. 2
- J. 3
- K. 4

25. A parallelogram has a perimeter of 80 inches, and 1 of its sides measures 18 inches. If it can be determined, what are the lengths, in inches, of the other 3 sides?

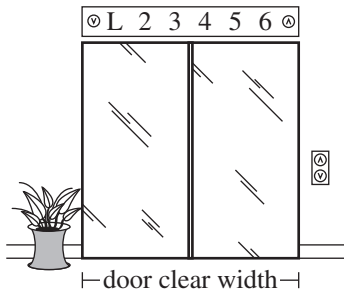
- A. 18, 18, 26
- B. 18, 13, 13
- C. 18, 22, 22
- D. 18, 31, 31
- E. Cannot be determined from the given information



Use the following information to answer questions 26–28.

DO YOUR FIGURING HERE.

The 2010 ADA Standards for Accessible Design require that elevator cars with centered doors, like the one shown below, have a minimum door clear width of 42 inches. They also require a minimum number of wheelchair spaces in 1 assembly area, such as a classroom, based on the number of seats in the assembly area, as the table below indicates.



Number of seats in 1 assembly area	Minimum number of wheelchair spaces
4 to 25	1
26 to 50	2
51 to 150	4
151 to 300	5
301 to 500	6

26. Door clear widths, in feet, of 5 elevator cars with centered doors built before 2010 are listed below.

3.5, 3.6, 3.8, 3.2, 2.8

How many of the elevator cars do NOT meet the 2010 ADA standard for minimum door clear width?

- F. 1  
G. 2  
H. 3  
J. 4  
K. 5
27. An elevator car with centered doors has a door clear width that is 8% wider than the minimum distance required by the 2010 ADA standard. Which of the following distances, in inches, is closest to the door clear width of the elevator car?
- A. 43  
B. 45  
C. 50  
D. 62  
E. 76



28. A local college will construct a 2-floor building next year. Each of the 5 classrooms on the 1st floor will have 20 seats, and each of the 8 classrooms on the 2nd floor will have 35 seats. To comply with the 2010 ADA standard, what is the fewest total number of wheelchair spaces needed in the 13 classrooms?

F. 4  
G. 6  
H. 11  
J. 13  
K. 21

DO YOUR FIGURING HERE.

29. A paint researcher collected the following data about the relationship between the paint level in a paint can and the surface area painted from this can.

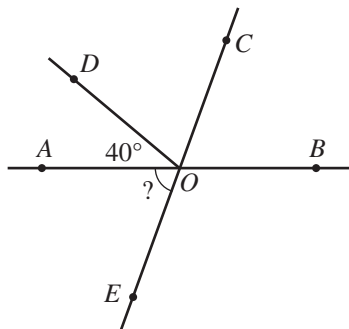
distance from top of can ( $x$ inches)	surface area painted ( $y$ square feet)
3	96
7	224
11	352

Assume there is a linear relationship between  $x$  and  $y$ . Which of the following is an equation showing this relationship?

- A.  $y = 32x$   
B.  $y = x + 96$   
C.  $y = x + 32$   
D.  $x = 32y$   
E.  $\frac{96}{3} = \frac{352}{11}$
30. Which of the following sentences is true about the 2 nonright angles of *any* right triangle?
- F. They are complementary angles.  
G. They are congruent angles.  
H. They are obtuse angles.  
J. They are supplementary angles.  
K. They are vertical angles.
31. The temperature in Chicago was  $-4^{\circ}\text{F}$  at noon and rose  $24^{\circ}\text{F}$  by 3:00 p.m. The temperature in New Orleans was  $42^{\circ}\text{F}$  at noon and dropped  $24^{\circ}\text{F}$  by 3:00 p.m. How did the temperatures in Chicago and New Orleans compare at 3:00 p.m. ?
- A. New Orleans was  $10^{\circ}\text{F}$  colder than Chicago.  
B. New Orleans was  $2^{\circ}\text{F}$  colder than Chicago.  
C. The temperatures were the same.  
D. New Orleans was  $22^{\circ}\text{F}$  warmer than Chicago.  
E. New Orleans was  $46^{\circ}\text{F}$  warmer than Chicago.



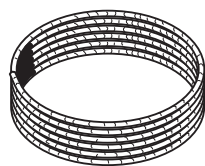
32. In the figure below,  $\overleftrightarrow{AB}$  and  $\overleftrightarrow{CE}$  intersect at  $O$ ,  $\overrightarrow{OC}$  bisects  $\angle BOD$ , and the measure of  $\angle AOD$  is  $40^\circ$ . What is the measure of  $\angle AOE$ ?



- F.  $40^\circ$   
 G.  $50^\circ$   
 H.  $60^\circ$   
 J.  $70^\circ$   
 K.  $80^\circ$

33. The entire length of a rope is coiled into 6 circular loops, each with a diameter of 10 inches, as shown below. Which of the following is closest to the length, in inches, of the rope?

10



- A. 30  
 B. 80  
 C. 95  
 D. 190  
 E. 315
34. Given the matrix equation below, what is the value of  $ab$ ?

$$\begin{bmatrix} 5 & -6 \\ 3 & 12 \end{bmatrix} + \begin{bmatrix} a & 2 \\ 0 & b \end{bmatrix} = \begin{bmatrix} 10 & -4 \\ 3 & 4 \end{bmatrix}$$

- F. -40  
 G. -3  
 H. -2  
 J.  $-\frac{1}{3}$   
 K.  $\frac{2}{3}$
35. In right triangle  $\triangle ABC$ , the right angle is at  $B$ , and  $\sin A = \frac{12}{13}$ . What is the value of  $\tan C$ ?

- A.  $\frac{5}{12}$   
 B.  $\frac{5}{13}$   
 C.  $\frac{12}{5}$   
 D.  $\frac{12}{13}$   
 E.  $\frac{13}{5}$

DO YOUR FIGURING HERE.



36. During rehearsal for the Founders' Day choir program, the director, Mrs. Mazurek, tried 3 different configurations, each using all the choir members at the rehearsal. One configuration was to have only rows of 12, one was to have only rows of 15, and one was to have only rows of 20. None of these configurations worked because for each, the last row had 1 person less than the other rows. What was the least of the possible numbers of choir members at the rehearsal?

F. 44  
 G. 47  
 H. 59  
 J. 79  
 K. 119

**DO YOUR FIGURING HERE.**

37. The equation  $x^2 + P = 0$ , where  $P$  is an integer, has 2 integer solutions for  $x$ . Which of the following is a possible value of  $P$ ?

A. -48  
 B. -36  
 C. -10  
 D. 36  
 E. 48

38. Of the 17 members of Xavier High School's honor society, 1 member will be chosen at random to attend a conference. The table below shows the number of honor society members according to class and whether they are in their first or second year in the honor society. What is the probability that the member chosen will NOT be a senior who is in his or her second year in the honor society?

	First year	Second year
Junior	2	0
Senior	8	7

F.  $\frac{2}{17}$   
 G.  $\frac{7}{17}$   
 H.  $\frac{8}{17}$   
 J.  $\frac{10}{17}$   
 K.  $\frac{17}{17}$

39. Given  $x = 4y$  and  $y = 2z$ , which of the following expressions is equivalent to  $x + 4y - 8z$  in terms of  $z$ ?

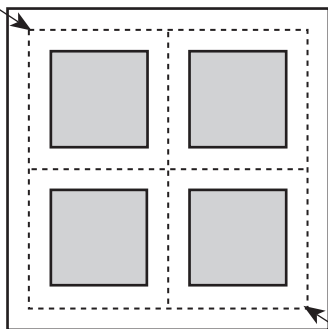
A.  $-3z$   
 B.  $-2z$   
 C.  $2z$   
 D.  $4z$   
 E.  $8z$





40. Using the street map shown below, you are directed to take a 4-block-long route to walk from First and Main Streets to Third and Market Streets. If each of the different 4-block-long routes consists of a unique sequence of streets, how many such routes could you take?

First and Main Streets



Third and Market Streets

- F. 4  
G. 6  
H. 8  
J. 12  
K. 16
41. For  $i = \sqrt{-1}$ ,  $(3 + i)^2 = ?$   
A. -9  
B. 8  
C.  $8 + 6i$   
D.  $6 + i$   
E.  $6 + 2i$
42. Define the functions  $f(x)$  and  $g(x)$  such that  $f(x) = 2x$  and  $g(x) = \sqrt{x + 3}$ . For all  $x$  such that  $x \geq -3$ , which of the following expressions is equal to  $f(g(x))$ ?  
F.  $2\sqrt{x + 3}$   
G.  $2x\sqrt{x + 3}$   
H.  $\sqrt{2x + 3}$   
J.  $\sqrt{2x^2 + 3}$   
K.  $\sqrt{2x^2 + 6x}$
43. In a small high school with 20 seniors, 8 of the seniors are in soccer, 9 of the seniors are in band, and 5 of the seniors are in both. How many seniors are in neither soccer nor band?  
A. 15  
B. 12  
C. 11  
D. 8  
E. 3

DO YOUR FIGURING HERE.



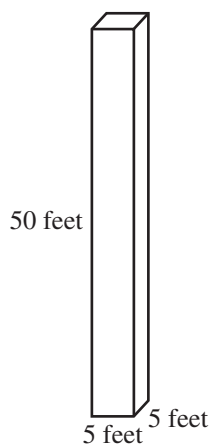
44. For any real number  $x$  such that  $x < -5$  in the equation below, which of the following statements *must* be true of the number represented by  $y$  ?

$$y = -\sqrt{x+5}$$

- F.  $y$  is irrational.  
 G.  $y > 0$   
 H.  $y = 0$   
 J.  $y < 0$   
 K.  $y$  is imaginary.
45. The population of Northtown on January 1 for the years 2001 through 2007 is shown in the table below. What is the average yearly change in population from January 1, 2003, to January 1, 2005 ?

Year	Population
2001	1,506
2002	1,612
2003	1,726
2004	1,844
2005	1,972
2006	2,098
2007	2,224

- A. 82  
 B. 120  
 C. 123  
 D. 124  
 E. 246
46. The bottom of the empty rectangular storage bin shown below is a square. If 175 cubic feet of salt are poured into the bin and leveled, how many feet of the bin will be filled?



- F. 7  
 G. 17.5  
 H. 25  
 J. 35  
 K. That much salt will more than fill the bin.

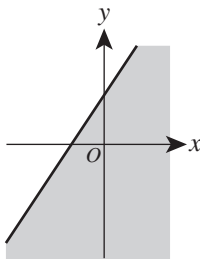
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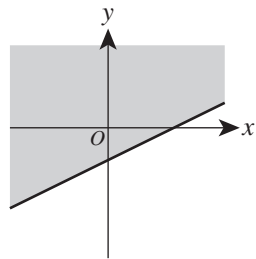
47. One of the following graphs is the graph of  $y \leq ax + b$  for some positive  $a$  and positive  $b$ . Which graph?

DO YOUR FIGURING HERE.

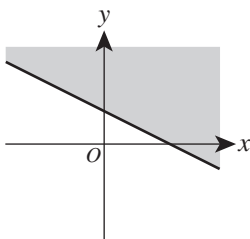
A.



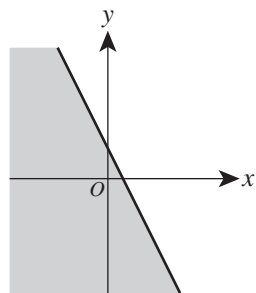
D.



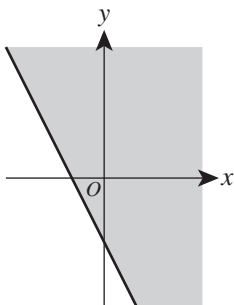
B.



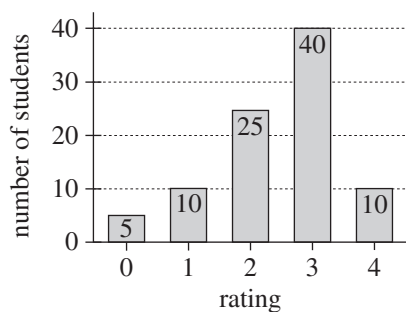
E.



C.



48. The ratings from a survey taken by 90 students are summarized in the frequency bar graph below. The possible ratings on the survey are 0, 1, 2, 3, and 4.



What is the mean of the 90 ratings?

F. 2

G.  $2\frac{4}{9}$

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

J.  $2\frac{10}{17}$

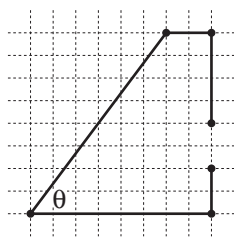


49. A vote revealed that chocolate ice cream was favored by more students in Hillhouse High School than any other flavor of ice cream. Which of the following statistical measures was most likely used to determine this result?

A. Mean  
 B. Median  
 C. Mode  
 D. Range  
 E. Variance

Use the following information to answer questions 50–52.

Harold is planning a garden as shown in the scale drawing below. The line segments represent the fence surrounding the garden, with an opening in the fence to access the garden. Each small square in the scale drawing represents a square with a side length of 2 feet. Each marked point is at the vertex of a small square in the drawing.



50. What will be the length, in feet, of the fence surrounding Harold's garden?

F. 26  
 G. 28  
 H. 52  
 J. 56  
 K. 60

51. What will be the area, in square feet, of Harold's garden?

A. 40  
 B. 64  
 C. 80  
 D. 128  
 E. 160

52. What is the measure of the angle labeled  $\theta$  in the scale drawing of the garden?

F.  $\cos^{-1}\left(\frac{6}{8}\right)$   
 G.  $\sin^{-1}\left(\frac{6}{8}\right)$   
 H.  $\tan^{-1}\left(\frac{6}{8}\right)$   
 J.  $\tan^{-1}\left(\frac{8}{8}\right)$   
 K.  $\tan^{-1}\left(\frac{8}{6}\right)$

DO YOUR FIGURING HERE.



53. What is the solution of the equation  $\log_2 \frac{\sqrt{3x+4}}{x-2} = 1$  ?

- A. 0
- B.  $\frac{3}{4}$
- C. 2
- D. 4
- E. 7

DO YOUR FIGURING HERE.

54. For the functions  $f(x) = 4x + 12$  and  $g(x) = \frac{1}{x}$ , what is the set of real numbers  $x$  on which  $g(f(x))$  is defined?

- F. All real numbers
- G. All real numbers except 3
- H. All real numbers except 0
- J. All real numbers except  $-\frac{1}{3}$
- K. All real numbers except  $-3$

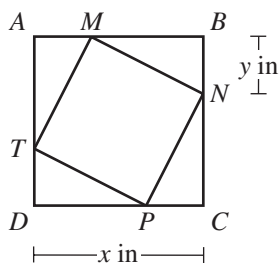
55. One alarm beeps 4 seconds after it is activated and at the end of every 6 seconds after that. Another alarm beeps 29 seconds after it is activated and at the end of every 30 seconds after that. The 2 alarms are activated at the same time and are left on for  $t$  minutes, where  $t$  is a whole number. What is the total number of times the 2 alarms beep in those  $t$  minutes?

- A.  $12t$
- B.  $18t$
- C.  $24t$
- D.  $60t$
- E.  $180t$

56. The inequality  $3x^4y < 0$  is true for real numbers  $x$  and  $y$ . If it can be determined, which of the following inequalities *must* be true?

- F.  $x < 0$
- G.  $x > 0$
- H.  $y < 0$
- J.  $y > 0$
- K. Cannot be determined from the given information

57. In the figure shown below, square  $MNPT$  is inscribed in square  $ABCD$ . The length of  $\overline{DC}$  is  $x$  inches, and the length of  $\overline{BN}$  is  $y$  inches. In terms of  $x$  and  $y$ , which of the following expressions gives the area, in square inches, of  $MNPT$  ?



- A.  $x^2 - y^2$
- B.  $x^2 + y^2$
- C.  $xy - y^2$
- D.  $x^2 - 2xy + y^2$
- E.  $x^2 - 2xy + 2y^2$



58. For all distinct nonzero values of  $x$  and  $y$ , which of the

following expressions is equivalent to  $\frac{\frac{x}{y} - 1}{\frac{1}{y} - \frac{1}{x}}$ ?

- F. 1
- G.  $x$
- H.  $\frac{1}{x}$
- J.  $\frac{1}{y}$
- K.  $\frac{x^2 - 1}{x - y}$

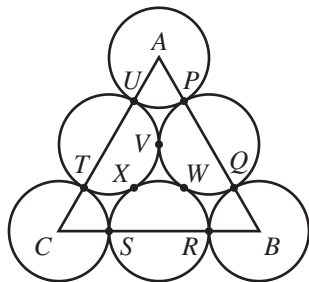
59. For  $0^\circ < a^\circ < 90^\circ$  and  $0 < b < 1$ , when  $\cos a^\circ = b$ , which of the following expressions is equivalent to  $\cos(2a^\circ)$ ?

(Note:  $\cos 2\theta = (\cos \theta)^2 - (\sin \theta)^2$ )

- A. -1
- B. 0
- C. 1
- D.  $b^2 - a^2$
- E.  $2b^2 - 1$

60. In the figure shown below, each of the points labeled  $P$  through  $X$  is a point of tangency between 2 circles. Each vertex of  $\triangle ABC$  is the center of a circle. Each circle has a radius of  $r$  cm. Which of the following expressions represents the area, in square centimeters, of  $\triangle ABC$ ?

- F.  $4r^2\sqrt{3}$
- G.  $6r^2$
- H.  $\frac{8r^2\sqrt{3}}{3}$
- J.  $8r^2$
- K.  $8r^2\sqrt{3}$



DO YOUR FIGURING HERE.

END OF TEST 2

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

DO NOT RETURN TO THE PREVIOUS TEST.

## READING TEST

35 Minutes—40 Questions

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

## Passage I

**LITERARY NARRATIVE:** This passage is adapted from the essay "Introduction" by Charlotte Noruzi (©2008 by Charlotte Noruzi).

When my family first moved to the United States, my father was still traveling back and forth to Iran before joining us permanently. After one trip, he brought with him a small collection of Iranian children's books. These books, along with numerous others, were created under the *Kanoon Parvaresh Fekri Koodakan va Nojavanan* (Institute for the Intellectual Development of Children and Adolescents). To me, its iconic stylized rooster logo conveyed a positive and bright outlook for the betterment of children. In 1961, the Kanoon was established to enhance the quality and educational standards of children's literature and activities. A large part of the program was devoted to the publishing of high-quality, richly written and illustrated books for children and adolescents.

I have six books from that era. They were loaded with cultural and historical references and set apart from each other and from my American children's books in their individual and unique styles of illustration.

In times where I felt the most disconnected, the most doubtful of my identity, I would turn to these books, get lost in them, in the fantasy of them. They were my one connection to the culture I left behind. In them I found some remnant of my past life. I would open a book and feel like I was "home" again. I see now how the seeds to express my thoughts and ideas through pictures were sown. Out of the endearing times I spent with my little collection sprung the desire to illustrate books, to use calligraphy and hand-written text. This was my introduction to art and words living together and there's a little from each book in some aspect of my work, my own children's book.

My favorite of the collection is called *Marmoolak Koochak Otagheh Man* (My Room's Little Lizard) by Farshid Mesqali. Its surrealistic watercolors draw you into the realm of dreams. The hand lettering of the book's title and the deep black, blues, greens and purples that bleed softly into one another, making up the body of the lizard, were so beguiling to me. They still are. I see the influence in my own work. *Baba Barfi*

was another, done in gorgeous hues of blue and greys, in a mix of drawing and watercolor. There is a quiet simplicity in the illustrations and the story that reminds me of the silence right after snowfall.

About 12 years ago, my mother visited Iran and brought back with her another set of children's books. These happened to be illustrated by an important figure from my childhood: Gholamali Maktabi, someone I hadn't thought of in years. I never until now got the message of the giving of all these books, first by my father and again by my mother. I had tucked Maktabi's wonderful books away in my memory all of these years and not until the idea for this essay presented itself, did I bring them out into the light. And he came out along with them.

Gholamali Maktabi was my father's dear and life-long friend from their school days. He was a part of our family and we endearingly called him "Dhayee Maktabi," which means Uncle Maktabi in Farsi. I remember a sense of warmth always surrounding that name. I knew him first as the person behind the poignant, sensitive photographs taken of us in Iran as we were growing up. The images he recorded have served time and again as windows into my childhood, my personality as a child, images that connect me with who I was. His innate ability to capture with such simplicity and affection the smile or frown of a child can also be seen in his lifework as an illustrator of children's books. Dhayee Maktabi would spend time drawing with my sister and me when we were children.

In October 2007, after more than 30 years, I called Dhayee Maktabi. No time, it felt, had gone by. "I was drawn from a young age to painting," Maktabi remembers. "This interest ultimately led to my desire to become an illustrator and slowly began to replace painting for me—though to this day I still have a special love for drawing and painting. I've spent about forty years illustrating children's and adolescents' books and I expect that I will continue to do this for the foreseeable future. The thing that has always attracted me to illustrating for children and adolescents is the world that they inhabit, one which is full of mysteries and secrets."

Indeed, I believe that those photographic portraits of my family done long ago also served this purpose.

My mother told me recently that Maktabi loved to just sit and observe us, our games and antics, our “secret worlds” that, through the small window of his shutter, were lovingly revealed.

1. The author of the passage can best be described as a children’s book author and illustrator who is:
  - A. remembering the day she first read a children’s book from Iran.
  - B. considering the influences on her artistic interests and work.
  - C. explaining the goals of the *Kanoon Parvareh Fekri Koodakan va Nojavanan*.
  - D. analyzing the loss of her cultural identity.
2. Which of the following events in the passage occurred first chronologically?
  - F. Noruzi moves to the United States.
  - G. Maktabi photographs Noruzi.
  - H. Maktabi and Noruzi speak on the phone.
  - J. Noruzi receives books by Maktabi.
3. In the passage, the label “the collection” (line 34) most nearly refers to the:
  - A. six books that Noruzi owns that are from the early years of the Kanoon.
  - B. books by Maktabi that Noruzi owns.
  - C. books that Noruzi herself has illustrated.
  - D. entire group of books that have been created under the Kanoon.
4. As presented in the passage, is Noruzi’s statement in lines 10–13 best described as a fact or an opinion?
  - F. A fact; it directly states the purpose behind the establishment of the Kanoon.
  - G. A fact; it makes clear that Noruzi is an expert on the history of the Kanoon.
  - H. An opinion; it presents Noruzi’s view on whether the Kanoon met its educational goals.
  - J. An opinion; it states that the books published by the Kanoon were richly written.
5. The main purpose of the fourth paragraph (lines 34–45) is for Noruzi to:
  - A. contrast the prose styles of the books *Marmoolak Koochak Otagheh Man* and *Baba Barfi*.
  - B. describe several specific ways the book *Baba Barfi* has influenced her work as an illustrator.
  - C. describe what is moving and inspiring to her about two of her favorite children’s books from Iran.
  - D. explain, using two examples, why most children’s books from Iran are painted in dark hues.
6. As it is used in line 63, the word *sensitive* most nearly means:
  - F. pliant.
  - G. touchy.
  - H. evasive.
  - J. perceptive.
7. In the passage, Maktabi describes his professional work as primarily that of:
  - A. a painter.
  - B. a photographer.
  - C. an illustrator.
  - D. a writer.
8. Noruzi indicates that each of the six books mentioned in the second paragraph (lines 16–20) features a:
  - F. similar style of illustration.
  - G. similar style of storytelling.
  - H. unique style of storytelling.
  - J. unique style of illustration.
9. The passage most strongly suggests that Noruzi’s own children’s book includes:
  - A. calligraphy.
  - B. pop-up images.
  - C. poems by other artists.
  - D. objects glued to the pages to create texture.
10. In a section of the essay not included here, Noruzi explains:
 

Little did I know that those little sessions [drawing with Maktabi] would awaken a desire for art and expression. I made the important connection between my love of children’s books and the time spent with Dhayee Maktabi as a child.

How does this statement expand on information provided in the passage?

  - F. It further explains the elements of Maktabi’s children’s books that Noruzi found most inspiring.
  - G. It provides further details about how spending time with Maktabi inspired Noruzi to create art.
  - H. It suggests the feelings Maktabi had about his time spent drawing with Noruzi and her sister.
  - J. It outlines the idea Noruzi had for what came to be her first project as a children’s book illustrator.



## Passage II

**SOCIAL SCIENCE:** This passage is adapted from the book *Down on the Batture* by Oliver A. Houck (©2010 by University Press of Mississippi).

The Mississippi River batture is unique. Here we have a place that is neither water nor land; it is both. It depends on the time of year. Spanish and French traditions going back to the time of Rome recognized public rights to public things. The civil code declared that rivers and their banks were public, which would have closed the matter. But in the late 1700s along came Edward Livingston, a New Yorker with an American notion of private property, a keen legal mind, a nose for money, and an ambition as big as the Ritz.

Livingston's accomplishments in the courthouse and the legislature remain monuments today, but the case that made him famous was about dirt on the banks of the Mississippi at a prime location in downtown New Orleans. Livingston and his client who claimed the dirt stood to make a fortune. Indeed, Livingston declined a fee in the case. Instead, if he won he would get a piece of the victory, the most valuable real estate in New Orleans.

The American notion of property was not popular in New Orleans, whose people were accustomed to using the banks of rivers to beach their boats, promenade, fish, swim, rake mussels, and even take fill for their front yards. By precedent rising from centuries, the Mississippi batture was common ground. In a city oppressed by heat, the batture was also treasured ground, the place where everyone in society from cotton brokers to boat hands could enjoy the breeze, air pleasant to inhale, and the very sight of the river. When Livingston's client undertook to develop the batture he was claiming, a public mob arrived to interrupt his work. Every day.

Livingston's client made a frontal assault. He went out at low water, diked off the batture, and then arrested people coming to take the river sand in the old and accustomed way. The ensuing lawsuits rivaled the twists and turns of a Dickens novel. On one side was Livingston, claiming that private property was sacred in America. On the other was a who's who of wellborn local names right on up to the president of the United States. Thomas Jefferson considered the public character of the Mississippi to be a civic right and essential to his ambitions for settling the West. After Livingston won his first case, Jefferson had U.S. marshals evict him from the batture anyway, at which point Livingston sued the officer who evicted him. It got that bad.

When the dust settled, years later, Livingston emerged with his property deed, but he had ceded important claims to the city, including part of his real estate and development controls on the rest. Compromise that it was, the New Orleans batture would go from small wharves and open space to an impressive accumulation of mega-wharves and warehouses. New

Orleanseans not only could no longer access the river; they could no longer even see it.

Enter Robert Livingston, Edward's brother, with an even more impressive list of accomplishments and a yet bigger coup in mind. He and Robert Fulton, who had either invented the steamboat or made a quick copy of someone else's, depending on your source, tendered an offer to New Orleans that it could not refuse, a monopoly on the Mississippi River.

Fulton's steamboat had one huge advantage for the future of the city; it could go upriver. The early flat-boats didn't even try. Fulton's new boat could get back up in a week, although he had not exactly done it yet. The Fulton-Livingston team proposed a deal. They would deliver steamboat commerce to New Orleans, if the city would grant them all rights to the river trade. They would own the river.

Enter another challenger. Henry Shreve came from the Red River in northwestern Louisiana and saw Livingston's monopoly as a threat to the future of his region. He built his own steamship, sailed it down to New Orleans, loaded it with goods, and sailed back home again to a hero's welcome. People did that sort of thing back then. Fulton had only talked about going back upriver. Now Shreve had actually done it, and with merchandise on board. More threatening, Shreve tried it again. Livingston had to make his move, and so, as the second Shreve boat was ready to leave New Orleans with its cargo, he had the captain and the boat arrested. The public sided against the Livingstons, as it had on the batture cases earlier, causing a small riot. Shreve was released the next day. A few months later a local judge dismissed the lawsuit. Edward Livingston might own a piece of the batture, but Robert would not own the river.

11. In the third and fourth paragraphs (lines 20–46), the author portrays the main conflict over the Mississippi River batture as primarily between:

- A. the government of New Orleans and that of the United States.
- B. a lawyer-client team and a large segment of the public, including the US president.
- C. two social classes.
- D. two ambitious brothers.

12. Which of the following events referred to in the passage occurred first chronologically?

- F. The Fulton-Livingston team proposed a deal to the city of New Orleans.
- G. Edward Livingston sued the officer who evicted him from the batture.
- H. Shreve sailed from New Orleans to northwestern Louisiana.
- J. A local judge threw out Robert Livingston's case against Shreve.

13. It can most reasonably be inferred that when the author mentions the “American notion of property” (line 20), he is referring to the idea that:
- A. limits should be placed on how much property one person can own.
  - B. the owner of public lands is the public, not the government.
  - C. the owner of private property controls the use and purpose of that property.
  - D. certain responsibilities to the public go along with owning property.
14. It is reasonable to infer that the author sets the phrase “every day” (line 32) apart from the preceding sentence to emphasize the:
- F. monotony of an endeavor.
  - G. enormous opportunity on the river.
  - H. determination of the public.
  - J. enduring character of the river.
15. Which of the following statements about Shreve is best supported by the passage?
- A. He foiled Robert Livingston’s plans to control commerce on the Mississippi River.
  - B. He designed and built a flatboat that could carry cargo up the Mississippi River.
  - C. He secured federal funding for the development of steamboat commerce on the Mississippi River.
  - D. He sued the Livingston brothers for stealing his steamboat design.
16. The author presents the drama in the last paragraph primarily as:
- F. a private citizen trying to respond to a public defeat.
  - G. a ferocious competition with an outcome the public favored.
  - H. an ongoing disagreement between a federal and a local judge.
  - J. a bitter rivalry that drove two brothers apart.
17. According to the passage, Edward Livingston’s client reacted to the public mob by:
- A. diking off the area of the batture that he was claiming.
  - B. using his influence to gain the media’s support for his position.
  - C. selling one part of the batture and purchasing another.
  - D. increasing the rents on his waterfront properties in New Orleans.
18. According to the passage, as a result of the Edward Livingston case, what replaced the small wharves on the New Orleans batture?
- F. Fishing docks and residential neighborhoods
  - G. Protected open space and recreational facilities
  - H. Steamboat-building facilities
  - J. Mega-wharves and warehouses
19. According to the passage, what deal did the Fulton-Livingston team propose to the city of New Orleans?
- A. They would provide steamboat service if the city would outlaw flatboats on the Mississippi River.
  - B. They would build commercial wharves downtown in exchange for tax relief from the city.
  - C. They would bring steamboat commerce to the city in exchange for all rights to the river trade.
  - D. They would fund city development if the city would endorse their steamboat business.
20. According to the passage, who achieved a heroic hometown status by establishing steamboat traffic to and from New Orleans?
- F. Robert Livingston
  - G. Edward Livingston
  - H. Thomas Jefferson
  - J. Henry Shreve

## Passage III

**HUMANITIES:** Passage A is adapted from the article “Searching for Silence: John Cage’s Art of Noise” by Alex Ross (©2010 by Condé Nast). Passage B is adapted from the book *This Is Your Brain on Music: The Science of a Human Obsession* by Daniel J. Levitin (©2006 by Daniel J. Levitin).

## Passage A by Alex Ross

On August 29, 1952, David Tudor walked onto the stage of the Maverick Concert Hall, near Woodstock, New York, sat down at the piano, and, for four and a half minutes, made no sound. He was performing  
5 “4’33,” a conceptual work by John Cage. It has been called the “silent piece,” but its purpose is to make people listen. “There’s no such thing as silence,” Cage said, recalling the première. “You could hear the wind stirring outside during the first movement. During the  
10 second, raindrops began pattering the roof, and during the third people themselves made all kinds of interesting sounds as they talked or walked out.”

Composer and scholar Kyle Gann defines “4’33”” as “an act of *framing*, of enclosing environmental and  
15 unintended sounds in a moment of attention in order to open the mind to the fact that all sounds are music.” That last thought ruled Cage’s life: he wanted to discard inherited structures, open doors to the exterior world, “let sounds be just sounds.” Gann writes, “It begged for  
20 a new approach to listening, perhaps even a new understanding of music itself, a blurring of the conventional boundaries between art and life.”

On a simpler level, Cage had an itch to try new things. What would happen if you sat at a piano and did  
25 nothing? If you chose among an array of musical possibilities by flipping a coin and consulting the I Ching? If you made music from junkyard percussion, squads of radios, the scratching of pens, an amplified cactus?

Many people, of course, won’t hear of it. Nearly  
30 six decades after the work came into the world, “4’33”” is still dismissed as “absolutely ridiculous,” “stupid,” and “a gimmick.” Such judgments are especially common within classical music where Cage, who died in 1992, remains an object of widespread scorn.

Morton Feldman, another avant-garde musician, once said, “John Cage was the first composer in the history of music who raised the question by implication that maybe music could be an art form rather than a musical form.” Feldman meant that, since the Middle  
40 Ages, even the most adventurous composers had labored within a craftsmanlike tradition. Cage held that an artist can work as freely with sound as with paint: he changed what it meant to be a composer, and every kid manipulating music on a laptop is in his debt. Not  
45 everything he did was laudable, or even tolerable. Yet the work remains inescapable, mesmerizing, and often unexpectedly touching. It encompasses some of the most violent sounds of the twentieth century, as well as some of the most gently beguiling. It confronts us with  
50 the elemental question of what music is, and confounds all easy answers.

## Passage B by Daniel J. Levitin

The music of many avant-garde composers stretches the bounds of what most of us think music is. Going beyond the use of melody and harmony, and even  
55 beyond the use of instruments, these composers use recordings of found objects in the world such as jackhammers, trains, and waterfalls. They edit the recordings, play with their pitch, and ultimately combine them into an organized collage of sound with the same  
60 type of emotional trajectory—the same tension and release—as traditional music. Composers in this tradition are like the painters who stepped outside the boundaries of representational and realistic art—the cubists, the Dadaists, many of the modern painters from  
65 Picasso to Kandinsky.

What do the music of Bach and John Cage fundamentally have in common? On the most basic level, what distinguishes Busta Rhymes’s “What’s It Gonna Be?!” or Beethoven’s “Pathétique” Sonata from, say,  
70 the collection of sounds you’d hear standing in the middle of Times Square or those you’d hear deep in a rainforest? As the composer Edgard Varèse famously defined it, “Music is organized sound.”

It is helpful to examine what music is made of.  
75 What are the fundamental building blocks of music? And how, when organized, do they give rise to music? The basic elements of any sound are loudness, pitch, contour, duration (or rhythm), tempo, timbre, spatial location, and reverberation. Our brains organize these  
80 fundamental perceptual attributes into higher-level concepts—just as a painter arranges lines into forms. When we listen to music, we are actually perceiving multiple attributes.

Each attribute can be varied without altering the  
85 others. The difference between *music* and a random or disordered set of sounds has to do with the way these fundamental attributes combine, and the relations that form between them.

Questions 21–24 ask about Passage A.

21. The author of Passage A most likely includes the anecdote in the first paragraph in order to:
- A. introduce Tudor as a musician who was one of Cage’s strongest supporters.
  - B. provide a sense of what a performance of “4’33”” might be like.
  - C. assert Cage’s importance to avant-garde music by describing a work he once performed.
  - D. illustrate how popular Cage was at the time “4’33”” premiered.

22. As it relates to “4’33”,” Gann’s definition of *framing* (lines 14–16) can best be understood to mean that:

- F. the piece treats as music any sounds that occur within the set period of time that is the work’s length.
- G. the piece is meant to be played only within small, enclosed spaces.
- H. a piano playing at the beginning and end of the piece provides a frame for other sounds occurring in the middle of the piece.
- J. the piano mimics any natural sounds that may typically occur in the four and a half minutes it takes to play the piece.

23. As it is used in line 31, the word *dismissed* most nearly means:

- A. released.
- B. sent away.
- C. let go.
- D. rejected.

24. Based on Passage A, which of the following statements best expresses how the author feels about Cage?

- F. He believes Cage had some interesting ideas but did not try hard enough to reach a wide audience.
- G. He tolerates Cage’s experiments but is not particularly moved by them.
- H. He enjoys “4’33”” but feels most of Cage’s other work was too gimmicky.
- J. He admires Cage’s work but acknowledges that it can be difficult to appreciate.

Questions 25–27 ask about Passage B.

25. Passage B is best described as:

- A. an argument for popular composers to take more risks when writing music.
- B. an outline of one theory about what determines musical preferences.
- C. a brief overview of what distinguishes music from sound.
- D. an in-depth analysis of the work of several famous avant-garde composers.

26. The main idea of the first paragraph of Passage B (lines 52–65) is that:

- F. many avant-garde composers step outside established musical traditions to make music.
- G. most avant-garde musicians approach composition the same way modern painters do.
- H. objects like jackhammers are often used instead of traditional instruments in avant-garde music.
- J. avant-garde music follows an emotional trajectory unlike that of traditional music.

27. Based on Passage B, the found objects used by avant-garde composers can most nearly be defined as:

- A. secondhand orchestral instruments.
- B. instruments that were once popular but have gone out of style.
- C. discarded scrap materials that can be used to build instruments.
- D. anything that can make sound but is not a standard musical instrument.

Questions 28–30 ask about both passages.

28. Based on the passages, Cage’s “4’33”” primarily differs from the compositions described in lines 54–61 of Passage B in that “4’33””:

- F. is mainly concerned with the absence of organized sound, while the other compositions have been manipulated into organized sound.
- G. features a piano as the only sound, while the other compositions feature varied and more unusual instruments.
- H. is much shorter than the other compositions, which can go on for hours.
- J. was only performed once, whereas the other compositions have been performed more often.

29. In Passage A, Gann is quoted as claiming, in part, that “all sounds are music” (line 16). Is this assertion supported by the definition of music put forth in lines 85–88 of Passage B?

- A. Yes, because Passage B develops the idea that avant-garde musicians use unconventional instruments to make music.
- B. Yes, because Passage B illustrates how avant-garde music follows the same emotional trajectory as traditional music.
- C. No, because Passage B mentions Cage only in passing and does not elaborate on his idea that any sound can be music.
- D. No, because Passage B states that random sounds have to combine to form relationships before they can be considered music.

30. Based on the passages, what is one similarity that the composers mentioned in the first paragraph of Passage B (lines 52–65) share with Cage as he is described in Passage A?

- F. The composers often debut material at the Maverick Concert Hall where Cage debuted “4’33”.”
- G. The composers build most of their music around loudness, pitch, and tempo, which is what Cage did.
- H. The composers experiment with unconventional objects to make music, just as Cage sometimes did.
- J. The composers often compose “silent” pieces like Cage’s “4’33”.”



## Passage IV

**NATURAL SCIENCE:** This passage is adapted from the article “How We Are Evolving” by Jonathan K. Pritchard (©2010 by Scientific American, a division of Nature America, Inc.).

A few years ago it was extremely difficult for scientists to trace our species’ genetic responses to our environment; the needed tools just did not exist. All that changed with the completion of the human genome sequence and the subsequent cataloguing of genetic variation. To understand exactly what we did, it helps to know a bit about how DNA is structured and how small changes can affect its function. The human genome sequence consists of about three billion pairs of DNA nucleotides, or “letters,” that serve as an instruction manual for how to assemble a human. The manual is now known to contain a parts list of about 20,000 genes—strings of DNA letters that spell out the information required to build proteins. (Proteins, which include enzymes, do much of the work in cells.) About 2 percent of the human genome encodes proteins, and a roughly similar amount seems to be involved in gene regulation. Most of the rest of the genome has no known role.

Overall the genomes of any two people are extremely similar, differing in only about one out of every 1,000 nucleotide pairs. Sites where one nucleotide pair substitutes for another are referred to as single-nucleotide polymorphisms, or SNPs (pronounced “snips”), and the alternative versions of the DNA at each SNP are called alleles. Because most of the genome does not encode proteins or regulate genes, most SNPs probably have no measurable effect on the individual. But if a SNP occurs in a region of the genome that does have a coding or regulating function, it may affect the structure or function of a protein or where and how much of the protein is made. In this way, SNPs can conceivably modify almost any trait, be it height, eye color, ability to digest milk, or susceptibility to diseases.

When natural selection strongly favors a particular allele, it becomes more common in the population with each generation, while the disfavored allele becomes less common. Eventually, if the environment remains stable, the beneficial allele will spread until everyone in the population carries it, at which point it has become fixed in that group. This process typically takes many generations. In theory, a helpful allele could become fixed in as little as a few hundred years if it conferred an extraordinarily large advantage. Conversely, a less advantageous allele could take many thousands of years to spread.

It would be great if in our efforts to understand recent human evolution, we could obtain DNA samples from ancient remains and actually track the changes of favored alleles over time. But DNA usually degrades quickly in ancient samples, thereby hindering this approach. Research groups around the world have developed methods of examining genetic variation in

modern-day humans for signs of natural selection that has happened in the past.

One such tactic is to comb DNA data from many different people for stretches that show few differences in SNP alleles within a population. The spread of selected alleles by natural selection can leave distinctive patterns in the SNP data: if an existing allele suddenly proves particularly helpful when a population finds itself in new circumstances, that allele can reach high frequency (while remaining rare in other populations).

Over the past few years multiple studies have identified several hundred genome signals of apparent natural selection that occurred within the past 60,000 years or so. In a few of these cases, scientists have a pretty good grasp on the selective pressures and the adaptive benefit of the favored allele. For example, among dairy-farming populations in Europe, the Middle East and East Africa, the region of the genome that houses the gene for the lactase enzyme that digests lactose (the sugar in milk) shows clear signs of having been the target of strong selection. In most populations, babies are born with the ability to digest lactose, but the lactase gene turns off after weaning, leaving people unable to digest lactose as adults. Writing in the *American Journal of Human Genetics* in 2004, a team at the Massachusetts Institute of Technology estimated that variants of the lactase gene that remain active into adulthood achieved high frequency in European dairy-farming groups in just 5,000 to 10,000 years. In 2006 a group led by Sarah Tishkoff, who is now at the University of Pennsylvania, reported in *Nature Genetics* that they had found rapid evolution of the lactase gene in East African dairy-farming populations. These changes were surely an adaptive response to a new subsistence practice.

31. The main purpose of the passage is to:

- A. explain the numerous steps involved in mapping the human genome sequence.
- B. discuss the evolutionary process of genetic traits spreading across populations.
- C. summarize researchers’ skeptical response to the conclusions drawn by the human genome project.
- D. compare two prominent methods of combing human DNA data for evidence of genetic evolution.

32. Based on the passage, if a SNP occurred in a part of the genome that does not encode protein or regulate genes, the SNP would most likely:

- F. affect the structure or function of a nearby protein.
- G. influence how much protein is made.
- H. modify the ability of an individual to digest milk.
- J. have no measurable effect on an individual.

33. In the passage, height, eye color, and the ability to digest milk are offered as examples of:
- A. the variety of traits that SNPs can modify.
  - B. a collection of traits caused by the same SNP in the human genome.
  - C. traits that SNPs could modify, but haven't.
  - D. traits caused by SNPs occurring in an unknown region of the human genome.
34. It can most reasonably be inferred from the passage that when examining modern-day human DNA data for signs of relatively recent natural selection, genetic researchers:
- F. look for distinctive patterns in SNP data.
  - G. study data from primarily ancient DNA samples.
  - H. expect to find that most SNPs have measurable effects on individuals.
  - J. comb the DNA of relatively few people within a population.
35. The passage suggests that for European and East African dairy-farming populations, variants of the lactase gene:
- A. occurred in numerous SNPs in an individual's genome.
  - B. spread by a means other than natural selection.
  - C. appeared prior to 60,000 years ago.
  - D. provided an adaptive benefit.
36. The passage indicates that after the completion of the human genome sequence, scientists found it easier to:
- F. prevent the DNA in ancient samples from degrading.
  - G. spread a beneficial allele through a population.
  - H. trace human genetic responses to the environment.
  - J. prime the environment for the spread of a beneficial allele.
37. The passage indicates that approximately what percent of the human genome has no known role?
- A. 2 percent
  - B. 4 percent
  - C. 96 percent
  - D. 100 percent
38. As it is used in line 42, the word *fixed* most nearly means:
- F. repaired.
  - G. established.
  - H. connected.
  - J. directed.
39. According to the passage, when natural selection strongly favors a beneficial allele, the allele will spread through a population until everyone carries it if:
- A. it is rare in other populations.
  - B. it does not alter the structure of a protein.
  - C. the environment remains stable.
  - D. the population is relatively large.
40. Lines 42–47 primarily serve to illustrate the point that the:
- F. amount of time needed for a beneficial allele to spread depends on the degree of advantage the allele provides.
  - G. evolution of the modern human genome is relatively slow compared to that of the ancient human genome.
  - H. spread of beneficial alleles in ancient populations will take scientists thousands of years to track.
  - J. length of time needed for a trait to appear in a population is widely disputed among researchers.

**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**

As a *polyol* (a natural sweetener) dissolves in water, the temperature of the solution that forms changes over time. Table 1 shows the change in temperature of each of 4 polyol solutions over the first 6 sec of formation. Each solution was formed by dissolving 0.5 kg of a polyol (either xylitol, maltitol, erythritol, or isomalt) in 1 L of water.

Table 1				
Time (sec)	Temperature (°C) immediately before adding or after adding:			
	xylitol	maltitol	erythritol	isomalt
0*	37.0	37.0	37.0	37.0
1	34.1	35.5	34.1	35.9
2	30.5	34.4	31.3	35.2
3	27.6	33.1	28.8	35.0
4	26.1	32.8	27.0	34.8
5	25.0	32.2	25.9	34.4
6	24.5	31.9	25.0	34.1

\*immediately before addition of polyol

The sweetness of a food containing a polyol is related to the polyol's *solubility* (maximum percent by mass of the polyol that can dissolve in water kept at a constant temperature). Table 2 shows, for each of the 4 polyols, the relative sweetness and the solubility in water at 4 temperatures.

Table 2					
Polyol	Relative sweetness*	Solubility (percent by mass <sup>†</sup> ) at a temperature of:			
		10°C	20°C	40°C	60°C
Xylitol	0.95	56	64	75	85
Maltitol	0.90	50	58	68	75
Erythritol	0.70	25	32	46	61
Isomalt	0.40	18	24	40	56

\*the sweetness as compared with the sweetness of sucrose, which is assigned a value of 1.0

<sup>†</sup> $\left( \frac{\text{g of polyol}}{\text{g of polyol} + \text{g of water}} \right) \times 100\%$

Tables adapted from H. Mitchell, ed., *Sweeteners and Sugar Alternatives in Food Technology*. ©2006 by Blackwell Publishing.



1. Which of the polyols listed in Table 2 is *least* soluble in water at 40°C ?
  - A. Xylitol
  - B. Maltitol
  - C. Erythritol
  - D. Isomalt
2. Based on Table 1, if the temperature of the erythritol solution had been recorded at 7 sec, it would most likely have been closest to which of the following?
  - F. 20.7°C
  - G. 21.8°C
  - H. 24.5°C
  - J. 28.3°C
3. *Tagatose* is a polyol that has a solubility of 58% by mass in water at 20°C. Based on Table 2, the relative sweetness of tagatose is most similar to the relative sweetness of:
  - A. xylitol.
  - B. maltitol.
  - C. erythritol.
  - D. isomalt.
4. Based on Tables 1 and 2, the polyol in the solution that had the *smallest* temperature change over the 6 sec period has a relative sweetness of:
  - F. 0.40.
  - G. 0.70.
  - H. 0.90.
  - J. 0.95.
5. Based on Table 2, it is NOT possible to dissolve enough xylitol in water to form a solution of 60% xylitol by mass if the water is kept at which of the following temperatures?
  - A. 10°C
  - B. 20°C
  - C. 40°C
  - D. 60°C
6. The dissolving of a polyol in water requires energy. Based on Table 1, the dissolving of which polyol over the 6 sec period required the most energy?
  - F. Xylitol; the temperature change was less for xylitol than for any of the other polyols.
  - G. Xylitol; the temperature change was greater for xylitol than for any of the other polyols.
  - H. Isomalt; the temperature change was less for isomalt than for any of the other polyols.
  - J. Isomalt; the temperature change was greater for isomalt than for any of the other polyols.



# Passage II

When a *13-lined ground squirrel* (a mammal) hibernates, it does not eat, and it alternates between *periods of torpor* (characterized by a reduced rate of metabolism, low body temperature, and little movement) and *active bouts* (characterized by a normal rate of metabolism, normal body temperature, and normal movement). Figure 1 shows the body temperature of a 13-lined ground squirrel during 12 consecutive months, including several months of hibernation. Figure 2 shows the average total blood cholesterol of a group of 13-lined ground squirrels at various times during the same 12 months.

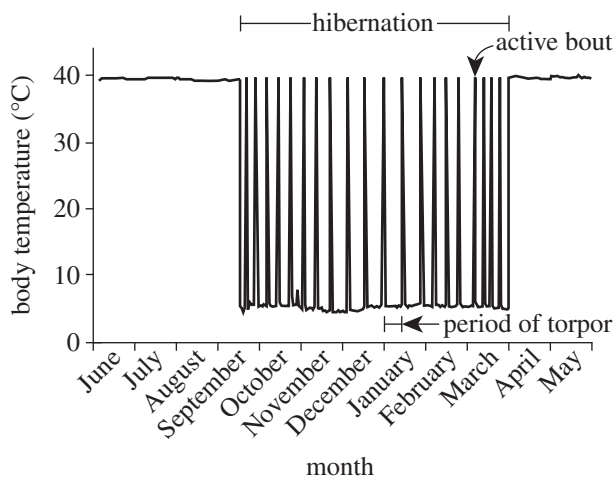
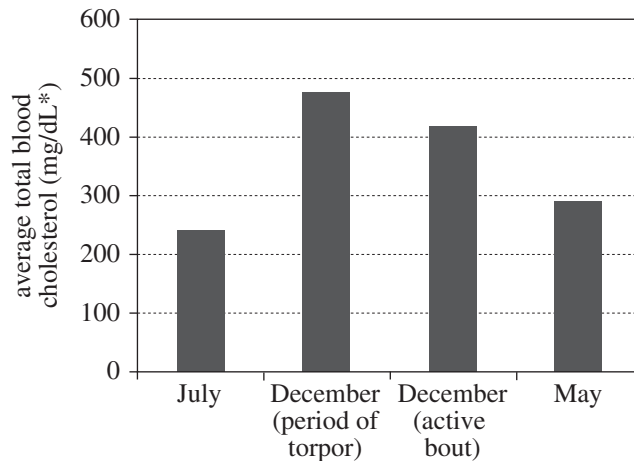


Figure 1



\*dL is the symbol for deciliter; 1 dL = 0.1 L or 100 mL

Figure 2

Figures adapted from Jessica P. Otis et al., "Cholesterol and Lipoprotein Dynamics in a Hibernating Mammal." ©2011 by Otis et al.



7. According to Figure 1, when the 13-lined ground squirrel was NOT hibernating, its average body temperature was approximately:
- A. 0°C.
  - B. 5°C.
  - C. 25°C.
  - D. 40°C.
8. According to Figure 1, of the following months, during which one did the 13-lined ground squirrel spend the most time in periods of torpor?
- F. August
  - G. September
  - H. February
  - J. April
9. Which of the following statements about hibernation and total blood cholesterol is best supported by Figure 2 ? On average, the 13-lined ground squirrels' total blood cholesterol was:
- A. above 300 mg/dL when the squirrels were hibernating and below 300 mg/dL when the squirrels were not hibernating.
  - B. below 300 mg/dL when the squirrels were hibernating and above 300 mg/dL when the squirrels were not hibernating.
  - C. above 500 mg/dL when the squirrels were hibernating and below 500 mg/dL when the squirrels were not hibernating.
  - D. below 500 mg/dL when the squirrels were hibernating and above 500 mg/dL when the squirrels were not hibernating.
10. Do 13-lined ground squirrels more likely consume O<sub>2</sub> at a greater rate during periods of torpor or during active bouts?
- F. Periods of torpor; the rate of metabolism is higher during periods of torpor than during active bouts.
  - G. Periods of torpor; the rate of metabolism is lower during periods of torpor than during active bouts.
  - H. Active bouts; the rate of metabolism is higher during active bouts than during periods of torpor.
  - J. Active bouts; the rate of metabolism is lower during active bouts than during periods of torpor.
11. Based on Figure 1, approximately what percent of the 12 months did the 13-lined ground squirrel spend in hibernation?
- A. 15%
  - B. 35%
  - C. 55%
  - D. 75%
12. Consider the blood samples having an average total cholesterol of 420 mg/dL, as shown in Figure 2. Based on Figure 1, were those blood samples collected when the 13-lined ground squirrels were hibernating?
- F. Yes; the samples were collected while the squirrels were in an active bout during hibernation.
  - G. Yes; the samples were collected while the squirrels were in a period of torpor during hibernation.
  - H. No; the samples were collected while the squirrels were in an active bout, which does not occur during hibernation.
  - J. No; the samples were collected while the squirrels were in a period of torpor, which does not occur during hibernation.



### Passage III

A study examined the production and consumption of methane ( $\text{CH}_4$ ) by soil bacteria in 4 areas of a particular forest: an area of healthy black spruce trees, an area of burned black spruce trees, an area of healthy jack pine trees, and an area of burned jack pine trees.

#### Study

On May 15, 4 identical soil gas collection cylinders were placed in the forest, one in each area. Each cylinder had an open end and a closed end; its open end was pushed into the soil, and then its aboveground surface was covered with shiny foil (see Figure 1). That same day, a gas sample was taken from each cylinder by inserting the needle of a 50  $\text{cm}^3$  syringe into the closed end (through an airtight seal). The  $\text{CH}_4$  content of each gas sample was determined. Likewise, on the 15th day of June, July, August, and September, a gas sample was taken from each cylinder and its  $\text{CH}_4$  content was determined.

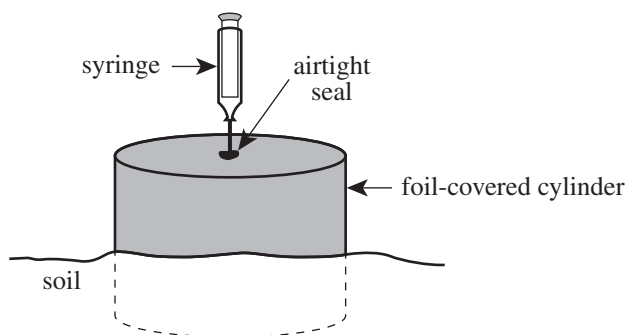


Figure 1

The difference in the  $\text{CH}_4$  contents of consecutive samples (for example, the samples taken on May 15 and June 15) from a cylinder indicated whether there had been a *net production* of  $\text{CH}_4$  (more  $\text{CH}_4$  had been produced than consumed) or a *net consumption* of  $\text{CH}_4$  (more  $\text{CH}_4$  had been consumed than produced) in the area over the month between the 2 sampling dates. From these differences, the average rate of  $\text{CH}_4$  production or consumption was calculated, in milligrams per square meter per day ( $\text{mg}/\text{m}^2/\text{day}$ ), for each area over each month (see Figure 2).

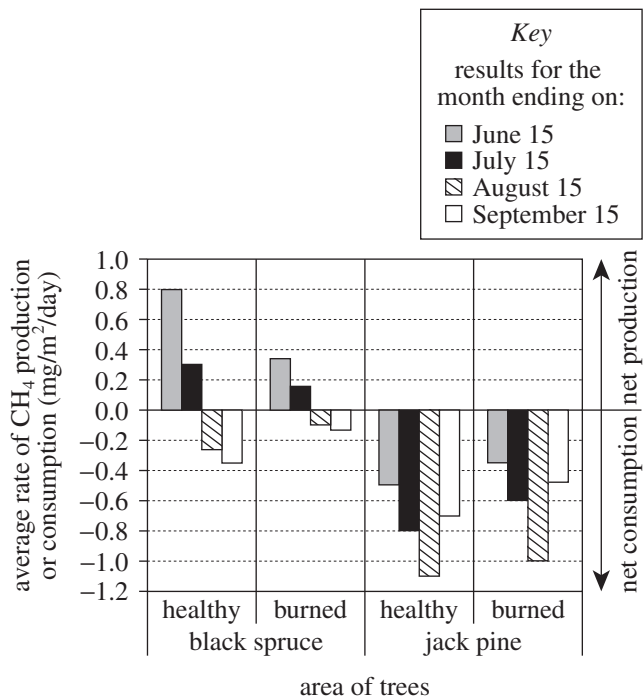


Figure 2

Figure 2 adapted from Sami Ullah et al., "Greenhouse Gas Fluxes from Boreal Forest Soils during the Snow-Free Period in Quebec, Canada." ©2009 by NRC Research Press.

13. According to the results of the study, in either area of jack pine trees,  $\text{CH}_4$  was consumed at the greatest rate over the month that ended on:

A. June 15.  
 B. July 15.  
 C. August 15.  
 D. September 15.



14. Over which 2 months was there a net production of  $\text{CH}_4$  in both areas of black spruce trees?

F. The month ending on June 15 and the month ending on July 15  
 G. The month ending on June 15 and the month ending on August 15  
 H. The month ending on July 15 and the month ending on September 15  
 J. The month ending on August 15 and the month ending on September 15

15. Consider the results for the 2 areas of black spruce trees. Over the months that both areas had a net production of  $\text{CH}_4$ , which area had the greater average rate of production; and over the months that both areas had a net consumption of  $\text{CH}_4$ , which area had the greater average rate of consumption?

	<u>greater production</u>	<u>greater consumption</u>
A.	healthy	healthy
B.	healthy	burned
C.	burned	healthy
D.	burned	burned

16. In the area of healthy jack pine trees, from June 15 to July 15, was there a net production of  $\text{CH}_4$  or a net consumption of  $\text{CH}_4$ , and what was the average rate?

	<u>net production or consumption</u>	<u>average rate</u>
F.	production	$-0.8 \text{ mg/m}^2/\text{day}$
G.	production	$0.4 \text{ mg/m}^2/\text{day}$
H.	consumption	$-0.8 \text{ mg/m}^2/\text{day}$
J.	consumption	$0.4 \text{ mg/m}^2/\text{day}$

17. Consider the unit of measurement in Figure 2 for the average rate of  $\text{CH}_4$  production or consumption. What quantity is represented by “mg,” and what quantity is represented by “ $\text{m}^2$ ”?

	<u>mg</u>	<u><math>\text{m}^2</math></u>
A.	mass of $\text{CH}_4$	area of soil
B.	mass of soil	area of soil
C.	density of $\text{CH}_4$	volume of cylinder
D.	density of air	volume of cylinder

18. Temperature affects the production and consumption of  $\text{CH}_4$  by bacteria. What part or component of the experimental apparatus was directly responsible for minimizing the daily temperature increase in the soil that was covered by a cylinder?

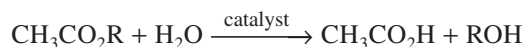
F. The airtight seal  
 G. The shiny foil  
 H. The syringe  
 J. The open end of the cylinder

19. Let  $x$  represent the  $\text{CH}_4$  content of the gas inside a cylinder on May 15, and let  $y$  represent the  $\text{CH}_4$  content of the gas inside the cylinder on June 15. Based on Figure 2, in the area of burned jack pine trees, was  $x > y$  or was  $x < y$ ?

A.  $x > y$ , because there was a net production of  $\text{CH}_4$  from May 15 to June 15 in that area.  
 B.  $x > y$ , because there was a net consumption of  $\text{CH}_4$  from May 15 to June 15 in that area.  
 C.  $x < y$ , because there was a net production of  $\text{CH}_4$  from May 15 to June 15 in that area.  
 D.  $x < y$ , because there was a net consumption of  $\text{CH}_4$  from May 15 to June 15 in that area.

**Passage IV**

*Acetates* are compounds with the chemical formula  $\text{CH}_3\text{CO}_2\text{R}$ , where R is an unreactive chain of carbon and hydrogen atoms. In the presence of a catalyst, acetates can undergo *hydrolysis* (reaction with  $\text{H}_2\text{O}$ ) to produce both acetic acid ( $\text{CH}_3\text{CO}_2\text{H}$ ) and an alcohol ( $\text{ROH}$ ):



The rate at which hydrolysis occurs is proportional to the rate constant,  $k$ , of the reaction.

Three experiments were done to determine  $k$  for the hydrolysis of various acetates. In each trial, Steps 1–3 were performed:

1. Three mL of aqueous 1.0 mole/liter (mol/L) potassium hydroxide (the catalyst) and 80 mL of a solvent were combined.
2. The solution was brought to a particular temperature, and then 0.2 mL of an acetate was added to the solution.
3. The progress of the hydrolysis reaction at the particular temperature was monitored over time to determine  $k$ , measured in  $\frac{\text{L}}{\text{mol}\cdot\text{sec}}$ .

**Experiment 1**

In Trials 1–6,  $k$  for each of 6 acetates with different R chains (groups) was determined using a solvent composed of 37% acetone and 63%  $\text{H}_2\text{O}$ , by volume, at 25°C. See Table 1.

Table 1		
Trial	R group of acetate	$k \left( \frac{\text{L}}{\text{mol}\cdot\text{sec}} \right)$
1	$\text{CH}_3$	0.151
2	$\text{CH}_3\text{CH}_2$	0.0661
3	$\text{CH}_3(\text{CH}_2)_2$	0.0469
4	$\text{CH}_3(\text{CH}_2)_3$	0.0426
5	$\text{CH}_3(\text{CH}_2)_4$	0.0356
6	$\text{CH}_3(\text{CH}_2)_5$	0.0315

**Experiment 2**

In Trials 7–10, Trials 1–4 of Experiment 1 were repeated, except with a solvent composed of 70% acetone and 30%  $\text{H}_2\text{O}$  by volume. See Table 2.

Table 2		
Trial	R group of acetate	$k \left( \frac{\text{L}}{\text{mol}\cdot\text{sec}} \right)$
7	$\text{CH}_3$	0.108
8	$\text{CH}_3\text{CH}_2$	0.0466
9	$\text{CH}_3(\text{CH}_2)_2$	0.0270
10	$\text{CH}_3(\text{CH}_2)_3$	0.0230

**Experiment 3**

In Trials 11–13, Trial 8 of Experiment 2 was repeated at 3 other temperatures: 20°C, 35°C, and 45°C. In Trials 14–16, Trial 9 was repeated at those 3 temperatures. In Trials 17–19, Trial 10 was repeated at those 3 temperatures. See Table 3.

Table 3				
Trial	R group of acetate	$k \left( \frac{\text{L}}{\text{mol}\cdot\text{sec}} \right)$		
		20°C	35°C	45°C
11–13	$\text{CH}_3\text{CH}_2$	0.0356	0.0822	0.135
14–16	$\text{CH}_3(\text{CH}_2)_2$	0.0202	0.0507	0.0880
17–19	$\text{CH}_3(\text{CH}_2)_3$	0.0174	0.0439	0.0766

Tables adapted from S. Hilal, "Estimation of Hydrolysis Rate Constants of Carboxylic Acid Ester and Phosphate Ester Compounds in Aqueous Systems from Molecular Structure by SPARC." U.S. Environmental Protection Agency. 2006.



20. According to the results of Experiment 1, from acetate to acetate, as the number of C atoms in the R group increased, the value of  $k$ :
- F. increased only.  
G. decreased only.  
H. increased, then decreased.  
J. decreased, then increased.
21. Trials 14–16 were different from Trial 9 with respect to what experimental factor?
- A. Amount of catalyst  
B. Identity of R group  
C. Temperature  
D. Composition of solvent
22. Which of the following pieces of laboratory equipment was most likely used in Step 1 of the experimental procedure?
- F. Electronic balance  
G. Thermometer  
H. Graduated cylinder  
J. Metric ruler
23. Suppose that in Experiment 3 the acetate with the R group  $\text{CH}_3(\text{CH}_2)_2$  had been hydrolyzed at  $32^\circ\text{C}$ . At that temperature, the value of  $k$  would most likely have been:
- A. less than  $0.0202 \frac{\text{L}}{\text{mol}\cdot\text{sec}}$ .  
B. between  $0.0202 \frac{\text{L}}{\text{mol}\cdot\text{sec}}$  and  $0.0507 \frac{\text{L}}{\text{mol}\cdot\text{sec}}$ .  
C. between  $0.0507 \frac{\text{L}}{\text{mol}\cdot\text{sec}}$  and  $0.0880 \frac{\text{L}}{\text{mol}\cdot\text{sec}}$ .  
D. greater than  $0.0880 \frac{\text{L}}{\text{mol}\cdot\text{sec}}$ .
24. In how many experiments, if any, was  $k$  an independent variable?
- F. 0  
G. 1  
H. 2  
J. 3
25. Can it be determined on the basis of Experiment 2 whether the rate constant depends on the temperature of the reaction solution?
- A. Yes, because in Experiment 2, the temperature of the reaction solution was varied.  
B. Yes, because in Experiment 2, the temperature of the reaction solution was held constant.  
C. No, because in Experiment 2, the temperature of the reaction solution was varied.  
D. No, because in Experiment 2, the temperature of the reaction solution was held constant.
26. The *dielectric constant* ( $\epsilon$ ) of a substance is a measure of the polarity of the substance; the greater the value of  $\epsilon$ , the greater the polarity. If the  $\epsilon$  of acetone is 21 and the  $\epsilon$  of  $\text{H}_2\text{O}$  is 80, was the solvent used in Experiment 1 less polar or more polar than the solvent used in Experiment 2?
- F. Less polar, because the solvent used in Experiment 1 contained a higher percent of acetone than did the solvent in Experiment 2.  
G. Less polar, because the solvent used in Experiment 1 contained a higher percent of  $\text{H}_2\text{O}$  than did the solvent in Experiment 2.  
H. More polar, because the solvent used in Experiment 1 contained a higher percent of acetone than did the solvent in Experiment 2.  
J. More polar, because the solvent used in Experiment 1 contained a higher percent of  $\text{H}_2\text{O}$  than did the solvent in Experiment 2.



### Passage V

When attacked by predators, tadpoles secrete *Protein F* into their surroundings. A scientist conducted 2 experiments with Protein F: one to examine how the activity of tadpoles changes immediately after a period of exposure to Protein F and the other to examine how depriving tadpoles of food affects their activity during a subsequent period of exposure to Protein F.

#### Experiment 1

One hundred tadpoles were equally divided into 4 groups (Groups 1–4). The groups were separately placed into equal volumes of water having the Protein F concentrations shown in Table 1.

Table 1	
Group	Protein F concentration (pM*)
1	0
2	100
3	200
4	300
*picomoles per liter	

After 2 hr, the groups were separately placed into equal volumes of pure water. The *tadpole activity* of each group was then monitored at regular intervals over the next 90 min. (The tadpole activity of a group was the number of tadpoles that were swimming during a 5 sec observation period.) The results are shown in Figure 1.

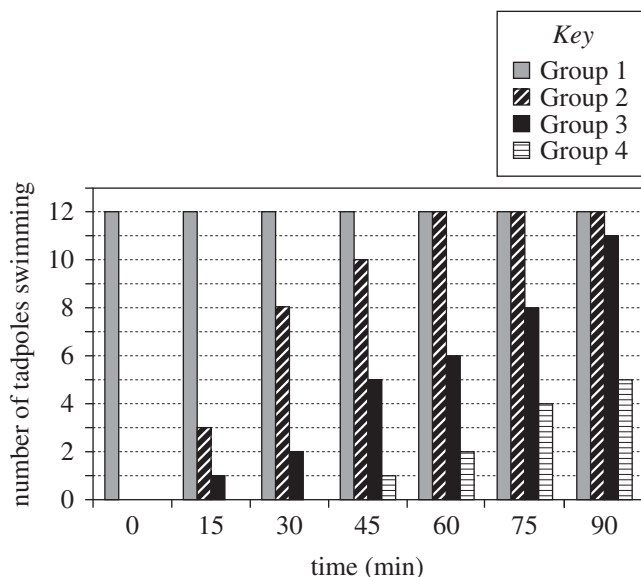


Figure 1

Figure 1 adapted from Michael E. Fraker, "The Dynamics of Predation Risk Assessment: Responses of Anuran Larvae to Chemical Cues of Predators." ©2008 by British Ecological Society.

#### Experiment 2

Two hundred tadpoles were equally divided into 4 groups (Groups 5–8), and the groups were separately placed into equal volumes of pure water. Each group was deprived of food for a specific length of time: Group 5 for 24 hr, Group 6 for 1 hr, Group 7 for 12 hr, and Group 8 for 24 hr. At the end of their respective deprivation periods, the groups were separately placed into equal volumes of water having the Protein F concentrations shown in Table 2.

Table 2	
Group	Protein F concentration (pM)
5	0
6	200
7	200
8	200

The tadpole activity of each group was then monitored at regular intervals over the next 150 min (see Figure 2).

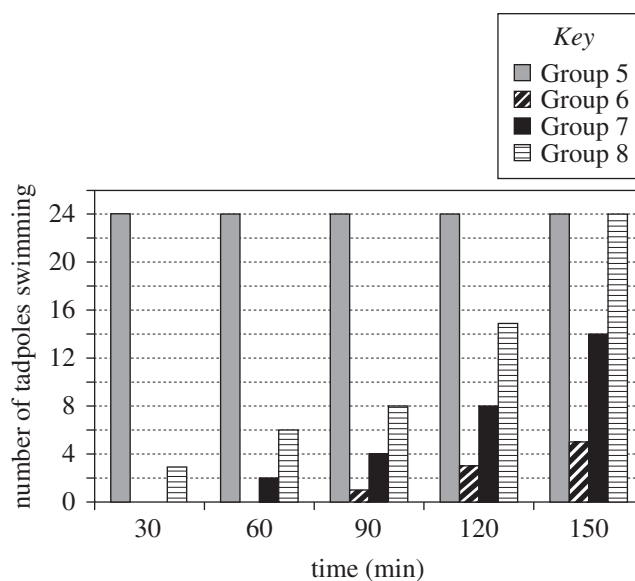


Figure 2

Figure 2 adapted from Michael E. Fraker, "Risk Assessment and Anti-Predator Behavior of Wood Frog (*Rana sylvatica*) Tadpoles: A Comparison with Green Frog (*Rana clamitans*) Tadpoles." ©2010 by Society for the Study of Amphibians and Reptiles.



27. Which of the following groups was most likely intended to serve as a control for the effect of Protein F on tadpole activity?
- Group 3
  - Group 4
  - Group 5
  - Group 6
28. Suppose Experiment 2 had been continued for another 30 min. How many Group 7 tadpoles would most likely have been observed to be swimming at 180 min?
- Fewer than 4
  - Between 4 and 8
  - Between 8 and 14
  - More than 14
29. Experiments 1 and 2 differed in which of the following ways?
- The number of tadpoles in each group was greater in Experiment 1 than in Experiment 2.
  - The number of tadpoles in each group was greater in Experiment 2 than in Experiment 1.
  - The groups of tadpoles were placed into equal volumes of water in Experiment 1 but not in Experiment 2.
  - The groups of tadpoles were placed into equal volumes of water in Experiment 2 but not in Experiment 1.
30. In Experiment 1, after a group was exposed to Protein F for 2 hr, how was the group more likely removed from the water containing Protein F and placed into its new environment—with a fine wire mesh basket or with a watertight plastic cup?
- A fine wire mesh basket, to maximize the amount of Protein F that would be transferred to the group's new environment
  - A fine wire mesh basket, to minimize the amount of Protein F that would be transferred to the group's new environment
  - A watertight plastic cup, to maximize the amount of Protein F that would be transferred to the group's new environment
  - A watertight plastic cup, to minimize the amount of Protein F that would be transferred to the group's new environment
31. The molecules of the substance secreted by the tadpoles are composed of what type of subunit?
- Amino acid
  - Monosaccharide
  - Fatty acid
  - Nucleotide
32. Consider the statement "When the tadpoles were in the presence of Protein F, the activity of the tadpoles that were more hungry increased faster than did the activity of the tadpoles that were less hungry." Do the results of Experiment 2 support this statement?
- Yes; as the length of time that tadpoles were deprived of food increased, the rate of increase in the number of swimming tadpoles increased.
  - Yes; as the length of time that tadpoles were deprived of food increased, the rate of increase in the number of swimming tadpoles decreased.
  - No; as the length of time that tadpoles were deprived of food increased, the rate of increase in the number of swimming tadpoles increased.
  - No; as the length of time that tadpoles were deprived of food increased, the rate of increase in the number of swimming tadpoles decreased.
33. Consider the statement "The activity of the tadpoles that had been exposed to 300 pM of Protein F increased faster than did the activity of the tadpoles that had been exposed to 100 pM of Protein F." Do the results of Experiment 1 support this statement?
- Yes; the rate at which tadpole activity increased was greater for Group 1 than it was for Group 3.
  - Yes; the rate at which tadpole activity increased was greater for Group 4 than it was for Group 2.
  - No; the rate at which tadpole activity increased was greater for Group 3 than it was for Group 1.
  - No; the rate at which tadpole activity increased was greater for Group 2 than it was for Group 4.



**Passage VI**

A physics teacher asked 3 students to predict the changes, if any, to light's energy,  $E$ ; frequency,  $f$  (the number of wave peaks passing a given point each second); wavelength,  $\lambda$  (the distance between adjacent peaks of a light wave); and speed,  $v_L$ , that occur when light travels from a vacuum into clear glass and then from the glass back into the vacuum. The teacher asked the students to base their predictions on one or both of the following equations:

$$E = h \times f, \text{ where } h \text{ always has the same value}$$

$$v_L = f \times \lambda$$

*Student 1*

When light enters the glass,  $f$  and  $E$  are unchanged. This occurs because light loses no energy when it collides with atoms of the glass. However,  $v_L$  becomes less than  $c$  (the speed of light in a vacuum,  $3 \times 10^8$  m/sec) due to these collisions, so  $\lambda$  must also decrease.

As the light leaves the glass, both  $f$  and  $E$  are still unchanged. But upon reentering the vacuum,  $v_L$  once again becomes  $c$ , so  $\lambda$  must increase.

*Student 2*

When light enters the glass, both  $f$  and  $E$  decrease, because light loses energy when it collides with atoms of the glass. In addition,  $v_L$  decreases due to these collisions, so the product  $f \times \lambda$  must also decrease. However,  $\lambda$  can either decrease or increase, so long as any increase in  $\lambda$  is not so great as to cause  $f \times \lambda$  to increase.

When the light leaves the glass, neither  $f$  nor  $E$  changes, because there is nothing present in a vacuum that will cause  $f$  or  $E$  to increase. But  $v_L$  increases to  $c$ , the speed of light in a vacuum, so  $\lambda$  must also increase.

*Student 3*

When light enters the glass, both  $f$  and  $E$  decrease, because light loses energy when it collides with atoms of the glass. However,  $v_L$  becomes greater than  $c$  due to the gravitational attraction between the glass atoms and the light, so the product  $f \times \lambda$  must also increase. Thus,  $\lambda$  must increase, and its increase must be great enough to overcome the decrease in  $f$ .

As the light leaves the glass,  $f$  and  $E$  will have the same values as they had inside the glass, because there is nothing present in a vacuum that will cause  $f$  and  $E$  to change. However, because of the gravitational attraction between the glass atoms and the light,  $v_L$  decreases to  $c$ , so  $\lambda$  must also decrease.

34. Based on Student 3's predictions, when light enters the glass from the vacuum, which of the properties of light listed below increase(s) in value?

- I.  $f$
- II.  $E$
- III.  $v_L$

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



35. Based on the information given, when light enters the glass, can light's  $f$  change without its  $E$  changing?
- A. Yes, because the value of  $h$  can change.
  - B. Yes, because the value of  $h$  is constant.
  - C. No, because the value of  $h$  can change.
  - D. No, because the value of  $h$  is constant.
36. Which students imply that light's frequency before entering the glass is different from its frequency after leaving the glass?
- F. Students 1 and 2 only
  - G. Students 1 and 3 only
  - H. Students 2 and 3 only
  - J. Students 1, 2, and 3
37. Which of the students, if any, implies that the collisions between light and atoms of the glass cause no change in light's energy?
- A. Student 1 only
  - B. Student 2 only
  - C. Student 3 only
  - D. None of the students
38. Which of the students, if any, implies that the speed of light in the vacuum can have more than one value?
- F. Student 1 only
  - G. Student 2 only
  - H. Student 3 only
  - J. None of the students
39. Why does Student 2 maintain that if light enters the glass and  $\lambda$  increases, the size of the increase must be limited? If the increase in  $\lambda$  were too great, the:
- A. quotient  $f \div \lambda$  would decrease.
  - B. quotient  $f \div \lambda$  would increase.
  - C. product  $f \times \lambda$  would decrease.
  - D. product  $f \times \lambda$  would increase.
40. If each of Students 1 and 2 were to provide a value for the  $E$  of light reentering the vacuum, would Student 1's value be greater than, less than, or equal to Student 2's value?
- F. Greater
  - G. Less
  - H. Equal
  - J. Cannot be determined from the given information

**END OF TEST 4**

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

## Scoring Keys for Form E25

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

### Test 1: English—Scoring Key

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

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

#### \*Reporting Categories

**POW** = Production of Writing

**KLA** = Knowledge of Language

**CSE** = Conventions of Standard English

#### Number Correct (Raw Score) for:

Production of Writing (POW) \_\_\_\_\_  
(23)

Knowledge of Language (KLA) \_\_\_\_\_  
(12)

Conventions of Standard English (CSE) \_\_\_\_\_  
(40)

Total Number Correct for English Test \_\_\_\_\_  
(POW + KLA + CSE) (75)

## Test 2: Mathematics—Scoring Key

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

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

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

### \*Reporting Categories

**PHM** = Preparing for Higher Math

N = Number & Quantity

A = Algebra

F = Functions

G = Geometry

S = Statistics & Probability

**IES** = Integrating Essential Skills

**MDL** = Modeling

### Number Correct (Raw Score) for:

Preparing for Higher Math (PHM)  
(N + A + F + G + S)

(35)

Integrating Essential Skills (IES)

(25)

Total Number Correct for Mathematics Test  
(PHM + IES)

(60)

Modeling (MDL)  
(Not included in total number correct for  
mathematics test raw score)

(16)

### Test 3: Reading—Scoring Key

Key	Reporting Category*		
	KID	CS	IKI
1. B			
2. G			
3. A			
4. F			
5. C			
6. J			
7. C			
8. J			
9. A			
10. G			
11. B			
12. G			
13. C			
14. H			
15. A			
16. G			
17. A			
18. J			
19. C			
20. J			

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

#### \*Reporting Categories

**KID** = Key Ideas & Details

**CS** = Craft & Structure

**IKI** = Integration of Knowledge & Ideas

#### Number Correct (Raw Score) for:

Key Ideas & Details (KID) \_\_\_\_\_  
(24)

Craft & Structure (CS) \_\_\_\_\_  
(12)

Integration of Knowledge & Ideas (IKI) \_\_\_\_\_  
(4)

Total Number Correct for Reading Test  
(KID + CS + IKI) \_\_\_\_\_  
(40)

### Test 4: Science—Scoring Key

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

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

#### \*Reporting Categories

**IOD** = Interpretation of Data

**SIN** = Scientific Investigation

**EMI** = Evaluation of Models,  
Inferences & Experimental Results

#### Number Correct (Raw Score) for:

Interpretation of Data (IOD) \_\_\_\_\_  
(16)

Scientific Investigation (SIN) \_\_\_\_\_  
(10)

Evaluation of Models, Inferences &  
Experimental Results (EMI) \_\_\_\_\_  
(14)

Total Number Correct for Science Test  
(IOD + SIN + EMI) \_\_\_\_\_  
(40)

## ACT Resource Links

**ACT Online Practice Tests:** <https://www.crackab.com/act/>

✧ **ACT English Practice Tests:**

<https://www.crackab.com/act/english/>

✧ **ACT Math Practice Tests:**

<https://www.crackab.com/act/math/>

✧ **ACT Reading Practice Tests:**

<https://www.crackab.com/act/reading/>

✧ **ACT Science Practice Tests:**

<https://www.crackab.com/act/science/>

**ACT Grammar:** <https://www.crackab.com/act/grammar/>

**ACT Real Past Papers Download:**

<https://www.crackab.com/act-downloads/>

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**Digital SAT & New SAT Practice Tests:**

<https://www.cracksat.net>

**Real SAT Tests Download:**

<http://www.cracksat.net/sat-downloads/>

**AP Exams Practice Tests:**

<https://www.crackap.com>

<https://www.apstudy.net>

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

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

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

**ACT Test E25** **Your Scale Score**

English \_\_\_\_\_

Mathematics \_\_\_\_\_

Reading \_\_\_\_\_

Science \_\_\_\_\_

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

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

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

Scale Score	Raw Scores				Scale Score
	Test 1 English	Test 2 Mathematics	Test 3 Reading	Test 4 Science	
36	74-75	59-60	40	40	36
35	71-73	57-58	39	39	35
34	69-70	56	38	38	34
33	68	55	37	—	33
32	67	54	36	37	32
31	66	52-53	35	36	31
30	64-65	51	34	—	30
29	63	49-50	33	35	29
28	62	47-48	32	34	28
27	60-61	44-46	31	33	27
26	58-59	41-43	30	32	26
25	56-57	39-40	29	30-31	25
24	53-55	36-38	28	28-29	24
23	50-52	34-35	26-27	27	23
22	47-49	32-33	25	25-26	22
21	44-46	31	23-24	23-24	21
20	42-43	29-30	22	21-22	20
19	40-41	27-28	21	20	19
18	38-39	24-26	19-20	18-19	18
17	36-37	21-23	18	17	17
16	33-35	17-20	16-17	15-16	16
15	30-32	13-16	15	14	15
14	27-29	10-12	13-14	12-13	14
13	25-26	8-9	12	11	13
12	23-24	6-7	10-11	10	12
11	20-22	5	9	9	11
10	17-19	4	7-8	7-8	10
9	15-16	—	6	6	9
8	13-14	3	—	5	8
7	10-12	—	5	4	7
6	8-9	2	4	3	6
5	7	—	3	—	5
4	5-6	1	—	2	4
3	3-4	—	2	—	3
2	2	—	1	1	2
1	0-1	0	0	0	1



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