Practice Multiple-Choice Sections

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The ACT®

Form 2176CPRE

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 Tests 1–4 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.

For Test 5, follow the directions on the first page of that test.

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

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ENGLISH TEST

45 Minutes—75 Questions

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

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

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

PASSAGE I

The following paragraphs may or may not be in the most logical order. Each paragraph is numbered in brackets, and question 14 will ask you to choose where Paragraph 3 should most logically be placed.

Bar Codes: A Linear History

[1]

In 1948, graduate students, Norman Woodland[1] and Bernard Silver,[1] took on a problem that had troubled retailers for years: how to keep track of store inventories. Inspired by the dots and dashes of Morse code, however,[2] Woodland and Silver created a system of lines that could encode data. Called a *symbology*, the pattern created by the spacing and widths of the lines encodes information by representing different characters.

1. **A.** NO CHANGE
B. students, Norman Woodland and Bernard Silver
C. students Norman Woodland and Bernard Silver
D. students Norman Woodland and Bernard Silver,

2. **F.** NO CHANGE
G. in other words,
H. consequently,
J. DELETE the underlined portion.

[2]

The first bar code was composed of four white lines set at specific distances from each other on a black background. The first line was always present. [4] Depending on the presence or absence of the remaining three lines, up to seven different arrangements were susceptible and, therefore, seven different encodings.

Today, twenty-nine white lines making more than half a billion encodings possible.

[3]

To create a bar code scanner, Woodland and Silver adapted technology from an optical movie sound system. Their prototype scanner used a 500-watt bulb, a photomultiplier tube (a device that detects light), and an oscilloscope (a device that translates electronic signals into readable information). Although successful, the concoction was both large and costly. For example, progress stalled until the 1970s, when laser technology (both more compact and less expensive) became available.

[4]

In today's scanners, a laser sends light back and forth across a bar code. While the black lines absorb the light, the white lines reflect it back at a fixed mirror inside the scanner. In this way, the scanner reads the symbology and decodes the information.

3. **A.** NO CHANGE
B. distances so that each was separated, one from the
C. locations, each one set apart from the
D. lengths of distance from each

4. The writer is considering deleting the preceding sentence. Should the sentence be kept or deleted?
F. Kept, because it begins the description that is completed in the sentence that follows.
G. Kept, because it gives a clear image of what the first bar code looked like.
H. Deleted, because it provides an extra detail that is not relevant to the subject of the paragraph.
J. Deleted, because it contradicts a point made later in the paragraph.

5. **A.** NO CHANGE
B. responsible
C. possible
D. capable

6. **F.** NO CHANGE
G. which make
H. to make
J. make

7. **A.** NO CHANGE
B. contraption
C. substance
D. stuff

8. **F.** NO CHANGE
G. As a result,
H. However,
J. Even so,

9. **A.** NO CHANGE
B. them
C. ones
D. one

[5]

10 Today, being that there are one- and two-dimensional bar codes using numeric and alphanumeric symbologies. Bar codes are used not only for a pack of gum or an airline ticket, but also for research. In one study, for instance, tiny bar codes were placed on bees tracking their activities. Shaping the way we gather, track, and share information, we have almost certainly exceeded even Woodland and Silver's expectations.

10. Which of the following true statements, if added here, would most effectively lead into the new subject of the paragraph?

- **F.** In the 1940s, Woodland and Silver were graduate students at the Drexel Institute of Technology in Philadelphia.
- **G.** Woodland and Silver were granted a patent for their bar code on October 7, 1952.
- **H.** Bar code equipment has been available for retail use since 1970.
- **J.** Bar codes themselves have advanced as well.

11. **A.** NO CHANGE
- **B.** there are
- **C.** where
- **D.** DELETE the underlined portion.

12. **F.** NO CHANGE
- **G.** had been placed on bees trying to track
- **H.** placed on bees, which would track
- **J.** were placed on bees to track

13. **A.** NO CHANGE
- **B.** exceeding Woodland and Silver's expectations about bar codes has almost certainly been done.
- **C.** bar codes have almost certainly exceeded even Woodland and Silver's expectations.
- **D.** it is almost certain that we have exceeded even Woodland and Silver's expectations.

Questions 14 and 15 ask about the preceding passage as a whole.

14. For the sake of the logic and coherence of the essay, Paragraph 3 should be placed:

- **F.** where it is now.
- **G.** before Paragraph 1.
- **H.** after Paragraph 1.
- **J.** after Paragraph 5.

15. Suppose the writer's primary purpose had been to describe how a specific technological advancement changed business practices. Would this essay accomplish that purpose?

- **A.** Yes, because it offers an overview of current bar code technology and indicates the variety of ways in which bar codes are used by specific businesses.
- **B.** Yes, because it explains how bar codes and scanners made it easier for stores to keep track of their inventories.
- **C.** No, because it focuses primarily on the development of bar codes and only briefly mentions how businesses have implemented the use of bar codes.
- **D.** No, because it focuses on why businesses needed new technology but does not explain how bar codes were able to serve that need.

PASSAGE II

Glowing on an Adventure

As I pulled my camera out of my backpack, I felt a tap on my arm.

"No photographs," whispered the woman next to me, pointing [16] up to the cave ceiling. "The flash will make them stop glowing," she said, whispering. [17]

She was referring to the thousands of glowworms that clung to the limestone ceiling and, with their radiant bodies, flooded the cave in aquamarine light. While [18] I was traveling on [19] canoe on a group tour through the renowned Glowworm Grotto of New Zealand's Waitomo Caves. Were it not for the twinkling light of these *Arachnocampa luminosa*, a species unique to New Zealand and abundant in these caves, this meandering subterranean passageway would feel as though it were downright ensconced in shadows. [20]

I sheepishly tucked the camera away and focused again on the glowworms. Collectively, they resembled the cosmos, a sea of stars in a clear night sky. Beautiful—yet what made them glow?

"Bioluminescence," the woman said, peculiarly sensing my curiosity. [21] A badge was [22] pinned to her shirt indicated she was a biochemist, here, I guessed, to research the organism.

16. **F.** NO CHANGE
G. me, and then pointing
H. me and she pointed
J. me, she pointed

17. **A.** NO CHANGE
B. glowing," she said as she pointed up to the ceiling.
C. glowing," she said in a hushed, whispering voice.
D. glowing."

18. **F.** NO CHANGE
G. Although
H. Since
J. DELETE the underlined portion.

19. **A.** NO CHANGE
B. with
C. by
D. in

20. **F.** NO CHANGE
G. end up pretty hard to see.
H. have not a lot of light.
J. be utterly dark.

21. At this point, the writer wants to emphasize the idea that the narrator found the woman's comment peculiar. Which of the following best accomplishes that goal?

A. I figured she had been to the caves before.
B. Surprised, I hesitantly turned toward her.
C. She had a notepad in her hand.
D. I happened to agree.

22. **F.** NO CHANGE
G. had been
H. it was
J. DELETE the underlined portion.

She explained that to attract prey, glowworms (not really worms at all, but the larval stage of a fungus gnat) emit light through their translucent skin; via a [23] cellular chemical reaction. The cells produce luciferin, a chemical pigment that reacts with oxygen to produce light that shines through the organism's tail-end intestine.

From its mouth, she showed me, all glowworms dangle [24] shimmering silken threads glossed in beads of mucus. Cave-dwelling insects are trapped in these threads, then reeled in [25] like fish on a line, and finally lured by the light. [25] The light responds to environmental factors. The sound of splashing water, however, [26] might signal that prey is nearby, causing them [27] to brighten. [28]

23. **A.** NO CHANGE
B. skin, and via
C. skin. Via
D. skin via

24. **F.** NO CHANGE
G. all of the glowworms are dangling
H. each of the glowworms dangle
J. each glowworm dangles

25. **A.** NO CHANGE
B. lured by the light, then trapped in these threads, and finally reeled in like fish on a line.
C. reeled in like fish on a line, then trapped in these threads, and finally lured by the light.
D. trapped in these threads, then lured by the light, and finally reeled in like fish on a line.

26. **F.** NO CHANGE
G. on the other hand,
H. for example,
J. above all,

27. **A.** NO CHANGE
B. the light
C. these
D. DELETE the underlined portion.

28. Which of the following choices, if added here, would best conclude the paragraph and refer back to the conversation at the beginning of the essay?

F. Insects are likely attracted to the light because the sky-like appearance of the glowworms fools the insects into believing they are outdoors.
G. She told me that the cave is usually quiet, with only occasional noises, such as tour boats passing through the water.
H. A camera flash, she reminded me, may also spell danger, and the glowworms' light is doused.
J. The light is also brighter in a hungry larva than in those that have just eaten.

Our trip neared its end. I spotted a dragonfly in the cave. I knew its fate, it would be ensnared, just as I had been by the brilliance of these luminescent glowworms.

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

soaring toward the light.

Should the writer make this revision?

A. Yes, because the revised phrase more specifically describes the dragonfly's actions to help support the narrator's claim that she knew what its fate would be.
B. Yes, because the revised phrase adds information that explains why the light of the glowworms was suddenly dim.
C. No, because the original phrase more clearly establishes that the trip is ending and that the narrator sees the dragonfly as they exit the cave.
D. No, because the original phrase builds on the suspense established in the narrative regarding the fate of the dragonfly.

30. **F.** NO CHANGE
G. fate; and
H. fate:
J. fate

PASSAGE III

A Rose by the Name Antique

With shears in hand, I clip a thin branch from the rosebush in my backyard garden. I place this clipping into the basket next to me and crouch under this again. I snip a few more branches and then rise to head to the greenhouse. There, I will deposit these clippings in rich soil; roots will take hold, buds will sprout, and a new plant will find a home in my garden.

My roses are not your average hybrid-tea roses (those long-stemmed, special occasion roses with well-formed buds). Mine are *antique* roses, old, or heirloom varieties, that have existed in gardens worldwide for centuries.

31. **A.** NO CHANGE
B. basket next, to me
C. basket, next to me
D. basket next to me,

32. **F.** NO CHANGE
G. the rosebush
H. one
J. it

33. Which choice most closely maintains the sentence pattern the writer establishes after the semicolon?

A. NO CHANGE
B. I will see new buds that have been sprouting,
C. followed by the buds, which have sprouted,
D. then come the sprouting buds after that,

34. **F.** NO CHANGE
G. roses, old or heirloom, varieties,
H. roses old, or heirloom varieties
J. roses, old or heirloom varieties

Compared to vibrant hybrid-tea colors, antique rose colors
35

35. **A.** NO CHANGE
B. vibrant hybrid-tea, colors,
C. vibrant, hybrid-tea colors
D. vibrant hybrid-tea colors

tend to be silenced. Their stems are also shorter, and their
36

36. **F.** NO CHANGE
G. reduced.
H. muted.
J. lower.

buds are a bit droopier. Their fragrance, however, is unmatched. And unlike the hybrid-tea whose long stems make into a rosebush that is rather scraggly looking,
37

37. **A.** NO CHANGE
B. about
C. like
D. for

antique rosebushes can be grown in a variety of colors,
38

handsomely landscaping gardens.

38. The writer wants to add a detail here that best completes the contrast to hybrid-tea roses in the first part of the sentence. Which choice best accomplishes that goal?

F. NO CHANGE
G. are lush and shapely,
H. can grow quite large,
J. tend to be less thorny,

The plant thrives best when it is exposed to six hours
39

of direct sunlight daily. The plant can withstand extreme
39

39. Which choice best introduces the main focus of the paragraph?

A. NO CHANGE
B. The varieties of antique roses are numerous, the most popular of which are the silken peach *Mutabilis* and the crimson *Louis Phillippe.*
C. Aside from the rose's beauty, what gardeners like me most appreciate is that antiques are incredibly durable and low maintenance.
D. While I am fond of bush varieties, I am also drawn to climbing varieties that can be placed against walls, fences, or trellises.

temperatures and survive nearly anywhere. It's also easier
40

40. **F.** NO CHANGE
G. They're
H. Their
J. Its

to grow antiques. Cultivating hybrid-teas having involved
41

a process of grafting two species of rose together, but the grafted area remains weak and susceptible to viruses. Antiques, on the other hand, are less prone to disease because they are grown simply by placing cuttings from a parent plant into nutrient-rich soil. They require far less
42

pruning, fertilizing, and nurturing than their hybrid-tea

41. **A.** NO CHANGE
B. which involves
C. involves
D. involving

42. **F.** NO CHANGE
G. Antiques, requiring
H. Antiques require
J. Requiring

counterparts, antiques can reportedly survive without any care from human hands, a fact that surprises many. [43]

[1] I dig small holes in a pot of soil, place each clipping a half inch deep, and pack down the soil around them. [2] Back in my greenhouse, I strip the clippings of all leaves and branches. [3] Then I wait: the roots will take hold and, eventually, buds will sprout. [44]

43. The writer wants to add a detail here that emphasizes the antique rose's ability to survive without human care. Which choice best accomplishes that goal?

A. NO CHANGE
B. blooming year after year even at abandoned sites.
C. making them more popular among gardeners.
D. often blooming between midspring and fall.

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

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

Question 45 asks about the preceding passage as a whole.

45. Suppose the writer's primary purpose had been to describe the process of planting a particular flower. Would this essay accomplish that purpose?

A. Yes, because the essay discusses the steps involved in growing and maintaining antique rosebushes.
B. Yes, because the writer explains the specific conditions needed to plant antique roses and how long it takes for new buds to sprout.
C. No, because the essay is more focused on comparing the qualities and cultivation of antique and hybrid-tea roses.
D. No, because while the writer mentions growing antique roses in his garden, the essay is more focused on the history of antiques in gardens worldwide.

PASSAGE IV

Jeremy Frey, Weaving Heritage Into Modern Art

[1]

The winning piece was a basket, it was [46] eighteen inches tall with a curved, vaselike silhouette. [A] It was made of ash wood finely woven into bold stripes of black and white that ran from its crown to its base. [B]

46. **F.** NO CHANGE
G. this work of art reached
H. the object stood
J. DELETE the underlined portion.

In the ninety-year history of the Santa Fe Indian Market—the largest Indian art festival in the nation—[47] the 2011 event marked the first time a basket won best of show. The creator of the piece, thirty-three-year-old Passamaquoddy Indian Jeremy Frey from Princeton, Maine, the [48] basket sold at auction for $16,000.

[2]

[C] Frey describes his baskets as "cutting-edge traditional." [D] He primarily weaves a classic material, wood from the brown ash tree, but, unlike most contemporary basketmakers, [49] he harvests, cuts, pounds, dries, and dyes the wood himself. Then creating [50] highly elaborate versions of the sturdy utility baskets that have been used by generations of Passamaquoddy [51] fishermen from Maine. He honors tradition, but he highlights artistic design. For example, his baskets feature complex weaving on [52] areas that are often hidden and therefore typically not embellished. Many traditional baskets have basic, woven lids.

47. **A.** NO CHANGE
B. Market the largest Indian art festival—in the nation—
C. Market, the largest Indian art festival, in the nation
D. Market, the largest Indian art festival in the nation

48. **F.** NO CHANGE
G. looked on as the
H. as his
J. his

49. **A.** NO CHANGE
B. but, unlike most, contemporary basketmakers
C. but unlike, most contemporary basketmakers,
D. but, unlike most contemporary basketmakers

50. **F.** NO CHANGE
G. Going on to create
H. Frey creates
J. Creating

51. If the writer were to delete the underlined portion, the essay would primarily lose:

A. an indication that Frey honors Passamaquoddy cultural heritage by creating baskets that look nearly identical to traditional pieces.
B. a mention of a physical characteristic of the earliest baskets used by Passamaquoddy fishermen.
C. a detail that connects Frey's basketry work to long-standing Passamaquoddy traditions.
D. a point revealing that Frey's baskets are used by Passamaquoddy fishermen today.

52. Which choice provides the clearest and most specific information about which parts of Frey's baskets are being referred to in the sentence and about Frey's manner of weaving those parts?

F. NO CHANGE
G. a remarkable level of detail on certain sections, the
H. intricately woven interiors and bottoms,
J. characteristic interiors and bottoms,

Frey's porcupine quill lids are often decorated
53

with art inlaid on birch bark; as far as lids go,
54
I wouldn't say that's basic. And while braids of
54

grass are customarily woven into ash baskets
55

to make them better, Frey incorporates braided
56
cedar bark to create striking new textures.

[3]

Now that he's a nationally recognized artist of who
57
has rejuvenated the art of basketry, Frey feels his role is to inspire. He's on the board of the Maine Indian Basketmakers Alliance, a group that works to help preserve it by reaching out to young members of Native
58
communities in the state. His other goal is to continue to

stand out. The woven grass bracelets he saw on a recent
59
trip to Hawaii have influenced how he shapes the bases of some of his newer baskets, as he finds yet another way to make traditional Passamaquoddy weaving something spectacularly his own.

53. Which placement of the underlined portion makes clear that the art that decorates the lid, not the lid itself, is made of porcupine quill?

A. Where it is now
B. After the word *are*
C. After the word *often*
D. After the word *with*

54. **F.** NO CHANGE
G. bark, which is not exactly formulating a lid through a conventional ideology.
H. bark; this is just part of his really artistic way.
J. bark.

55. **A.** NO CHANGE
B. has been
C. is seen
D. is

56. Which choice provides the clearest and most specific reason that grass is woven into ash baskets?

F. NO CHANGE
G. for the sake of the objects,
H. for a useful purpose,
J. to strengthen them,

57. **A.** NO CHANGE
B. being whom
C. whom
D. who

58. **F.** NO CHANGE
G. this art
H. that
J. DELETE the underlined portion.

59. **A.** NO CHANGE
B. distinguish himself from other weavers so as a weaver he is set apart from them.
C. remain to be someone who gets noticed.
D. keep on being fully distinct.

Question 60 asks about the preceding passage as a whole.

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

> The black stripes were woven flat, sharply setting off the white stripes, which were woven to form raised columns of perfectly even points that seemed to cascade down the piece.

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

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

PASSAGE V

The Flow of Time

Nine hundred years ago, Emperor Zhezong of China, [61]
ordered the design and construction of a clock

built to keep time more accurately than other clocks. [62]

This would be no simple timepiece and because [63]

Chinese dynasties continued [64] to astrology, they relied
on complicated clocks that not only kept time but also
helped track stars, planets, the sun, and the moon. An
eminent scientist and bureaucrat named Su Song lead [65]
Zhezong's ambitious project.

Using his expertise in calendrical science, [66]

Su Song created a spectacular timepiece housed within [67]
an ornate forty-foot-tall tower. At the tower's top sat an

armillary sphere, or [68] a nest of metal rings representing
celestial reference points such as the horizon and
the sun's path—that rotated in sync with the
earth, enabling precise astronomical observations.
Inside the tower, a sphere depicting the sky
revolved to display the stars that were overhead.

61. **A.** NO CHANGE
B. ago, Emperor Zhezong, of China
C. ago, Emperor Zhezong of China
D. ago Emperor Zhezong of China,

62. **F.** NO CHANGE
G. to keep time more accurately than clocks that had previously come before it.
H. more accurate at keeping time correctly than any other clock of the time.
J. more accurate than any other.

63. **A.** NO CHANGE
B. timepiece. Because
C. timepiece, because
D. timepiece because

64. **F.** NO CHANGE
G. adhered
H. linked
J. fixed

65. **A.** NO CHANGE
B. imminent scientist and bureaucrat named Su Song lead
C. imminent scientist and bureaucrat named Su Song led
D. eminent scientist and bureaucrat named Su Song led

66. Given that all the choices are accurate, which one best indicates that Su Song relied on engineering achievements from earlier times?
F. NO CHANGE
G. Building on centuries of Chinese clock-making knowledge,
H. While authoring his treatise on astronomical clockwork,
J. After first crafting a working small-scale wooden model,

67. **A.** NO CHANGE
B. secured between
C. encased around
D. nestled among

68. **F.** NO CHANGE
G. sphere—
H. sphere:
J. sphere,

Besides, below the star sphere, the tower's open sides exposed a detailed model of a five-story pagoda. Automated figurines would appear in the pagoda's doorways and ring bells to announce hours, sunsets, seasons, and other chronological events.

69. **A.** NO CHANGE
B. Sooner or later,
C. Lastly,
D. Thus,

70. Which of the following alternatives to the underlined portion would NOT be acceptable?
F. bells, which served to announce
G. bells, they announced
H. bells that announced
J. bells, announcing

The clock's inner workings were equally remarkable. Hidden in the tower, a waterwheel eleven feet in diameter powered the entire clock. Therefore, water would pour at a constant rate into one of the wheel's thirty-six buckets. When the bucket was full, the water's weight pulled it down, rotating the waterwheel. Then a stop mechanism halted the wheel and positioned the next bucket for filling.

71. **A.** NO CHANGE
B. reveals themselves as being
C. was shown to be
D. has proved

72. **F.** NO CHANGE
G. In other words, water
H. For example, water
J. Water

Chinese clockmakers had long used waterwheels, but Su Song's stop mechanism, which regulated the inertia of the waterwheel, represented significant innovation.

73. **A.** NO CHANGE
B. nevertheless,
C. regardless,
D. DELETE the underlined portion.

Unfortunately, after Su Song's clock ran for thirty years, invaders stole it. Later the clock vanished altogether. It would be a few hundred years until with the refinement of mechanical clocks in Europe other clocks approached the complexity of Su Song's masterpiece.

74. **F.** NO CHANGE
G. until—with the refinement of mechanical clocks in Europe—
H. until with the refinement (of mechanical clocks in Europe)
J. until, with the refinement, of mechanical clocks in Europe

75. **A.** NO CHANGE
B. eventually became able to draw anywhere near to the complexity
C. grew to attain such a high degree as that
D. could even fathom coming within reach

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.

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1. The numbers 1 through 15 were each written on individual pieces of paper, 1 number per piece. Then the 15 pieces of paper were put in a jar. One piece of paper will be drawn from the jar at random. What is the probability of drawing a piece of paper with a number less than 9 written on it?

A. $\frac{1}{9}$
B. $\frac{1}{15}$
C. $\frac{6}{15}$
D. $\frac{7}{15}$
E. $\frac{8}{15}$

2. Which of the following expressions is equivalent to $-4x^3 - 12x^3 + 9x^2$?

F. x^8
G. $-7x^8$
H. $-8x^3 + 9x^2$
J. $-16x^3 + 9x^2$
K. $-16x^6 + 9x^2$

3. When $x = 2$, $10 + 3\big(12 \div (3x)\big) =$?

A. 12
B. 16
C. 26
D. 34
E. 104

4. $|6 - 4| - |3 - 8| =$?

F. −7
G. −3
H. 3
J. 7
K. 21

5. The expression $(4c - 3d)(3c + d)$ is equivalent to:

A. $12c^2 - 13cd - 3d^2$
B. $12c^2 - 13cd + 3d^2$
C. $12c^2 - 5cd - 3d^2$
D. $12c^2 - 5cd + 3d^2$
E. $12c^2 - 3d^2$

6. Of the 180 students in a college course, $\frac{1}{4}$ of the students earned an A for the course, $\frac{1}{3}$ of the students earned a B for the course, and the rest of the students earned a C for the course. How many of the students earned a C for the course?

F. 75
G. 90
H. 105
J. 120
K. 135

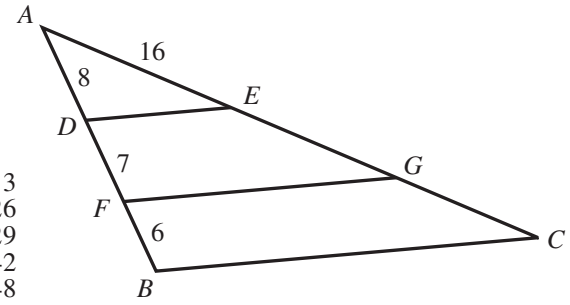
7. The number of fish, f, in Skipper's Pond at the beginning of each year can be modeled by the equation $f(x) = 3(2^x)$, where x represents the number of years after the beginning of the year 2000. For example, $x = 0$ represents the beginning of the year 2000, $x = 1$ represents the beginning of the year 2001, and so forth. According to the model, how many fish were in Skipper's Pond at the beginning of the year 2006 ?

A. 96
B. 192
C. 384
D. 1,458
E. 46,656

8. Manish drove from Chicago to Baton Rouge. At 8:00 a.m., he was 510 km from Baton Rouge. At 1:00 p.m., he was 105 km from Baton Rouge. Which of the following values is closest to Manish's average speed, in kilometers per hour, from 8:00 a.m. to 1:00 p.m. ?

F. 58
G. 68
H. 81
J. 94
K. 102

9. In the figure shown below, E and G lie on $\overline{AC}$, D and F lie on $\overline{AB}$, $\overline{DE}$ and $\overline{FG}$ are parallel to $\overline{BC}$, and the given lengths are in feet. What is the length of $\overline{AC}$, in feet?



A. 13
B. 26
C. 29
D. 42
E. 48

10. Katerina runs 15 miles in $2\frac{1}{2}$ hours. What is the average number of *minutes* it takes her to run 1 mile?

F. 6
G. 10
H. $12\frac{1}{2}$
J. $16\frac{2}{3}$
K. $17\frac{1}{2}$

11. A bag contains 8 red marbles, 9 yellow marbles, and 7 green marbles. How many additional red marbles must be added to the 24 marbles already in the bag so that the probability of randomly drawing a red marble is $\frac{3}{5}$?

A. 11
B. 16
C. 20
D. 24
E. 32

12. In the standard (x,y) coordinate plane, the point (2,1) is the midpoint of $\overline{CD}$. Point C has coordinates (6,8). What are the coordinates of point D ?

F. $\left(-2,-\frac{7}{2}\right)$
G. $(-2,-6)$
H. $\left(4,\ \frac{9}{2}\right)$
J. $(10, 10)$
K. $(10, 15)$

13. At his job, the first 40 hours of each week that Thomas works is *regular time*, and any additional time that he works is *overtime*. Thomas gets paid \$15 per hour during regular time. During overtime Thomas gets paid 1.5 times as much as he gets paid during regular time. Thomas works 46 hours in 1 week and gets \$117 in deductions taken out of his pay for this week. After the deductions are taken out, how much of Thomas's pay for this week remains?

A. \$492
B. \$573
C. \$609
D. \$618
E. \$735

14. At Sweet Stuff Fresh Produce the price of a bag of grapes depends on the total number of bags purchased at 1 time, as shown in the table below. In 2 trips to Sweet Stuff this week, Janelle purchased 3 bags of grapes on Monday and 4 bags of grapes on Wednesday. How much money would Janelle have saved if she had instead purchased 7 bags of grapes in 1 trip on Monday?

Number of bags	Price per bag
1–3	\$3.00
4–6	\$2.80
7–9	\$2.60
10 or more	\$2.50

F. \$0.20
G. \$1.00
H. \$1.40
J. \$2.00
K. \$2.50

15. What is 3% of 4.14×10^4 ?

A. 1,242
B. 1,380
C. 12,420
D. 13,800
E. 124,200

16. What value of x satisfies the equation $-3(4x - 5) = 2(1 - 5x)$?

F. $-\frac{17}{2}$

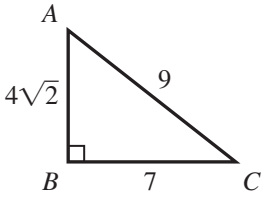
G. $-\frac{17}{22}$

H. -1

J. $\frac{3}{17}$

K. $\frac{13}{2}$

17. In right triangle $\triangle ABC$ shown below, the given lengths are in millimeters. What is sin A ?



A. $\frac{4\sqrt{2}}{9}$

B. $\frac{4\sqrt{2}}{7}$

C. $\frac{7\sqrt{2}}{8}$

D. $\frac{7}{9}$

E. $\frac{9}{7}$

18. $\left(\frac{27}{64}\right)^{-\frac{2}{3}} = ?$

F. $-\frac{9}{16}$

G. $-\frac{9}{32}$

H. $\frac{9}{32}$

J. $\frac{16}{9}$

K. $\frac{32}{9}$

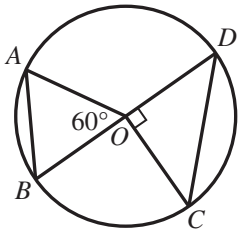
19. Loto begins at his back door and walks 8 yards east, 6 yards north, 12 yards east, and 5 yards north to the barn door. About how many yards less would he walk if he could walk directly from the back door to the barn door?

A. 8
B. 19
C. 23
D. 26
E. 31

20. For a given set of data, the standard score, z, corresponding to the raw score, x, is given by $z = \frac{x - \mu}{\sigma}$, where μ is the mean of the set and σ is the standard deviation. If, for a set of scores, $\mu = 78$ and $\sigma = 6$, which of the following is the raw score, x, corresponding to $z = 2$?

F. 90
G. 84
H. 80
J. 76
K. 66

21. In the figure below, A, B, C, and D lie on the circle centered at O.



Which of the following does NOT appear in the figure?

A. Acute triangle
B. Equilateral triangle
C. Isosceles triangle
D. Right triangle
E. Scalene triangle

22. What is the slope of a line, in the standard (x,y) coordinate plane, that is parallel to $x + 5y = 9$?

F. -5

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

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

J. $\frac{9}{5}$

K. 9

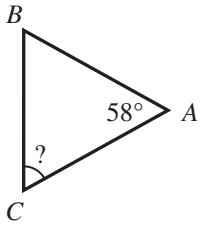
23. Given $y = \frac{x}{x - 1}$ and $x > 1$, which of the following is a possible value of y ?

A. -1.9
B. -0.9
C. 0.0
D. 0.9
E. 1.9

24. The set of all positive integers that are divisible by both 15 and 35 is infinite. What is the least positive integer in this set?

F. 5
G. 50
H. 105
J. 210
K. 525

25. In $\triangle ABC$ shown below, the measure of $\angle A$ is 58°, and $\overline{AB} \cong \overline{AC}$. What is the measure of $\angle C$?



A. 32°
B. 42°
C. 58°
D. 61°
E. 62°

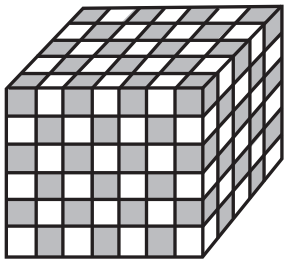
26. About 1.48×10^8 square kilometers of Earth's surface is land; the rest, about 3.63×10^8 square kilometers, is water. If a returning space capsule lands at a random point on Earth's surface, which of the following is the best estimate of the probability that the space capsule will land in water?

F. 80%
G. 71%
H. 65%
J. 41%
K. 29%

27. On the first 7 statistics tests of the semester, Jamal scored 61, 76, 79, 80, 80, 84, and 91. The mean, median, and mode of his scores were 79, 80, and 80, respectively. On the 8th statistics test, Jamal scored 90. How do the mean, median, and mode of all 8 of his scores compare to the mean, median, and mode of his first 7 scores?

	Mean	Median	Mode
A.	equal	greater	greater
B.	greater	greater	greater
C.	greater	greater	equal
D.	greater	equal	greater
E.	greater	equal	equal

28. The solid rectangular prism shown below was built by alternating congruent black cubes and white cubes such that 2 cubes of the same color have at most 1 edge touching. What is the total number of *white* cubes that were used to build the prism?



F. 45
G. 102
H. 105
J. 140
K. 210

29. One side of square *ABCD* has a length of 12 meters. A certain rectangle whose area is equal to the area of *ABCD* has a width of 8 meters. What is the length, in meters, of the rectangle?

A. 12
B. 16
C. 18
D. 20
E. 24

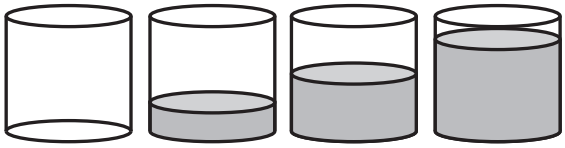
30. The average of a list of 4 numbers is 92.0. A new list of 4 numbers has the same first 3 numbers as the original list, but the fourth number in the original list is 40, and the fourth number in the new list is 48. What is the average of this new list of numbers?

F. 81.0
G. 92.0
H. 94.0
J. 94.4
K. 96.6

31. The vector **i** represents 1 mile per hour east, and the vector **j** represents 1 mile per hour north. Maria is jogging south at 12 miles per hour. One of the following vectors represents Maria's velocity, in miles per hour. Which one?

A. $-12\mathbf{i}$
B. $-12\mathbf{j}$
C. $12\mathbf{i}$
D. $12\mathbf{j}$
E. $12\mathbf{i} + 12\mathbf{j}$

32. Four identical glasses are shown below. One glass is empty, and the other 3 glasses are $\frac{1}{4}$ full, $\frac{1}{2}$ full, and $\frac{4}{5}$ full of water, respectively. If the water were redistributed equally among the 4 glasses, what fractional part of each glass would be filled?



F. $\frac{2}{11}$

G. $\frac{8}{11}$

H. $\frac{3}{22}$

J. $\frac{31}{60}$

K. $\frac{31}{80}$

33. Aurelio is purchasing carpet tiles to cover an area of his living room floor that is $8\frac{1}{3}$ feet wide by 10 feet long. Each carpet tile is a square 20 inches wide by 20 inches long. What is the minimum number of carpet tiles that Aurelio must purchase to cover this area of his living room floor?

A. 5
B. 11
C. 21
D. 30
E. 84

34. In the standard (x,y) coordinate plane, a circle with its center at (8,5) and a radius of 9 coordinate units has which of the following equations?

F. $(x-8)^2+(y-5)^2=81$
G. $(x-8)^2+(y-5)^2=9$
H. $(x+8)^2+(y+5)^2=81$
J. $(x+8)^2+(y+5)^2=9$
K. $(x+5)^2+(y+8)^2=81$

Use the following information to answer questions 35–38.

Many humans carry the gene Yq77. The Yq test determines, with 100% accuracy, whether a human carries Yq77. If a Yq test result is positive, the human carries the Yq77 gene. If a Yq test result is negative, the human does NOT carry Yq77. Sam designed a less expensive test for Yq77 called the Sam77 test. It produces some incorrect results. To determine the accuracy of the Sam77 test, both tests were administered to 1,000 volunteers. The results from this administration are summarized in the table below.

	Positive Yq test	Negative Yq test
Positive Sam77 test	590	10
Negative Sam77 test	25	375

35. It cost \$2,500 to administer each Yq test and \$50 to administer each Sam77 test. What was the total cost to administer both tests to all the volunteers?

A. \$1,537,500
B. \$1,556,750
C. \$1,568,250
D. \$2,500,000
E. \$2,550,000

36. What percent of the volunteers actually carry Yq77 ?

F. 57.5%
G. 60.0%
H. 60.5%
J. 61.5%
K. 62.5%

37. For how many volunteers did the Sam77 test give an incorrect result?

A. 10
B. 25
C. 35
D. 385
E. 400

38. One of the volunteers whose Sam77 test result was positive will be chosen at random. To the nearest 0.001, what is the probability the chosen volunteer does NOT possess Yq77 ?

F. 0.017
G. 0.026
H. 0.035
J. 0.041
K. 0.063

39. Given matrices $X = [-1\ 0]$ and $Y = \begin{bmatrix} -2 \\ -1 \end{bmatrix}$, which of the following matrices is XY ?

A. $[-4]$
B. $[-3]$
C. $[-2]$
D. $[\ 2]$
E. $[\ 3]$

40. Regardless of how the graph is oriented in the standard (x,y) coordinate plane, NO graph in one of the following categories has a vertical line of symmetry. Which one?

F. Line
G. Square
H. Pentagon
J. Parallelogram
K. Scalene triangle

41. The equation $24x^2 + 2x = 15$ has 2 solutions. What is the greater of the 2 solutions?

A. $\frac{3}{4}$
B. $\frac{4}{3}$
C. $\frac{5}{6}$
D. $\frac{7}{6}$
E. $\frac{11}{15}$

42. Which of the following expressions is equal to $(\sin 60°)(\cos 30°) + (\cos 60°)(\sin 30°)$?

F. $\cos(60° - 30°)$
G. $\cos(60° + 30°)$
H. $\sin(60° - 30°)$
J. $\sin(60° + 30°)$
K. $\sin\left(\frac{60° + 30°}{2}\right)$

43. What is the area, in square units, of a circle that has a circumference 12π units long?

A. 6π
B. 12π
C. 24π
D. 36π
E. 144π

44. A barrel contains 25 liters of a solvent mixture that is 40% solvent and 60% water. Lee will add pure solvent to the barrel, without removing any of the mixture currently in the barrel, so that the new mixture will contain 50% solvent and 50% water. How many liters of pure solvent should Lee add to create this new mixture?

F. 2.5
G. 5
H. 10
J. 12.5
K. 15

45. For all $x \neq \pm y$, $\frac{x}{x+y} + \frac{y}{x-y} = ?$

A. $\frac{1}{x-y}$
B. $\frac{x+y}{x-y}$
C. $\frac{x+y}{2x}$
D. $x^2 + y^2$
E. $\frac{x^2+y^2}{x^2-y^2}$

46. Mary, James, and Carlos sold $\frac{1}{4}$-page advertisements for the school yearbook. Mary sold twice as many as Carlos did, and James sold 3 times as many as Mary did. What fraction of these advertisements did Carlos sell?

F. $\frac{1}{9}$
G. $\frac{1}{7}$
H. $\frac{1}{6}$
J. $\frac{1}{5}$
K. $\frac{1}{3}$

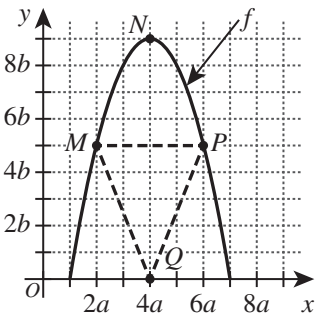
47. In a window display at a flower shop, there are 3 spots for 1 plant each. To fill these 3 spots, Emily has 6 plants to select from, each of a different type. Selecting from the 6 plants, Emily can make how many possible display arrangements with 1 plant in each spot?

(Note: The positions of the unselected plants do not matter.)

A. 3
B. 6
C. 15
D. 120
E. 216

Use the following information to answer questions 48–50.

The quadratic function f and $\triangle MPQ$ are graphed in the standard (x,y) coordinate plane below. Points $M(2a, 5b)$, $N(4a, 9b)$, and $P(6a, 5b)$ are on f. Point $Q(4a, 0)$ is NOT on f.



48. In terms of a and b, what is the area, in square coordinate units, of $\triangle MPQ$?

F. $8ab$
G. $10ab$
H. $12ab$
J. $15ab$
K. $20ab$

49. Point M will remain fixed, and point Q will move to the right along the x-axis. As Q continues to move to the right, which of the following statements describes what will happen to the slope of $\overline{MQ}$?

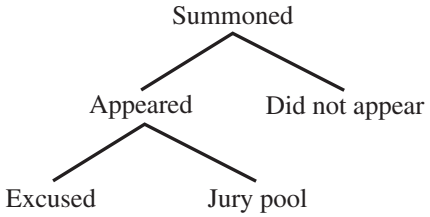
A. It will decrease and eventually be negative.
B. It will decrease but never be negative.
C. It will stay the same.
D. It will increase but never be positive.
E. It will increase and eventually be positive.

50. One of the following values is equal to $f(5a)$. Which one?

F. $3a$
G. $5a$
H. $5b$
J. $8a$
K. $8b$

51. Twelve jurors are needed for an upcoming trial. The diagram below illustrates a part of the process of jury selection. The 12 jurors will be selected from a jury pool of about 60 people. The court records show a trend that only 40% of the people who are summoned for jury duty actually appear and that of the people who appear, $\frac{1}{3}$ are excused. If this same trend continues, how many people should be summoned to have as close as possible to 60 people in the jury pool?

A. 45
B. 90
C. 150
D. 225
E. 800



52. What is the 275th digit after the decimal point in the repeating decimal $0.\overline{6295}$?

F. 0
G. 2
H. 5
J. 6
K. 9

53. Given that $f(x) = x^2 - 4$ and $g(x) = x + 3$, what are all the values of x for which $f(g(x)) = 0$?

A. -5 and -1
B. -3, -2, and 2
C. -1 and 1
D. 1 and 5
E. $-\sqrt{5}$ and $\sqrt{5}$

54. Given that p is a positive number, n is a negative number, and $|p| > |n|$, which of the following expressions has the greatest value?

F. $\left|\frac{p-n}{p}\right|$
G. $\left|\frac{p-n}{n}\right|$
H. $\left|\frac{p+n}{p-n}\right|$
J. $\left|\frac{p+n}{p}\right|$
K. $\left|\frac{p+n}{n}\right|$

55. If $i = \sqrt{-1}$, then $\frac{i + i^2 + i^3}{i^3 + i^4 + i^5} = ?$

A. -3

B. -1

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

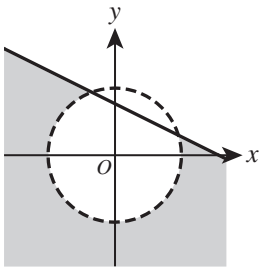
D. 1

E. 3

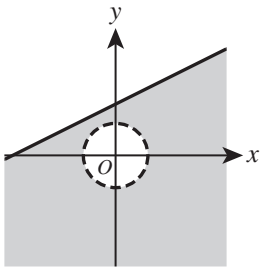
56. In one of the following graphs in the standard (x,y) coordinate plane, the solution set to the system of inequalities below is shown shaded. Which one?

$$\begin{cases} x + 2y \le 6 \\ 3x^2 > 12 - 3y^2 \end{cases}$$

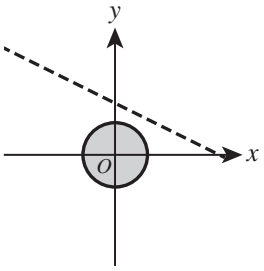
F.



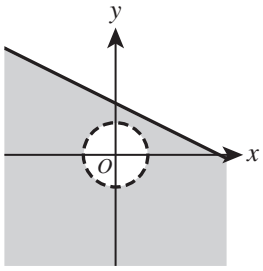
J.



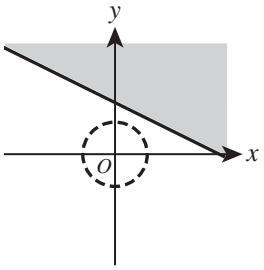
G.



K.



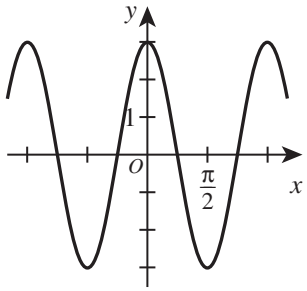
H.



57. Let a, b, c, and d be real numbers. Given that $ac = 1$, $\frac{b+c}{d}$ is undefined, and $abc = d$, which of the following *must* be true?

A. $a = 0$ or $c = 0$
B. $a = 1$ and $c = 1$
C. $a = -c$
D. $b = 0$
E. $b + c = 0$

58. A cosine function is shown in the standard (x,y) coordinate plane below.



One of the following equations represents this function. Which one?

F. $y = 2\cos\left(\frac{x}{3}\right)$

G. $y = 2\cos(3x)$

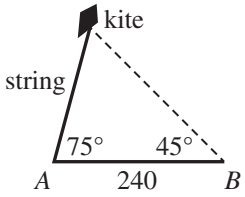
H. $y = 3\cos\left(\frac{x}{3}\right)$

J. $y = 3\cos\left(\frac{x}{2}\right)$

K. $y = 3\cos(2x)$

59. The figure below shows a flying kite. At a certain moment, the kite string forms an angle of elevation of 75° from point A on the ground. At the same moment, the angle of elevation of the kite at point B, 240 ft from A on level ground, is 45°. What is the length, in feet, of the string?

A. $60\sqrt{3}$
B. $80\sqrt{6}$
C. 144
D. 180
E. 240



60. If a publisher charges \$15 for the first copy of a book that is ordered and \$12 for each additional copy, which of the following expressions represents the cost of y books?

F. $12y + 3$
G. $12y + 15$
H. $15y - 3$
J. $15y + 3$
K. $15y + 12$

END OF TEST 2

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

DO NOT RETURN TO THE PREVIOUS TEST.

READING TEST

35 Minutes—40 Questions

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

Passage I

LITERARY NARRATIVE: Passage A is adapted from the memoir *The Piano Shop on the Left Bank* by Thad Carhart (©2001 by T.E. Carhart). Passage B is adapted from the article "Me and My Violin" by Arnold Steinhardt (©2014 by Listen: Life with Classical Music).

Passage A by Thad Carhart

Even when Luc was busy and could not talk he always made me welcome and allowed me to wander around the inner sanctum of the back room on my own. When things were quieter, he seemed glad of the company and would tell me about the pianos that had just arrived. Our talks made real for me one of his fundamental beliefs, that each and every piano had completely individual characteristics, even if of the same manufacturer and age.

Sometimes he knew all the details, had even met the owners and talked about their instrument with them and knew intimately how they had treated it. Other times he knew nothing beyond what he could see, feel, or hear. Most often pianos came to him from auctions and charity sales, their history anonymous. But even then, like an expert in artifacts, he could deduce a great deal: whether a piano had been played much or little, whether it had been in an environment with the proper level of humidity (one of his cardinal rules), whether there had been children in the household, even whether it had recently been transported by ship. ("The worst thing you can possibly do to a piano," he told me more than once.) At these moments he was part detective, part archaeologist, part social critic.

His attitude about how people treated their pianos seemed to mirror his philosophy of life. While regretting the depredations worked by children on keyboards and strings, he regarded them as tolerable because the piano was at least used and, as he put it, *"au sein de la famille"* ("at the heart of the family"). It was more than just any piece of furniture, but it was that, too, and if drinks were spilled and stains bit into shiny finishes, it was the price one paid for initiating the young to a joy that should stem from familiarity rather than reverence.

Those who preserved their piano as an altar upon which the art of music was to be worshipped irritated Luc, but he was deeply respectful of serious musicians who used and depended upon their instrument for their livelihood.

Passage B by Arnold Steinhardt

Marc Lifschey, one of the greatest oboists of his era, told me that after retiring as a performer and teacher, he sold his oboe. On the face of it, giving up an instrument you no longer use seems perfectly reasonable, but nevertheless I was taken aback. Marc was not merely an excellent oboist; he was a great artist. Still, Marc didn't do it alone. He and his oboe did it together. Even in retirement, wouldn't Marc have some sort of lasting relationship with his oboe that transcended performing on it? Wouldn't he want to keep it if for no other reason than as a reminder of the magnificent music the two of them had made together?

Joseph Roisman, the distinguished first violinist of the Budapest String Quartet, seemed to be content to give up his beloved Lorenzo Storioni when he agreed to sell it to me after the Quartet retired. But when I finally met with him, he had second thoughts. "Steinhardt," he said to me plaintively, "I'll sell the violin to you some day, but for now I'm enjoying playing chamber music with my friends every Friday night." And that is exactly what he did until his death a year or two later.

Lifschey and Roisman dealt with retirement in different ways, but their stories made me wonder about not only what I'll do with my violin if and when I retire, but also about the very nature of a musician's day-to-day, year-to-year relationship with his instrument.

I began playing violin when I was six years old, and now I'm seventy-six. It has been an integral part of my life for the last seven decades. Does that make the violin my very close friend? Well, yes. Sometimes. The violin obviously can't speak with words, but when I ask something of it, the instrument can respond with an astonishing range of substance and emotion. This is friendship on a most exalted level.

There are other moments, however, when the violin stubbornly refuses to do my bidding—when it only reluctantly plays in tune, or makes the sound I want, or delivers the music's essence for which I strive. Then I have to cajole, bargain or adjust to its every

whim. Some friend; more like an adversary, you might say.

Or is the violin my partner? A woman once went backstage to congratulate the great violinist Jascha Heifetz after a concert. "What a wonderful sound your violin has, Mr. Heifetz!" she exclaimed. Heifetz leaned over his violin that lay in its open case, listened intently for a moment, and said, "Funny, I don't hear a thing." My violin also lies mute in its case without me—but, on the other hand, I stand mute on the concert stage without it.

1. In Passage A, the parenthetical information in line 19 and lines 21–23 mainly serves to:

- **A.** specify how Luc identified certain aspects of a piano's history.
- **B.** portray Luc as overly judgmental about piano transportation.
- **C.** describe the types of rules that visitors to Luc's shop were required to follow.
- **D.** indicate some of Luc's firm beliefs about piano care.

2. Based on the assertion in Passage A that Luc's "attitude about how people treated their pianos seemed to mirror his philosophy of life" (lines 25–26), which of the following statements would most nearly describe Luc's philosophy of life?

- **F.** It's better to live a full and imperfect life than not participate because something might go wrong.
- **G.** Life is a fragile gift that must be cherished and kept safe at all times.
- **H.** Living well is like playing the piano well; it requires dedication and practice.
- **J.** It's important not to take life's opportunities for granted because they may not come a second time.

3. As it is used in line 32, the phrase *bit into* most nearly means:

- **A.** pinched.
- **B.** ingested.
- **C.** marred.
- **D.** severed.

4. In the third paragraph of Passage B (lines 61–65), the author most clearly shifts from:

- **F.** making an argument against musicians selling their instruments to using evidence from his life to support that argument.
- **G.** introducing musicians he admires to explaining why he hopes people admire him as a musician.
- **H.** examining his own emotions about his violin to explaining why musicians must develop a partnership with their instruments.
- **J.** discussing the connection between other musicians and their instruments to pondering his own connection with his violin.

5. In Passage B, the statement that Lifschey "was not merely an excellent oboist; he was a great artist" (lines 44–45) can best be described as:

- **A.** a fact supported by details about Lifschey's career.
- **B.** a fact confirmed by experts quoted in the passage.
- **C.** an opinion that the author attributes to Lifschey's colleagues and students.
- **D.** an opinion that the author asserts but does not explain.

6. In Passage B, it can most reasonably be inferred that Heifetz's response to the woman who congratulates him is intended to point out that:

- **F.** the woman hears Heifetz's violin differently than Heifetz does.
- **G.** the woman isn't qualified to judge the quality of Heifetz's violin.
- **H.** Heifetz enjoyed the woman's humorous comment.
- **J.** Heifetz's violin doesn't make sounds by itself.

7. In Passage B, the author most directly indicates that the violin is sometimes an adversary by stating that it:

- **A.** lies mute in its case.
- **B.** makes him adjust to its whims.
- **C.** responds with a range of emotion.
- **D.** can't speak with words.

8. Compared to Passage A, Passage B is more directly focused on the:

- **F.** damage a musician can do to an instrument.
- **G.** characteristics of an instrument that give clues to its history.
- **H.** interdependence between musician and instrument.
- **J.** benefits of making instruments available to young children.

9. In contrast to the way the pianos are described in Passage A, the passage author's violin in Passage B is described as:

- **A.** exhibiting unique characteristics.
- **B.** having an active personality of its own.
- **C.** sustaining damage from careless children.
- **D.** being important to daily life.

10. Which of the following assertions about instruments is most strongly supported by details provided in both Passage A and Passage B?

- **F.** Familiarity with your instrument is an important part of the joy of playing music.
- **G.** Instruments should be revered and never treated like furniture.
- **H.** Selling your instrument shows disrespect for the music you have made together.
- **J.** Maintaining proper humidity levels is essential to preserving an instrument.

Passage II

INFORMATIONAL: This passage is adapted from the article "Notes from a Wedding" by Lauren Wilcox Puchowski (©2010 by Lauren Wilcox Puchowski).

It was never Kenney Holmes's intention to become a wedding singer. The grandson of West Indian immigrants, Holmes was raised in Gordon Heights, on Long Island, in what he calls "a small black community founded by like-minded thinkers," families of immigrants and Southern blacks who, as Holmes says, "didn't come here to fool around" and who handed down to their children their own keen sense of ambition.

"We grew up in that kind of atmosphere," he says, "of positive thinking, of getting educated, whether or not you had a degree."

Like any American boy in the 1950s and '60s, he was fascinated with popular music: He listened to the area's one radio station, which "mostly played Sinatra"; sometimes in the evenings, with a coat hanger stuck into the top of his portable radio, he could pick up a faint signal from WWRL, a rhythm and blues station in New York City. When he was a teenager, his brother brought home a guitar. "I was 16, it was a Sunday night," he says. "I sat down and played 'I Can't Get No Satisfaction.' I was addicted."

While he was not a virtuoso, he was, he discovered, good at making money at it. He learned three songs—"Satisfaction" by the Rolling Stones, "And I Love Her" by the Beatles, and "Shotgun" by Junior Walker and the All Stars—and formed a band. "We went out and sold it," he says. "We could play those three songs all night. We got pretty popular out on the island, playing battle of the bands, fire halls, high school proms, for $10 a night."

Still, a career as a musician was not what he, or his family, had had in mind. Over the next few years, he says: "I did everything I could not to be a guitar player. I went to college not to be a guitar player." Thinking he would be a psychiatrist, he took pre-med classes but didn't complete a degree. Along the way, he continued playing nightclubs and parties.

In his mid-20s, he visited his brother in Washington. Washington looked, to Holmes, like a good place to be an ambitious, career-minded black man, but it also had a thriving music scene in nightclubs and hotel lounges, and the next 15 years played out as a sort of tussle between his creative pursuits and his more business-driven impulses. Trying to work his way up in the music scene, he played five and six nights a week in nightclubs and wrote his own music. He started a recording studio called Sound Ideas, which trawled local talent for the makings of a hit song, but he found the pickings slim.

The club scene, after a long while, began to wear on him, as well. Unwilling to resign himself to the life of a starving artist, when an agent approached him in the early '90s about specializing in wedding and private parties, Holmes decided to try it.

It was a revelation. "I could make in one night what I used to make in five," he says. And "it changed the culture of what I was doing."

Holmes was well-suited for the role of event bandleader. His production skills helped him control his band's sound, and his familiarity with country, big-band and classical music made him popular with audiences who wanted, as he says, "a tango or a Viennese waltz," as well as Wilson Pickett.

Because business ebbs and flows with the seasons and the economy, Holmes has always kept a variety of sidelines, including a job driving a limousine for nine years to put his oldest daughter through a private high school and college. These days, at gigs, he hands out a stack of million-dollar "bills" printed with his image and his current enterprises: bandleader, commercial mortgage broker, hard money lender.

Holmes uses as many as eight musicians and two singers for weddings. He accepts turnover as a fact of running a band, but his current core lineup has, in the mercurial world of part-time performers, been fairly steady. Sam Brawner, the drummer, and Atiba Taylor, the sax player, have played with him for three and four years, respectively, and Bruce Robinson, the keyboardist, has played with him for 15.

This is perhaps partly because Holmes insists on making music. During performances, he lets his musicians take the lead and uses specialized, stripped-down tracks, called digital sequences, to set the tempo and fill in musical parts when necessary, ultimately preferring the messy alchemy of live music to something more canned. The musicians say that this is in contrast to other bandleaders they've worked for, who often rely heavily on recordings and use musicians more as visual props. Holmes's respect for the music endears him to his musicians. "These guys play from the heart," says Robinson. "They're not just trying to get through the gig."

11. The main purpose of the passage is to:

- **A.** explain why Holmes's musical tastes gradually changed over time.
- **B.** describe how Holmes's hectic professional life affects his personal life.
- **C.** highlight the different instruments Holmes mastered in becoming a famous musician.
- **D.** document how Holmes eventually became an enterprising bandleader.

12. One theme of the passage is that:

- **F.** one's previous experiences and pursuits can be useful in achieving success.
- **G.** talent is the most important factor in achieving success in both business and music.
- **H.** recognizing one's limitations is necessary in overcoming one's failures.
- **J.** pursuing one's dreams should take precedence over more practical matters.

13. Which of the following events referred to in the passage occurred last chronologically?

- **A.** Taylor joined Holmes's band.
- **B.** Brawner joined Holmes's band.
- **C.** Holmes started driving a limousine.
- **D.** Holmes started Sound Ideas.

14. Based on the passage, the residents of Gordon Heights in the 1950s and 1960s would best be described as:

- **F.** artistic and sophisticated.
- **G.** driven and optimistic.
- **H.** friendly and easygoing.
- **J.** generous and dependable.

15. The main purpose of the third paragraph (lines 13–22) is to:

- **A.** indicate why Holmes preferred rhythm and blues to Sinatra songs.
- **B.** establish that Holmes's parents disapproved of his interest in music.
- **C.** reveal that Holmes was considered a musical prodigy.
- **D.** describe what inspired Holmes to start playing music.

16. The main idea of the fourth paragraph (lines 23–31) is that:

- **F.** Holmes was better at playing music than he was at promoting his band.
- **G.** Holmes's band was able to earn money despite having a limited repertoire.
- **H.** Holmes's band became a national phenomenon despite the band members' lack of musical talent.
- **J.** Holmes would have had more success early on if he had taken the time to learn more songs.

17. Based on the passage, the main reason Holmes eventually preferred playing music at weddings and private parties to playing music in clubs was that:

- **A.** he could play a wider variety of music at weddings and private parties.
- **B.** audiences at weddings and private parties were easier to please.
- **C.** weddings and private parties were more profitable.
- **D.** weddings and private parties required less travel.

18. The main idea of the eleventh paragraph (lines 73–80) is that:

- **F.** Holmes often has to alter his musical style based on which band members are available to play a gig.
- **G.** Holmes typically needs more band members to play at weddings than he needs to play at private parties.
- **H.** Holmes's core lineup of band members has been relatively consistent for a business with a high turnover rate.
- **J.** Holmes's core lineup of band members is constantly changing because Holmes expects his musicians to travel long distances.

19. It can most reasonably be inferred from the passage that Holmes's band members like playing music with Holmes in part because, in contrast to other band leaders, Holmes:

- **A.** is familiar with big band, classical, and country music.
- **B.** allows band members to showcase their talents during gigs.
- **C.** played music in the Washington club scene for fifteen years.
- **D.** uses sophisticated elements like digital sequences during gigs.4

20. In the passage, the phrase *something more canned* (lines 86–87) most nearly refers to:

- **F.** sound effects.
- **G.** music videos.
- **H.** improvised music.
- **J.** recorded music.

Passage III

INFORMATIONAL: This passage is adapted from the article "Photography Changes How Cultural Groups Are Represented and Perceived" by Edwin Schupman (©2012 by The Smithsonian Institution).

The author of the passage is a citizen of the Muscogee (Creek) Nation of Oklahoma.

Using photographs as educational resources presents particular challenges and must be done with care. There is always more than face value in any photo, and historical photos of American Indians are no exception. Photography's rise in the late nineteenth century coincided with great change in American Indian communities—an era that capped over three hundred years of diseases, wars, cultural disruption, and land dispossession. As Indian people struggled to adapt to catastrophic changes to their old ways of living, photographers took thousands of studio portraits and made what they believed to be neutral ethnographic images of the "vanishing Indian." As Indian cultures bent under pressure to assimilate into mainstream America, photographers routinely captured images that compared the new "civilized" Indian to the tradition-bound "savages." Indian delegations that traveled to Washington, D.C., to defend tribal treaty rights were photographed in studios and in front of federal buildings. Photographers also accompanied government expeditions to the West where they documented traditional cultures, leading the way for tourists and commercial photographers who followed, carrying their cameras and preconceptions into Native American communities. These efforts generated a legacy of photographic images of American Indian people that can serve today as rich educational resources. But if used carelessly, they can also fuel romanticized and stereotypical perceptions of American Indians.

Consider some of the many photographs of Goyathlay, the Apache man who Mexicans named "Geronimo." He and other Chiricahua Apaches fought a protracted war from 1863 to 1886 against the United States for the right to live in their traditional homelands rather than on reservations.

The Chiricahua Apaches' fight for freedom captured the American imagination in the late nineteenth century. "Geronimo," especially, became a legendary figure and a media phenomenon whose legacy has lasted into the twenty-first century. He became synonymous with courage, daring, and savage ruthlessness. World War II paratroopers shouted his name as they jumped from airplanes into combat. Movies, television shows, comic books, popular songs, posters, T-shirts, and American cities have borne his image and name. One photo that shows Goyathlay and three other Chiricahuas in their camp just prior to surrendering to U.S. forces in 1886 documents a critical and difficult day for the people who had fought so diligently for their freedom.

In another well-known studio portrait, circa 1890, Goyathlay poses with a rifle. To late-nineteenth-century Americans, Geronimo was a dangerous enemy, yet at the same time a curiosity and romantic symbol of the "Wild West." This photo personifies the renegade image but, strangely, it was taken about two to four years after Goyathlay surrendered—while he was a prisoner of war. Why, then, was this photo taken? What meaning did it convey at the time? What must have been in Goyathlay's mind? What does the photo mean today? Is it loaded with historical truths or is it as empty as the prisoner's bullet chamber?

A few years later, Goyathlay was photographed again, this time in a more pastoral pose and place—holding a melon in a garden with his wife and three of their children. What was the meaning behind this photo? Did people of the time see it as a simple family photo, or did it personify the government's policy toward Indians at the time—subduing feared and hated warriors, "re-educating" them, and teaching them to farm in order to guide them toward a "better" way of life? Ironically, the Apaches had long farmed as part of the traditional life they fought so tenaciously to protect.

The educational potential of photographs is enormous. However, photographs are not objective; they can easily tell as many lies as truths. As much as any written document, they have to be read with care in order to be understood accurately in unbiased and non-stereotypical terms. Every photo of people contains history, culture, and context. To do justice to the subjects and their stories, it is crucial to fill in the information gaps. In addition to conducting background research, try putting yourself inside these photos—stand next to Goyathlay, his peers, his wife, and their children, and imagine their lives—you might begin to understand the world from their points of view. Framed with factual information and viewed empathetically, each photograph can reach its richest potential as a significant educational opportunity and resource.

21. Which of the following rhetorical techniques does the author repeatedly use in the passage as a means to engage the reader?

- **A.** Forthright attacks on what he labels as readers' misunderstanding of basic historical fact
- **B.** Open-ended questions and appeals directed to readers
- **C.** Direct quotations from past readers of his work that capture their responses to his ideas
- **D.** Descriptions of his own experiences as a citizen of the Muscogee (Creek) Nation of Oklahoma

22. It can most reasonably be inferred that the author's statements about the educational use of photographs apply to photographs taken during what time period?

F. Any time period since photographs were first taken
G. In the nineteenth century exclusively
H. Any time period prior to the digital age, but not beyond
J. Only in the ten years after photographers first joined government expeditions to the West

23. Which of the following words is most nearly given a negative connotation in the passage?

A. Educational (line 1)
B. Old (line 10)
C. Romanticized (line 28)
D. Traditional (line 34)

24. Which of the following actions referred to in the passage most clearly characterizes a hypothetical event rather than an actual event?

F. "Traveled to" (line 17)
G. "Defend" (line 18)
H. "Farmed" (line 72)
J. "Stand next to" (line 83)

25. Particular photographs of Goyathlay are referred to and described by the author to support his claim that:

A. accurately understanding a photograph depends on knowing the circumstances in which a photograph was taken.
B. photographs can be used to date events in the life of a legendary figure like Goyathlay.
C. anyone can control his or her public image by becoming more involved in the field of photography.
D. the merits of a photograph from the nineteenth century depend on who took the photograph.

26. The author most strongly suggests that one reason commercial photographers began to photograph Native American communities was that commercial photographers were:

F. instructed to do so by the US government.
G. devoted to creating educational resources about Native American communities.
H. committed to overcoming their preconceived ideas about the West.
J. influenced to do so by the photographers who had joined government expeditions to the West.

27. In the passage, the author notes that a strange aspect of the photo of Goyathlay with a rifle is that the photo was taken:

A. by an unknown photographer.
B. when Goyathlay was a prisoner of war.
C. with Goyathlay's permission.
D. by a US government photographer.

28. The author directly refers to which of the following aspects of the photograph of Goyathlay in a garden as being ironic?

F. Goyathlay was not a gardener but instead was in the midst of trying to stop the US government's attack on his people.
G. Goyathlay's people had long practiced farming, but the photo seemed to suggest that Goyathlay had learned farming from others.
H. People do not automatically think of Goyathlay as a man of peace.
J. For years it was assumed to be a photograph of someone other than Goyathlay.

29. The author indicates that for the sake of an unbiased interpretation, compared to reading written documents with care, reading photographs with care is:

A. significantly more important.
B. slightly more important.
C. just as important.
D. slightly less important.

30. In line 86, the word *framed* is used figuratively to describe:

F. the way background research can support the proper viewing of a photograph.
G. a common means of preserving a photograph.
H. a technique in which a photograph is displayed with factual information surrounding it.
J. the manner in which many photographs of Goyathlay are displayed in museums.

Passage IV

INFORMATIONAL: This passage is adapted from *Summer World: A Season of Bounty* by Bernd Heinrich (©2009 by Bernd Heinrich).

Adaptations of plants to deserts include dormancy and a variety of structural and behavioral adaptations. The majority of desert plants depend on a strategy that capitalizes on small size. They are annuals that spring up from dry, dormant, heat-resistant seeds. Some of these seeds may wait up to half a century before they are activated. The plants' challenge is to be quick enough to respond to rain so that they can produce their seeds before the earth dries up again, while not jumping the gun to start growth until there is sufficient water for them to grow to maturity for seed production. Some achieve this balance on a tightrope by "measuring" rainfall. They have chemicals in their seeds that inhibit germination, and a minimum amount of rain is required before these are leached out. Others have seed coats that must be mechanically scarred to permit sufficient wetting for germination, and the scarring happens only when they are subjected to flash floods in the riverbeds where they grow. A plant in the Negev Desert releases its seed from a tough capsule only under the influence of water through a mechanism that resembles a Roman ballistic machine. Its two outer sepals generate sideways tension that can fling two seeds out of the fruit, but the two seeds are held inside by a lock mechanism at the top. However, when the sepals are sufficiently wetted, then the tension increases to such an extent that the lock mechanism snaps, and the capsule "explodes" and releases the seeds.

In moist regions where it rains predictably (though not necessarily in abundance), we help agricultural plants to capture the precipitation by scarring the soil to facilitate the infiltration of the water into it, and hence into the roots. Least runoff and maximum water absorption are achieved by plowing the soil. However, such a strategy would not work in a true desert such as the Negev. A different program is required there because rain is infrequent and plowing would facilitate only the evaporation of scarce water from the soil. The solution applied by the peoples who inhabited the Negev in past centuries was a practice they called "runoff farming." Farmers had mastered harnessing the flash floods that rush down into the gullies by catching the runoffs—not only by making terraces but also by building large cisterns into which the water was directed to be held for later use. Remnants of these constructions still exist.

Water-storage mechanisms have been invented by other organisms living in deserts, but mainly through modifications of body plan. Many plants, especially cacti and euphorbia, have the ability to swell their roots or stems with water stores. Possibly the most familiar is the saguaro cactus, *Carnegiea gigantea*, of the Sonoran desert in the American southwest. It has a shallow root system that extends in all directions to distances of about its height, fifty feet. In one rainstorm the root system can soak up 200 gallons of water, which are transferred into its tall trunk. This trunk is pleated like an accordion and can swell to store tons of water that can last the plant for a year. The cactus has no leaves, but the stem is green and can photosynthesize and produce nutrients as well as store water. The saguaro's survival strategy requires it to grow extremely slowly. But it lives a century or more.

Some desert animals similarly store water. The frog *Cyclorana platycephala*, from the northern Australian desert, fills up and greatly expands its urinary bladder to use as a water bag before burying itself in the soil, where it spends most of the year waiting for the next rain. While in the ground it sloughs off skin and forms around itself a nearly waterproof cocoon that resembles a plastic bag and reduces evaporative water loss.

Desert ants of a variety of species (of at least seven different genera) in American as well as Australian deserts collectively called "honeypot ants" have evolved a solution that combines water storage with energy storage. Ants typically feed each other; and some of the larger worker ants may take up more liquid than the others, and others may bring more. Those that take the fluid may gorge themselves until they distend their abdomens up to the size of a grape, by which time they are unable to move from the spot. They then hang in groups of dozens to hundreds from the ceiling of a chamber in the ant nest, where they are then the specialized so-called repletes that later regurgitate fluid when the colony members are no longer bringing the fluid in but rather needing it.

31. The fourth paragraph (lines 63–71) marks a shift in the focus of the passage from:

- **A.** plants that store water above ground to plants that store water below ground.
- **B.** animals that don't go dormant to animals that do go dormant.
- **C.** desert-dwelling plants to desert-dwelling animals.
- **D.** inhabitants of the Negev Desert to inhabitants of northern Australian deserts.

32. Based on the passage, the author's use of the word "measuring" (line 12) most nearly describes the way that some desert plants:

- **F.** have roots that are extremely sensitive to moisture levels in the soil.
- **G.** have methods of delaying seed germination until a certain amount of water is present.
- **H.** are visibly more vigorous after a rainfall.
- **J.** can calculate how many inches of rain have fallen in recent days.

33. Which of the following statements best summarizes the process by which the frog *Cyclorana platycephala* survives in the desert?

A. The frog stores water in its body, buries itself, and conserves water until emerging at the next rain.
B. The frog buries itself, waits for rain, absorbs rainwater through its skin, and emerges.
C. The frog forms a nearly waterproof cocoon around itself, buries itself, and waits to emerge until it needs water.
D. The frog buries itself, absorbs water through its skin, and goes dormant until springtime.

34. Based on the passage, which of the following plants and animals employ a communal strategy to survive in the desert?

F. The saguaro cactus only
G. The saguaro cactus and the frog *Cyclorana platycephala* only
H. The frog *Cyclorana platycephala* and honeypot ants only
J. Honeypot ants only

35. The passage most strongly suggests that compared to the frog *Cyclorana platycephala*, the honeypot ants are unique in that they:

A. can store water inside their bodies.
B. live in Australian deserts.
C. combine water storage with energy storage.
D. go dormant during dry times.

36. Which of the following provides the best paraphrase of lines 7–11?

F. Annual plants survive in deserts by making seeds swiftly when conditions are right.
G. Annual plants in deserts make seeds during dry conditions so the seeds will be ready when rain arrives.
H. Dry conditions require the seeds of desert plants to start germination prior to the arrival of rain.
J. The seeds of annual plants in deserts are designed to wait years for the right conditions for growth.

37. Based on the passage, it can most reasonably be inferred that the scarring some seeds require before germination is accomplished through:

A. intense drying experienced between rainfalls.
B. internal tension from the seed capsule's sepals.
C. chemicals in the seeds.
D. abrasion sustained during flash floods.

38. As it is used in line 26, the word *extent* most nearly means:

F. length.
G. degree.
H. reach.
J. boundary.

39. According to the passage, which of the following actions did people in the Negev Desert take in order to farm there?

A. Plowing the soil
B. Widening gullies
C. Constructing terraces
D. Constructing aqueducts

40. Based on the passage, the pleats in the body of the saguaro cactus:

F. increase the efficiency of photosynthesis.
G. allow the cactus to expand for storing water.
H. reduce evaporative water loss.
J. regulate the cactus's growth.

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

In a particular *playa* (relatively flat, dry desert basin) evidence shows that some large rocks have moved along the surface, leaving shallow trails in the clay sediment, some up to several hundred meters long. Three scientists provided explanations for how these rocks moved.

Scientist 1

In the spring, snowmelt from surrounding mountains runs downhill and collects in the playa. At night, cold temperatures cause this water to freeze around the rocks. When temperatures rise again, the ice begins to melt, leaving a layer of mud on the surface and ice "rafts" around the rocks. The buoyancy of the ice rafts floats the rocks on top of the mud such that even light winds can then push the rocks along the surface. Evidence of this lifting is seen in that the trails left by rocks are both shallow and only about 2/3 as wide as the rocks themselves. Due to the combination of ice, mud, and light winds, the rocks are able to move several hundred meters in a few days.

Scientist 2

Snowmelt from surrounding mountains does collect in the playa during the spring. However, the temperature in the playa does not get cold enough for ice to form. When the playa's surface gets wet, the top layer of clay transforms into a slick, muddy film. In addition, dormant algae present in the dry clay begin to grow rapidly when the clay becomes wet. The presence of mud and algae reduces friction between the rocks and the clay. Even so, relatively strong winds are required to push the rocks along the wet surface, forming trails. Due to the combination of mud, algae, and strong winds, the rocks are able to move several hundred meters in a few hours.

Scientist 3

Water does collect in the playa, producing mud and ice. However, neither mud nor ice is responsible for the rocks' movements. The playa is located along a fault line between tectonic plates. Minor vertical shifts in the plates cause the rocks to move downhill, leaving trails. Due to the combination of tectonic plate movement and strong winds, the rocks are able to move only a few meters over several years.

1. According to Scientist 2, friction between the rocks and the clay is reduced by which of the following?

A. Ice only
B. Algae only
C. Ice and mud only
D. Mud and algae only

2. Suppose a researcher observed that wind speeds greater than 80 miles per hour are needed to move the rocks in the playa. This observation is consistent with which of the scientists' explanations?

F. Scientists 1 and 2 only
G. Scientists 1 and 3 only
H. Scientists 2 and 3 only
J. Scientists 1, 2, and 3

3. Suppose that no seismic activity was recorded in the playa where the trails left by the rocks are found. This finding would *weaken* which of the scientists' explanations?

A. Scientist 1 only
B. Scientist 3 only
C. Scientist 1 and Scientist 2 only
D. Scientist 2 and Scientist 3 only

4. Suppose it were discovered that a particular rock formed a 200 m long trail in 72 hr. Would this discovery support Scientist 1's explanation?

F. Yes; Scientist 1 indicated the rocks can move several hundred meters in a few hours.
G. Yes; Scientist 1 indicated the rocks can move several hundred meters in a few days.
H. No; Scientist 1 indicated the rocks can move several hundred meters in a few hours.
J. No; Scientist 1 indicated the rocks can move several hundred meters in a few days.

5. Suppose that during one year there was no measurable movement of any rocks in the playa during the spring. Scientists 1 and 2 would most likely both agree that this was due to the absence of which of the following factors?

A. Algae
B. Snowmelt
C. Strong winds
D. Subzero temperatures

6. Suppose that air temperature in the playa varies between 4°C and 47°C. Would this information support the explanation of Scientist 2 ?

F. Yes, because ice cannot form in that temperature range.
G. Yes, because ice can form in that temperature range.
H. No, because ice cannot form in that temperature range.
J. No, because ice can form in that temperature range.

7. Based on Scientist 1's explanation, a rock trail that is 33 cm wide was most likely made by a rock with approximately what width?

A. 10 cm
B. 25 cm
C. 50 cm
D. 65 cm

Passage II

When certain substances are added to diet cola, CO_2 gas is produced, generating a foam. Two experiments were done to study this process.

In each trial, an apparatus like that shown in Figure 1 was used as follows: A jar was nearly filled with H_2O and fitted with a 2-holed lid. One end of a tube (Tube B) was inserted through one of the holes and submerged. The other end of Tube B was placed in an empty graduated cylinder. Another tube (Tube A) was inserted through the other hole in the lid. A certain solid substance was inserted into the other end of Tube A, and the substance was secured by a clamp. Tube A was then attached to a freshly opened bottle containing 355 mL of diet cola. The clamp was removed, releasing the substance into the diet cola. The foam that was produced traveled into the jar, and liquid was transferred into the cylinder. The mass of CO_2 produced was calculated based on the volume of liquid that was measured in the cylinder after foaming had ceased.

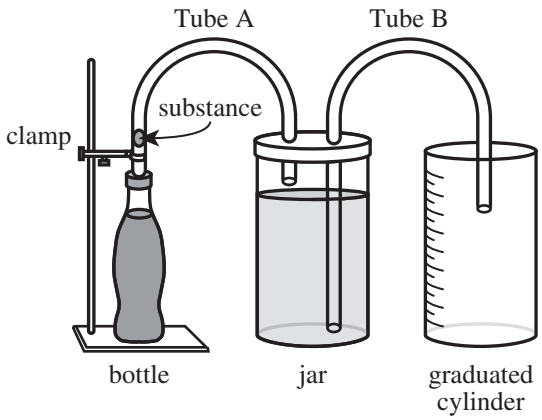


Figure 1

Experiment 1

In each of Trials 1–4, a different 1 of 4 substances of equal mass—a piece of chalk, a sugar cube, a fruit-flavored piece of candy, or a mint-flavored piece of candy—was added to a bottle of diet cola at 3°C. See Table 1.

Table 1

Trial	Substance	Volume of liquid in cylinder (mL)	Mass of CO_2 produced (g)
1	chalk	699	1.36
2	sugar cube	570	1.11
3	fruit candy	525	1.02
4	mint candy	631	1.23

Experiment 2

In each of Trials 5–8, Trial 4 from Experiment 1 was repeated, except that the temperature of the diet cola was different in each trial. See Table 2.

Table 2

Trial	Temperature (°C)	Volume of liquid in cylinder (mL)	Mass of CO_2 produced (g)
5	10	598	1.13
6	25	539	0.969
7	45	501	0.844
8	60	476	0.766

Tables 1 and 2 adapted from Christopher J. Huber and Aaron M. Massari, "Quantifying the Soda Geyser." ©2014 by Division of Chemical Education, Inc., American Chemical Society.

8. If another trial had been performed in Experiment 2 and 450 mL of liquid had been measured in the cylinder, the temperature of the diet cola in this trial would most likely have been:

F. less than 25°C.
G. between 25°C and 45°C.
H. between 45°C and 60°C.
J. greater than 60°C.

9. Suppose Trial 6 had been repeated, but the bottle of diet cola had been opened and then left undisturbed at 25°C for 12 hours *before* it was attached to the apparatus. Would the mass of CO_2 produced in this trial likely be greater than 0.969 g or less than 0.969 g ?

A. Greater, because over the 12 hours, the concentration of CO_2 in the diet cola would have decreased.
B. Greater, because over the 12 hours, the concentration of CO_2 in the diet cola would have increased.
C. Less, because over the 12 hours, the concentration of CO_2 in the diet cola would have decreased.
D. Less, because over the 12 hours, the concentration of CO_2 in the diet cola would have increased.

10. One *millimole* (mmol) of CO_2 has a mass of 0.044 g. How many trials resulted in the production of at least 1 mmol of CO_2 ?

F. 1
G. 4
H. 5
J. 8

11. According to Figure 1, which of Tube A and Tube B, if either, had at least one end submerged in a liquid before the clamp was removed?

A. Tube A only
B. Tube B only
C. Both Tube A and Tube B
D. Neither Tube A nor Tube B

12. Is the relationship between the volume of liquid in the cylinder at the end of the experiment and the mass of CO_2 produced a direct relationship or an inverse relationship?

F. Direct; as the volume of liquid that was measured in the cylinder increased, the mass of CO_2 produced increased.
G. Direct; as the volume of liquid that was measured in the cylinder increased, the mass of CO_2 produced decreased.
H. Inverse; as the volume of liquid that was measured in the cylinder increased, the mass of CO_2 produced increased.
J. Inverse; as the volume of liquid that was measured in the cylinder increased, the mass of CO_2 produced decreased.

13. Consider these steps that were performed in each trial.

1. Removing clamp
2. Measuring liquid in cylinder
3. Inserting a solid substance into Tube A
4. Attaching Tube A to a bottle of diet cola

According to the procedure, these steps were performed in what sequence?

A. 3, 1, 2, 4
B. 3, 4, 1, 2
C. 4, 2, 3, 1
D. 4, 3, 1, 2

14. Assume that *room temperature* is 25°C. In how many trials was the diet cola tested at a temperature *lower* than room temperature?

F. 1
G. 2
H. 5
J. 8

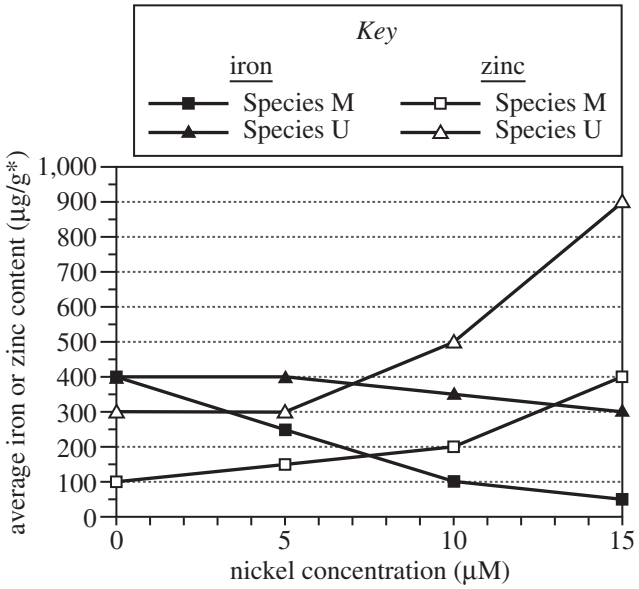
Passage III

Scientists studied the effects of pH and of nickel concentration on plant growth and on the uptake of iron and zinc by plants. Recently germinated seedlings of Species M and Species U were fed 1 of 12 nutrient solutions (Solutions 1–12) for 8 days and then were harvested. Solutions 1–12 differed only in pH and/or nickel concentration. Table 1 shows, for each species, the average dry mass of the plants that were fed each nutrient solution. Figure 1 shows, for each species, the average iron content and the average zinc content of the plants that were fed Solutions 1–4.

Table 1

Solution	pH	Nickel concentration (μM*)	Average dry mass (g) of plants of Species: M	U
1	7	0	33.9	10.7
2	7	5	28.8	10.7
3	7	10	23.8	9.6
4	7	15	18.7	8.5
5	6	0	33.9	9.2
6	6	5	28.8	9.2
7	6	10	23.8	8.1
8	6	15	18.7	7.0
9	5	0	27.8	7.7
10	5	5	22.7	7.7
11	5	10	17.6	6.6
12	5	15	12.4	5.4

*μM = micromoles per liter



*μg/g = micrograms of iron or zinc per gram of plant dry mass

Figure 1

15. According to Figure 1, as the nickel concentration in the nutrient solutions increased, the average iron content of Species M plants:

A. increased only.
B. decreased only.
C. increased, then decreased.
D. decreased, then increased.

16. According to Table 1, the Species U plants that were fed the solution that had a pH of 6 and a nickel concentration of 10 μM had an average dry mass of:

F. 7.0 g.
G. 8.1 g.
H. 9.2 g.
J. 23.8 g.

17. According to Table 1, Species M plants that were fed a nutrient solution with which of the following combinations of pH and nickel concentration had the greatest average dry mass?

	pH	nickel concentration
A.	6	0 μM
B.	6	5 μM
C.	5	0 μM
D.	5	5 μM

18. According to Table 1 and Figure 1, the Species M plants that were fed Solution 3 had an average zinc content of:

F. 100 μg/g.
G. 150 μg/g.
H. 200 μg/g.
J. 400 μg/g.

19. According to Table 1 and Figure 1, for the Species M plants that were fed Solutions 1–4, what was the order of the nutrient solutions, from the solution that resulted in the lowest average iron content to the solution that resulted in the highest average iron content?

A. 1, 2, 3, 4
B. 1, 4, 3, 2
C. 4, 2, 1, 3
D. 4, 3, 2, 1

20. According to Table 1, compared to the average dry mass of Species U plants that were fed Solution 3, the average dry mass of Species M plants that were fed Solution 6 was approximately:

F. $\frac{1}{3}$ as great.
G. $\frac{1}{2}$ as great.
H. 2 times as great.
J. 3 times as great.

Passage IV

Ammonia (NH_3) can be produced according to the chemical equation

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The *equilibrium arrow* ($\rightleftharpoons$) indicates that this reaction proceeds in both directions until it is at *equilibrium*, so that both the forward reaction (production of NH_3) and the backward reaction (production of N_2 and H_2) occur at the same rate. Equilibrium can be shifted forward or backward by changing the temperature, pressure, or concentration of reactants or products.

Two experiments were done using the following apparatus to produce NH_3.

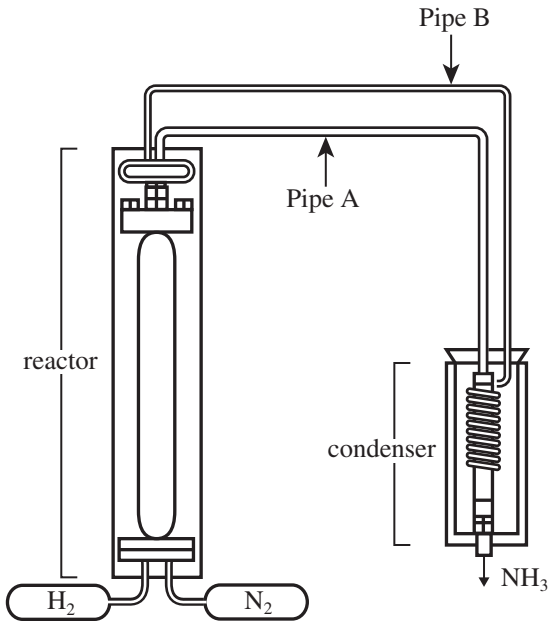


diagram of apparatus

In each trial, Steps 1–4 occurred:

1. A fresh catalyst (Catalyst W, X, Y, or Z), 160 kg of H_2, and 745 kg of N_2 were placed in the reactor.
2. The H_2 and N_2 reacted at a constant temperature and a constant pressure until equilibrium was established.
3. A mixture of NH_3 and any unreacted H_2 and N_2 flowed through Pipe A to a −50°C condenser at 1 atmosphere (atm) of pressure.
4. NH_3 condensed and exited the apparatus. (H_2 and N_2 do not condense at −50°C.) Any unreacted H_2 and N_2 flowed into Pipe B, returning to the reactor.

Steps 2–4 reoccurred in cycles until no more H_2 and N_2 returned from the condenser.

Experiment 1

A set of 9 trials was conducted with each of the 4 catalysts. For each set, the pressure was 150 atm; within each set, the temperature was different for each trial. Figure 1 shows, for each trial, the number of cycles of Steps 2–4.

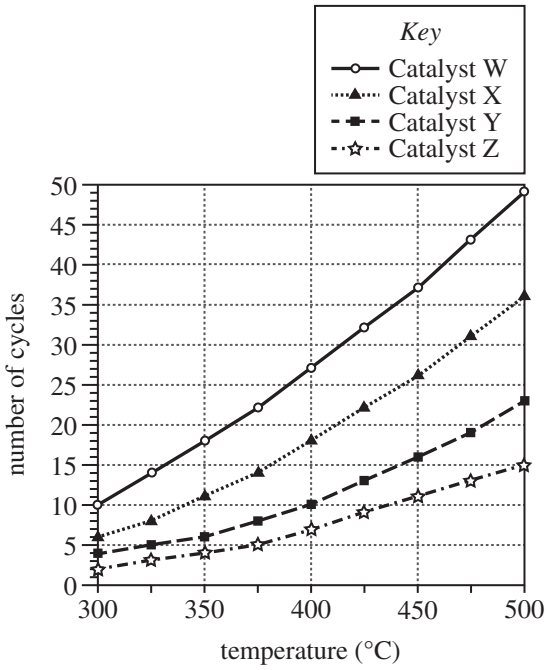


Figure 1

Experiment 2

Four sets of 9 trials each were conducted with Catalyst Z. For each set, the temperature was different; within each set, the pressure was different for each trial. Figure 2 shows, for each trial, the amount of NH_3 produced in the *first* cycle of Steps 2–4.

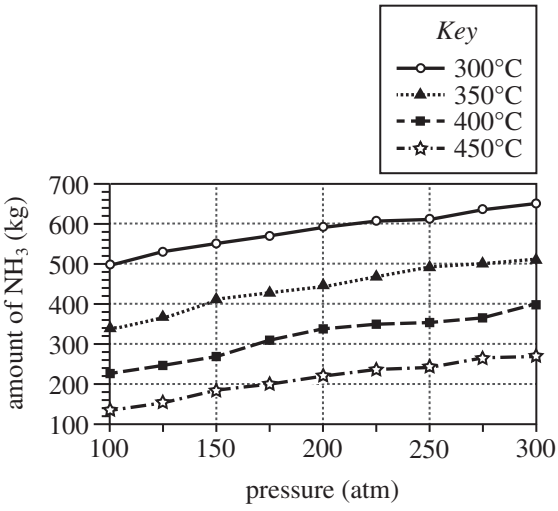


Figure 2

Diagram and figures adapted from Jayant M. Modak, "Haber Process for Ammonia Synthesis." ©2002 by Indian Academy of Sciences.

21. According to the results of Experiment 1, for any given catalyst, as the temperature was increased, the number of cycles needed to complete the reaction:

A. increased only.
B. decreased only.
C. increased, then decreased.
D. decreased, then increased.

22. In Experiment 1, 26 cycles were needed to complete the reaction at 450°C when which catalyst was used?

F. Catalyst W
G. Catalyst X
H. Catalyst Y
J. Catalyst Z

23. The movement of H_2 and N_2 through the apparatus as Steps 1–4 occurred is best represented by which of the following expressions?

A. Reactor → condenser → Pipe A → Pipe B
B. Condenser → reactor → Pipe A → Pipe B
C. Reactor → Pipe A → condenser → Pipe B
D. Condenser → Pipe A → reactor → Pipe B

24. Consider the results of Experiment 1 for 375°C. All the H_2 and N_2 were consumed in less than 20 cycles when which catalysts were used?

F. Catalysts W and X only
G. Catalysts Y and Z only
H. Catalysts W, X, and Y only
J. Catalysts X, Y, and Z only

25. If a trial had been performed in Experiment 2 at 425°C and 225 atm, the amount of NH_3 produced would most likely have been:

A. less than 230 kg.
B. between 230 kg and 320 kg.
C. between 320 kg and 410 kg.
D. greater than 410 kg.

26. At 1 atm of pressure, the melting point of NH_3 is –77°C and the boiling point of NH_3 is –33°C. Based on this information and the description of the apparatus, when the NH_3 exited the condenser, was it more likely a solid or a liquid?

F. Solid, because the temperature of the condenser was lower than the melting point of NH_3 and the boiling point of NH_3.
G. Solid, because the temperature of the condenser was between the melting point of NH_3 and the boiling point of NH_3.
H. Liquid, because the temperature of the condenser was higher than the melting point of NH_3 and the boiling point of NH_3.
J. Liquid, because the temperature of the condenser was between the melting point of NH_3 and the boiling point of NH_3.

27. Consider the trial in Experiment 2 that produced 550 kg of NH_3. Based on Figure 1, the number of cycles that were needed to complete the reaction in this trial was most likely:

A. less than 5.
B. between 5 and 10.
C. between 10 and 15.
D. greater than 15.

Passage V

As a sound wave travels through a medium, the wave becomes *attenuated* (loses energy). The attenuation coefficient, α, is the rate at which the wave's *intensity level* (a measure of sound volume) decreases with distance as a result of this energy loss; the greater the value of α, the greater the decrease in intensity level with distance. Figure 1 shows, for waves of 3 different frequencies (in hertz, Hz), how α (in decibels per kilometer, dB/km) varies with temperature in air at 10% relative humidity.

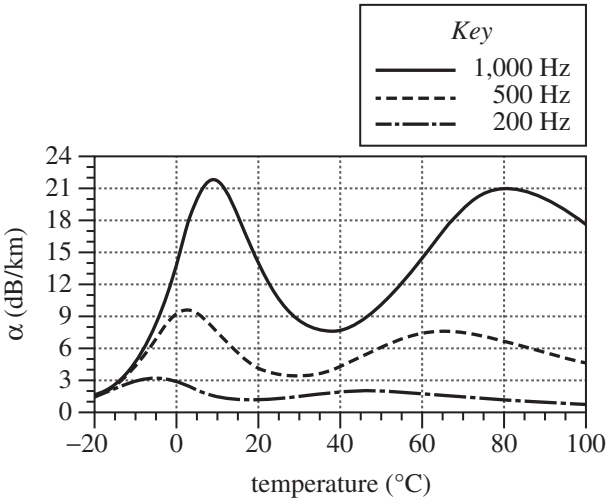


Figure 1

Figure 2 shows, for waves of 3 different frequencies, how α varies with relative humidity in air at 20°C.

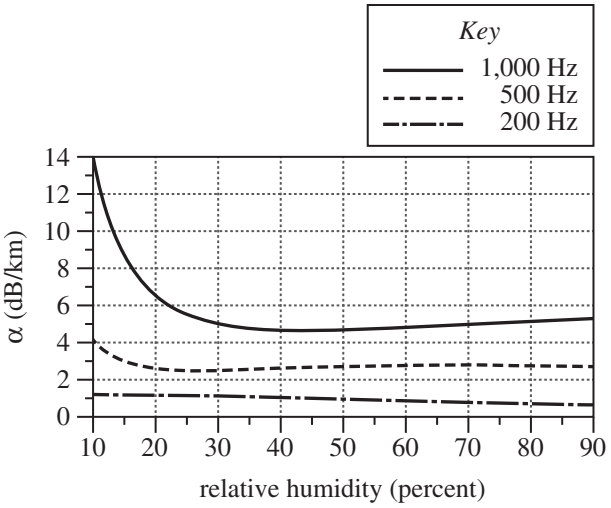


Figure 2

Figures adapted from Richard Lord, "Calculation of Absorption of Sound by the Atmosphere." ©2004 National Physical Laboratory.

28. What is the approximate maximum α shown in Figure 1 for a 200 Hz sound wave in air at 10% relative humidity, and at approximately what temperature does that maximum occur?

	α (dB/km)	temperature (°C)
F.	3.0	−5
G.	3.0	35
H.	9.5	−5
J.	9.5	35

29. Based on Figure 2, the attenuation coefficient for a 1,000 Hz sound wave in air at 20°C reaches a *minimum* value at a relative humidity closest to which of the following?

A. 25%
B. 45%
C. 65%
D. 85%

30. For the range of temperatures and the range of relative humidities shown in Figures 1 and 2, respectively, is α for a 200 Hz sound wave more strongly affected by changes in temperature or by changes in relative humidity?

F. Temperature, because the maximum variation in α is about 0.5 dB/km in Figure 1 but about 2.5 dB/km in Figure 2.
G. Temperature, because the maximum variation in α is about 2.5 dB/km in Figure 1 but about 0.5 dB/km in Figure 2.
H. Relative humidity, because the maximum variation in α is about 0.5 dB/km in Figure 1 but about 2.5 dB/km in Figure 2.
J. Relative humidity, because the maximum variation in α is about 2.5 dB/km in Figure 1 but about 0.5 dB/km in Figure 2.

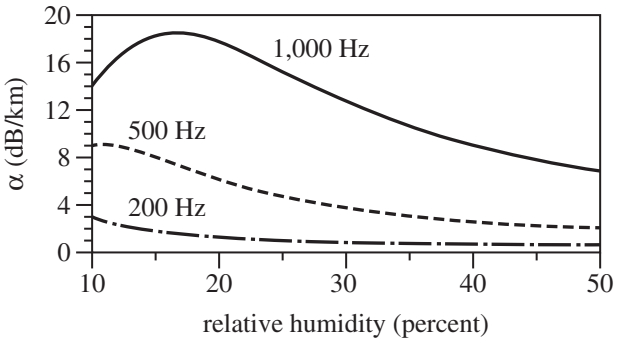
31. Consider a 1,000 Hz sound wave in air at 10% relative humidity. At how many of the temperatures shown in Figure 1 does α for this wave have a value of 18 dB/km ?

A. 2
B. 3
C. 4
D. 5

32. Suppose that 2 sound waves—a 150 Hz wave and a 1,100 Hz wave—are simultaneously emitted from a speaker into air at 20°C and 45% relative humidity. Based on Figure 2, as the waves travel away from the speaker, the intensity level of which wave will more likely decrease at the greater rate due to attenuation?

F. The 150 Hz wave, because the value of α is lesser for the 150 Hz wave than for the 1,100 Hz wave.
G. The 150 Hz wave, because the value of α is greater for the 150 Hz wave than for the 1,100 Hz wave.
H. The 1,100 Hz wave, because the value of α is lesser for the 1,100 Hz wave than for the 150 Hz wave.
J. The 1,100 Hz wave, because the value of α is greater for the 1,100 Hz wave than for the 150 Hz wave.

33. The graph below shows, for sound waves of 3 different frequencies, how α varies with relative humidity in air at a particular temperature.



Based on Figure 1, the particular air temperature is most likely which of the following?

A. −20°C
B. 0°C
C. 20°C
D. 100°C

Passage VI

Three studies compared the effects of 5 sweeteners (Sweeteners Q–U) on food consumption by rats and on the concentrations of *leptin* and *ghrelin* (hormones that regulate appetite) in the blood of rats. Sweeteners Q–U differ only in the percent by mass of fructose and of glucose (see Table 1).

Table 1

Sweetener	Percent by mass of: fructose	glucose
Q	0	100
R	42	58
S	50	50
T	55	45
U	100	0

Study 1

Each of 5 groups (Groups 1–5) of rats was assigned a solution having a 100 g/L concentration of 1 of the 5 sweeteners. Each rat was placed in a separate cage and provided unlimited access to the assigned sweetener solution and to solid food for 56 days. Table 2 shows, for each group, the amounts of sweetener solution and solid food consumed per rat per day. On Day 56, blood was collected from each rat for analysis in Studies 2 and 3.

Table 2

Group	Sweetener	Amount consumed per rat per day: sweetener solution (mL)	solid food (g)
1	Q	73	9
2	R	55	14
3	S	52	16
4	T	48	18
5	U	29	23

Table 2 adapted from Heather R. Light et al., "The Type of Caloric Sweetener Added to Water Influences Weight Gain, Fat Mass, and Reproduction in Growing Sprague-Dawley Female Rats." ©2009 by the Society for Experimental Biology and Medicine.

Study 2

A 1 mL blood sample from each rat was placed in a separate test tube containing 0.2 mL of *Indicator N* (which reacts with leptin to form a blue dye). The concentration of blue dye in each tube was directly proportional to the leptin concentration in the blood sample. Table 3 shows the leptin concentration per sample for each group.

Table 3

Group	Sweetener	Leptin concentration per sample (pM*)
1	Q	804
2	R	622
3	S	553
4	T	475
5	U	251

*picomolar

Study 3

Study 2 was repeated, except that *Indicator P* (which reacts with ghrelin to form a yellow dye) was used instead of Indicator N. The concentration of yellow dye in each tube was directly proportional to the ghrelin concentration in the blood sample (see Table 4).

Table 4

Group	Sweetener	Ghrelin concentration per sample (pM)
1	Q	852
2	R	1,125
3	S	1,279
4	T	1,450
5	U	1,758

Tables 3 and 4 adapted from Andreas Lindqvist, Annemie Baelemans, and Charlotte Erlanson-Albertsson, "Effects of Sucrose, Glucose and Fructose on Peripheral and Central Appetite Signals." ©2008 by Elsevier B.V.

34. In Study 1, as the ratio of fructose to glucose in the sweetener solutions increased, the amount of sweetener solution consumed per rat per day:

F. increased only.
G. decreased only.
H. increased and then decreased.
J. decreased and then increased.

35. In Study 1, the amount of sweetener solution consumed daily by each rat could be measured because which of the following steps had been taken?

A. The rats' access to solid food had been restricted.
B. The rats' access to solid food had not been restricted.
C. The rats had been placed in the same cage.
D. The rats had been placed in separate cages.

36. Suppose that a sweetener composed of 46% fructose and 54% glucose by mass had been tested in Study 1. Based on Table 1 and the results of Study 3, the ghrelin concentration per sample would most likely have been:

F. less than 852 pM.
G. between 852 pM and 1,125 pM.
H. between 1,125 pM and 1,279 pM.
J. greater than 1,279 pM.

37. Consider the claim "The group of rats that consumed the lowest amount of solid food per rat per day was also the group that had the lowest concentration of leptin per sample." Do the results of Studies 1 and 2 support this claim?

A. Yes; the rats in Group 1 consumed the lowest amount of solid food per rat per day and also had the lowest concentration of leptin per sample.
B. Yes; the rats in Group 5 consumed the lowest amount of solid food per rat per day and also had the lowest concentration of leptin per sample.
C. No; the rats in Group 1 consumed the lowest amount of solid food per rat per day, but the rats in Group 5 had the lowest concentration of leptin per sample.
D. No; the rats in Group 5 consumed the lowest amount of solid food per rat per day, but the rats in Group 1 had the lowest concentration of leptin per sample.

38. Which of the following groups of rats should have been included in Study 1 to serve as a control for the effect of consuming a sweetener solution on the consumption of solid food by rats? A group of rats that had access:

F. only to water.
G. only to solid food.
H. only to water and solid food.
J. to neither water nor solid food.

39. Consider the sweetener that resulted in a solid food consumption of 16 g per rat per day in Study 1. Based on Table 1, how many grams of fructose would be present in 200 g of this sweetener?

A. 50 g
B. 100 g
C. 150 g
D. 200 g

40. The experimental designs of Studies 2 and 3 were identical with respect to which of the factors listed below, if either?

I. The chemical indicator that was used
II. The hormone with which the chemical indicator reacted

F. I only
G. II only
H. Both I and II
J. Neither I nor II

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.