

Name: _____
(Please print.)

Your Student ID Number:

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Form 19A

Pre **ACT**[®]

Directions

This booklet contains tests in English, math, 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 math test only.**

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

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

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

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

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

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

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

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



1

ENGLISH TEST

30 Minutes—45 Questions

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

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

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

PASSAGE I

A Saturday with the Sea Turtles

Hawaii’s green sea turtle, has been classified as¹ an endangered species for over 25 years. Signs around the Mauna Lani lagoon warn² tourists to keep their distance from the humped creatures that look like gray-green boulders along the shoreline. My friends and me, however,³ ignore the signs, wade into the water, and struggling to⁴ flip a 150-pound turtle onto its back in the center of an oversized inner tube. We aren’t being intentionally cruel. Nor are we breaking the law. We are spending another sunny Hawaiian Saturday volunteering for a government-sponsored sea turtle research project.

We float our latest turtle ashore. Flippers flapping and beak snapping, the turtle resists as we hoist it onto the examination table that we’ve set up beneath an awning on the beach. It’s my turn to enact⁵ the exam.

1. **A.** NO CHANGE
B. turtle has been classified as
C. turtle, has been classified as,
D. turtle has been classified: as
2. **F.** NO CHANGE
G. warns
H. is warning
J. has warned
3. **A.** NO CHANGE
B. I, however,
C. I however,
D. me, however
4. **F.** NO CHANGE
G. the struggle
H. were struggling
J. struggle
5. **A.** NO CHANGE
B. act out
C. perform
D. operate

1

As I weigh the turtle and measure its carapace (shell), another volunteer, Kiko, watches as I record the data.⁶ Tourists always seem delighted by the opportunity to closely observe a turtle.

Kiko tells the tourists that this turtle has likely⁷ made a remarkable migration from breeding grounds

in shoals located over 400 miles away. 8 I open the

turtle's⁹ mouth so I can document what it has been eating,

and I wonder if the turtle is hungry.¹⁰ Kiko laughs and says that one of the first lessons a volunteer learns is that green sea turtles have terrible breath! A supervising marine biologist helps me insert a small microchip—a tag—beneath the skin of one flipper. Tagging helps with monitoring the turtle population and gathering information to help the turtles recover from their endangered status.

After we pull the heavy turtle back to the water.¹¹ I don fins, a mask, and a

snorkel watching¹² the turtle after it's released.

6. Given that all the choices are true, which one would most effectively provide a transition into the next sentence?
- F. NO CHANGE
G. explains the project to people who have gathered nearby.
H. stands near me as I work at the examination table.
J. was the one who introduced me to this turtle project.
7. Which of the following alternatives to the underlined portion would NOT be acceptable?
- A. totally
B. most likely
C. probably
D. presumably
8. If the writer were to delete the phrase “in shoals located over 400 miles away” from the preceding sentence, the sentence would primarily lose:
- F. background information about why the turtles choose the shoals as breeding grounds.
G. important geographical data for tourists who are interested in seeing a turtle.
H. a generalization about the size of the breeding grounds.
J. a specific detail that helps clarify why the migration would be remarkable.
9. A. NO CHANGE
B. turtles'
C. turtles
D. turtles's
10. Which choice most specifically anticipates the lesson described in the next sentence?
- F. NO CHANGE
G. wrinkle my nose.
H. peer inside.
J. look at the tongue.
11. A. NO CHANGE
B. water. So
C. water,
D. water;
12. F. NO CHANGE
G. that watch
H. in order to watch
J. that will be watching

Though shy and quiet on land, these animals are graceful

13

swimmers. Kicking my fins, I follow the turtle as

14

it beats its flippers like wings and soars through the
canyon reefs toward the deep water beyond.

15

13. Which choice sets up the clearest contrast with the sentence's later description of the sea turtles' swimming?
- A. NO CHANGE
B. sluggish and cumbersome
C. mysterious and reclusive
D. sleek and colorful
14. F. NO CHANGE
G. I followed
H. were I to follow
J. if I follow
15. Given that all the choices are true, which one most effectively completes the sentence and the essay by maintaining the focus on the turtle?
- A. NO CHANGE
B. I dream of being a marine biologist who spends a lifetime making the ocean a better place.
C. it swims farther into the ocean; when we both surface, my friends are distant figures on the sand.
D. I am soon left behind, and I look forward to returning to the sunny Hawaiian Saturday.

PASSAGE II

The Great Wall of Los Angeles

Judith Francisca Baca believes a mural can tell a story and that a largeness of it gives its creator an

16

amplified voice. It began in the summer of 1976, Baca led the creation of what is likely the longest mural in the world, the Great Wall of Los Angeles.

17

This tourist attraction, painted on the concrete wall of the Tujunga Wash, a flood-control channel in

18

the San Fernando Valley, is over thirteen feet high and almost a half mile long. The project was commissioned

19

by Los Angeles city officials, those wanted well-known local muralist Baca to beautify the channel area. She took this opportunity to bring the people of multiethnic

20

16. F. NO CHANGE
G. to make large
H. a large mural
J. if the mural is large
17. A. NO CHANGE
B. With a beginning
C. For it to begin
D. Beginning
18. The writer would like to describe the mural in a way that strongly emphasizes the mural's visual energy. Which choice best accomplishes this purpose?
- F. NO CHANGE
G. noticeable piece of art,
H. vibrant ribbon of colors,
J. decoration in Los Angeles,
19. A. NO CHANGE
B. which has a height of over thirteen feet
C. with a height that's over thirteen feet
D. over thirteen feet high
20. F. NO CHANGE
G. whom
H. they
J. who

1

Los Angeles together to produce a narrative mural of their stories.

Baca imagined the mural, on the channel wall as a timeline. It would proclaim the historical experiences of

California's people's, focusing mainly on the experiences

of women, the poor, and minorities. She wants as many people as possible, especially young people, to help create the mural.

24 For guidance, they interviewed hundreds of city residents, historians, and social activists. The subjects

they picked ranged from: Dust Bowl refugees to civil

rights activists, Olympic champions to labor organizers, land disputes to the growth of suburbia.

Next, area artists drew miniature sketches of the scenes on grids. After that, they created a blueprint of the

mural including "bridge images" that wove them together.

21. A. NO CHANGE
B. mural, on the channel wall,
C. mural on the channel wall
D. mural on the channel wall,
22. F. NO CHANGE
G. peoples,
H. peoples',
J. persons',
23. A. NO CHANGE
B. wanted
C. is wanting
D. has been wanting
24. Which of the following true statements, if added here, would provide the most effective transition into the information that follows in the paragraph?
F. The Social and Public Art Resource Center (SPARC), which Baca and two other artists founded, is based in Venice, California.
G. Baca and her team began by choosing subjects for the mural scenes.
H. Baca's work can be seen all over Los Angeles, as well as at the National Museum of American Art at the Smithsonian Institution.
J. Baca has taught people of all ages and backgrounds.
25. A. NO CHANGE
B. picked ranged from
C. picked, ranged from,
D. picked, ranged from
26. F. NO CHANGE
G. activists and also having
H. activists, being included were
J. activists, with
27. Which of the following alternatives to the underlined portion would NOT be acceptable?
A. scaled-down
B. reduced-sized
C. teeny-tiny
D. small-scale
28. F. NO CHANGE
G. those
H. what it is
J. the scenes

A huge grid was traced onto a smoothed and sealed section of the channel wall, and the blueprint sketches were outlined onto it. The drawings were then painted, over numerous summers, by Los Angeles teens in groups recruited with the help of outreach organizations. 29

In 1983, the mural was finally finished. Dozens of professional artists, over four hundred teens, and thousands of other community members had contributed to the Great Wall of Los Angeles, a celebration of the many voices of the city.

30

29. If the writer were to delete the phrase “in groups recruited with the help of outreach organizations” from the preceding sentence, the paragraph would primarily lose:
- A. information about how the teen painters were brought together to paint the mural.
 - B. an indication that leaders of several outreach organizations helped teens paint the mural.
 - C. an explanation of what the teen painters liked about working on the mural.
 - D. nothing at all, since the phrase repeats a fact stated earlier in the paragraph.
30. Given that all the choices are true, which one best concludes the essay by clearly linking the essay’s conclusion to an image in the essay’s opening paragraph?
- F. NO CHANGE
 - G. which now, several years later, needs some repair and touching up.
 - H. just one work of art in the city.
 - J. and each scene was painted in stages, starting with a magenta undercoat.

PASSAGE III

A Taste for Sassafras

Sassafras trees are fairly common where I spent my childhood years growing up, in a small town near Akron, Ohio. There's a stand of the trees along the edge of our backyard, and they can be found in the parks and empty lots around our neighborhood. My grandmother used to have us dig up pieces of sassafras roots so she

could make the scented tea that we liked so much.

At some point, I acquired a taste for the leaves of the

sassafras. It is large, sometimes oblong, sometimes shaped like a mitten, sometimes shaped into three lobes, and they are soft, almost velvety soft. I think it was the tenderness of the leaf that made it seem edible to me—but being a curious kid, I sampled lots of plants then. Sassafras leaves aren't sweet, but neither are they bitter like most leaves. I came to enjoy the tenderness of the leaves and their mild flavor. Whenever I felt like it while outside playing, I'd pluck a leaf and nibble on it for a snack. My buddies made fun of this habit of mine. None of them would even try a leaf, even though oil of sassafras was once a key ingredient in root beer.

31. A. NO CHANGE
 B. lived during the youthful years of my childhood,
 C. lived as a child while growing up,
 D. grew up,
32. Which of the following alternatives to the underlined portion would NOT be acceptable?
 F. in order that
 G. with which
 H. so that
 J. that
33. Which choice would most clearly emphasize that the narrator's memory of the tea is a positive one?
 A. NO CHANGE
 B. aromatic
 C. odorous
 D. pungent
34. Which choice provides the best transition from the preceding paragraph to this paragraph and to this sentence?
 F. NO CHANGE
 G. As often happens in such cases,
 H. Despite all that had transpired,
 J. On top of everything else,
35. A. NO CHANGE
 B. They are
 C. It's
 D. Its
36. F. NO CHANGE
 G. bitter. As with
 H. bitter. As are
 J. bitter. Like
37. Given that all the choices are true, which one would be most relevant to the writer's purpose here of revealing the young narrator's personality?
 A. NO CHANGE
 B. so I'd tease them back for their reluctance.
 C. so we'd return to our game of kick-the-can.
 D. which come in a variety of shapes.

1

Recently, I read a magazine article about sassafras that places my habit from the elderly days in a new

38

light. It turns out that filé powder, an essential spice, and thickening ingredient in the delicious gumbo

39

soups of Louisiana Creole cooking, 40

is simply dried and ground sassafras leaves. In addition,

41

I learned that the Creole cooks, who blended French, Spanish, and African American traditions, got the idea

for using sassafras from the Native peoples of the

southeastern United States, they have long used the

42

powdered leaves not only for cooking but also for

medicinal purposes. 43 In fact, the Choctaw people used to travel to the famous French Market in

New Orleans to sell the filé powder they made.

44

38. F. NO CHANGE
G. habit of days gone by
H. age-encrusted habit
J. old habit
39. A. NO CHANGE
B. powder an essential spice,
C. powder, an essential spice
D. powder an essential spice
40. At this point, the writer is considering adding the following clause:
which also features other tasty and popular dishes such as jambalaya,
Given that the statement is true, should the writer make this addition here?
F. Yes, because it helps explain why the narrator likes Creole cooking so much.
G. Yes, because it provides background information about the origins of Creole cooking.
H. No, because it digresses from the essay's focus at this point on sassafras and filé powder.
J. No, because it does not clarify why Creole food is so delicious.
41. A. NO CHANGE
B. simply consist of
C. were simply
D. are simply
42. F. NO CHANGE
G. these people
H. whom
J. who
43. If the writer were to delete from the preceding sentence the clause "who blended French, Spanish, and African American traditions" (and the commas before and after it), the sentence would primarily lose:
A. a statement that clarifies what traditional practices the narrator learned from the Creole cooks.
B. an explanation for where the Creole cooks got the idea for using sassafras in their cooking.
C. background information that suggests the Creole cooks drew from various sources.
D. a description that indicates where the filé gumbo soup recipe originated.
44. F. NO CHANGE
G. powder, that
H. powder;
J. powder,

1

It's comforting to know that my taste wasn't as odd as my childhood pals made it out to be. Next time I see them, I'll have to explain that I wasn't just eating sassafras leaves, I was tapping into time-honored wisdom about edible plants.

Question 45 asks about the preceding passage as a whole.

45. If the writer's goal here was to introduce readers to Louisiana Creole cooking and its special dishes, would this essay successfully accomplish that goal?
- A. Yes, because it explains the role of sassafras, in the form of filé powder, in Louisiana Creole cooking.
 - B. Yes, because it describes how Louisiana Creole cooking is based on a variety of traditions.
 - C. No, because it primarily focuses on the narrator's memories of sassafras, not only this style of cooking.
 - D. No, because it neither explains nor justifies the narrator's interest in this style of cooking.

END OF TEST 1

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

2

MATH TEST

40 Minutes—36 Questions

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

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

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

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

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

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

-
1. Sienna will be paid \$75, plus 25% of her total weekly sales, for the hours she is scheduled to work next week. Let w represent Sienna's total weekly sales, in dollars, for next week. Which of the following expressions gives Sienna's pay, in dollars, for the hours she is scheduled to work next week?
- A. $0.25w + 75$
 - B. $0.25w + 0.75$
 - C. $0.75w + 0.25$
 - D. $25w + 75$
 - E. $75w + 0.25$

DO YOUR FIGURING HERE.

2. Mr. Chiang announced the grade distribution for this week's book reports. Of the 24 students in the class, 8 received A's for their book reports, 11 received B's, and 5 received C's. When a student is chosen at random to be the first one to read his or her book report to the class, what is the probability that the student chosen had received an A for the book report?

- F. $\frac{5}{24}$
- G. $\frac{1}{3}$
- H. $\frac{11}{24}$
- J. $\frac{1}{2}$
- K. $\frac{8}{11}$

2

3. The chart below gives the average high and low temperatures, in degrees Celsius, for the month of June for 4 cities throughout the world.

Average High and Low Temperatures for June

City	High	Low
Amsterdam, the Netherlands	29	21
Harare, Zimbabwe	24	4
Madrid, Spain	32	13
Shanghai, China	35	24

In which of these cities was it the hottest on June 15 ?

- A. Amsterdam
 - B. Harare
 - C. Madrid
 - D. Shanghai
 - E. Cannot be determined from the given information
4. The regular price of a calculator is \$49.95 before taxes. It goes on sale at 20% below the regular price. Before taxes are added, what is the sale price of the calculator?
- F. \$ 9.99
 - G. \$24.98
 - H. \$29.95
 - J. \$39.96
 - K. \$44.95

5. $4b^8 \cdot 5b^3$ is equivalent to:

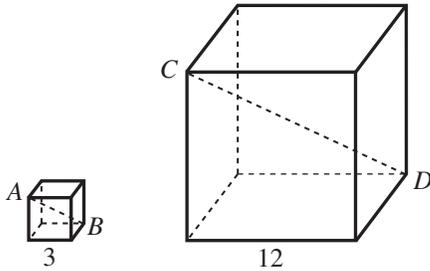
- A. $9b^5$
- B. $9b^{11}$
- C. $9b^{24}$
- D. $20b^{11}$
- E. $20b^{24}$

DO YOUR FIGURING HERE.

2

DO YOUR FIGURING HERE.

6. The 2 cubes shown below have diagonals \overline{AB} and \overline{CD} , respectively. The side lengths given are in feet. What is the ratio of the length of \overline{AB} to the length of \overline{CD} ?



- F. 1:4
 G. 1:16
 H. 4:1
 J. 16:1
 K. 64:1
7. What is the value of $-x + y + z$ for $x = -1$, $y = -3$, and $z = 2$?
- A. -6
 B. -2
 C. 0
 D. 4
 E. 6
8. Let a square represent the value of x and a circle represent 1. Which of the following expressions accurately represents $2(3x + 5)$?

F. $\begin{array}{|c|c|c|} \hline \square & \square & \square \\ \hline \square & \square & \square \\ \hline \end{array} + \begin{array}{|c|c|c|c|c|c|} \hline \circ & \circ & \circ & \circ & \circ & \circ \\ \hline \circ & \circ & \circ & \circ & \circ & \circ \\ \hline \end{array}$

G. $\begin{array}{|c|c|c|} \hline \square & \square & \square \\ \hline \square & \square & \square \\ \hline \end{array} + \begin{array}{|c|c|c|} \hline \circ & \circ & \circ \\ \hline \circ & \circ & \circ \\ \hline \end{array}$

H. $\begin{array}{|c|c|c|} \hline \square & \square & \square \\ \hline \square & \square & \square \\ \hline \end{array} + \begin{array}{|c|c|c|c|c|c|} \hline \circ & \circ & \circ & \circ & \circ & \circ \\ \hline \end{array}$

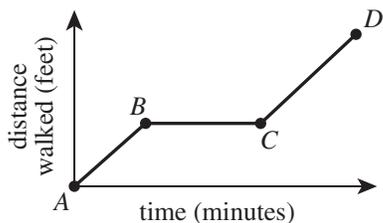
J. $\begin{array}{|c|c|c|} \hline \square & \square & \square \\ \hline \end{array} + \begin{array}{|c|c|c|c|c|c|} \hline \circ & \circ & \circ & \circ & \circ & \circ \\ \hline \end{array}$

K. $\begin{array}{|c|c|c|c|} \hline \circ & \circ & \square & \square & \square \\ \hline \circ & \circ & \circ & \circ & \circ \\ \hline \end{array} + \begin{array}{|c|c|c|} \hline \circ & \circ & \circ \\ \hline \circ & \circ & \circ \\ \hline \end{array}$

2

9. The distance-versus-time graph below represents Barbara Jean's walk to school on Friday.

DO YOUR FIGURING HERE.



Which of the following statements could describe what Barbara Jean did during the time interval covered by the horizontal line segment BC ?

- A. She walked due east.
 - B. She walked up some steps.
 - C. She walked on level ground.
 - D. She walked at a faster speed.
 - E. She stopped to talk to friends.
10. To determine a student's overall test score for the semester, Ms. Ackerman deletes the lowest test score and calculates the average of the remaining test scores. Niels took all 5 tests and earned the following test scores in Ms. Ackerman's class this semester: 62, 78, 83, 86, and 93. What overall test score did Niels earn in Ms. Ackerman's class this semester?
- F. 77.5
 - G. 80.4
 - H. 83.0
 - J. 85.0
 - K. 85.5

11. $|6 - 4| - |3 - 9| = ?$

- A. -8
- B. -4
- C. 4
- D. 8
- E. 22

2

DO YOUR FIGURING HERE.

12. The cost of a long-distance call to a certain city is \$1.05 for the first minute and \$0.15 for each additional minute or part thereof. What is the cost of a 15-minute call to this city?

F. \$1.20
G. \$2.25
H. \$3.15
J. \$3.30
K. \$3.45

13. Dalia is taking inventory of cases of soda cans. There are 24 cans in a full case, and Dalia has 4 partially filled cases: 1 case is $\frac{1}{2}$ full, 1 case is $\frac{2}{3}$ full, and 2 cases are each $\frac{5}{6}$ full. How many soda cans are in the 4 partially filled cases?

A. 48
B. 64
C. 68
D. 80
E. 96

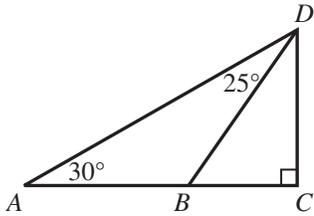
14. Solar panels that produce 150 amps of electric current each are needed for a proposed space station. If the solar panels are manufactured to produce 0.75 amps per square meter of surface area, the surface area of each solar panel needs to be how many square meters?

F. 20
G. 75
H. 112.5
J. 150
K. 200

GO ON TO THE NEXT PAGE.

2

15. In right triangle $\triangle ACD$ shown below, B lies on side \overline{AC} . Some angle measures are given. What is the measure of $\angle BDC$?



- A. 25°
B. 35°
C. 50°
D. 55°
E. 60°
16. In the standard (x,y) coordinate plane, what is the midpoint of the line segment with endpoints $(1,9)$ and $(7,-3)$?
- F. $(-3,-6)$
G. $(-1, 8)$
H. $(4, 3)$
J. $(5, 2)$
K. $(8, 6)$
17. Bert's Building Supply receives shipments of only 2 kinds of lawn mowers: Tough Cuts and Easy Pushes. Today's shipment contains 96 lawn mowers with twice as many Tough Cuts as Easy Pushes. How many of these 96 are Tough Cuts?

- A. 16
B. 32
C. 47
D. 48
E. 64

DO YOUR FIGURING HERE.

2

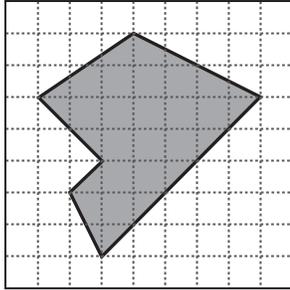
DO YOUR FIGURING HERE.

18. The expression $x^2 + 5x - 6$ is equivalent to:
- F. $(x - 6)(x + 1)$
 - G. $(x - 6)(x + 5)$
 - H. $(x - 3)(x - 2)$
 - J. $(x - 3)(x + 2)$
 - K. $(x - 1)(x + 6)$
19. What is the positive solution to the equation $16x^2 = 30$?
- A. $\frac{30}{16}$
 - B. $\left(\frac{30}{16}\right)^2$
 - C. $\frac{\sqrt{30}}{16}$
 - D. $\sqrt{\frac{16}{30}}$
 - E. $\sqrt{\frac{30}{16}}$
20. The length of a rectangle is 4 inches longer than the width. The perimeter of the rectangle is 28 inches. What is the width of the rectangle, in inches?
- F. 5
 - G. 7
 - H. 10
 - J. 12
 - K. 14

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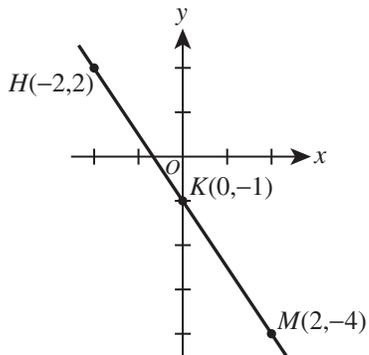
21. Each small square on the grid shown below has a side length of 1 cm. Each vertex of the shaded region lies on a vertex of a small square. What is the area, in square centimeters, of the shaded region?



- A. 17
- B. 23
- C. 28
- D. 29
- E. 39

DO YOUR FIGURING HERE.

22. What is the slope of \overleftrightarrow{HM} , shown in the standard (x,y) coordinate plane below?

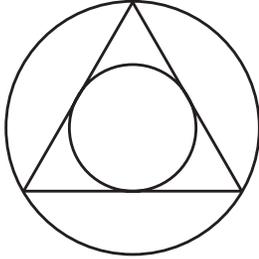


- F. $-\frac{3}{2}$
- G. -1
- H. $-\frac{2}{3}$
- J. $\frac{2}{3}$
- K. $\frac{3}{2}$

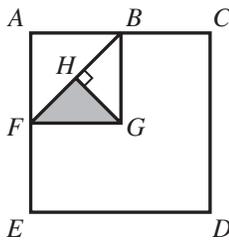
GO ON TO THE NEXT PAGE.

DO YOUR FIGURING HERE.

23. An equilateral triangle is inscribed in a circle and a smaller circle is inscribed in the triangle, as shown in the figure below. If the radius of the smaller circle is 3 inches, what is the radius, in inches, of the larger circle?



- A. $\frac{3\sqrt{3}}{2}$
 B. $3\sqrt{3}$
 C. 6
 D. $3\sqrt{6}$
 E. 9
24. Given the functions f and g defined by $f(x) = x + 3$ and $g(x) = x^2 + 1$, what is the value of $f(g(1))$?
- F. 2
 G. 5
 H. 6
 J. 8
 K. 17
25. In the diagram below, B , F , and H are on \overline{AC} , \overline{AE} , and \overline{BF} , respectively, and $\overline{GH} \perp \overline{BF}$. The area of square $ABGF$ is $\frac{1}{4}$ the area of square $ACDE$. The area of $\triangle FGH$ is what fraction of the area of $ACDE$?

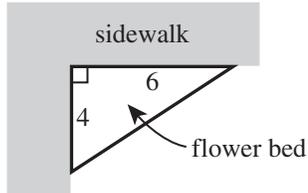


- A. $\frac{1}{4}$
 B. $\frac{1}{8}$
 C. $\frac{1}{12}$
 D. $\frac{1}{16}$
 E. $\frac{1}{20}$

2

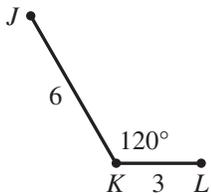
DO YOUR FIGURING HERE.

26. Royce plans to construct a triangular flower bed on the corner of his property where a sidewalk forms a right angle. The flower bed and the lengths, in feet, of 2 of its sides are shown in the figure below. The flower bed will be enclosed by a garden fence that is set up along its entire perimeter. To the nearest foot, how many feet of garden fence will enclose the flower bed?



- F. 12
- G. 14
- H. 16
- J. 17
- K. 20

27. Angle $\angle JKL$ is shown below with the given lengths in coordinate units. What is the measure of $\angle JKL$ in radians?



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

2

DO YOUR FIGURING HERE.

28. Which of the following expressions is equal to

$$\frac{3}{4 - \sqrt{5}} ?$$

F. $\frac{3}{11}$

G. $\frac{3}{7}$

H. $\frac{12 - 3\sqrt{5}}{21}$

J. $\frac{12 + \sqrt{15}}{11}$

K. $\frac{12 + 3\sqrt{5}}{11}$

29. A health club surveyed 175 members about which types of equipment they had used in the past month. Of the 175 members, 117 had used treadmills, 89 had used stationary bikes, and 53 had used both types of equipment. Some members had used neither type of equipment. Of the 175 members, how many had used treadmills, stationary bikes, or both?

- A. 53
B. 81
C. 122
D. 134
E. 153

30. For right triangle $\triangle ABC$, $\sin \angle A = \frac{2}{3}$. What is $\cos \angle A$?

F. $-\frac{2}{3}$

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

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

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

K. $\frac{\sqrt{13}}{3}$

DO YOUR FIGURING HERE.

31. Given that $i^2 = -1$ and that k is a positive integer, what is the value of $i^{(4k+2)}$?

- A. $-i$
- B. -1
- C. 0
- D. 1
- E. i

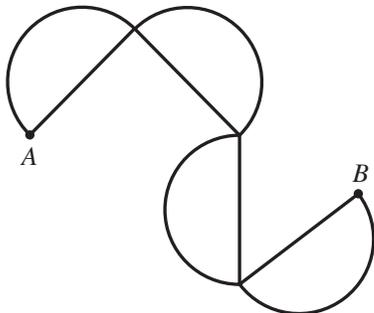
32. A committee will be selected from a group of 12 women and 18 men. The committee will consist of 5 women and 5 men. Which of the following expressions gives the number of different committees that could be selected from these 30 people?

- F. ${}_{30}P_{10}$
- G. $({}_{12}P_5)({}_{18}P_5)$
- H. ${}_{30}C_{10}$
- J. $({}_{30}C_5)({}_{30}C_5)$
- K. $({}_{12}C_5)({}_{18}C_5)$

33. A container is $\frac{1}{8}$ full of water. After 10 cups of water are added, the container is $\frac{3}{4}$ full. What is the volume of the container, in cups?

- A. $13\frac{1}{3}$
- B. $13\frac{1}{2}$
- C. 15
- D. 16
- E. 40

34. Four congruent semicircles touch only at their corners, as shown in the figure below. If the path from A to B along the diameters of the semicircles is 100 centimeters long, how many centimeters long is the path from B back to A along the arcs of these semicircles?



- F. 25π
 G. 50π
 H. 100π
 J. 150π
 K. 230π

35. The system of equations below has multiple solutions, all of which satisfy the equation $y = \frac{4}{3}x - 2$. If it can be determined, what is the value of a ?

$$\begin{aligned} 8x - 6y &= 12 \\ 12x - ay &= 18 \end{aligned}$$

- A. -6
 B. 9
 C. 14
 D. 18
 E. Cannot be determined from the given information

DO YOUR FIGURING HERE.

2

36. Consecutive terms of a certain arithmetic sequence have a positive common difference. The sum of the first 3 terms of the sequence is 120. Which of the following values CANNOT be the first term of the arithmetic sequence?

- F. 20
- G. 24
- H. 30
- J. 39
- K. 44

DO YOUR FIGURING HERE.

END OF TEST 2

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

DO NOT RETURN TO THE PREVIOUS TEST.

3

READING TEST

30 Minutes—25 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

SOCIAL SCIENCE: This passage is adapted from the article “In a Lonely Place” by Martha Nussbaum (©2006 by The Nation).

Nussbaum is reviewing the biography *The Solitude of Self* by Vivian Gornick.

In 1840 the young Elizabeth Cady Stanton attended the World Anti-Slavery Convention in London with her new husband, an abolitionist politician. At least she tried to attend it. On her arrival at the convention site, the people in charge refused to seat her because she was a woman. All the women were required to withdraw to the periphery, where, Vivian Gornick writes in her new book on Stanton, *The Solitude of Self*, “they could see but not be seen, hear but not be heard.” Most of the men, including her husband, went along with this arrangement, unwilling to complicate discussion of the all-important antislavery issue. Only a few, notably the prominent abolitionist William Lloyd Garrison, refused to participate on terms that excluded women. Stanton recalled later that it was on this day that she realized for the first time that “in the eyes of the world I was not as I was in my own eyes, I was only a woman.”

So began the career of one of America’s greatest radicals. Perhaps, however, it really began much earlier. When Stanton, around age 12, heard of a local woman who had suffered outrageous but legally sanctioned injustice at the hands of her dead husband’s son, she grabbed a knife and cut the offending passage out of the law book on her father’s desk. Her father told her that she could work to change the law but that, in Gornick’s words, defacing the book was “not only forbidden . . . it was also useless.” She reflects that at this point it was “already too late: an educated, upright, law-and-order household had spawned a daughter who was going to cut the laws out of the books with a knife.”

Gornick loves Stanton’s uncompromising radicalism, her inextinguishable and rather joyous sense of outrage. In this woman who raised seven children during the day and wrote at night, her prolific output fueled by an abiding passion for justice, Gornick finds the archetype of the feminist movement she knew in the 1970s, with its creative energy, its excitement at having identified the problem to be solved. Stanton, Gornick

40 argues, is the model for this revolutionary feminism, because she was the one who always refused to scale back her just demands out of political expediency, who remained faithful to the radical vision of full equality.

Stanton’s revolutionary life was not entirely happy. Although she and her husband initially shared political passions, they gradually grew apart, and the whole abolitionist movement, with its insistence that slavery had to be the sole focus of attention, came to seem to her deeply compromised. Stanton’s radical demand for equality for both blacks and women lost her, moreover, the friendship of many feminist women, who were willing to postpone the suffrage fight to be on good terms with powerful men and to preserve solidarity with the abolitionist cause. Nonetheless, Stanton loved her life and her enduring friendships, and she loved her struggle. In 1878, after recalling the exhausting efforts she and other feminists had expended in the cause, she then says, “And all our theme is as fresh and absorbing as it was the day we started. . . . In this struggle for justice we have deepened and broadened our own lives, and extended the horizon of our vision.”

Gornick’s account of Stanton’s life is exhilarating and deftly written. She follows Stanton from her rebellious childhood through the early days of her engagement with abolitionism to that moment of conversion in London when she realizes that women aren’t respected, even in the abolitionist movement. From there, the road leads to the famous meeting at Seneca Falls in 1848, the first women’s rights convention in the United States, when Stanton boldly showed her radical colors, demanding suffrage for women. The next fifty-four years (she died in 1902) were filled with passionate speech-making and activism, as Stanton traveled tirelessly around the country on the lecture circuit with her friend Susan B. Anthony. In one seven-month period, for example, they lectured 148 times in 140 towns in ten states. Gornick vividly conveys the combination of constructive anger and ceaseless activity that marked Stanton’s relationship to the world around her, and she makes her refusal to surrender her radical demands seem deeply right. Gornick makes a good case that Stanton is indeed the key precursor to the feminist movement of the late twentieth century, which refused to compromise while at the same time maintaining a hopeful attitude to the potential of law as a force for social reform.

3

- The passage's author most strongly implies that over time, Stanton's relationship with her husband:
 - grew gradually stronger as they found a shared passion in abolitionism.
 - grew gradually weaker as their interests and priorities diverged.
 - worsened after an 1840 antislavery convention in London, then slowly improved.
 - ended abruptly after an 1840 antislavery convention in London.
- According to the passage, who approved of the action described in lines 6–10?
 - Garrison
 - Stanton herself
 - Gornick
 - Most of the men at the 1840 antislavery convention in London
- As portrayed in the passage, the reaction of Stanton's father to her cutting out a passage from a book is best described as:
 - proud and thankful.
 - concerned but hopeful.
 - sympathetic but critical.
 - angry and afraid.
- In the statement in lines 28–31, Gornick most strongly stresses:
 - the love for the law and education that Stanton shared with her father.
 - how overprotective parents led Stanton to act out at home and at school.
 - how a happy home life led Stanton to become involved in political activism.
 - the contrast between Stanton's conventional home life and her rebellious behavior.
- According to the passage, Gornick believes that Stanton is the model for the type of feminism found in the 1970s because Stanton:
 - wanted nothing more than a quiet, private life as a writer and parent.
 - tempered her passion for justice with a sense of compassion.
 - refused to compromise her strongly held, radical belief in full equality.
 - was realistic about the limits of what reformers could accomplish.
- The passage most strongly suggests that Stanton looked back on her life with:
 - deep satisfaction.
 - reluctant acceptance.
 - mild regret.
 - weary bitterness.
- Lines 15–18 most nearly mean that Stanton:
 - had been aware since childhood of the restrictions that society placed on women.
 - abruptly discovered that just being a woman reduced her value in many people's eyes.
 - was devastated to learn that even Garrison thought less of her because she was a woman.
 - slowly began to question whether women had fewer rights than men because of their gender.
- For the passage's author, lines 75–77 mainly serve to support her earlier point that:
 - Stanton and Anthony were close friends who enjoyed travel.
 - Stanton was a relentless promoter of the causes she believed in.
 - lectures were a popular form of entertainment in the nineteenth century.
 - Stanton ruined her health in the cause of feminism.
- Another reviewer of Gornick's book sums up Stanton in this way:

An icon of the American feminist movement, Elizabeth Cady Stanton devoted her life to the cause of women's suffrage, . . . traveling ceaselessly, speaking passionately about the issue that she felt should define her generation.

How does this account of Stanton compare to that of the passage's author?

 - Both offer a similar and positive assessment of Stanton's work as a feminist.
 - Both offer a similar and negative assessment of Stanton's work as a feminist.
 - This account stresses Stanton's commitment to women's suffrage, while the passage's author questions it.
 - This account mentions Stanton's extensive travel, while the passage's author doesn't.

3

Passage II

HUMANITIES: This passage is adapted from *The Professor and the Madman* by Simon Winchester (©1998 by Simon Winchester).

The “English dictionary,” in the sense that we commonly use the phrase today, is a relatively new invention. Four hundred years ago there was no such convenience available on any English bookshelf.

5 There was none available, for instance, when William Shakespeare was writing his plays. Whenever he came to use an unusual word, or to set a word in what seemed an unusual context—and his plays are extraordinarily rich with examples—he had almost no
10 way of checking the propriety of what he was about to do. He could not, as the saying goes, “look something up.” Indeed, the very phrase—when it is used in the sense of “searching for something in a dictionary or encyclopedia or other book of reference”—simply did
15 not exist. It does not appear in the English language, in fact, until as late as 1692, when an Oxford historian named Anthony Wood used it.

One might think Shakespeare would want to look things up all the time. “Am not I consanguineous?” he
20 writes in *Twelfth Night*. A few lines on he talks of “thy doublet of changeable taffeta.” He then declares: “Now is the woodcock near the gin.” Shakespeare’s vocabulary was evidently prodigious: But how could he be certain that in all the cases where he employed unfamiliar
25 words, he was grammatically and factually right?

At the time he was writing there were atlases aplenty, there were prayer books, missals, histories, biographies, romances, and books of science and art. Shakespeare is thought to have drawn many of his classical allusions from a specialized *Thesaurus* that had
30 been compiled by a man named Thomas Cooper—its many errors are replicated far too exactly in the plays for it to be coincidence—and he is thought also to have drawn from Thomas Wilson’s *Arte of Rhetorique*. It is perhaps difficult to imagine so creative a mind working
35 without a single work of lexicographical reference beside him, other than Mr. Cooper’s crib (which Mrs. Cooper once threw into the fire, prompting the great man to begin all over again) and Mr. Wilson’s little
40 manual, but that was the condition under which his particular genius was compelled to flourish. The English language was spoken and written—but at the time of Shakespeare it was not defined, not *fixed*. It was like the air—it was taken for granted, the medium that
45 enveloped and defined all Britons. But as to exactly what it was, what its components were—who knew?

That is not to say there were no dictionaries at all. There had been a collection of Latin words published as a *Dictionarius* as early as 1225, and a little more than a
50 century later another, also Latin-only, as a helpmeet for students of Saint Jerome’s difficult translation of the Scriptures known as the Vulgate. In 1538 the first of a series of Latin-English dictionaries appeared in London—Thomas Elyot’s alphabetically arranged list,

55 which happened to be the first book to employ the English word *dictionary* in its title. Twenty years later a man named Withals put out *A Shorte Dictionarie for Yonge Beginners* in both languages, but with words arranged not alphabetically, but by subject, such as “the
60 names of the Byrdes, Byrdes of the Water, Byrdes about the house, as cockes, hennes, etc., of Bees, Flies, and others.”

But what was still lacking was a proper English dictionary, a full statement of the extent of the English
65 tongue. With one single exception, of which Shakespeare probably did not know when he died in 1616, this need remained stubbornly unfulfilled. Others were to remark on the apparent lack as well. In the very same year as Shakespeare’s death, his friend John
70 Webster wrote his play *The Duchess of Malfi*, incorporating a scene in which the duchess’s brother Ferdinand imagines that he is turning into a wolf, “a pestilent disease they call licanthropia.” “What is that?” cries one of the cast. “I need a dictionary to’t!”

75 But in fact someone, a Rutland schoolmaster named Robert Cawdrey, who later moved to teach in Coventry, had evidently been listening to this drumbeat of demand. He read and took copious notes from all the reference books of the day and eventually produced his
80 first halfhearted attempt at what was wanted by publishing such a list in 1604. It was a small octavo book of 120 pages, which Cawdrey titled *A Table Alphabeticall . . . of hard unusual English Words*. It had about 2,500 word entries. It had many shortcomings; but it
85 was without doubt the very first true monolingual English dictionary, and its publication remains a pivotal moment in the history of English lexicography.

10. The passage’s author uses quotations from Shakespeare mainly to help make the point that Shakespeare:
- F. intentionally misused some obscure words and phrases in his plays.
 - G. avoided consulting dictionaries for fear of stifling his creativity.
 - H. saved his most innovative and memorable expressions for *Twelfth Night*.
 - J. had few language references available to guide how he used words in his plays.
11. It can reasonably be inferred that in terms of the main topic under discussion, the passage’s author views which of the following works as the most important?
- A. The *Dictionarius* published in 1225
 - B. Wilson’s *Arte of Rhetorique*
 - C. Withals’s *A Shorte Dictionarie for Yonge Beginners*
 - D. Cawdrey’s *A Table Alphabeticall . . . of hard unusual English Words*

3

12. To support his assertion about Shakespeare's use of Cooper's *Thesaurus*, the passage's author points to:
- F. evidence from Shakespeare's plays.
 - G. Shakespeare's own admission.
 - H. scholarly articles.
 - J. Wilson's *Arte of Rhetorique*.
13. The passage quotes dialogue from the play *The Duchess of Malfi* primarily to:
- A. point out that Webster and Shakespeare were friends.
 - B. indicate that some people in the early 1600s recognized the need for an English dictionary.
 - C. claim that the word *licanthropia* lacked an adequate definition in Shakespeare's time.
 - D. document Webster's role in expanding the English language through his plays.
14. The passage's author most likely intends the question in lines 45–46 to be read in what manner?
- F. Rhetorically; he asks the question for effect and doesn't expect anyone to answer it.
 - G. Genuinely; he hopes to learn the components of the English language in Shakespeare's day.
 - H. Critically; he's scolding Shakespeare scholars for not knowing the answer to the question.
 - J. Ironically; he believes people of Shakespeare's day knew precisely what the English language was.
15. The passage makes clear that one purpose of the early Latin-only word collections was as an aid to the study of:
- A. religious writings.
 - B. natural science.
 - C. agriculture.
 - D. plays.
16. According to the passage, all of the following are true about Elyot's word list EXCEPT that it:
- F. debuted in London in 1538.
 - G. was the first of a series of Latin-English dictionaries.
 - H. was the first to use the English word *dictionary* in its title.
 - J. was organized by subject rather than alphabetically.
17. The primary purpose of the words in quotation marks in lines 59–62 is to:
- A. indicate that the focus of Withals's dictionary was on waterfowl and domesticated birds.
 - B. provide examples of the categories Withals used to organize his dictionary.
 - C. prove that Withals's dictionary was inspired by Elyot's earlier work.
 - D. suggest that Withals's dictionary was too advanced for "young beginners."

Passage III

NATURAL SCIENCE: This passage is adapted from the article “Call of the Leviathan” by Eric Wagner (©2011 by Smithsonian Institution).

In 1839, in the first scientific treatise on the sperm whale, Thomas Beale, a surgeon aboard a whaler, wrote that it was “one of the most noiseless of marine animals.” While they do not sing elaborate songs, like humpbacks or belugas, in fact they are not silent. Whalers in the 1800s spoke of hearing loud knocking, almost like hammering on a ship’s hull, whenever sperm whales were present. Only in 1957 did two scientists from the Woods Hole Oceanographic Institution confirm the sailors’ observations. Aboard a research vessel, the *Atlantis*, they approached five sperm whales, shut off the ship’s motors and listened with an underwater receiver. At first, they assumed the “muffled, smashing noise” they heard came from somewhere on the ship. Then they determined the sounds were coming from the whales.

Biologists now believe that the sperm whale’s massive head functions like a powerful telegraph machine, emitting pulses of sound in distinct patterns. At the front of the head are the spermaceti organ, a cavity that contains the bulk of the whale’s spermaceti, and a mass of oil-saturated fatty tissue. Two long nasal passages branch away from the bony nares of the skull, twining around the spermaceti organ and the fatty tissue. The left nasal passage runs directly to the blowhole at the top of the whale’s head. But the other twists and turns, flattens and broadens, forming a number of air-filled sacs capable of reflecting sound. Near the front of the head sit a pair of clappers called “monkey lips.”

Sound generation is a complex process. To make its clicking sounds, a whale forces air through the right nasal passage to the monkey lips, which clap shut. The resulting *click!* bounces off one air-filled sac and travels back through the spermaceti organ to another sac nestled against the skull. From there, the click is sent forward, through the fatty tissue, and amplified out into the watery world. Sperm whales may be able to manipulate the shape of both the spermaceti organ and the fatty tissue, possibly allowing them to aim their clicks.

Biologist Dr. Hal Whitehead has identified four patterns of clicks. The most common clicks are used for long-range sonar. So-called “creaks” sound like a squeaky door and are used at close range when prey capture is imminent. “Slow clicks” are made only by large males, but no one knows precisely what they signify. (“Probably something to do with mating,” Whitehead guesses.) Finally, “codas” are distinct patterns of clicks most often heard when whales are socializing.

Codas are of particular interest. Whitehead has found that different groups of sperm whales, called vocal clans, consistently use different sets; the reper-

toire of codas the clan uses is its dialect. Vocal clans can be huge—thousands of individuals spread out over thousands of miles of ocean. Clan members are not necessarily related. Rather, many smaller, durable matrilineal units make up clans, and different clans have their own specific ways of behaving.

A recent study in *Animal Behaviour* took the specialization of codas a step further. Not only do clans use different codas, the authors argued, but the codas differ slightly among individuals. They could be, in effect, unique identifiers: names.

Whitehead cautions that a full understanding of codas is still a long way off. Even so, he believes the differences represent cultural variants among the clans. “Think of culture as information that is transmitted socially between groups,” he says. “You can make predictions about where it will arise: in complex societies, richly modulated, among individuals that form self-contained communities.” That sounds to him a lot like sperm whale society.

But most of a sperm whale’s clicking, if not most of its life, is devoted to one thing: finding food. And in the Sea of Cortez, the focus of its attention is *Dosidicus gigas*, the jumbo squid.

The most celebrated natural antagonism between sperm whales and squid almost certainly involves the jumbo squid’s larger cousin, the giant squid, a species that grows to 65 feet long. The relationship between sperm whales and squid is pretty dramatic. A single sperm whale can eat more than one ton of squid per day. They do eat giant squid on occasion, but most of what whales pursue is relatively small and over-matched. With their clicks, sperm whales can detect a squid less than a foot long more than a mile away, and schools of squid from even farther away. But the way that sperm whales find squid was until recently a puzzle.

18. The main purpose of the passage is to:

- F. describe how sperm whales use clicks to hunt their prey.
- G. evaluate historical theories regarding sperm whale clicks.
- H. provide details about the antagonism between sperm whales and squid.
- J. explain how sperm whales generate and use clicks.

19. In the eighth paragraph (lines 74–77), the passage begins to focus on the relationship between:

- A. squid and their prey.
- B. sperm whales and sonar.
- C. sperm whales and codas.
- D. squid and sperm whales.

3

20. The main purpose of the second paragraph (lines 17–30) is to:
- F. compare sperm whales to telegraph machines.
 - G. explain the function of the spermaceti organ.
 - H. outline how scientists came to understand the anatomy of the sperm whale.
 - J. describe the sperm whale anatomy involved in creating sound.
21. It can reasonably be inferred from the passage that codas are of particular interest because scientists don't yet fully understand:
- A. how codas help sperm whales hunt.
 - B. how codas function in sperm whale socialization.
 - C. why codas are emitted only by male whales.
 - D. why codas are so difficult to detect.
22. As it is presented in the passage, the study that appeared in *Animal Behaviour* concluded that sperm whale vocal clans:
- F. each use a distinct dialect, and individuals within each clan have unique codas.
 - G. can adopt the codas of other clans, but individuals within each clan maintain unique dialects.
 - H. each use many dialects, and individuals within each clan develop complex codas.
 - J. can adopt the codas of other clans, but individuals within each clan retain unique identifiers.
23. As it is used in line 25, the word *runs* most nearly means:
- A. acts.
 - B. hastens.
 - C. operates.
 - D. leads.
24. Based on the passage, the notion that slow clicks are related to sperm whale mating behavior is best described as a:
- F. fact that is supported by several scientific studies.
 - G. fact that whalers discovered in the 1800s.
 - H. reasoned judgment from an expert in biology.
 - J. reasoned judgment from the passage author.
25. Which of the following statements about the mystery of how sperm whales locate squid is best supported by the passage?
- A. The mystery was solved in the 1800s.
 - B. The mystery was solved recently.
 - C. The mystery is likely to be solved in the near future.
 - D. The mystery is likely to remain unsolved until better technology is invented.

END OF TEST 3

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

DO NOT RETURN TO A PREVIOUS TEST.

4

SCIENCE TEST

30 Minutes—30 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

Negative cloud-to-ground (–CG) and positive cloud-to-ground (+CG) lightning strokes move negative charges and positive charges, respectively, from a cloud to the ground during a thunderstorm. Typically, +CG strokes are less numerous than –CG strokes. Figure 1 shows the number of –CG strokes and the number of +CG strokes during each 5 min of a 3 hr period during a thunderstorm that produced a tornado. Also shown are the time of tornado formation (TF) and the time of tornado dissipation (TD). Table 1 shows the average current and the average duration of the strokes during each 30 min period of the 3 hr.

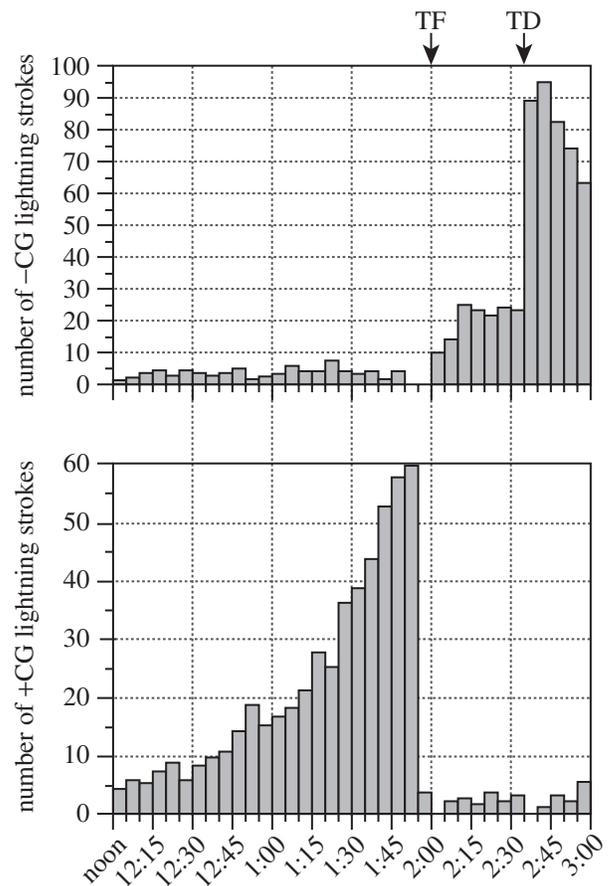


Figure 1

Figure 1 adapted from Donald MacGorman and Donald Burgess, "Positive Cloud-to-Ground Lightning in Tornadoic Storms and Hailstorms." ©1994 by the American Meteorological Society.

4

Time period	Average current (kA*)		Average duration (msec†)	
	+CG strokes	-CG strokes	+CG strokes	-CG strokes
noon–12:30 p.m.	+75.2	-11.6	280	26
12:30 p.m.–1:00 p.m.	+79.4	-14.8	250	24
1:00 p.m.–1:30 p.m.	+83.7	-16.6	233	22
1:30 p.m.–2:00 p.m.	+89.5	-18.1	260	25
2:00 p.m.–2:30 p.m.	+42.2	-32.0	246	22
2:30 p.m.–3:00 p.m.	+37.1	-33.7	259	28

*kA = kiloamperes
†msec = milliseconds

- According to Figure 1, from 1:25 p.m. to 1:55 p.m., the number of +CG strokes in a 5 min period:
 - increased only.
 - decreased only.
 - increased, then decreased.
 - decreased, then increased.
- According to Table 1, the average duration of +CG strokes was at least 10 times greater than the average duration of -CG strokes for all the time periods EXCEPT:
 - noon–12:30 p.m.
 - 1:00 p.m.–1:30 p.m.
 - 1:30 p.m.–2:00 p.m.
 - 2:30 p.m.–3:00 p.m.
- Assume that the storm data in Figure 1 are typical of thunderstorms that produce tornadoes. For such thunderstorms, which type of lightning stroke, -CG or +CG, is predominant before TF and which type of lightning stroke is predominant after TF?

	<u>before TF</u>	<u>after TF</u>
A.	-CG	-CG
B.	+CG	+CG
C.	-CG	+CG
D.	+CG	-CG
- Is the statement “The number of -CG strokes in the 5 min period just after TD will be less than the number of -CG strokes in the 5 min period just before TD” supported by Figure 1?
 - Yes; the number of -CG strokes in the 5 min period just after TD was less than half the number of -CG strokes in the 5 min period just before TD.
 - Yes; the number of -CG strokes in the 5 min period just after TD was the same as the number of -CG strokes in the 5 min period just before TD.
 - No; the number of -CG strokes in the 5 min period just after TD was more than twice the number of -CG strokes in the 5 min period just before TD.
 - No; the number of -CG strokes in the 5 min period just after TD was the same as the number of -CG strokes in the 5 min period just before TD.
- According to Table 1, from noon until 2:00 p.m., did the *magnitude* (absolute value) of the average current of the +CG strokes increase or decrease, and did the magnitude of the average current of the -CG strokes increase or decrease?

	<u>+CG strokes</u>	<u>-CG strokes</u>
A.	increase	increase
B.	decrease	decrease
C.	increase	decrease
D.	decrease	increase

4

Passage II

Most fruit flies have red eyes; some have white eyes. One gene that affects eye color is located on the X chromosome. Female offspring receive 1 X chromosome from both their mother and their father, so they have 2 copies of this gene. Male offspring receive 1 X chromosome from their mother and no X chromosomes from their father (instead, they receive 1 Y chromosome from their father), so they have 1 copy of this gene.

There are 2 *alleles* (forms) of this gene: the red-eye allele (X^R) and the white-eye allele (X^r). X^R is *dominant* to X^r , and X^r is *recessive* to X^R . This means an individual with 1 X^R and 1 X^r will be red-eyed.

Genotype refers to the combination of alleles an individual has at a gene. The table lists each genotype and the corresponding eye color.

Genotype	Eye color
$X^R X^R$	red
$X^R X^r$	red
$X^r X^r$	white
$X^R Y$	red
$X^r Y$	white

Students did 4 experiments to investigate the inheritance of eye color in fruit flies. In each experiment, 50% of the offspring were females and 50% were males.

Experiment 1

Fifty red-eyed females with Genotype $X^R X^R$ were mated with 50 white-eyed males. The results were as follows:

Females: 100% red-eyed.
Males: 100% red-eyed.

Experiment 2

Fifty female offspring and 50 male offspring from Experiment 1 were mated together. The results were as follows:

Females: 100% red-eyed.
Males: 50% red-eyed; 50% white-eyed.

Experiment 3

Fifty female offspring from Experiment 1 were mated with 50 white-eyed males. The results were as follows:

Females: 50% red-eyed; 50% white-eyed.
Males: 50% red-eyed; 50% white-eyed.

Experiment 4

Fifty white-eyed female offspring from Experiment 3 were mated with 50 red-eyed males. The results were as follows:

Females: 100% red-eyed.
Males: 100% white-eyed.

- To produce only white-eyed offspring, one would mate fruit flies with which of the following sets of genotypes?
 - $X^r X^r$ and $X^r Y$
 - $X^R X^r$ and $X^r Y$
 - $X^r X^r$ and $X^R Y$
 - $X^R X^r$ and $X^R Y$
- A white-eyed female has which of the following genotypes?
 - $X^r X^r$
 - $X^R X^r$
 - $X^r Y$
 - $X^R Y$
- Some or all of the male offspring had 1 white-eye allele in Experiments:
 - 2 and 4 only.
 - 3 and 4 only.
 - 1, 2, and 3 only.
 - 2, 3, and 4 only.
- Suppose that 1,000 offspring were produced in Experiment 3. Based on the results, the number of red-eyed male offspring produced in Experiment 3 would most likely have been closest to:
 - 0.
 - 250.
 - 500.
 - 750.

4

10. The ratio of red-eyed offspring to white-eyed offspring produced in Experiment 2 was:
- F. 1:0.
 - G. 1:1.
 - H. 2:1.
 - J. 3:1.
11. In Experiment 3, the parents most likely had which of the following genotypes?
- A. X^rX^r and X^RY
 - B. X^RX^R and X^rY
 - C. X^RX^r and X^RY
 - D. X^RX^r and X^rY

4

Passage III

In 3 studies, students investigated the stiffness of rectangular metal beams (see Figure 1).

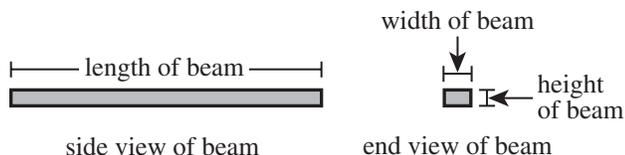


Figure 1

Using the apparatus shown in Figure 2, the students deformed each beam under a variety of conditions.

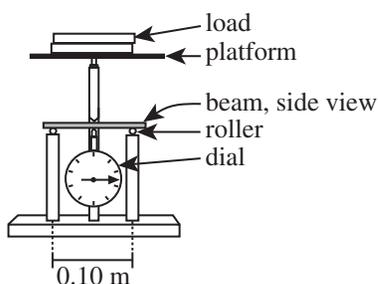


Figure 2

In each trial, the beam being tested was supported at 2 points that were 0.10 m apart and equidistant from the midpoint of the beam. The beam was subjected to a *load*, W , measured in newtons (N), at the midpoint of the beam. W was provided by weights placed on the platform of the apparatus. During deformation, each beam became slightly U-shaped (see Figure 3).

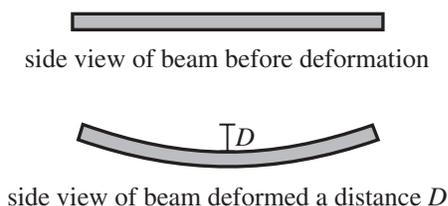


Figure 3

A dial on the apparatus registered the distance, D , the beam was deformed in multiples of 10^{-6} m. After D was measured, the load was removed, and the beam returned to its original shape.

The intrinsic stiffness of the metal composing a beam was represented by *Young's modulus*, E . The effect of the width and height of a beam (see Figure 1) on D was represented by the quantity I , given in m^4 .

Study 1

In Trials 1–4, students determined D for beams with different I (see Table 1). In every trial, $W = 20$ N and $E = 50 \times 10^9$ N/m².

Trial	I (10^{-9} m ⁴)	D (10^{-6} m)
1	2.0	4.2
2	4.0	2.1
3	6.0	1.4
4	8.0	1.0

Study 2

In Trials 5–8, students determined D for beams composed of Metals S–V, respectively. Each metal had a different value of E (see Table 2). In every trial, $W = 20$ N and $I = 2.0 \times 10^{-9}$ m⁴.

Trial	Metal	E (10^9 N/m ²)	D (10^{-6} m)
5	S	25	8.3
6	T	50	4.2
7	U	75	2.8
8	V	100	1.4

Study 3

In Trials 9–12, students determined D for different W (see Table 3). In every trial, $I = 2.0 \times 10^{-9}$ m⁴ and $E = 50 \times 10^9$ N/m².

Trial	W (N)	D (10^{-6} m)
9	10	2.1
10	20	4.2
11	30	6.3
12	40	8.4

GO ON TO THE NEXT PAGE.

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12. Which of the following diagrams of the side view of a beam correctly portrays the direction(s) of the 3 forces that the apparatus exerted on the beam?



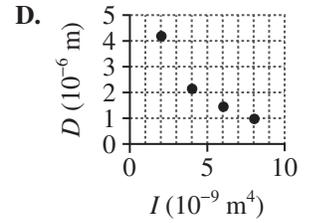
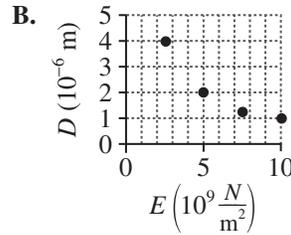
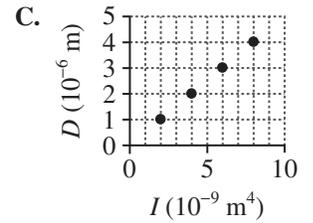
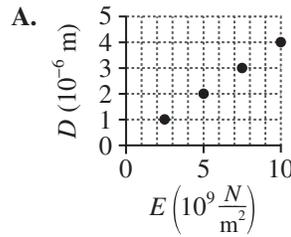
13. If, in Study 3, a trial had been conducted in which $W = 25 \text{ N}$, D would most likely have been closest to which of the following?

- A. $3.1 \times 10^{-6} \text{ m}$
- B. $5.2 \times 10^{-6} \text{ m}$
- C. $7.3 \times 10^{-6} \text{ m}$
- D. $9.4 \times 10^{-6} \text{ m}$

14. If the amount of work done to deform a beam equaled $W \times D$, in which of the following trials was the amount of work the greatest?

- F. Trial 2
- G. Trial 4
- H. Trial 6
- J. Trial 8

15. The results of Study 1 are best represented by which of the following graphs?



16. The beam tested in Study 3 was most likely composed of which of the metals tested in Study 2?

- F. Metal S
- G. Metal T
- H. Metal U
- J. Metal V

17. Based on the results of Studies 1 and 2, for a given W , which of the following combinations of I and E would yield the stiffest beam?

	I (10^{-9} m^4)	E (10^9 N/m^2)
A.	3.0	30
B.	3.0	40
C.	4.0	30
D.	4.0	40

Passage IV

To increase corn crop *yield* (amount produced), *fertilizer nitrogen* (fertilizer N) is added to soil to supplement *soil test N* (various naturally occurring N sources in soil). In a *responsive* soil, the yield is greater when fertilizer N is added than when fertilizer N is not added. In a *nonresponsive* soil, the yield does not change when fertilizer N is added.

A soil's *amino sugar N* (a naturally occurring N source different from soil test N) content can determine whether a soil will be responsive. Two studies were done over 2 consecutive years in 25 cornfields in the same 1,000-hectare area. The soils' amino sugar N and soil test N contents were examined, as well as how the yield was affected by adding fertilizer N.

Study 1

For each field, just before the spring planting, samples of the top 15 cm of soil were collected in several locations, then thoroughly mixed and oven-dried for 24 hr. The dried mixed soil for each field was analyzed for amino sugar N content and soil test N content, in milligrams per kilogram (mg/kg). The results are shown in Figure 1. No fertilizer N was added to any of the fields. At harvest, the yield for each field was recorded.

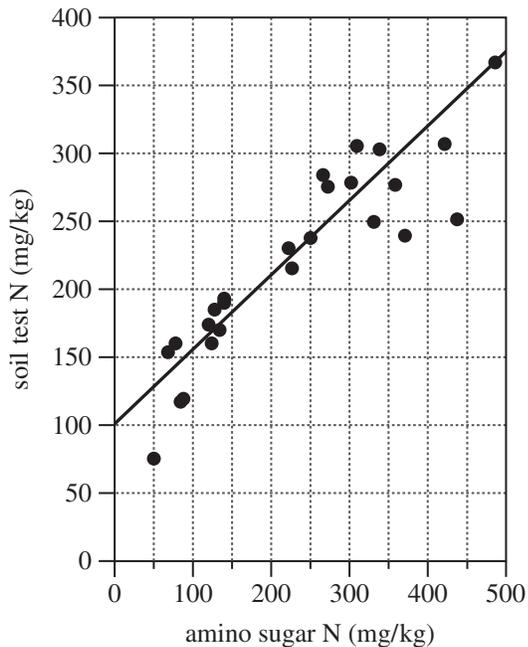


Figure 1

Study 2

The next spring, for each field, soil samples were collected, mixed, dried, and analyzed for amino sugar N as in Study 1. After collection and before spring planting, fertilizer N was added to each field at a rate of 120 kg N/hectare. No other fertilizer N was added over the growing season. At harvest, the yield for each field was recorded. Then, for each field, the percent increase in yield from the previous year was determined and plotted against the soil amino sugar N content (see Figure 2).

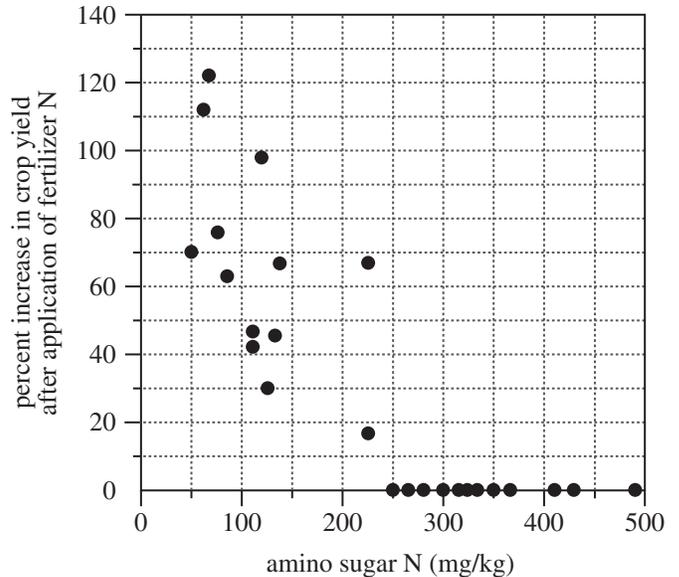


Figure 2

Figures adapted from S. A. Khan, R. L. Mulvaney, and R. G. Hoefl, "A Simple Soil Test for Detecting Sites that are Nonresponsive to Nitrogen Fertilization." ©2001 by the Soil Science Society of America.

18. Suppose another cornfield in the same area had been included in Study 1 and that the soil in this field had been found to have a soil test N content of 200 mg/kg. Based on Figure 1, this soil's amino sugar N content would most likely have been closest to which of the following?

- F. 75 mg/kg
- G. 175 mg/kg
- H. 275 mg/kg
- J. 375 mg/kg

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19. Consider the cornfield with soil that had an amino sugar N content of 350 mg/kg in Study 2. Based on Figure 2 and other information provided, was the soil in the cornfield responsive or nonresponsive?
- A. Responsive, because the yield did not increase.
 - B. Responsive, because the yield increased.
 - C. Nonresponsive, because the yield did not increase.
 - D. Nonresponsive, because the yield increased.
20. In the 2 studies, the purpose of oven-drying the mixed soil was to remove all the:
- F. moisture.
 - G. organic matter.
 - H. soil test N.
 - J. amino sugar N.
21. According to the results of Study 2, what was the greatest percent increase in yield for a cornfield, and what was the amino sugar N content of the soil in the cornfield with this increase in percent yield?
- | | <u>% increase in yield</u> | <u>amino sugar N</u> |
|----|----------------------------|----------------------|
| A. | 100% | 65 mg/kg |
| B. | 112% | 100 mg/kg |
| C. | 122% | 65 mg/kg |
| D. | 122% | 125 mg/kg |
22. By selecting cornfields that were all located in the same 1,000-hectare area, the researchers who performed the studies ensured that which of the factors listed below would be nearly identical for all the fields?
- I. Rainfall
 - II. Amount of sunlight
 - III. Amino sugar N content
- F. I only
 - G. I and II only
 - H. II and III only
 - J. I, II, and III
23. One of the cornfields involved in the studies had an area of 2.5 hectares. In Study 2, how many kg N was added to that field as fertilizer N ?
- A. 60 kg N
 - B. 100 kg N
 - C. 240 kg N
 - D. 300 kg N

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Passage V

A teacher placed 50 mL of Liquid A at 20°C in a *buret* (see Figure 1). A buret is a graduated tube with a *stopcock*. Liquid flows out of the buret when the stopcock is opened.

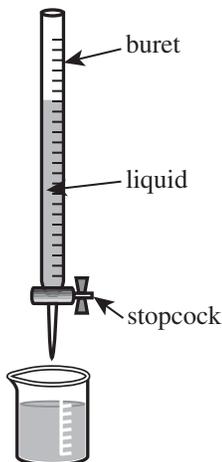


Figure 1

The stopcock was opened and the *flow time*, the time it took for 20 mL of the liquid to flow out of the buret, was measured and found to be 7 sec. The procedure was repeated with Liquid B, which had a flow time of 14 sec.

The teacher asked 3 students to try to explain why the liquids had different flow times.

Student 1

Liquid B drained more slowly than Liquid A because it is denser than Liquid A. As a liquid flows, some of its molecules bump into each other. This causes the molecules to lose speed in the direction of flow, slowing the overall flow of the liquid. Since molecules of a denser liquid are closer together than are molecules of a less dense liquid, collisions occur more often in the denser liquid. Thus, if 2 liquids are at the same temperature, the less dense liquid will always flow more easily.

Student 2

Liquid B drained more slowly than Liquid A because it has a greater *molecular mass* (the mass of each molecule) than Liquid A. Consider 2 objects of different mass. More force is required to move the object with the greater mass. Thus, if 2 liquids are at the same temperature, the liquid with the smaller molecular mass will always flow more easily.

Student 3

Liquid B drained more slowly than Liquid A because it has a larger *molecular volume* (the volume occupied by each molecule) than Liquid A. Large molecules readily bump into each other when a liquid flows, forming molecular “logjams” that slow down the overall flow. Thus, if 2 liquids are at the same temperature, the liquid with the smaller molecular volume will always flow more easily.

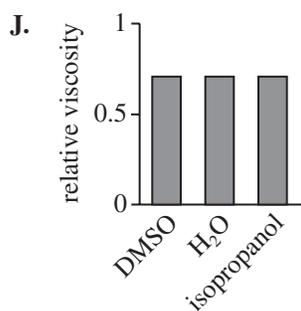
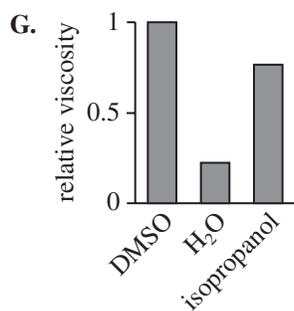
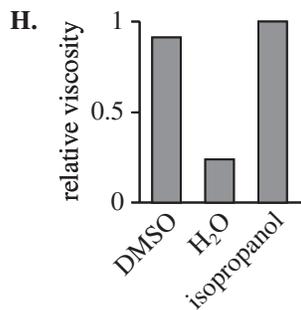
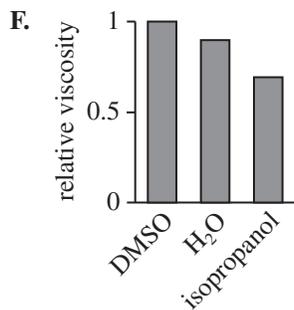
Table 1 gives the density, molecular mass (in atomic mass units, amu), and molecular volume (in nm³; 1 billion nm = 1 m) for several liquids at 20°C.

Liquid	Density (g/mL)	Molecular mass (amu)	Molecular volume (nm ³)
Acetone	0.791	58.08	0.122
DMSO	1.100	78.13	0.118
H ₂ O	1.000	18.02	0.030
Isopropanol	0.786	60.10	0.127
Nonane	0.718	128.3	0.297
Toluene	0.865	92.14	0.177

24. In the teacher’s demonstration, as the 7 sec elapsed during the measurement of Liquid A, the height of the liquid in the buret:
- F. increased only.
 - G. decreased only.
 - H. increased, then decreased.
 - J. decreased, then increased.
25. Based on Student 1’s explanation, which of the liquids listed in Table 1 would flow most easily at 20°C ?
- A. Acetone
 - B. DMSO
 - C. Nonane
 - D. Toluene
26. Suppose that the teacher had also tested isopropanol in the demonstration and found it to have a flow time of 11 sec. Student 1 would claim that isopropanol:
- F. is more dense than Liquid A, but not as dense as Liquid B.
 - G. is more dense than Liquid B, but not as dense as Liquid A.
 - H. has a greater molecular mass than Liquid A, but a smaller molecular mass than Liquid B.
 - J. has a greater molecular mass than Liquid B, but a smaller molecular mass than Liquid A.
27. Is the claim “At 20°C, nonane flows more easily than acetone” consistent with Student 2’s explanation?
- A. No, because nonane has a greater molecular mass than acetone.
 - B. No, because nonane has a larger molecular volume than acetone.
 - C. Yes, because nonane has a greater molecular mass than acetone.
 - D. Yes, because nonane has a larger molecular volume than acetone.

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28. Which of the following graphs of the relative viscosities of DMSO, H₂O, and isopropanol is most consistent with Student 3's explanation?



29. Suppose that Liquid A had been isopropanol and Liquid B had been nonane. The results of the teacher's demonstration would have supported the explanation(s) provided by which student(s)?

- A. Student 1 only
- B. Student 2 only
- C. Students 1 and 2 only
- D. Students 2 and 3 only

30. Consider the data for heptane (a liquid) at 20°C shown in the table below:

Density	Molecular mass	Molecular volume
0.684 g/mL	100.20 amu	0.243 nm ³

Which student(s), if any, would predict that heptane would have a shorter flow time than toluene at 20°C?

- F. Student 1 only
- G. Students 2 and 3 only
- H. Students 1, 2, and 3
- J. None of the students

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.

ACT[®]

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