# Form Z15

(April 2019)

M|S

The ACT®

2019

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

If you wish to order a photocopy of your scanned answer document—including, if you took the writing test, a copy of your written essay—please use the order form on the inside back cover of this booklet.

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## 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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**DO YOUR FIGURING HERE.**

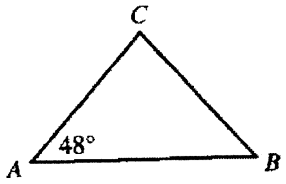
1. Given $r = 4$, $b = 2$, and $g = -5$, $(r + b - g)(b + g) = ?$

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

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

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

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




   **A.** 48°
   **B.** 84°
   **C.** 90°
   **D.** 96°
   **E.** 132°

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

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

**DO YOUR FIGURING HERE.**

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

   **A.** $\frac{1}{21}$

   **B.** $\frac{1}{9}$

   **C.** $\frac{3}{7}$

   **D.** $\frac{2}{3}$

   **E.** $\frac{3}{4}$

6. What is the value of $|-7| - |7 - 29|$ ?

   **F.** −29
   **G.** −15
   **H.** 15
   **J.** 29
   **K.** 43

7. A store's revenue is the amount of money received for goods sold. A store's cost is the amount of money the store pays for the goods plus all the store's operating costs like rent, utilities, wages, etc. A store's net profit is the difference between revenue and cost. During 1 month, a grocery store paid $30,000 for goods that were sold for $39,500. With operating costs as shown below, what was the store's net profit for that month?

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

   **A.** $ 700
   **B.** $ 800
   **C.** $ 900
   **D.** $1,000
   **E.** $1,100

8. When Jorge began a driving trip, his car's odometer read 42 miles. After Jorge drove for 3 hours, the odometer read 165 miles. Which of the following values is closest to Jorge's average driving speed, in miles per hour, during those 3 hours?

   **F.** 36
   **G.** 41
   **H.** 54
   **J.** 55
   **K.** 62

DO YOUR FIGURING HERE.

9. Melinda and Jericho are painting a room in the city recreation center. They started with 5 gallons of paint. On the first day, Melinda used $\frac{3}{4}$ gallon of paint and Jericho used $2\frac{1}{2}$ gallons of paint. How many gallons of paint were left after the first day?

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

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

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

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

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

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

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

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

**DO YOUR FIGURING HERE.**

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

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

**B.** $\frac{2}{5}$

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

**D.** 2

**E.** 8

**14.** For an angle with measure $\alpha$ in a right triangle, $\sin \alpha = \frac{15}{17}$ and $\tan \alpha = \frac{15}{8}$. What is the value of $\cos \alpha$ ?

**F.** $\frac{17}{8}$

**G.** $\frac{8}{15}$

**H.** $\frac{8}{17}$

**J.** $\frac{8}{\sqrt{161}}$

**K.** $\frac{8}{\sqrt{514}}$

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

**A.** 4

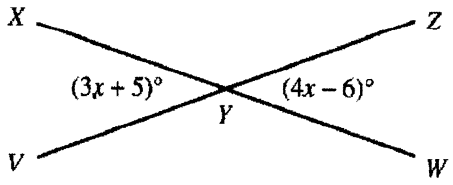
**B.** 6

**C.** 8

**D.** 12

**E.** $3\sqrt{21}$

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




**F.** 83°
**G.** 97°
**H.** 104°
**J.** 142°
**K.** 169°

DO YOUR FIGURING HERE.

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

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

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

**A.** 0.3
**B.** 0.4
**C.** 0.6
**D.** 0.7
**E.** 0.9

18. For what value of $n$ does the quadratic equation $x^2 - 2x + n = 0$ have solutions of $x = 4$ and $x = -2$ ?

**F.** $-8$
**G.** $-2$
**H.** 2
**J.** 6
**K.** 8

19. The circumference of a circle is $12\pi$ inches. What is the area of the circle, in square inches?

**A.** $4\pi$
**B.** $9\pi$
**C.** $12\pi$
**D.** $16\pi$
**E.** $36\pi$

20. The application for a license plate states that the license plate number has 3 letters followed by a 3-digit number, for example, AEE123. The letters O and I and the digit 0 cannot be part of the license plate number. Any of the other letters and digits may be used up to 3 times. Which of the following expressions represents how many different license plate numbers are possible?

**F.** 24(23)(22)(9)(8)(7)
**G.** 24(23)(22)(10)(10)(10)
**H.** 24(24)(24)(9)(9)(9)
**J.** 26(25)(24)(10)(9)(8)
**K.** 26(26)(26)(10)(10)(10)

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

**A.** $a - 9b$
**B.** $a - 7b$
**C.** $a - 4b$
**D.** $a + 8b$
**E.** $a + 13b$

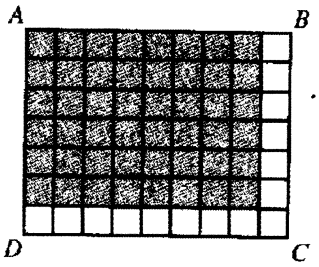


GO ON TO THE NEXT PAGE

**DO YOUR FIGURING HERE.**

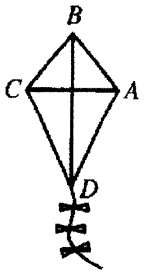
22. In the figure below, all of the small squares are equal in area, and the area of rectangle $ABCD$ is 1 square unit. Which of the following expressions represents the area, in square units, of the shaded region?

F. $\frac{1}{9} \cdot \frac{1}{7}$
G. $\frac{1}{9} \cdot \frac{6}{7}$
H. $\frac{1}{9} \cdot \frac{8}{9}$
J. $\frac{8}{9} \cdot \frac{1}{7}$
K. $\frac{8}{9} \cdot \frac{6}{7}$



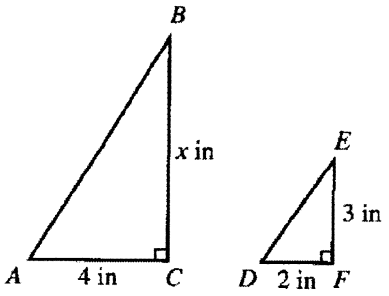

23. Marie is building a kite. In a drawing of her kite, shown below, $AB = BC$, $AD = DC$, the measure of $\angle ABC$ is 80°, and the measure of $\angle ADC$ is 50°. What is the measure of $\angle BAD$ ?

A. 50°
B. 65°
C. 90°
D. 115°
E. 130°




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

F. $\frac{1}{2}(2+4)(3+x)$
G. $\frac{1}{2}(2)(3)$
H. $\frac{1}{2}(2)(3)(2)$
J. $\frac{1}{2}\left(\frac{x}{3}\right)(2)$
K. $\frac{1}{2}(4)(6)$



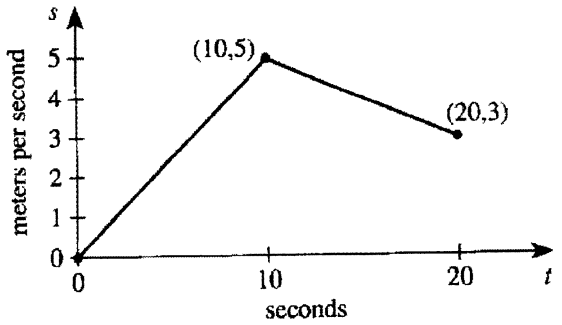

25. The interior of a rectangular shipping crate has dimensions 2 ft by 3 ft by 6 ft. The crate will be filled with cube-shaped boxes whose exteriors have dimensions 12 in by 12 in by 12 in. Given that no box can extend beyond the dimensions of the crate's interior, what is the maximum number of boxes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

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

DO YOUR FIGURING HERE.

Use the following information to answer questions 26–29.

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




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

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

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

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

**A.** $-5$

**B.** $-\frac{1}{5}$

**C.** $\frac{1}{5}$

**D.** 2

**E.** 5

**DO YOUR FIGURING HERE.**

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

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

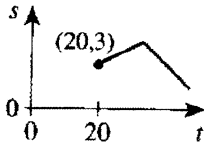
G. 25

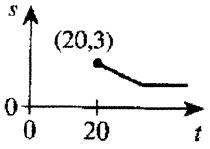
H. $37\frac{1}{2}$

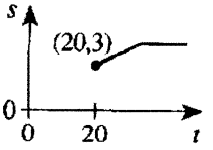
J. 45

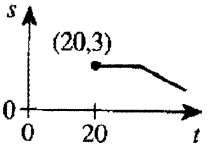
K. 75

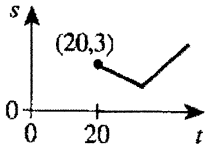
29. Which of the following graphs best represents the portion of Shasta's ride beginning at $t = 20$ seconds?

A.



D.



B.



E.



C.



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

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

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

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

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

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

DO YOUR FIGURING HERE.

31. The lengths of 2 adjacent sides of a rectangle are represented by $x + 2$ feet and $2x + 7$ feet. In terms of $x$, what is the area, in square feet, of the rectangle?

A. $6x + 18$
B. $2x^2 + 14$
C. $2x^2 + 9x + 14$
D. $2x^2 + 11x + 9$
E. $2x^2 + 11x + 14$

32. Which one of the following inequalities is true?

F. $2 < \sqrt{3} < 4$
G. $\frac{1}{2} < \sqrt{\frac{1}{3}} < \frac{1}{4}$
H. $4 < 2(\sqrt{5}) < 5$
J. $\sqrt{3} < 4 < \sqrt{5}$
K. $\sqrt{2} < 2(\sqrt{2}) < \sqrt{3}$

33. Two fair coins are repeatedly tossed simultaneously. What is the probability that both coins land heads up on the 36th toss?

A. $\frac{1}{144}$
B. $\frac{1}{108}$
C. $\frac{1}{36}$
D. $\frac{1}{9}$
E. $\frac{1}{4}$

34. Suppose a student's course grade is determined solely by that student's scores on 8 tests, which are worth 100 points each. If Bane has an average of exactly 88 points on the first 6 tests, how many points must he average on the last 2 tests to earn exactly a 90-point course grade?

F. 99
G. 96
H. 95
J. 94
K. 92

35. Which of the following operations will produce the largest result when substituted for the blank in the expression 62 ___ $\left(-\frac{1}{65}\right)$?

A. Averaged with
B. Divided by
C. Minus
D. Plus
E. Multiplied by



GO ON TO THE NEXT PAGE.

**DO YOUR FIGURING HERE.**

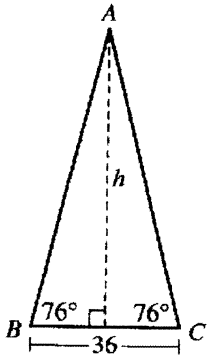
**36.** Given the sets $A = \{0, 1, 2, 3\}$ and $B = \{1, 3, 5, 7\}$, which of the following defines a function $f$ from $A$ onto $B$ ?

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

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

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

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




**F.** 18 sin 76°
**G.** 18 tan 76°
**H.** 36 cot 76°
**J.** 36 sin 76°
**K.** 36 tan 76°

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

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

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

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

DO YOUR FIGURING HERE.

Use the following information to answer questions 41–43.

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

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

**41.** Which of the following expressions is equal to the approximate number of adults from the sample that said they spend an average of less than $100 each week on food?

**A.** 1,014(22)
**B.** 1,014(25)
**C.** 1,014(47)
**D.** 1,014(0.22)
**E.** 1,014(0.25)

**42.** What percent of adults in the sample responded that they spend, on average, at least $150 each week on food?

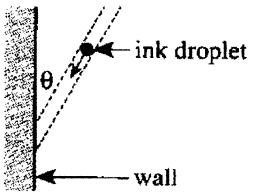
**F.** 15%
**G.** 46%
**H.** 49%
**J.** 51%
**K.** 66%

**43.** A pollster will create a circle graph using the information in the table. One sector of the circle graph will represent the percent of adults in the sample who said they spend an average of $300 or more on food each week. What will be the measure of the central angle for that sector?

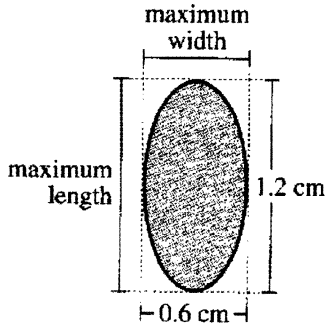
**A.** 10°
**B.** 13°
**C.** 36°
**D.** 45°
**E.** 47°

**DO YOUR FIGURING HERE.**

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

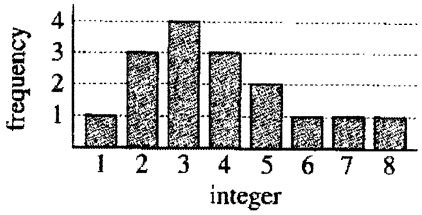



The stain the droplet leaves on the wall is oval-shaped. Scientists can measure the maximum length and maximum width of the stain to determine the angle of impact according to the formula $\sin\theta = \frac{\text{maximum width}}{\text{maximum length}}$. The figure below models such a stain. What was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




**F.** 30°
**G.** 45°
**H.** 60°
**J.** 90°
**K.** 120°

**45.** The graph below shows the distribution of a data set consisting of 16 positive integers. Which of the following statements about the mean, median, and mode of the data set is true?




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

DO YOUR FIGURING HERE.

46. Yolanda collects trading cards, and she has started her younger brothers, Xavier and Zach, collecting cards as well. As of today, Zach owns 5 more cards than Xavier, and Yolanda owns twice as many cards as Xavier and Zach combined. Which of the following equations expresses the relationship between $y$, the number of cards Yolanda owns, and $x$, the number of cards Xavier owns?

F. $y = x - 5$
G. $y = x + 5$
H. $y = 2x$
J. $y = 4x - 10$
K. $y = 4x + 10$

47. What is the distance, in coordinate units, between the points $(-2,1)$ and $(1,10)$ in the standard $(x,y)$ coordinate plane?

A. $\sqrt{72}$
B. $\sqrt{80}$
C. $\sqrt{82}$
D. $\sqrt{90}$
E. 12

48. A rectangular solid has a volume of 100 cubic units. If the length, width, and height of the solid are each doubled, what will the volume, in cubic units, of the new solid be?

F. 200
G. 400
H. 600
J. 800
K. 2,700

49. The set of all values of $x$ that satisfies $|x - 2| < 7$ is the same as the set of all values of $x$ that satisfies:

A. $0 < x < 5$
B. $0 < x < 9$
C. $-5 < x < 5$
D. $-5 < x < 9$
E. $-9 < x < 9$

50. The fifth power of a number is 380,204,032. The number is between:

F. 1 and 10.
G. 10 and 100.
H. 100 and 1,000.
J. 1,000 and 100,000.
K. 100,000 and 100,000,000.

**DO YOUR FIGURING HERE.**

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

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

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

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

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

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

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

F. 0

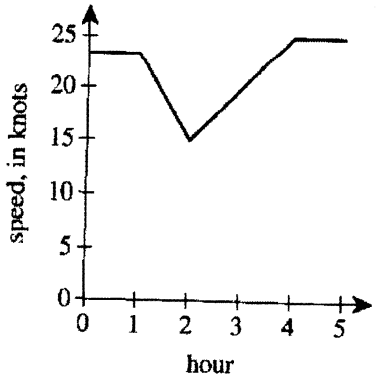
G. 1

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

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

K. Cannot be determined from the given information

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




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

DO YOUR FIGURING HERE.

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

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

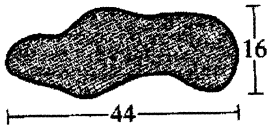
G. $\frac{4}{5}$

H. $\frac{4}{9}$

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

K. $\frac{3}{10}$

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




A. 3,150
B. 3,335
C. 3,520
D. 3,720
E. Cannot be determined from the given information

56. For all positive integers $a$ and $b$, the expression $(a!)^b$ is equivalent to one of the following expressions. Which one?

F. $(a^b)!$

G. $(ab)!$

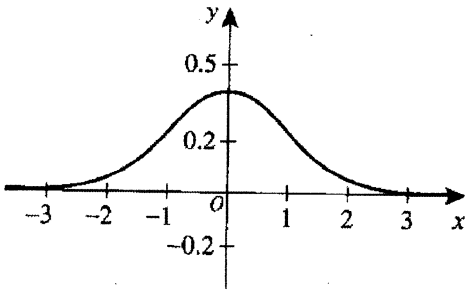
H. $b(a!)$

J. $a^b(-1 + -2 + -3 + \cdots)$

K. $[a(a-1)(a-2)\cdots(1)]^b$

**DO YOUR FIGURING HERE.**

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




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

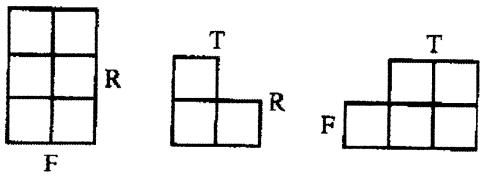
**58.** For what value of $b$ will the determinant of the matrix $\begin{bmatrix} 4 & b \\ 2 & 3 \end{bmatrix}$ have a value of 18 ?

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

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

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

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




top front right side

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

**END OF TEST 2**

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

**DO NOT RETURN TO THE PREVIOUS TEST.**

## SCIENCE TEST

*35 Minutes—40 Questions*

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

You are NOT permitted to use a calculator on this test.

### Passage I

A *mineral hydrate* (MH) is an ionic compound that has associated $H_2O$ molecules. *Dehydration* (removal of all $H_2O$) of an MH produces its *anhydrous salt* (an ionic compound that has no associated $H_2O$ molecules), which may differ in color from the MH. Table 1 shows, for each of 4 MHs, the chemical formula of one formula unit of the MH, its color, and the color of its anhydrous salt.

Table 1

| MH | Chemical formula | Color | Color of anhydrous salt |
|---|---|---|---|
| Bieberite | $CoSO_4 \cdot 7H_2O$ | pink | red |
| Chalcanthite | $CuSO_4 \cdot 5H_2O$ | blue | pale green |
| Melanterite | $FeSO_4 \cdot 7H_2O$ | blue-green | white |
| Retgersite | $NiSO_4 \cdot 6H_2O$ | blue-green | yellow |

Figure 1 shows the mass of a sample that was converted from chalcanthite to $CuSO_4$ as its temperature was increased from 0°C to 350°C.

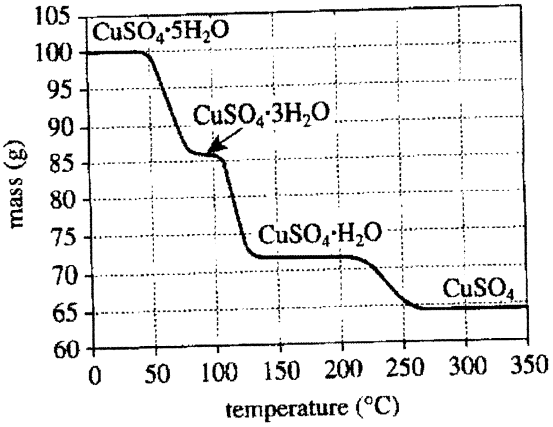



Figure 1

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

Table 2 shows the solubility in $H_2O$ of each anhydrous salt at 20°C, 40°C, 60°C, and 80°C.

Table 2

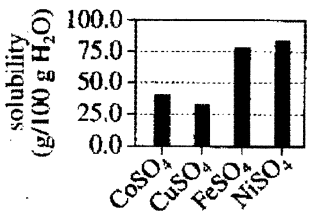
| Temperature (°C) | Solubility (g/100 g $H_2O$*) of: | | | |
|---|---|---|---|---|
| | $CoSO_4$ | $CuSO_4$ | $FeSO_4$ | $NiSO_4$ |
| 20 | 35.3 | 20.0 | 26.3 | 37.7 |
| 40 | 47.7 | 28.5 | 40.4 | 47.1 |
| 60 | 56.0 | 40.4 | 55.0 | 55.8 |
| 80 | 49.7 | 57.0 | 43.7 | 66.4 |

*grams of anhydrous salt per 100 grams of $H_2O$

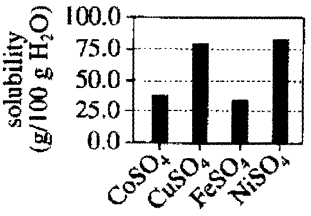
Tables 1 and 2 adapted from W. M. Haynes, ed., *CRC Handbook of Chemistry and Physics on CD-ROM*, Version 2011. ©2011 by CRC Press, LLC.

1. According to Table 2, which of the following graphs best shows, for each of the 4 anhydrous salts, the solubility in $H_2O$ at 80°C ?

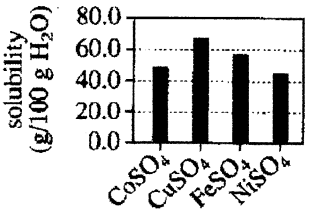
A.



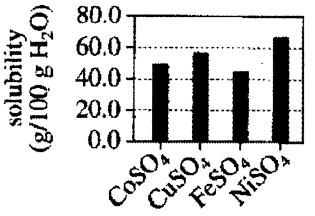

B.




C.




D.




2. According to Table 2, as temperature increases from 20°C through 80°C, the solubility in $H_2O$ of $CoSO_4$ and the solubility in $H_2O$ of $FeSO_4$:

F. increase only.
G. decrease only.
H. increase, then decrease.
J. decrease, then increase.

3. Based on Table 1 and Figure 1, the color of the sample at 30°C was:

A. blue.
B. pale green.
C. red.
D. yellow.

4. Based on Figure 1, as the sample was heated from 0°C to 100°C, the mass of the sample decreased by approximately:

F. 7 g.
G. 14 g.
H. 21 g.
J. 28 g.

5. Based on Figure 1, the change that occurred in the sample as it was heated from 175°C to 300°C would be best represented by which of the following chemical equations?

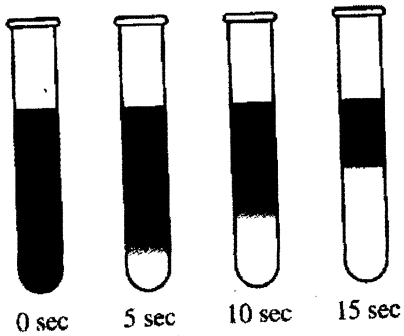
A. $CuSO_4 \cdot H_2O \rightarrow CuSO_4 + H_2O$
B. $CuSO_4 \cdot 3H_2O \rightarrow CuSO_4 \cdot H_2O + 2H_2O$
C. $CuSO_4 + H_2O \rightarrow CuSO_4 \cdot H_2O$
D. $CuSO_4 \cdot H_2O + 2H_2O \rightarrow CuSO_4 \cdot 3H_2O$

6. A student claimed that 50 g of $CuSO_4$ will dissolve in 300 g of $H_2O$ at 20°C. Does Table 2 support this claim?

F. No; only 20 g of $CuSO_4$ will dissolve.
G. No; only 40 g of $CuSO_4$ will dissolve.
H. Yes; up to 60 g of $CuSO_4$ will dissolve.
J. Yes; up to 80 g of $CuSO_4$ will dissolve.

## Passage II

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




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

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

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

*Student 1*

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

*Student 2*

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

*Student 3*

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

*Student 4*

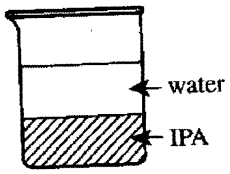
Over the 15 sec, the mixture separated into 2 layers because the AS dissolved in the water only, causing the density of the water layer to increase. The IPA layer was on top, and the water layer was on the bottom. The AS dissolved in the water only, because AS breaks apart into ions when dissolved in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

7. Which of Students 1 and 2, if either, claimed that water is denser than IPA ?

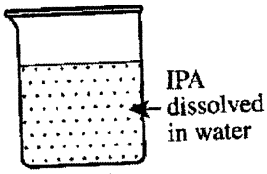
   **A.** Student 1 only
   **B.** Student 2 only
   **C.** Both Student 1 and Student 2
   **D.** Neither Student 1 nor Student 2

8. Suppose that 20 mL of water and 20 mL of IPA are poured into a beaker, mixed, and then allowed to settle. Based on Student 2's explanation, the resulting contents of the beaker would best be represented by which of the following diagrams?

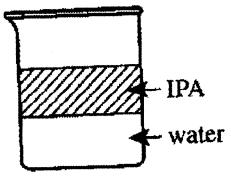
**F.**



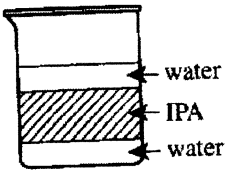

**H.**



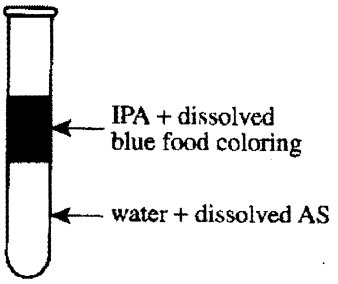

**G.**




**J.**



9. Consider the diagram below.




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

A. Student 1 only
B. Student 4 only
C. Students 1 and 3 only
D. Students 2 and 4 only

10. Which students, if any, would be likely to agree that after the 2 layers completely separated, the blue food coloring and the AS were both dissolved in the same layer?

F. Students 1 and 3 only
G. Students 1, 2, and 4 only
H. Students 2, 3, and 4 only
J. None of the students

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

A. Heterogeneous, because the contents of the test tube varied in composition from one region to another.
B. Heterogeneous, because the contents of the test tube were uniform in composition throughout.
C. Homogeneous, because the contents of the test tube varied in composition from one region to another.
D. Homogeneous, because the contents of the test tube were uniform in composition throughout.

12. The statement "When AS dissolves in a liquid, the density of the resulting solution is greater than the density of the liquid alone" is consistent with the explanation(s) given by which of Students 3 and 4, if either?

F. Student 3 only
G. Student 4 only
H. Both Student 3 and Student 4
J. Neither Student 3 nor Student 4

13. The chemical formula of AS is $(NH_4)_2SO_4$. Based on Student 3's explanation, which of the following chemical equations best represents a process that only occurred in the IPA ?

A. $(NH_4)_2SO_4 \rightarrow 2NH_4^+ + SO_4^{2-}$
B. $(NH_4)_2SO_4 \rightarrow 2NH_4 + SO_4$
C. $(NH_4)_2SO_4 \rightarrow 2NH_4SO_4^{2+}$
D. $(NH_4)_2SO_4 \rightarrow 2NH_4SO_4$

## Passage III

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

*Study 1*

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

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

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

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

Table 1

| System | Road type | Average $S$ (m) | Average $B$ (m/sec$^2$) |
|---|---|---|---|
| X | dry | 43.1 | 10.4 |
| | wet | 45.8 | 9.8 |
| Y | dry | 57.5 | 7.7 |
| | wet | 62.6 | 7.2 |
| Z | dry | 45.1 | 10.0 |
| | wet | 52.3 | 8.6 |

*Study 2*

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

Table 2

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

*Study 3*

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

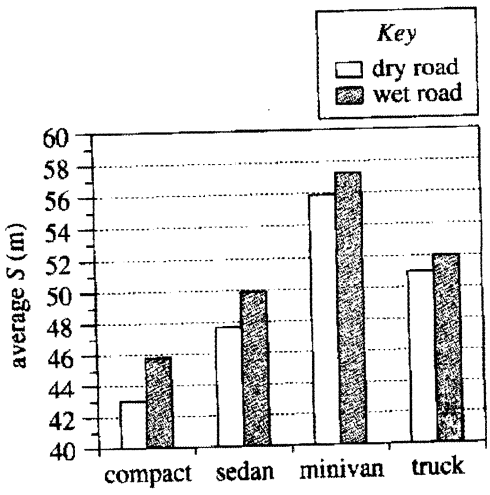



Figure 1

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

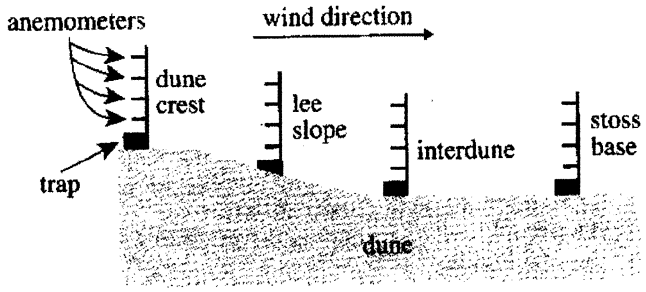
$$B = \frac{(60 \text{ m/sec})^2}{2 \times S}$$

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

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

## Passage IV

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




Note: Diagram is not to scale.

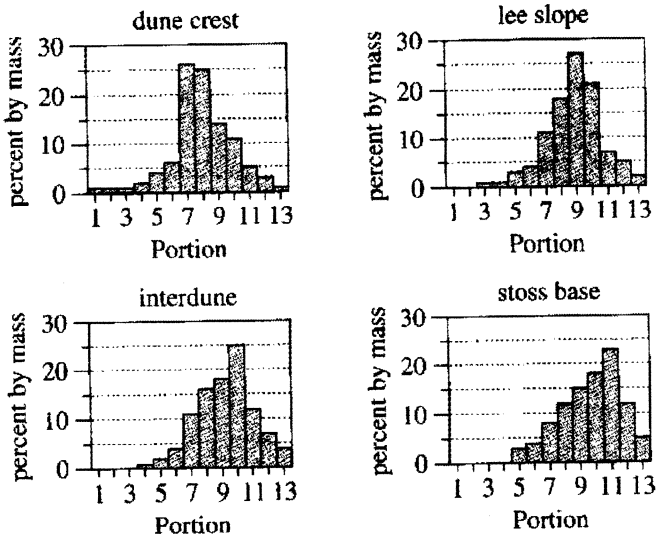
diagram of sites

*Study*

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

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

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




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

Figure 2

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

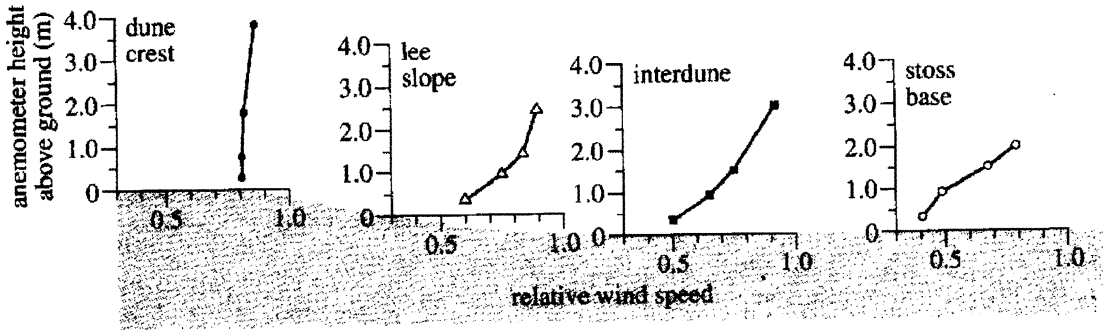



Figure 1

21. According to Figure 1, at the interdune site, as anemometer height above the ground increased, relative wind speed:

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

22. According to Figure 2, sand grains making up which 2 adjacent portions accounted for more than half of the total mass of the collected sand from the dune crest site?

F. Portions 5 and 6
G. Portions 6 and 7
H. Portions 7 and 8
J. Portions 8 and 9

23. If in the study an anemometer had been attached to the pole at the dune crest site at a height of 4.1 m above the ground, the relative wind speed at that anemometer would most likely have been closest to which of the following?

A. 0.2
B. 0.4
C. 0.6
D. 0.8

24. What was the average wind speed 12.0 m above the ground at the dune crest site for the 45 min period?

F. 0.5 m/sec
G. 1.0 m/sec
H. 5.0 m/sec
J. Cannot be determined from the given information

25. The *best-sorted* sand in the study was the sand made up of grains having the smallest range of diameters. Based on Figure 2, the collected sand from which site was the best sorted?

A. Dune crest
B. Lee slope
C. Interdune
D. Stoss base

26. Suppose that the collected sand from the stoss base site had a total mass of 200 g. Based on Figure 2, the sand grains making up Portion 9 would have had a mass closest to which of the following?

F. 10 g
G. 20 g
H. 30 g
J. 40 g

27. The *medium* sand grains collected in the study were those that made up Portions 1–4, and the *very fine* sand grains collected in the study were those that made up Portions 10–13. According to Figure 2, from site to site downwind, how did the total percent by mass of the medium sand grains change, and how did the total percent by mass of the very fine sand grains change?

| | medium sand grains | very fine sand grains |
|---|---|---|
| A. | decreased | increased |
| B. | increased | decreased |
| C. | increased | increased |
| D. | decreased | decreased |

## Passage V

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

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

Table 1

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

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

*Study 1*

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

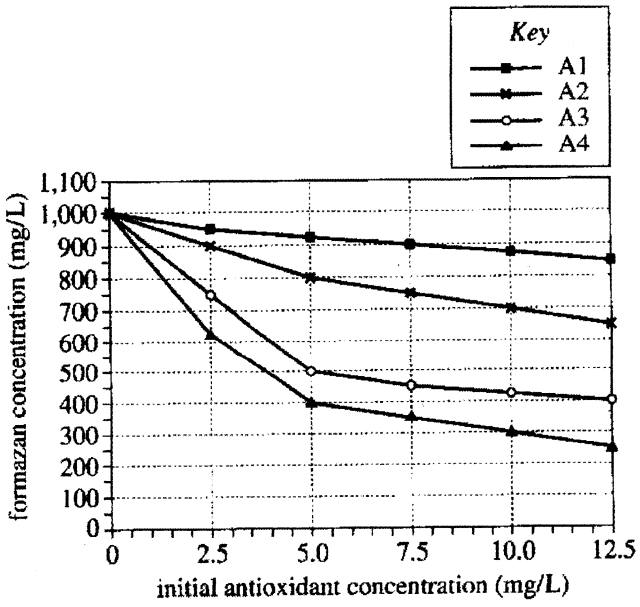



Figure 1

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

*Study 2*

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

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

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

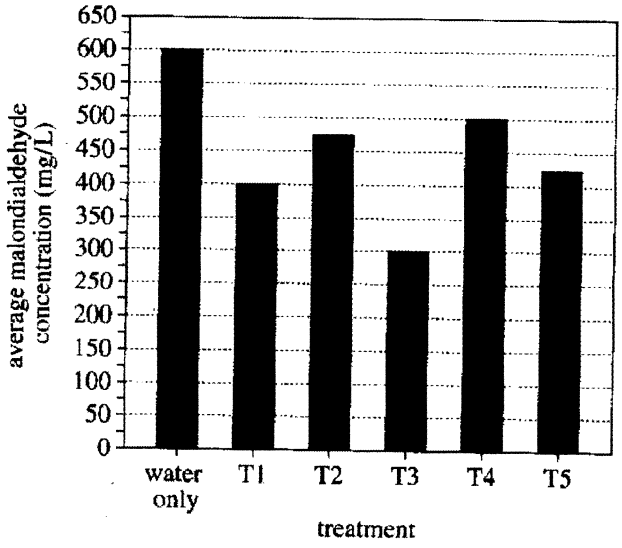



Figure 2

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

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

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

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

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

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

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

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

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

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

| | temperature | time |
|---|---|---|
| **F.** | Study 1 | Study 1 |
| **G.** | Study 1 | Study 2 |
| **H.** | Study 2 | Study 1 |
| **J.** | Study 2 | Study 2 |

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

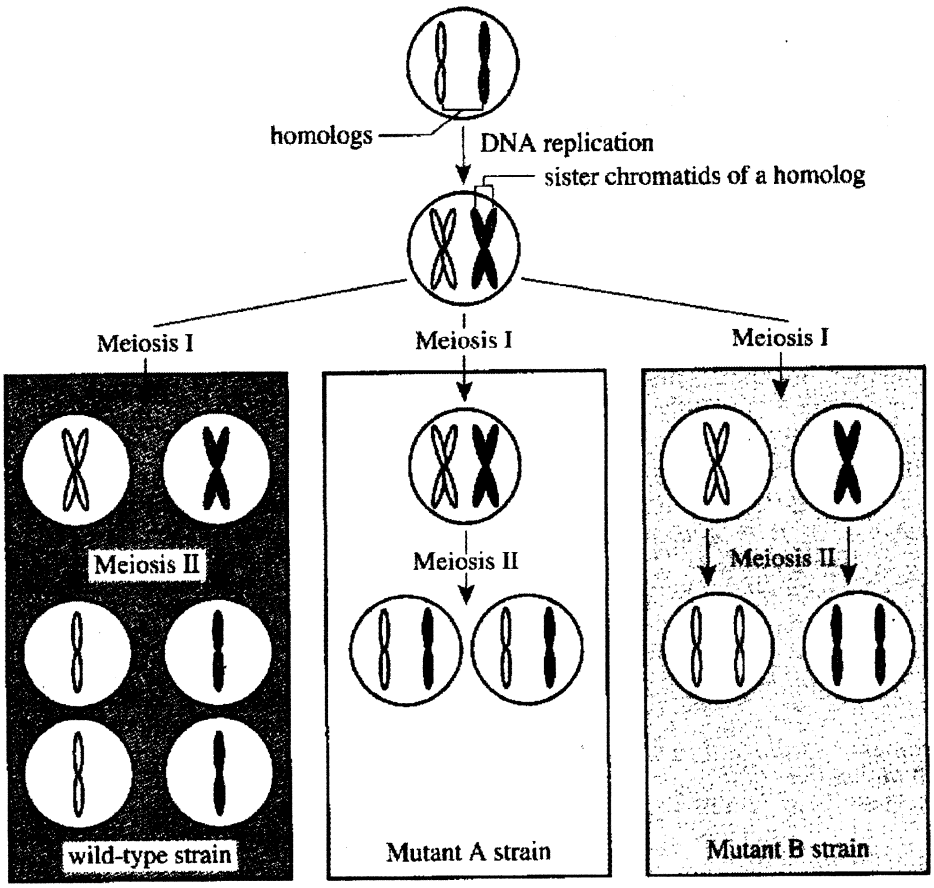
**A.** Higher, because fewer ROM would be eliminated.
**B.** Higher, because more ROM would be eliminated.
**C.** Lower, because fewer ROM would be eliminated.
**D.** Lower, because more ROM would be eliminated.

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

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

## Passage VI

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




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

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

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

| | Mutant A strain | Mutant B strain |
|---|---|---|
| **A.** | 1 | 1 |
| **B.** | 1 | 2 |
| **C.** | 2 | 1 |
| **D.** | 4 | 2 |

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

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

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

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

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

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

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

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

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

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

**END OF TEST 4**

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

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

Section **1**

## ENGLISH

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

Section **2**

## MATH

| | |
|---|---|
| 1. A | 41. E |
| 2. J | 42. G |
| 3. B | 43. C |
| 4. H | 44. F |
| 5. C | 45. A |
| 6. G | 46. K |
| 7. A | 47. D |
| 8. G | 48. J |
| 9. A | 49. D |
| 10. F | 50. G |
| 11. B | 51. B |
| 12. F | 52. H |
| 13. A | 53. C |
| 14. H | 54. K |
| 15. A | 55. A |
| 16. J | 56. K |
| 17. E | 57. D |
| 18. F | 58. G |
| 19. E | 59. C |
| 20. H | 60. G |
| 21. E | |
| 22. K | |
| 23. D | |
| 24. K | |
| 25. C | |
| 26. F | |
| 27. B | |
| 28. H | |
| 29. D | |
| 30. J | |
| 31. E | |
| 32. H | |
| 33. E | |
| 34. G | |
| 35. C | |
| 36. F | |
| 37. D | |
| 38. G | |
| 39. E | |
| 40. J | |

Section **3**

## READING

| |
|---|
| 1. C |
| 2. H |
| 3. D |
| 4. F |
| 5. C |
| 6. J |
| 7. D |
| 8. G |
| 9. C |
| 10. J |
| 11. A |
| 12. G |
| 13. D |
| 14. H |
| 15. B |
| 16. F |
| 17. B |
| 18. F |
| 19. B |
| 20. H |
| 21. B |
| 22. G |
| 23. C |
| 24. H |
| 25. C |
| 26. G |
| 27. B |
| 28. F |
| 29. D |
| 30. F |
| 31. B |
| 32. G |
| 33. D |
| 34. J |
| 35. C |
| 36. F |
| 37. B |
| 38. H |
| 39. A |
| 40. F |

Section **4**

## SCIENCE

| |
|---|
| 1. D |
| 2. H |
| 3. A |
| 4. G |
| 5. A |
| 6. H |
| 7. B |
| 8. G |
| 9. D |
| 10. J |
| 11. A |
| 12. H |
| 13. A |
| 14. G |
| 15. C |
| 16. F |
| 17. D |
| 18. H |
| 19. B |
| 20. J |
| 21. A |
| 22. H |
| 23. D |
| 24. J |
| 25. D |
| 26. H |
| 27. A |
| 28. J |
| 29. B |
| 30. H |
| 31. C |
| 32. J |
| 33. A |
| 34. F |
| 35. B |
| 36. F |
| 37. C |
| 38. F |
| 39. D |
| 40. G |

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

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

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

| ACT Test Z15 | Your Scale Score |
|---|---|
| English | _____ |
| Mathematics | _____ |
| Reading | _____ |
| Science | _____ |
| **Sum of scores** | _____ |
| **Composite score (sum ÷ 4)** | _____ |

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

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