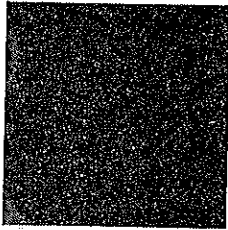


# Form B05

(December 2018)



The **ACT**<sup>®</sup>

2018 | 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.

If you wish to order a photocopy of your 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,

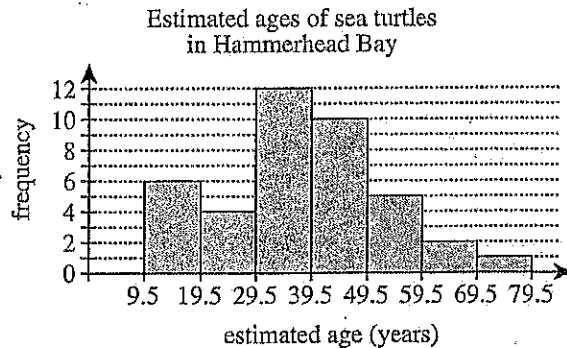
but some of the problems may best be done without using a calculator.

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.

1. Marine biologists collected a sample of 40 adult sea turtles from Hammerhead Bay and estimated the age, in whole years, of each turtle. The histogram below shows the frequency of sea turtles for each of the estimated age groups. What is the maximum possible number of sea turtles that could have had an estimated age of 45 years?

**DO YOUR FIGURING HERE.**



- A. 1  
 B. 5  
 C. 9  
 D. 10  
 E. 40
2. The sum of the measures of the interior angles of a convex polygon with  $t$  sides is  $180(t - 2)$  degrees. What is the sum of the measures of the interior angles of a convex polygon with 10 sides?
- F.  $900^\circ$   
 G.  $1,440^\circ$   
 H.  $1,798^\circ$   
 J.  $1,800^\circ$   
 K.  $2,160^\circ$

**2****2****DO YOUR FIGURING HERE.**

3. In the standard  $(x,y)$  coordinate plane, point  $A$  has coordinates  $(-8,-3)$ . Point  $A$  is translated 8 units to the right and 3 units up, and that image is labeled  $A'$ . What are the coordinates of  $A'$  ?
- A.  $(-16, -6)$   
 B.  $(-11, -11)$   
 C.  $(-8, -6)$   
 D.  $(0, 0)$   
 E.  $(16, 6)$
4. For all nonzero values of  $x$  and  $y$ , which of the following expressions is equivalent to  $-\frac{28x^4y^3}{4xy}$  ?
- F.  $-7x^3y^2$   
 G.  $-7x^4y^4$   
 H.  $-7x^5y^4$   
 J.  $-24x^3y^2$   
 K.  $-32x^3y^2$
5. What is the volume, in cubic inches, of a right circular cone with radius 3 inches and height 6 inches?  
 (Note: The volume of a right circular cone with radius  $r$  and height  $h$  is  $\frac{1}{3}\pi r^2 h$ .)
- A.  $6\pi$   
 B.  $12\pi$   
 C.  $18\pi$   
 D.  $27\pi$   
 E.  $36\pi$
6. The expression  $(x^4)^6$  is equivalent to:
- F.  $x^{10}$   
 G.  $x^{24}$   
 H.  $x^{4,096}$   
 J.  $6x^2$   
 K.  $6x^3$
7. Milo earns his regular pay of \$12.00 per hour for up to 40 hours of work per week. For each hour over 40 hours of work per week, Milo earns  $1\frac{1}{2}$  times his regular pay. How much does Milo earn in a week in which he works 45 hours?
- A. \$337.50  
 B. \$540.00  
 C. \$570.00  
 D. \$607.50  
 E. \$810.00



8. Which of the following matrices is equal to

$$\begin{bmatrix} 5 & 7 \\ -4 & 4 \end{bmatrix} + \begin{bmatrix} -6 & 3 \\ 6 & 8 \end{bmatrix}?$$

F.  $\begin{bmatrix} -1 & 10 \\ 2 & 12 \end{bmatrix}$

G.  $\begin{bmatrix} -1 & 10 \\ 10 & 12 \end{bmatrix}$

H.  $\begin{bmatrix} 11 & 10 \\ 10 & 12 \end{bmatrix}$

J.  $\begin{bmatrix} 12 & -3 \\ 0 & 14 \end{bmatrix}$

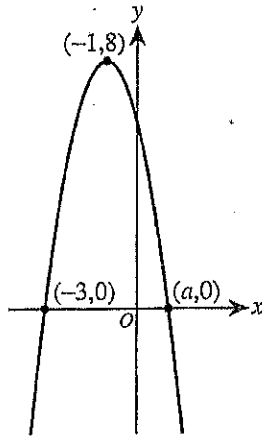
K.  $\begin{bmatrix} 12 & 71 \\ 48 & 20 \end{bmatrix}$

DO YOUR FIGURING HERE.

9. Tomi has 6 pairs of shoes, 4 pairs of pants, and 6 shirts, which can be worn in any combination. He needs to choose a clothes combination to wear to the school dance. How many different combinations consisting of 1 of his 6 pairs of shoes, 1 of his 4 pairs of pants, and 1 of his 6 shirts are possible for Tomi to wear to the dance?

- A. 10  
B. 16  
C. 24  
D. 48  
E. 144

10. In the standard  $(x,y)$  coordinate plane below, the graph of the equation  $y = -2(x+1)^2 + 8$  intersects the  $x$ -axis at points  $(-3,0)$  and  $(a,0)$  and has its vertex at point  $(-1,8)$ . What is the value of  $a$ ?



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

11. What is the least common denominator of the fractions

$$\frac{4}{21}, \frac{1}{24}, \text{ and } \frac{3}{16}?$$

- A. 112  
B. 336  
C. 504  
D. 2,688  
E. 8,064

**2****2**

12. In the standard  $(x,y)$  coordinate plane, what is the slope of the line through  $(-7,3)$  and  $(2,4)$  ?

**DO YOUR FIGURING HERE.**

F.  $-\frac{7}{5}$

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

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

J.  $\frac{1}{9}$

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

13. A group of 60 students and 4 sponsors took a field trip to a local museum. For their first guided tour, students were given a choice of 1 of 3 art exhibits. Of the 60 students,  $\frac{1}{2}$  chose Modern,  $\frac{1}{4}$  chose American Folk, and  $\frac{1}{6}$  chose Western. Each student that expressed a choice chose exactly 1 exhibit. The remaining students expressed no choice. How many of the students expressed no choice?

A. 5

B. 6

C. 10

D. 15

E. 30

14. What is the greatest integer solution to  $6x - 2 \leq 11.2$  ?

F. -2

G. -1

H. 1

J. 2

K. 3

15. Classics Online charges a onetime registration fee of \$17.50 and sells classical music downloads for \$0.70 per song. Ian has \$50.00 that he will use to pay the registration fee and buy classical music from Classics Online. What is the maximum number of songs Ian can buy?

A. 25

B. 32

C. 35

D. 46

E. 53



DO YOUR FIGURING HERE.

16. The lengths of corresponding sides of 2 similar right triangles are in the ratio 2:9. The hypotenuse of the smaller triangle is 8 inches long. How many inches long is the hypotenuse of the larger triangle?

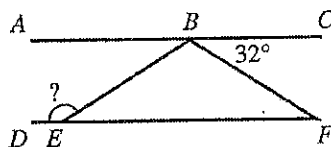
F. 4.5  
G. 11  
H. 15  
J. 18  
K. 36

17. The mean age of the 5 people in a room is 30 years. One of the 5 people, whose age is 50 years, leaves the room. What is the mean age of the 4 people remaining in the room?

A. 14  
B. 20  
C. 25  
D. 30  
E. 35

18. In the figure below,  $B$  lies on  $\overline{AC}$ ,  $E$  lies on  $\overline{DF}$ ,  $\overline{AC} \parallel \overline{DF}$ ,  $\triangle EBF$  is isosceles with  $\overline{BE} \cong \overline{BF}$ , and  $\angle CBF$  measures  $32^\circ$ . What is the measure of  $\angle BED$ ?

F.  $106^\circ$   
G.  $116^\circ$   
H.  $122^\circ$   
J.  $132^\circ$   
K.  $148^\circ$



19. If  $x = -1$  and  $y = 2$ , what is the value of  $x^3 - 2x^2y - 4xy^2 + 8$ ?

A. -13  
B. -5  
C. 19  
D. 23  
E. 27

20. A retailer is comparing the costs of buying 3 products from 1 of 2 companies. The cost of each product from both companies is shown in the table below.

	Company A	Company B
Product 1	\$ 5.00	\$5.50
Product 2	\$10.00	\$9.50
Product 3	\$ 6.00	\$5.75

The retailer will buy 10 of Product 1, 12 of Product 2, and 5 of Product 3. How much more will it cost the retailer to purchase these products from Company A than to purchase these products from Company B?

F. \$ 0.25  
G. \$ 1.25  
H. \$ 2.25  
J. \$ 6.75  
K. \$12.25



21. Line  $l$  is shown in the standard  $(x,y)$  coordinate plane below. Alicia drew line  $p$  with a slope that is  $\frac{1}{2}$  of the slope of line  $l$  and with a  $y$ -intercept that is 3 times the  $y$ -intercept of line  $l$ . One of the following equations represents line  $p$ . Which one?

DO YOUR FIGURING HERE.

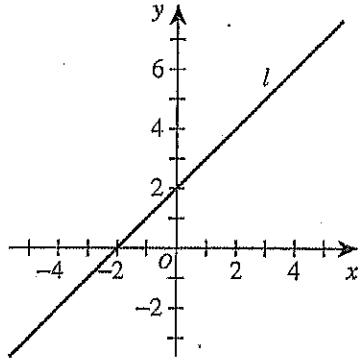
A.  $y = x + 3$

B.  $y = -3x + 1$

C.  $y = 3x + 1$

D.  $y = -\frac{1}{2}x + 6$

E.  $y = \frac{1}{2}x + 6$



22. One angle measure and 2 side lengths, in inches; are given in the right scalene triangle below. In terms of  $a$  and  $b$ , what is  $\sin \theta$ ?

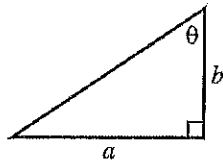
F.  $\frac{a}{b}$

G.  $\frac{b}{a}$

H.  $\frac{a}{\sqrt{a^2 + b^2}}$

J.  $\frac{b}{\sqrt{a^2 + b^2}}$

K.  $\frac{\sqrt{a^2 + b^2}}{b}$



23. Each side of square  $ABCD$  has a length of 50 cm. A certain rectangle whose area is equal to the area of  $ABCD$  has a width of 10 cm. What is the length, in centimeters, of the rectangle?

A. 40

B. 50

C. 60

D. 125

E. 250

24. If  $f(x) = 5x^2 - 6x + 1$  and  $g(x) = x^2 - 2$ , which of the following expressions represents  $(fg)(x)$ ?

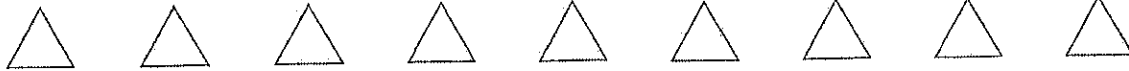
F.  $6x^2 - 6x - 1$

G.  $5x^4 - 26x^2 + 33$

H.  $5x^4 - 20x^2 - 6x + 21$

J.  $5x^4 - 6x^3 - 9x^2 + 12x - 2$

K.  $25x^4 - 60x^3 + 46x^2 - 12x - 1$

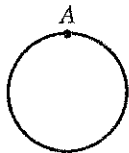


25. A bag contains 12 red marbles, 14 yellow marbles, and 8 green marbles. How many additional red marbles must be added to the 34 marbles already in the bag so that the probability of randomly drawing a red marble is  $\frac{3}{5}$ ?

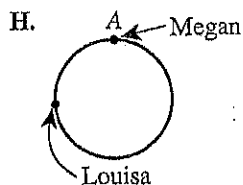
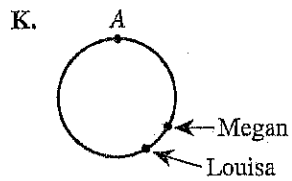
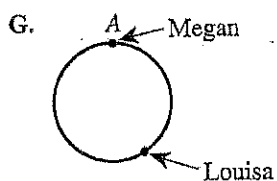
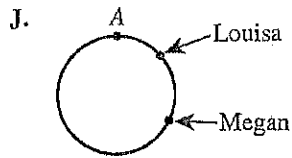
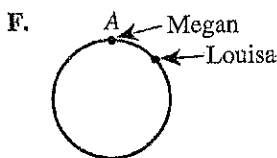
A. 16  
 B. 21  
 C. 29  
 D. 34  
 E. 44

DO YOUR FIGURING HERE.

26. Megan and Louisa are side-by-side (at point A in the figure shown below) when they begin to run at the same time clockwise (C) around a small circular track. Megan runs at a rate of 40 seconds per lap, while Louisa runs at a rate of 70 seconds per lap.



Which of the following figures best represents Megan's and Louisa's locations 120 seconds after they begin to run?



27. The statement  $3x - (x + 6) + 8 = 2x + 14$  is true for:

A.  $x = 0$  only.  
 B.  $x = 4$  only.  
 C.  $x = 7$  only.  
 D. all values of  $x$ .  
 E. no values of  $x$ .



**2****2**

28. The first 7 terms in an arithmetic sequence are listed below. What is the difference between the mean and the median of the 7 terms?

**DO YOUR FIGURING HERE.**

$$\frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}, 3, \frac{7}{2}$$

- F. 0
- G.  $\frac{3}{7}$
- H.  $\frac{1}{2}$
- J. 2
- K. 9
29. What is the product of the complex numbers  $(-2i + 5)$  and  $(2i + 5)$ ?
- A. 3
- B. 21
- C. 29
- D.  $20i - 21$
- E.  $20i + 21$
30. Which of the following expressions represents the sum of  $3.8 \times 10^5$  and  $6.4 \times 10^4$  in scientific notation?
- F.  $1.02 \times 10^{10}$
- G.  $4.44 \times 10^4$
- H.  $4.44 \times 10^5$
- J.  $10.2 \times 10^{20}$
- K.  $44.4 \times 10^4$
31. Lian has  $6\frac{1}{2}$  yards of ribbon she will use to make bows. She will use  $\frac{3}{4}$  yard of ribbon to make each bow. After Lian has made all the bows possible with the ribbon, what length of ribbon, in yards, will NOT have been used to make bows?
- A. 0
- B.  $\frac{1}{2}$
- C.  $\frac{21}{32}$
- D.  $\frac{2}{3}$
- E.  $\frac{7}{8}$



DO YOUR FIGURING HERE.

Use the following information to answer questions 32–34.

Carl purchased a new car. The fuel economy window sticker on the new car contained the information shown below. In this figure, MPG is miles per gallon.

EPA Fuel Economy DOT		You save <b>\$3,500*</b> in fuel costs over 5 years compared to the average new vehicle.	
<b>25</b> MPG combined city/highway	22 city	32 highway	
Annual fuel COST <b>\$2,400*</b>	*Cost estimates are based on the combined city/highway MPG, a certain number of miles per year the car is driven, and an average fuel cost of \$4.00 per gallon.		

32. Carl is planning a trip in his new car that will include 350 miles of highway driving. Using the average fuel cost per gallon given in the fuel economy window sticker, which of the following dollar amounts is closest to his total cost for fuel over the 350 miles of highway driving?
- F. \$43.75  
G. \$51.85  
H. \$56.00  
J. \$63.64  
K. \$87.50
33. The cost estimates are based on a certain number of miles driven per year. To the nearest 1,000 miles, what is this number?
- A. 13,000  
B. 15,000  
C. 16,000  
D. 19,000  
E. 22,000
34. Based on the annual fuel cost estimate for this car and the estimate for how much Carl will save in fuel costs over the next 5 years, what would be the expected annual fuel cost of an average new vehicle?
- F. \$1,180  
G. \$2,950  
H. \$3,100  
J. \$3,500  
K. \$3,980



35. A certain race car has a maximum speed of 240 miles per hour. Which of the following is an expression for this maximum speed in feet per second?

(Note: 1 mile = 5,280 feet)

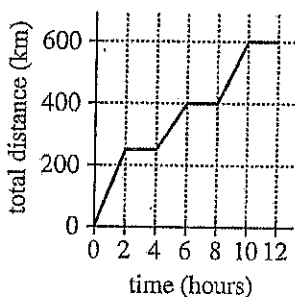
- A.  $\frac{240(5,280)}{36,000}$   
 B.  $\frac{240(3,600)}{5,280}$   
 C.  $\frac{240(5,280)}{3,600}$   
 D.  $\frac{60(5,280)}{240}$   
 E.  $\frac{240(5,280)}{360}$

DO YOUR FIGURING HERE.

36. A chemist needs 1 ounce of element X. The only way which the chemist can get element X is to buy compound Y, which contains 10% X. Compound Y costs \$2.40 per pound (16 ounces). How much must the chemist pay in order to ensure that she receives 1 ounce of element X?

- F. \$ .15  
 G. \$ .24  
 H. \$1.50  
 J. \$2.40  
 K. \$3.84

37. Emi traveled to 3 locations during a workday. Emi remained at each location a whole number of hours. The graph below shows the relationship between time, in hours, into her workday and total distance, in kilometers, traveled. Which of the following values is closest to Emi's average speed, in kilometers per hour, for the parts of the workday when she was traveling?



- A. 60  
 B. 75  
 C. 80  
 D. 100  
 E. 125

38. What are all and only the values of  $x$  that are NOT in the domain of the function  $f(x) = \frac{(x-7)(x+2)}{(x+6)(x-8)}$ ?

- F. -8 and 6  
 G. -6 and 8  
 H. -2 and 7  
 J. -8, -7, 2, and 6  
 K. -6, -2, 7, and 8



DO YOUR FIGURING HERE.

39. A new band asked its audience to rate the band's performance on a scale from 1 (poor) through 5 (excellent). The table below gives the percentage of the audience that gave each of the ratings. To the nearest 0.1, what was the mean rating given by this audience?

Rating	Percentage
1	0%
2	0%
3	10%
4	70%
5	20%

- A. 2.0  
 B. 2.8  
 C. 3.0  
 D. 4.0  
 E. 4.1
40. In  $\triangle DEF$ , the length of  $\overline{DE}$  is  $\sqrt{60}$  cm, and the length of  $\overline{EF}$  is 6 cm. If it can be determined, what is the length, in centimeters, of  $\overline{DF}$ ?
- F. 6  
 G.  $\sqrt{60}$   
 H.  $\sqrt{66}$   
 J.  $\sqrt{96}$   
 K. Cannot be determined from the given information
41. Let  $a$  and  $b$  represent real numbers with the property  $|a - b - 1| > 0$ . Which of the following statements about  $a$  and  $b$  CANNOT be true?
- A.  $a - b < 1$   
 B.  $a - b = 1$   
 C.  $a < 1$  and  $b > 0$   
 D.  $a < 1$  and  $b = 0$   
 E.  $a < 0$  and  $b > 0$
42. Juwan has 150 cm of wire. For a craft project, he uses all the wire to make 1 circle with a radius of 5 cm and 1 square. To the nearest 0.1 cm, what is the side length of the square?
- F. 17.9  
 G. 29.6  
 H. 32.6  
 J. 33.6  
 K. 118.6



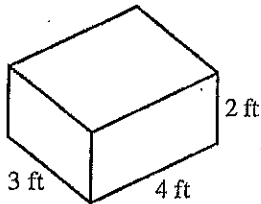
Use the following information to answer questions 43–46.

DO YOUR FIGURING HERE.

A local recycling center pays customers for cans, bottles, and cardboard. After processing these items, the center then resells them to XYZ Inc. The recycling center's payments to customers and the resale prices paid by XYZ Inc. are given in the table below.

Item	Payment	Resale price
Can	\$0.05 each	\$0.15 each
Bottle	\$0.10 each	\$0.18 each
Cardboard	\$0.01 per pound	\$0.02 per pound

43. The closed box with no overlapping pieces whose dimensions are given below is made with cardboard that weighs 1 pound per square foot of the surface area of the box. Which of the following values is closest to the amount the recycling center will pay a customer for this box?



- A. \$0.24  
 B. \$0.36  
 C. \$0.48  
 D. \$0.52  
 E. \$1.04
44. The cost of processing cans and bottles at the recycling center is \$0.03 per can and \$0.02 per bottle. After paying the processing cost and the payment to customers, what is the recycling center's profit on the resale of 200 cans and 300 bottles to XYZ Inc. ?
- F. \$ 32.00  
 G. \$ 40.00  
 H. \$ 48.00  
 J. \$ 84.00  
 K. \$112.00
45. To the nearest 1%, the recycling center's payment to a customer for a bottle is what percent of the resale price of a bottle sold to XYZ Inc. ?
- A. 8%  
 B. 56%  
 C. 80%  
 D. 125%  
 E. 180%
46. In 1 shipment, the recycling center sold a total of 2,700 cans and bottles to XYZ Inc. for \$441.00. How many bottles were in the shipment?
- F. 1,200  
 G. 1,230  
 H. 1,350  
 J. 1,470  
 K. 1,500



47. Given constants  $c$ ,  $d$ ,  $m$ , and  $n$  such that  $x^2 + mx + c$  has factors of  $(x + 2)$  and  $(x + 4)$  and  $x^2 + nx + d$  has factors of  $(x + 3)$  and  $(x + 7)$ , what is  $mn$ ?

A. 16  
 B. 18  
 C. 29  
 D. 60  
 E. 168

DO YOUR FIGURING HERE.

48. For every angle  $\theta$ , measured in radians, which of the following is equal to  $\sin(2\pi + \theta)$ ?

F.  $\sin(-\pi + \theta)$

G.  $\sin(\theta)$

H.  $\sin\left(\frac{\pi}{2} + \theta\right)$

J.  $\sin\left(\frac{2\pi}{3} + \theta\right)$

K.  $\sin(\pi + \theta)$

49. A small circle and a large circle are tangent at  $T$ , as shown in the figure below. The center,  $O$ , of the large circle lies on the small circle. The diameter of the large circle is 12 cm. What is the ratio of the area of the small circle to the area of the large circle?

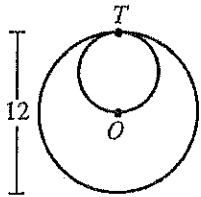
A.  $\frac{1}{4}$

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

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

D.  $\frac{\pi}{4}$

E.  $\frac{\pi}{2}$



50. For all positive values of  $a$  and  $b$ , which of the following expressions is equal to  $\frac{2a}{b} + \frac{b}{2a}$ ?

F.  $\frac{2a+b}{b+2a}$

G.  $\frac{2a+b}{2ab}$

H.  $\frac{4a+b}{2ab}$

J.  $\frac{4a^2+b^2}{2ab}$

K.  $\frac{4a^2+b^2}{2a+b}$



51. The vector  $\mathbf{i}$  represents 1 mile per hour east, and the vector  $\mathbf{j}$  represents 1 mile per hour north. According to her GPS, at a particular instant, Tia is biking  $30^\circ$  west of north at 16 miles per hour. One of the following vectors represents Tia's velocity, in miles per hour, at that instant. Which one?

DO YOUR FIGURING HERE.

- A.  $-8\mathbf{i} - 8\sqrt{3}\mathbf{j}$   
 B.  $-8\mathbf{i} + 8\sqrt{3}\mathbf{j}$   
 C.  $8\mathbf{i} + 8\sqrt{3}\mathbf{j}$   
 D.  $8\sqrt{3}\mathbf{i} - 8\mathbf{j}$   
 E.  $8\sqrt{3}\mathbf{i} + 8\mathbf{j}$
52. Let  $(f \circ g)(x) = \sqrt[3]{x+1} - 2$  and  $g(x) = x + 1$ . Which of the following expressions defines  $(g \circ f)(x)$ ?
- F.  $\sqrt[3]{x-1}$   
 G.  $\sqrt[3]{x} - 1$   
 H.  $\sqrt[3]{x} - 2$   
 J.  $(x+2)^3 - 1$   
 K.  $(x-1)^3 + 2$
53. Consider sets  $A$ ,  $B$ ,  $C$ , and  $D$  such that  $B$  is a subset of  $A$ ,  $C$  is a subset of  $B$ , and  $D$  is a subset of  $C$ . Whenever  $x$  is an element of  $B$ ,  $x$  *must* be an element of:
- A.  $A$ .  
 B.  $D$ .  
 C.  $A$  and  $C$ .  
 D.  $C$  and  $D$ .  
 E.  $A$ ,  $C$ , and  $D$ .
54. For all positive values of  $x$ , which of the following expressions is equivalent to  $\sqrt[9]{x^4}(\sqrt[3]{x^4})$ ?
- F.  $x^{\frac{8}{9}}$   
 G.  $x$   
 H.  $x^{\frac{9}{8}}$   
 J.  $x^2$   
 K.  $x^{\frac{9}{4}}$



DO YOUR FIGURING HERE.

55. A company sells ice cream in 2-quart containers for \$3.00 per container. The company also sells ice cream in 1.5-quart containers for \$2.50 per container. What is the ratio of the price per quart for the 2-quart container to the price per quart for the 1.5-quart container?

- A.  $\frac{9}{10}$   
B.  $\frac{10}{9}$   
C.  $\frac{3}{2}$   
D.  $\frac{5}{3}$   
E.  $\frac{5}{2}$

56. Each of 100 distinct playing cards is 1 of 5 solid colors and is numbered with 1 integer. There are 20 each of blue, red, yellow, green, and orange cards numbered 1–20. One of the 100 cards will be selected at random. What is the probability that the selected card will be blue OR numbered 17?

- F.  $\frac{5}{100}$   
G.  $\frac{17}{100}$   
H.  $\frac{20}{100}$   
J.  $\frac{24}{100}$   
K.  $\frac{25}{100}$

57. The changes in a city's population from one decade to the next decade for 3 consecutive decades were a 20% increase, a 30% increase, and a 20% decrease. About what percent was the increase in the city's population over the 3 decades?

- A. 10%  
B. 20%  
C. 25%  
D. 30%  
E. 70%

58. Four golfers will be randomly split into 2 groups of 2 for a tournament. If Jill and Ramona are among the 4, what is the probability that they will be paired together?

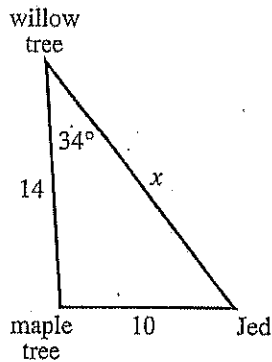
- F.  $\frac{1}{12}$   
G.  $\frac{1}{8}$   
H.  $\frac{1}{6}$   
J.  $\frac{1}{4}$   
K.  $\frac{1}{3}$





59. Jed is standing 10 meters from a maple tree that is 14 meters from a willow tree, as shown in the figure below, in which the measure of an angle is given. Which of the following equations, when solved for  $x$ , gives the distance,  $x$  meters, between Jed and the willow tree?

(Note: For a triangle with sides of length  $a$ ,  $b$ , and  $c$  that are opposite angles  $\angle A$ ,  $\angle B$ , and  $\angle C$ , respectively,  $c^2 = a^2 + b^2 - 2ab \cos \angle C$ .)



DO YOUR FIGURING HERE.

- A.  $10^2 = x^2 + 14^2 - 2x(14)(\cos 34^\circ)$   
 B.  $10^2 = x^2 + 14^2 - 2(10)(14)(\cos 34^\circ)$   
 C.  $14^2 = x^2 + 10^2 - 2x(14)(\cos 34^\circ)$   
 D.  $x^2 = 10^2 + 14^2 - 2x(14)(\cos 34^\circ)$   
 E.  $x^2 = 10^2 + 14^2 - 2(10)(14)(\cos 34^\circ)$
60. Suppose the equations  $(x - 4)^2 + (y - 3)^2 = 4$  and  $\frac{(x - 4)^2}{4} + \frac{(y - 10)^2}{16} = 1$  are graphed in the same standard  $(x, y)$  coordinate plane. How many points of intersection do these graphs share?

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

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

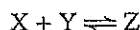
**DIRECTIONS:** There are several passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

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

## Passage I

A reaction is at *equilibrium* when the rate of the forward reaction equals the rate of the reverse reaction. At equilibrium, the ratio of product concentration(s) to reactant concentration(s) is the *equilibrium constant*,  $K$ .

Consider the following reaction at equilibrium:



For this reaction,  $K$  is given by:

$$K = \frac{[Z]}{[X][Y]}$$

The brackets ([ ]) around the symbol for a substance indicate the equilibrium concentration of the substance.

This reaction was studied in 10 trials. Trials 1–5 were conducted at the same temperature (see Table 1), and Trials 6–10 were conducted at different temperatures (see Table 2).

Trial	[X] (mol/L*)	[Y] (mol/L)	[Z] (mol/L)	K
1	1.00	1.50	0.15	0.10
2	1.00	2.00	0.20	0.10
3	2.00	1.00	0.20	0.10
4	2.00	1.50	0.30	0.10
5	2.00	2.50	0.50	0.10

\*moles per liter

Note: The *initial* concentration of X, of Y, and of Z was varied across Trials 1–5. In no trial was the initial concentration of one substance equal to that of either of the other two substances.

Trial	Temperature (°C)	[X] (mol/L*)	[Y] (mol/L)	[Z] (mol/L)	K
6	-15	0.15	0.65	1.00	10.5
7	0	0.68	1.18	0.47	0.59
8	10	1.00	1.50	0.15	0.10
9	25	1.13	1.63	0.016	0.0087
10	40	1.15	1.65	0.002	0.0011

\*moles per liter

Note: The *initial* concentration of X, of Y, and of Z was the same in each of Trials 6–10. In no trial was the initial concentration of one substance equal to that of either of the other two substances.

- According to Table 1, in Trial 5, what was the equilibrium concentration of Z?
  - 0.10 mol/L
  - 0.50 mol/L
  - 2.00 mol/L
  - 2.50 mol/L
- Suppose that Trial 7 had been conducted at  $-5^{\circ}\text{C}$ . Based on Table 2,  $K$  would most likely have been closest to which of the following?
  - 0.020
  - 0.20
  - 2.0
  - 20

4



4

3. Suppose an additional trial had been conducted at the same temperature at which Trials 1–5 were conducted. If  $[X]$  and  $[Y]$  had each been  $2.00 \text{ mol/L}$ ,  $[Z]$  would most likely have been:
- A.  $0.15 \text{ mol/L}$ .
  - B.  $0.20 \text{ mol/L}$ .
  - C.  $0.40 \text{ mol/L}$ .
  - D.  $0.60 \text{ mol/L}$ .
4. Based on Tables 1 and 2, how many trials were most likely conducted at temperatures above the freezing point of water?
- E. 3
  - G. 5
  - H. 8
  - J. 10
5. Consider the temperature data in Table 2. Did the reaction more likely reach equilibrium faster in Trial 6 or Trial 10?
- A. Trial 6, because the rate of a reaction is generally greater at a lower temperature.
  - B. Trial 6, because the rate of a reaction is generally greater at a higher temperature.
  - C. Trial 10, because the rate of a reaction is generally greater at a lower temperature.
  - D. Trial 10, because the rate of a reaction is generally greater at a higher temperature.
6. Assume that substances X, Y, and Z were gases throughout each trial. The boiling points of X, Y, and Z must each be:
- F. below  $-15^\circ\text{C}$ .
  - G. between  $-15^\circ\text{C}$  and  $10^\circ\text{C}$ .
  - H. between  $10^\circ\text{C}$  and  $40^\circ\text{C}$ .
  - J. above  $40^\circ\text{C}$ .



### Passage II

Juvenile *Callinectes sapidus* (a species of crab) typically hide among *Zostera marina* (a species of sea grass) to avoid detection by aquatic predators. Two experiments examined how *Z. marina* population density and *C. sapidus* body size affect the ability of juvenile *C. sapidus* to avoid predation in a particular coastal area.

#### Experiment 1

Each of 200 small (4.5 mm wide) juvenile *C. sapidus* was prepared for testing as follows: One end of a 1.0 m piece of nylon fishing line was tied around the middle of the *C. sapidus*, and the knot was then securely attached to the *C. sapidus* with *cyanoacrylate* (a strong waterproof glue). The other end of the line was tied to its own metal rod. After being prepared, the 200 *C. sapidus* were equally divided into 4 groups (Groups 1–4).

Each rod associated with a Group 1 *C. sapidus* was randomly placed within a 100 m<sup>2</sup> plot having a *Z. marina* population density of 0 shoots/m<sup>2</sup> (sand only, no plants). Twenty-four hours later, the number of surviving Group 1 *C. sapidus* was determined.

The procedure for Group 1 was repeated for Groups 2–4, except that Group 2, Group 3, and Group 4 were placed in plots having a *Z. marina* population density of 380 shoots/m<sup>2</sup>, 760 shoots/m<sup>2</sup>, and 1,600 shoots/m<sup>2</sup>, respectively.

The results are shown in Table 1.

Group	<i>Z. marina</i> population density (shoots/m <sup>2</sup> )	Number of surviving <i>C. sapidus</i>
1	0	26
2	380	31
3	760	24
4	1,600	12

#### Experiment 2

Each of 200 large (23.3 mm wide) juvenile *C. sapidus* was prepared as in Experiment 1. After being prepared, the *C. sapidus* were equally divided into 4 groups (Groups 5–8). The procedures for Groups 1–4 were repeated for Groups 5–8 (see Table 2).

Group	<i>Z. marina</i> population density (shoots/m <sup>2</sup> )	Number of surviving <i>C. sapidus</i>
5	0	0
6	380	5
7	760	19
8	1,600	37

Tables adapted from J. L. Schulman, "Habitat Complexity as a Determinant of Juvenile Blue Crab Survival." ©1986 by The College of William and Mary.

7. According to the results of Experiment 2, as the *Z. marina* population density increased from 0 shoots/m<sup>2</sup> through 1,600 shoots/m<sup>2</sup>, the number of surviving large juvenile *C. sapidus*:
- increased only.
  - decreased only.
  - increased, then decreased.
  - decreased, then increased.



8. Suppose that in Experiment 2 a group of *C. sapidus* had been placed in a *Z. marina* plot having a population density of 562 shoots/m<sup>2</sup>. The number of surviving *C. sapidus* in that group would most likely have been:
- F. less than 5.
  - G. between 5 and 19.
  - H. between 19 and 37.
  - J. greater than 37.
9. To consider whether the body size of juvenile *C. sapidus* affects their ability to avoid predation, the results for which of the following 2 groups should be compared?
- A. Groups 1 and 4
  - B. Groups 2 and 5
  - C. Groups 4 and 8
  - D. Groups 5 and 7
10. Which of the nylon line and the cyanoacrylate, if either, functioned to prevent the *C. sapidus* from escaping?
- F. The nylon line only
  - G. The cyanoacrylate only
  - H. Both the nylon line and the cyanoacrylate
  - J. Neither the nylon line nor the cyanoacrylate
11. Which of *C. sapidus* or *Z. marina* would occupy the higher trophic level in a food chain?
- A. *C. sapidus*, because *C. sapidus* is a producer and *Z. marina* is a consumer.
  - B. *C. sapidus*, because *C. sapidus* is a consumer and *Z. marina* is a producer.
  - C. *Z. marina*, because *Z. marina* is a producer and *C. sapidus* is a consumer.
  - D. *Z. marina*, because *Z. marina* is a consumer and *C. sapidus* is a producer.
12. Which of the following statements describes a difference between the cells of *C. sapidus* and the cells of *Z. marina*? The cells of *C. sapidus*:
- F. have a nucleus, whereas the cells of *Z. marina* lack a nucleus.
  - G. lack a nucleus, whereas the cells of *Z. marina* have a nucleus.
  - H. have a cell wall, whereas the cells of *Z. marina* lack a cell wall.
  - J. lack a cell wall, whereas the cells of *Z. marina* have a cell wall.
13. Which of the following statements comparing an aspect of the design of the 2 experiments is accurate?
- A. The *C. sapidus* in Experiment 2 were exactly 3 times as wide as the *C. sapidus* in Experiment 1.
  - B. The length of time needed to perform Experiment 1 was less than the length of time needed to perform Experiment 2.
  - C. The number of surviving *Z. marina* was measured in both Experiments 1 and 2.
  - D. In both experiments, there were initially 50 *C. sapidus* per group.



### Passage III

Two students were each asked to experimentally determine the speed of sound in air,  $s_a$ . For the atmospheric conditions in which their experiments were performed, the correct value of  $s_a$  was 347.1 m/sec.

#### Experiment 1

Student 1 placed a horn, which could emit a short pulse of sound waves, at a distance  $x$ , in m, from a tall cliff (see Figure 1):

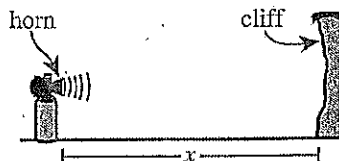


Figure 1

He started a stopwatch when he heard the horn emit a sound pulse and stopped the stopwatch when he heard an echo return from the cliff. He recorded this time interval,  $\Delta t_1$ , in sec, and then calculated  $s_a$  using the equation

$$s_a = \frac{2x}{\Delta t_1}$$

Student 1 performed 3 trials at each of 3 values of  $x$ , averaging the  $s_a$  results at each value of  $x$  (see Table 1).

Trial	$x$ (m)	$\Delta t_1$ (sec)	$s_a$ (m/sec)	Average $s_a$ (m/sec)
1	200	1.4	290	280
2		1.5	270	
3		1.4	290	
4	500	3.0	330	330
5		3.1	320	
6		3.0	330	
7	1,000	5.9	340	340
8		5.8	350	
9		5.9	340	

#### Experiment 2

Student 2 placed the horn and 2 microphones— $M_1$  and  $M_2$ —in a straight line such that the microphones were separated by a distance  $y$ . She then connected a timer to both microphones (see Figure 2).

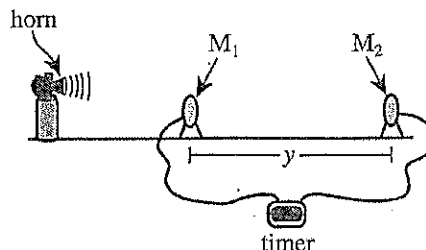


Figure 2

She set the timer to start when the first microphone detected a sound pulse and to stop when the second microphone detected a sound pulse. She recorded this time interval,  $\Delta t_2$ , and then calculated  $s_a$  using the equation

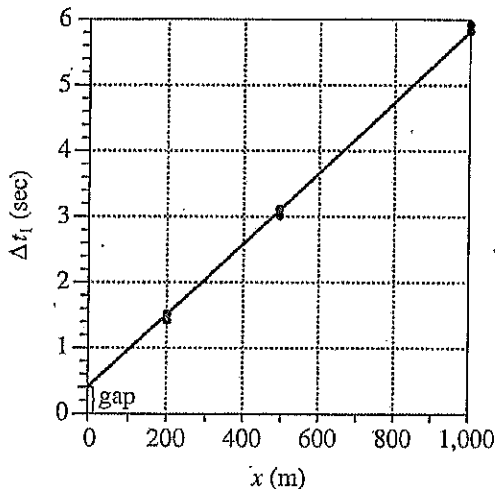
$$s_a = \frac{y}{\Delta t_2}$$

Student 2 performed 3 trials at each of 3 values of  $y$ , averaging the  $s_a$  results at each value of  $y$  (see Table 2).

Trial	$y$ (m)	$\Delta t_2$ (sec)	$s_a$ (m/sec)	Average $s_a$ (m/sec)
10	50	0.144	347	347
11		0.143	350	
12		0.145	345	
13	75	0.217	346	346
14		0.216	347	
15		0.218	344	
16	100	0.290	345	346
17		0.289	346	
18		0.288	347	



14. Suppose Student 2 had conducted a trial in which  $\Delta t_2$  was 0.191 sec. The value of  $y$  in this trial would most likely have been:
- less than 50 m.
  - between 50 m and 75 m.
  - between 75 m and 100 m.
  - greater than 100 m.
15. Which of the objects listed below were used in both Experiment 1 and Experiment 2?
- A horn
  - A microphone
  - A timing device
- I only
  - I and II only
  - I and III only
  - I, II, and III
16. Student 1 plotted the  $\Delta t_1$  data versus  $x$  and then graphed a line of best fit to the data, as shown below.



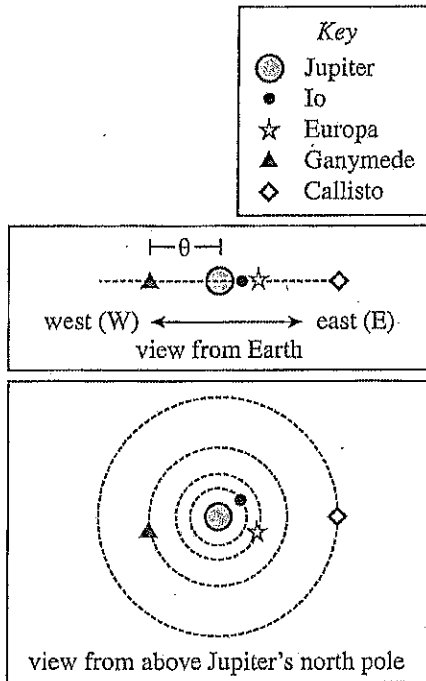
The gap shown near the bottom of the vertical axis suggests that even if the value of  $x$  had been 0 m, the value of  $\Delta t_1$  would not have been 0 sec, as one might expect. Based on the description of Experiment 1, this gap was most likely the result of:

- errors due to human reaction time in starting and/or stopping the stopwatch.
  - the stopwatch itself consistently underestimating the value of  $\Delta t_1$ .
  - the echoes traveling faster than the original sound pulses.
  - the horn being accidentally placed closer to the cliff than intended.
17. In general, the farther a sound wave travels, the more it *attenuates* (reduces in volume), making detection more difficult. In which experiment was attenuation of greater concern?
- Experiment 1; sound waves had to travel shorter distances in Experiment 1 than in Experiment 2.
  - Experiment 1; sound waves had to travel longer distances in Experiment 1 than in Experiment 2.
  - Experiment 2; sound waves had to travel shorter distances in Experiment 2 than in Experiment 1.
  - Experiment 2; sound waves had to travel longer distances in Experiment 2 than in Experiment 1.
18. Based on the results of both experiments, regardless of the apparatus or procedure used, on average, as a sound pulse's travel distance increased, the recorded time interval:
- increased only.
  - decreased only.
  - remained constant.
  - varied, but with no general trend.
19. In calculating the value of  $s_a$ , Student 1 needed to include a factor of 2 in the numerator. However, Student 2 did not include this factor because:
- in Experiment 1, sound had to travel over the distance  $x$  twice, whereas in Experiment 2, sound had to travel over the distance  $y$  once.
  - in Experiment 1, sound had to travel over the distance  $x$  once, whereas in Experiment 2, sound had to travel over the distance  $y$  twice.
  - every value of  $x$  was at least 2 times every value of  $y$ .
  - every value of  $x$  was less than 2 times every value of  $y$ .
20. Overall, which student obtained the more *accurate* set of  $s_a$  data?
- (Note: This question is concerned with the *accuracy* of a data set, NOT the *precision* of a data set.)
- Student 1, because the  $s_a$  values in Table 1 are spread over a larger range than are the  $s_a$  values in Table 2.
  - Student 1, because the  $s_a$  values in Table 1 are closer, on average, to the correct value of  $s_a$  than are the values of  $s_a$  in Table 2.
  - Student 2, because the  $s_a$  values in Table 2 are spread over a smaller range than are the  $s_a$  values in Table 1.
  - Student 2, because the  $s_a$  values in Table 2 are closer, on average, to the correct value of  $s_a$  than are the values of  $s_a$  in Table 1.



## Passage IV

As viewed from Earth, Jupiter's 4 largest moons—the *Galilean* moons—appear to move relative to Jupiter along an east-west line. The farther from Jupiter a moon appears to be, the greater its *angular separation*,  $\theta$ . Figure 1 shows these moons' positions at midnight on a certain day in June 2012 as viewed from Earth (top section) and as viewed from above Jupiter's north pole (bottom section).



Note: The figure is not drawn to scale. In the top section, only  $\theta$  for Ganymede is shown.

Figure 1

Figure 2 shows  $\theta$  for each moon from midnight on June 20, 2012, to midnight on June 28, 2012. For each moon, 1 *wave cycle* represents 1 orbit around Jupiter. (The time to complete 1 orbit is the time between any 2 consecutive peaks or any 2 consecutive troughs.)

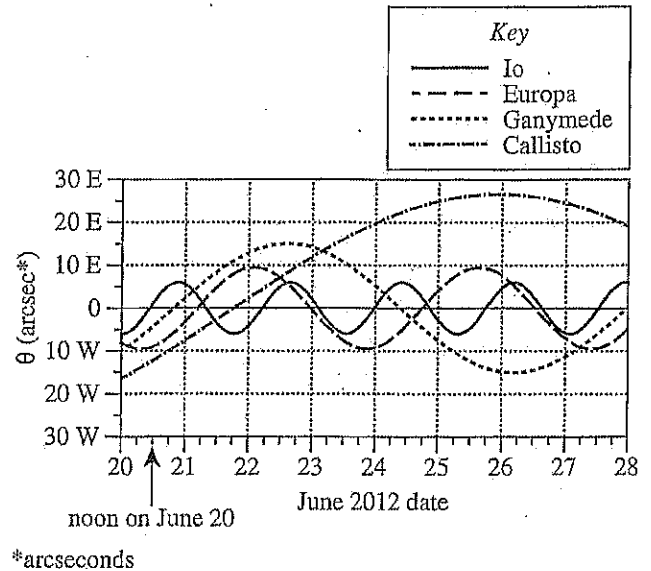


Figure 2

Figure 2 adapted from Sylvain Rondi, *Jupiter Version 2: Programme gratuit de calcul d'éphémérides des satellites galiléens de Jupiter*. ©2009 by Sylvain Rondi.

21. The number of orbits per week is a measure of *orbital frequency*. Based on Figure 2, which Galilean moon has the highest orbital frequency?
- A. Io  
B. Europa  
C. Ganymede  
D. Callisto
22. Based on Figure 2, Callisto completes 1 orbit around Jupiter in approximately how many days?
- F. Fewer than 4  
G. Between 4 and 6  
H. Between 6 and 8  
J. More than 8



4



4

23. Based on Figure 2, as viewed from Earth at midnight on June 27, which Galilean moon appeared farthest west of Jupiter?
- A. Io
  - B. Europa
  - C. Ganymede
  - D. Callisto
24. According to Figure 2, at *noon* on June 23,  $\theta$  for Ganymede was approximately:
- F. 10 arcsec east.
  - G. 10 arcsec west.
  - H. 14 arcsec east.
  - J. 14 arcsec west.
25. According to Figure 2, at which of the following times in 2012 was the angular separation for Callisto closest to 20 arcsec east?
- A. 6:00 a.m. on June 26
  - B. 6:00 a.m. on June 27
  - C. 6:00 p.m. on June 26
  - D. 6:00 p.m. on June 27
26. *Thebe* is one of Jupiter's smaller moons. *Thebe* completes 1 orbit of Jupiter in approximately 0.7 days. Based on Figure 2, regardless of direction, the maximum value of  $\theta$  for *Thebe* is most likely:
- F. less than 7 arcsec.
  - G. between 7 arcsec and 10 arcsec.
  - H. between 10 arcsec and 13 arcsec.
  - J. greater than 13 arcsec.



### Passage V

Two scientists discussed the evolution of 3 animal groups: crocodiles, *nonavian dinosaurs* (all dinosaurs except modern birds), and modern birds. The scientists characterized the animals in each group by their *resting metabolic rate*, RMR (the rate at which an animal uses caloric energy when at rest), and according to whether they were *poikilothermic* (had body temperatures that varied significantly) or *homeothermic* (had body temperatures that remained relatively constant).

#### Scientist 1

Crocodiles and nonavian dinosaurs evolved from a common ancestor that had a low RMR and was poikilothermic. Crocodiles retained these traits. However, nonavian dinosaurs had a high RMR and were homeothermic. Modern birds inherited these traits when the group first evolved from nonavian dinosaurs, and both traits have been retained by all modern birds.

The bones of nonavian dinosaurs had a porous structure, no growth rings, and extensive *vascularization* (channels containing blood vessels). Extensive vascularization, which is also seen in modern birds, is evidence of an efficient circulatory system and a high RMR. Efficient circulation distributes heat evenly throughout the body. Thus, nonavian dinosaurs were homeothermic and could have survived in cold climates.

#### Scientist 2

Crocodiles and nonavian dinosaurs evolved from a common ancestor that had a low RMR and was poikilothermic. Crocodiles retained these traits. Nonavian dinosaurs also had a low RMR and were poikilothermic. In contrast, modern birds have had a high RMR ever since the group first evolved from nonavian dinosaurs. Modern birds only became homeothermic after nonavian dinosaurs went extinct 65 million years ago.

The bones of nonavian dinosaurs were dense and had growth rings. Each of these features indicates a low RMR, and neither is seen in the bones of modern birds. Nonavian dinosaur bones also lacked extensive vascularization, suggesting an inefficient circulatory system that would not have been able to distribute heat evenly throughout the body. Thus, nonavian dinosaurs were poikilothermic and could not have survived in cold climates.

27. Both scientists would be likely to agree that modern birds:
- evolved from crocodiles.
  - evolved from nonavian dinosaurs.
  - have always had a low RMR.
  - have always had bones with growth rings.
28. Would Scientist 2 more likely expect to find bones that have growth rings in a crocodile or in a modern bird?
- Crocodile; Scientist 2 suggested that growth rings indicate a high RMR.
  - Crocodile; Scientist 2 suggested that growth rings indicate a low RMR.
  - Modern bird; Scientist 2 suggested that growth rings indicate a high RMR.
  - Modern bird; Scientist 2 suggested that growth rings indicate a low RMR.
29. In which of the 3 animal groups would Scientist 1 most likely expect to find animals having bones with extensive vascularization?
- Crocodiles only
  - Nonavian dinosaurs only
  - Crocodiles and modern birds only
  - Nonavian dinosaurs and modern birds only
30. Consider a crocodile and a modern bird, each having the same body mass. Based on Scientist 2's discussion, which animal would more likely produce CO<sub>2</sub> at a faster rate: the crocodile or the modern bird?
- Crocodile; Scientist 2 argues that modern birds have a high RMR and that crocodiles have a low RMR.
  - Crocodile; Scientist 2 argues that modern birds have a low RMR and that crocodiles have a high RMR.
  - Modern bird; Scientist 2 argues that modern birds have a high RMR and that crocodiles have a low RMR.
  - Modern bird; Scientist 2 argues that modern birds have a low RMR and that crocodiles have a high RMR.

**4****4**

31. Consider a rock formation containing many bones and nesting sites from nonavian dinosaurs as well as indicators of a stable but cold climate. Suppose it were discovered that both the nonavian dinosaur fossils and climate indicators have been present together throughout the entire 50-million-year history of the formation. This discovery would support the viewpoint(s) of which of the scientists, if either?
- A. Scientist 1 only
  - B. Scientist 2 only
  - C. Both Scientist 1 and Scientist 2
  - D. Neither Scientist 1 nor Scientist 2
32. Scientist 1 characterized the animals in which of the 3 groups as poikilothermic?
- F. Crocodiles only
  - G. Modern birds only
  - H. Crocodiles and nonavian dinosaurs
  - J. Modern birds and nonavian dinosaurs
33. Suppose it were confirmed that the common ancestor of nonavian dinosaurs and crocodiles had a low RMR. This finding would be consistent with the viewpoint(s) of which of the scientists, if either?
- A. Scientist 1 only
  - B. Scientist 2 only
  - C. Both Scientist 1 and Scientist 2
  - D. Neither Scientist 1 nor Scientist 2

## Passage VI

*Biosorption* is a process that uses certain biological materials (*biomass*) to remove metal ions from a solution. Three experiments were done to study the removal of the chromium ion  $\text{Cr}^{6+}$  from aqueous solutions using a biomass composed of crushed shells of the fruit *Litchi chinensis*. In each trial in each experiment, the following steps were performed:

1. In a flask, 1.0 g of fresh biomass was added to 100 mL of an aqueous solution having a particular pH and  $\text{Cr}^{6+}$  concentration.
2. The flask was capped, and the contents were shaken for a particular time at a particular temperature.
3. Periodically, shaking was stopped so that a 0.01 mL sample could be removed from the flask. This sample was analyzed to determine the percentage of  $\text{Cr}^{6+}$  remaining in the solution.

*Experiment 1*

In each of Trials 1–4, an aqueous solution with an initial  $\text{Cr}^{6+}$  concentration of 100 mg/L was tested at a temperature of 30°C. The pH was varied from trial to trial. The results are shown in Figure 1.

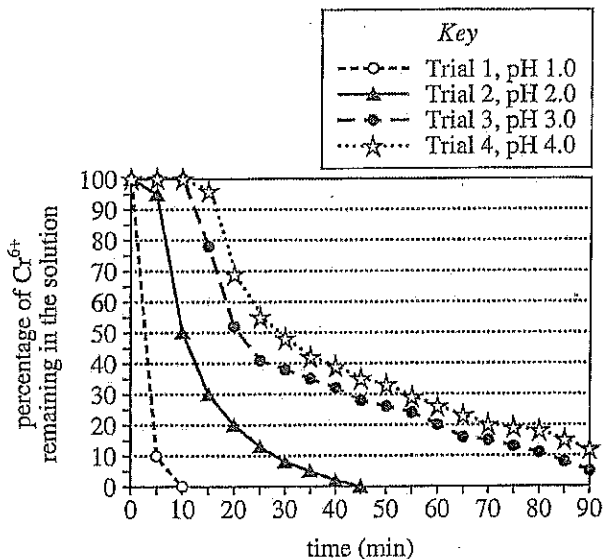


Figure 1

*Experiment 2*

In each of Trials 5–7, an aqueous solution with an initial  $\text{Cr}^{6+}$  concentration of 100 mg/L was tested at a pH of 1.0. The temperature was varied from trial to trial. The results are shown in Figure 2.

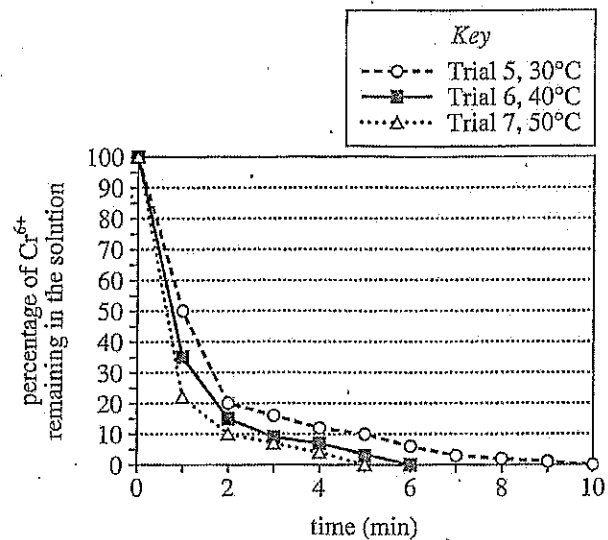


Figure 2

*Experiment 3*

In each of Trials 8–11, an aqueous solution at a pH of 1.0 was tested at a temperature of 30°C. The initial  $\text{Cr}^{6+}$  concentration was varied from trial to trial. The results are shown in Figure 3.

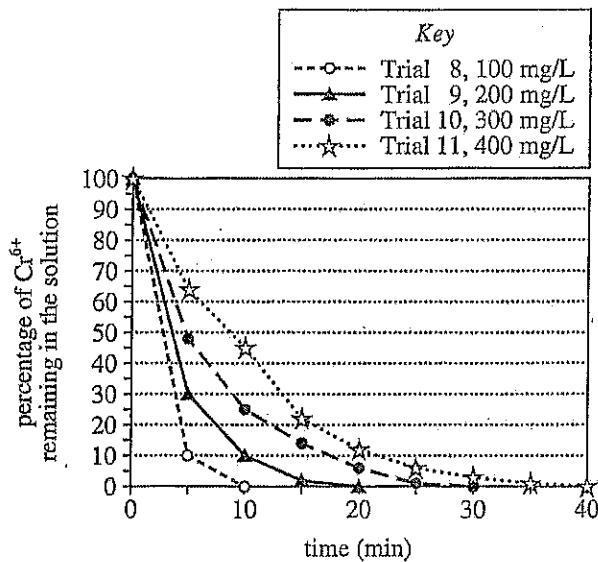


Figure 3

Figures adapted from Ismael Acosta-Rodríguez et al., "Removal of Hexavalent Chromium from Solutions and Contaminated Sites by Different Natural Biomasses." ©2013 by Ismael Acosta-Rodríguez et al.

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34. According to the results of Experiment 2, as the temperature was increased from 30°C to 50°C from trial to trial, the time needed to remove all the  $\text{Cr}^{6+}$  from the solution:
- decreased only.
  - increased only.
  - decreased and then increased.
  - increased and then decreased.
35. Based on Figure 1, if a sample from Trial 3 had been analyzed at 95 min, the percentage of  $\text{Cr}^{6+}$  remaining in the solution would most likely have been:
- less than 5%.
  - between 5% and 10%.
  - between 10% and 15%.
  - greater than 15%.
36. According to the results of Experiment 1, as the pH was increased from trial to trial, the time needed to remove 90% of the  $\text{Cr}^{6+}$  from the solution:
- increased only.
  - decreased only.
  - increased and then decreased.
  - decreased and then increased.
37. In how many trials in Experiments 1–3 did the percentage of  $\text{Cr}^{6+}$  remaining in solution reach 0% in less than 1 hr?
- 0
  - 2
  - 9
  - 11
38. Biosorption using *L. chinensis* involves the one-time transfer of 3 electrons from the biomass to each chromium ion. Based on information in the passage, the resulting charge on each chromium ion after it gains 3 electrons is:
- 3+, because electrons have negative charge.
  - 3+, because electrons have positive charge.
  - 9+, because electrons have negative charge.
  - 9+, because electrons have positive charge.
39. How many of the trials performed in Experiment 1 were done at an acidic pH?
- Zero, because any pH less than 7.0 is basic.
  - Zero, because any pH less than 7.0 is acidic.
  - Four, because any pH less than 7.0 is basic.
  - Four, because any pH less than 7.0 is acidic.
40. Based on Figure 3, which of the following expressions best approximates the mass of  $\text{Cr}^{6+}$  remaining in the 200 mg/L solution at 5 min?
- $100 \text{ mL} \times \frac{1,000 \text{ mL}}{1 \text{ L}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 5\%$
  - $100 \text{ mL} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 5\%$
  - $100 \text{ mL} \times \frac{1,000 \text{ mL}}{1 \text{ L}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 30\%$
  - $100 \text{ mL} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 30\%$

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.

**Test 2: Mathematics—Scoring Key**

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

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

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

**\*Reporting Categories**

PHM = Preparing for Higher Math

N = Number & Quantity

A = Algebra

F = Functions

G = Geometry

S = Statistics & Probability

IES = Integrating Essential Skills

MDL = Modeling

Number Correct (Raw Score) for:	
Preparing for Higher Math (PHM) (N + A + F + G + S)	_____ (35)
Integrating Essential Skills (IES)	_____ (25)
Total Number Correct for Mathematics Test (PHM + IES)	_____ (60)
Modeling (MDL) (Not included in total number correct for mathematics test raw score)	_____ (21)

**Test 3: Reading—Scoring Key**

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

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

**\*Reporting Categories**  
**KID** = Key Ideas & Details  
**CS** = Craft & Structure  
**IKI** = Integration of Knowledge & Ideas

Number Correct (Raw Score) for:	
Key Ideas & Details (KID)	_____ (23)
Craft & Structure (CS)	_____ (12)
Integration of Knowledge & Ideas (IKI)	_____ (5)
Total Number Correct for Reading Test (KID + CS + IKI)	_____ (40)

**Test 4: Science—Scoring Key**

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

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

**\*Reporting Categories**  
**IOD** = Interpretation of Data  
**SIN** = Scientific Investigation  
**EMI** = Evaluation of Models, Inferences & Experimental Results

Number Correct (Raw Score) for:	
Interpretation of Data (IOD)	_____ (18)
Scientific Investigation (SIN)	_____ (12)
Evaluation of Models, Inferences & Experimental Results (EMI)	_____ (10)
Total Number Correct for Science Test (IOD + SIN + EMI)	_____ (40)

## 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 B05	Your Scale Score
English	_____
Mathematics	_____
Reading	_____
Science	_____
<b>Sum of scores</b> _____	
<b>Composite score (sum ÷ 4)</b> _____	

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	73-75	59-60	40	39-40	36
35	69-72	56-58	39	38	35
34	67-68	55	38	37	34
33	66	53-54	37	36	33
32	65	52	36	—	32
31	64	50-51	35	35	31
30	63	48-49	34	34	30
29	62	46-47	—	33	29
28	61	43-45	33	32	28
27	60	41-42	32	31	27
26	58-59	38-40	31	30	26
25	56-57	36-37	30	28-29	25
24	53-55	34-35	28-29	26-27	24
23	50-52	33	27	24-25	23
22	47-49	31-32	26	23	22
21	44-46	30	24-25	21-22	21
20	41-43	28-29	23	20	20
19	39-40	27	21-22	18-19	19
18	37-38	24-26	20	16-17	18
17	35-36	22-23	18-19	14-15	17
16	33-34	18-21	17	13	16
15	29-32	15-17	15-16	12	15
14	27-28	11-14	14	11	14
13	25-26	9-10	12-13	10	13
12	23-24	7-8	10-11	9	12
11	19-22	6	9	8	11
10	16-18	5	8	7	10
9	14-15	4	7	6	9
8	11-13	3	6	5	8
7	9-10	—	5	4	7
6	8	2	4	3	6
5	6-7	—	3	2	5
4	4-5	1	—	—	4
3	3	—	2	1	3
2	2	—	1	—	2
1	0-1	0	0	0	1