

Mathematics Level 2

Sample Questions

All questions in the Mathematics Level 2 Test are multiple-choice questions in which you must choose the BEST response from the five choices offered. The directions that follow are the same as those that are in the Mathematics Level 2 test.

For each of the following problems, decide which is the BEST of the choices given. If the exact numerical value is not one of the choices, select the choice that best approximates this value. Then fill in the corresponding circle on the answer sheet.

Notes: (1) A scientific or graphing calculator will be necessary for answering some (but not all) of the questions in this test. For each question you will have to decide whether or not you should use a calculator.

(2) For some questions in this test you may have to decide whether your calculator should be in the radian mode or the degree mode.

(3) Figures that accompany problems in this test are intended to provide information useful in solving the problems. They are drawn as accurately as possible EXCEPT when it is stated in a specific problem that its figure is not drawn to scale. All figures lie in a plane unless otherwise indicated.

(4) Unless otherwise specified, the domain of any function f is assumed to be the set of all real numbers x for which $f(x)$ is a real number. The range of f is assumed to be the set of all real numbers $f(x)$, where x is in the domain of f .

(5) Reference information that may be useful in answering the questions in this test can be found on the page preceding Question 1.

Reference Information: The following information is for your reference in answering some of the questions in this test.

Volume of a right circular cone with radius r and height h : $V = \frac{1}{3}\pi r^2 h$

Lateral Area of a right circular cone with circumference of the base c and slant height ℓ : $S = \frac{1}{2}c\ell$

Volume of a sphere with radius r : $V = \frac{4}{3}\pi r^3$

Surface Area of a sphere with radius r : $S = 4\pi r^2$

Volume of a pyramid with base area B and height h : $V = \frac{1}{3}Bh$

Number and Operations

1. From a group of 6 juniors and 8 seniors on the student council, 2 juniors and 4 seniors will be chosen to make up a 6-person committee. How many different 6-person committees are possible?
(A) 84
(B) 85
(C) 1,050
(D) 1,710
(E) 1,890

Choice (C) is the correct answer to question 1. The 2 juniors on the committee can be chosen from the 6 juniors in $\binom{6}{2} = 15$ ways. The 4 seniors on the committee can be chosen from the 8 seniors in $\binom{8}{4} = 70$ ways. Therefore, there are $(15)(70) = 1,050$ possibilities for the 6-person committee.

Algebra and Functions

2. If $2^x = 3$, what does 3^x equal?
(A) 5.7
(B) 5.2
(C) 2.0
(D) 1.8
(E) 1.6

A calculator is useful for this problem. To solve for x , you can take the natural log of both sides of the equation.

$$\begin{aligned}\ln 2^x &= \ln 3 \\ x \ln 2 &= \ln 3 \\ x = \frac{\ln 3}{\ln 2} &= \frac{1.0986}{0.6931} \approx 1.5850 \\ 3^x &\approx 5.7045\end{aligned}$$

Choice (A) is the correct answer to question 2. Since the directions to this test state, “If the exact numerical value is not one of the choices, select the choice that best approximates this value,” the correct answer is choice (A).

You can also solve this problem by graphing $Y_1 = 2^x$ and $Y_2 = 3$ and finding the point of intersection of the two graphs in the standard viewing window. The two graphs intersect at the point with x -coordinate ≈ 1.5850 . You can store this x -value and then evaluate 3^x , which gives 5.7045. Many graphing calculators retain the last calculation from the graph screen in memory. If you return to the home screen immediately after finding the point of intersection, you can use the x -coordinate (called “X” or “ xc ,” depending on the calculator) to evaluate 3^x .

$$ax^5 + bx^4 + cx^3 + dx^2 + e = 0$$

3. Let a , b , c , d , and e represent nonzero real numbers in the equation above. If the equation has $2i$ as a root, which of the following statements must be true?
- The only other nonreal root of the equation is $-2i$.
 - The equation has an odd number of nonreal roots.
 - The equation has exactly one real root.
 - The equation has an odd number of real roots.
 - All real roots of the equation are positive.

Choice (D) is the correct answer to question 3. Since $ax^5 + bx^4 + cx^3 + dx^2 + e = 0$ is a 5th-degree polynomial equation with real coefficients, the equation has exactly 5 roots in the complex number system. Because $2i$ is a root of the equation, $-2i$ is also a root. Complex roots always occur in conjugate pairs $a \pm bi$, where a and b are real numbers and $b \neq 0$.

There are two possibilities for the other 3 roots of the equation.

- 1 real root, 2 complex (nonreal) roots
- 3 real roots

Since the equation could have 4 nonreal roots, choice (A) does not have to be true. Since nonreal roots always occur in pairs, choice (B) cannot be true. Since the equation could have 3 real roots, choice (C) does not have to be true. We do not have enough information about the polynomial equation to determine the sign of the real roots. Therefore, choice

(E) does not have to be true. Since the equation could have 1 or 3 real roots, choice (D) must be true.

4. Two environmentalists have proposed two different function models for the survival rate of a particular endangered species.

$$f(t) = 100(0.7)^t$$
$$g(t) = 100(0.999993)^t$$

For the functions f and g above, $f(t)$ and $g(t)$ represent the percentage of the species that survive t years from a starting point $t=0$. Which of the following statements about the models are true?

- I. Both models give the same prediction at approximately $t=15$ years.
 - II. Model g predicts that the population size will decrease most rapidly from $t=0$ to $t=5$ years.
 - III. The greatest difference in the two model predictions occurs at approximately $t=6$ years.
- (A) I only
(B) I and II only
(C) I and III only
(D) II and III only
(E) I, II, and III

Choice (C) is the correct answer to question 4 since statements I and III are true. You can use a graphing calculator to help you solve this problem. Enter functions f and g in the calculator as Y_1 and Y_2 , respectively.

By examining the graphs of the two functions or a table of values for the two functions, you can determine that $f(t)=g(t)$ for a value between $t=15$ and $t=16$. Both models give the same prediction at approximately $t=15.024$. Thus, statement I is true.

By examining the graph of g or a table of values for g on the interval from $t=0$ to $t=5$, you can see that the $g(t)$ values are fairly constant and show little decrease. The function values start to decrease after $t=5$ years. Thus, statement II is not true.

You can look at the graph of $Y_1 - Y_2$ or a table of values for $Y_1 - Y_2$ to determine where the greatest difference between the two model predictions occurs. The greatest difference occurs at approximately $t=5.976$. Thus, statement III is true.

5. If $f(x) = \frac{1-x}{x-1}$ for all $x \neq 1$, which of the following statements must be true?

- I. $f(3) = f(2)$
 - II. $f(0) = f(2)$
 - III. $f(0) = f(4)$
- (A) None
 (B) I only
 (C) II only
 (D) II and III only
 (E) I, II, and III

Choice (E) is the correct answer to question 5. Realizing that $\frac{1-x}{x-1} = -1$ for all $x \neq 1$ greatly simplifies this problem. Since $f(0)$, $f(2)$, $f(3)$, and $f(4)$ are all equal to -1 , statements I, II, and III are all true. If you do not realize $f(x) = -1$, you can easily substitute the numbers in f . Using a calculator may actually be a disadvantage to you if you spend time substituting the numbers into an expression of this kind to find the answer. However, using a graphing calculator, you can graph $y = \frac{1-x}{x-1}$ and see that the graph is a horizontal line crossing the y -axis at -1 . Therefore, $f(x) = -1$ for all values of x except 1.

6. Let h be the function defined by $h(t) = |5\cos\left(\frac{2}{3}t\right) - 2|$. What is the period of h ?

- (A) $\frac{2}{3}$
 (B) 3
 (C) 5
 (D) 2π
 (E) 3π

Choice (E) is the correct answer to question 6. The period of h corresponds to the length of one cycle of the graph of h . The smallest positive real number k such that $h(x+k) = h(x)$ for every value of x in the domain of h is the period. By examining the graph of h on your graphing calculator, you can see that the values of $h(x)$ repeat every 3π units.

Alternately, note that the graph of h is obtained from the graph of $y = \cos t$ by applying several transformations. The vertical “stretch” by a factor of 5 units and the shift down 2 units do not affect the period of the function. The absolute value, in this case, also does not affect the period of the function. The horizontal “stretch” is a result of the $\frac{2}{3}$.

This affects the period. Since the period of $\cos t$ is 2π , the period of h can be found by $\frac{2\pi}{\left|\frac{2}{3}\right|} = 3\pi$.

7. If $f(x) = \frac{1}{x-5}$ and $g(x) = \sqrt{x+4}$, what is the domain of $f-g$?

- (A) All x such that $x \neq 5$ and $x \leq 4$
- (B) All x such that $x \neq -5$ and $x \leq 4$
- (C) All x such that $x \neq 5$ and $x \geq -4$
- (D) All x such that $x \neq -4$ and $x \geq -5$
- (E) All real numbers x

Choice (C) is the correct answer to question 7. The function $f-g$ will be defined at exactly those points where f and g are both defined. In other words, the domain of $f-g$ is the intersection of the domain of f and the domain of g . Since $f(x) = \frac{1}{x-5}$ is defined for all $x \neq 5$, and $g(x) = \sqrt{x+4}$ is defined for all $x \geq -4$, the domain of $f-g$ is all x such that $x \neq 5$ and $x \geq -4$.

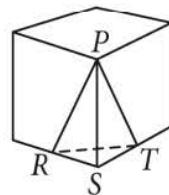
You can also examine the graph of $f-g$. The graph is defined for all real numbers $x \geq -4$ except for $x=5$, where the graph has a vertical asymptote.

Geometry and Measurement: Coordinate Geometry

8. A translation in the xy -plane moves the point with coordinates (x, y) to the point with coordinates $(x-4, y+7)$. If point A' is the image of point A under this translation, what is the distance between points A and A' ?
- (A) 3.0
 - (B) 5.7
 - (C) 7.9
 - (D) 8.1
 - (E) 11.0

Choice (D) is the correct answer to question 8. Point A' is 4 units to the left and 7 units above point A in the xy -plane. Point A can be represented by coordinates (x, y) and point A' can be represented by coordinates $(x-4, y+7)$. You can use the distance formula to find the distance between the two points.

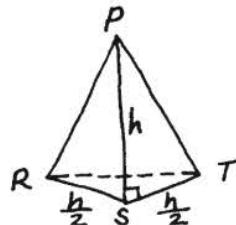
$$\begin{aligned}\text{distance} &= \sqrt{(x-4-x)^2 + ((y+7)-y)^2} \\ &= \sqrt{16+49} = \sqrt{65} \approx 8.1\end{aligned}$$

Geometry and Measurement: Three-Dimensional Geometry

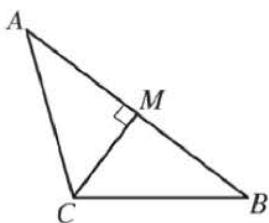
9. In the figure above, R and T are the midpoints of two adjacent edges of the cube. If the length of each edge of the cube is h , what is the volume of pyramid $PRST$?

- (A) $\frac{h^3}{24}$
- (B) $\frac{h^3}{12}$
- (C) $\frac{h^3}{8}$
- (D) $\frac{h^3}{6}$
- (E) $\frac{h^3}{4}$

The formula for the volume of the pyramid and several other formulae are given in the reference information at the beginning of the test. The volume of a pyramid is $\frac{1}{3}Bh$, where B is the area of the base of the pyramid and h is its height. It may be helpful to mark the figure to indicate those parts whose lengths are given or that can be deduced.



Choice (A) is the correct answer to question 9. Since \overline{PS} is perpendicular to the triangular base RST , its length h is the height of the pyramid $PRST$. R and T are the midpoints of the two adjacent edges of the cube; therefore, $RS = ST = \frac{h}{2}$. Since $\triangle RST$ is a right triangle, its area is $\left(\frac{1}{2}\right)\left(\frac{h}{2}\right)\left(\frac{h}{2}\right) = \frac{h^2}{8}$. Thus, the volume of $PRST$ is $\left(\frac{1}{3}\right)\left(\frac{h^2}{8}\right)(h) = \frac{h^3}{24}$.

Geometry and Measurement: Trigonometry

Note: Figure not drawn to scale.

10. In $\triangle ABC$ above, $\overline{CM} \perp \overline{AB}$. If $AM = 9$, $MB = 15$, and the measure of $\angle BAC$ is 22° , what is the length of \overline{CB} ?

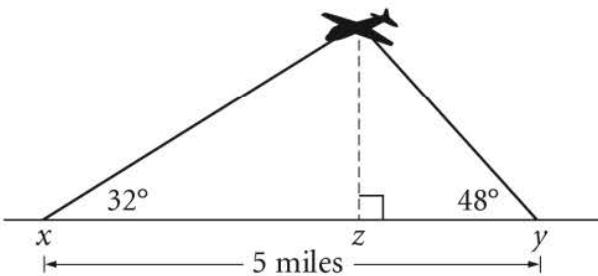
- (A) 3.64
- (B) 9.71
- (C) 15.43
- (D) 17.16
- (E) 17.49

Choice (C) is the correct answer to question 10. You can use right triangle ACM to find the length of \overline{CM} .

$$\tan 22^\circ = \frac{CM}{9}; \text{ thus, } CM \approx 3.636.$$

Now you can use the Pythagorean theorem on right triangle CMB to find the length of \overline{CB} .

$$\begin{aligned} CM^2 + MB^2 &= CB^2 \\ CB &= \sqrt{(3.636)^2 + 15^2} \\ CB &\approx \sqrt{238.2205} \approx 15.43 \end{aligned}$$

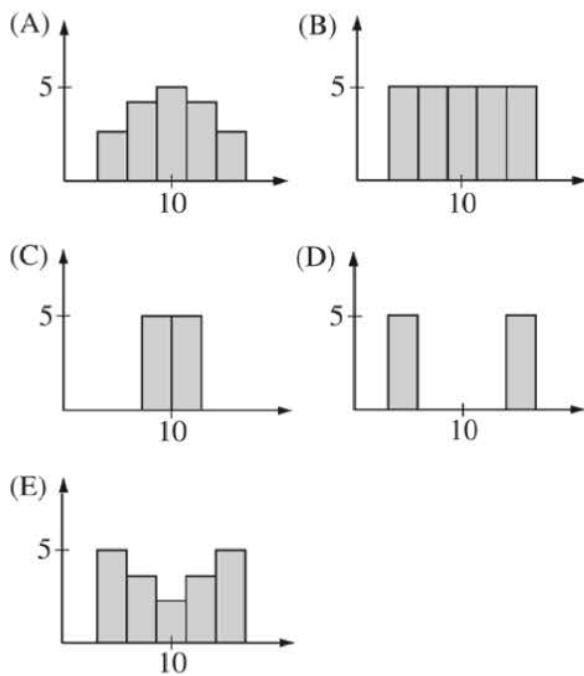


11. The airplane in the figure above is flying directly over point Z on a straight, level road. The angles of elevation for points X and Y are 32° and 48° , respectively. If points X and Y are 5 miles apart, what is the distance, in miles, from the airplane to point X ?
- (A) 1.60
 (B) 2.40
 (C) 2.69
 (D) 3.77
 (E) 7.01

Choice (D) is the correct answer to question 11. Label the location of the airplane as point W . Then in $\triangle XYW$, the measure of $\angle X$ is 32° , the measure of $\angle Y$ is 48° , and the measure of $\angle W$ is 100° . Let x , y , and w denote the lengths, in miles, of the sides of $\triangle XYW$ opposite $\angle X$, $\angle Y$, and $\angle W$, respectively. By the law of sines, $\frac{x}{\sin X} = \frac{y}{\sin Y} = \frac{w}{\sin W}$. Since $w=5$ and the distance from the plane to point X is y , it follows that $\frac{5}{\sin 100^\circ} = \frac{y}{\sin 48^\circ}$. This gives $y \approx 3.77$ for the distance, in miles, from the plane to point X .

Data Analysis, Statistics, and Probability

12. The standard deviation is least for the data shown in which of the following histograms?



Choice (C) is the correct answer to question 12. The standard deviation is a measure of spread—how far the observations in a set of data are from their mean.

The data is closest to 10 in the histogram in choice (C), and thus has the least standard deviation. In each of the other choices, the data is further spread from 10.

Mathematics Level 2 Test

Practice Helps

The test that follows is an actual, recently administered SAT Subject Test in Mathematics Level 2. To get an idea of what it's like to take this test, practice under conditions that are much like those of an actual test administration.

- Set aside an hour when you can take the test uninterrupted. Make sure you complete the test in one sitting.
- Sit at a desk or table with no other books or papers. Dictionaries, other books, or notes are not allowed in the test room.
- Remember to have a scientific or graphing calculator with you.
- Tear out an answer sheet from the back of this book and fill it in just as you would on the day of the test. One answer sheet can be used for up to three Subject Tests.
- Read the instructions that precede the practice test. During the actual administration you will be asked to read them before answering test questions.
- Time yourself by placing a clock or kitchen timer in front of you.
- After you finish the practice test, read the sections "How to Score the SAT Subject Test in Mathematics Level 2" and "How Did You Do on the Subject Test in Mathematics Level 2?"
- The appearance of the answer sheet in this book may differ from the answer sheet you see on test day.

MATHEMATICS LEVEL 2 TEST

The top portion of the section of the answer sheet that you will use in taking the Mathematics Level 2 Test must be filled in exactly as shown in the illustration below. Note carefully that you have to do all of the following on your answer sheet.

1. Print MATHEMATICS LEVEL 2 on the line under the words “Subject Test (print).”

2. In the shaded box labeled “Test Code” fill in four circles:

—Fill in circle 5 in the row labeled V.

—Fill in circle 3 in the row labeled W.

—Fill in circle 5 in the row labeled X.

—Fill in circle E in the row labeled Y.

Test Code									
V	1	2	3	4	5	6	7	8	9
W	1	2	3	4	5	6	7	8	9
X	1	2	3	4	5	6	7	8	9
Y	A	B	C	D	E	F	G	H	I
Q	1	2	3	4	5	6	7	8	9

Subject Test (print)
MATHEMATICS LEVEL 2

3. Please answer Part I and Part II below by filling in the specified circles in row Q that correspond to the courses you have taken or are presently taking, and the circle that corresponds to the type of calculator you are going to use to take this test. The information that you provide is for statistical purposes only and will not affect your score on the test.

Part I. Which of the following describes a mathematics course you have taken or are currently taking? (FILL IN **ALL** CIRCLES THAT APPLY.)

- Algebra I or Elementary Algebra **OR** Course I of a college preparatory mathematics sequence —Fill in circle 1.
- Geometry **OR** Course II of a college preparatory mathematics sequence —Fill in circle 2.
- Algebra II or Intermediate Algebra **OR** Course III of a college preparatory mathematics sequence —Fill in circle 3.
- Elementary Functions (Precalculus) and/or Trigonometry **OR** beyond Course III of a college preparatory mathematics sequence —Fill in circle 4.
- Advanced Placement Mathematics (Calculus AB or Calculus BC) —Fill in circle 5.

Part II. What type of calculator did you bring to use for this test? (FILL IN THE **ONE** CIRCLE THAT APPLIES. If you did not bring a scientific or graphing calculator, do not fill in any of circles 6-9.)

- Scientific —Fill in circle 6.
- Graphing (Fill in the circle corresponding to the model you used.)
 - Casio 9700, Casio 9750, Casio 9800, Casio 9850, Casio FX 1.0, Sharp 9200, Sharp 9300, Sharp 9600, Sharp 9900, TI-82, TI-83, TI-83 Plus, TI-83 Plus Silver, TI-84 Plus, TI-84 Plus Silver, TI-85, or TI-86 —Fill in circle 7.
 - Casio 9970, Casio Algebra FX 2.0, HP 38G, HP 39 series, HP 40G, HP 48 series, HP 49 series, TI-89, or TI-89 Titanium —Fill in circle 8.
 - Some other graphing calculator —Fill in circle 9.

When the supervisor gives the signal, turn the page and begin the Mathematics Level 2 Test. There are 100 numbered circles on the answer sheet and 50 questions in the Mathematics Level 2 Test. Therefore, use only circles 1 to 50 for recording your answers.

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MATHEMATICS LEVEL 2 TEST**REFERENCE INFORMATION**

THE FOLLOWING INFORMATION IS FOR YOUR REFERENCE IN ANSWERING SOME OF THE QUESTIONS IN THIS TEST.

Volume of a right circular cone with radius r and height h : $V = \frac{1}{3}\pi r^2 h$

Lateral Area of a right circular cone with circumference of the base c and slant height ℓ : $S = \frac{1}{2}c\ell$

Volume of a sphere with radius r : $V = \frac{4}{3}\pi r^3$

Surface Area of a sphere with radius r : $S = 4\pi r^2$

Volume of a pyramid with base area B and height h : $V = \frac{1}{3}Bh$

DO NOT DETACH FROM BOOK.

MATHEMATICS LEVEL 2 TEST

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(5) Reference information that may be useful in answering the questions in this test can be found on the page preceding Question 1.

USE THIS SPACE FOR SCRATCHWORK.

1. If $3x + 6 = \frac{k}{4}(x + 2)$ for all x , then $k =$
(A) $\frac{1}{4}$ (B) 3 (C) 4 (D) 12 (E) 24

3YBC

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GO ON TO THE NEXT PAGE 

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

2. The relationship between a reading C on the Celsius temperature scale and a reading F on the Fahrenheit temperature scale is $C = \frac{5}{9}(F - 32)$, and the relationship between a reading on the Celsius temperature scale and a reading K on the Kelvin temperature scale is $K = C + 273$. Which of the following expresses the relationship between readings on the Kelvin and Fahrenheit temperature scales?

- (A) $K = \frac{5}{9}(F - 241)$
(B) $K = \frac{5}{9}(F + 305)$
(C) $K = \frac{5}{9}(F - 32) + 273$
(D) $K = \frac{5}{9}(F - 32) - 273$
(E) $K = \frac{5}{9}(F + 32) + 273$
3. What is the slope of the line containing the points $(3, 11)$ and $(-2, 5)$?
(A) 0.17
(B) 0.83
(C) 1.14
(D) 1.20
(E) 6
4. If $x + y = 2$, $y + z = 5$, and $x + y + z = 10$, then $y =$
(A) -3
(B) $\frac{3}{17}$
(C) 1
(D) 3
(E) $\frac{17}{3}$

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MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

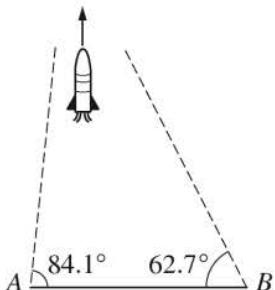
5. If $f(x) = 3 \ln(x) - 1$ and $g(x) = e^x$,
then $f(g(5)) =$

(A) 6.83
(B) 12
(C) 14
(D) 45.98
(E) 568.17

6. The intersection of a cube with a plane could
be which of the following?

I. A square
II. A parallelogram
III. A triangle

(A) I only
(B) II only
(C) III only
(D) I and III only
(E) I, II, and III



7. The figure above shows a rocket taking off
vertically. When the rocket reaches a height of
12 kilometers, the angles of elevation from points
A and B on level ground are 84.1° and 62.7° ,
respectively. What is the distance between
points A and B?

(A) 0.97 km
(B) 6.36 km
(C) 7.43 km
(D) 22.60 km
(E) 139.37 km

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MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

8. What is the value of x^2 if $x = \sqrt{15^2 - 12^2}$?
- (A) $\sqrt{3}$ (B) 3 (C) 9 (D) 81 (E) 81^2
9. The points in the rectangular coordinate plane are transformed in such a way that each point $P(x, y)$ is moved to the point $P'(2x, 2y)$. If the distance between a point P and the origin is d , then the distance between the point P' and the origin is
- (A) $\frac{1}{d}$
(B) $\frac{d}{2}$
(C) d
(D) $2d$
(E) d^2

10. If $f(g(x)) = \frac{2\sqrt{x^2 + 1} - 1}{\sqrt{x^2 + 1} + 1}$ and $f(x) = \frac{2x - 1}{x + 1}$,
then $g(x) =$
- (A) \sqrt{x}
(B) $\sqrt{x^2 + 1}$
(C) x
(D) x^2
(E) $x^2 + 1$

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

11. If A is the degree measure of an acute angle and $\sin A = 0.8$, then $\cos(90^\circ - A) =$

- (A) 0.2
- (B) 0.4
- (C) 0.5
- (D) 0.6
- (E) 0.8

12. The set of points (x, y, z) such that

$$x^2 + y^2 + z^2 = 1$$

- (A) empty
- (B) a point
- (C) a sphere
- (D) a circle
- (E) a plane

13. The graph of the rational function f , where

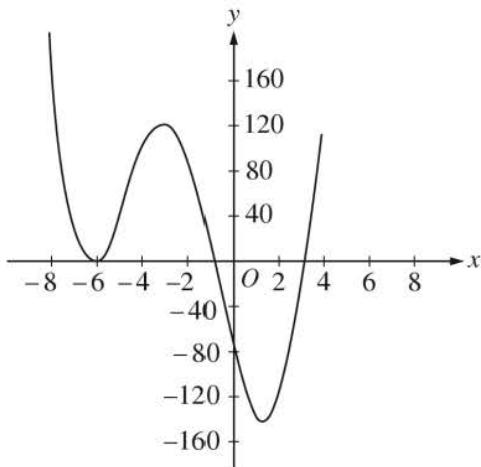
$$f(x) = \frac{5}{x^2 - 8x + 16},$$
 has a vertical

asymptote at $x =$

- (A) 0 only
- (B) 4 only
- (C) 5 only
- (D) 0 and 4 only
- (E) 0, 4, and 5

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.



14. The graph of $y = x^4 + 10x^3 + 10x^2 - 96x + c$ is shown above. Which of the following could be the value of c ?
- (A) 3,240
(B) 1,080
(C) 72
(D) -72
(E) -3,240

15. If $\cos x = 0.4697$, then $\sec x =$
- (A) 2.1290
(B) 2.0452
(C) 1.0818
(D) 0.9243
(E) 0.4890

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

16. A club is planning a trip to a museum that has an admission price of \$7 per person. The club members going on the trip must share the \$200 cost of a bus and the admission price for 2 chaperones who will accompany them on the trip. Which of the following correctly expresses the cost, in dollars, for each club member as a function of n , the number of club members going on the trip?

(A) $c(n) = \frac{200 + 7n}{n}$

(B) $c(n) = \frac{214 + 7n}{n}$

(C) $c(n) = \frac{200 + 7n}{n + 2}$

(D) $c(n) = \frac{200 + 7n}{n - 2}$

(E) $c(n) = \frac{214 + 7n}{n - 2}$

17. Which of the following is an equation whose graph is the set of points equidistant from the points $(0, 0)$ and $(0, 4)$?

(A) $x = 2$

(B) $y = 2$

(C) $x = 2y$

(D) $y = 2x$

(E) $y = x + 2$

18. What is the sum of the infinite geometric series

$$\frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \dots ?$$

(A) $\frac{1}{2}$ (B) 1 (C) $\frac{3}{2}$ (D) 2 (E) $\frac{5}{2}$

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

19. Which of the following is equivalent to
 $p + s > p - s$?

- (A) $p > s$
- (B) $p > 0$
- (C) $s > p$
- (D) $s > 0$
- (E) $s < 0$

20. If a and b are in the domain of a function f and
 $f(a) < f(b)$, which of the following must be true?

- (A) $a = 0$ or $b = 0$
- (B) $a < b$
- (C) $a > b$
- (D) $a \neq b$
- (E) $a = b$

21. In a recent survey, it was reported that 75 percent of the population of a certain state lived within ten miles of its largest city and that 40 percent of those who lived within ten miles of the largest city lived in single-family houses. If a resident of this state is selected at random, what is the probability that the person lives in a single-family house within ten miles of the largest city?

- (A) 0.10
- (B) 0.15
- (C) 0.30
- (D) 0.35
- (E) 0.53

22. To the nearest degree, what is the measure of the smallest angle in a right triangle with sides of lengths 3, 4, and 5?

- (A) 27°
- (B) 30°
- (C) 37°
- (D) 45°
- (E) 53°

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

23. Which of the following is an equation of a line perpendicular to $y = -2x + 3$?

- (A) $y = 3x - 2$
(B) $y = 2x - 3$
(C) $y = \frac{1}{2}x + 4$
(D) $y = -\frac{1}{2}x + 3$
(E) $y = \frac{1}{-2x + 3}$

24. What is the range of the function f , where $f(x) = -4 + 3 \sin(2x + 5\pi)$?

- (A) $-7 \leq f(x) \leq 3$
(B) $-7 \leq f(x) \leq -1$
(C) $-3 \leq f(x) \leq 3$
(D) $-3 \leq f(x) \leq -1$
(E) $-1 \leq f(x) \leq 1$

25. Of the following lists of numbers, which has the smallest standard deviation?

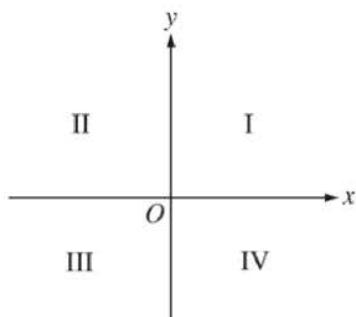
- (A) 1, 5, 9
(B) 3, 5, 8
(C) 4, 5, 8
(D) 7, 8, 9
(E) 8, 8, 8

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

26. The formula $A = Pe^{0.08t}$ gives the amount A that a savings account will be worth after an initial investment P is compounded continuously at an annual rate of 8 percent for t years. Under these conditions, how many years will it take an initial investment of \$1,000 to be worth approximately \$5,000?

- (A) 4.1
- (B) 5.0
- (C) 8.7
- (D) 20.1
- (E) 23.0



27. If $\sin \theta > 0$ and $\sin \theta \cos \theta < 0$, then θ must be in which quadrant in the figure above?

- (A) I
- (B) II
- (C) III
- (D) IV
- (E) There is no quadrant in which both conditions are true.

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

28. If $f(-x) = f(x)$ for all real numbers x and if $(3, 8)$ is a point on the graph of f , which of the following points must also be on the graph of f ?

- (A) $(-8, -3)$
- (B) $(-3, -8)$
- (C) $(-3, 8)$
- (D) $(3, -8)$
- (E) $(8, 3)$

If $x = y$, then $x^2 = y^2$.

29. If x and y are real numbers, which of the following CANNOT be inferred from the statement above?
- (A) In order for x^2 to be equal to y^2 , it is sufficient that x be equal to y .
 - (B) A necessary condition for x to be equal to y is that x^2 be equal to y^2 .
 - (C) x is equal to y implies that x^2 is equal to y^2 .
 - (D) If x^2 is not equal to y^2 , then x is not equal to y .
 - (E) If x^2 is equal to y^2 , then x is equal to y .
30. In how many different orders can 9 students arrange themselves in a straight line?
- (A) 9
 - (B) 81
 - (C) 181,440
 - (D) 362,880
 - (E) 387,420,489

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

31. What value does $\frac{\ln x}{x - 1}$ approach as x approaches 1?

- (A) 0
- (B) 0.43
- (C) 1
- (D) 2
- (E) It does not approach a unique value.

32. If $f(x) = |5 - 3x|$, then $f(2) =$

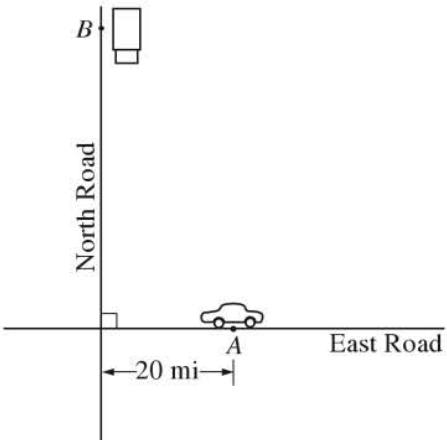
- (A) $f(-2)$
- (B) $f(-1)$
- (C) $f(1)$
- (D) $f\left(\frac{4}{3}\right)$
- (E) $f\left(\frac{7}{3}\right)$

33. What is the period of the graph of $y = 2 \tan(3\pi x + 4)$?

- (A) $\frac{2\pi}{3}$
- (B) $\frac{2}{3}$
- (C) 2
- (D) $\frac{1}{3}$
- (E) $\frac{\pi}{3}$

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.



34. The figure above shows a car that has broken down on East Road. A tow truck leaves a garage on North Road at point B . The straight-line distance between points A and B is 50 miles. If the tow truck travels at an average speed of 45 miles per hour along North and East Roads, how long will it take the tow truck to get to the car?
- (A) 27 minutes
(B) 1 hour and 7 minutes
(C) 1 hour and 28 minutes
(D) 1 hour and 33 minutes
(E) 1 hour and 46 minutes

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GO ON TO THE NEXT PAGE

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

x	$f(x)$
-1	0
0	1
1	-1
2	0

35. If f is a polynomial of degree 3, four of whose values are shown in the table above, then $f(x)$ could equal

- (A) $\left(x + \frac{1}{2}\right)(x + 1)(x + 2)$
(B) $(x + 1)(x - 2)\left(x - \frac{1}{2}\right)$
(C) $(x + 1)(x - 2)(x - 1)$
(D) $(x + 2)\left(x - \frac{1}{2}\right)(x - 1)$
(E) $(x + 2)(x + 1)(x - 2)$

36. The only prime factors of a number n are 2, 5, 7, and 17. Which of the following could NOT be a factor of n ?

- (A) 10 (B) 20 (C) 25 (D) 30 (E) 34

37. If $0 \leq x \leq \frac{\pi}{2}$ and $\sin x = 3 \cos x$, what is the value of x ?

- (A) 0.322
(B) 0.333
(C) 0.340
(D) 1.231
(E) 1.249

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

38. If $f(x) = 5\sqrt{2x}$, what is the value of $f^{-1}(10)$?

- (A) 0.04
- (B) 0.89
- (C) 2.00
- (D) 2.23
- (E) 22.36

39. The Fibonacci sequence can be defined recursively as

$$a_1 = 1$$

$$a_2 = 1$$

$$a_n = a_{n-1} + a_{n-2} \text{ for } n \geq 3.$$

What is the 10th term of this sequence?

- (A) 21
- (B) 34
- (C) 55
- (D) 89
- (E) 144

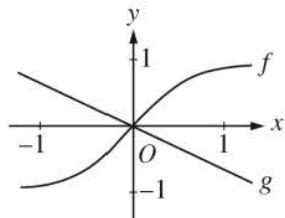
40. If $f(x) = x^3 - 4x^2 - 3x + 2$, which of the following statements are true?

- I. The function f is increasing for $x \geq 3$.
- II. The equation $f(x) = 0$ has two nonreal solutions.
- III. $f(x) \geq -16$ for all $x \geq 0$.

- (A) I only
- (B) II only
- (C) I and II
- (D) I and III
- (E) II and III

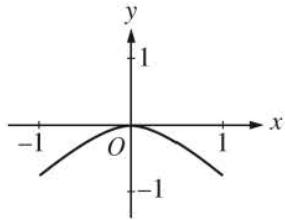
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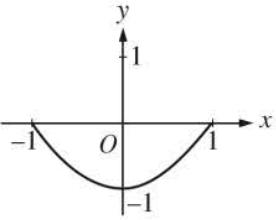


41. Portions of the graphs of f and g are shown above. Which of the following could be a portion of the graph of fg ?

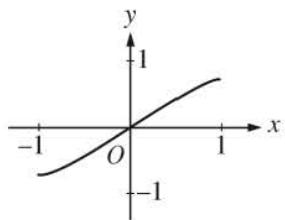
(A)



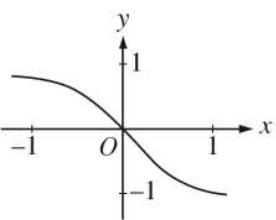
(B)



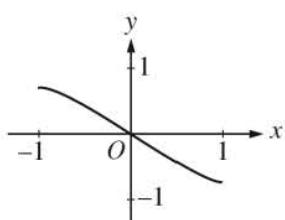
(C)



(D)



(E)



MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

42. The set of all real numbers x such that $\sqrt{x^2} = -x$ consists of

- (A) zero only
- (B) nonpositive real numbers only
- (C) positive real numbers only
- (D) all real numbers
- (E) no real numbers



43. In the triangle shown above, $\sin \alpha =$

- (A) $\frac{3}{8}$
- (B) $\frac{1}{2}$
- (C) $\frac{2}{3}$
- (D) $\frac{3}{4}$
- (E) $\frac{4}{5}$

44. The length, width, and height of a rectangular solid are 8, 4, and 1, respectively. What is the length of the longest line segment whose end points are two vertices of this solid?

- (A) $4\sqrt{5}$
- (B) 9
- (C) $3\sqrt{10}$
- (D) 10
- (E) 12

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

45. If $\log_a 3 = x$ and $\log_a 5 = y$, then $\log_a 45 =$

- (A) $2x + y$
- (B) $x^2 + y$
- (C) x^2y
- (D) $x + y$
- (E) $9x + y$

46. If $\sin \theta = t$, then, for all θ in the interval

$$0 < \theta < \frac{\pi}{2}, \tan \theta =$$

- (A) $\frac{1}{\sqrt{1-t^2}}$
- (B) $\frac{t}{\sqrt{1-t^2}}$
- (C) $\frac{1}{1-t^2}$
- (D) $\frac{t}{1-t^2}$
- (E) 1

47. Which of the following shifts of the graph of $y = x^2$ would result in the graph of $y = x^2 - 2x + k$, where k is a constant greater than 2?

- (A) Left 2 units and up k units
- (B) Left 1 unit and up $k + 1$ units
- (C) Right 1 unit and up $k + 1$ units
- (D) Left 1 unit and up $k - 1$ units
- (E) Right 1 unit and up $k - 1$ units

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.

48. If the height of a right circular cone is decreased by 8 percent, by what percent must the radius of the base be decreased so that the volume of the cone is decreased by 15 percent?

(A) 4%
(B) 7%
(C) 8%
(D) 30%
(E) 45%

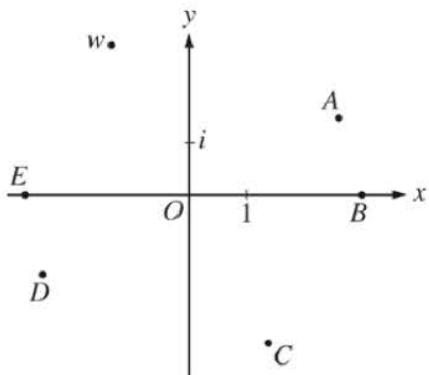
49. If matrix A has dimensions $m \times n$ and matrix B has dimensions $n \times p$, where m , n , and p are distinct positive integers, which of the following statements must be true?

- I. The product BA does not exist.
II. The product AB exists and has dimensions $m \times p$.
III. The product AB exists and has dimensions $n \times n$.

(A) I only
(B) II only
(C) III only
(D) I and II
(E) I and III

MATHEMATICS LEVEL 2 TEST—Continued

USE THIS SPACE FOR SCRATCHWORK.



50. If w is the complex number shown in the figure above, which of the following points could be $-iw$?
- (A) A (B) B (C) C (D) D (E) E

S T O P

**IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS TEST ONLY.
DO NOT TURN TO ANY OTHER TEST IN THIS BOOK.**

How to Score the SAT Subject Test in Mathematics Level 2

When you take an actual SAT Subject Test in Mathematics Level 2, your answer sheet will be “read” by a scanning machine that will record your responses to each question. Then a computer will compare your answers with the correct answers and produce your raw score. You get one point for each correct answer. For each wrong answer, you lose one-fourth of a point. Questions you omit (and any for which you mark more than one answer) are not counted. This raw score is converted to a scaled score that is reported to you and to the colleges you specify.

Worksheet 1. Finding Your Raw Test Score

STEP 1: Table A lists the correct answers for all the questions on the Subject Test in Mathematics Level 2 that is reproduced in this book. It also serves as a worksheet for you to calculate your raw score.

- Compare your answers with those given in the table.
- Put a check in the column marked “Right” if your answer is correct.
- Put a check in the column marked “Wrong” if your answer is incorrect.
- Leave both columns blank if you omitted the question.

STEP 2: Count the number of right answers.

Enter the total here: _____

STEP 3: Count the number of wrong answers.

Enter the total here: _____

STEP 4: Multiply the number of wrong answers by .250.

Enter the product here: _____

STEP 5: Subtract the result obtained in Step 4 from the total you obtained in Step 2.

Enter the result here: _____

STEP 6: Round the number obtained in Step 5 to the nearest whole number.

Enter the result here: _____

The number you obtained in Step 6 is your raw score.

Table A
**Answers to the Subject Test in Mathematics Level 2, Form 3YBC, and
Percentage of Students Answering Each Question Correctly**

Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*	Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*
1	D			88	26	D			85
2	C			91	27	B			70
3	D			90	28	C			65
4	A			87	29	E			47
5	C			90	30	D			73
6	E			54	31	C			54
7	C			62	32	D			72
8	D			93	33	D			23
9	D			85	34	C			62
10	B			89	35	B			57
11	E			84	36	D			51
12	C			54	37	E			63
13	B			87	38	C			52
14	D			75	39	C			52
15	A			88	40	D			48
16	B			67	41	A			42
17	B			62	42	B			33
18	A			70	43	C			63
19	D			76	44	B			54
20	D			72	45	A			46
21	C			82	46	B			46
22	C			67	47	E			44
23	C			70	48	A			35
24	B			66	49	D			25
25	E			60	50	A			26

* These percentages are based on an analysis of the answer sheets of a representative sample of 15,855 students who took the original form of this test in May 2002, and whose mean score was 652. They may be used as an indication of the relative difficulty of a particular question. Each percentage may also be used to predict the likelihood that a typical SAT Subject Test in Mathematics Level 2 candidate will answer that question correctly on this edition of the test.

Finding Your Scaled Score

When you take SAT Subject Tests, the scores sent to the colleges you specify are reported on the College Board scale, which ranges from 200–800. You can convert your practice test score to a scaled score by using Table B. To find your scaled score, locate your raw score in the left-hand column of Table B; the corresponding score in the right-hand column is your scaled score. For example, a raw score of 26 on this particular edition of the Subject Test in Mathematics Level 2 corresponds to a scaled score of 620.

Raw scores are converted to scaled scores to ensure that a score earned on any one edition of a particular Subject Test is comparable to the same scaled score earned on any other edition of the same Subject Test. Because some editions of the tests may be slightly easier or more difficult than others, College Board scaled scores are adjusted so that they indicate the same level of performance regardless of the edition of the test taken and the ability of the group that takes it. Thus, for example, a score of 400 on one edition of a test taken at a particular administration indicates the same level of achievement as a score of 400 on a different edition of the test taken at a different administration.

When you take the SAT Subject Tests during a national administration, your scores are likely to differ somewhat from the scores you obtain on the tests in this book. People perform at different levels at different times for reasons unrelated to the tests themselves. The precision of any test is also limited because it represents only a sample of all the possible questions that could be asked.

Table B

Scaled Score Conversion Table					
Subject Test in Mathematics Level 2 (Form 3YBC)					
Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score
50	800	28	630	6	470
49	800	27	630	5	460
48	800	26	620	4	450
47	800	25	610	3	440
46	800	24	600	2	430
45	800	23	600	1	420
44	800	22	590	0	410
43	790	21	580	-1	400
42	780	20	580	-2	390
41	770	19	570	-3	370
40	760	18	560	-4	360
39	750	17	560	-5	350
38	740	16	550	-6	340
37	730	15	540	-7	340
36	710	14	530	-8	330
35	700	13	530	-9	330
34	690	12	520	-10	320
33	680	11	510	-11	310
32	670	10	500	-12	300
31	660	9	490		
30	650	8	480		
29	640	7	480		

How Did You Do on the Subject Test in Mathematics Level 2?

After you score your test and analyze your performance, think about the following questions:

Did you run out of time before reaching the end of the test?

If so, you may need to pace yourself better. For example, maybe you spent too much time on one or two hard questions. A better approach might be to skip the ones you can't answer right away and try answering all the questions that remain on the test. Then if there's time, go back to the questions you skipped.

Did you take a long time reading the directions?

You will save time when you take the test by learning the directions to the Subject Test in Mathematics Level 2 ahead of time. Each minute you spend reading directions during the test is a minute that you could use to answer questions.

How did you handle questions you were unsure of?

If you were able to eliminate one or more of the answer choices as wrong and guess from the remaining ones, your approach probably worked to your advantage. On the other hand, making haphazard guesses or omitting questions without trying to eliminate choices could cost you valuable points.

How difficult were the questions for you compared with other students who took the test?

Table A shows you how difficult the multiple-choice questions were for the group of students who took this test during its national administration. The right-hand column gives the percentage of students that answered each question correctly.

A question answered correctly by almost everyone in the group is obviously an easier question. For example, 93 percent of the students answered question 8 correctly. But only 23 percent answered question 33 correctly.

Keep in mind that these percentages are based on just one group of students. They would probably be different with another group of students taking the test.

If you missed several easier questions, go back and try to find out why: Did the questions cover material you haven't yet reviewed? Did you misunderstand the directions?

Chapter 6

Chemistry

Purpose

The Subject Test in Chemistry measures the understanding of chemistry you would be expected to have after successfully completing a college-preparatory course in high school and is designed to be independent of the particular textbook or instructional approach used.

Format

This is a one-hour test with 85 multiple-choice questions.

Content

The test covers the topics listed in the chart on the next page. Different aspects of these topics are stressed from year to year. However, because high school courses differ, both in the amount of time devoted to each major topic and in the specific subtopics covered, it is likely that most students will encounter some questions on topics with which they are not familiar. Every edition of the test contains approximately five questions on equation balancing and/or predicting products of chemical reactions; these are distributed among the various content categories.

Topics Covered	Approximate Percentage of Test
I. Structure of Matter	25
Atomic Structure , including experimental evidence of atomic structure, quantum numbers and energy levels (orbitals), electron configurations, periodic trends	
Molecular Structure , including Lewis structures, three-dimensional molecular shapes, polarity	
Bonding , including ionic, covalent, and metallic bonds; relationships of bonding to properties and structures; intermolecular forces such as hydrogen bonding, dipole-dipole forces, dispersion (London) forces	
II. States of Matter	16
Gases , including the kinetic molecular theory, gas law relationships, molar volumes, density, stoichiometry	
Liquids and Solids , including intermolecular forces in liquids and solids, types of solids, phase changes and phase diagrams	
Solutions , including molarity and percent by mass concentrations; solution preparation and stoichiometry; factors affecting solubility of solids, liquids, and gases; qualitative aspects of colligative properties	
III. Reaction Types	14
Acids and Bases , including Brønsted-Lowry theory, strong and weak acids and bases, pH, titrations, indicators	
Oxidation-Reduction , including recognition of oxidation-reduction reactions, combustion, oxidation numbers, use of activity series	
Precipitation , including basic solubility rules	
IV. Stoichiometry	14
Mole Concept , including molar mass, Avogadro's number, empirical and molecular formulas	
Chemical Equations , including the balancing of equations, stoichiometric calculations, percent yield, limiting reactants	
V. Equilibrium and Reaction Rates	5
Equilibrium Systems , including factors affecting position of equilibrium (LeChâtelier's principle) in gaseous and aqueous systems, equilibrium constants, equilibrium expressions	
Rates of Reactions , including factors affecting reaction rates, potential energy diagrams, activation energies	
VI. Thermochemistry	6
Including conservation of energy, calorimetry and specific heats, enthalpy (heat) changes associated with phase changes and chemical reactions, heating and cooling curves, randomness (entropy)	
VII. Descriptive Chemistry	12
Including common elements, nomenclature of ions and compounds, periodic trends in chemical and physical properties of the elements, reactivity of elements and prediction of products of chemical reactions, examples of simple organic compounds and compounds of environmental concern	
VIII. Laboratory	8
Including knowledge of laboratory equipment, measurements, procedures, observations, safety, calculations, data analysis, interpretation of graphical data, drawing conclusions from observations and data	
Skills Specifications	Approximate Percentage of Test
Recall of Knowledge	20
Remembering fundamental concepts and specific information; demonstrating familiarity with terminology	
Application of Knowledge	45
Applying a single principle to unfamiliar and/or practical situations; to obtain a qualitative result or solve a quantitative problem	
Synthesis of Knowledge	35
Inferring and deducing from qualitative data and/or quantitative data; integrating two or more relationships to draw conclusions or solve problems	

How to Prepare

- Take a one-year introductory chemistry course at the college-preparatory level.
- Laboratory experience is a significant factor in developing reasoning and problem-solving skills and should help in test preparation even though laboratory skills can be tested only in a limited way in a multiple-choice test.
- Mathematics preparation that enables handling simple algebraic relationships and applying these to solving word problems will help.
- Familiarize yourself with the concepts of ratio and direct and inverse proportions, exponents, and scientific notation.
- Familiarize yourself with directions in advance. The directions in this book are identical to those that appear on the test.

You should have the ability to

- recall and understand the major concepts of chemistry and to apply the principles to solve specific problems in chemistry.
- organize and interpret results obtained by observation and experimentation and to draw conclusions or make inferences from experimental data, including data presented in graphic and/or tabular form.

Notes: (1) A periodic table indicating the atomic numbers and masses of elements is provided for all test administrations.

- (2) Calculators aren't allowed to be used during the test.
- (3) Problem solving requires simple numerical calculations.
- (4) The metric system of units is used.

Score

The total score is reported on the 200-to-800 scale.

Sample Questions

Three types of questions are used in the Chemistry Subject Test: classification questions, relationship analysis questions, and five-choice completion questions.

Note: For all questions involving solutions, assume that the solvent is water unless otherwise noted.

Classification Questions

Each set of classification questions has, in the heading, five lettered choices that you will use to answer all of the questions in the set. The choices may be statements that refer to concepts, principles, substances, or observable phenomena; or they may be graphs, pictures, equations, numbers, or experimental settings or situations.

Because the same five choices are applicable to several questions, the classification questions usually require less reading than other types of multiple-choice questions. Answering a question correctly depends on the sophistication of the set of questions. One set may test your ability to recall information; another set may ask you to apply information to a specific situation or to translate information from one form to another (descriptive, graphical, mathematical). The directions for this type of question specifically state that you should not eliminate a choice simply because it is the correct answer to a previous question.

Following are the directions for and an example of a classification set.

Directions: Each set of lettered choices below refers to the numbered statements immediately following it. Select the one lettered choice that best fits each statement or answers each question and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1–3 refer to the following aqueous solutions:

- (A) 0.1 M HCl
- (B) 0.1 M NaCl
- (C) 0.1 M $\text{HC}_2\text{H}_3\text{O}_2$
- (D) 0.1 M CH_3OH
- (E) 0.1 M KOH

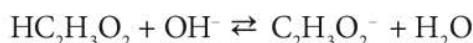
1. Is weakly acidic
2. Has the highest pH
3. Reacts with an equal volume of 0.05 M Ba(OH)_2 to form a solution with $\text{pH} = 7$

These three questions belong to the topic category of acids and bases and require you to apply knowledge in this area to the particular solutions specified in the five choices.

Choice (C) is the correct answer to question 1. To answer the first question, you must recognize which of the choices above are acid solutions. Only choices (A) and (C) satisfy this requirement. Choice (B) refers to a neutral salt solution, choice (D) is a solution of an alcohol, and choice (E) is a basic solution. Both choices (A) and (C) are acidic solutions, but choice (A) is a strong acid that is completely ionized in aqueous solution, while choice (C) is only partially ionized in aqueous solution. Since the concentrations of all the solutions are the same, you do not need to consider this factor. The hydrogen ion concentration of a 0.1-molar acetic acid solution is considerably smaller than 0.1-molar. The hydrogen ion concentration in choice (A) is equal to 0.1-molar. Thus, choice (C) is a weakly acidic solution and is the correct answer.

Choice (E) is the correct answer to question 2. To answer the second question, you need to understand the pH scale, which is a measure of the hydrogen ion concentration in solution and is defined as $\text{pH} = -\log [\text{H}^+]$. The higher the pH, the lower the hydrogen ion concentration and the more basic the solution. Among the choices given above, choice (E) is the most basic solution.

Choice (A) is the correct answer to question 3. To answer the third question, you need to know that acids react with bases to form salts and water. Since the question refers to equal volumes of each solution, assume 1 liter of each solution is available. Barium hydroxide solution is a strong base, i.e., is completely ionized in water, and 1 liter of 0.05 M Ba(OH)₂ provides 0.1 mole of OH⁻ ions in solution. When 1 liter of this solution is added to 1 liter of either 0.1 M NaCl, 0.1 M CH₃OH, or 0.1 M KOH no reactions occur and the resulting solutions remain basic, i.e., the pH will be greater than 7 in each case. When 0.1 mole OH⁻ ions reacts with 0.1 mole of acetic acid, the resulting solution will also be basic and have a pH greater than 7 because acetic acid is a weak acid, i.e., is incompletely ionized in water. The acetic acid reacts with the OH⁻ ions as follows:



The acetate salt formed hydrolyzes in water yielding a solution containing more OH⁻ ions than H⁺ ions. When 1 liter of 0.05 M Ba(OH)₂ reacts with 1 liter of 0.1 M HCl, there is a reaction between 0.1 mole OH⁻ ions and 0.1 mole H⁺ to form 0.1 mole H₂O. The resulting solution contains Ba²⁺ ions and Cl⁻ ions and equal concentrations of OH⁻ and H⁺ ions. The solution formed is neutral and the pH is 7.

Relationship Analysis Questions

This type of question consists of a specific statement or assertion (Statement I) followed by an explanation of the assertion (Statement II). The question is answered by determining if the assertion and the explanation are each true statements and, if so, whether the explanation (or reason) provided does in fact properly explain the statement given in the assertion.

This type of question tests your ability to identify proper cause-and-effect relationships. It probes whether you can assess the correctness of the original assertion and then evaluate the truth of the “reason” proposed to justify it. The analysis required by this type of question provides you with an opportunity to demonstrate developed reasoning skills and the scope of your understanding of a particular topic.

On the actual Chemistry Test, the following type of question must be answered on a special section (labeled “Chemistry”) at the lower left-hand corner of your answer sheet. These questions will be numbered beginning with 101 and must be answered according to the following directions.

SAMPLE ANSWER GRID

	I	II	CE*
101	(T) (F)	(T) (F)	()

Directions: Each question below consists of two statements, I in the left-hand column and II in the right-hand column. For each question, determine whether statement I is true or false and whether statement II is true or false and fill in the corresponding T or F circles on your answer sheet. Fill in circle CE only if statement II is a correct explanation of the true statement I.

EXAMPLES:			
I		II	
EX 1. H_2SO_4 is a strong acid	BECAUSE	H_2SO_4 contains sulfur.	
EX 2. An atom of oxygen is electrically neutral	BECAUSE	an oxygen atom contains an equal number of protons and electrons.	
SAMPLE ANSWERS	EX 1 EX 2	I <input checked="" type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/>	II <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/>

I

II

4. The electrolysis of a concentrated solution of sodium chloride produces chlorine BECAUSE sodium chloride is a covalent compound.

The above question has several components. Statement I, the assertion, has to do with an oxidation-reduction reaction, more specifically, an electrochemical reaction. This statement is true because the electrolysis of a concentrated sodium chloride solution yields chlorine gas at the anode (oxidation) and hydrogen gas at the cathode (reduction). The electrolytic solution gradually becomes alkaline with the accumulation of hydroxide ions (i.e., OH^- ions) as the reaction proceeds.

Statement II, the reason, is false because the type of chemical bonding in sodium chloride is ionic. According to the directions for answering this question type, you should fill in the corresponding T and F circles on your answer sheet.

I

II

5. Atoms of different elements can have the same mass number BECAUSE atoms of each element have a characteristic number of protons in the nucleus.

This is a question on atomic structure. The sum of the number of protons plus the number of neutrons contained in the nucleus of an atom is the mass number. However, atoms of the same element may have different numbers of neutrons in their nuclei and thus have different masses. Such atoms, which have the same number of protons but different numbers of neutrons, are called isotopes of an element (${}^{12}\text{C}$ and ${}^{14}\text{C}$, for example). The existence of isotopes makes it possible for atoms of different elements,

that is, with different numbers of protons, to have the same total mass or mass number ($^{14}_6\text{C}$ and $^{14}_7\text{N}$, for example). Thus Statement I is true. Statement II is also true because the number of protons in the nucleus of an atom is a characteristic feature that identifies each element. But it is not the reason that explains the existence of isotopes and so does not properly explain Statement I. Thus, to answer this question, you should fill in both T circles for this question, but not the CE circle.

I

6. When the system $\text{CO}(g) + \text{Cl}_2(g) \rightleftharpoons \text{COCl}_2(g)$ is at equilibrium and the pressure on the system is increased by decreasing the volume at constant temperature, more $\text{COCl}_2(g)$ will be produced

BECAUSE

an increase of pressure on a system will be relieved when the system shifts to a smaller total number of moles of gas.

II

Statement I is true because whenever stress is applied to a system at equilibrium the system will tend to shift to relieve the stress (Le Chatelier's principle). In the system described, the stress is caused by an increase in pressure resulting from a decrease in the volume and will be relieved by the reaction of some CO and Cl₂ to form more COCl₂. The new equilibrium that will be established will contain a smaller total number of moles of gas, thereby reducing the pressure stress. This is the explanation given in Statement II, which is not only true but also correctly explains the phenomenon described in Statement I. Thus, to answer this question correctly you should fill in both T circles as well as the CE circle.

Five-Choice Completion Questions

The five-choice completion question is written either as an incomplete statement or as a question. It is appropriate when: (1) the problem presented is clearly delineated by the wording of the question so that you are asked to choose not a universal solution but the best of the solutions offered; (2) the problem is such that you are required to evaluate the relevance of five plausible, or even scientifically accurate, options and to select the one most pertinent; (3) the problem has several pertinent solutions and you are required to select the one inappropriate solution that is presented. Such questions normally contain a word in capital letters such as NOT, LEAST, or EXCEPT.

A special type of five-choice completion question is used in some tests, including the SAT Subject Test in Chemistry, to allow for the possibility of multiple correct answers. For these questions, you must evaluate each response independently of the others in order to select the most appropriate combination. In questions of this type several (usually three or four) statements labeled by Roman numerals are given with the question. One or more of these statements may correctly answer the question. You must select, from among the five lettered choices that follow, the one combination of statements that best answers the question. In the test, questions of this type are intermixed among the more standard five-choice completion questions. (Question 8 is an example of this type of question.)

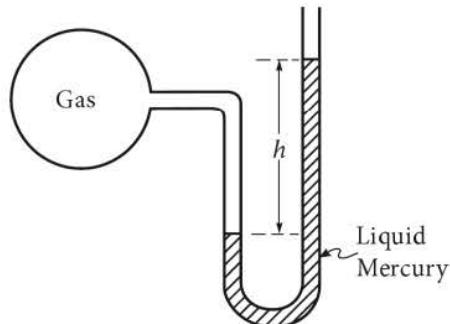
In five-choice completion questions, you may be asked to convert the information given in a word problem into graphical form or to select and apply the mathematical relationship necessary to solve the scientific problem. Alternatively, you may be asked to interpret experimental data, graphical stimuli, or mathematical expressions.

When the experimental data or other scientific problems to be analyzed are comparatively extensive, it is often convenient to organize several five-choice completion questions into sets, that is, direct each question in a set to the same material. This practice allows you to answer several questions based on the same material. In no case, however, is the answer to one question necessary for answering a subsequent question correctly. Each question in a set is independent of the others and refers only to the material given for the entire set.

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

7. The hydrogen ion concentration of a solution prepared by diluting 50 milliliters of 0.100-molar HNO₃ with water to 500 milliliters of solution is
 - (A) 0.0010 M
 - (B) 0.0050 M
 - (C) 0.010 M
 - (D) 0.050 M
 - (E) 1.0 M

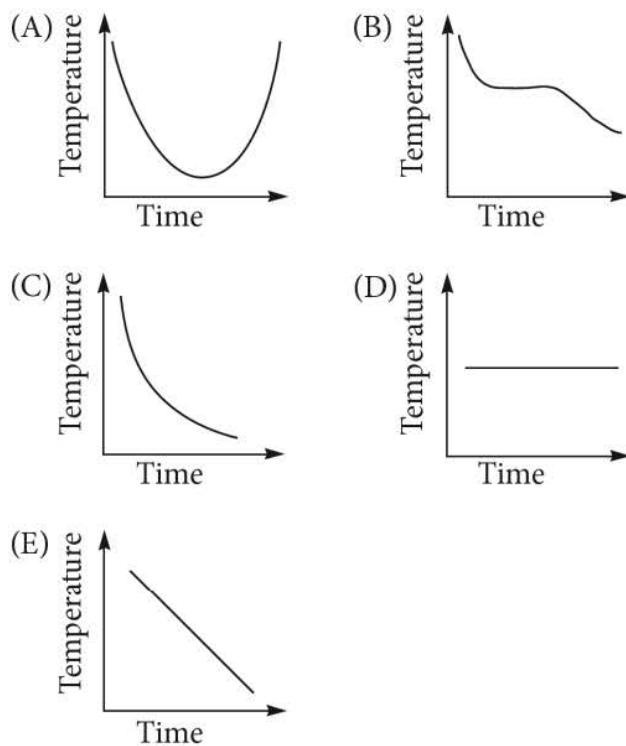
Choice (C) is the correct answer to question 7. This is a question that concerns solution concentrations. One way to solve the problem is through the use of ratios. In this question, a solution of nitric acid is diluted 10-fold; therefore, the concentration of the solution will decrease by a factor of 10, that is, from 0.100-molar to 0.010-molar. Alternatively, you could calculate the number of moles of H⁺ ions present and divide this value by 0.50 liter: $(0.100 \times 0.050)/0.5 = M$ of the diluted solution.



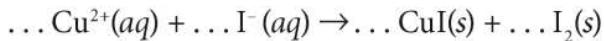
8. The bulb of the open-end manometer shown above contains a gas. True statements about this system include which of the following?
- Only atmospheric pressure is exerted on the exposed mercury surface in the right side of the tube.
 - The gas pressure is greater than atmospheric pressure.
 - The difference in the height, h , of mercury levels is equal to the pressure of the gas.
- (A) II only
 (B) III only
 (C) I and II only
 (D) I and III only
 (E) I, II, and III

Choice (C) is the correct answer to question 8. This is a laboratory-oriented question pertaining to the measurement of gas pressures. It demands higher-level analytical skills that involve drawing conclusions from results obtained in an experiment. To answer this question correctly, you must first understand that, in an open type of manometer, the air exerts pressure on the column of liquid in the open side of the U-tube and the gas being studied exerts pressure on the other side of the U-tube. It is clear then that Statement I is true since the data given show that the manometer is open-ended and its right side is exposed to the atmosphere. Statement II is also a true statement because the level of liquid mercury is higher in the right side, which is exposed to the atmosphere, than in the left side, which is exposed to the gas. Thus the gas pressure is greater than atmospheric pressure. Statement III is not a correct statement because the pressure of the gas in the bulb, expressed in millimeters of mercury, is equal to the difference in height, h , of the two mercury levels, plus the atmospheric pressure. Thus only Statements I and II are correct.

9. A thermometer is placed in a test tube containing a melted pure substance. As slow cooling occurs, the thermometer is read at regular intervals until well after the sample has solidified. Which of the following types of graphs is obtained by plotting temperature versus time for this experiment?



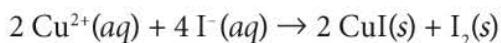
Choice (B) is the correct answer to question 9. This is a question on states of matter. You must convert the description of the physical phenomenon given in the question to graphical form. When a liquid is cooled slowly, its temperature will decrease with time. Thus the first portion of a graph depicting this phenomenon must show a decrease when temperature is plotted against time. When a pure liquid substance reaches its fusion (melting) point, continued cooling will release heat with time as the substance solidifies. During this period there is no drop in temperature. After the substance has completely solidified, further cooling will cause an additional drop in temperature. The only graph shown that accurately depicts the events described is (B), which is the answer.



10. When the equation above is balanced and all coefficients are reduced to lowest whole-number terms, the coefficient for $\text{I}^-(aq)$ is

- (A) 1
- (B) 2
- (C) 3
- (D) 4
- (E) 5

Choice (D) is the correct answer to question 10. This question pertains to the balancing of chemical equations. In order to answer this question correctly, you need to recognize that both mass and charge must be conserved in any chemical equation. With this in mind, the chemical equation is correctly written as



The coefficient for $\text{I}^-(aq)$ is 4.

11. From their electron configurations, one can predict that the geometric configuration for which of the following molecules is NOT correct.

- (A) PF_3 trigonal planar
- (B) CF_4 tetrahedral
- (C) CHCl_3 irregular tetrahedron
- (D) OF_2 bent (v-shaped)
- (E) HF linear

Choice (A) is the correct answer to question 11. This is a question on chemical bonding and requires you to apply the principles of molecular bonding. Each of the molecules given is correctly paired with the term describing its molecular geometry except choice (A). The geometry of PF_3 is not trigonal planar, but trigonal pyramidal, because this geometry corresponds to a maximum possible separation of the electron pairs around the central atom, phosphorus, and therefore yields the most stable configuration; the central atom of the molecule is surrounded by three single bonds and one unshared electron pair. Thus, the correct answer is choice (A). Note that this is the type of question that asks you to identify the *one* solution to the problem that is *inappropriate*.



12. According to the reaction above, how many moles of $\text{SO}_2(g)$ are required to react completely with 1 mole of $\text{O}_2(g)$?

- (A) 0.5 mole
- (B) 1 mole
- (C) 2 moles
- (D) 3 moles
- (E) 4 moles

Choice (C) is the correct answer to question 12. This is a question on descriptive chemistry that also tests your ability to balance chemical equations. The correct answer to this question depends first on your knowing that the combustion of sulfur dioxide, $\text{SO}_2(g)$, produces sulfur trioxide, SO_3 . The stoichiometry of the correctly balanced equation indicates that 2 moles of $\text{SO}_2(g)$ are needed to react completely with 1 mole of $\text{O}_2(g)$ to form 2 moles of SO_3 .

13. Analysis by mass of a certain compound shows that it contains 14.4 percent hydrogen and 85.6 percent carbon. Which of the following is the most informative statement that can properly be made about the compound on the basis of these data?
- (A) It is a hydrocarbon.
 - (B) Its empirical formula is CH_2 .
 - (C) Its molecular formula is C_2H_4 .
 - (D) Its molar mass is 28 grams.
 - (E) It contains a triple bond.

Choice (B) is the correct answer to question 13. This is a question on stoichiometry that tests the important skill of scientific reasoning based on experimental evidence. The question states that 100 percent of the composition of the compound analyzed can be accounted for with the elements hydrogen and carbon. Thus, this compound is a hydrocarbon and choice (A) is a correct statement. It is not the correct answer to the question, however, because you can deduce more specific conclusions about this compound from the information given. The relative percentage composition provides evidence that the atomic ratio of carbon to hydrogen in the compound must be $85.6/12.0 : 14.4/1.0$ or 1:2. Therefore, you can conclude that the empirical formula for the compound is CH_2 , a hydrocarbon. Thus choice (B) is a better answer than choice (A). Since you do not know the total number of moles of the compound used for analysis, you cannot calculate the molar mass or derive the molecular formula for this compound. Thus choices (C) and (D) cannot be determined from the information given and so they are not correct answers to the question. It is known, however, that a substance with an empirical formula of CH_2 cannot have a triple bond. Therefore, choice (E) is incorrect.

Chemistry Test

Practice Helps

The test that follows is an actual, recently administered SAT Subject Test in Chemistry. To get an idea of what it's like to take this test, practice under conditions that are much like those of an actual test administration.

- Set aside an hour when you can take the test uninterrupted. Make sure you complete the test in one sitting.
- Sit at a desk or table with no other books or papers. Dictionaries, other books, or notes are not allowed in the test room.
- Tear out an answer sheet from the back of this book and fill it in just as you would on the day of the test. One answer sheet can be used for up to three Subject Tests.
- Read the instructions that precede the practice test. During the actual administration you will be asked to read them before answering test questions.
- Time yourself by placing a clock or kitchen timer in front of you.
- After you finish the practice test, read the sections "How to Score the SAT Subject Test in Chemistry" and "How Did You Do on the Subject Test in Chemistry?"
- The appearance of the answer sheet in this book may differ from the answer sheet you see on test day.

CHEMISTRY TEST

The top portion of the section of the answer sheet that you will use in taking the Chemistry Test must be filled in exactly as shown in the illustration below. Note carefully that you have to do all of the following on your answer sheet.

1. Print CHEMISTRY on the line under the words "Subject Test (print)."

2. In the shaded box labeled "Test Code" fill in four circles:

—Fill in circle 2 in the row labeled V.

—Fill in circle 2 in the row labeled W.

—Fill in circle 4 in the row labeled X.

—Fill in circle D in the row labeled Y.

Test Code									
V	1	●	3	4	5	6	7	8	9
W	1	●	3	4	5	6	7	8	9
X	1	2	3	●	5	Y	(A)	(B)	(C)
Q	1	2	3	4	5	6	7	8	9

Subject Test (print) CHEMISTRY
--

3. Please answer the questions below by filling in the appropriate circles in the row labeled Q on the answer sheet. The information you provide is for statistical purposes only and will not affect your score on the test.

Question I

How many semesters of chemistry have you taken in high school? (If you are taking chemistry this semester, count it as a full semester.) Fill in only one circle of circles 1-3.

- One semester or less
- Two semesters
- Three semesters or more

—Fill in circle 1.
—Fill in circle 2.
—Fill in circle 3.

Question II

How recently have you studied chemistry?

- I am currently enrolled in or have just completed a chemistry course.
- I have not studied chemistry for 6 months or more.

—Fill in circle 4.
—Fill in circle 5.

Question III

Which of the following best describes your preparation in algebra? (If you are taking an algebra course this semester, count it as a full semester.) Fill in only one circle of circles 6-8.

- One semester or less
- Two semesters
- Three semesters or more

—Fill in circle 6.
—Fill in circle 7.
—Fill in circle 8.

Question IV

Are you currently taking Advanced Placement Chemistry? If you are, fill in circle 9.

When the supervisor gives the signal, turn the page and begin the Chemistry Test. There is a total of 85 questions in the Chemistry Test (1-70 plus questions 101-115 that must be answered on the special section at the lower left-hand corner of the answer sheet).

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CHEMISTRY TEST

MATERIAL IN THE FOLLOWING TABLE MAY BE USEFUL IN ANSWERING THE QUESTIONS IN THIS EXAMINATION.

DO NOT DETACH FROM BOOK.

PERIODIC TABLE OF THE ELEMENTS

H	1.0079	3	4	
Li	6.941	11	12	Be
				9.012
Na	22.99	24.30		
K	39.10	40.08	44.96	47.90
			50.94	52.00
Ca	37	38	39	40
				41
Sc				42
Ti				43
V				44
Cr				45
Mn				46
Fe				47
Co				48
Ni				49
Cu				50
Zn				51
Ga				52
Ge				53
As				54
Se				55
Br				56
Kr				57
Rb	85.47	87.62	88.91	91.22
				92.91
Sr				95.94
Y				(98)
Zr				101.1
Nb				102.91
Mo				106.42
Tc				107.87
Ru				112.41
Pd				114.82
Ag				118.71
Cd				121.75
In				127.60
Sn				126.91
Sb				131.29
Te				131.00
I				131.29
Xe				131.29
Cs	55	56	57	72
Ba				73
*La				74
Hf				75
Ta				76
W				77
Re				78
Os				79
Ir				80
Pt				81
Au				82
Hg				83
Tl				84
Pb				85
Bi				86
Po				86
At				86
Rn				(222)
Fr	87	88	89	104
Ra				105
†Ac				106
Rf				107
Db				108
Sg				109
Bh				110
Hs				111
Mt				112
§				§
§				§
				(277)

§Not yet named

He	2	4,0026
B	5	6
C	6	7
N	7	8
O	8	9
F	9	10
Ne	10	20,179
Al	10,811	12,011
Si	13	14
P	14	15
S	15	16
Cl	16	17
Ar	17	18
Ge	26,98	28,09
As	31	32
Se	32	33
Br	33	34
Kr	34	35
Ga	35,972	74,92
In	65,39	69,72
Tl	69,72	74,92
Sn	72,59	78,96
Sb	74,92	78,96
Te	112,41	118,71
Pb	114,82	121,75
Bi	118,71	127,60
Po	204,38	207,2
At	200,59	208,98
Rn	(209)	(210)

Ce	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Pr	140.12	140.91	144.24	(145)	150.4	151.97	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97
Nd	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Pm														
Eu														
Gd														
Tb														
Dy														
Ho														
Er														
Tm														
Yb														
Lu														
Th	232.04	231.04	227.03	(261)	(262)	(263)	(262)	(265)	(266)	(269)	(272)	(277)	(258)	(260)
Pa														
U														
Np														
Am														
Cm														
Bk														
Cf														
Es														
Mn														
Dy														
Ho														
Er														
Tm														
Yb														
Lu														

*Lanthanide Series

†Actinide Series



CHEMISTRY TEST



Note: For all questions involving solutions, assume that the solvent is water unless otherwise stated.

Throughout the test the following symbols have the definitions specified unless otherwise noted.

H	= enthalpy	atm	= atmosphere(s)
M	= molar	g	= gram(s)
n	= number of moles	J	= joule(s)
P	= pressure	kJ	= kilojoule(s)
R	= molar gas constant	L	= liter(s)
S	= entropy	mL	= milliliter(s)
T	= temperature	mm	= millimeter(s)
V	= volume	mol	= mole(s)
		V	= volt(s)

Part A

Directions: Each set of lettered choices below refers to the numbered statements or questions immediately following it. Select the one lettered choice that best fits each statement or answers each question and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-3 refer to the following pieces of laboratory equipment.

- (A) Condenser
 - (B) Funnel
 - (C) Pipet
 - (D) Balance
 - (E) Barometer
1. Commonly used to transfer an exact volume of liquid from one container to another
 2. Commonly used in a distillation setup
 3. Commonly used in a filtration setup

Questions 4-6 refer to the following information.

- Na_2CrO_4 , a soluble yellow solid
 PbCrO_4 , an insoluble yellow solid
 NaNO_3 , a soluble white solid
 $\text{Pb}(\text{NO}_3)_2$, a soluble white solid
- (A) Yellow solid and colorless solution
 - (B) Yellow solid and yellow solution
 - (C) White solid and colorless solution
 - (D) No solid and yellow solution
 - (E) No solid and colorless solution
4. Observed when 1.0 mol of Na_2CrO_4 and 2.0 mol of $\text{Pb}(\text{NO}_3)_2$ are mixed with 1 L of water
 5. Observed when 3.0 mol of Na_2CrO_4 and 1.0 mol of $\text{Pb}(\text{NO}_3)_2$ are mixed with 1 L of water
 6. Observed when 1.0 mol of NaNO_3 and 1.0 mol of $\text{Pb}(\text{NO}_3)_2$ are mixed with 1 L of water

3YAC2

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GO ON TO THE NEXT PAGE 



CHEMISTRY TEST—Continued



Questions 7-9 refer to the following.

- (A) Reduction potential
 - (B) Ionization energy (ionization potential)
 - (C) Electronegativity
 - (D) Heat of formation
 - (E) Activation energy
7. Is the energy change accompanying the synthesis of a compound from its elements in their standard states
8. Is the energy needed to remove an electron from a gaseous atom in its ground state
9. Is the minimum energy needed for molecules to react and form products

Questions 10-13 refer to the following pairs of substances.

- (A) NH₃ and N₂H₄
 - (B) ¹⁶O and ¹⁷O
 - (C) NH₄Cl and NH₄NO₃
 - (D) CH₃OCH₃ and CH₃CH₂OH
 - (E) O₂ and O₃
10. Are isotopes
11. Have both ionic and covalent bonds
12. Are allotropes
13. Are strong electrolytes in aqueous solution

Questions 14-17 refer to the following subshells.

- (A) 1s
 - (B) 2s
 - (C) 3s
 - (D) 3p
 - (E) 3d
14. Contains up to ten electrons
15. Contains one pair of electrons in the ground-state electron configuration of the lithium atom
16. Is exactly one-half filled in the ground-state electron configuration of the phosphorus atom
17. Contains the valence electrons in the ground-state electron configuration of the magnesium atom

Questions 18-20 refer to the following gases.

- (A) O₃
 - (B) O₂
 - (C) CO
 - (D) Cl₂
 - (E) SO₂
18. Contributes to acid rain
19. In the stratosphere, screens out a large fraction of ultraviolet rays from the Sun
20. Is a product of the incomplete combustion of hydrocarbons

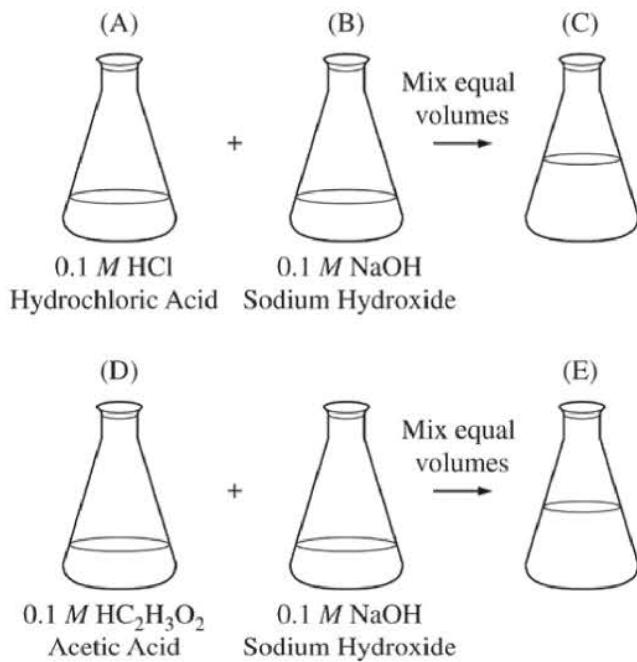
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CHEMISTRY TEST—Continued

Questions 21–24 refer to the lettered solutions in the laboratory schemes represented below.



21. Has a hydroxide ion concentration of 10^{-7} M at 298 K
22. Has the highest pH at 298 K
23. Has a pH greater than 7, but less than 13 at 298 K
24. Has a pH greater than 2, but less than 7 at 298 K



CHEMISTRY TEST—Continued

PLEASE GO TO THE SPECIAL SECTION LABELED CHEMISTRY AT THE LOWER LEFT-HAND CORNER OF THE PAGE OF THE ANSWER SHEET YOU ARE WORKING ON AND ANSWER QUESTIONS 101-115 ACCORDING TO THE FOLLOWING DIRECTIONS.

Part B

Directions: Each question below consists of two statements, I in the left-hand column and II in the right-hand column. For each question, determine whether statement I is true or false and whether statement II is true or false and fill in the corresponding T or F circles on your answer sheet. Fill in circle CE only if statement II is a correct explanation of the true statement I.

EXAMPLES:

- | I | II |
|---|---|
| EX 1. H ₂ SO ₄ is a strong acid | BECAUSE H ₂ SO ₄ contains sulfur. |
| EX 2. An atom of oxygen is electrically neutral | BECAUSE an oxygen atom contains an equal number of protons and electrons. |

SAMPLE ANSWERS

	I	II	CE*
EX1	● (F)	● (F)	○
EX2	● (F)	● (F)	●

- | I | II |
|---|--|
| 101. C ₂ H ₂ and C ₆ H ₆ have the same chemical and physical properties | BECAUSE C ₂ H ₂ and C ₆ H ₆ have the same percentages by mass of hydrogen. |
| 102. The melting of ice is an exothermic process | BECAUSE water has a relatively high specific heat capacity. |
| 103. A 2 g sample of nitrogen and a 2 g sample of oxygen contain the same number of molecules | BECAUSE equal masses of gaseous substances contain the same number of molecules. |
| 104. When an atom absorbs a photon of visible light, one of its electrons is promoted to a higher energy state | BECAUSE an electron has a negative charge. |
| 105. The alkali metals are very good reducing agents | BECAUSE the alkali metals are easily oxidized. |
| 106. A 1.0 g sample of calcium citrate, Ca ₃ (C ₆ H ₅ O ₇) ₂ (molar mass 498 g/mol), contains more Ca than a 1.0 g sample of calcium carbonate, CaCO ₃ (molar mass 100 g/mol), | BECAUSE there are more Ca atoms in 1.0 mol of calcium carbonate than in 1.0 mol of calcium citrate. |
| 107. The water molecule is polar | BECAUSE the radius of an oxygen atom is greater than that of a hydrogen atom. |

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GO ON TO THE NEXT PAGE 



CHEMISTRY TEST—Continued



I

108. All indicators are colorless in neutral solution

BECAUSE indicators develop color only in the presence of a strong acid or a strong base.

109. A 1 *M* sucrose solution and a 1 *M* NaCl solution have the same freezing point

BECAUSE a 1 *M* sucrose solution and a 1 *M* NaCl solution contain the same number of solute particles per liter of solution.

110. The average kinetic energy of gas molecules increases as the temperature increases

BECAUSE the average speed of gas molecules decreases as the temperature increases.

111. When a concentrated acid is diluted, the acid should be added slowly to the water

BECAUSE if water is added to a concentrated acid, violent splattering might occur.

112. Methane, CH₄, is very soluble in water

BECAUSE water molecules form hydrogen bonds with methane molecules.

113. A 1 mol sample of electrons is required to reduce 0.5 mol of chlorine gas to chloride ions

BECAUSE chlorine molecules are diatomic and the charge on the chloride ion is -1.

114. In 0.1 *M* acetic acid, [H⁺] is smaller than [H⁺] is in 0.1 *M* hydrochloric acid

BECAUSE a molecule of acetic acid contains more atoms than does a molecule of hydrogen chloride.

115. A fluoride ion, F⁻, and an oxide ion, O²⁻, have the same diameter

BECAUSE the fluoride ion, F⁻, and the oxide ion, O²⁻, have the same number of electrons.

II

RETURN TO THE SECTION OF YOUR ANSWER SHEET YOU STARTED FOR CHEMISTRY AND ANSWER QUESTIONS 25-70.

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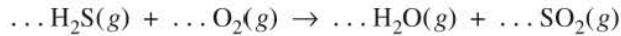


CHEMISTRY TEST—Continued



Part C

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.



25. When 2 mol of $\text{H}_2\text{S}(g)$ react with an excess of oxygen according to the equation above, how much $\text{H}_2\text{O}(g)$ is produced? (Equation is not balanced.)

- (A) 1 mol
- (B) 2 mol
- (C) 3 mol
- (D) 4 mol
- (E) 6 mol

26. Increasing the temperature of a gas in a rigid closed container increases which of the following?

- I. The pressure of the gas
 - II. The average speed of the gas molecules
 - III. The mass of the gas
- (A) I only
 - (B) II only
 - (C) I and II only
 - (D) II and III only
 - (E) I, II, and III

27. The number of electrons in $^{118}_{50}\text{Sn}^{2+}$ is

- (A) 2
- (B) 48
- (C) 50
- (D) 52
- (E) 68

28. When two colorless liquid reagents are mixed, which of the following observations would suggest that a chemical reaction has occurred?

- I. Formation of a precipitate
 - II. A color change
 - III. Appearance of gas bubbles
- (A) I only
 - (B) III only
 - (C) I and II only
 - (D) II and III only
 - (E) I, II, and III

29. Which of the following is the correct and complete Lewis electron-dot diagram for PF_3 ?

- (A) $\text{F}:\ddot{\text{P}}:\text{F}$
 F
- (B) $:\ddot{\text{F}}:\text{P}:\ddot{\text{F}}:$
 $:\ddot{\text{F}}:$
- (C) $:\ddot{\text{F}}:\text{P}:\ddot{\text{F}}:$
 $:\ddot{\text{F}}:$
- (D) $:\ddot{\text{F}}:\ddot{\text{P}}:\ddot{\text{F}}:$
 $:\ddot{\text{F}}:$
- (E) $:\ddot{\text{F}}:\ddot{\text{P}}:\ddot{\text{F}}:$
 $:\ddot{\text{F}}:$



CHEMISTRY TEST—Continued

30. Which of the following is a transition element?
- (A) Iron
(B) Carbon
(C) Potassium
(D) Tin
(E) Radium
31. When 50. mL of 1.5 M $\text{NaCl}(aq)$ is diluted with pure water to a final volume of 150. mL, what is the molarity of the resulting solution?
- (A) 0.10 M
(B) 0.50 M
(C) 1.5 M
(D) 4.5 M
(E) 5.0 M
32. A 40.0 g sample of a hydrated salt was heated until all the water was driven off. The mass of the solid remaining was 32.0 g. What was the percent of water by mass in the original sample?
- (A) 13.0%
(B) 20.0%
(C) 25.0%
(D) 75.0%
(E) 80.0%
33. A solution that has pH of 6.0 is
- (A) strongly basic
(B) slightly basic
(C) neutral
(D) slightly acidic
(E) strongly acidic
34. Which of the following molecules is a saturated hydrocarbon?
- (A) C_3H_8
(B) C_2H_4
(C) CH_3Cl
(D) CCl_4
(E) CO_2
35. When the equation above is balanced and all the coefficients are reduced to lowest whole-number terms, what is the coefficient for $\text{Fe}_2\text{O}_3(s)$?
- ... $\text{Fe}_2\text{O}_3(s) + \dots \text{CO}(g) \rightarrow \dots \text{Fe}(s) + \dots \text{CO}_2(g)$
- (A) 1
(B) 2
(C) 3
(D) 4
(E) 5
36. In which of the following compounds does nitrogen have an oxidation number of +5?
- (A) HNO_3
(B) N_2
(C) NO_2
(D) N_2O
(E) NH_2OH
37. If both NaOH and KOH were the same price per kilogram, it would be cheaper to use NaOH to neutralize a quantity of acid because NaOH
- (A) weighs less per mole than KOH
(B) weighs more per mole than KOH
(C) neutralizes more acid per mole than KOH
(D) neutralizes less acid per mole than KOH
(E) is less dense than KOH
38. When a given amount of $\text{Ca}(\text{OH})_2$ is completely neutralized with H_2SO_4 , which of the following is the mole ratio of $\text{Ca}(\text{OH})_2$ to H_2SO_4 in this reaction?
- (A) 1 : 4
(B) 1 : 2
(C) 1 : 1
(D) 2 : 1
(E) 4 : 1

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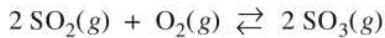
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CHEMISTRY TEST—Continued

39. Factors that influence whether or not two colliding molecules will react include which of the following?

- I. The energy of the collision
 - II. The orientation of the molecules
 - III. The size difference between the reactant and product molecules
- (A) I only
(B) III only
(C) I and II only
(D) I and III only
(E) I, II, and III



40. What is the expression for the equilibrium constant, K_{eq} , for the reaction represented above?

(A) $K_{eq} = \frac{[\text{SO}_3]}{[\text{SO}_2][\text{O}_2]}$

(B) $K_{eq} = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$

(C) $K_{eq} = \frac{[\text{SO}_2] + [\text{O}_2]}{[\text{SO}_3]}$

(D) $K_{eq} = \frac{[\text{SO}_2]^2 + [\text{O}_2]}{[\text{SO}_3]^2}$

(E) $K_{eq} = \frac{[\text{SO}_3]}{[\text{SO}_2] + [\text{O}_2]}$

41. A solution contains 1.00 mol of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, and 2.00 mol of urea, $(\text{NH}_2)_2\text{CO}$, in 7.00 mol of water. What is the mole fraction of glucose in the solution?

- (A) 0.100
(B) 0.143
(C) 0.200
(D) 0.333
(E) 0.500

Temperature (°C)	Vapor Pressure of Ethyl Alcohol (mm Hg)
60	350
70	538
80	813
90	1,182
100	1,698

42. The barometric pressure on Pikes Peak (14,109 feet) in Colorado averages 455 mm Hg. From the table above, one can conclude that the boiling point of ethyl alcohol at this altitude would be

- (A) 100°C
- (B) between 90°C and 100°C
- (C) between 80°C and 90°C
- (D) between 70°C and 80°C
- (E) between 60°C and 70°C



43. When the equation for the reaction represented above is completed and balanced and all coefficients are reduced to lowest whole-number terms, the coefficient for $\text{H}^+(aq)$ is

- (A) 2
- (B) 3
- (C) 4
- (D) 5
- (E) 6

44. Which of the following statements is true concerning a saturated solution of a salt at a constant temperature?

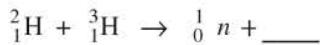
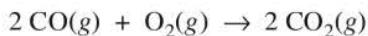
- (A) The concentrations of salt and solvent are usually equal.
- (B) The amount of dissolved salt is constant.
- (C) Addition of solid salt shifts the equilibrium, which results in an increase in the amount of dissolved salt.
- (D) The solution is unstable and sudden crystallization could occur.
- (E) At the same temperature, a saturated solution of any other salt has the same concentration.

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CHEMISTRY TEST—Continued



45. According to the reaction represented above, 1.00 mol of $\text{CO}(g)$ reacts at 0°C and 1 atm to consume how much $\text{O}_2(g)$?

(A) 32.0 g
(B) 11.2 L
(C) 22.4 L
(D) 1.00 mol
(E) 2.00 mol

46. Species that in water can either accept or donate protons include which of the following?

I. CH_4
II. HCO_3^-
III. HPO_4^{2-}

(A) I only
(B) II only
(C) III only
(D) II and III only
(E) I, II, and III

47. The ionization energies of Li and H are 520 kJ/mol and 1,312 kJ/mol, respectively. The ionization energy of He is

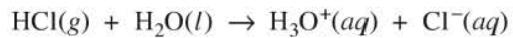
(A) 496 kJ/mol
(B) 656 kJ/mol
(C) 899 kJ/mol
(D) 1,086 kJ/mol
(E) 2,372 kJ/mol

48. An active ingredient in common household bleach solutions is most likely to be which of the following?

(A) NaCl
(B) NaClO
(C) NaHCO_3
(D) Na_2SO_4
(E) $\text{HC}_2\text{H}_3\text{O}_2$

49. The missing product in the nuclear reaction represented above is

(A) ^1_1H
(B) ^3_2He
(C) ^4_2He
(D) ^4_3Li
(E) ^5_3Li



50. All of the following statements are correct for the reaction represented by the equation above EXCEPT:

(A) H_3O^+ is the conjugate acid of H_2O .
(B) Cl^- is the conjugate base of HCl.
(C) H_2O is behaving as a Brønsted-Lowry base.
(D) HCl is a weaker Brønsted-Lowry acid than H_2O .
(E) The reaction proceeds essentially to completion.

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CHEMISTRY TEST—Continued



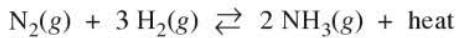
P (atm)	2	1	0.5	0.4
V (L)	100	200	400	500
T (K)	200	200	200	200

51. The data given in the table above describe the behavior of a sample of gas. Which of the following empirical laws does the data illustrate? (k is a constant.)

- (A) $P = kT$ at constant V
(B) $P_T = P_1 + P_2 + P_3 + \dots$ at constant V and T
(C) $P = \frac{k}{V}$ at constant T
(D) $V = kT$ at constant P
(E) $P = kn$ (number of moles) at constant V and T

52. Of the following, which is an example of an oxidation-reduction reaction?

- (A) $\text{Fe}(s) + \text{Sn}^{2+}(aq) \rightarrow \text{Sn}(s) + \text{Fe}^{2+}(aq)$
(B) $\text{HCO}_3^-(aq) + \text{OH}^-(aq) \rightarrow \text{CO}_3^{2-}(aq) + \text{H}_2\text{O}(l)$
(C) $\text{Pb}^{2+}(aq) + 2\text{I}^-(aq) \rightarrow \text{PbI}_2(s)$
(D) $\text{HCl}(g) + \text{NH}_3(g) \rightarrow \text{NH}_4\text{Cl}(s)$
(E) $\text{Ba}^{2+}(aq) + \text{MnO}_4^{2-}(aq) \rightarrow \text{BaMnO}_4(s)$



53. Which of the following statements about the reaction represented above is true?

- (A) The forward reaction is endothermic.
(B) A 28 g sample of $\text{N}_2(g)$ reacts completely with a 3 g sample of $\text{H}_2(g)$.
(C) $\text{NH}_3(g)$ will dissociate into equal masses of $\text{N}_2(g)$ and $\text{H}_2(g)$.
(D) The reactants occupy a smaller volume than the products when measured at the same temperature and pressure.
(E) The equilibrium concentration of ammonia is affected by a change in temperature.



CHEMISTRY TEST—Continued



54. The element carbon is the chief constituent of all of the following EXCEPT

(A) coal
(B) glass
(C) diamond
(D) charcoal
(E) graphite

55. At 0°C and 1.0 atm, the density of C_2H_4 gas is approximately

(A) 0.80 g/L
(B) 1.0 g/L
(C) 1.3 g/L
(D) 2.5 g/L
(E) 28 g/L

56. Which of the following contains a weak organic acid?

(A) Vinegar
(B) Hydrogen peroxide
(C) Baking soda
(D) Freon gas
(E) Ammonia



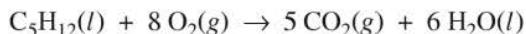
57. When 1 mol of $P_4O_{10}(s)$ reacts completely with water to produce $H_3PO_4(aq)$ according to the reaction represented by the unbalanced equation above, the number of moles of $H_2O(l)$ consumed is

(A) 1 mol
(B) 3 mol
(C) 4 mol
(D) 6 mol
(E) 12 mol

58. Increased randomness results under which of the following conditions?

I. A 1 L sample of $He(g)$ and a 1 L sample of $Ne(g)$ are mixed in a 2 L flask.
II. Ice melts.
III. $CaO(s)$ reacts with $CO_2(g)$ to form $CaCO_3(s)$.

(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III



59. According to the balanced equation above, when 4 mol of $O_2(g)$ react completely with $C_5H_{12}(l)$, which of the following is true?

(A) 1 mol of $C_5H_{12}(l)$ must react.
(B) 2 mol of $C_5H_{12}(l)$ must react.
(C) 3 mol of $H_2O(l)$ must be formed.
(D) 12 mol of $H_2O(l)$ must be formed.
(E) 5 mol of $CO_2(g)$ must be formed.

60. True statements about transition metals include which of the following?

I. Most can exhibit more than one stable oxidation state.
II. Their compounds are often colored.
III. Their ions have partially filled p -orbitals.

(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

61. The molarity of solution X is to be determined by a titration procedure. To carry out this procedure, all of the following must be known EXCEPT the

(A) equation for the chemical reaction that occurs during the titration
(B) volume of solution X that is used
(C) mass of solution X that is used
(D) volume of the solution that reacts with X
(E) molarity of the solution that reacts with X

62. The primary intermolecular attraction that makes it possible to liquefy hydrogen gas is called

(A) London dispersion forces
(B) dipole-dipole attraction
(C) covalent bonding
(D) ionic bonding
(E) hydrogen bonding

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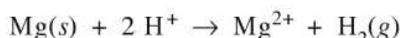
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CHEMISTRY TEST—Continued



Questions 63-65



A student performed an experiment to determine the amount of hydrogen gas released in a reaction. The student produced the hydrogen gas by reacting hydrochloric acid and a strip of magnesium metal according to the equation above. All of the magnesium metal was consumed and the hydrogen gas was collected by displacement of water in an inverted bottle. The student's data contain the following information.

Mass of Mg 0.024 g
Volume of gas collected over water 25.2 mL
Water temperature 22.0°C
Room temperature 22.0°C
Atmospheric pressure 749.8 mm Hg
Vapor pressure of water at 22°C 19.8 mm Hg

63. What number of moles of magnesium was used?

- (A) 5.8×10^{-1} mol
- (B) 3.0×10^{-2} mol
- (C) 2.4×10^{-2} mol
- (D) 1.4×10^{-3} mol
- (E) 1.0×10^{-3} mol

64. Why is it essential to know the water temperature in this experiment?

- I. To find the vapor pressure of the water
 - II. To control the rate of reaction
 - III. To make sure that the reaction goes to completion
- (A) I only
 - (B) II only
 - (C) I and III only
 - (D) II and III only
 - (E) I, II, and III

65. The volume of the dry hydrogen gas at 1 atm and room temperature would be

- (A) $\frac{(25.2)(749.8 + 19.8)}{760}$ mL
- (B) $\frac{(25.2)(760 - 19.8)}{749.8}$ mL
- (C) $\frac{(25.2)(749.8 - 19.8)}{760}$ mL
- (D) $\frac{(749.8 - 19.8)}{(760)(25.2)}$ mL
- (E) $\frac{(760 - 19.8)}{(749.8)(25.2)}$ mL



CHEMISTRY TEST—Continued



66. If 0.10 mol of HF(g) is formed according to the reaction represented above, approximately how much heat is evolved?

- (A) 13 kJ
- (B) 27 kJ
- (C) 54 kJ
- (D) 110 kJ
- (E) 220 kJ

67. A chemical reaction is used to separate a mixture into separate substances in which of the following situations?

- (A) Pure water is obtained from ocean water by evaporating the water and condensing it.
- (B) Iron filings are separated from sand by the use of a magnet.
- (C) Iron metal is produced from ore containing iron(III) oxide.
- (D) Plant pigments in a solution are separated by the use of paper chromatography.
- (E) Sand is obtained from a sand-sugar mixture by adding water to dissolve the sugar.

68. If a compound has an empirical formula of CH₂ and a molar mass of 70 g/mol, which of the following is most likely to be its molecular formula?

- (A) C₃H₆
- (B) C₄H₄
- (C) C₄H₈
- (D) C₅H₅
- (E) C₅H₁₀

69. The system above is at equilibrium in a closed container. Which of the following would increase the amount of PCl₃ in the system?

- (A) Decreasing the pressure of the system at constant temperature
- (B) Lowering the temperature at constant pressure
- (C) Adding a catalyst
- (D) Adding some Cl₂(g) to the reaction vessel
- (E) Removing some PCl₅(g) from the reaction vessel

70. Which of the following terms gives a qualitative rather than a quantitative description of the concentration of a solution?

- (A) Molality
- (B) Mass percentage
- (C) Dilute
- (D) Mole fraction
- (E) Molarity

STOP

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How to Score the SAT Subject Test in Chemistry

When you take an actual SAT Subject Test in Chemistry, your answer sheet will be “read” by a scanning machine that will record your responses to each question. Then a computer will compare your answers with the correct answers and produce your raw score. You get one point for each correct answer. For each wrong answer, you lose one-fourth of a point. Questions you omit (and any for which you mark more than one answer) are not counted. This raw score is converted to a scaled score that is reported to you and to the colleges you specify.

Worksheet 1. Finding Your Raw Test Score

STEP 1: Table A lists the correct answers for all the questions on the Subject Test in Chemistry that is reproduced in this book. It also serves as a worksheet for you to calculate your raw score.

- Compare your answers with those given in the table.
- Put a check in the column marked “Right” if your answer is correct.
- Put a check in the column marked “Wrong” if your answer is incorrect.
- Leave both columns blank if you omitted the question.

STEP 2: Count the number of right answers.

Enter the total here: _____

STEP 3: Count the number of wrong answers.

Enter the total here: _____

STEP 4: Multiply the number of wrong answers by .250.

Enter the product here: _____

STEP 5: Subtract the result obtained in Step 4 from the total you obtained in Step 2.

Enter the result here: _____

STEP 6: Round the number obtained in Step 5 to the nearest whole number.

Enter the result here: _____

The number you obtained in Step 6 is your raw score.

Table A

Answers to the Subject Test in Chemistry, Form 3YAC2, and Percentage of Students Answering Each Question Correctly									
Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*	Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*
1	C			77	33	D			80
2	A			71	34	A			58
3	B			75	35	A			60
4	A			35	36	A			61
5	B			31	37	A			54
6	E			59	38	C			63
7	D			60	39	C			55
8	B			69	40	B			66
9	E			77	41	A			60
10	B			79	42	E			73
11	C			52	43	A			56
12	E			39	44	B			44
13	C			48	45	B			50
14	E			68	46	D			55
15	A			51	47	E			42
16	D			71	48	B			33
17	C			69	49	C			66
18	E			66	50	D			53
19	A			73	51	C			74
20	C			78	52	A			53
21	C			48	53	E			48
22	B			48	54	B			71
23	E			40	55	C			32
24	D			51	56	A			63
25	B			85	57	D			70
26	C			84	58	C			24
27	B			71	59	C			76
28	E			78	60	C			41
29	E			66	61	C			45
30	A			66	62	A			25
31	B			64	63	E			52
32	B			78	64	A			37

Table A continued on next page

Table A continued from previous page

Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*	Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*
65	C			23	106	F,F			22
66	B			54	107	T,T			51
67	C			51	108	F,F			38
68	E			70	109	F,F			37
69	A			37	110	T,F			81
70	C			67	111	T,T,CE			62
101	F,T			40	112	F,F			43
102	F,T			47	113	T,T,CE			45
103	F,F			68	114	T,T			26
104	T,T			58	115	F,T			36
105	T,T,CE			67					

* These percentages are based on an analysis of the answer sheets of a representative sample of 5,571 students who took the original form of this test in November 2002, and whose mean score was 593. They may be used as an indication of the relative difficulty of a particular question. Each percentage may also be used to predict the likelihood that a typical SAT Subject Test in Chemistry candidate will answer that question correctly on this edition of the test.

Finding Your Scaled Score

When you take SAT Subject Tests, the scores sent to the colleges you specify are reported on the College Board scale, which ranges from 200–800. You can convert your practice test score to a scaled score by using Table B. To find your scaled score, locate your raw score in the left-hand column of Table B; the corresponding score in the right-hand column is your scaled score. For example, a raw score of 39 on this particular edition of the Subject Test in Chemistry corresponds to a scaled score of 590.

Raw scores are converted to scaled scores to ensure that a score earned on any one edition of a particular Subject Test is comparable to the same scaled score earned on any other edition of the same Subject Test. Because some editions of the tests may be slightly easier or more difficult than others, College Board scaled scores are adjusted so that they indicate the same level of performance regardless of the edition of the test taken and the ability of the group that takes it. Thus, for example, a score of 400 on one edition of a test taken at a particular administration indicates the same level of achievement as a score of 400 on a different edition of the test taken at a different administration.

When you take the SAT Subject Tests during a national administration, your scores are likely to differ somewhat from the scores you obtain on the tests in this book. People perform at different levels at different times for reasons unrelated to the tests themselves. The precision of any test is also limited because it represents only a sample of all the possible questions that could be asked.

Table B

Scaled Score Conversion Table Subject Test in Chemistry (Form 3YAC2)					
Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score
85	800	49	640	13	450
84	800	48	630	12	440
83	800	47	630	11	440
82	800	46	620	10	430
81	790	45	620	9	420
80	790	44	610	8	420
79	780	43	610	7	410
78	780	42	600	6	400
77	770	41	600	5	400
76	770	40	590	4	390
75	760	39	590	3	390
74	760	38	580	2	380
73	750	37	580	1	370
72	750	36	570	0	370
71	740	35	570	-1	360
70	740	34	560	-2	350
69	730	33	560	-3	350
68	730	32	550	-4	340
67	720	31	550	-5	340
66	720	30	540	-6	330
65	710	29	540	-7	320
64	710	28	530	-8	320
63	710	27	530	-9	310
62	700	26	520	-10	310
61	700	25	520	-11	300
60	690	24	510	-12	300
59	690	23	500	-13	300
58	680	22	500	-14	290
57	680	21	490	-15	290
56	670	20	490	-16	290
55	670	19	480	-17	280
54	660	18	480	-18	280
53	660	17	470	-19	280
52	650	16	470	-20	270
51	650	15	460	-21	270
50	640	14	450		

How Did You Do on the Subject Test in Chemistry?

After you score your test and analyze your performance, think about the following questions:

Did you run out of time before reaching the end of the test?

If so, you may need to pace yourself better. For example, maybe you spent too much time on one or two hard questions. A better approach might be to skip the ones you can't answer right away and try answering all the questions that remain on the test. Then if there's time, go back to the questions you skipped.

Did you take a long time reading the directions?

You will save time when you take the test by learning the directions to the Subject Test in Chemistry ahead of time. Each minute you spend reading directions during the test is a minute that you could use to answer questions.

How did you handle questions you were unsure of?

If you were able to eliminate one or more of the answer choices as wrong and guess from the remaining ones, your approach probably worked to your advantage. On the other hand, making haphazard guesses or omitting questions without trying to eliminate choices could cost you valuable points.

How difficult were the questions for you compared with other students who took the test?

Table A shows you how difficult the multiple-choice questions were for the group of students who took this test during its national administration. The right-hand column gives the percentage of students that answered each question correctly.

A question answered correctly by almost everyone in the group is obviously an easier question. For example, 79 percent of the students answered question 10 correctly. But only 40 percent answered question 23 correctly.

Keep in mind that these percentages are based on just one group of students. They would probably be different with another group of students taking the test.

If you missed several easier questions, go back and try to find out why: Did the questions cover material you haven't yet reviewed? Did you misunderstand the directions?

Chapter 7

Physics

Purpose

The Subject Test in Physics measures the knowledge you would be expected to have after successfully completing a college-preparatory course in high school. The test is not based on any one textbook or instructional approach, but concentrates on the common core of material found in most texts.

Format

This one-hour test consists of 75 multiple-choice questions. Topics that are covered in most high school courses are emphasized. Because high school courses differ, both in percentage of time devoted to each major topic and in the specific subtopics covered, most students will find that there are some questions on topics with which they are not familiar.

Content

This test covers topics listed in the chart on the next page.

Topics Covered	Approximate Percentage of Test
I. Mechanics	36–42
Kinematics , such as velocity, acceleration, motion in one dimension, motion of projectiles Dynamics , such as force, Newton's laws, statics Energy and Momentum , such as potential and kinetic energy, work, power, impulse, conservation laws Circular Motion , such as uniform circular motion and centripetal force Simple Harmonic Motion , such as mass on a spring, and the pendulum Gravity , such as the law of gravitation, orbits, Kepler's Laws	
II. Electricity and Magnetism	18–24
Electric Fields, Forces, and Potentials , such as Coulomb's law, induced charge, field and potential of groups of point charges, charged particles in electric fields Capacitance , such as parallel-plate capacitors and transients Circuit Elements and DC Circuits , such as resistors, lightbulbs, series and parallel networks, Ohm's law, Joule's law Magnetism , such as permanent magnets, fields caused by currents, particles in magnetic fields, Faraday's law, Lenz's law	
III. Waves and Optics	15–19
General Wave Properties , such as wave speed, frequency, wavelength, superposition, standing waves, Doppler effect Reflection and Refraction , such as Snell's law, changes in wavelength and speed Ray Optics , such as image formation using pinholes, mirrors, and lenses Physical Optics , such as single-slit diffraction, double-slit interference, polarization, color	
IV. Heat and Thermodynamics	6–11
Thermal Properties , such as temperature, heat transfer, specific and latent heats, thermal expansion Laws of Thermodynamics , such as first and second laws, internal energy, entropy, heat engine efficiency	
V. Modern Physics	6–11
Quantum Phenomena , such as photons, photoelectric effect Atomic , such as the Rutherford and Bohr models, atomic energy levels, atomic spectra Nuclear and Particle Physics , such as radioactivity, nuclear reactions, fundamental particles Relativity , such as time dilation, length contraction, mass-energy equivalence	
VI. Miscellaneous	4–9
General , such as history of physics and general questions that overlap several major topics Analytical Skills , such as graphical analysis, measurement, and math skills Contemporary Physics , such as astrophysics, superconductivity, and chaos theory	

How to Prepare

The test is intended for students who have completed a one-year introductory physics course at the college-preparatory level. You should be able to:

- recall and understand the major concepts of physics and to apply these physical principles you have learned to solve specific problems
- understand simple algebraic, trigonometric, and graphical relationships, and the concepts of ratio and proportion and apply these to physics problems

Laboratory experience is a significant factor in developing reasoning and problem-solving skills. This multiple-choice test can measure laboratory skills only in a limited way, such as data analysis. Familiarize yourself with directions in advance. The directions in this book are identical to those that appear on the test.

Skills Specification	Approximate Percentage of Test
Recall	20–33
Generally involves remembering and understanding concepts or information	
Single-Concept Problem	40–53
Recall and use of a single physical relationship	
Multiple-Concept Problem	20–33
Recall and integration of two or more physical relationships	
Laboratory Skills	
In each of the six major content topics, some questions may deal with laboratory skills in context	

Notes: (1) This test assumes that the direction of any current is the direction of flow of positive charge (conventional current).

- (2) Calculator use is not allowed during the test.
- (3) Numerical calculations are not emphasized and are limited to simple arithmetic.
- (4) This test predominantly uses the metric system.

Score

The total score for each test is reported on the 200-to-800 scale.

Sample Questions

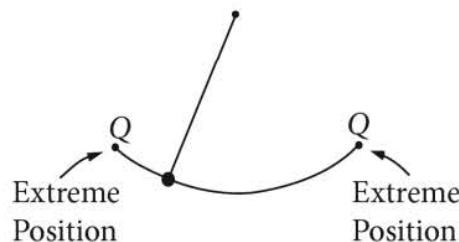
Two types of questions are used in the Subject Test in Physics and are shown in the following samples. All questions in the test are multiple-choice questions in which you must choose the BEST response from the five choices offered.

Classification Questions

Each set of classification questions includes five lettered choices that you will use to answer all of the questions in the set (see sample questions 1–4). These choices appear before the questions in the set. In addition, there may be descriptive material that is relevant in answering the questions in the set. The choices may take various forms, such as words, phrases, sentences, graphs, pictures, equations, or data. The numbered questions themselves may also take such forms, or they may be given in the question format directly. To answer each question, select the lettered choice that provides the most appropriate response. You should consider all of the lettered choices before answering a question. The directions for this type of question state specifically that a choice cannot be eliminated just because it is the correct answer to a previous question.

Because the same five choices are applicable to several questions, the classification questions usually require less reading than other types of multiple-choice questions. Therefore, classification questions provide a quick means, in terms of testing time, of determining how well you have mastered the topics represented. The set of questions may ask you to recall appropriate information, or the set may ask you to apply information to a specific situation or to translate information between different forms (descriptive, graphical, mathematical). Thus, different types of abilities can be tested by this type of question.

Directions: Each set of lettered choices below refers to the numbered questions immediately following it. Select the one lettered choice that best answers each question and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1–2

A small sphere attached to the end of a string swings as a simple pendulum. The sphere moves along the arc shown above. Consider the following properties of the sphere.

- (A) Acceleration
- (B) Kinetic energy
- (C) Mass
- (D) Potential energy
- (E) Velocity

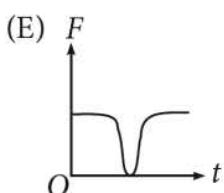
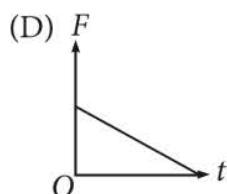
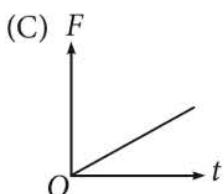
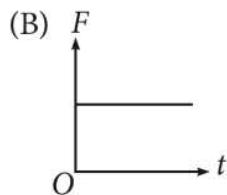
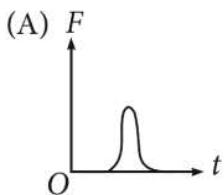
1. Which property remains constant throughout the motion of the sphere?
2. Which property goes to zero and changes direction at each extreme position Q?

Choice (C) is the correct answer to question 1. To answer this question, you may know that in classical mechanics mass is a fundamental property of an object that does not depend on the position or velocity of the object. Alternately, you may realize that, since a pendulum during its motion repeatedly speeds up, slows down, and changes direction, the sphere's velocity, kinetic energy, and acceleration must also change. Also, since the height of the sphere varies, so must its potential energy. Thus you can also obtain the answer by the process of elimination.

Choice (E) is the correct answer to question 2. To answer this question, you must know some specific details about the motion of the pendulum. At each extreme position Q, the velocity and the kinetic energy (which is proportional to the square of the speed) are both zero, but kinetic energy has magnitude only and thus no direction to change. Velocity does have direction, and in this case the velocity of the sphere is directed away from the center, or equilibrium position, just before the sphere reaches Q, but directed toward the center just after leaving Q. The velocity changes direction at each point Q. The only other choice that has direction is acceleration, but acceleration has its maximum magnitude at each point Q and is directed toward the center, both shortly before and shortly after the sphere is at Q.

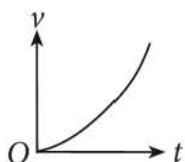
Questions 3–4

The following graphs show the net force F on an object versus time t , for the object in straight-line motion in different situations.

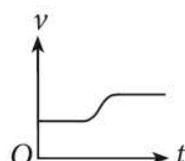


For each of the following speed v versus time t graphs for the object, choose the graph above with which it is consistent.

3.



4.



Questions 3 and 4 test the application of physical principles to information presented in graphical form. In each of these questions two concepts are involved. From Newton's second law we know that the net force on an object is equal to the object's acceleration multiplied by the object's mass, a constant. Thus graphs of acceleration versus time must have the same shape as the graphs of force versus time that are given in the options. We must also know that at a particular time the acceleration of an object in its direction of motion is equal to the rate of change of its speed, as determined by the slope of the speed v versus time t graph at that particular time.

Choice (C) is the answer to question 3. The slope of the graph continually increases with increasing t ; therefore, the object's acceleration and consequently the net force on the object must also increase continually. The only graph that shows this relationship is graph (C). Choice (A) is the correct answer to question 4. In this question, the graph initially shows a constant speed, implying an acceleration and net force of zero. Then the curve sharply increases for a brief time, implying a large positive acceleration and large net force. Finally the curve returns to constant speed, implying a return to a zero net force. Graph (A) is the only choice that shows a force that varies in this manner.

Five-Choice Completion Questions

The five-choice completion question is written either as an incomplete statement or as a question. In its simplest application, it poses a problem that intrinsically has a unique solution. It is also appropriate when: (1) the problem presented is clearly delineated by the wording of the question so that you choose not a universal solution but the best of the five offered solutions; (2) the problem is such that you are required to evaluate the relevance of five plausible, or scientifically accurate, choices and to select the one most pertinent; or (3) the problem has several pertinent solutions and you are required to select the one that is *inappropriate* or *not correct* from among the five choices presented. Questions of this latter type (see sample question 6) will normally contain a word in capital letters such as NOT, EXCEPT, or LEAST.

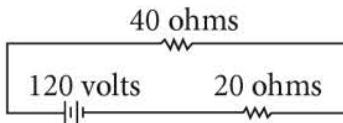
A special type of five-choice completion question is used in some tests to allow for the possibility of more than one correct answer. Unlike many quantitative problems that must by their nature have one unique solution, situations do arise in which there may be more than one correct answer. In such situations, you should evaluate each answer independently of the others in order to select the most appropriate combination (see sample question 7). In questions of this type, several (usually three) statements labeled by Roman numerals are given with the question. One or more of these statements may correctly answer the question. The statements are followed by five lettered choices, with each choice consisting of some combination of the Roman numerals that label the statements. You must select from among the five lettered choices the one that gives the combination of statements that best answers the question. In the test, questions of this type are intermixed among the more standard five-choice completion questions.

The five-choice completion question also tests problem-solving skills. With this type of question, you may be asked to convert the information given in a word problem into graphical forms or to select and apply the mathematical relationship necessary to solve the scientific problem. Alternatively, you may be asked to interpret experimental data, graphs, or mathematical expressions. Thus, the five-choice completion question can be adapted to test several kinds of abilities.

When the experimental data or other scientific problems to be analyzed are comparatively long, it is often convenient to organize several five-choice completion questions into sets, with each question in the set relating to the same common material that precedes the set (see sample questions 8–9). This practice allows you to answer several questions based on

information that may otherwise take considerable testing time to read and comprehend. Such sets also test how thorough your understanding is of a particular situation. Although the questions in a set may be related, you do not have to know the answer to one question in a set to answer a subsequent question correctly. Each question in a set can be answered directly from the common material given for the entire set.

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.



5. If the internal resistance of the 120-volt battery in the circuit shown above is negligible, the current in the wire is

- (A) 0 A
- (B) 2 A
- (C) 3 A
- (D) 6 A
- (E) 9 A

Choice (B) is the correct answer to question 5. In this question, you must apply two concepts to solve the problem. First, you must recognize that the two resistors are connected in series and thus are equivalent to a single resistor whose resistance is 60 ohms, the sum of the two component resistances. Next, applying Ohm's law, you will find that the current is given by the potential difference divided by this equivalent resistance. Thus, the answer is $\frac{120 \text{ volts}}{60 \text{ ohms}}$, which equals 2 amperes.

6. All of the following are vector quantities EXCEPT

- (A) force
- (B) velocity
- (C) acceleration
- (D) power
- (E) momentum

Choice (D) is the correct answer to question 6. This question is a straightforward question that tests your knowledge of vector and scalar quantities. A vector quantity is one that has both magnitude and direction. All five quantities have a magnitude associated with

them, but only quantities (A), (B), (C), and (E) also have a direction. Power, a rate of change of energy, is not a vector quantity, so the correct answer is choice (D).

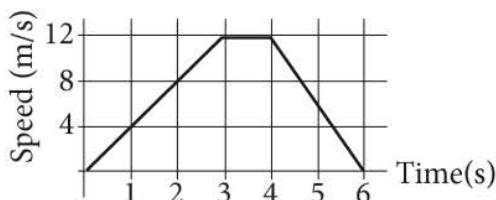
7. A ball is thrown upward. Air resistance is negligible. After leaving the hand, the acceleration of the ball is downward under which of the following conditions?

- I. On the way up
 - II. On the way down
 - III. At the top of its rise
- (A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

Choice (E) is the correct answer to question 7. In this question, one or several of the phrases represented by the Roman numerals may be correct answers to the question. One must evaluate each in turn. When the ball is on the way up, its speed is decreasing so the acceleration of the ball must be directed in the direction opposite to the ball's velocity. Since the velocity is upward, the acceleration must be downward, making I correct. When the ball is on the way down, its speed is increasing, so its acceleration must be directed in the same direction as its velocity, which is downward. So II is also correct. Finally, at the top of the rise, the ball has an instantaneous speed of zero, but its velocity is changing from upward to downward, implying a downward acceleration and making III correct also. A simpler analysis would be to realize that in all three cases, the ball is acted on by the downward force of gravity and no other forces. By Newton's second law, the acceleration must be in the direction of the net force, so it must be downward in all three cases. Since the phrases in I, II, and III are each correct answers to the question, the correct answer is choice (E).

Questions 8–9

In the following graph, the speed of a small object as it moves along a horizontal straight line is plotted against time.



8. The magnitude of the acceleration of the object during the first 3 seconds is
 - (A) 3 m/s^2
 - (B) 4 m/s^2
 - (C) 6 m/s^2
 - (D) 12 m/s^2
 - (E) 36 m/s^2

9. The average speed of the object during the first 4 seconds is
 - (A) 1.9 m/s
 - (B) 3.0 m/s
 - (C) 4.0 m/s
 - (D) 6.0 m/s
 - (E) 7.5 m/s

Questions 8 and 9 are a set of questions, both based on the graph provided.

Choice (B) is the correct answer to question 8. To answer this question, you need to know that the magnitude of the acceleration is equal to the magnitude of the slope of a graph of speed versus time. In this situation, from time = 0 to time = 3 seconds, the graph has a constant slope of $\frac{12 \text{ m/s}}{3 \text{ s}} = 4 \text{ m/s}^2$, which is the magnitude of the acceleration. So the correct answer is choice (B).

Choice (E) is the correct answer to question 9. The average speed of an object during a certain time is equal to the total distance traveled by the object during that time divided by the time. In question 9, the total distance traveled by the object during the first 4 seconds is equal to the area under the graph from time = 0 to time = 4 seconds. This area is $\frac{1}{2}(3 \text{ s})(12 \text{ m/s}) + (1 \text{ s})(12 \text{ m/s}) = 18 \text{ m} + 12 \text{ m} = 30 \text{ m}$. The average speed is therefore $\frac{30 \text{ m}}{4 \text{ s}} = 7.5 \text{ m/s}$.

Physics Test

Practice Helps

The test that follows is an actual, recently administered SAT Subject Test in Physics. To get an idea of what it's like to take this test, practice under conditions that are much like those of an actual test administration.

- Set aside an hour when you can take the test uninterrupted. Make sure you complete the test in one sitting.
- Sit at a desk or table with no other books or papers. Dictionaries, other books, or notes are not allowed in the test room.
- Do not use a calculator. Calculators are not allowed for the Subject Test in Physics.
- Tear out an answer sheet from the back of this book and fill it in just as you would on the day of the test. One answer sheet can be used for up to three Subject Tests.
- Read the instructions that precede the practice test. During the actual administration you will be asked to read them before answering test questions.
- Time yourself by placing a clock or kitchen timer in front of you.
- After you finish the practice test, read the sections "How to Score the SAT Subject Test in Physics" and "How Did You Do on the Subject Test in Physics?"
- The appearance of the answer sheet in this book may differ from the answer sheet you see on test day.

PHYSICS TEST

The top portion of the section of the answer sheet that you will use in taking the Physics Test must be filled in exactly as shown in the illustration below. Note carefully that you have to do all of the following on your answer sheet.

1. Print PHYSICS on the line under the words "Subject Test (print.)".
 2. In the shaded box labeled "Test Code" fill in four circles:
 - Fill in circle 2 in the row labeled V.
 - Fill in circle 3 in the row labeled W.
 - Fill in circle 3 in the row labeled X.
 - Fill in circle C in the row labeled Y.

Test Code										Subject Test (print)				
V	1	●	3	4	5	6	7	8	9					
W	1	2	●	4	5	6	7	8	9					
X	1	2	●	4	5	Y	A	B	●	D	E			
Q	1	2	3	4	5	6	7	8	9					

3. Please answer the three questions below by filling in the appropriate circles in the row labeled Q on the answer sheet. The information you provide is for statistical purposes only and will not affect your score on the test.

Question 1

How many semesters of physics have you taken in high school, including any semester in which you are currently enrolled? (Count as two semesters any case in which a full year's course is taught in a one-semester [half-year] compressed schedule.) Fill in only one circle of circles 1-3.

- One semester or less —Fill in circle 1.
 - Two semesters —Fill in circle 2.
 - Three semesters or more —Fill in circle 3.

Question 2

About how often did you do lab work in your first physics course? (Include any times when you may have watched a film or a demonstration by your teacher and then discussed or analyzed data.) Fill in only one circle of circles 4-7.

- Less than once a week —Fill in circle 4.
 - About once a week —Fill in circle 5.
 - A few times a week —Fill in circle 6.
 - Almost every day —Fill in circle 7.

Question 3

If you have taken or are currently taking an Advanced Placement (AP) Physics course, which of the following describes the course? Fill in both circles if applicable. (If you have never had AP Physics, leave circles 8 and 9 blank.)

- A course that uses algebra and trigonometry but NOT calculus (Physics B) _____ —Fill in circle 8.
 - A course that uses calculus (Physics C) _____ —Fill in circle 9.

When the supervisor gives the signal, turn the page and begin the Physics Test. There are 100 numbered circles on the answer sheet and 75 questions in the Physics Test. Therefore, use only circles 1 to 75 for recording your answers.

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PHYSICS TEST

Note: To simplify calculations, you may use $g = 10 \text{ m/s}^2$ in all problems.

Part A

Directions: Each set of lettered choices below refers to the numbered questions immediately following it. Select the one lettered choice that best answers each question, and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-3

- (A) Coefficient of linear expansion
- (B) Latent heat of fusion
- (C) Latent heat of vaporization
- (D) Specific heat
- (E) Coefficient of thermal conductivity

Select the quantity above that should be used in the calculation of each of the following.

1. The amount of heat required to change 100 grams of ice at 0°C into water at 0°C
2. The temperature at which a 0.5-centimeter gap between 1.0-meter concrete slabs in a sidewalk will close up completely
3. The time required for 100 joules of heat to pass through a copper rod of length 2 meters and cross-sectional area 0.5 square meter that connects two objects at different temperatures

Questions 4-5 relate to the following particles.

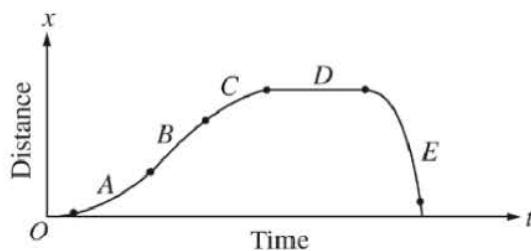
- (A) Electron
 - (B) Neutron
 - (C) Proton
 - (D) Neutrino
 - (E) Photon
4. Which particle constitutes the nucleus of an ordinary hydrogen atom?
 5. Which charged particle in the list is the least massive?

K-3XAC

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Questions 6-7

An automobile starts from rest and moves along a straight road. In the graph below, the distance x of the automobile from its starting point is given as a function of time t .



- (A) Interval A
 - (B) Interval B
 - (C) Interval C
 - (D) Interval D
 - (E) Interval E
6. During which interval is the automobile stationary and farthest from its starting position?
 7. During which interval does the speed of the automobile have its maximum value?

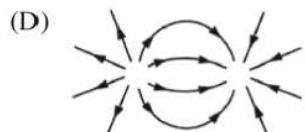
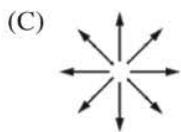
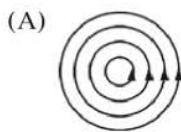
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PHYSICS TEST — *Continued*



Questions 8-9 relate to the field lines that are shown in the following diagrams.



8. Which diagram best represents the electric field produced by two oppositely charged particles?
9. Which diagram best represents an electric field produced by oppositely charged parallel plates that are large and close together?

Questions 10-12 relate to calculations or explanations based on the following principles.

- (A) Conservation of energy alone
(B) Conservation of momentum alone
(C) Conservation of both energy and momentum
(D) Conservation of charge
(E) Mechanical equivalence of heat

10. Used to calculate the velocity of two moving freight cars, after they couple and move together, given the initial masses and velocities of the freight cars
11. Used to calculate the speed of a lump of clay that hits and sticks to a block of wood suspended as a pendulum, given the height to which the block swings and the masses of the block and the clay
12. Used to calculate the speed of a pendulum bob at the bottom of its swing given the height from which the bob is released from rest



PHYSICS TEST — *Continued*



Part B

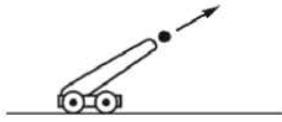
Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

13. A skydiver has been in the air long enough to be falling at a constant terminal speed of 50 meters per second. How much farther will the skydiver fall in the next 2.00 seconds?

(A) 19.6 m
(B) 50 m
(C) 98 m
(D) 100 m
(E) 120 m

14. It takes about 1.0 second for an object to fall 5 meters vertically. If this same object is thrown horizontally with a speed of 30 meters per second from a roof-top 5 meters above ground, about how many meters from the base of the building will the object land?

(A) 30 m
(B) $30\sqrt{2}$ m
(C) $30\sqrt{3}$ m
(D) 60 m
(E) 90 m



15. Assume that every projectile fired by the toy cannon shown above experiences a constant net force F along the entire length of the barrel. If a projectile of mass m leaves the barrel of the cannon with a speed v , at what speed will a projectile of mass $2m$ leave the barrel?

(A) $\frac{v}{2}$
(B) $\frac{v}{\sqrt{2}}$
(C) v
(D) $2v$
(E) $4v$

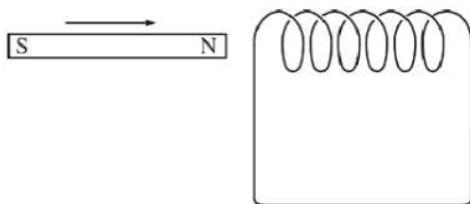


PHYSICS TEST — *Continued*



Questions 16–17

The following diagram shows a permanent magnet and a coil of copper wire that is part of a closed circuit.



16. What happens as the north pole of the magnet is moved at constant speed into the coil?

- (A) The magnet gains potential energy.
- (B) The magnet attracts the coil.
- (C) The coil attracts the magnet.
- (D) A current flows in the coil, producing a magnetic field.
- (E) The magnet loses kinetic energy.

17. Which of the following would be different if the magnet were turned around so the south pole moved into the coil at the same speed as before?

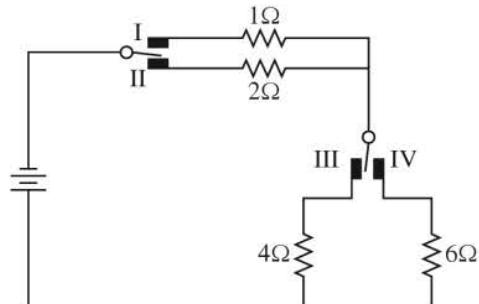
- (A) The direction of the forces on the magnet
- (B) The direction of the energy transfer
- (C) The direction of the current in the coil
- (D) The magnitude of the current in the coil
- (E) The sign of the charges moving in the coil

18. An electric current in a copper wire is the result of the motion of which of the following?

- (A) Copper atoms
- (B) Copper oxide molecules
- (C) Protons
- (D) Electrons
- (E) Neutrons

19. Eyeglasses, magnifying glasses, and optical microscopes depend for their operation primarily on the phenomenon of

- (A) reflection
- (B) refraction
- (C) interference
- (D) dispersion
- (E) diffraction

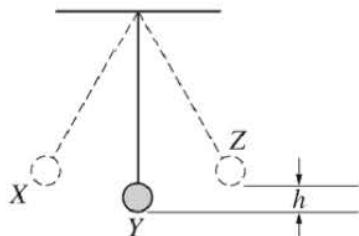


20. In the circuit shown above, the current through the battery will be greatest when the switches are in which of the following positions?

- (A) I and III
- (B) I and IV
- (C) II and III
- (D) II and IV
- (E) The current will be the same regardless of how the switches are positioned.

PHYSICS TEST — *Continued*

Questions 21-23



The diagram above shows a pendulum that swings to a maximum height h above its lowest point Y . The mass of the pendulum bob is 0.05 kilogram. At point Y , the bob has a speed of 3.0 meters per second.

21. The momentum of the pendulum bob as it passes through point Y is most nearly

(A) 0.05 kg·m/s
(B) 0.15 kg·m/s
(C) 0.23 kg·m/s
(D) 0.45 kg·m/s
(E) 0.50 kg·m/s

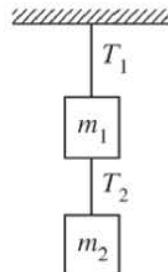
22. The height h is most nearly

(A) 0.15 m
(B) 0.30 m
(C) 0.45 m
(D) 0.60 m
(E) 0.90 m

23. If the potential energy of the pendulum bob is zero at point Y , the total energy (kinetic plus potential) of the pendulum bob is most nearly

(A) 0.05 J
(B) 0.15 J
(C) 0.23 J
(D) 0.45 J
(E) 0.50 J

Questions 24-25

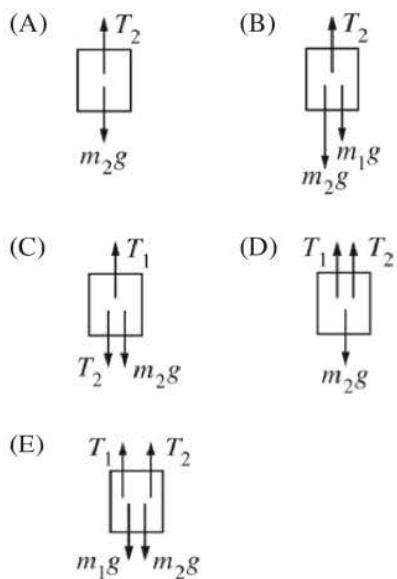


Two masses m_1 and m_2 are hung from the ceiling by two ropes as shown above. The tension in the upper rope is T_1 and the tension in the lower rope is T_2 .

24. Which of the following is correct?

(A) T_1 is always greater than T_2 .
(B) T_1 is always less than T_2 .
(C) T_1 is always equal to T_2 .
(D) T_1 is greater than T_2 only if m_1 is greater than m_2 .
(E) T_1 is greater than T_2 only if m_2 is greater than m_1 .

25. Which of the following best represents the forces acting on m_2 ?



PHYSICS TEST — *Continued*

26. A boat that can move at 5 kilometers per hour in still water is crossing a river whose current is 2 kilometers per hour. The problem is to steer the boat so that it will land directly across the river from where it started. The solution to the problem is best represented by which of the following sketches in which the river is flowing to the right?

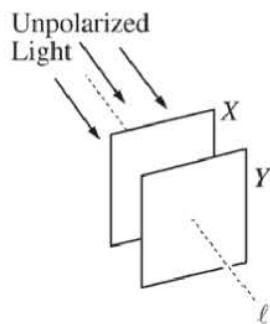
- (A) 
- (B) 
- (C) 
- (D) 
- (E) 

27. One harmonic of a note produced by a flute has a wavelength λ and an associated frequency f . If the wavelength of another harmonic of this note is 2λ , what is its associated frequency?

- (A) $\frac{1}{4}f$
- (B) $\frac{1}{2}f$
- (C) f
- (D) $2f$
- (E) $4f$

28. Sound waves can exhibit which of the following wave properties?

- I. Interference
 - II. Diffraction
 - III. Refraction
- (A) I only
- (B) II only
- (C) I and III only
- (D) II and III only
- (E) I, II, and III



29. Polarizing sheets X and Y shown above are oriented so that none of the unpolarized light shining on X is transmitted through Y . Axis ℓ is perpendicular to both sheets. Which of the following will result in the transmission of light through Y ?

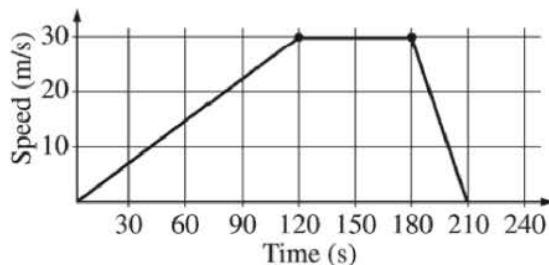
- (A) Rotation of Y by 90° about axis ℓ
- (B) Rotation of Y by 180° about axis ℓ
- (C) Rotation of Y by 360° about axis ℓ
- (D) Placement of a third polarizer between X and Y , with its polarizing axis oriented the same way as X
- (E) Placement of a third polarizer between X and Y , with its polarizing axis oriented the same way as Y



PHYSICS TEST — *Continued*



Questions 30-32



An automobile with a mass of 1.5×10^3 kilograms is traveling on a flat, level road. The above graph shows the automobile's speed as a function of time.

30. The automobile's acceleration at the end of 60 seconds is

(A) 0.25 m/s^2
(B) 2.5 m/s^2
(C) 4 m/s^2
(D) 15 m/s^2
(E) 60 m/s^2

31. The constant braking force applied to stop the car is

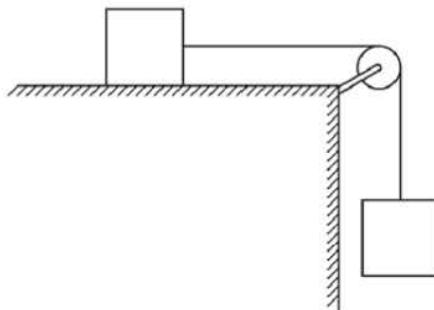
(A) 1.7 N
(B) 50 N
(C) $1.5 \times 10^3 \text{ N}$
(D) $4.5 \times 10^4 \text{ N}$
(E) $1.4 \times 10^5 \text{ N}$

32. The speed of the automobile 10 seconds after the brakes are applied is

(A) 1 m/s
(B) 10 m/s
(C) 15 m/s
(D) 20 m/s
(E) 30 m/s

33. An object of mass m is attached to a vertically mounted spring that has spring constant k . The object is displaced from its equilibrium position and allowed to oscillate. Assume that air resistance and friction are negligible. To increase the frequency of the motion, one could

(A) increase the amplitude of the motion
(B) change to a spring with a greater spring constant
(C) mount the spring horizontally
(D) attach an object of greater mass
(E) attach an object of the same mass but greater density



34. Two blocks of identical mass are connected by a light string as shown above. The surface is frictionless and the pulley is massless and frictionless. The acceleration of the two-block system is most nearly

(A) 20 m/s^2
(B) 15 m/s^2
(C) 10 m/s^2
(D) 5 m/s^2
(E) 2.5 m/s^2



PHYSICS TEST — *Continued*

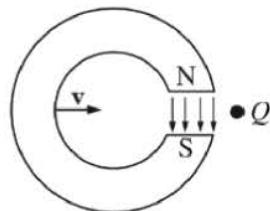


35. Consider the following four forces involving an object at rest on a tabletop.

- I. The gravitational force on the object due to the Earth
- II. The gravitational force on the Earth due to the object
- III. The force on the tabletop due to the object
- IV. The force on the object due to the tabletop

Which, if any, of these forces are action-reaction pairs in accordance with Newton's third law?

- (A) Pair I and II only
- (B) Pair I and IV only
- (C) Pair I and II, and pair III and IV
- (D) Pair I and IV, and pair II and III
- (E) There are no action-reaction pairs among these forces.



38. A magnet, whose poles are shown in the figure above, moves with velocity v toward a small object of charge Q initially at rest. Which of the following is a correct statement about the force on the object due to the magnet as the object initially encounters the field?

- (A) It is zero.
- (B) It is perpendicular to the page.
- (C) It is directed parallel to the magnetic field.
- (D) It is in the same direction as v .
- (E) It is in the direction opposite to v .

Questions 36-37

A heat engine operates between two reservoirs, one at a temperature of 300 K and the other at 200 K. In one cycle, the engine absorbs 600 joules of heat and does 150 joules of work.

36. How much heat is exhausted by the engine in one cycle?

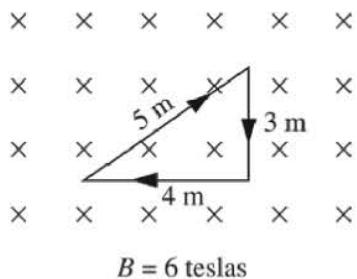
- (A) 150 J
- (B) 450 J
- (C) 550 J
- (D) 600 J
- (E) 750 J

37. The actual efficiency of the engine is most nearly

- (A) 75%
- (B) 67%
- (C) 50%
- (D) 33%
- (E) 25%



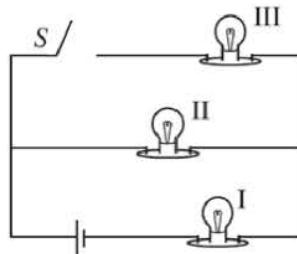
PHYSICS TEST — *Continued*



39. A loop of wire shaped into a triangle, shown above, carries a current of 2 amperes in a clockwise direction. A magnetic field of 6 teslas is directed into the paper. What are the magnitude and direction of the force applied by the magnetic field to the 5-meter edge of the triangle?

Magnitude Direction

- (A) 60 N
- (B) 60 N
- (C) 48 N
- (D) 48 N
- (E) 36 N
40. If two electrically charged particles repel each other with forces of equal magnitude, then the charges must
- (A) have different magnitudes
(B) have the same magnitude
(C) have different signs
(D) have the same sign
(E) be separated by unit distance



41. A battery and three identical lightbulbs are connected as shown in the figure above. With the switch S closed, the brightness of each lightbulb is noted. When switch S is opened, the brightness of which of the lightbulbs will change?
- (A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III
42. All of the following scientists made significant contributions to the field of nuclear physics EXCEPT
- (A) Galileo
(B) Rutherford
(C) Becquerel
(D) Curie
(E) Fermi
43. Which of the following distinguishes an atom of one isotope of an element from an atom of a different isotope of the same element?
- (A) The addition or loss of a beta particle
(B) The addition or loss of an alpha particle
(C) The amount of nuclear charge
(D) The number of orbital electrons
(E) The amount of nuclear mass



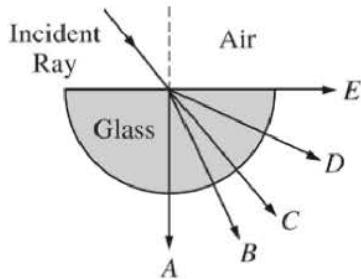
PHYSICS TEST — *Continued*

44. A hydrogen atom, originally in its ground state, absorbs a photon and goes into an excited state. The atom will then most likely

- (A) be ionized
- (B) emit a photon
- (C) emit an electron
- (D) always be in that excited state
- (E) undergo nuclear fission

45. A worker hits a metal pipe with a hammer. The ratio of the intensity of loudness as heard by people standing 100 meters away from the worker to the intensity as heard by people standing 200 meters away from the worker is

- (A) 4:1
- (B) 2:1
- (C) 1:1
- (D) 1:2
- (E) 1:4



46. A light ray is incident from air upon a semicircular piece of glass as shown above. Which of the labeled rays best represents the subsequent path of the light?

- (A) A
- (B) B
- (C) C
- (D) D
- (E) E

47. Huygens' principle states that every point on a wave front is the source of a new wave front. To which of the following types of waves does Huygens' principle apply?

- I. Water waves
 - II. Sound waves
 - III. Electromagnetic waves
- (A) I only
 - (B) II only
 - (C) III only
 - (D) II and III only
 - (E) I, II, and III

48. When coal burns, it produces heat in the amount of 2.5×10^4 joules per gram. About 4,000 joules of heat is required to raise the temperature of one kilogram of water by one degree. The amount of coal required to heat 5 kilograms of water from 10°C to 60°C is most nearly

- (A) 10 grams
- (B) 40 grams
- (C) 100 grams
- (D) 400 grams
- (E) 1,600 grams

49. When a person touches the metal part of a bicycle handlebar on a cold day, the metal seems much colder than the plastic handgrip, even though both are at the same temperature. This phenomenon is due primarily to which of the following?

- (A) The thermal conductivity of the metal is greater than that of the plastic.
- (B) The thermal conductivity of the metal is less than that of the plastic.
- (C) The density of the metal is greater than that of the plastic.
- (D) The density of the metal is less than that of the plastic.
- (E) The latent heat of fusion of the metal is greater than that of the plastic.

PHYSICS TEST — *Continued*

50. An object of mass m rests on a horizontal frictionless surface. A force F making an angle θ with the horizontal is then applied to the object to move it along the surface. The acceleration of the object is

- (A) $\frac{F}{m}$
- (B) $\frac{F}{2m}$
- (C) $\frac{F \cos \theta}{m}$
- (D) $\frac{F \sin \theta}{m}$
- (E) $\frac{F \tan \theta}{m}$

Questions 51-52

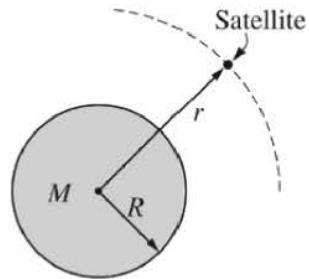
A person is standing on a scale that is located on a platform at the surface of Earth. The platform is supported by a machine that can move the platform up and down at various accelerations while keeping it level.

51. At what acceleration of the platform does the machine have to exert the LEAST force on the platform?

- (A) Zero
- (B) 4.9 m/s^2 down
- (C) 9.8 m/s^2 up
- (D) 9.8 m/s^2 down
- (E) 19.6 m/s^2 up

52. If the person's weight has apparently doubled according to the reading on the scale, what is the acceleration of the platform?

- (A) About 9.8 m/s^2 up
- (B) About 9.8 m/s^2 down
- (C) About 19.6 m/s^2 up
- (D) About 19.6 m/s^2 down
- (E) It cannot be determined without knowing the mass of the person.



53. A satellite moves in a circular orbit of radius r around a planet of mass M and radius R , as shown above. The speed of the satellite would be greater if M and r were changed in which of the following ways?

- | | |
|---------------|-----------|
| M | r |
| (A) Decreased | No change |
| (B) Decreased | Increased |
| (C) No change | No change |
| (D) No change | Increased |
| (E) Increased | No change |

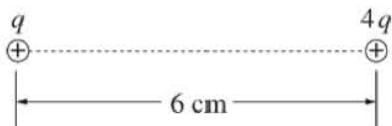
54. A circuit consists of a battery of voltage V and a resistor of resistance R . The current through the circuit is I . If the battery is changed to one of voltage $2V$ and the resistor to one with resistance $4R$, the current through the circuit is

- (A) $4I$
- (B) $2I$
- (C) I
- (D) $\frac{I}{2}$
- (E) $\frac{I}{4}$

PHYSICS TEST — *Continued*

55. An electrically charged, insulated metal rod is observed to attract a neutral pith ball and, after contact is made, to repel the ball. Which of the following can be concluded about the rod?

- (A) The rod had a positive charge before contact and a negative charge after contact.
- (B) The rod had a negative charge before contact and a positive charge after contact.
- (C) The rod's charge before and after contact had the same sign.
- (D) The rod had a charge before contact, but no charge after contact.
- (E) The rod had less charge before contact than after contact.

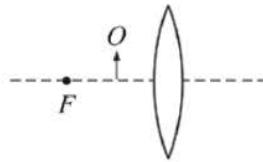


56. Two positive charges of magnitudes q and $4q$ are 6 centimeters apart, as shown above. If the electric field is zero at a point P (not shown) located on the line segment joining the charges, what is the distance of point P from the charge of magnitude q ?

- (A) 1 cm
- (B) 2 cm
- (C) 3 cm
- (D) 4 cm
- (E) 5 cm

57. A beam of light traveling through the air strikes the surface of a material in which the speed of light is different from what it is in the air. Which of the following is true of the light as it passes into the new medium?

- (A) The frequency changes but the wavelength stays the same.
- (B) The wavelength changes but the frequency stays the same.
- (C) Neither the frequency nor the wavelength change.
- (D) Both the frequency and the wavelength change.
- (E) Since the speed of light is a universal constant, the speed in the new material is the same as it was in air.



58. A convex lens is used as a magnifier when a real object O is placed inside the focus F , as shown above. The image produced is

- (A) real and inverted
- (B) real and upright
- (C) virtual and inverted
- (D) virtual and upright
- (E) none of the above

59. The separation of white light into colors by a glass prism is a result of

- (A) interference
- (B) diffraction
- (C) total internal reflection
- (D) variation of absorption with wavelength
- (E) variation of index of refraction with frequency

60. An object with a mass of 5 kilograms is placed at rest on an imaginary planet where the gravitational field is 4 newtons per kilogram. One can be certain that the object on this planet, as compared to the object when it is on Earth, will

- (A) require a greater force to accelerate it on a horizontal surface at 1 m/s^2
- (B) have less weight
- (C) have less mass
- (D) have greater mass
- (E) have greater acceleration during free fall

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PHYSICS TEST — *Continued*

61. A car travels around a circular track that has a radius of 1 kilometer. If the car completes 3 trips around the track in 5 minutes, which of the following expressions gives the average speed of the car in kilometers per hour?

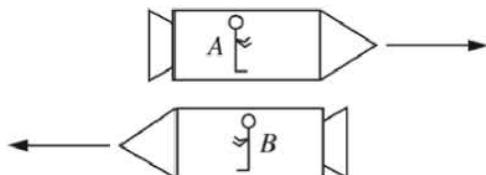
(A) $\frac{(3)(2\pi)(1)}{5(1/60)}$

(B) $\frac{(5)(60)(2\pi)(1)}{3}$

(C) $\frac{(3)(2\pi)(1)}{5(60)}$

(D) $\frac{(5)(2\pi)(1)}{(3)(60)}$

(E) $\frac{(3\pi)(1)}{5(1/60)}$



62. Two identical, human-looking robots are standing and facing forward in separate spaceships. Both ships are moving at $0.8c$ but are traveling in opposite directions, as shown above. If a person on the spaceship with robot A could make measurements on both robots, which of the following would the person observe to be different?

- (A) The robots' heights
(B) The length of the robots' feet from toe to heel
(C) The width of the robots' faces
(D) The length of the robots' legs
(E) The width of the robots' shoulders

63. The experimental study of the photoelectric effect and its analysis by Einstein confirmed the assumption of the

- (A) photon aspect of light
(B) crystal structure of materials
(C) discrete charge on the electron
(D) energy-mass relationship of special relativity
(E) uncertainty principle of position and momentum

64. The radius of the first Bohr orbit of an electron in a hydrogen atom is about 10^{-11} meter. The radius of the nucleus is about 10^{-15} meter. If a model of the hydrogen atom were built with the diameter of the electron orbit equal to the width of a classroom (about 10 meters), which of the following would most closely represent the size of the nucleus?

- (A) The chair you are sitting in
(B) Your head
(C) The eraser on the end of a new pencil
(D) The point of a ball point pen
(E) A red blood cell

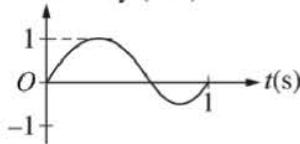
65. Which of the following is true of any material in a superconducting state that carries a current?

- (A) It has a large internal magnetic field.
(B) It has no external magnetic field.
(C) It has no resistance.
(D) It has a temperature of absolute zero.
(E) It has a very high temperature.

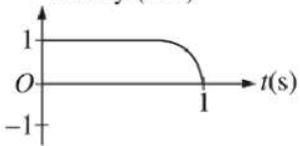
PHYSICS TEST — *Continued*

66. The graphs below represent velocity as a function of time t for five different particles, each moving along a straight line. Which particle experiences the greatest displacement between $t = 0$ and $t = 1$ second?

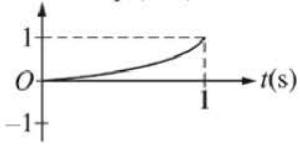
(A) Velocity (m/s)



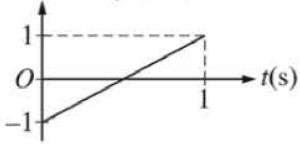
(B) Velocity (m/s)



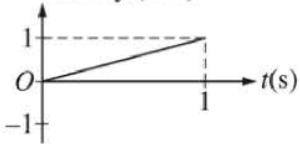
(C) Velocity (m/s)



(D) Velocity (m/s)



(E) Velocity (m/s)



67. The density of a certain material is 3 grams per cubic centimeter. What is the density of the material expressed in kilograms per cubic meter?

- (A) 0.3 kg/m^3
- (B) 3 kg/m^3
- (C) 30 kg/m^3
- (D) 300 kg/m^3
- (E) $3,000 \text{ kg/m}^3$

68. A system consists of two pucks moving without friction on a horizontal surface. If the pucks collide elastically, properties of the system that are the same before and after the collision include which of the following?

- I. Momentum
- II. Kinetic energy
- III. Total energy

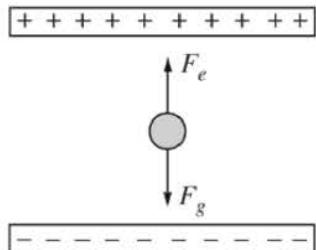
- (A) I only
- (B) III only
- (C) I and II only
- (D) II and III only
- (E) I, II, and III

69. It takes an amount of work W to stretch a spring a distance x beyond its natural length. If the spring obeys Hooke's law, how much work is required to stretch the spring a distance $2x$ beyond its natural length?

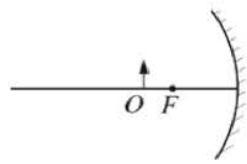
- (A) W
- (B) $2W$
- (C) $3W$
- (D) $4W$
- (E) $6W$

70. A child on a swing can greatly increase the amplitude of the swing's motion by "pumping" at the natural frequency of the swing. This is an example of which of the following?

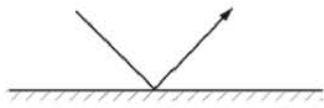
- (A) Conservation of momentum
- (B) Newton's first law of motion
- (C) Newton's third law of motion
- (D) Resonance
- (E) Interference

PHYSICS TEST — *Continued*

71. A negatively charged oil drop is maintained at rest between charged parallel plates, as shown above, by balancing the downward gravitational force F_g on the drop with an upward electric force F_e . If the mass of the oil drop is 1×10^{-6} kilogram and the electric field strength between the plates is 10 newtons per coulomb, then the charge on the oil drop is most nearly
- (A) 1×10^{-3} C
(B) 1×10^{-4} C
(C) 1×10^{-5} C
(D) 1×10^{-6} C
(E) 1×10^{-19} C

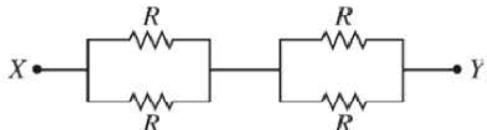


72. An object O is just outside the focal point F of a concave mirror, as shown in the diagram above. As the object is moved away from the mirror, the image will do which of the following?
- (A) Decrease in size and move closer to the mirror.
(B) Decrease in size and move farther from the mirror.
(C) Increase in size and move closer to the mirror.
(D) Increase in size and move farther from the mirror.
(E) It cannot be determined without knowing the exact focal length.

PHYSICS TEST — *Continued*

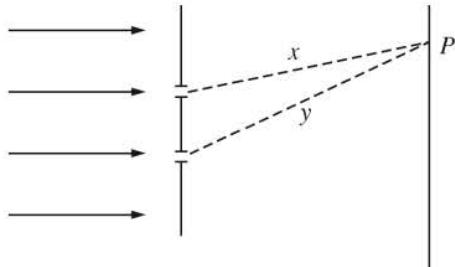
73. Which of the following occurs when light is reflected from a smooth flat glass surface, as shown above?

(A) The light is somewhat intensified.
(B) The light is somewhat polarized.
(C) The light is focused.
(D) The velocity of the light is reduced.
(E) The color of the light is shifted toward the blue end of the spectrum.



75. Four resistors of equal resistance R are connected as shown above. What is the total resistance between points X and Y ?

(A) $\frac{R}{4}$
(B) $\frac{R}{2}$
(C) R
(D) $2R$
(E) $4R$



74. Light of wavelength λ is incident from the left on a pair of narrow slits, as shown above. If point P is a bright spot (maximum intensity) on a distant screen, one can be certain that the difference between distances x and y is

(A) zero
(B) $\lambda/2$
(C) $n\lambda$, where n is an integer
(D) $\left(n + \frac{1}{2}\right)\lambda$, where n is an integer
(E) $\left(n - \frac{1}{2}\right)\lambda$, where n is an integer

S T O P

If you finish before time is called, you may check your work on this test only.
Do not turn to any other test in this book.

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How to Score the SAT Subject Test in Physics

When you take an actual SAT Subject Test in Physics, your answer sheet will be “read” by a scanning machine that will record your responses to each question. Then a computer will compare your answers with the correct answers and produce your raw score. You get one point for each correct answer. For each wrong answer, you lose one-fourth of a point. Questions you omit (and any for which you mark more than one answer) are not counted. This raw score is converted to a scaled score that is reported to you and to the colleges you specify.

Worksheet 1. Finding Your Raw Test Score

STEP 1: Table A lists the correct answers for all the questions on the Subject Test in Physics that is reproduced in this book. It also serves as a worksheet for you to calculate your raw score.

- Compare your answers with those given in the table.
- Put a check in the column marked “Right” if your answer is correct.
- Put a check in the column marked “Wrong” if your answer is incorrect.
- Leave both columns blank if you omitted the question.

STEP 2: Count the number of right answers.

Enter the total here: _____

STEP 3: Count the number of wrong answers.

Enter the total here: _____

STEP 4: Multiply the number of wrong answers by .250.

Enter the product here: _____

STEP 5: Subtract the result obtained in Step 4 from the total you obtained in Step 2.

Enter the result here: _____

STEP 6: Round the number obtained in Step 5 to the nearest whole number.

Enter the result here: _____

The number you obtained in Step 6 is your raw score.

Table A

Answers to the Subject Test in Physics, Form K-3XAC, and Percentage of Students Answering Each Question Correctly									
Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*	Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*
1	B			54	33	B			57
2	A			76	34	D			28
3	E			80	35	C			66
4	C			72	36	B			59
5	A			63	37	E			61
6	D			89	38	B			38
7	E			55	39	A			30
8	D			76	40	D			65
9	E			60	41	E			40
10	B			70	42	A			64
11	C			65	43	E			56
12	A			69	44	B			33
13	D			83	45	A			40
14	A			67	46	B			58
15	B			14	47	E			38
16	D			80	48	B			49
17	C			69	49	A			77
18	D			87	50	C			71
19	B			71	51	D			65
20	A			61	52	A			46
21	B			87	53	E			57
22	C			49	54	D			69
23	C			58	55	C			35
24	A			76	56	B			39
25	A			61	57	B			37
26	C			60	58	D			37
27	B			62	59	E			32
28	E			44	60	B			65
29	A			42	61	A			48
30	A			78	62	B			34
31	C			66	63	A			41
32	D			74	64	D			29

Table A continued on next page

Table A continued from previous page

Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*	Question Number	Correct Answer	Right	Wrong	Percentage of Students Answering the Question Correctly*
65	C			40	71	D			30
66	B			51	72	A			24
67	E			42	73	B			28
68	E			56	74	C			33
69	D			43	75	C			51
70	D			43					

* These percentages are based on an analysis of the answer sheets of a representative sample of 2,410 students who took this test in January 2003, and whose mean score was 628. They may be used as an indication of the relative difficulty of a particular question. Each percentage may also be used to predict the likelihood that a typical SAT Subject Test in Physics candidate will answer that question correctly on this edition of the test.

Finding Your Scaled Score

When you take SAT Subject Tests, the scores sent to the colleges you specify are reported on the College Board scale, which ranges from 200–800. You can convert your practice test score to a scaled score by using Table B. To find your scaled score, locate your raw score in the left-hand column of Table B; the corresponding score in the right-hand column is your scaled score. For example, a raw score of 41 on this particular edition of the Subject Test in Physics corresponds to a scaled score of 670.

Raw scores are converted to scaled scores to ensure that a score earned on any one edition of a particular Subject Test is comparable to the same scaled score earned on any other edition of the same Subject Test. Because some editions of the tests may be slightly easier or more difficult than others, College Board scaled scores are adjusted so that they indicate the same level of performance regardless of the edition of the test taken and the ability of the group that takes it. Thus, for example, a score of 400 on one edition of a test taken at a particular administration indicates the same level of achievement as a score of 400 on a different edition of the test taken at a different administration.

When you take the SAT Subject Tests during a national administration, your scores are likely to differ somewhat from the scores you obtain on the tests in this book. People perform at different levels at different times for reasons unrelated to the tests themselves. The precision of any test is also limited because it represents only a sample of all the possible questions that could be asked.

Table B**Scaled Score Conversion Table
Subject Test in Physics (Form K-3XAC)**

Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score
75	800	39	660	3	410
74	800	38	650	2	400
73	800	37	640	1	400
72	800	36	640	0	390
71	800	35	630	-1	380
70	800	34	620	-2	380
69	800	33	620	-3	370
68	800	32	610	-4	360
67	800	31	600	-5	360
66	800	30	600	-6	350
65	800	29	590	-7	340
64	800	28	580	-8	330
63	800	27	580	-9	330
62	800	26	570	-10	320
61	800	25	560	-11	310
60	800	24	560	-12	310
59	800	23	550	-13	300
58	790	22	540	-14	290
57	780	21	530	-15	290
56	780	20	530	-16	280
55	770	19	520	-17	280
54	760	18	510	-18	270
53	750	17	510	-19	270
52	750	16	500		
51	740	15	490		
50	730	14	490		
49	730	13	480		
48	720	12	470		
47	710	11	470		
46	710	10	460		
45	700	9	450		
44	690	8	450		
43	690	7	440		
42	680	6	430		
41	670	5	420		
40	670	4	420		

How Did You Do on the Subject Test in Physics?

After you score your test and analyze your performance, think about the following questions:

Did you run out of time before reaching the end of the test?

If so, you may need to pace yourself better. For example, maybe you spent too much time on one or two hard questions. A better approach might be to skip the ones you can't answer right away and try answering all the questions that remain on the test. Then if there's time, go back to the questions you skipped.

Did you take a long time reading the directions?

You will save time when you take the test by learning the directions to the Subject Test in Physics ahead of time. Each minute you spend reading directions during the test is a minute that you could use to answer questions.

How did you handle questions you were unsure of?

If you were able to eliminate one or more of the answer choices as wrong and guess from the remaining ones, your approach probably worked to your advantage. On the other hand, making haphazard guesses or omitting questions without trying to eliminate choices could cost you valuable points.

How difficult were the questions for you compared with other students who took the test?

Table A shows you how difficult the multiple-choice questions were for the group of students who took this test during its national administration. The right-hand column gives the percentage of students that answered each question correctly.

A question answered correctly by almost everyone in the group is obviously an easier question. For example, 89 percent of the students answered question 6 correctly. But only 14 percent answered question 15 correctly.

Keep in mind that these percentages are based on just one group of students. They would probably be different with another group of students taking the test.

If you missed several easier questions, go back and try to find out why: Did the questions cover material you haven't yet reviewed? Did you misunderstand the directions?