

22. All of the following can act as Brønsted-Lowry acids (proton donors) in aqueous solution EXCEPT

- (A) HI                      (B)  $\text{NH}_4^+$                       (C)  $\text{HCO}_3^-$   
 (D)  $\text{H}_2\text{S}$                       (E)  $\text{NH}_3$

### ANSWERS

The estimated difficulty level, on a scale of 1 to 5, with 1 the easiest and 5 the most difficult, is in parentheses.

1. C (2)                      5. C (1)                      9. E (2)  
 2. E (3)                      6. A (2)                      10. A (2)  
 3. A (4)                      7. C (3)  
 4. A (3)                      8. A (3)

Questions 101–105: See box for difficulty level.

	I	II	CE*	Diff. Level
101	● (F)	● (F)	●	3
102	● (F)	⊖ (T)	○	3
103	● (F)	● (F)	○	3
104	● (F)	● (F)	●	4
105	⊖ (T)	● (T)	●	5

11. C (3)                      16. C (2)                      21. D (3)  
 12. D (2)                      17. B (3)                      22. E (4)  
 13. C (4)                      18. D (2)  
 14. B (3)                      19. D (1)  
 15. A (3)                      20. E (3)

Answer explanations for these practice questions are available online. Visit [SATSubjectTests.org/chemistryanswers](http://SATSubjectTests.org/chemistryanswers) to view and download the complete document.

## Physics

Questions cover topics emphasized in most high school courses. Because of course differences, most students will find that there are some questions on topics with which they are not familiar. You may not be able to complete all the questions in the time given, but it's not necessary to get every question correct to get a high score or even the highest score on the test.

### Skills Covered in the Context of Physics

- Recalling and understanding of the major concepts of physics and the application of these physical principles to solve specific problems
  - ◆ Fundamental Knowledge: remembering and understanding concepts or information (about 12%–20% of test)
  - ◆ Single-Concept Problems: applying a single physical relation or concept (about 48%–64% of test)
  - ◆ Multiple-Concept Problems: integrating of two or more physical relationships or concepts (about 20%–35% of test)
- Understanding simple algebraic, trigonometric, and graphical relationships and the concepts of ratio and proportion and the application of these to physics problems
- Application of laboratory skills in the context of the physics content outlined below

### Important Things to Note on This Subject Test

- Numerical calculations are not emphasized and are limited to simple arithmetic.
- Questions predominantly use the metric system; pay attention to the units stated.
- You should assume that the direction of any current is the direction of flow of positive charge (conventional current).
- Calculator use is not permitted.

### Recommended Preparation

- One-year introductory physics course on the college-preparatory level
- Laboratory experience—a significant factor in developing reasoning and problem-solving skills—even though this test can only measure lab skills in a limited way, such as data analysis

FORMAT/CONTENT	Approximate % of Test
75 multiple-choice questions	
<b>Topics Covered</b>	
<b>Mechanics</b> <b>Kinematics</b> , such as velocity, acceleration, and motion in one and two dimensions <b>Dynamics</b> , such as force, Newton's laws, statics, and friction <b>Energy and Momentum</b> , such as potential and kinetic energy, work, power, impulse, and conservation laws <b>Circular Motion</b> , such as uniform circular motion and centripetal force <b>Simple Harmonic Motion</b> , such as mass on a spring and the pendulum <b>Gravity</b> , such as the law of gravitation, orbits, and Kepler's laws	<b>36%–42%</b>
<b>Electricity and Magnetism</b> <b>Electric Fields, Forces and Potentials</b> , such as Coulomb's law, induced charge, field and potential of groups of point charges, and charged particles in electric fields <b>Capacitance</b> , such as parallel-plate capacitors and time-varying behavior in charging/discharging <b>Circuit Elements and DC Circuits</b> , such as resistors, light bulbs, series and parallel networks, Ohm's law, and Joule's law <b>Magnetism</b> , such as permanent magnets, fields caused by currents, particles in magnetic fields, Faraday's law, and Lenz's law	<b>18%–24%</b>
<b>Waves and Optics</b> <b>General Wave Properties</b> , such as wave speed, frequency, wavelength, superposition, standing waves, and Doppler effect <b>Reflection and Refraction</b> , such as Snell's law and changes in wavelength and speed <b>Ray Optics</b> , such as image formation using pinholes, mirrors, and lenses <b>Physical Optics</b> , such as single-slit diffraction, double-slit interference, polarization, and color	<b>15%–19%</b>
<b>Heat and Thermodynamics</b> <b>Thermal Properties</b> , such as temperature, heat transfer, specific and latent heats, and thermal expansion <b>Laws of Thermodynamics</b> , such as first and second laws, internal energy, entropy, and heat engine efficiency	<b>6%–11%</b>

FORMAT/CONTENT	Approximate % of Test
<b>Modern Physics</b> <b>Quantum Phenomena</b> , such as photoelectric effect and electron diffraction <b>Atomic</b> , such as the Rutherford and Bohr models, atomic energy levels, and atomic spectra <b>Nuclear Physics</b> , such as radioactivity, fission, fusion, and other nuclear processes <b>Relativity</b> , such as time dilation, length contraction, and mass-energy equivalence	<b>6%–11%</b>
<b>Miscellaneous</b> <b>General</b> , such as history of physics and general questions that overlap several major topics <b>Analytical Skills</b> , such as graphical analysis, measurement, and math skills <b>New Topics in Physics</b> , current developments in such areas as astrophysics, elementary particle physics, nanophysics, and new technological applications of physics	<b>4%–9%</b>

## Sample Questions

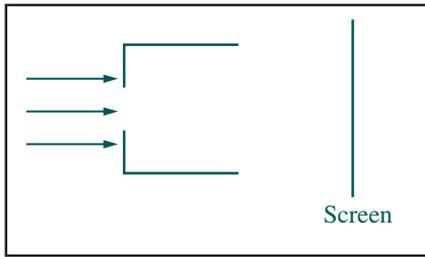
Two types of questions are used in the Physics Subject Test: classification questions and five-choice completion questions. Both are noted in the following samples. The directions that follow match those that are in the test. All questions in the test are multiple-choice questions in which you must choose the BEST response from the five choices offered.

### Part A

#### Directions

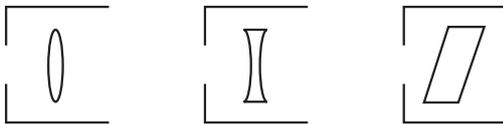
Each set of lettered choices on the next page refers to the numbered questions immediately following it. Select the one lettered choice that best answers each question and then fill in the corresponding bubble on the answer sheet. A choice may be used once, more than once or not at all in each set.

Questions 1-2



A beam of light is incident on a rectangular opening in the front of a box, as shown in the side view above. The back of the box is open. After passing through the box, the light is incident on a screen. The following devices may be in the box, positioned as shown below.

- (A) A convex lens      (B) A concave lens      (C) A thick sheet of glass

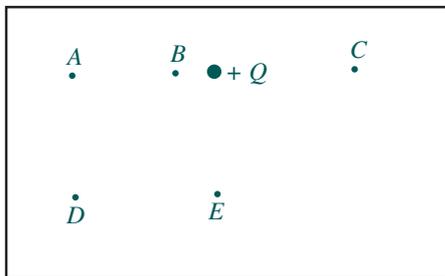


- (D) An opaque card with a very narrow slit      (E) A prism with vertex pointing downward



- Which device could produce a tiny spot of light on the screen?
- Which device could produce a diffraction pattern consisting of a central bright fringe with parallel secondary fringes that decrease in intensity with increasing distance from the center of the screen?

Questions 3-4 relate to a point charge  $+Q$  fixed in position, as shown below. Five points near the charge and in the plane of the page are shown.



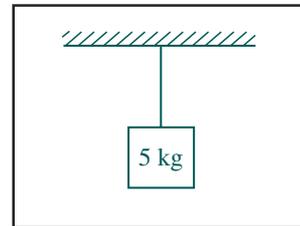
- At which point will the magnitude of the electric field be least?
- At which point will an electron experience a force directed toward the top of the page?

Part B

Directions

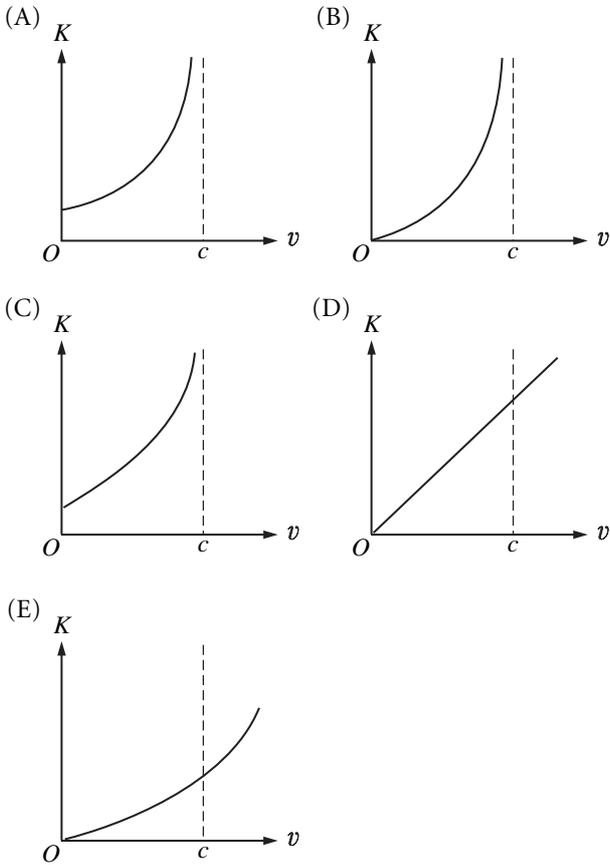
Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding bubble on the answer sheet.

- When a vector of magnitude 6 units is added to a vector of magnitude 8 units, the magnitude of the resultant vector will be
  - exactly 2 units
  - exactly 10 units
  - exactly 14 units
  - 0 units, 10 units, or some value between them
  - 2 units, 14 units, or some value between them



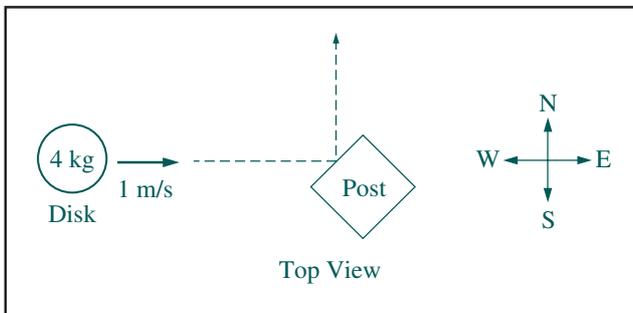
- A 5-kilogram block is suspended by a cord from the ceiling, as shown above. The force exerted on the block by the cord is most nearly
  - zero
  - 25 N
  - 50 N
  - 100 N
  - 200 N
- An experiment is performed to measure the specific heat of copper. A lump of copper is heated in an oven, then dropped into a beaker of water. To calculate the specific heat of copper, the experimenter must know or measure the value of all of the quantities below EXCEPT the
  - mass of the water
  - original temperatures of the copper and the water
  - final (equilibrium) temperature of the copper and the water
  - time taken to achieve equilibrium after the copper is dropped into the water
  - specific heat of the water

8. Which of the following graphs best represents the kinetic energy  $K$  of an elementary particle as a function of its speed  $v$ , where  $c$  is the speed of light?



9. In a given process, 12 joules of heat is added to an ideal gas and the gas does 8 joules of work. Which of the following is true about the internal energy of the gas during this process?

- (A) It has increased by 20 joules.
- (B) It has increased by 4 joules.
- (C) It has not changed.
- (D) It has decreased by 4 joules.
- (E) It has decreased by 20 joules.



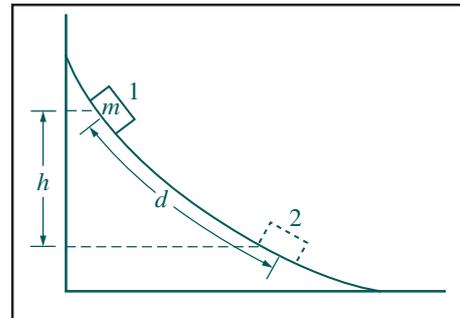
10. A 4-kilogram disk slides over level ice toward the east at a velocity of 1 meter per second, as shown at the bottom of the left-hand column. The disk strikes a post and rebounds toward the north at the same speed. The change in the magnitude of the eastward component of the momentum of the disk is

- (A)  $-4 \text{ kg} \cdot \text{m/s}$
- (B)  $-1 \text{ kg} \cdot \text{m/s}$
- (C)  $0 \text{ kg} \cdot \text{m/s}$
- (D)  $1 \text{ kg} \cdot \text{m/s}$
- (E)  $4 \text{ kg} \cdot \text{m/s}$

$n$	Energy Above Ground State
3	7 eV
2	4 eV
1	0 eV

11. Three energy levels of an atom are shown above. Atoms in the  $n = 2$  state can spontaneously emit photons having which of the following energies?

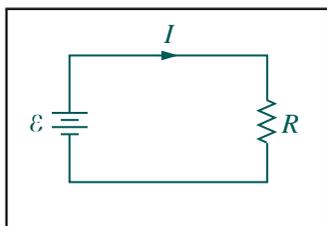
- (A) 4 eV only
- (B) 7 eV only
- (C) 3 eV and 4 eV only
- (D) 3 eV and 7 eV only
- (E) 3 eV, 4 eV, and 7 eV



12. A box of mass  $m$  is released from rest at position 1 on the frictionless curved track shown above. It slides a distance  $d$  along the track in time  $t$  to reach position 2, dropping a vertical distance  $h$ . Let  $v$  and  $a$  be the instantaneous speed and instantaneous acceleration, respectively, of the box at position 2. Which of the following equations is valid for this situation?

- (A)  $h = vt$
- (B)  $h = \frac{1}{2}gt^2$
- (C)  $d = \frac{1}{2}at^2$
- (D)  $v^2 = 2ad$
- (E)  $mgh = \frac{1}{2}mv^2$

Questions 13-14 relate to the following circuit.



A single resistor  $R$  is connected to a battery as shown above. The current is  $I$  and the power dissipated as heat is  $P$ . The circuit is changed by doubling the emf  $\mathcal{E}$  of the battery while  $R$  is kept constant.

13. After the change, the current is  
 (A)  $\frac{I}{4}$  (B)  $\frac{I}{2}$  (C)  $I$   
 (D)  $2I$  (E)  $4I$
14. After the change, the power dissipated in  $R$  is  
 (A)  $\frac{P}{4}$  (B)  $\frac{P}{2}$  (C)  $P$   
 (D)  $2P$  (E)  $4P$
15. Which of the following is true of the magnetic field produced by a current in a long, straight wire?  
 (A) The field is uniform.  
 (B) The field increases in strength as the distance from the wire increases.  
 (C) The field lines are directed parallel to the wire, but opposite to the direction of the current.  
 (D) The field lines are directed radially outward from the wire.  
 (E) The field lines form circles about the wire.
16. The Earth has a radius of 6,400 kilometers. A satellite orbits the Earth at a distance of 12,800 kilometers from the center of the Earth. If the weight of the satellite on Earth is 100 kilonewtons, the gravitational force on the satellite in orbit is  
 (A) 11 kilonewtons  
 (B) 25 kilonewtons  
 (C) 50 kilonewtons  
 (D) 100 kilonewtons  
 (E) 200 kilonewtons

17. A pendulum of length  $\ell$  with a bob of mass  $m$  is oscillating with small amplitude. Which of the following changes in the pendulum would double its period?  
 (A) Doubling the mass  $m$  of the bob  
 (B) Doubling the initial force used to set the pendulum in motion  
 (C) Doubling the amplitude of the pendulum's swing  
 (D) Quadrupling the mass  $m$  of the bob  
 (E) Quadrupling the length  $\ell$  of the pendulum

#### Questions 18-19

A piece of chalk is thrown vertically upward and caught during its descent at the same height from which it was thrown. Position is measured from the location of the chalk when it left the hand. The positive direction for position, velocity, and acceleration is upward.

18. What are the signs of the position, velocity, and acceleration during the ascending part of the trajectory?

	<u>POSITION</u>	<u>VELOCITY</u>	<u>ACCELERATION</u>
(A)	Positive	Positive	Positive
(B)	Positive	Positive	Negative
(C)	Positive	Negative	Negative
(D)	Negative	Positive	Negative
(E)	Negative	Negative	Negative

19. What are the signs of the position, velocity, and acceleration during the descending part of the trajectory?

	<u>POSITION</u>	<u>VELOCITY</u>	<u>ACCELERATION</u>
(A)	Positive	Positive	Positive
(B)	Positive	Positive	Negative
(C)	Positive	Negative	Negative
(D)	Negative	Positive	Negative
(E)	Negative	Negative	Negative

#### ANSWERS

The estimated difficulty level, on a scale of 1 to 5, with 1 the easiest and 5 the most difficult, is in parentheses.

- |         |          |          |          |
|---------|----------|----------|----------|
| 1. A(3) | 7. D(3)  | 13. D(3) | 19. C(5) |
| 2. D(3) | 8. B(2)  | 14. E(5) |          |
| 3. D(1) | 9. B(3)  | 15. E(3) |          |
| 4. E(2) | 10. A(4) | 16. B(5) |          |
| 5. E(2) | 11. A(4) | 17. E(4) |          |
| 6. C(1) | 12. E(4) | 18. B(4) |          |

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