

Chemistry, Physics, and General Science (0070)

Test at a Glance

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| Test Name | Chemistry, Physics, and General Science | | |
| Test Code | 0070 | | |
| Time | 2 hours | | |
| Number of Questions | 120 | | |
| Format | Multiple-choice questions; calculator use prohibited | | |
| | Content Categories | Approximate Number of Questions | Approximate Percentage of Questions |
| | I. Major Ideas of Chemistry and Physics | 24 | 20% |
| | II. Chemistry | 36 | 30% |
| | III. Physics | 36 | 30% |
| | IV. Earth and Space Science | 12 | 10% |
| | V. Life Science | 12 | 10% |

About This Test

The Chemistry, Physics, and General Science test measures the subject-area knowledge of prospective teachers in chemistry, physics, and/or general science at the junior or senior high school level. Examinees are expected to have completed or nearly completed a bachelor's degree.

The 120 multiple-choice questions concern topics specific to the fields of chemistry and physics as well as major ideas common to both fields, including the nature of matter and interactions of energy and matter. The questions also cover topics drawn from earth and space science and life science. There are also some questions concerning environmental issues. Approximately three-quarters of the questions deal with chemistry and physics, with equal numbers devoted to each. Of the remaining questions, about half are based on biology, and about half deal with the earth and space sciences.

This test may contain some questions that will not count toward your score.

In addition, the questions assess scientific skills, methodology, and philosophy, requiring examinees to demonstrate their ability to recall scientific terminology, principles, generalizations, and classifications; to make direct applications of principles and theories, which may involve the use of mathematics, models, equations, and formulas; and to integrate concepts through interpretation, analysis, synthesis, and evaluation. *Calculator use is not permitted.*

Topics Covered

Representative descriptions of topics covered in each category are provided below.

I. Major Ideas of Chemistry & Physics

- Atomic models, structure, and spectra
- Kinetic molecular theory, including ideal and real gas behavior
- Organization of matter: elements, compounds, mixtures, and solutions
- Physical and chemical properties and changes
- Thermal effects:
 - laws of thermodynamics, heat and temperature, temperature scales, calorimetry, and heat capacity
 - heat transfer, expansion and contraction of materials
 - states of matter, phase changes, and phase diagrams
- Radioactivity: radioactive decay, nuclear reactions, and fusion and fission
- Math, measurement, and data collection and analysis
 - accuracy, precision, and error analysis
 - interpretation of tables and graphs
 - measurement equipment
 - organization of data, scientific notation, significant figures, and units of measurement
- Scientific methodology and philosophy
 - interpretation of data and experimental designs
 - scientific method: observation, forming and testing hypothesis and theories, and drawing generalizations and conclusions

II. Chemistry

- Mole concept and stoichiometry
- Periodic trends in the properties of elements
- Kinetics and reaction mechanisms
- Chemical thermodynamics and equilibrium
- Solutions: concentrations, colligative properties, and solubility
- Oxidation and reduction reactions and electrochemistry

- Bonding, chemical formulas, and molecular geometry
- Acid-base chemistry
- Descriptive chemistry: organic, inorganic, and biochemistry
- Laboratory safety
- Environmental issues related to chemistry

III. Physics

- Mechanics:
 - kinematics: linear, curvilinear, and periodic motion
 - dynamics: forces, torque, Newton's laws, Kepler's laws, gravitation and weight, and conservation of momentum and energy
 - fluid mechanics
- Electricity and magnetism:
 - circuits, components, and applications, including AC and DC circuits, Kirchhoff's laws, and Ohm's laws
 - electric forces and fields, including Coulomb's law and Gauss's law
 - magnetic forces and fields, including laws, magnets, transformers, and motors
 - conductors, insulators, and semiconductors
- Waves and optics:
 - light: color, spectrum, lenses, mirrors, polarization
 - wave phenomena, including diffraction, reflection, interference, Doppler effect, refraction and Snell's law, resonance, scattering, transmission, and other wave behavior
 - wave characteristics, including amplitude, frequency, intensity, speed, and wavelength
 - sound, including characteristics and air columns
- Modern physics: Black body radiation, deBroglie's hypothesis, Heisenberg uncertainty, nuclear forces, photoelectric effect, wave-particle duality, and special relativity
- Environmental issues related to physics

IV. Earth and Space Science

- Geology: minerals, rocks, plate tectonics, earthquakes, Earth's interior, weathering, erosional and depositional processes, geological features on maps, historical geology (origin of the earth, relative and absolute time, major stratigraphic principles, paleontology)
- Oceanography/Land Waters: physical aspects, chemical aspects, geological aspects, biological aspects
- Meteorology: energy flows, water cycle, atmosphere, weather systems, climate
- Astronomy: origin of the universe, galaxies, solar system, properties of stars, Earth-Sun-Moon relationships, space exploration
- Environmental issues related to earth and space science

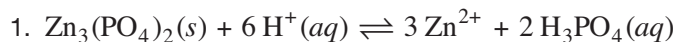
V. Life Science

- Cells
 - biochemistry of life
 - structure and function
 - energetics
 - genetics
- Organisms
 - animals
 - plants
 - fungi, monera, protista
- Ecology
 - communities
 - populations
 - ecosystems
- Environmental issues related to life science

Sample Test Questions

The sample questions that follow illustrate the types of questions in the test. They are not, however, representative of the entire scope of the test in either content or difficulty. Answers with explanations follow the questions.

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.



The expression representing the equilibrium constant, K_c , for the equation above is

(A) $\frac{[\text{Zn}^{2+}][\text{H}_3\text{PO}_4]}{[\text{Zn}_3(\text{PO}_4)_2][\text{H}^+]}$

(B) $\frac{[\text{Zn}^{2+}]^3[\text{H}_3\text{PO}_4]^2}{[\text{Zn}_3(\text{PO}_4)_2][\text{H}^+]}$

(C) $\frac{[\text{Zn}^{2+}][\text{H}_3\text{PO}_4]}{[\text{H}^+]}$

(D) $\frac{[\text{Zn}^{2+}]^3[\text{H}_3\text{PO}_4]^2}{[\text{H}^+]^6}$

(E) $\frac{[\text{H}^+]^6}{[\text{Zn}^{2+}]^3[\text{H}_3\text{PO}_4]^2}$

2. A certain gas has a density of 3.40 g/L at standard temperature and pressure. The molar mass of the gas is

(A) $(22.4 \times 3.40) \text{ g}$

(B) $\left[22.4 \times 3.40 \times \frac{273}{760} \right] \text{ g}$

(C) 22.4 g

(D) $\frac{22.4}{3.40} \text{ g}$

(E) $\frac{3.40}{22.4} \text{ g}$

3. In the Northern Hemisphere, the spring and summer seasons together last about five days longer than the fall and winter seasons together because the

(A) seasons are defined by the mean air temperature over the entire Northern Hemisphere

(B) Earth is closest to the Sun in January, causing the Earth to move about its orbit faster

(C) greater area of continental masses in the Northern Hemisphere makes the Earth “top-heavy”

(D) rotation rate of the Earth about its axis increases when greater amounts of energy are received from the Sun in the summer

(E) ancients who constructed our calendar thought the year was only 360 days long

4. In guinea pigs, coat color is determined by a pair of allelic genes, B for black and b for white. According to Mendelian principles of inheritance, if a male guinea pig heterozygous for black fur (Bb) is mated to a female that is also heterozygous black, the percentage of offspring that are expected to have white fur is

(A) 0%

(B) 25%

(C) 50%

(D) 75%

(E) 100%

5. Of the following, the best method of determining the Earth's age is studying the

(A) rate of increase in saline content of the oceans

(B) ratio of uranium or thorium content to lead content in granite rock

(C) percentage of radioactive carbon-14 in organic remains

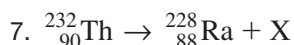
(D) rate of sedimentation characteristic of alluvial deposits

(E) number of annual rings found in fossilized wood

Directions: The group of questions below consists of five lettered headings followed by a list of numbered phrases. For each numbered phrase, select the one heading that is most clearly related to it. One heading may be used once, more than once, or not at all.

Questions 6–7

- (A) Proton
 (B) Neutron
 (C) Photon
 (D) Alpha particle
 (E) Beta particle
6. The particle that is slowed down by the moderators in a nuclear reactor



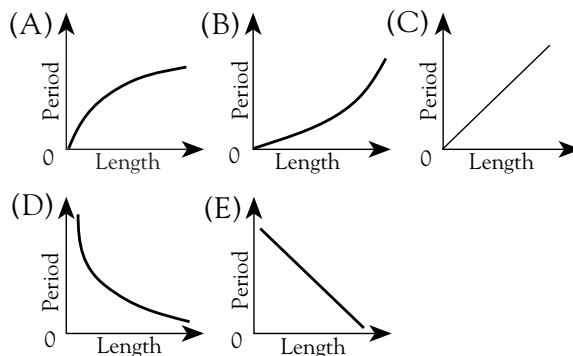
The particle X produced by the radioactive decay of thorium-232 represented in the equation above

Directions: Each group of questions below concerns a laboratory situation. First study the description of the situation. Then choose the one best answer to each of the questions following the situation.

Questions 8–9

An experiment is designed to investigate the factors that affect the period of a simple pendulum. Factors to be tested, as suggested by students, are (1) the length of the pendulum, (2) the amplitude of the oscillations, (3) the mass of the pendulum bob, and (4) the material of which the bob is made. The students have pendulum bobs, thin strings, stopwatches, meter sticks, clamps, ring stands, and protractors.

8. If each of the following procedures is used, which gives the most reliable determination of the period?
- (A) Measuring the time of a half swing and doubling it to get the period; repeating this about 10 times and averaging the results
 (B) Measuring the time of a complete swing; repeating this about 20 times and averaging the results
 (C) Having students simultaneously measure the time of a complete swing and averaging their results
 (D) Measuring the time of 30 complete swings and dividing the time by 30; repeating once or twice and averaging the results
 (E) Counting the number of complete swings in 5 seconds and dividing the 5 seconds by the number of complete swings; repeating once or twice and averaging the results
9. As the length of a pendulum is varied, the effect on the period is represented by which type of curve below?



10. Which of the following elements is a metal?
- (A) S
 (B) Se
 (C) I
 (D) Ga
 (E) Rn

11. How many moles of HCl must be added to sufficient water to form 3 liters of a 2 M HCl solution?
- (A) 1 mol
(B) 2 mol
(C) 3 mol
(D) 6 mol
(E) 12 mol
12. Of the following, which atom has the smallest atomic radius?
- (A) S
(B) Al
(C) Na
(D) Ba
(E) K
13. Of the following, which element is most likely to react with water at room temperature and pressure?
- (A) Au
(B) C
(C) Na
(D) Ne
(E) Ag
14. When a gas turns into a liquid, the process is called
- (A) condensation
(B) evaporation
(C) deposition
(D) sublimation
(E) fusion
15. Which of the following types of organic compounds exhibit hydrogen bonding?
- (A) Ketones
(B) Aldehydes
(C) Hydrocarbons
(D) Alcohols
(E) Ethers
16. Which of the following is a strong acid in water?
- (A) HCl
(B) HCN
(C) HCOOH
(D) RbOH
(E) HF
17. Animals in which of the following groups may have a backbone and a spinal cord?
- (A) Mollusks
(B) Chordates
(C) Invertebrates
(D) Echinoderms
(E) Segmented worms
18. Polarized sunglasses are used to cut glare from sunlight reflected at a glancing angle off cars, water, and other surfaces. Such sunglasses are a practical application of which of the following physical principles?
- (A) Brewster's law
(B) Lenz's law
(C) Coulomb's law
(D) Snell's law
(E) Kepler's law
19. If equal and opposite charges are placed on the two plates of a parallel plate capacitor and the plates are then moved apart, which of the following remain(s) constant?
- I. Voltage
II. Capacitance
III. Charge
- (A) I only
(B) II only
(C) III only
(D) I and II only
(E) I, II, and III

20. A thin ring of mass 50 g and radius 5.0 cm is spinning at a frequency of 6.0 rev/s. Mass is added uniformly to the ring until it has a final mass of 75 g. What is the final spinning frequency of the ring?
- (A) 0 rev/s
 - (B) 4 rev/s
 - (C) 6 rev/s
 - (D) 8 rev/s
 - (E) 18 rev/s
21. A washer consists of a 3.00 cm diameter circle of sheet metal with a 1.00 cm diameter circular hole in the middle. If the metal washer is heated until the diameter of the washer is 3.03 cm, then the diameter of the hole will be
- (A) 0.97 cm
 - (B) 0.99 cm
 - (C) 1.00 cm
 - (D) 1.01 cm
 - (E) 1.03 cm
22. In a particle accelerator, it becomes increasingly difficult to increase a particle's speed because of
- (A) relativistic mass increase
 - (B) time dilation
 - (C) length contraction
 - (D) inelastic collisions
 - (E) elastic collisions
23. The true length of a block of wood is 1.010 cm. Three measurements of this block produced the following values: 1.4 cm, 1.2 cm, and 0.9 cm. Which of the following statements is true concerning these measurements?
- (A) They are precise and accurate.
 - (B) They are precise but not accurate.
 - (C) They are accurate but not precise.
 - (D) They are neither precise nor accurate.
 - (E) Only one measurement is precise.
24. Which of the following items will be attracted to the north pole of a permanent magnet by a magnetic force?
- (A) The north pole of another permanent magnet
 - (B) A piece of iron that is not a permanent magnet
 - (C) A positively charged glass rod
 - (D) A negatively charged rubber rod
 - (E) A piece of copper

Answers

1. For a reaction at equilibrium, the equilibrium constant K_c is equal to the product of the concentrations of the reaction products divided by the product of the concentration of the reactants, each factor raised to the power equal to the stoichiometric coefficient of that substance in the balanced equation for the reaction. In a chemical reaction, the concentration of a solid is always the same, and as long as some of the solid is present, equilibrium is reached the same way. Moreover, adding or taking away some of the solid will not affect the equilibrium once it is established. For this reason, the concentration terms for solids do not appear in expressions for equilibrium constants. The correct answer is D.

2. If 1 L of the given gas has a mass of 3.40 g, then 22.4 L (the volume of 1 mol of any gas at STP) would have a mass 22.4 times larger. Therefore, the molar mass of the gas is $22.4 \times 3.40 \text{ g}$, and the correct answer is choice A.

3. The orbit of the Earth is an ellipse with the Sun at one of its foci (Kepler's first law). During the fall and winter in the Northern Hemisphere, i.e., between the autumnal and vernal equinoxes, the Earth is generally closer to the Sun than in the other half of the year, and by virtue of Kepler's second law it moves comparatively faster. The correct answer is B.

4. Since the assortment of chromosomes containing the genes for coat color is assumed to occur at random, this problem is equivalent to that of determining the probability of picking two white balls in one draw out of a box in which there are two white balls (labeled *b*) and two black balls (labeled *B*). Assuming the first letter in a pair is the gene provided by the male guinea pig, the possibilities are thus: *BB*, *Bb*, *bB*, and *bb*. Because the black allele is dominant, only the combination *bb* produces white fur, its probability being 1 out of 4, or 0.25. Thus, only 25% of the offspring are expected to be white. The correct answer is B.

5. Choices A, C, D, and E deal with variable phenomena (oceans, life, etc.) that appeared on Earth during its formation or long afterward. The decay of certain isotopes of uranium and thorium, on the contrary, occurs at a fixed rate. Each of these elements has a half-life long enough (4.5 and 14 billion years for U^{238} and Th^{232} , respectively) to permit a reasonable estimation of the age of our planet. Choice B is the correct answer.

6. When uranium-235 undergoes fission in a nuclear reactor, it releases fast neutrons that are capable of causing the fission of other nuclei, which in turn release more nuclei, thus setting up a chain reaction. Moderators are used to slow down the fast neutrons, because slower neutrons are more effective for producing additional fission reactions. Even though there are other particles involved in the different reactions in a nuclear reactor, the correct answer is B.

7. When thorium (atomic mass 232; atomic number 90) decays into radium (atomic mass 228; atomic number 88), it loses 2 protons and altogether 4 nucleons, which means that it has to lose 2 neutrons in the process. Of the choices given, the alpha particle is the only one consisting of 4 nucleons. The correct answer is, therefore, D.

8. To minimize the errors involved in the start and the end of timing with a stopwatch, and also the uncertainty involved in determining the start and the end of a complete swing, the best procedure to follow is one that minimizes both types of errors by allowing the pendulum to oscillate the greatest number of times. Of the choices presented, D satisfies this condition.

9. The period of a simple pendulum is given by

$$T = 2\pi \sqrt{\frac{L}{g}},$$

where L is its length and g is the acceleration of gravity. Of the figures shown, only choice A correctly represents the mathematical relationship between the variables T and L .

10. The correct answer is D. The element Ga is a metal. S, Se, I, and Rn are nonmetals.

11. The correct answer is D. A concentration of 2 M means there are 2 moles of HCl per liter of water. So 6 moles of HCl must be added to sufficient water to form 3 liters of a 2 M HCl solution.

12. The correct answer is A. S has the smallest atomic radius. The relative atomic radii of the atoms of various elements can be predicted from the position of the element on the periodic table. Going across a row of the periodic table from left to right, the radii get smaller, and going down a column, the radii get larger. The correct order of atomic radii for elements in this question is $\text{Ba} > \text{K} > \text{Na} > \text{Al} > \text{S}$.

13. The correct answer is C. Na is most reactive with water. Au, C, Ne, and Ag are extremely unreactive with water.

14. The correct answer is A. When a gas turns into a liquid, the process is called condensation.

15. The correct answer is D. Alcohols exhibit some degree of hydrogen bonding. Ketones, aldehydes, hydrocarbons, and ethers do not exhibit hydrogen bonding.

16. The correct answer is A. HCl is a strong acid. HCN, HCOOH, and HF are weak acids. RbOH is a base.

17. The correct answer is B. Most chordates possess a vertebral column (backbone) that surrounds a dorsal nerve cord. Mollusks (e.g., clams and mussels), echinoderms (e.g., sea stars and sea urchins), and segmented worms (annelids) are all invertebrates that lack a vertebral column and dorsal nerve cord.

18. The correct answer is A. According to Brewster's law, reflected light will always be polarized in a horizontal direction, parallel to the reflecting surface. Polarized sunglasses are constructed to block this reflected light and to transmit light polarized only in the vertical direction.

19. The correct answer is C. The capacitance C of a parallel plate capacitor decreases as the distance between the plates increases. The charge Q on the plates is isolated and will not change. By the definition of capacitance, namely $C = Q/V$, the voltage V will increase, since C decreases and Q remains constant.

20. The correct answer is B. The additional mass is added uniformly to the ring, which means that no external torques act on the system and angular momentum is conserved. Now, the angular momentum is equal to the product of the ring's mass, the ring's angular velocity, and the square of the ring's radius. Because the radius is also constant, conservation of angular momentum gives $(50 \text{ g}) \times (6.0 \text{ rev/s}) = (75 \text{ g}) \times (\text{final angular frequency})$, or final angular frequency = 4 rev/s.

21. The correct answer is D. At a given radius, the linear expansion is the same in all radial directions and is equal to the product of the radius, the thermal expansion coefficient, and the temperature change. Thus, the expansion of the inner diameter will be equal to one-third the expansion of the outer diameter, or 0.01 cm, for a total internal diameter of 1.01 cm.

22. The correct answer is A. In a particle accelerator, the particles are accelerated to relativistic speeds. According to the theory of special relativity, a particle's mass (inertia) increases as the particle's speed increases. Thus, greater and greater forces are needed to accelerate the particle as its speed increases.

23. The correct answer is D. The measurements differ from the true length by 0.39 cm, 0.19 cm, and -0.11 cm. Thus, the measurements are quite different in value from the true value, which means that they are not accurate. The measurements are also quite different in value from one another (not repeatable), which means that they are not precise.

24. The correct answer is B. Iron is easily magnetized. When iron is brought close to a permanent magnet, the iron will become magnetized in such a way as to be attracted to the permanent magnet.



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