

Chemistry: Content Knowledge (0241)

Test at a Glance

Test Name	Chemistry: Content Knowledge		
Test Code	0241		
Time	1 hour		
Number of Questions	50		
Format	Multiple-choice questions; calculator use prohibited		
	Content Categories	Approximate Number of Questions	Approximate Percentage of Examination
	I. Atomic Structure/Chemical Periodicity/Thermodynamics of Chemical Reactions	12	24%
	III. Nomenclature/The Mole, Bonding, and Geometry	11	22%
	III. Solutions and Solubility	13	26%
	IV. Chemical Reactions/Biochemistry	14	28%

About This Test

The Chemistry: Content Knowledge test measures the knowledge and competencies necessary for a beginning teacher of chemistry in a secondary school. Examinees have typically completed or nearly completed a bachelor's degree program in chemistry, with appropriate coursework in education.

The 50 multiple-choice questions address examinees' knowledge of atomic structure, chemical periodicity, and chemical thermodynamics; nomenclature, the mole, bonding, and geometry; solutions and solubility; chemical reactions and biochemistry.

Topics are typically covered in introductory college-level chemistry and physical science courses, although some questions of a more advanced nature are included because secondary school instructors must understand the subject matter from a more advanced viewpoint than that presented to their students.

Examinees are not permitted to use calculators in taking this test; test books contain a periodic table and a table of information that presents various physical constants and a few conversion factors among SI units. Whenever necessary, additional values of physical constants are printed with the text of the question.

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

Topics Covered

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

I. Atomic Structure/Chemical Periodicity/

Thermodynamics of Chemical Reactions

- Atomic structure, electron configuration, and chemical properties related to electron configuration
- Chemical periodicity: the interpretation of periodic trends in atomic and elemental properties, bond types and chemical reactivity as related to periodicity
- Thermodynamics of chemical reactions

II. Nomenclature/

The Mole, Bonding, and Geometry

- Nomenclature: systematic nomenclature of ionic and molecular compounds, including acids, as well as the nomenclature of organic compounds according to their functional groups
- The mole, chemical bonding, and molecular geometry: interpret and use chemical formulas, the mole concept and chemical composition, ionic, covalent, and metallic bonding, structural formulas and molecular geometry, bond properties and correlation to chemical reactivity, and intermolecular forces and correlation to physical properties

III. Solutions and Solubility

- Solution terminology and types of solutions
- Factors affecting solubility and dissolution rate
- Concentration terms and calculations
- Colligative properties and conductivity of solutions
- Acid-base concepts, reactions, equilibria, titrations, and calculations
- Ionic equilibrium in precipitation and calculations involving K_{sp}

IV. Chemical Reactions/Biochemistry

- Equation balancing and stoichiometry
- General types of chemical reactions
- Chemical kinetics involving rates and simple reaction mechanisms
- Chemical equilibrium
- Redox chemistry and electrochemistry
- Organic functional groups and their reactions
- Biologically important compounds and reactions

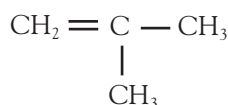
Sample Test Questions

The sample questions that follow illustrate the kinds 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.

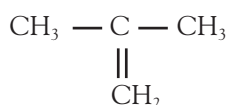
Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case.

- Which of the following statements is correct about any chemical reaction that is at equilibrium?
 - The molecules stop reacting.
 - Only side reactions continue; the main reaction stops.
 - Forward and backward reactions occur at equal rates.
 - There are as many molecules of reactant as there are molecules of product.
- Which, if any, of the following structural formulas represent the same compound?

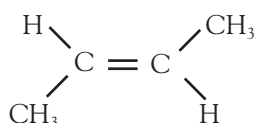
Structure I



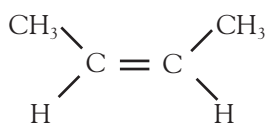
Structure II



Structure III

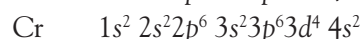
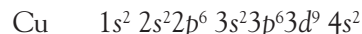


Structure IV

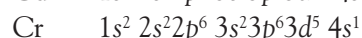
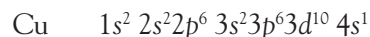


- I and II only
- III and IV only
- I, II, III, and IV
- None of the formulas represent identical compounds.

- According to modern atomic theory, if electron additions were orderly, chromium and copper atoms should have the following electron configurations.



However, the presently accepted configurations are as follows.



Which of the following is the best explanation for the half-filled 4s orbitals?

- The Pauli exclusion principle
 - The assumption that there must be one electron in each orbital before an orbital can be filled (Hund's rule)
 - The lower-than-expected energy of the 3d subshell due to screening
 - The ease with which having a single 4s electron allows the formation by both chromium and copper atoms of univalent negative ions
- The correct formula for copper (I) sulfate is
 - CuSO_4
 - Cu_2SO_4
 - Cu_4SO
 - Cu_4SO_4
 - The pH of a 4.0×10^{-4} M HCl solution is between
 - 2 and 3
 - 3 and 4
 - 4 and 5
 - 5 and 6

6. A reaction is spontaneous at all temperatures if the values of ΔH and ΔS have which signs?
- | | ΔH | ΔS |
|-----|------------|------------|
| (A) | Positive | Negative |
| (B) | Positive | Positive |
| (C) | Negative | Negative |
| (D) | Negative | Positive |
7. $\text{Ag}^+ + \text{e}^- \longrightarrow \text{Ag}(s) \quad E^\circ = +0.80 \text{ V}$
 $\text{Cr}^{+3} + 3\text{e}^- \longrightarrow \text{Cr}(s) \quad E^\circ = -0.74 \text{ V}$
 Based on the standard reduction potentials for chromium and silver shown above, what is the cell potential for the reaction below?
- $$3 \text{Ag}^+ + \text{Cr}(s) \longrightarrow 3 \text{Ag}(s) + \text{Cr}^{+3}$$
- (A) 0.06 V
 (B) 1.54 V
 (C) 1.66 V
 (D) 3.14 V
8. Which of the following is an important function of carbohydrates in living organisms?
- (A) They are the primary component of enzymes.
 (B) They constitute a source of energy for the organism.
 (C) They contain the genetic information of the cell.
 (D) They comprise structural parts such as cartilage and tendons.
9. The two elements in which of the following pairs have a valence of +3?
- (A) Al and Ga
 (B) N and O
 (C) Li and Na
 (D) F and Cl
10. Liquids with molecules held together by van der Waals forces have which of the following properties?
- (A) High solubilities in water
 (B) High melting points
 (C) Low boiling points
 (D) Significant electrical conductivities in the solid phase
11. The solubility product, K_{sp} , for $\text{Mg}(\text{OH})_2$ is 1.0×10^{-11} . What is the concentration of Mg^{2+} in a saturated solution of this base?
- (A) $\sqrt[2]{5.0 \times 10^{-12}} \text{ M}$
 (B) $\sqrt{1.0 \times 10^{-11}} \text{ M}$
 (C) $\sqrt[3]{2.5 \times 10^{-12}} \text{ M}$
 (D) $\sqrt[3]{1.0 \times 10^{-11}} \text{ M}$
12. When 0.50 mol of octane, C_8H_{18} , is burned completely and the reaction products are brought to 10°C and 1 atm, the products include approximately
- (A) 18 mol of water
 (B) 100 L of carbon dioxide
 (C) 200 L of carbon dioxide
 (D) 220 L of water vapor

Answers

- 1.** The correct answer is C. The definition of an equilibrium is that the forward and backward reactions occur at equal rates.
- 2.** The correct answer is A. I and II are the same compound, 2-methyl-1-propene. III and IV are cis and trans isomers. They are geometric isomers with different properties.
- 3.** Choice C is the best explanation. The last electron goes into the available orbital of lowest energy.
- 4.** The correct answer is B. Copper (I) is Cu^+ and sulfate is SO_4^{2-} ; therefore, for charge neutrality the compound is Cu_2SO_4 .
- 5.** Choice B is the correct answer. HCl dissociates completely, so $[\text{H}^+] = 4.0 \times 10^{-4} \text{ M}$ and the pH is between 3 and 4.
- 6.** Reactions are spontaneous if they result in lower Gibbs free energy, G . $\Delta G = \Delta H - T\Delta S$. If ΔG is to be negative at all values of T , then ΔH must be negative and ΔS must be positive. Thus, D is the correct answer.
- 7.** The correct answer is B.
 $E = E^\circ(\text{Ag}) - E^\circ(\text{Cr}) = 0.80 + 0.74 = 1.54$
- 8.** Choice B is the correct answer. Carbohydrates are broken down to glucose during digestion and glucose is oxidized in the cell to produce energy in the form of ATP.
- 9.** The correct answer is A. The valences of Al and Ga are both +3.
- 10.** Van der Waals forces is the collective name for weak attractive forces between molecules. In general, liquids held together only by these forces have low boiling points relative to their molecular weights since only weak forces must be overcome during vaporization. Thus, C is the correct answer.
- 11.** The K_{sp} of a salt is the product of the ion concentrations in a saturated solution. In the present case, $K_{sp} = [\text{Mg}^{2+}][\text{OH}^-]^2$.
 Since $[\text{OH}^-] = 2[\text{Mg}^{2+}]$, $K_{sp} = [\text{Mg}^{2+}](2[\text{Mg}^{2+}])^2 = 4[\text{Mg}^{2+}]^3 = 1.0 \times 10^{-11}$.
 Solving for $[\text{Mg}^{2+}]$ one obtains $[\text{Mg}^{2+}] = [1 \times 10^{-11}/4]^{1/3}$.
 The correct answer is C.
- 12.** The balanced equation for the reaction is
 $2 \text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow 16 \text{CO}_2 + 18 \text{H}_2\text{O}$.
 Choice B is correct; 0.5 mol octane produces 4 mol of CO_2 , which, at 10°C STP, occupies

$$\frac{(4 \text{ mol} \times 22.4 \text{ L/mol})293 \text{ K}}{273 \text{ K}} = 96 \text{ L} \cong 100 \text{ L}$$



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