Harvard Undergraduate Science Olympiad Dubai 2026

Chemistry, 7-8th Grade

Number of Problems: 30 Questions

Instructions: This test consists of two sections:

- *Section A: 20 multiple choice questions, 1 point each.*
- *Section B: 10 short answer questions, 2 point each.*

For the multiple choice questions, select the correct answer and fill in the corresponding bubble on the answer sheet.

For the short answer questions, write the correct answer in the corresponding box on the answer sheet. Round numerical solutions to a reasonable number of significant figures.

Only responses on the answer sheet will be graded. You can use this test packet as scratch paper, but no points will be awarded for any work shown.

To determine tiesbreakers, we will compare scores on the last problem; if still tied, compare the second-to-last; continue backward until the score differs.

You are allowed with you a pencil or pen, erasers, and a non-programmable, scientific calculator. Any other electronic devices or notes are strictly prohibited. You have 60 minutes to complete this exam. Good luck!

Multiple Choice Questions (20 total)

1. Which of the following elements is classified as a metalloid?
   A. Argon (Ar)
   B. Silicon (Si)
   C. Iron (Fe)
   D. Bromine (Br)
   E. Sodium (Na)

2. Which of the following pairs of elements would most likely form an ionic bond?
   A. Carbon (C) and Oxygen (O)
   B. Hydrogen (H) and Oxygen (O)
   C. Nitrogen (N) and Sulfur (S)
   D. Sodium (Na) and Chlorine (Cl)
   E. Iron (Fe) and Copper (Cu)

3. Which of the following chemical equations represents a decomposition reaction?
   A. $2H_2O_2 \rightarrow 2H_2O + O_2$
   B. $2H_2 + O_2 \rightarrow 2H_2O$
   C. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
   D. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
   E. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

4. Which of the following is the correctly balanced equation for the reaction of aluminum metal with oxygen gas to form aluminum oxide?
   A. $4Al + 2O_2 \rightarrow 2Al_2O_3$
   B. $2Al + 3O_2 \rightarrow 2Al_2O_3$
   C. $4Al + 3O_2 \rightarrow 2Al_2O_3$
   D. $4Al + 3O_2 \rightarrow Al_2O_3$
   E. $2Al + 2O_2 \rightarrow 2Al_2O_3$

5. Which statement best describes a Brønsted–Lowry base?
   A. A substance that donates a proton (H^+)
   B. A substance that produces hydronium ions (H_3O^+) in water
   C. A substance that donates an electron pair to form a covalent bond
   D. A substance that releases hydroxide ions (OH^-) in aqueous solution
   E. A substance that accepts a proton (H^+)

6. Which statement correctly describes the relationship between an acid's dissociation constant (K_a) and its strength?
   A. The larger the value of K_a, the stronger the acid

B. The smaller the value of K_a, the stronger the acid

C. A weak acid typically has a K_a value greater than 1

D. All strong acids have identical K_a values

E. Strong acids do not have a K_a value since they dissociate completely in water

7. Which metal ion produces a bright yellow-colored flame in a flame test?

A. Copper (Cu^{2+})

B. Potassium (K^{+})

C. Calcium (Ca^{2+})

D. Lithium (Li^{+})

E. Sodium (Na^{+})

8. In the reaction $2, Mg + O_2 \rightarrow 2, MgO$, which species acts as the oxidizing agent?

A. Mg (magnesium)

B. MgO (magnesium oxide)

C. O_2 (oxygen)

D. Mg^{2+} (magnesium ion in the product)

E. O^{2-} (oxide ion in the product)

9. If the enthalpy change (ΔH) of a reaction is negative, which of the following is true of the reaction?

A. It absorbs heat from the surroundings

B. It releases heat to the surroundings

C. It is an endothermic process

D. It causes the temperature of the surroundings to decrease

E. The products have higher enthalpy than the reactants

10. Doubling the concentration of reactant X is observed to double the rate of a certain reaction. What is the reaction order with respect to X?

A. Zero order

B. Third order

C. Second order

D. First order

E. Cannot be determined from the information given

11. Which of the following elements has the largest atomic radius?

A. Lithium (Li)

B. Carbon (C)

C. Potassium (K)

D. Fluorine (F)

E. Neon (Ne)

12. During a beta-minus (β^-) radioactive decay, which of the following particles is emitted from the nucleus?

A. An alpha particle (helium-4 nucleus)

B. A positron (positively charged electron)

C. A neutron

D. A gamma ray (high-energy photon)

E. An electron (beta particle)

13. Which of the following molecules is polar (i.e., has an overall dipole moment)?

A. NH_3 (ammonia)

B. CO_2 (carbon dioxide)

C. CH_4 (methane)

D. CCl_4 (carbon tetrachloride)

E. BF_3 (boron trifluoride)

14. Consider the equilibrium: $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + \text{heat}$. According to Le Châtelier's principle, what will happen if the temperature of this system is increased?

A. The equilibrium will shift toward the products (to the right)

B. The equilibrium will shift toward the reactants (to the left)

C. The position of equilibrium will not change with temperature

D. The equilibrium constant K will increase at the higher temperature

E. The reaction will proceed to completion (all reactants converted to products)

15. Which of the following aqueous solutions is expected to have the lowest freezing point? (Assume ideal behavior and complete dissociation of ionic compounds.)

A. Pure water

B. 0.10 M glucose (a non-electrolyte sugar solution)

C. 0.10 M NaCl (sodium chloride solution)

D. 0.10 M $CaCl_2$ (calcium chloride solution)

E. 0.05 M NaCl (sodium chloride solution)

16. For a typical chemical reaction, which of the following changes will **not** result in an increased reaction rate?

A. Increasing the concentration of reactants

B. Increasing the reaction temperature

C. Adding a suitable catalyst

D. Lowering the reaction temperature

E. Grinding a solid reactant into a fine powder (increasing surface area)

17. Which pair of aqueous solutions, when mixed, will produce a precipitate due to an insoluble product?

A. Na_2CO_3 (aq) + KCl (aq)

B. $NaNO_3$ (aq) + KBr (aq)

C. $Pb(NO_3)_2$ (aq) + K_2SO_4 (aq)

D. $Cu(NO_3)_2$ (aq) + NaCl (aq)

E. $CaCl_2$ (aq) + KNO_3 (aq)

18. Which of the following oxides will form an acidic solution when added to water?

A. CaO (s)

B. Na_2O (s)

C. Al_2O_3 (s)

D. CO_2 (g)

E. CO (g)

19. Which of the processes below involves an increase in entropy ($\Delta S > 0$)?

A. $2\,NH_3(g) \rightarrow N_2(g) + 3\,H_2(g)$

B. $H_2O(l) \rightarrow H_2O(s)$

C. $CO_2(g) \rightarrow CO_2(s)$

D. Compressing an ideal gas into a smaller volume (constant T)

E. $N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g)$

20. Which piece of laboratory equipment is most suitable for accurately measuring out **25.00 mL** of a liquid sample?

A. 50 mL beaker

B. 100 mL graduated cylinder

C. 50 mL Erlenmeyer flask

D. 50 mL burette

E. 25 mL volumetric pipette

Short Answer Questions (10 total)

1. Chlorine has two naturally occurring isotopes: ^{35}Cl (mass = 34.97 amu, abundance 75.78%) and ^{37}Cl (mass = 36.96 amu, abundance 24.22%). Calculate the average atomic mass of chlorine.

2. Methane (CH_4) combusts in oxygen to form carbon dioxide and water, according to the equation: $\mathsf{CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O}$. If 8.00 g of CH_4 is reacted with 16.0 g of O_2, determine which reactant is the limiting reagent and calculate the mass of CO_2 that can be produced.

3. A compound is analyzed and found to consist of 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen by mass. Determine the empirical formula of this compound.

4. Using Hess's law, determine the enthalpy change ΔH for the reaction $\mathrm{C(s)} + \mathrm{O_2}(g) \rightarrow \mathrm{CO_2}(g)$. You are provided with the following reactions and their enthalpy changes: $\mathrm{C(s)} + \frac{1}{2}\mathrm{O_2}(g) \rightarrow \mathrm{CO}(g)$ ($\Delta H = -110.5$ kJ); $\mathrm{CO}(g) + \frac{1}{2}\mathrm{O_2}(g) \rightarrow \mathrm{CO_2}(g)$ ($\Delta H = -283.0$ kJ). Combine these steps to find ΔH for $\mathrm{C(s)} + \mathrm{O_2}(g) \rightarrow \mathrm{CO_2}(g)$.

5. Calculate the pH of a 0.0020 M HCl solution (assume HCl dissociates completely in water).

6. A 0.500 mol sample of an ideal gas is confined in a 10.0 L container at 300 K. Use the ideal gas equation $PV = nRT$ to calculate the pressure of the gas in atmospheres (use $R = 0.08206\ \mathrm{L \cdot atm/(mol \cdot K)}$).

7. Determine the molecular geometry (VSEPR shape) of sulfur hexafluoride, SF_6.

8. In a laboratory experiment, a student measures the density of a liquid to be 0.78 g/mL. The true accepted density of the liquid is 0.85 g/mL. Calculate the percent error of the student's measurement.

9. What volume (in mL) of 0.250 M NaOH solution is required to completely neutralize 50.0 mL of 0.100 M HCl?

10. For the reaction $H_2(g) + I_2(g) \rightleftharpoons 2, HI(g)$, the equilibrium concentrations at a certain temperature are $[H_2] = 0.200$ M, $[I_2] = 0.200$ M, and $[HI] = 1.200$ M. Calculate the equilibrium constant K_c for this reaction.