Class 11 Chemistry (Theory)

Half-Yearly Examination

Time: 3 Hours **Full Marks:** 70

General Instructions:

1. *All questions are compulsory.*
2. *The question paper has five sections: Section A, Section B, Section C, Section D, and Section E.*
3. ***Section A** contains 16 Multiple Choice Questions (MCQs), carrying 1 mark each.*
4. ***Section B** contains 7 Very Short Answer (VSA) type questions, carrying 2 marks each.*
5. ***Section C** contains 4 Short Answer (SA-I) type questions, carrying 3 marks each. Internal choice is provided in 2 questions. You have to attempt only one of the alternatives in all such questions.*
6. ***Section D** contains 3 Long Answer (LA) type questions, carrying 5 marks each. Internal choice is provided in all such questions. You have to attempt only one of the alternatives in all such questions.*
7. ***Section E** contains 2 Case-Based/Competency-Based questions, carrying a total of 13 marks (7 marks for Q.28 and 6 marks for Q.29). Each case study has internal sub-parts.*
8. *Use of calculators is **not** permitted. However, log tables may be used if necessary.*

Useful Constants:

- Avogadro's number (N_A) = 6.022×10^{23} mol^{-1}
- Speed of light (c) = 3.0×10^{8} m/s

- Planck's constant (h) = 6.626×10^{-34} Js
- Mass of electron = 9.1×10^{-31} kg
- Atomic masses: H=1 u, C=12 u, O=16 u, N=14 u, Na=23 u, S=32 u, Cl=35.5 u, Ca=40 u

Section A: Multiple Choice Questions (1 mark each)

1. A sample of pure water, irrespective of its source, contains 11.1% hydrogen and 88.9% oxygen by mass. This illustrates the law of:

   A) Conservation of Mass B) Multiple Proportions C) Definite Proportions D) Reciprocal Proportions

2. If the uncertainty in position of an electron is zero, the uncertainty in its momentum would be:

   A) Zero B) Infinite C) Finite and non-zero D) Less than zero

3. The correct order of increasing energy of orbitals is:

   A) 3p<4s<3d B) 4s<3p<3d C) 3d<4s<3p D) 3p<3d<4s

4. Which of the following electronic configurations is an exception to the Aufbau principle?

   A) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$ B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$ D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$

5. Which of the following is the correct order of increasing atomic radii?

   A) F<Cl<Br<I B) I<Br<Cl<F C) Cl<F<Br<I D) Br<Cl<F<I

6. The correct order of increasing first ionization enthalpy is:

   A) Li<Be<B<C B) B<Be<Li<C C) Li<B<Be<C D) Be<Li<B<C

7. Which of the following has the highest lattice enthalpy?

A) NaCl B) KCl C) MgO D) CaO

8. The molecule with the highest dipole moment among the following is:

A) CH_4 B) CCl_4 C) $CHCl_3$ D) H_2O

9. Which of the following is paramagnetic?

A) N_2 B) CO C) O_2 D) C_2

10. The number of sigma (σ) and pi (π) bonds in C_2H_4 are:

A) 4σ,1π B) 5σ,1π C) 4σ, 2π D) 5σ, 2π

11. The bond order of O_2^- (superoxide ion) is:

A) 1 B) 1.5 C) 2 D) 2.5

12. Which of the following is an example of a molecule with an expanded octet?

A) PCl_3 B) BF_3 C) SF_6 D) NH_3

13. The number of radial nodes in a 4s orbital is: A) 0 B) 1 C) 2 D) 3

14. The correct order of decreasing electronegativity is:

A) F>O>N>Cl B) F>Cl>O>N C) O>F>N>Cl D) F>O>Cl>N

15. The empirical formula of a compound is CH_2O. If its molar mass is 180 g/mol, its molecular formula is:

A) CH_2O B) $C_2H_4O_2$ C) $C_6H_{12}O_6$ D) $C_3H_6O_3$

16. Which of the following statements about the photoelectric effect is incorrect?

A) There is no time lag between the incidence of light and the ejection of electrons. B) The number of ejected electrons is proportional to the intensity of incident light. C) The kinetic energy of ejected electrons is independent of the frequency of incident light. D) The photoelectric effect is observed only if the frequency of incident light is above a threshold frequency.

Section B: Very Short Answer Questions (2 marks each)

17. Calculate the mass of 11.2 L of CO_2 gas at STP.

18. Explain why the 4s orbital is filled before the 3d orbital in multi-electron atoms.

19. Explain why the electron gain enthalpy of F is less negative than that of Cl.

20. Using VSEPR theory, predict the shape of ClF_3. Justify your answer.

21. Differentiate between precision and accuracy with an example.

22. What is the significance of the wave function (ψ) in quantum mechanics? What does ψ^2 represent?

23. Explain why Na^+ and Mg^{2+} are iso-electronic but have different ionic radii. Which one is smaller and why?

Section C: Short Answer Questions Type I (3 marks each)

24. A compound on analysis gave the following percentage composition: Na=29.11%, S=40.51%, and O=30.38%. Determine its empirical formula. (Atomic masses: Na=23, S=32, O=16)

OR

20 g of NaOH is dissolved in 100 mL of water. Calculate the molarity of the solution. If the density of the solution is 1.2 g/mL, calculate its molality.

25. (a) State Heisenberg's Uncertainty Principle. (b) Calculate the de Broglie wavelength of a proton moving with a velocity of 1.0×10^{5} m/s. (Mass of proton = 1.67×10^{-27} kg)

OR

(a) Explain the concept of atomic orbitals and their shapes (s and p). (b) How many electrons in an atom can have the following quantum numbers: (i) n=3, l=1, m_s=+1/2 (ii) n=4, m_l=0

26. Explain the concept of hybridization. Discuss sp^3d hybridization with an example of PCl_5. Draw its geometry.

27. Using Molecular Orbital Theory, explain why O_2 is paramagnetic while O_2^{2-} is diamagnetic. Calculate the bond order for both species.

Section D: Long Answer Questions (5 marks each)

28. (a) What are the main postulates of Bohr's atomic model? (b) Calculate the energy of the electron in the third Bohr orbit of the hydrogen atom. (Given: Ground state energy $=-2.18\times10^{-18}$ J/atom) (c) What are the limitations of Bohr's model? (Any two)

OR

(a) Explain the significance of all four quantum numbers. (b) Write the electronic configurations of Cr^{3+} (Atomic number = 24) and Cu^{+} (Atomic number = 29). (c) Describe the shapes of d orbitals.

29. (a) Define bond enthalpy and bond length. How are they related to bond order? (b) Explain the formation of a covalent bond using the concept of orbital overlap. (c) What is resonance? Draw the resonance structures of the NO_2^- ion and explain why its bond angles are equal.

OR

(a) Explain the concept of hydrogen bonding. Discuss the two types of hydrogen bonding (intermolecular and intramolecular) with one example each. (b) Why is NH_3 a polar molecule, but CCl_4 is non-polar, even though both contain polar bonds? (c) What is lattice enthalpy? How does it affect the stability of an ionic compound?

30. (a) State the Law of Multiple Proportions. (b) Carbon and oxygen are known to form two compounds. The carbon content in one of these is 42.9% and in the other is 27.3%. Show that these data are in agreement with the Law of Multiple Proportions. (c) Calculate the number of atoms in 0.05 moles of H_2O.

OR

(a) Define limiting reagent. (b) 10 g of hydrogen reacts with 64 g of oxygen to form water. ($2H_2(g)+O_2(g)\rightarrow 2H_2O(l)$) (i) Identify the limiting reagent. (ii) Calculate the mass of water formed. (iii) Calculate the mass of the reactant left unreacted.

Section E: Case-Based/Competency-Based Questions

31. **Read the passage given below and answer the questions that follow:** The modern periodic table organizes elements based on their atomic number, leading to periodic trends in various properties. Ionization enthalpy, electron gain enthalpy, and electronegativity are key properties that show systematic variations across periods and down groups. These trends are influenced by factors such as effective nuclear charge and shielding effect. Understanding these trends helps in predicting the chemical behaviour and reactivity of elements. However, some elements show anomalous behaviour due to their small size, high electronegativity, and absence of d-orbitals.

    (i) Explain why the first ionization enthalpy of oxygen is lower than that of nitrogen. (1 mark)

    (ii) (iWhy is the atomic radius of Na^+ smaller than that of Na? (1 mark)

(iii) Arrange the following in increasing order of their ionic radii: N^{3-}, O^{2-}, F^{-}, Na^{+}, Mg^{2+}. Justify your answer. (2 marks)

(iv) What is diagonal relationship? Give one example. (2 marks)

32. **Read the passage given below and answer the questions that follow:** The quantum mechanical model of the atom describes electrons in terms of orbitals, which are three-dimensional regions around the nucleus where the probability of finding an electron is high. Each orbital is characterized by a set of quantum numbers (n, l, m_l). The spin quantum number (m_s) describes the intrinsic angular momentum of an electron. The filling of electrons into these orbitals follows specific rules, leading to the electronic configuration of an atom, which dictates its chemical properties. The dual nature of matter and Heisenberg's uncertainty principle are fundamental concepts in this model.

(i) What is the significance of ψ^2 in quantum mechanics? (1 mark)

(ii) How many orbitals are associated with n=3? (1 mark)

(iii) An electron is in a 4f orbital. What are the possible values for n, l, m_l? (2 marks)

(iv) Why is it impossible to determine simultaneously the exact position and exact momentum of a microscopic particle? (2 marks)

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