

2025

CHEMISTRY

(Theory)

Full Marks: 70

Pass Marks: 21

Time: Three hours

All the Questions are compulsory.

The figures in the right margin indicate full marks for the questions.

Question Nos. 1-7 are Very short Answer (VSA) type of 1 mark each.

1. What is meant by significant figures? 1
2. What is the standard enthalpy for formation of an element in its reference/standard state? 1
3. The ionization constants for formic acid and acetic acid are 1.8×10^{-4} and 1.74×10^{-5} respectively. Which one will be stronger acid? 1
4. Write the structural formula of 3, 3-Dimethyl butan-2-ol. 1
5. Which geometrical isomer of but-2-ene is more polar? 1
6. Why does fluorine not show disproportionation reaction? 1
7. BF_3 does not have proton but still acts as an acid and reacts with NH_3 . Why is it so? 1

P.T.O.

Question Nos. 8-17 are Multiple Choice Question (MCQ) carrying 1 mark each. Choose and rewrite the best answer out of the given alternatives.

8. Ethyne on passing through red hot iron tube at 873 K will give 1
(A) Butane (B) Benzene
(C) Hexane (D) Toluene
9. A chemical reaction has reached a state where the rates of the forward and reverse reactions are equal. Which term accurately describes this condition? 1
(A) Irreversible reaction (B) Reversible reaction
(C) Dynamic equilibrium (D) Static equilibrium
10. Which one exhibits the highest electronegativity value? 1
(A) Chlorine (B) Bromine
(C) Oxygen (D) Nitrogen
11. Which of the following represent the correct order of acidic strength? 1
(A) $\text{CH}_3-\text{CH}_3 > \text{CH}_2=\text{CH}_2 > \text{CH} \equiv \text{CH}$
(B) $\text{CH}_2=\text{CH}_2 > \text{CH} \equiv \text{CH} > \text{CH}_3-\text{CH}_3$
(C) $\text{CH}_3-\text{CH}_3 > \text{CH} \equiv \text{CH} > \text{CH}_2=\text{CH}_2$
(D) $\text{CH} \equiv \text{CH} > \text{CH}_2=\text{CH}_2 > \text{CH}_3-\text{CH}_3$
12. In an adiabatic process the work done is 40 KJ, what is its internal energy? 1
(A) 40 KJ (B) 50 KJ
(C) -40 KJ (D) -50 KJ
13. Which of the following pairs constitutes a buffer solution? 1
(A) NaOH and NaCl (B) HNO_3 and NH_4NO_3
(C) HCl and NaOH (D) NH_4OH and NH_4Cl

14. Which of the following temperature will read the same value on Celsius and Fahrenheit scales? 1

- (A) -40° (B) $+40^{\circ}$
(C) -80° (D) -20°

15. Two electrons occupying the same orbital are distinguished by – 1

- (A) Azimuthal quantum number (B) Spin quantum number
(C) Magnetic quantum number (D) Orbital quantum number

For Question Nos. 16 and 17, two statements are given-one labelled as Assertion(A) and the other labelled as Reason(R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below :

- (A) Both Assertion(A) and Reason(R) are true and Reason(R) is the correct explanation of Assertion(A).
(B) Both Assertion(A) and Reason(R) are true but Reason(R) is not the correct explanation of Assertion(A).
(C) Assertion(A) is true but Reason(R) is false.
(D) Assertion(A) is false but Reason(R) is true.

16. Assertion (A) : Removal of s-electron is relatively easier than removal of p- electron of the same main shell. 1

Reason (R) : s-electrons are closer to the nucleus than p-electrons of the same shell and hence, are more strongly attracted by the nucleus.

17. Assertion (A) : Kjeldahl method is not applicable for estimation of nitrogen in compounds containing nitrogen in the form of nitro and azo group. 1

Reason (R) : Nitrogen of nitro and azo group does not change to ammonium sulphate by Kjeldahl's method.

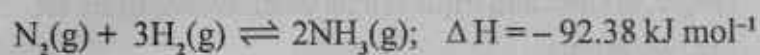
Question Nos. 18-27 are Short Answer (SA-II) type and each carries 2 marks.

18. Explain Wurtz reaction with a suitable example. 2
19. Explain the structure of the carbonate ion (CO_3^{2-}) using the concept of resonance. 2
20. The two naturally occurring isotopes of chlorine ^{35}Cl and ^{37}Cl exist in relative abundance ratio of 3:1. Calculate the average atomic mass of chlorine. 2
21. Consider the following reaction : 2
- $$2\text{Cu}_2\text{O}(\text{s}) + \text{Cu}_2\text{S}(\text{s}) \rightarrow 6\text{Cu}(\text{s}) + \text{SO}_2(\text{g})$$
- Justify that this is a redox reaction.
22. The pK_a of acetic acid and pK_b of ammonium hydroxide are 4.76 and 4.75 respectively. Calculate the pH of ammonium acetate solution. 2
23. Although fluorine (F) is more electronegative than chlorine (Cl), its electron gain enthalpy is less negative than that of chlorine. Why? 2
24. Potassium dichromate reacts with sodium sulphite in acidic medium to give chromium ion and the sulphate ion. Write the balanced ionic equation for the reaction. 2
25. Explain why atoms with half-filled and completely filled configurations have extra stability? 2
26. Draw the first to fourth successive ionization enthalpy diagrams for the elements with valence shell electronic configuration, $3s^2 3p^3$. 2
27. Draw the molecular orbital (MO) level energy diagram for N_2^+ ion indicating the different energy levels with the number of electrons in each orbital. 2

Question Nos. 28-33 are Short Answer (SA-I) type and each carries 3 marks. There is internal option for three questions.

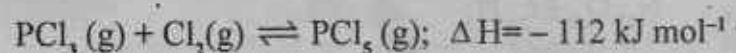
28. Illustrate the Gay Lussac's law of gaseous volumes with suitable example. 3
29. Explain the term Inductive effect with suitable example. 3
30. Calculate oxidation number of – 3
- (i) Cr in $\text{Cr}_2\text{O}_7^{2-}$
- (ii) Mn in KMnO_4
- (iii) S in $\text{H}_2\text{S}_2\text{O}_7$

31. (a) (i) State the law of chemical equilibrium. 1+2=3
- (ii) On the basis of Le Chatelier principle explain how temperature and pressure can be adjusted to increase the yield of ammonia in the following reaction.



Or

- (b) (i) State Le-Chatelier's Principle. 1+2=3
- (ii) Write the expression for the equilibrium constant, K_c and K_p for the following reaction :



32. (a) Write the structural formula of the possible isomers of the organic compound with the molecular formula $\text{C}_3\text{H}_6\text{O}$ and identify the type of isomerism exhibited. 3

Or

- (b) Write the possible resonance structures for $\text{CH}_3-\text{O}-\overset{+}{\text{C}}\text{H}_2$ and predict which of the structures is more stable. 3

33. The following questions are case based questions. Read the case carefully and answer the questions that follow :

- (a) When it comes to describing bonding, the Molecular Orbital Theory incorporates the wave like characteristics of electrons. Atomic orbitals are used in Molecular Orbital Theory to describe how atoms are linked together in bonds. The Molecular Orbital Theory provides answers to more complex questions than the Valence Bond Theory and Lewis Structures. The electrons are delocalized in the Molecular Orbital Theory. When electrons are not assigned to a specific atom or bond, this is referred to as "delocalization".

According to molecular orbital theory, bond order may be defined as one half the difference between the number of electrons present in the bonding and the antibonding orbitals. Using the concept of bond order as a measure of binding strength is a common occurrence in valence bond theories. It is called a bond when two atoms share an electron. It is possible to create single, double and triple bonds when two or more electrons are shared by the two atoms.

Based on the above information, answer the following questions :

- (i) Explain why the He_2 molecule does not exist? 1
- (ii) Which one of the following molecules is paramagnetic? 1
 $\text{N}_2, \text{O}_2, \text{Li}_2, \text{H}_2$
- (iii) Arrange the following species in order of decreasing bond length:
 $\text{O}_2, \text{O}_2^+, \text{O}_2^-$ 1

Or

- (b) In order to explain the characteristic geometrical shapes of polyatomic molecules like CH_4, NH_3 and H_2O etc., Pauling introduced the concept of hybridisation. According to him the atomic orbitals combine to form new

set of equivalent orbitals known as hybrid orbitals. Unlike pure orbitals, the hybrid orbitals are used in bond formation. The phenomenon is known as hybridisation which can be defined as the process of intermixing of the orbitals of slightly different energies so as to redistribute their energies, resulting in the formation of new set of orbitals of equivalent energies and shape. For example, when one 2s and three 2p-orbitals of carbon hybridize, there is the formation of four new sp^3 hybrid orbitals.

Based on the above information, answer the following questions :

- (i) Why is sigma bond stronger than pi bond? 1
- (ii) State the type of hybridisation of Br in BrF_5 . 1
- (iii) What is the percentage of s-character in sp^2 hybrid orbital? 1

Question Nos. 34-36 are Essay(E) type and each carries 5 marks.

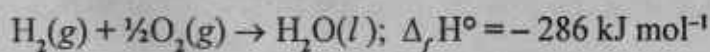
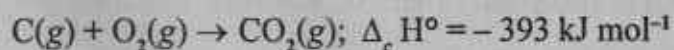
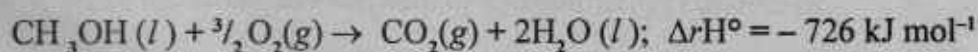
34. (a) Write the important postulates of Bohr's Theory of hydrogen atom. Mention two limitations of it. 5

Or

- (b) Write the main postulates of Rutherford's Nuclear Model of Atom. Mention two limitations of it. 5

35. (a) (i) Derive the relationship between ΔH and ΔU for reactions involving gases. 2+3=5

- (ii) Calculate the standard enthalpy of formation of $CH_3OH(l)$ from the following data :

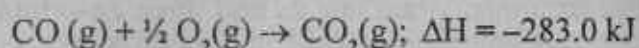


Or

(b) (i) Derive the relationship between ΔG^θ and K for a reversible reaction.

(ii) For the reaction: $\text{CO (g)} + \text{NO (g)} \rightarrow \text{CO}_2\text{(g)} + \frac{1}{2} \text{N}_2\text{(g)}$ 2+3=5

Calculate the enthalpy change of reaction ($\Delta_r H$) using the following information :



36. (a) (i) Why does benzene undergoes electrophilic substitution reactions easily and nucleophilic substitution reactions with difficulty?

3+2=5

(ii) An unsaturated hydrocarbon (X) with molecular formula C_4H_6 on treatment with hydrogen in the presence of palladised charcoal and quinoline forms a compound (Y). The compound (Y) on reductive ozonolysis produces a single aldehyde (Z). Identify the compounds "X", "Y" and "Z".

Or

(b) (i) In the presence of a peroxide, the addition of HBr to propene follows Anti- Markovnikov's rule but peroxide effect is not observed in the case of HCl and HI. Give reason.

3+2=5

(ii) A primary alkyl halide $\text{C}_3\text{H}_7\text{Br}$ (A) reacts with alcoholic KOH to give an alkene (B). When treated with Br_2 the compound (B) gives compound (C). Identify "A", "B" and "C".