Chemistry (Theory)

[Time allowed: 3 hours] [*Maximum marks:70]*

General Instructions:
(i) All questions are compulsory.
(ii) Marks for each question are indicated against it.
(iii) Question numbers **1** to **8** are very short-answer questions and carry **1** mark each.
(iv) Question numbers **9** to **18** are short-answer questions and carry **2** marks each.
(v) Question numbers **19** to **27** are also short-answer questions and carry **3** marks each.
(vi) Question numbers **28** to **30** are long-answer questions and carry **5** marks each.
(vii) Use Log Tables, if necessary. Use of calculators is not allowed.

Q9. A 1.00 molal aqueous solution of trichloroacetic acid (CCl_3COOH) is heated to its boilinig point. The solution has the boiling point of 100.18°C. Determine the van't Hoff factor for trichloroacetic aci. (K_b for water = 0.512 kg mol^{-1}) **2**

OR

Define the following terms:
(i) Mole fraction
(ii) Isotonic solutions
(iii) van't Hoff factor
(iv) Ideal solution

Ans. Molality of solution = m = 1.00 m
Boiling points of solution = T_b = 100.18° C = 373.18 K
Boiling point of water (solvent) = $T°_b$ = 100.00° C = 373 K
Elevation in boiling point = $T_b - T_b$
Observed boiling point = 373.18 K - 373 K = 0.18 K
K_b water = 0.512 K kg mol^{-1}
$\therefore\ \Delta T_b = K_b\, m$
$= 0.512 \times 1 = 0.512$ K
$\therefore$ Calculated boiling point = 0.512 K

$$\text{van't Hoff Factor (i)} = \frac{\text{Observed colligative property}}{\text{Calculated colligative property}}$$

$$= \frac{0.18\,\text{K}}{0.512\ \text{K}}$$

$$i = 0.35$$

OR

(i) **Mole fraction:**

The mole fraction of a component in a mixture is defined as the ratio of the number of moles of the component to the total number of moles of all the components in the mixture. Mathematically, it is represented as:

$$\text{Mole fraction of a component} = \frac{\text{Number of moles of the component}}{\text{Total number of moles of all components}}$$

Mole fraction is denoted by 'x'.

(ii) **Isotonic solution:**
It is a type of solution that has the same salt concentration as its surrounding environment and thus the substances around it neither lose nor gain water by osmosis.

(iii) **van't Hoff factor :**
It is defined as the ratio of the experimental value of colligative property to the calculated value of the colligative property and is used to find out the extent of dissociation or association. Mathematically, it is represented as:

$$i = \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$$
$$= \frac{\text{Observed colligative property}}{\text{Calculated colligative property}}$$
$$= \frac{\text{Total number of moles of particles after association/dissociation}}{\text{Number of moles of particles before association/dissociation}}$$

Value of i :

For association, $i < 1$

For dissociation, $i > 1$

No association or dissociation, $i = 1$

(iv) **Ideal Solutions**:
The solutions which obey Raoult's law over the entire range of concentration are known as **ideal solutions.**

Q10. Name the two groups into which phenomenon of catalysis can be divided. Give an example of each group with the chemical equation involved. **2**

Ans. The phenomenon of catalysis can be divided into two groups.

(i) **Homogeneous catalysis**
When the reactant and catalyst are in same phase
e.g. $2SO_{2(g)} + O_{2(g)} \xrightarrow{NO(g)} 2SO_{3(g)}$

(ii) **Heterogeneous catalysis**
When the reactant and catalyst are in different phase

e.g. $N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe(s)} 2NH_{3(g)}$

Q11. What do you understand by the 'order of a reaction'? Identify the reaction order from each of the following units of reaction rate constant: **2**

(i) L^{-1} mol s^{-1}

(ii) L mol^{-1} s^{-1}

Ans. The sum of the powers of the concentrations of the reactants of a chemical reaction in the rate law expression is called the order of that chemical reaction.

Rate = $k[A]^x[B]^y$

Order of reaction = $x + y$

The orders of reaction for the following units are:

(i) L^{-1} mol s^{-1}: Zero order

(ii) L mol^{-1} s^{-1}: Second order

Q12. Explain the following terms giving one example for each: **2**

(i) Miscelles

(ii) Aerosol

Ans. (i) **Micelles:** Some substances at higher concentrations show colloidal behavior due to formation of aggregates. These aggregated particles are called micelles or associated colloids. For example: soap at concentration 10^{-4} to 10^{-3} mol/L behaves as micelles.

(ii) **Aerosol:** If dispersion medium is gas, then the colloidal system is known as aerosol.

For example: (a) Liquid-gas aerosol like fog, insecticide sprays

(b) Solid-gas aerosol like smoke, dust

Q13. Explain the following giving an appropriate reason in each case. **2**

(i) O_2 and F_2 both stabilize higher oxidation states of metals but O_2 exceeds F_2 in doing so.

(ii) Structures of Xenon fluorides cannot be explained by Valence Bond approach.

Ans. (i) O_2 and F_2 both stabilize higher oxidation states of metals but O_2 exceeds F_2 in doing so due to ability of oxygen to form multiple bonds to metals.

(ii) According to the valence bond approach, covalent bonds are formed by the overlapping of half filled atomic orbital. But xenon has fully filled electronic configuration. Hence the structure of xenon fluorides cannot be explained by VBT.

Q14. Describe the principle involved in each of the following processes. **2**

(i) Mond process for refining of Nickel.

(ii) Column chromatography for purification of rare elements.

Ans. **(i) Mond process for refining of Nickel** is based upon the principle that nickel is heated in the presence of carbon monoxide to form nickel tetracarbonyl, which is a volatile complex.

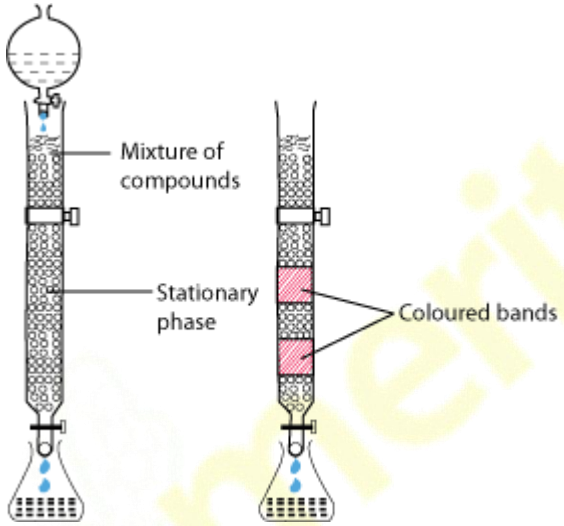
$$Ni + 4CO \xrightarrow{330-350K} Ni(CO)_4$$

Nickel tetracarbonyl

Then, the obtained nickel tetracarbonyl is decomposed by subjecting it to a higher temperature (450 – 470 K) to obtain pure nickel metal.

$$\underset{\text{Nickel tetracarbonyl}}{Ni(CO)_4} \xrightarrow{450-470K} \underset{\text{Nickel}}{Ni} + 4CO$$

(ii) **Column chromatography** is based on the principle that different components of a mixture are differently adsorbed on an adsorbent. In it, there are two phases: mobile phase and stationary phase. The stationary phase is immobile and immiscible. Al_2O_3 column is usually used as the stationary phase in column chromatography. The mobile phase may be a gas, liquid, or supercritical fluid in which the sample extract is dissolved. Then, the mobile phase is forced to move through the stationary phase. The component that is more strongly adsorbed on the column takes a longer time to travel through it than the component that is weakly adsorbed. The adsorbed components are then removed (eluted) using a suitable solvent (eluant).



Q15. What is meant by (i) peptide linkage (ii) biocatalysts? **2**

Ans. (i) **Peptide linkage:** Peptide linkage is an amide formed between –COOH group and $–NH_2$ group of two amino acids. Peptide linkage is responsible for the primary structure of proteins.

(ii) **Biocatalyst:** A biocatalyst is a substance, especially an enzyme that initiates or modifies the rate of a chemical reaction in a living body. Example, amylase

Q16. Complete the following chemical equations: **2**

(i) $Cr_2O_7^{2-} + H^+ + I^- \rightarrow$

(ii) $MnO_4^- + NO_2^- + H^+ \rightarrow$

Ans. (i) $Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$

(ii) $2MnO_4^- + 5NO_2^- + 6H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$

Q17. Draw the structure of the monomer for each of the following polymers: **2**

(i) Nylon 6

(ii) Polypropene

Ans. (i)

$\left[NH-(CH_2)_5-CO\right]$, which is derived from Caprolactam

(ii) Propene whose structural formula is $\left[CH_3-CH=CH_2\right]$

Q18. Write any two reactions of glucose which cannot be explained by the open chain structure of glucose molecule. **2**

Ans. The following two reactions of glucose cannot be explained by the open chain structure of glucose.

(i) Despite having the aldehyde group glucose does not give 2, 4-DNP test.

(ii) The pentacetate of glucose does not react with hydroxylamine indicating the absence of free - CHO group.