Chemistry

Academic Year: 2016-2017 Marks: 70
Date: July 2017

Question 1: Select and write the most appropriate answer from the given alternatives for each sub-question: **[7]**

Question 1.1: Which of the following is a basic oxide? **[1]**

(A) SiO_2
(B) P_4O_{10}
(C) MgO
(D) Al_2O_3

Solution: (C) MgO

The oxide which combines with water to form a base is termed as basic oxide.

$$MgO + H_2O \rightarrow Mg(OH)_{2(aq)}$$

Magnesium oxide	Magnesium hydroxide

Question 1.2: In the representation of the galvanic cell, the ions in the same phase are separated by a ______. **[1]**

single vertical line
comma
double vertical line
semicolon

Solution: In the representation of the galvanic cell, the ions in the same phase are separated by a **comma**.

Question 1.3: An ionic crystal lattice has limiting value of radius ratio as 0.414 to 0.732; the co-ordination number of its cation is ______. **[1]**

(A) 6
(B) 4
(C) 3
(D) 12

Solution: (A) 6

Question 1.4: The unit of rate constant for zero order reaction is ______. **[1]**

(A) t^{-1}
(B) mol dm^{-3} t^{-1}
(C) mol^{-1} dm^3 t^{-1}
(D) mol^{-2} dm^6 t^{-1}

Solution: (B) mol dm^{-3} t^{-1}

Question 1.5: Calcium carbonate used in the extraction of iron acts as ______. **[1]**

(A) oxidising agent
(B) reducing agent
(C) gangue
(D) flux

Solution: (D) flux

Question 1.6: 10.0 grams of caustic soda when dissolved in 250 cm^3 of water, the resultant gram molarity of solution is ______. **[1]**

(A) 0.25 M
(B) 0.5 M
(C) 1.0 M
(D) 0.1 M

Solution:

(C) 1.0 M [1]

Molarity of NaOH solution = $\frac{10}{40 \times 0.25 = 1.0M}$

Question 1.7: 55 L atm of work is obtained when 1.0 mole of an ideal gas is compressed isothermally from a volume of 28.5 L to 18.5 L, the constant external pressure is **[1]**

(A) 5.05 atm
(B) 5.5 atm
(C) 0.05 atm
(D) 0.55 atm

Solution:

(B) 5.5 atm [1]

$$W = -P_{ex}.\Delta V$$
$$55 = -P_{ex}(18.5 - 28.5)$$
$$-Pex = -\frac{55}{10} = 5.5atm$$

Question 2: Answer any SIX of the following: **[12]**

Question 2.1.i: State Henry's law. **[2]**

Solution 1: Henry's law: The mass of a gas dissolved in a given volume of the liquid at constant temperature is directly proportional to the pressure of the gas present in equilibrium with the liquid.

Solution 2: Henry's law relates solubility of a gas with external pressure. The law states that, "the
solubility of a gas in liquid at constant temperature is proportional to the pressure of the gas above the solution".

f S is the solubility of the gas in mol dm−3, then according to Henry's law,

$S \propto P$ i.e. $S = KP$

where, P is the pressure of the gas in atmosphere, K is constant of proportionality and has the unit of mol dm^{-3} atm^{-1}.

Question 2.1.ii: What is the effect of temperature on solubility of a gas in a liquid?

Solution: Effect of temperature on solubility of a gas in a liquid:
1. According to Charles' law, volume of a given mass of a gas increases with increase in temperature.

2. Therefore, volume of a given mass of dissolved gas in solution also increases with increase in temperature, so that it becomes impossible for the solvent in solution to accommodate gaseous solute in it and gas bubbles out. Hence, solubility of gas in liquid decreases with increase in temperature.

Question 2.2: How is nitric acid prepared by Ostwald's process? **[2]**

Solution 1: a. This method is based upon catalytic oxidation of NH3 by atmospheric oxygen.

$$4NH_{3(g)} + 5O_{2(g)} \xrightarrow[\text{500k,9bar}]{\text{Pt/Rh Catalyst}} 4NO_g + 6H_2O_g$$

Ammonia Air Nitric acid

b. Nitric oxide reacts with oxygen to form nitrogen dioxide.

$$2NO_g \quad + \quad O_{2(g)} \rightleftharpoons 2NO_{2(g)}$$

Nitric oxide Oxygen Nitrogen

dioxide

c. Nitrogen dioxide on dissolution in water gives nitric acid.

$$3NO_{2(g)} + H_2O(l) \rightarrow 2HNO_3(l) + NO_g$$

Nitrogen dioxide Water Nitric acid

Solution 2: Ostwald's process (Large scale preparation): Ostwald's process is used to prepare nitric acid on a large scale

a) This method is based upon catalytic oxidation of NH3 by atmospheric oxygen.

$$\underset{\text{Ammonia}}{4NH_{3(g)}} + \underset{\text{(From air)}}{5O_{2(g)}} \xrightarrow[\text{500K, 9bar}]{\text{Pt/Rh gauge catalyst}} \underset{\text{Nitric oxide}}{4NO_{(g)}} + 6H_2O_{(g)}$$

b) Nitric oxide reacts with oxygen to form nitrogen dioxide

$$\underset{\text{Nitric oxide}}{2NO_{(g)}} + \underset{\text{Oxygen}}{O_{2(g)}} \rightleftharpoons \underset{\text{Nitrogen dioxide}}{2NO_{2(g)}}$$

c) Nitrogen dioxide on dissolution in water gives nitric acid

$$\underset{\text{Nitrogen dioxide}}{3NO_{2(g)}} + \underset{\text{Water}}{H_2O_{(l)}} \longrightarrow \underset{\text{Nitric acid}}{2HNO_{3(l)}} + NO_{(g)}$$

The nitric oxide (NO) thus formed is recycled and the aqueous HNO3 is concentrated by distillation to give 68 % HNO3 by mass. Further, concentration to 98 % can be achieved by dehydration with concentrated H_2SO_4.

Question 2.3: Classify the following solids into different types: **[2]**

a. Ammonium phosphate
b. Brass
c. S_8 molecule
d. Diamond

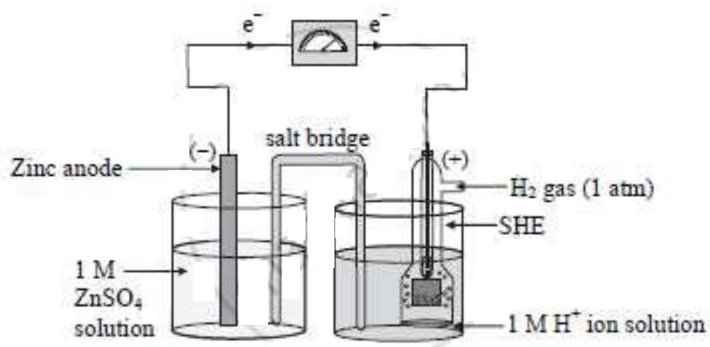
Solution: a. Ammonium phosphate - Ionic solid
b. Brass - Metallic solid
c. S8 molecule - Molecular solid
d. Diamond - Covalent or network solid

Question 2.4: **[2]**

Construct a labelled diagram for the following cell:
$Zn|Zn^{2+}(1M)||H^{+}(1M)|H_{2(g,1atm)} \mid Pt$

Solution: In the given representation of the cell, a standard $Zn^{2+}(1M)|Zn$ electrode is combined with standard hydrogen electrode to form the cell:

$Zn|Zn^{2+}(1M)||H^{+}(1M)|H_{2(g,1atm)} \mid Pt$



Standard zinc electrode combined with SHE

Question 2.5: Explain the nature of zinc oxide with the help of the reactions. **[2]**

Solution: Zinc oxide is an amphoteric oxide which shows both basic and acidic properties.

$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$ (basic nature)
Zinc chloride

$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$ (acidic nature)
Sodium zincate

Question 2.6: Write the names and chemical formulae of any 'two' minerals of aluminium. **[2]**

Solution:

1) Bauxite $\rightarrow Al_2O_3.2H_2O$

2) Cryolite $\rightarrow Na_3AlF_6$

Question 2.7: **[2]**

The rate law for the reaction

$2H_{2(g)} + 2NO_{(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$

is given by rate= $K[H_2][NO]^2$

The reaction occurs in the following two steps:

a. $H_{2(g)} + 2NO_{(g)} \rightarrow N_2O_{(g)} + H_2O_{(g)}$

b. $N_2O_{(g)} + H_{2(g)} \rightarrow N_{2(g)} + H_2O_{(g)}$

What is the role of N_2O in the mechanism? What is the molecularity of each of the elementary steps?

Solution: a. Role of N_2O: N_2O acts as an intermediate since it is produced in first step and consumed in second step.

b. The first step is trimolecular/termolecular. The second step is bimolecular.

Question 2.8.i: Write mathematical equation of first law of thermodynamics for the following processes : **[2]**
Adiabatic process.

Solution: The mathematical expression for the first law of thermodynamics is,
$\Delta U = q + w$
When ΔU = change in energy
q = heat absorbed by the system
w = Amount of work done
Adiabatic Process : A process in which heat is not allowed to enter or leave the system at any stage the process is called adiabatic process.
$\therefore q = 0$
The mathematical expression for first law of thermodynamics is,
$\Delta U = q + w$
$\therefore \Delta U = + w$

Question 2.8.ii:

Write mathematical equation of first law of thermodynamics for Isochoric process

Solution:

By substituting equation $W = -p_{ex}.\triangle V$ in the equation $\triangle U = q + W$, we get

$\triangle U = q - p_{ex}.\triangle V$.........(1)

If the reaction is carried out in a closed container so that the volume of the system is constant, then $\Delta V = 0$. n such a case, no work is involved.

The equation (1) becomes ΔU = qu.

Equation (1) suggests that the change in internal energy of the system is due to heat transfer. The subscript v indicates a constant volume process. As U is a state function, qv is also a state function. We see that an increase in the internal energy of a system is numerically equal to the heat absorbed by the system in a constant volume (isochoric) process.

Question 2.8.iii:

Write the mathematical expression of the First Law of Thermodynamics for Isothermal Process

Solution:

Condition: $\Delta T = 0$ Hence $\Delta U = 0$

Mathematical expression of the first law : **W = -q**

Question 2.8.iv:

Write the mathematical expression of the First Law of Thermodynamics for the Isobaric process

Solution: Condition: P= constant hence q=qp

Mathematical expression of the first law :

$\Delta U = qp + W$

$\Delta U = qp - P_{ex}\Delta V[W = -P_{ex}\Delta V]$ or $[qp = \Delta U + P_{ex}\Delta V]$

Question 3: Answer any THREE of the following: [9]

Question 3.1: From the following data for the liquid phase reaction A → B, determine the order of reaction and calculate its rate constant [3]

t/s	0	600	1200	1800
[A]/ $molL^{-1}$	0.624	0.446	0.318	0.226

Solution:

Calculation:

We require to calculate the rate constant at different time intervals.

$$k = \frac{2.303}{t}\log_{10}\left[\frac{[A]_0}{[A]_t}\right]$$ ....[Integrated rate law for first order reaction]

A.

$$[A]_0 = 0.624$$

$$[A]_{t1} = 0.446$$

t1=600s

$$k_1 = \frac{2.303}{t_1}\log\left[\frac{[A]_0}{[A]_t}\right]$$

$$k_1 = \frac{2.303}{600}\log\left[\frac{0.624}{0.446}\right]$$

$$k_1 = 3.838 \times 10^{-3}\log[1.399]$$

$$k_1 = 3.838 \times 10^{-3} \times 0.1458$$

$$\therefore k_1 = 5.596 \times 10^{-4} s^{-1}$$

B.

$$[A]_0 = 0.624$$

$$[A]_t = 0.318$$

$$t_2 = 1200s$$

$$k_2 = \frac{2.303}{t_2}\log_{10}\left[\frac{0.624}{0.318}\right]$$

$$k_2 = 1.919 \times 10^{-3}\log(1.962)$$

$$k_2 = 1.919 \times 10^{3} \times 0.2927$$

$$k_2 = 5.617 \times 10^{-4} s^{-1}$$

C.

$$[A]_0 = 0.624$$

$$[A]_{t3} = 0.226$$

$$t_3 = 1800s$$

$$k_3 = \frac{2.303}{1800}\log\left[\frac{0.624}{0.226}\right]$$

$$k_3 = 1.279 \times 10^{-3} \times 0.4411$$

$$k_3 = 1.279 \times 10^{-3} \times 0.4411$$

$$k_3 = 5.641 \times 10^{-4} s^{-1}$$

$$k = \frac{k_1 + k_2 + k_3}{3} = \frac{(5.596 \times 10^{-4}) + (5.617 \times 10^{-4}) + (5.641 \times 10^{-4})}{3}$$

$$k = 5.618 \times 10^{-4} s^{-1}$$

All the k values calculated at different time intervals are almost the same. This implies that the reaction obeys the integrated rate equation of first order reaction. Hence, the reaction is a first order reaction.

Question 3.2: [3]

Calculate the standard enthalpy of combustion of $CH_3COOH(l)$ from the following data:

$\Delta_f H^\circ(CO_2) = -393.3 kJmol^{-1}$

$\Delta_f H^\circ(H_2O) = -285.8 kJmol^{-1}$

$\Delta_f H^\circ(CH_3COOH) = -483.2 kJmol^{-1}$

Solution:

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\quad \Delta_f H^\circ = -393.3 kJmol^{-1}$...(1)

$H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow H_2O_{(l)}$ $\quad \Delta_f H^\circ = -285.8 kJmol^{-1}$...(2)

$2C_{(s)} + 2H_{2(g)} + O_{2(g)} \rightarrow CH_3COOH$ $\quad \Delta_f H^\circ = -483.2 kJmol^{-1}$ ...(3)

The required equation is,

$CH_3COOH(l) + 2O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(l)}$

Multiplying equation (1) and equation (2) by 2, then adding to reverse of equation (3).

$2C_{(s)} + 2O_{2(g)} \rightarrow 2CO_{2(g)}$ $\quad \Delta_f H^\circ = -786.6 kJmol^{-1}$

$2H_{2(g)} + 1O_{2(g)} \rightarrow 2H_2O_{(l)}$ $\quad \Delta_f H^\circ = -571.6 kJmol^{-1}$

$CH_3COOH_l \rightarrow 2C_{(s)} + 2H_{2(g)} + O_{2(g)}$ $\quad \Delta_f H^\circ = 483.2 kJmol^{-1}$

$CH_3COOH_l + 2O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(l)}$ $\quad \Delta_f H^\circ = -875 kJmol^{-1}$

Question 3.3: [3]

Write the cell representation and calculate equilibrium constant for the following redox reaction:

$Ni_{(s)} + 2Ag^+_{(aq)}(1M) \rightarrow Ni^{2+}_{(aq)}(1M) + 2Ag_{(s)}$ at $25^\circ C$

E^+_{ni}=-0.25V and $E^+_{Ag} = 0.799V$

Solution:

$Ni_{(s)} + 2Ag^{+}_{(aq)}(1M) \rightarrow Ni^{2+}_{(aq)}(1M) + 2Ag_{(s)}$ at $25^{\circ}C$

E^{+}_{ni}=-0.25V and $E^{+}_{Ag} = 0.799V$

Cell representation :

$Ni_{(s)} \left| Ni^{2+}_{(aq)}(1M) \right| \left| Ag^{+}_{aq}(1M) \right| Ag(s)$

Calculation of equilibrium constant

$E^{\circ}_{cell} = \frac{0.0592}{n} \log_{10} K$

$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{Ag}} - E^{\circ}_{\text{Ni}}$

=0.799-(-0.25)=1.049 V

Hence $1.049 = \frac{0.0592}{2} \log_{10} K$

$\log_{10} K = \frac{1.049 \times 2}{0.0592} = 35.44$

$K = anti \log(35.44)$

$= 2.754 \times 10^{35}$

Question 3.4.i: What is the action of concentrated sulphuric acid on phosphorous pentachloride [3]

Solution:

Concentrated sulphuric acid reacts with PCl5 to form chlorosulphuric acid.

$HOSO_2OH \; + \; PCl_5 \; \rightarrow ClSO_2OH + POCl_3 + HCl$

Sulphuric acid Phosphorus Chlorosulphuric acid

pentachloride

Chlorosulphuric acid further reacts with PCl5 to form sulphuryl chloride.

$ClSO_2OH \; + PCl_5 \rightarrow ClSO_2Cl + POCl_3 + HCL$

Chlorosulphuric Phosphorus Sulphuryl

acid pentachloride chloride

Question 3.4.ii: What is the action of concentrated sulphuric acid on copper [3]

Solution:

Sulphuric acid oxidizes metal Cu.

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

Copper Sulphuric acid Copper sulphate Sulphur dioxide Water

Question 3.4.iii: What is the action of concentrated sulphuric acid on potassium chlorate? **[3]**

Solution: Sulphuric acid reacts with KClO3 to form KHSO4, HClO4 and ClO2.

$$3KClO_3 + 2H_2SO_4 \rightarrow 2KHSO_4 + 2ClO_4 + KClO_2 + H_2O$$

Potassium chlorate Sulphuric acid Potassium hydrogen sulphate Perchloric acid

Potassium chlorate react with sulfuric acid to produce potassium bisulfate, chlorine dioxide, potassium perchlorate and water. Potassium chlorate - solid. Sulfuric acid - concentrated solution.

Question 4: Answer any ONE of the following: **[7]**

Question 4.1.i: Define Molality

Solution: Molality

Molality (m) is defined as the number of moles of the solute per kilogram of the solvent. It is expressed as:

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Mass of solvent in Kg}}$$

Question 4.1.ii:

Define Osmotic pressure

Solution: Osmotic pressure: The excess of pressure on the side of the solution, that stops the net flow of solvent into the solution through a semipermeable membrane is called osmotic pressure.

Question 4.1.iii:

Write any ‘two’ advantages of calomel electrode.

Solution:

1. It is convenient to handle, easy to construct and transport.
2. No separate salt bridge is required for its combination with other electrode.
3. The potential of the electrode is reproducible and remains constant

Question 4.1.iv:

A metal crystallises into two cubic faces namely face centered (FCC) and body centered (BCC), whose unit cell edge lengths are 3.5 Å and 3.0 Å respectively. Find the ratio of the densities of FCC and BCC.

Solution:

Edge length of FCC unit cell (a1) = 3.5 Å

Edge length of BCC unit cell (a2) = 3.0 Å

Density of unit cell = $d = \frac{Z \times M}{N_A \times a^3} gcm^{-3}$

Density of FCC unit cell = $d_1 = \frac{4 \times M}{N_A \times (3.5A)^3}$

Density of BCC unit cell = $d_2 = \frac{2 \times M}{N_A \times (3.0A)^3}$

Ratio of densities of FCC and BCC unit cell is,

$$\frac{d_1}{d_2} = \frac{4 \times M}{N_A \times (3.5A)^3} \times \frac{N_A \times (3.0A)^3}{2 \times M}$$

$$\frac{d_1}{d_2} = \frac{54}{42.875} = 1.259 \approx 1.26$$

Question 4.1.v:

Arrange the following oxyacids of chlorine – HClO, $HClO_2$, $HClO_3$, and $HClO_4$ with respect to Increasing order of thermal stability.

Solution: Increasing order of thermal stability:
HClO < HOClO < $HOClO_2$ < $HOClO_3$
OR
HClO < $HClO_2$ < $HClO_3$ < $HClO_4$

Question 4.1.vi:

Arrange the following oxyacids of chlorine – HClO, $HClO_2$, $HClO_3$, and $HClO_4$ with respect to Increasing order of oxidizing power.

Solution: Increasing order of oxidizing power:
$HOClO_3$ < $HOClO_2$ < HOClO < HClO

OR
$HClO_4 < HClO_3 < HClO_2 < HClO$.

Question 4.2.i: An organic substance (M = 169 gram mol^{-1}) is dissolved in 2000 cm^3 of water. Its osmotic pressure at 12°C was found to be 0.54 atm. If R = 0.0821 L atm K^{-1} mol^{-1}, calculate the mass of the solute. **[7]**

Solution: Given: T = 273.15 + 12 = 285.15 K
V = 2000 cm^3 = 2 L
M_2= 169 g mol^{-1}
R = 0.0821 L atm K^{-1} mol^{-1}
π = 0.54 atm

To find: Mass of solute (W_2)

$$\pi = \frac{W_2RT}{M2V}$$

$$W_2 = \frac{\pi M_2V}{RT}$$

$$W_2 = \frac{0.54 \times 169 \times 2}{0.0821 \times 285.15}$$

$$W_2 = \frac{182.52}{23.4108} = 7.796g$$

Question 4.2.ii:

How many atoms constitute one unit cell of a face-centered cubic crystal?

Solution: Number of atoms in one face centered cubic unit cell can be determined from the number of atoms contributed from the faces and the corners of the unit cell as: (8 corners x 1/8 atom per corner =8x 1/8 = 1 atom) + (6 faces x 1/2 atom per unit face = 6 x1/2 = 3 atoms).

∴ Total no. of atoms per unit cell = 4 atoms.

Question 4.2.iii:

Distinguish between isothermal process and adiabatic process.

Solution:

No	Isothermal process	Adiabatic process
1	The temperature of system remains constant (ΔT = 0).	The temperature of system changes i.e. increases or decreases (ΔT ≠0).

2	System can exchange heat with the surroundings ($q \neq 0$).	System cannot exchange heat with the surroundings ($q = 0$).
3	The internal energy of the system remains constant ($\Delta U = 0$).	The internal energy of the system changes ($\Delta U \neq 0$).
4	System is not thermally isolated from its surroundings. Hence, open or closed system is required.	System is thermally isolated from its surroundings. Hence, isolated system is required.
5	In this $\Delta U = 0$, hence $q = -W$.	In this $q = 0$, hence $\Delta U = W$.
6	Enthalpy remains constant ($\Delta H = 0$).	Enthalpy changes in this process ($\Delta H \neq 0$).
7	Expansion takes place by absorbing heat from surroundings	Expansion takes place by utilizing internal energy of the system
8	Heat supplied is used only for doing work.	Work done is only at the cost of internal energy.
9	Compression takes place by losing heat to the surroundings.	Compression takes place by adding heat into internal energy of the system.
10	Fusion of ice.	Expansion of gas in vacuum.

Question 4.2.iv:

Mention the names of various steps involved in the extraction of pure metals from their ores.

Solution: The various steps involved in the extraction of pure metals from their ores are as follows:
1. Concentration of ores
2. Conversion of ores into oxides or other desired compounds.
3. Reduction of ores to form crude metals.
4. Refining of metals

Question 5: Select and write the most appropriate answer from the given alternatives for each sub-question: [7]

Question 5.1: In the following [1]

$$C_2H_5-\overset{\overset{\displaystyle H}{|}}{C}=O+NH_2OH \longrightarrow A \xrightarrow[\Delta]{Na/C_2H_5OH} B$$

The compound 'B' is _______.
(A) Propan–1–amine
(B) Propan–2–amine
(C) Isopropylamine

(D) Dimethylamine

Solution: (A) Propan–1–amine

Question 5.2: The stability order for carbocation is ______. [1]

(A) 2° > 3° > 1°
(B) 3° > 2° > 1°
(C) 3° > 1° > 2°
(D) 1° > 3° > 2°

Solution: (B) 3° > 2° > 1°

Question 5.3:

Effective atomic number rule is used to find ______.
(A) geometry of complex
(B) stability of complex
(C) number of isomers of complex
(D) number of possible ligands around metal ion in complex

Solution: (D) number of possible ligands around metal ion in complex
EAN rule can be used to determine the number of possible ligands around a metal ion as the ligands are added to a metal ion until the number of electrons around the metal ion reaches to its EAN.

Question 5.4: Which one of the following ions is coloured? [1]
(A) Sc^{3+}

(B) Zn^{2+}
(C) Ti^{4+}
(D) V^{2+}

Solution: (D) V2+ [1]
V (Z = 23): [Ar] $3d^3$ $4s^2$
V^{2+} : [Ar]$3d^3$
Due to the presence of 3 unpaired electrons, V^{2+} is coloured.

Question 5.5: When phenol is heated with conc. HNO_3 in presence of conc. H_2SO_4 it yields ______. [1]

(A) o-nitrophenol
(B) p-nitrophenol
(C) 2,4,6-trinitrophenol
(D) m-nitrophenol

Solution: (C) 2,4,6-trinitrophenol

Question 5.6: The secondary structure of protein is determined by ______. **[1]**

(A) co-ordinate bond
(B) ionic bond
(C) hydrogen bond
(D) covalent bond

Solution: (C) hydrogen bond

Question 5.7: Ethylidene dichloride when boiled with aqueous solution of NaOH yields ______. **[1]**

(A) formaldehyde
(B) acetaldehyde
(C) acetone
(D) ethyl methyl ketone

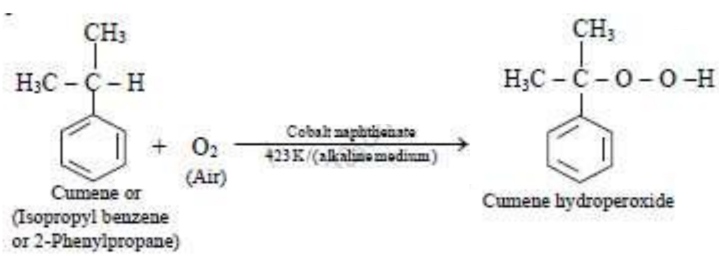
Solution: (B) acetaldehyde

Question 6: Answer any SIX of the following: [12]

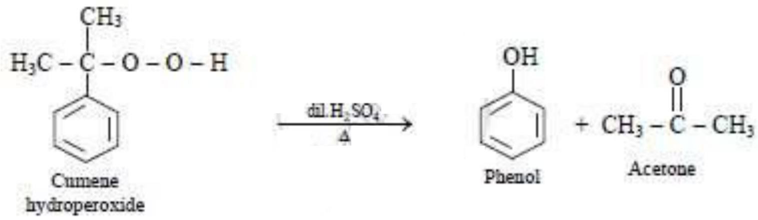
Question 6.1: How is phenol prepared from cumene? **[2]**

Solution: Preparation of phenol from cumene:

a. When an alkaline solution of cumene (isopropyl benzene or 2-Phenylpropane) in sodium carbonate is oxidised by passing air or oxygen in the presence of cobalt naphthenate as a catalyst at 423 K, cumene hydroperoxide is obtained.



b. Auto oxidation: Cumene hydroperoxide on heating with dilute H_2SO_4 decomposes forming phenol and acetone. In this method, acetone is obtained as an important byproduct which is separated by distillation.



Question 6.2: Write a note on the self oxidation-reduction reaction of an aldehyde with a suitable example. **[2]**

Solution: Cannizaro's Reaction:-

(a) This is a characteristic reaction of those aldehydes which do not contain α -hydrogen atom.

(b) When such aldehydes are heated with concentrated alkali solutions like NaOH or KOH then simultaneous oxidation-reduction takes place.

(c) Out of two molecules of aldehyde one molecule, gets oxidised to form sodium or potassium salt of carboxylic acid and the second molecule is reduced to form corresponding primary alcohol.

(d) It is an auto oxidation-reduction reaction under the influence of base

(e) Formaldehyde and benzaldehyde undergo Cannizaro's reaction as they do not contain α -hydrogen atom.

e.g.

$$2\underset{\text{Formaldehyde(40-50\%)}}{H-CHO} + NaOH \xrightarrow[\text{Reaction}]{\text{Redox}} \underset{\text{Sodium formate}}{HCOONa} + \underset{\text{Methanol}}{CH_3} - OH$$

$$\underset{\text{Benzaldehyde(50\%)}}{2\,C_6H_5CHO} + NaOH \xrightarrow[\text{Reaction}]{\text{Redox}} \underset{\text{Benzylalcohol}}{C_6H_5CH_2OH} + \underset{\text{Sodiumbenzoate}}{C_6H_5COONa}$$

(f) Acetaldehyde does not give this reaction since it contains α -Hydrogen atoms.

Question 6.3: Explain basic nature of amines. **[2]**

Solution: Nitrogen atom of amines contains a lone pair of electrons which can be donated. Thus, amines act as Lewis bases. Amines are Lowry-Bronsted bases as they accept a proton. Thus, amines act as bases and nucleophiles.

$$\underset{\text{Amine}}{R-\ddot{N}H_2} + \underset{\text{Halogen acid}}{H-X} \rightleftharpoons \underset{\text{Alkyl ammonium halide}}{R-NH_3^+X^-}$$

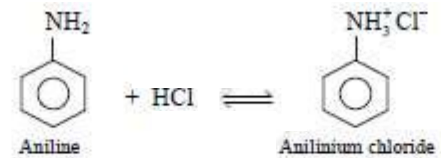
eg.

a. The reaction of ethylamine with dilute hydrochloric acid results in the formation of ethyl ammonium chloride.

$$CH_3 - CH_2 - NH_2 + HCl \rightleftharpoons CH_3 - CH_2NH_3^+Cl^-$$

Ethylamine (Ethanamine) — Ethyl ammonium chloride

b. The reaction of aniline with dilute hydrochloric acid results in the formation of anilinium chloride.



Question 6.4: Explain the term Antiseptics **[2]**

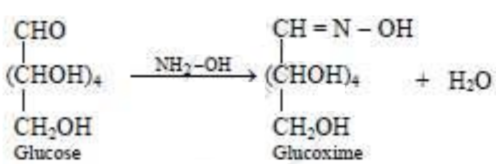
Solution 1: Antiseptic

- Chemicals which either kill or prevent the growth of microorganisms
- Antiseptics are applied to living tissues such as wounds, cuts, ulcers and diseased skin surfaces.
- Example:
- Furacine
- Soframicine
- Dettol (mixture of chloroxylenol and terpineol)

Solution 2: Anticeptic: Chemicals which either kill or prevent the growth of microorganismsn are called anticeptic drug. Antiseptics are applied to living tissues such as wounds, cuts, ulcers and diseased skin surfaces. For example: Soframicine, dettol etc.

Question 6.5.i: What happens when glucose is treated with hydroxylamine? **[2]**

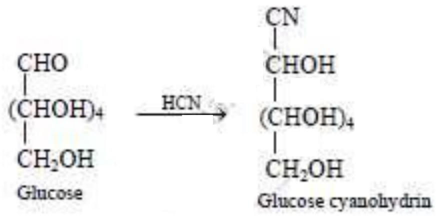
Solution: Action of hydroxylamine (NH2OH) on glucose: The reaction of glucose with hydroxylamine gives an oxime. This indicates the presence of carbonyl group.



Question 6.5.ii:

What happens when glucose is treated with hydrogen cyanide?

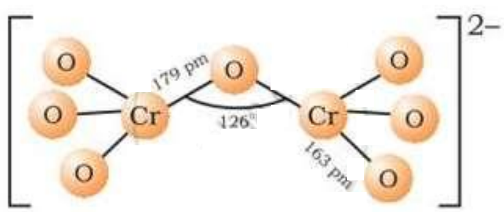
Solution: Action of hydrogen cyanide (HCN) on glucose: The reaction of glucose with hydrogen cyanide gives cyanohydrin. This indicates the presence of carbonyl group.



Question 6.6.i: Draw structure of dichromate ion **[2]**

Solution: Dichromate salts contain the dichromate anion, $Cr_2O_7^{2-}$
They are oxoanions of chromium in the oxidation state +6.
They are moderately strong oxidizing agents.
In an aqueous solution, dichromate ions can be interconvertible.

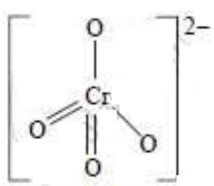
structure of dichromate ion $Cr_2O_7^{2-}$:



Dichromate ion

Question 6.6.ii: Draw structure of chromate ion

Solution:



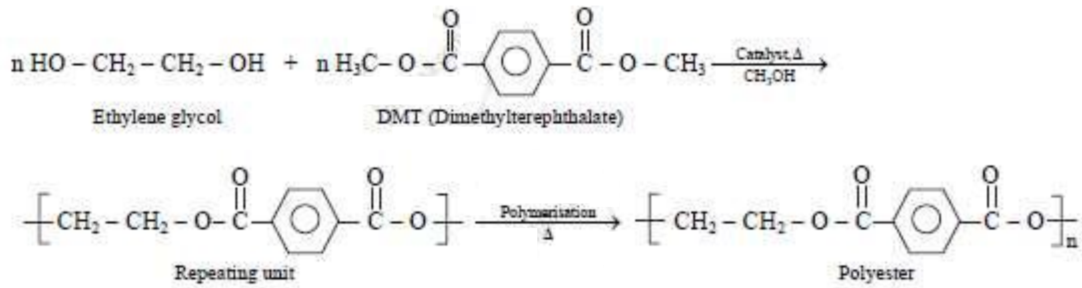
Chromate ion

Question 6.7: How is terylene prepared? **[2]**

Solution: a. Dacron (Terylene) is obtained by the condensation polymerization of ethylene glycol (1,2-Ethanediol) and dimethylterephthalate.

b. Monomers are heated at 503 K. The catalyst used is a mixture of zinc acetate and antimony trioxide.

c. Transesterification followed by polymerization gives terylene.



Question 6.8: **[2]**

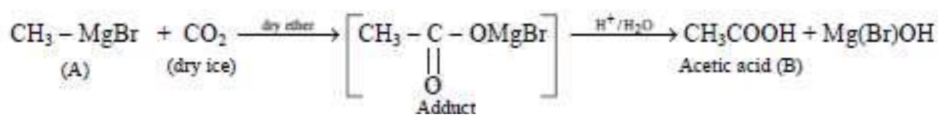
Identify A and B in the following reaction:

$$CH_3 - Br + Mg \xrightarrow{\text{dry ether}} A + CO_2 \xrightarrow[\frac{H^+}{H_2O}]{\text{dry ether}} B + Mg(Br)OH$$

Solution:

$$CH_3 - Br + Mg \xrightarrow{\text{dry ether}} CH_3 - MgBr$$

Methyl bromide Methyl magnesium bromide (A)



A- CH_3MgBr (Methyl magnesium bromide)
B - CH_3COOH (Acetic acid)

Question 7: Answer any THREE of the following: **[3]**

Question 7.1: How ligands are classified? Explain with suitable examples. **[3]**

Solution: a. Mono or unidentate ligands: The ligand molecule or ion which has only one donor atom or one point of attachment and can coordinate with the metal ion at only one site in a complex is called unidentate or monodentate ligand.
eg. Cl–, OH–, NH3, H2O, etc. (Explanation + Example)

b. Poly or multidentate ligands: The ligand molecule or ion which has two or more donor atoms or points of attachments and can be linked to the same metal in a complex using two or more donating sites is called poly or multidentate ligands. Thus, multiple sites of ligands are used in the coordination with metal. Based on the number of donor atoms, polydentate ligands are further classified as bidentate, tridentate, tetradentate, etc.

1. Bidentate ligands have two donor atoms.
eg. Ethylenediammine (en)

2. Tridentate ligands have three donor atoms.
eg. Diethylenetriammine (dien)

3. Tetradentate ligands have four donor atoms.
eg. Triethylenetetraammine (trien)

4. Hexadentate ligands have six donor atoms.
eg. Ethylenediamminetetraacetate (EDTA)
(Explanation + Examples) [1]

c. Ambidentate ligands: Ambidentate ligands are the ligands which have two or more donor atoms capable of forming coordinate bonds; however only one donor atom is utilized during complex formation.

eg. 2 NO– group can form complexes by utilizing either N or O as donor atom, but not both. This results in formation of either M–NO2 or M–ONO complex respectively.

Question 7.2.i: What is lanthanoid contraction? **[3]**

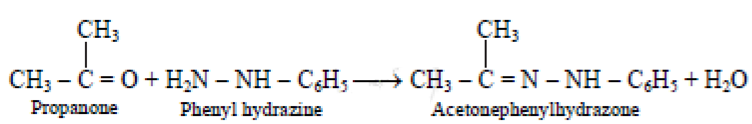
Solution: Lanthanoid contraction:
The atomic and ionic radii of lanthanoids show gradual decrease with increase in atomic number. It is known as Lanthanoid contraction.

Question 7.2.ii: Explain, why lanthanum (Z = 57) forms La^{3+} ion, while cerium (Z = 58) forms Ce^{4+} ion?

Solution: 57La -Electronic configuration is $[Xe]4f^0\ 5d^1\ 6s^2$
After losing 3 electrons La forms La^{3+} ion which is stable due to empty 4f-orbitals.
58Ce - Electronic configuration is $[Xe]4f^2\ 5d^0\ 6s^2$
After losing 4 electrons Ce forms Ce^{4+} ion which is stable due to empty 4f-orbitals.
Thus, lanthanum (Z = 57) forms La^{3+} ion, while cerium (Z = 58) forms Ce^{4+} ion.

Question 7.3.i: What is the action of phenyl hydrazine on propanone? **[2]**

Solution: a. Propanone on reaction with phenyl hydrazine produces acetonephenylhydrazone.



Question 7.3.ii:

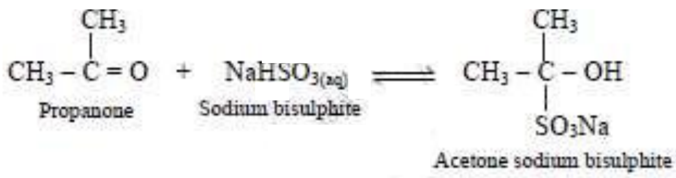
What is the action of Zn – Hg / conc. HCl on propanone?

Solution: Propanone on reduction with zinc-amalgam and concentrated hydrochloric acid gives propane

$$\underset{\text{Propanone}}{CH_3-CO-CH_3} + 4[H] \xrightarrow[\Delta]{Zn-Hg+conc.HCl} \underset{\text{Propane}}{CH_3-CH_2-CH_3} + H_2O$$

Question 7.3.iii: What is the action of Sodium bisulphite on propanone?

Solution: Propanone, when shaken with a saturated aqueous solution of sodium bisulphite gives acetone sodium bisulphite.



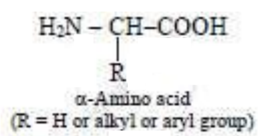
Question 7.4.i: Define enzymes. **[3]**

Solution: Enzymes are defined as biocatalysts, produced by the living cells which catalyse many biochemical reactions in animals and plant bodies.

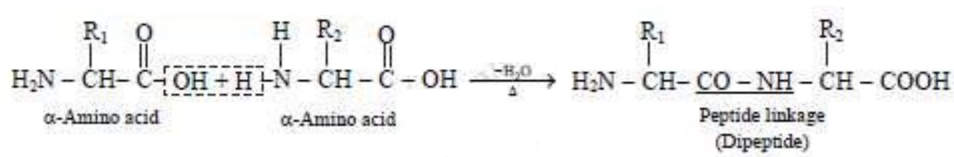
Question 7.4.ii:

How is peptide linkage formed?

Solution: 1. α-Amino acids are bifunctional compounds containing a carboxylic acid group and an amino group on α-carbon.



2. The reaction of the COOH group of one amino acid molecule and NH2 group of the neighbouring amino acid molecule forms peptide having -CO-NH-linkage by elimination of water.



3. Above reaction repeats itself to give tri, tetra, penta and finally polypeptides

(i.e., protein).

Question 8: Answer any ONE of the following: **[7]**

Question 8.1.i: How is nitroethane converted into ethylamine.

Solution: Nitroethane reduced to ethylamine by the action of tin and conc. HCl.

$$CH_3CH_2NO_2 + 6[H] \xrightarrow{\text{Sn/conc.HCl}} CH_3CH_2NH_2 + 2H_2O$$

Nitroethane Ethylamine

Question 8.1.ii:

How is nitroethane converted into N-ethylhydroxylamine

Solution: When nitroethane is reduced in a neutral medium with metal, it forms N-ethylhydroxylamine.

$$CH_3CH_2NO_2 + 4[H] \xrightarrow{\frac{Zn}{NH_4Cl}} CH_3CH_2 - NHOH + H_2O$$

Nitroethane N-Ethylhydroxylamine

Question 8.1.iii:

How is nitroethane converted into acetic acid

Solution: Nitroethane undergoes hydrolysis on boiling with hydrochloric acid to give acetic along with hydroxylamine.

$$CH_3CH_2NO_2 + H_2O \xrightarrow[\Delta]{\text{HCl}} CH_3COOH + NH_2OH$$

Nitroethane Acetic acid Hydroxylamine

Question 8.1.iv:

Write names and chemical formulae of monomers used in preparing Buna-N.

Solution:

Preparation of Buna-N:

1. Monomer : Buta-1,3-diene → Formula : $CH_2 = CH - CH = CH_2$
2. Monomer : Acrylonitrile → Formula : $CH_2 = CH - CN$

Question 8.1.v:

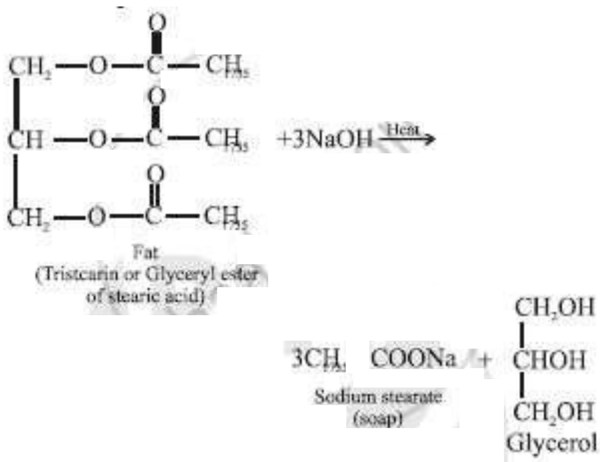
What is a soap?

Solution: Soaps: Soaps are sodium or potassium salts of higher acids such as lauric ($C_{11}H_{23}COOH$), palmitic acid ($C_{15}H_{31}COOH$) , stearic acid ($C_{15}H_{31}COOH$) , oleic acid ($C_{17}H_{33}COOH$) or linoleic acid ($C_{17}H_{31}COOH$) .

Question 8.1.vi:

How soap is prepared?

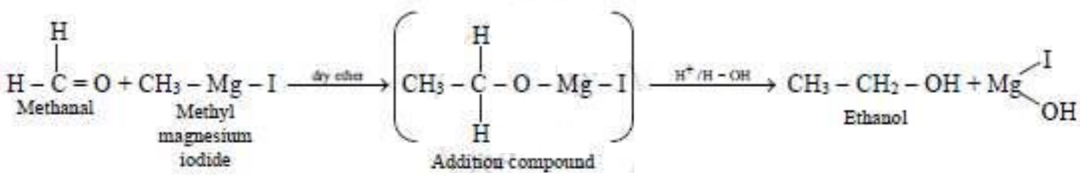
Solution: Soaps are formed by heating fat or oil (i.e. glyceryl esters of fatty acids) with aqueous sodium hydroxide solution. This reaction is called saponification.



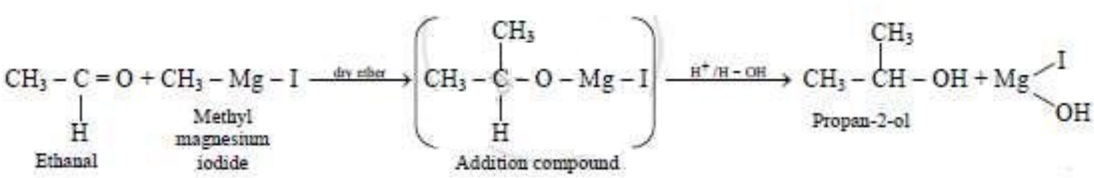
During the process of hydrolysis esters of fatty acids are hydrolyzed and the soap is obtained in the colloidal form. It floats in solution as curd. It is precipited from the solution by adding sodium chloride.

Question 8.2.i: How will you prepare ethanol, propan-2-ol and 2-methylpropan-2-ol from Grignard's reagent? **[7]**

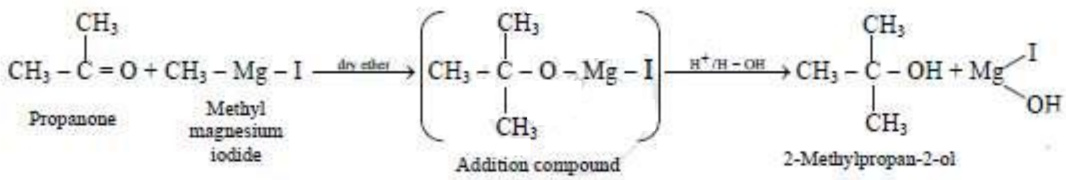
Solution: a. 1. Methanal reacts with methyl magnesium iodide in presence of dry ether to give an addition compound, which on acid hydrolysis gives ethanol.



2. Ethanal reacts with methyl magnesium iodide in presence of dry ether to give an addition compound, complex which on acid hydrolysis gives propan-2-ol.



3. Propanone reacts with methyl magnesium iodide in presence of dry ether to give an addition compound, which on acid hydrolysis gives 2-methylpropan-2-ol.



Question 8.2.ii:

Explain Optical activity

Solution: Optical activity:
Optical activity is the property of certain organic substances to rotate the plane of plane polarised light towards the right (clockwise) or towards the left (anticlockwise).

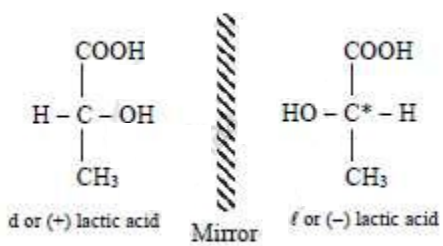
Question 8.2.iii:

Explain optical activity of lactic acid

Solution: The optical activity of lactic acid can be discussed as:

1. Presence of asymmetrical carbon atom:
   i. Lactic acid contains one asymmetrical carbon atom.
   ii. According to van't Hoff's rule: a = 2^n, where, a is the number of isomers and n is the number of asymmetric carbon atom.
   iii. Thus, two isomers of lactic acid are possible.

2. Non-superimposable mirror image structures:



Hence, lactic acid can exist as d-form and l-form which are non-superimposable mirror images of each other.

3. (dl) Racemic mixture and its optical inactivity:
A mixture containing equal moles of the d and l forms of lactic acid is a racemic mixture which is optically inactive i.e., dl or (±) form. This inactivity arises due to external compensation.