

Solution
CHEMISTRY
Class 12 - Chemistry
Section A

1. Select and write the correct answer:

(i) (b) $r = \frac{\sqrt{3}}{4} a$

Explanation: {

$$r = \frac{\sqrt{3}}{4} a$$

(ii) (a) CH_3COONa

Explanation: {



(iii) (b) zero

Explanation: {

The decomposition of N_2O on platinum surface follows zero order kinetics. Most of the N_2O molecules (which remain in gaseous phase) are unreactive while those which occupy all the active sites on metal surface take part in reaction. Thus, the reaction rate is independent of total concentration of N_2O .

(iv) (d) Zinc

Explanation: {

Zinc

(v) (b) $[Fe(CN)_6]^{3-}$

Explanation: {



Oxidation state of Fe is +3 and ligands donate 12 electrons.

$$Z = 26, X = 3, Y = 12$$

$$EAN \text{ of } Fe^{3+} = Z - X + Y$$

$$= 26 - 3 + 12 = 35$$

(vi) (c) Finkelstein reaction

Explanation: {

Finkelstein reaction

(vii) (a) H_2

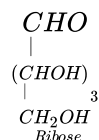
Explanation: {



(viii) (a) 1, 3

Explanation: {

The structure of ribose is



Hence, ribose contains 1 primary hydroxyl group and 3 secondary hydroxyl groups.

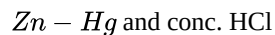
(ix) (d) zero waste technology

Explanation: {

zero waste technology

(x) (a) $Zn - Hg$ and conc. HCl

Explanation: {

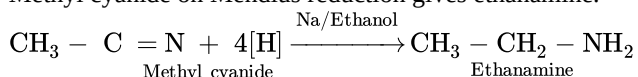


2. Answer the following:

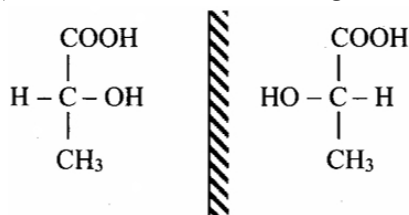
(i) Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales where properties differ significantly from those at a larger scale.

(ii) **Ethanamine from methyl cyanide:**

Methyl cyanide on Mendius reduction gives ethanamine.



(iii) Enantiomers of lactic acid using Fischer projection formulae:



(iv) Cryolite is Na_3AlF_6 .

(v) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$

(vi) i. Statement: Henry's law states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas over the solution.

ii. When gases are dissolved in water, the gas molecules in liquid phase are condensed.

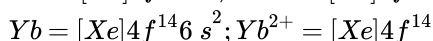
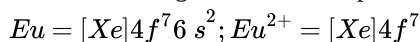
The condensation is an exothermic process. Hence, the solubility of gases in water decreases with increase in temperature.

(vii) **Enthalpy of a system** is sum of internal energy of a system and the energy equivalent to pressure-volume (PV) work.

(viii) The unit of cell constant is m^{-1} (SI unit) or cm^{-1} (C.G.S unit).

Section B

3. i. Electronic configurations of Europium (Eu) and Ytterbium (Yb) are given below:



ii. It is clear from the configuration of Eu that Eu^{2+} is favoured by its half filled f-subshell. Similarly, Yb^{2+} ion is stabilized due to completely filled f-subshell.

Thus, ${}_{63}\text{Eu}$ and ${}_{70}\text{Yb}$ show +2 oxidation state.

4. i. The hydrostatic pressure (on the side of solution) that stops osmosis is called an osmotic pressure of the solution.

ii. For very dilute solutions, the osmotic pressure follows the equation,

$$\pi = \frac{n_2 RT}{V} \dots (1)$$

If the mass of solute in V litres of solution is W_2 and its molar mass is M_2 , then $n_2 = \frac{W_2}{M_2}$.

Substituting the value of n_2 in equation (1), we get $\pi = \frac{W_2}{M_2} \frac{RT}{V}$

$$\therefore M_2 = \frac{W_2 RT}{\pi V}$$

This formula can be used for the calculation of molar mass of a nonionic solute (i.e., nonelectrolyte), by osmotic pressure measurement.

5. **Advantages of nanoparticles and nanotechnology:**

i. Revolution in electronics and computing.

ii. Energy sector:

a. Nanotechnology will make solar power more economical.

b. Energy storage devices will become more efficient.

iii. Medical field:

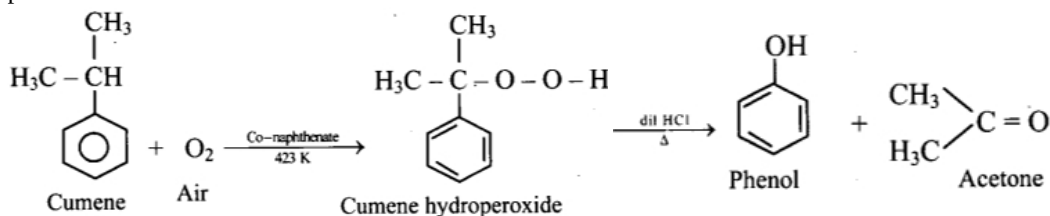
a. Manufacturing of smart drugs, helps cure faster and without side effects.

b. Curing of life threatening diseases like cancer and diabetes.

(Any two advantages)

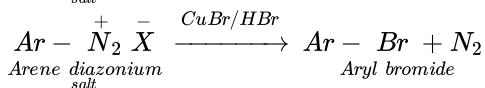
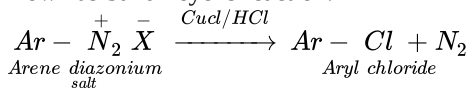
6. This is the commercial method of preparation of phenol. Cumene (isopropylbenzene) on air oxidation in presence of Co-naphthenate gives cumene hydroperoxide, which on decomposition with dilute acid gives phenol with acetone as a valuable by

product.



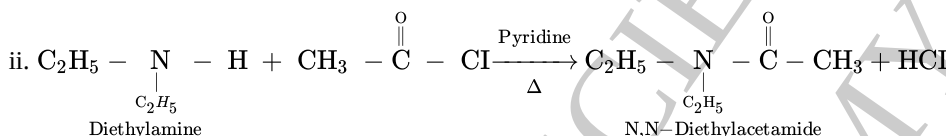
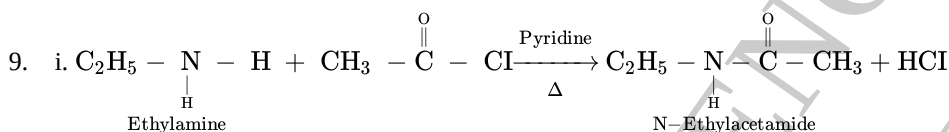
7. Sandmeyer's reaction:

Aryl halides are most commonly prepared by replacement of nitrogen of diazonium salt using copper(I) salts. This reaction is known as Sandmeyer's reaction.



8. Limitations of Arrhenius theory:

- Arrhenius theory accounts for properties of different acids and bases but is applicable only to aqueous solutions.
- It does not account for the basicity of compounds such as NH_3 and Na_2CO_3 which do not have OH group.



10. Given: $\Delta H^\circ = -224 \text{ kJ}$

$$\Delta S^\circ = -153 \text{ J K}^{-1} = -0.153 \text{ kJ K}^{-1}$$

To find: Temperature (T) at which the change over from spontaneous to nonspontaneous will occur.

$$\text{Formula: } T = \frac{\Delta H^\circ}{\Delta S^\circ}$$

$$\text{Calculation: } T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{-224 \text{ kJ}}{-0.153 \text{ kJ K}^{-1}} = +1464 \text{ K}$$

Since ΔH° and ΔS° are both negative, the reaction is spontaneous at low temperatures. A change over will occur at **1464 K**.

The reaction is spontaneous **below 1464 K**.

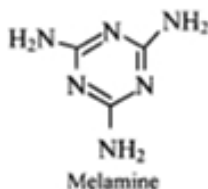
Temperature (T) at which the change over from spontaneous to nonspontaneous will occur is **1464 K**.

- Cellulose: Polysaccharide
- Maltose: Disaccharide
- Raffinose: Trisaccharide
- Fructose: Monosaccharide

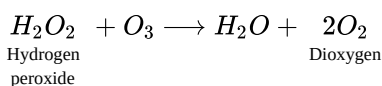
12. Standard enthalpy of combustion:

The **standard enthalpy of combustion** of a substance is the standard enthalpy change accompanying a reaction in which one mole of the substance in its standard state is completely oxidised.

13. The structure of melamine:



14. Ozone reduces hydrogen peroxide.



Section C

15. i. The boiling point elevation is directly proportional to the molality of the solution. Thus,

$$\Delta T_b = K_b m \dots(1)$$

ii. Suppose we prepare a solution by dissolving W_2 g of solute in W_1 g of solvent.

$$\text{Moles of solute in } W_1 \text{ g of solvent} = \frac{W_2}{M_2}$$

where, M_2 is the molar mass of solute.

$$\text{Mass of solvent} = W_1 \text{ g} = \frac{W_1 \text{ g}}{1000 \text{ g/kg}} = \frac{W_1}{1000} \text{ kg}$$

iii. The molality is expressed as,

$$m = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

$$m = \frac{W_2/M_2 \text{ mol}}{W_1/1000 \text{ kg}}$$

$$m = \frac{1000 W_2}{M_2 W_1} \text{ mol kg}^{-1} \dots(2)$$

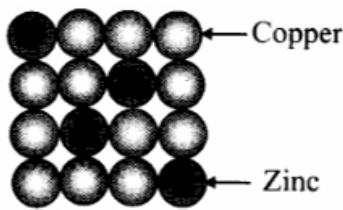
iv. Substituting equation (2) in equation (1), we get,

$$\Delta T_b = \frac{1000 K_b W_2}{M_2 W_1}$$

$$\text{Hence, } M_2 = \frac{1000 K_b W_2}{\Delta T_b W_1}$$

16. i. **Substitutional impurity defect:** In this defect, the foreign atoms are found at the lattice sites in place of host atoms. The regular atoms are displaced from their lattice sites by impurity atoms.

e.g.: Brass

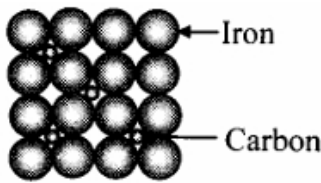


Brass

Substitutional impurity defect

ii. **Interstitial impurity defect:** In this defect, the impurity atoms occupy interstitial spaces of lattice structure.

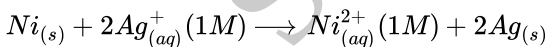
e.g.: Steel



Stainless steel

Interstitial impurity defect

17. Given: The cell reaction at 25°C ,



$$E_{Ni}^\circ = -0.25 \text{ V}, E_{Ag}^\circ = 0.799 \text{ V}$$

$$\text{Formulae: i. } E_{\text{cell}}^\circ = E_{\text{cathode}}^\circ - E_{\text{anode}}^\circ$$

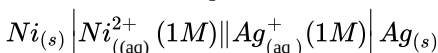
$$\text{ii. } E_{\text{cell}}^\circ = \frac{0.0592 \text{ V}}{n} \log_{10} K$$

To find:

i. Cell representation

ii. Equilibrium constant (K)

Calculation: Cell representation:



Calculation of equilibrium constant :

Using formula (i),

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

$$= 0.799 - (-0.25) = 1.049 \text{ V}$$

Using formula (ii),

$$E_{\text{cell}}^\circ = \frac{0.0592 \text{ V}}{2} \log_{10} K$$

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

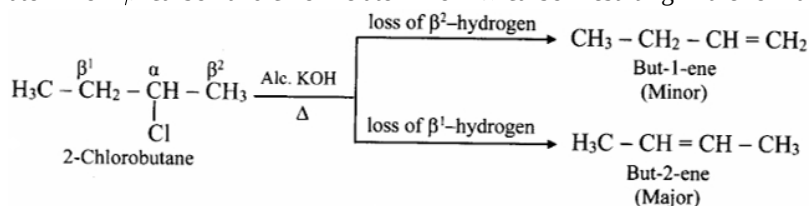
$$\therefore \log_{10} K = \frac{1.049 \times 2}{0.0592} = 35.44$$

$$\therefore K = \text{antilog}(35.44) = 2.754 \times 10^{35}$$

The equilibrium constant of the reaction is 2.754×10^{35} .

18. Dehydrohalogenation reaction of 2-chlorobutane:

- i. When 2-chlorobutane is boiled with alcoholic solution of potassium hydroxide (KOH), it undergoes elimination of hydrogen atom from β -carbon and chlorine atom from α -carbon resulting in the formation of an alkene.



- ii. In 2-chlorobutane, there are two non-equivalent β -hydrogen atoms (shown by β^1 and β^2).

iii. Saytzeff elimination is preferred formation of more highly stabilized alkene during an elimination reaction.

iv. Therefore, in the above reaction but-2-ene is the preferred product, and is formed as the major product.

19. Given: Amount of ideal gas = $n = 2000 \text{ mmol} = 2 \text{ mol}$

Initial volume = $V_1 = 20 \text{ L}$

Final volume = $V_2 = 30 \text{ L}$

Gas constant = $R = 8.314 \text{ J K}^{-1} \cdot \text{mol}^{-1}$

To find: Work done (W_{max})

$$\text{Formula: } W_{\text{max}} = -2.303nRT \log_{10} \frac{V_2}{V_1}$$

Calculation: From formula,

$$\begin{aligned}
 W_{\text{max}} &= -2.303nRT \log_{10} \frac{V_2}{V_1} \\
 &= -2.303 \times 2 \text{ mol} \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 300 \text{ K} \times \log_{10} \frac{30}{20} \\
 &= -2.303 \times 2 \times 8.314 \text{ J} \times 300 \times \log_{10} 1.5 \\
 &= -2.303 \times 2 \times 8.314 \text{ J} \times 300 \times 0.1761 \\
 &= -2023 \text{ J} = -2.023 \text{ kJ}
 \end{aligned}$$

The maximum work done is **-2.023 kJ**.

20. i. **Lanthanoid contraction:** As we move along the lanthanoid series, there is a decrease in atomic and ionic radii. This steady decrease in the atomic and ionic radii is called lanthanoid contraction.

ii. **Causes of lanthanoid contraction:**

- As we move from one element to another (i.e., from Ce to Lu), the nuclear charge increases by one unit and one electron is added.
- The new electrons are added to the same inner 4f subshell. Thus, the 4f electrons shield each other from the nuclear charge poorly owing to their diffused nature.
- With increasing atomic number and nuclear charge, the effective nuclear charge experienced by each 4f electrons increases. As a result, the whole of 4f electron shell contracts at each successive element.

iii. **Effects of lanthanoid contraction:** Since the ionic size decreases from La^{3+} to Lu^{3+} , the basicity of hydroxides decreases.

$\text{La}(\text{OH})_3$ is the strongest base while $\text{Lu}(\text{OH})_3$ is the weakest base.

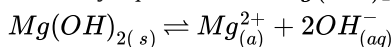
21. Given: Solubility product (K_{sp}) = 1.4×10^{-11}

To find: Solubility, S

$$\text{Formula: } K_{sp} = x^x y^y S^{x+y}$$

Calculation:

Solubility equilibrium of $\text{Mg}(\text{OH})_2$ is:



$$x = 1, y = 2$$

$$K_{sp} = x^x y^y S^{x+y} = (1)^1 (2)^2 S^{1+2} = 4 S^3$$

The molar solubility (S) of $\text{Mg}(\text{OH})_2$ is

$$S = \sqrt[3]{\frac{K_{sp}}{4}} = \sqrt[3]{\frac{1.4 \times 10^{-11}}{4}} = \sqrt[3]{3.5 \times 10^{-12}}$$

$$= 1.518 \times 10^{-4} \text{ moldm}^{-3}$$

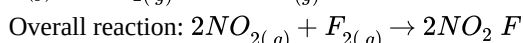
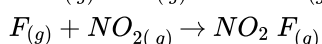
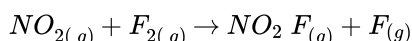
Solubility (S) of magnesium hydroxide, $Mg(OH)_2$ is $1.518 \times 10^{-4} \text{ moldm}^{-3}$.

22. The postulates of Werner theory are as follows:

- i. **Postulate (1):** Unlike metal salts, the metal in a complex possesses two types of valencies: primary (ionizable) valency and secondary (nonionizable) valency.
- ii. **Postulate (2):** The ionizable sphere consists of entities which satisfy the primary valency of the metal. Primary valencies are generally satisfied by anions.
- iii. **Postulate (3):** The secondary coordination sphere consists of entities which satisfy the secondary valencies and are non ionizable. The secondary valencies for a metal ion are fixed and satisfied by either by anions or neutral ligands. Number of secondary valencies is equal to the coordination number.
- iv. **Postulate (4):** The secondary valencies have a fixed spatial arrangement around the metal ion.

23. i. The overall reaction is obtained by adding the two elementary steps of the mechanism.

Thus,



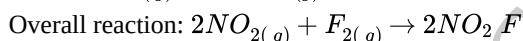
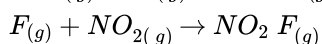
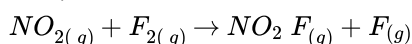
$F_{(g)}$ is produced in step 1 and consumed in step 2. Hence, $F_{(g)}$ is the reaction intermediate.

ii. Step 1 is slow. The rate law of the reaction is predicted from its stoichiometry.

$$\text{Thus, rate} = k[NO_2][F_2]$$

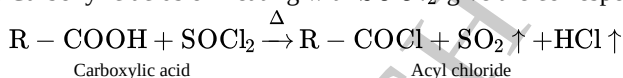
iii. The overall reaction is obtained by adding the two elementary steps of the mechanism.

Thus,

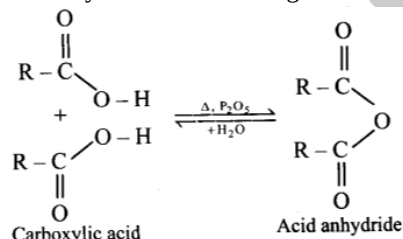


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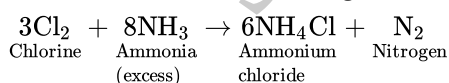
24. i. Carboxylic acids on heating with $SOCl_2$ give the corresponding acyl chlorides.



ii. Carboxylic acids on heating with strong dehydrating agent like P_2O_5 give the corresponding acid anhydrides.



25. i. With excess ammonia, chlorine gives nitrogen and ammonium chloride.



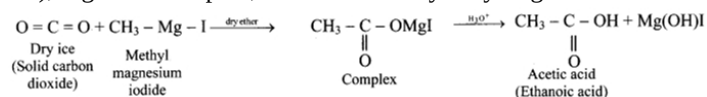
ii. Chlorine reacts with phosphorus to form phosphorus trichloride.



26. Answer the following:

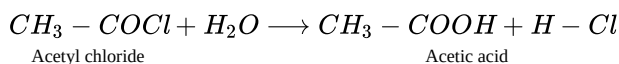
(i) i. **Preparation of acetic acid from dry ice:**

When solution of methyl magnesium iodide (Grignard reagent) in dry ether is added to solid carbon dioxide (dry ice), it gives a complex, which on acid hydrolysis gives ethanoic acid or acetic acid.

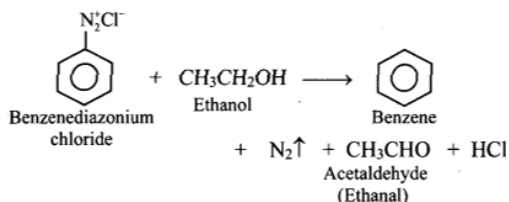


ii. **Preparation of acetic acid from acetyl chloride:**

Acetyl chloride on hydrolysis with water gives acetic acid.



(ii) Action of benzene diazonium chloride on ethanol:



Section D

27. Answer the following:

- (i) i. The average rate of a reaction is the change in concentration of reactant or product divided by time interval over which the change occurs.
- ii. The rate of a reaction at a specific instant is called instantaneous rate of reaction.

(ii) **Haematite:** Fe_2O_3

(iii) The reaction involved in sol-gel process during hydrolysis:



28. Answer the following:

- (i) A process conducted in such a way so that at every stage the driving force due to pressure (P) is infinitesimally greater than the opposing force due to external pressure (P_{ext}) and which can be reversed by a slight change of the opposing force is called **reversible process**.
- (ii) Elastomers are elastic polymers having weak van der Waals type of intermolecular forces which permit them to be stretched.
- (iii) **Monosaccharides** are carbohydrates which do not hydrolyse further into smaller units of polyhydroxy aldehydes or ketones.
e.g. Glucose, fructose, ribose

29. Answer the following:

(i) Given: Edge length (a) = 400 pm = 4.00×10^{-8} cm

Atomic mass of Ag = M = 108 g mol⁻¹

To find: Density (ρ)

$$\text{Formula: Density } (\rho) = \frac{M \times n}{a^3 N_A}$$

Calculation: For an fcc lattice, number of atoms per unit cell is 4.

$$\therefore n = 4$$

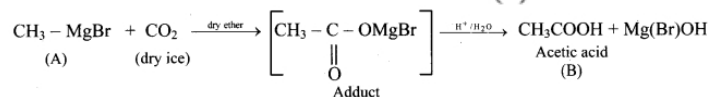
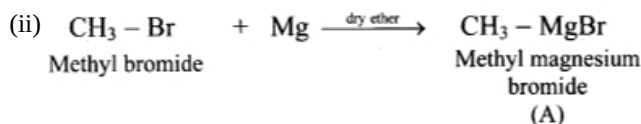
From formula,

$$\text{Density, } \rho = \frac{M \times n}{a^3 N_A}$$

$$\therefore \rho = \frac{108 \text{ g mol}^{-1} \times 4 \text{ atom}}{(4.00 \times 10^{-8})^3 \text{ cm}^3 \times 6.022 \times 10^{23} \text{ mol}^{-1}}$$

$$= 11.2 \text{ g cm}^{-3}$$

Density of silver is 11.2 g cm⁻³.



A - CH₃MgBr (Methyl magnesium bromide)

B - CH₃COOH (Acetic acid)

30. Answer the following:

(i) EAN rule states that " a metal ion continues to accept electrons pairs till it attains the electronic configuration of the next noble gas."

EAN = Number of electrons of metal ion + total number of electrons donated by ligands

= Atomic number of metal (Z) - Number of electrons lost by metal to form the ion (X) + Number of electrons donated

