CBSE
Class XI Chemistry
Sample Paper – 4 Solution

Section A

1. Organic compound is fused with sodium metal to convert N, S, P and halogens present in organic compound to their corresponding sodium salts.

OR

   $CH_3CH_2OCH_2CH_3$ and $CH_3OCH_2CH_2CH_3$ are metamers.

2. sp^3d hybrid orbitals -Trigonal bipyramidal
    sp^3d^2 hybrid orbitals-Octahedral

OR

   Increasing bonds order of ionic character:
   Br-H< C-H< F-H< Na-I< Li-Cl< K-F

3. It is due to the delocalization of $\prod$ electrons in benzene it is highly stable.

4. Mixing of soil or rock particles in water is called siltation.

5. Because alkali and alkaline earth metals are themselves stronger reducing agents than the majority of other reducing agents.

6. Atomic radii decrease across a period. Cations is smaller than their parent atoms. Among isoelectronic species, the one with the larger positive nuclear charge will have a smaller radius. Hence the largest species is Mg; the smallest one is Al3+.

7.
    (a) All of them are isoelectronic in nature and have 10 electrons each.
    (b) In isoelectronic species, greater the nuclear charge, lesser will be the atomic or ionic radius.
       $Al^{3+} < Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$

8.
   According to Rydberg equation,

   $$\bar{v} = 109,677 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \ cm^{-1}$$

R = 109,677 which is the Rydberg's constant

$$\bar{v} = \frac{1}{\text{Wavelength}}$$

For first line in Balmer series, $n_1 = 2$, $n_2 = 3$

Given wavelength of 1st spectral line = 6561 Å

Therefore, $\dfrac{1}{6561} = R\left(\dfrac{1}{2^2} - \dfrac{1}{3^2}\right) = R\left(\dfrac{5}{36}\right)$ (i)

For second line in Balmer series, $n_1 = 2$, $n_2 = 4$

Therefore, $\dfrac{1}{\text{Wavelength}} = R\left(\dfrac{1}{2^2} - \dfrac{1}{4^2}\right) = R\left(\dfrac{3}{16}\right)$ (ii)

Dividing eq. (i) by (ii), we get:

$$\frac{\text{Wavelength}}{6561} = \frac{5 \times 16}{36 \times 3}$$

$\therefore$ Wavelength = 4860 Å

9.

$V_1 = 2$ L

$T_1 = (23.4 + 273)$ K
   = 296.4 K

$T_2 = (26.1 + 273)$ K
   = 299.1 K

From Charles law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\Rightarrow V_2 = \frac{V_1 T_2}{T_1}$$

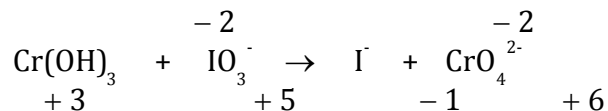$$\Rightarrow V_2 = \frac{2L \times 299.1\ K}{296.4\ K}$$

$$= 2\ L \times 1.009$$

$$= 2.018\ L$$

10.

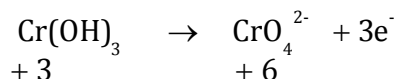a) First, we will write down the oxidation number of each atom

$$\underset{+3}{Cr(OH)_3} + \underset{+5}{\overset{-2}{IO_3^-}} \rightarrow \underset{-1}{I^-} + \underset{+6}{\overset{-2}{CrO_4^{2-}}}$$
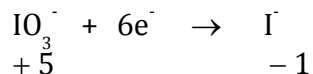
b) Write separately oxidation & reduction half reactions

Oxidation half reaction:

$$\underset{+3}{Cr(OH)_3} \rightarrow \underset{+6}{CrO_4^{2-}} + 3e^-$$

Reduction half reaction:
$$\underset{+5}{IO_3^-} + 6e^- \rightarrow \underset{-1}{I^-}$$

c) Balance O atoms by adding H_2O molecules to the side deficient in 'O' atoms and then balancing H atoms

$$Cr(OH)_3 + H_2O \rightarrow CrO_4^{2-} + 3e^-$$

$$IO_3^- + 6e^- \rightarrow I^- + 3H_2O$$
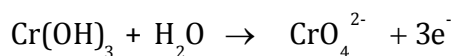
d) Balance H atoms. Since the medium is alkaline, therefore H_2O molecules are added to the side deficient in H atoms and equal no. of OH^- ions to the other side :

$$Cr(OH)_3 + 5OH^- \rightarrow CrO_4^{2-} + 3e^- + 4H_2O$$
$$(\because Cr(OH)_3 + H_2O + 5OH^- \rightarrow CrO_4^{2-} + 3e^- + 5H_2O)$$

$$IO_3^- + 6e^- + 3H_2O \rightarrow I^- + 6OH^-$$
$$(\because IO_3^- + 6e^- + 6H_2O \rightarrow I^- + 3H_2O + 6OH^-)$$

e) Equalise the electrons lost and gained by multiplying the oxidation half reaction with 2.

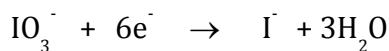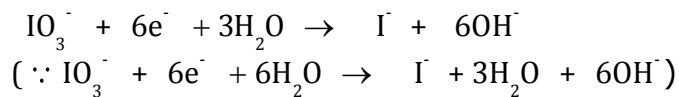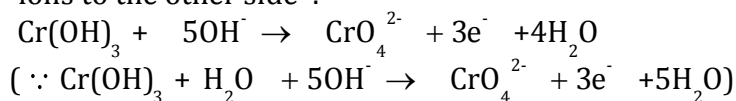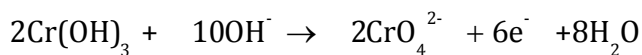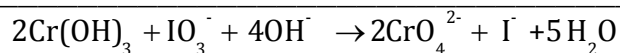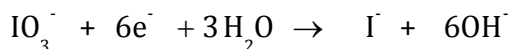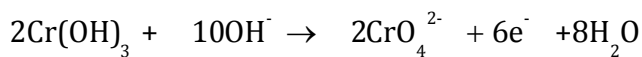$$2Cr(OH)_3 + 10OH^- \rightarrow 2CrO_4^{2-} + 6e^- + 8H_2O$$

Adding the oxidation half reaction and reduction half reaction we get

$$2Cr(OH)_3 + 10OH^- \rightarrow 2CrO_4^{2-} + 6e^- + 8H_2O$$

$$IO_3^- + 6e^- + 3H_2O \rightarrow I^- + 6OH^-$$
_____

$$2Cr(OH)_3 + IO_3^- + 4OH^- \rightarrow 2CrO_4^{2-} + I^- + 5H_2O$$

11.

(a) Anhydrous AlCl$_3$ is covalent but hydrated AlCl$_3$ is electrovalent because when it is dissolved in water the high heat of hydration is sufficient to break the covalent bond of AlCl$_3$ into Al^{3+} and Cl$^-$ ions.

(b) Boric acid behaves as Lewis acid by accepting a pair of electron from OH$^-$ ion (in water).

$$B(OH)_3 + 2\text{H-O-H} \rightarrow [B(OH)_4]^- + H_3O^+$$
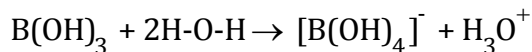
12. 1 molar solution contains 1mole of solute in 1 L of solution while
1 molal solution contains 1 mole of solute in 1000g of solvent.
Considering density of water as almost 1g/mL, then 1mole of solute is present in 1000mL of water in 1molal solution while 1mole of it is present in less than 1000mL of water in 1 molar solution
(1000mL solution in molar solution = Volume of solute + Volume of solvent).
Thus 1M solution is more concentrated than 1m solution.

OR

Given:

Molarity of solution = 0.5 M

Volume of solution = 250 cm^3

0.5 M NaCl solution contains 0.5 mole of NaCl in 1 litre of solution.

Number of moles of NaCl in 250 cm^3

$$= \frac{0.500}{4}$$

$$= 0.125\,\text{mol}$$

Molar mass of NaCl = 58.44 g

Mass of 0.125 mol of NaCl = 58.44 ×0.125

$$= 7.305 \text{ g of NaCl}$$

Section C

13. Given:

$\lambda = 150\,pm$

$\quad = 150 \times 10^{-12}\ m$

$v = 1.5 \times 10^{7}\,m/s$

$h = 6.626 \times 10^{-34}\ Js$

$c = 3.8 \times 10^{8}\ m/s$

Energy of the incident photon

$= \dfrac{hc}{\lambda}$

$= \dfrac{6.626 \times 10^{-34}\ \times 3.8 \times 10^{8}}{150 \times 10^{-12}\ m}$

$= 13.25 \times 10^{-16}\ J$

Energy of the ejected electron

$= \dfrac{1}{2}mv^{2}$

$= \dfrac{1}{2}\left(9.11 \times 10^{-31}\right)\left(1.5 \times 10^{7}\right)^{2}$

$= \dfrac{20.49 \times 10^{-17}}{2}$

$= 1.024 \times 10^{-16}\ J$

The energy with which the electron is bound to the nucleus $= 13.25 \times 10^{-16}\ J - 1.024 \times 10^{-16}\ J$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad = 12.226 \times 10^{-16}\ J$

The energy with which the electron is bound to the nucleus is $12.226 \times 10^{-16}\ J$.

OR

(a) Orbitals which possess equal energies are called degenerate orbitals.
For example: $2p_x$, $2p_y$ and $2p_z$ orbital which are oriented alon X, Y and Z axes are degenerate. Similarly, five d-orbitals d_{xy}, d_{yz}, d_{zx}, $d_{x^2-y^2}$ and d_{z^2} are degenerate orbitals.

(b) The angular momentum of an electron in a given stationary state can be expressed as

$$mvr = n\frac{h}{2\Pi} \quad \text{where} \ \ n = 1,2,3 \ ......\text{(Bohr equation)}$$

$$2\Pi r = n\frac{h}{mv}$$

But

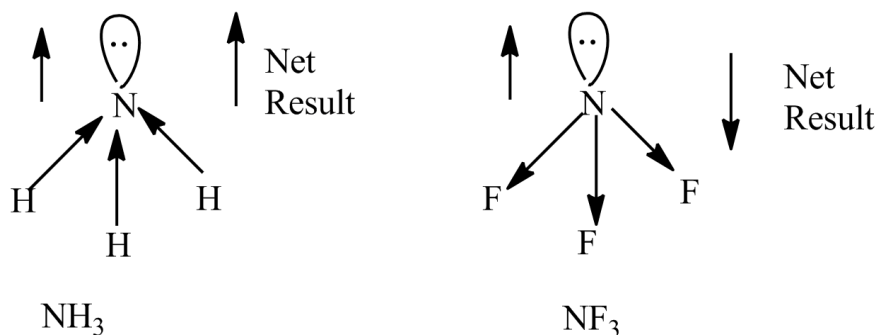$$\frac{h}{mv} = \lambda \quad (\text{de Broglie equation})$$

From the two equations, we have,

$$2\Pi r = n\lambda$$

or

circumference of Bohr orbit $= n\lambda$

14. NH_3 and NF_3 both have pyramidal structure and a lone pair of electron on nitrogen as shown below:


Dipole momemnts in NH_3 and NF_3

NH_3 has a higher dipole moment than NF_3, the orbital dipole due to lone pair is in the same direction as the resultant dipole moment of N-H bonds whereas in NF_3, the dipole due to lone pair is in a direction opposite to the resultant dipole moment of three N-F bonds. The dipole due to lone pair in NF_3 causes a decrease in the dipole moment of NF_3.
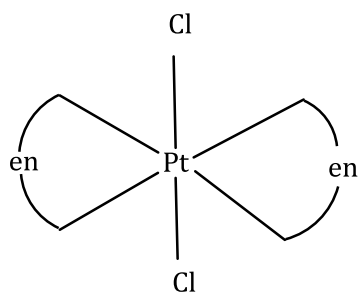
OR

(a)
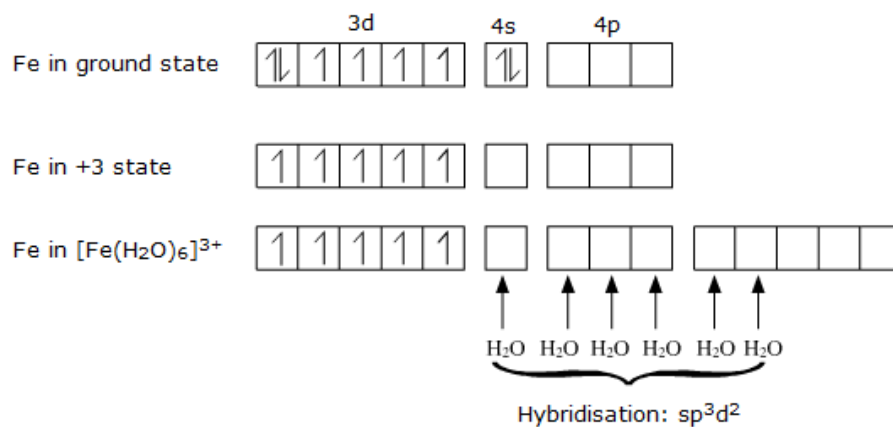
Hybridisation: sp³d²
Magnetic character: Paramagnetic
Spin of complex: High spin complex

(b) Trans isomer of [Pt(en)₂Cl₂]²⁺ is optically inactive.

15.

Calculation of volume of nitrogen at S.T.P

Experimental conditions

Pressure of dry gas P_1 = 755.8 - 23.8 = 732 mL

V_1 = 31.7 mL
T_1 = 25+273 = 298 K

S.T.P condition

P_2 = 760 mm
V_2 = ?
T_2 = 273 K

Applying gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\therefore \frac{732 \times 31.7}{298} = \frac{760 \times V_2}{273}$$
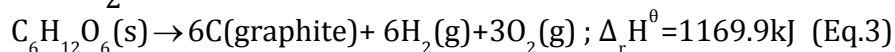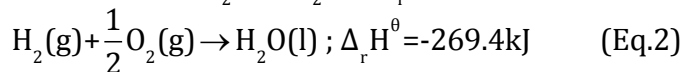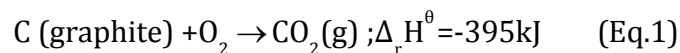
$$\Rightarrow V_2 = 27.97 \text{ mL}$$

$$\% \text{ of Nitrogen} = \frac{28 \times \text{Volume of } N_2 \text{ at S.T.P} \times 100}{22400 \times \text{Mass of compound}}$$
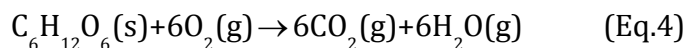
$$= \frac{28 \times 27.97 \times 100}{22400 \times 0.2325}$$
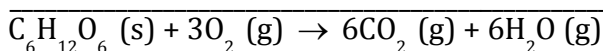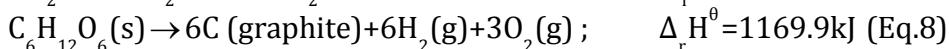
$$= 15.04$$

16. Given:

C (graphite) $+O_2 \rightarrow CO_2(g)$; $\Delta_r H^\theta = -395kJ$ (Eq.1)

$H_2(g) + \dfrac{1}{2}O_2(g) \rightarrow H_2O(l)$; $\Delta_r H^\theta = -269.4kJ$ (Eq.2)

$C_6H_{12}O_6(s) \rightarrow 6C(graphite) + 6H_2(g) + 3O_2(g)$; $\Delta_r H^\theta = 1169.9kJ$ (Eq.3)

Combustion of graphite is given by the equation shown below

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$ (Eq.4)

Thus enthalpy for combustion reaction can be obtained by multiplying

(Eq.1) an(d Eq.2) by 6 and adding equation (Eq.3)

$6C(graphite) + 6O_2 \rightarrow 6CO_2$ (g) ; $\Delta_r H^\theta = -2370kJ$ (Eq.6)
$6H_2(g) + 3O_2(g) \rightarrow 6 H_2O(l)$; $\Delta_r H^\theta = -1614.4kJ$ (Eq.7)
$C_6H_{12}O_6(s) \rightarrow 6C$ (graphite)$+6H_2(g)+3O_2(g)$; $\Delta_r H^\theta = 1169.9kJ$ (Eq.8)
_____

$C_6H_{12}O_6$ (s) $+ 3O_2$ (g) $\rightarrow 6CO_2$ (g) $+ 6H_2O$ (g)

Reaction enthalpy = (-2370 kJ-1614kJ) + (1169.9 kJ+0)

$= -2814.1kJ$

17.

For $Ni(OH)_2$ $K_{sp} = 2.0 \times 10^{-15}$

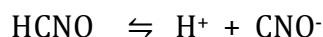As K_{sp} is small, 2s << 0.10 so that 2s + 0.10 = 0.10

$\therefore K_{sp} = s \times (0.10)^2$

$s = \dfrac{K_{sp}}{(0.10)^2}$

$= \dfrac{2.0 \times 10^{-15}}{(0.10)^2}$

$= 2.0 \times 10^{-13}$

Molar solubility of $Ni(OH)_2$ in 0.1 M NaOH = 2.0 x 10^{-13} M

OR

$HCNO \leftrightharpoons H^+ + CNO^-$

pH= 2.34 that is,

-log[H⁺] =2.34

log[H⁺] = -2.34

[H⁺] =antilog(-2.34)

$$= 4.57 \times 10^{-3} \text{ M}$$

Ionisation constant:

$$K_a = \frac{\left(4.57 \times 10^{-3}\right)\left(4.57 \times 10^{-3}\right)}{0.1}$$

$$= 2.09 \times 10^{-4}$$

Degree of dissociation:

$$\alpha = \sqrt{\frac{K_a}{C}}$$

$$= \sqrt{\frac{2.09 \times 10^{-4}}{0.1}}$$

$$= 0.0457$$

18.

  (a)

    (i) Cr is getting oxidized and MnO_4^- is getting reduced.

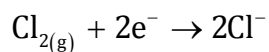   (ii) Cr is negative electrode, Pt in MnO_4^- acts as positive electrode.

  (b)

    (i) $KMnO_4$

       K(+1), Mn(+7), O(-2)

    (ii) $K_2Cr_2O_7$

       K(+1), Cr(+7), O(-2)

<div align="center">OR</div>

  (a) $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$

        $2H^+ + 2e^- \rightarrow H_{2(g)}$

  (b) $Ag_{(aq)} + e^- \rightarrow Ag_{(s)}$

        $Al_{(s)} \rightarrow Al^{3+} + 3e^-$

  (c) $Na_{(s)} \rightarrow Na^{2+}_{(aq)} + 2e^-$

        $Cl_{2(g)} + 2e^- \rightarrow 2Cl^-$
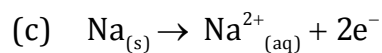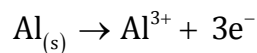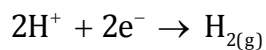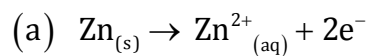
19.

  (a) $BeH_2 < TiH_2 < CaH_2$

  (b) $LiH < NaH < CsH$

  (c) F–F < H–H < D–D

20.

  (a) This is because, in the presence of sulphuric acid, lead acetate will react with it forming white precipitate of $PbSO_4$, thus interfering with the test.

  (b) $(CH_3)_3C^+$ is most stable because it has the maximum number of alkyl groups i.e. three. Greater the number of alkyl groups on the carbon carrying positive charge, greater would be the dispersal of charge and hence more will be the stability of carbocation. So, tertiary carbocation is the most stable due to maximum dispersal of charge.

  (c) In steam distillation, water and organic substance vaporize together and total pressure becomes equal to atmospheric pressure. Thus organic substance vaporizes and distils at a temperature lower than its boiling point.

21.

  (i) Functional isomerism or functional group isomerism
  (ii) Position isomerism
  (iii) Metamerism

22.

  (a) As the temperature increases solubility of gas in water decreases. Due to high temperature of water, amount of dissolved oxygen is less, which creates a problem for fish. So, fish do not grow well in warm water.

  (b) Rain water is acidic due to dissolution of CO_2 in it, leading to formation of H_2CO_3 which lowers the pH. Hence the pH is about 5.6

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 \rightarrow 2H^+ + CO_3^{2-}$$
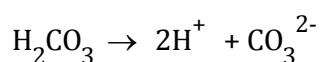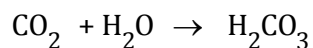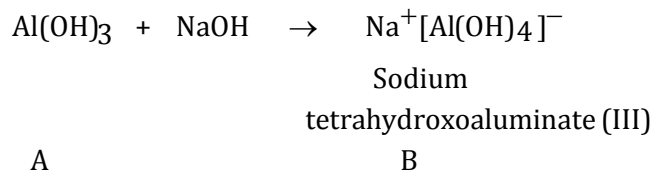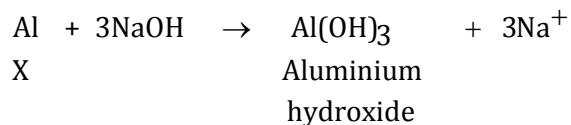
 (c) Carbon dioxide and methane are two major greenhouse gases.

23.

  (a) 2-Methylbut-2-ene
  (b) 2-Methylphenol
  (c) 4-Phenlybut-1-ene

24. Since metal X reacts with NaOH to first give a white ppt. A which dissolves in excess of NaOH to give a soluble complex B , therefore metal X is aluminium ;ppt A is $Al(OH)_3$ and complex B is sodium teterahydroxoaluminate (III)

$$Al\ +\ 3NaOH\ \rightarrow\ Al(OH)_3\ +\ 3Na^+$$

X   Aluminium
hydroxide

$$Al(OH)_3\ +\ NaOH\ \rightarrow\ Na^+[Al(OH)_4]^-$$

Sodium
tetrahydroxoaluminate (III)

     A   B

Since A is amphoteric in nature, it reacts with dilute HCl to form compound C which is $AlCl_3$

$$Al(OH)_3 + 3HCl \longrightarrow AlCl_3 + 3H_2O$$

   A   C
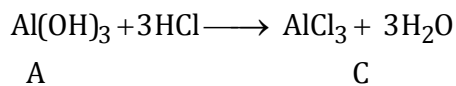
Since A on heating gives D which is used to extract metal, therefore, D must be alumina (Al_2O_3)

$$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$$

    A   D
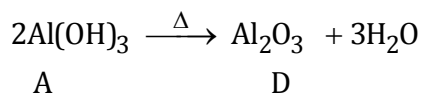
25.

(a) A process which can take place of its own or initiate under some condition.
Conditions for spontaneity in terms i=of free energy:
If ΔG is negative, the process is spontaneous.
If ΔG is positive the process is non-spontaneous.

(b)

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

If N_2O_4 is 50% dissociated, the mole fraction of both the substances is given by
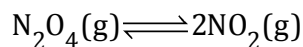
$$x_{N_2O_4} = \frac{1-0.5}{1+0.5} = \frac{0.5}{1.5};$$

$$x_{NO_2} = \frac{2 \times 0.5}{1+0.5} = \frac{1}{1.5}$$

$$p_{N_2O_4} = \frac{0.5}{1.5} \times 1 \text{ atm} = \frac{0.5}{1.5}$$

$$p_{NO_2} = \frac{1}{1.5} \times 1 \text{ atm} = \frac{1}{1.5}$$

The equilibrium constant K_P is given by

$$K_P = \frac{\left(pNO_2\right)^2}{pN_2O_4}$$

$$= \frac{1.5}{(1.5)^2(0.5)}$$

$$= 1.33 \text{ atm}$$

Since $\Delta_r G^\theta = -RT \ln K_P$

$$\Delta_r G^\theta = (-8.314 \text{ JK}^{-1}\text{mol}^{-1}) \times (333 \text{ K}) \times (\ln(1.33))$$

$$= (-8.314 \text{ JK}^{-1}\text{mol}^{-1}) \times (333 \text{ K}) \times (2.303) \times (0.1239)$$

$$\Delta_r G^\theta = -789.98 \text{ kJ mol}^{-1}$$

26.

(a) Unlike NaHCO₃, the intermediate KHCO₃ formed during reaction, is highly soluble in water and thus cannot be taken out from solution to obtain K₂CO₃. Hence, K₂CO₃ cannot be prepared by Solvay process.

(b) Alkali metals are highly reactive because of low ionization enthalpy value and therefore are not found in nature. They are present in combined state only in form of halides, oxides etc.

(c) Ionization Energy of potassium is less than sodium because of large size or less effective nuclear charge. Thus, potassium is more reactive than sodium.

(d) Alkali metals are strong reducing agents due to their greater ease to lose electrons.

(e) Alkali metals have one unpaired electrons (ns¹) and are paramagnetic. However, during the salt formation, the unpaired electron is lost by alkali metals to other atom forming anion. Their salts have all paired electrons and show diamagnetic nature.

OR

(a) The size of anions being much larger compared to cations, the lattice enthalpy will remain almost constant within a particular group. Since the hydration enthalpies decrease down the group, solubility will decrease as found for alkaline earth metal carbonates and sulphates

(b) $Cs^+ > Rb^+ > K^+ > Na^+ > Li^+$
    Smaller the size of the ion greater is the degree of hydration. Lithium being small in size is hydrated to a large extent and cesium being large in size is hydrated to small extent.

(c) The M-OH bond in hydroxides of alkali metal is very weak and can easily ionize to form M^+ ions and OH^- ions. This accounts for the basic character. Since ionization energy decreases down the group, bond between metal and oxygen becomes weak. Therefore basic strength of hydroxides increases accordingly.

  Thus NaOH is a stronger base than LiOH.

(d) Alkali metals are highly sensitive towards air and water and are kept therefore in kerosene or paraffin oil.

(e) This is because of exceptionally small size of Lithium and high charge to radius ratio of Li^+.

27.
  (a)
  (i)

$$CH_3-CH=CH_2+H_2O+O \xrightarrow[273 \text{ K}]{\text{dil. KMnO}_4}$$
$$CH_3CH(OH)CH_2OH$$
$$\text{Propane-1, 2-diol}$$

  (ii)

$$\underset{CH_3}{\overset{CH_3}{|}}CH_3\text{-CHBr} \xrightarrow{\text{alc. KOH}} CH_3CH=CH_2 \xrightarrow[\text{Peroxide effect}]{\text{HBr}} CH_3CH_2CH_2Br$$
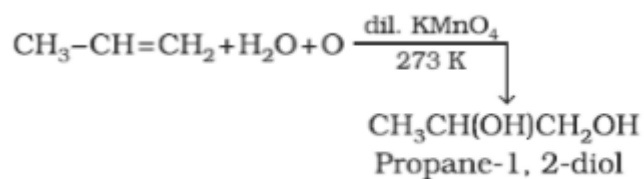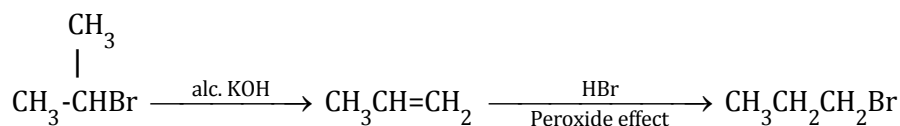
(b) From the given products of Ozonolysis,
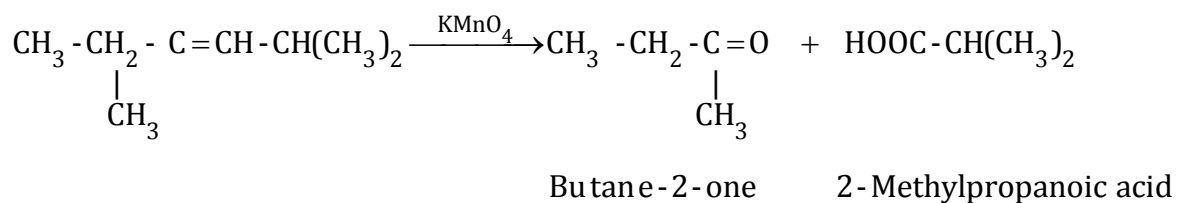
$$CH_3 - CH_2 - \overset{\underset{\displaystyle \|}{\displaystyle O}}{C} - CH_3 \quad \text{and} \quad CH_3 - CH - \overset{\underset{\displaystyle \|}{\displaystyle}}{\underset{\displaystyle CH_3}{C}} = O$$

The alkene would be: $CH_3 - CH_2 - \overset{\underset{\displaystyle |}{\displaystyle CH_3}}{\overset{\displaystyle CH_3}{\underset{\displaystyle |}{C}}} = CH - CH - CH_3$
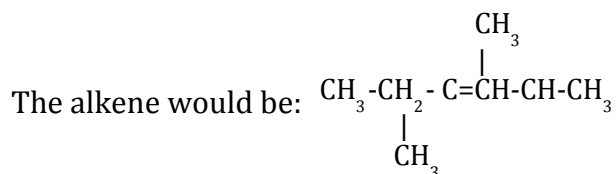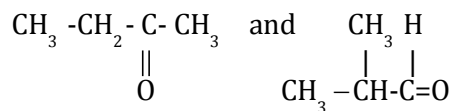
IUPAC Name: 2, 4-dimethylhex-3-ene

$$CH_3 - CH_2 - \overset{\underset{\displaystyle |}{\displaystyle CH_3}}{C} = CH - CH(CH_3)_2 \xrightarrow{KMnO_4} CH_3 - CH_2 - \overset{\underset{\displaystyle |}{\displaystyle CH_3}}{C} = O \quad + \quad HOOC - CH(CH_3)_2$$

Butane-2-one   2-Methylpropanoic acid

OR

(i)

$$CH_2 = CHBr \xrightarrow{NaNH_2} HC \equiv CH \xrightarrow[873K]{\text{Red hot iron tube}} C_6H_6$$

A   B

(ii)

$$C_6H_6 + CH_3COCl \xrightarrow[AlCl_3]{\text{Anhydrous}} C_6H_5COCH_3 + HCl$$

A   B

(iii)

$$CH_3COOH \xrightarrow{NaOH\,(aq)} CH_3COONa \xrightarrow[\Delta]{\text{Sodalime}} CH_4$$

A   B

(iv)

$$CH_2 = CH - CH_2 - CH_2 - CH_2 - CH_3 \ + HBr \xrightarrow{\text{No peroxide}} CH_3 - \underset{\underset{Br}{|}}{CH} - CH_2 - CH_2 - CH_2 - CH_3$$

Hex – 1 – ene   2 – Bromohexane

(v)

$$CH_2 = CH - CH_2 - CH_2 - CH_2 - CH_3 \ + HBr \xrightarrow{\text{peroxide}} \underset{\underset{Br}{|}}{CH_2} - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$$

Hex – 1 – ene   1 – Bromohexane