

# Chemistry

Q.1 HCHO and  $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$  are the products obtained on ozonolysis of a monomer (A) of a polymer.

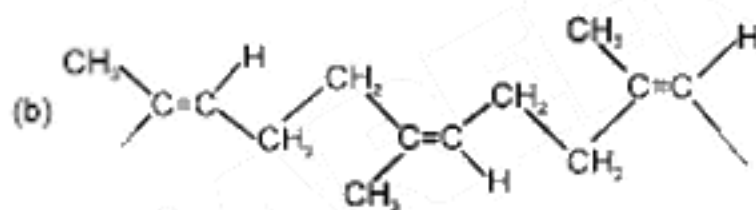
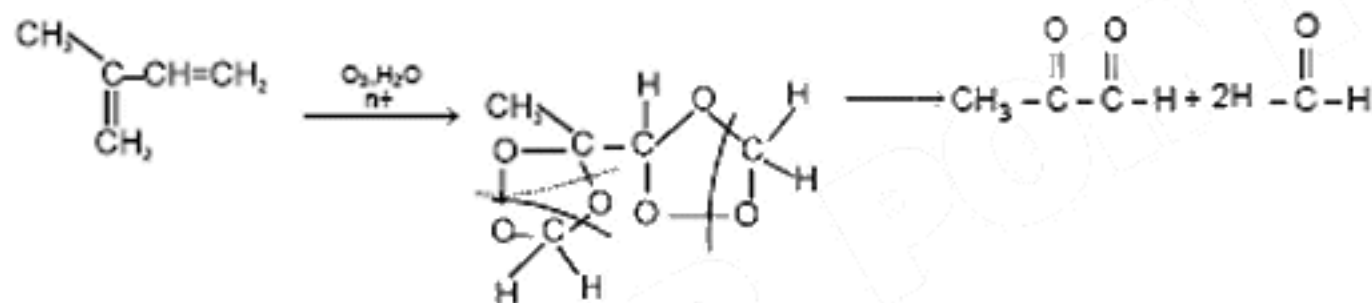
(a) Give the structure of (A)

(b) Draw the "all-cis" form of a polymer of a monomer (A)

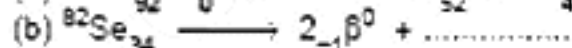
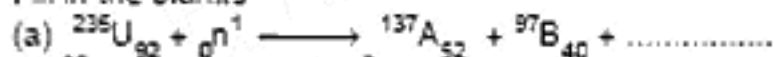
[2]

Sol. (a) Since the products obtained are  $\text{HCHO}$  (two moles) and  $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$  (One mole), it confirms the presence of two double bonds.

Therefore the structure will be :



Q.2 Fill in the blanks



[2]

Sol. (a)  ${}^{235}_{92}\text{U} + {}_0^1\text{n} \longrightarrow {}^{137}_{52}\text{A} + {}^{97}_{40}\text{B} + 2 {}_0^1\text{n}$



Q.3 For an element of FCC crystal lattice having edge length 400 pm, calculate the maximum diameter of an atom which can be placed in interstitial site so that the structure remain same.

[2]

Sol. For FCC, interstitial

For octahedral voids and Tetrahedral voids

$$\frac{r_1}{r_2} = 0.414$$

$$\frac{r_1}{r_2} = 0.225$$

$r_1$  = Radius of atomic interstitial site

$r_2$  = Radius of atom arranged in FCC.

$$4r_2 = \sqrt{2} a$$

Octahedral voids will be considered and for maximum diameter of atom in interstitial sites

$$\text{Diameter} = 2r_1 = 2(\sqrt{2} r_2) = 2 \times 0.414 \times \frac{400}{2\sqrt{2}} = 117.1 \text{ pm.}$$

- Q.4 (a) What is the weight of calcium oxide when 852 gms of  $P_4O_{10}$  reacts with it.  
 (b) Draw the structure of  $P_4O_{10}$ .

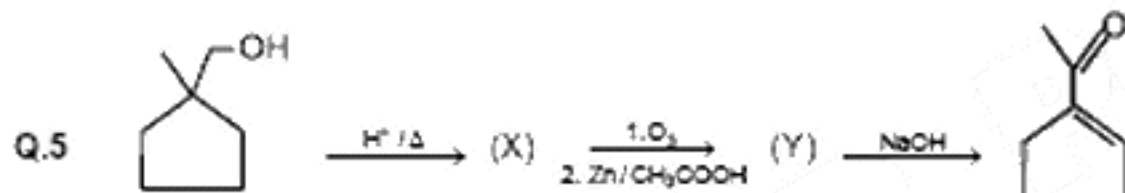
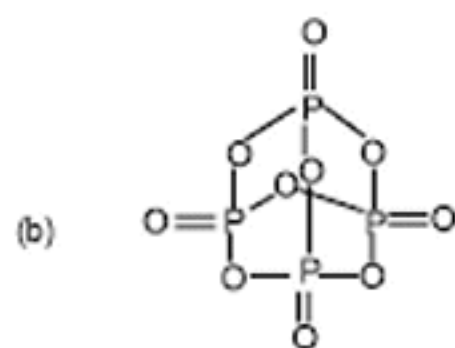
[2]

- Sol. (a) The balanced chemical equations  
 $6 CaO + P_4O_{10} \longrightarrow 2Ca_3(PO_4)_2$   
 6 moles of CaO reacts with 1 mole of  $P_4O_{10}$

$$\text{moles of } P_4O_{10} = \frac{852}{284} = 3$$

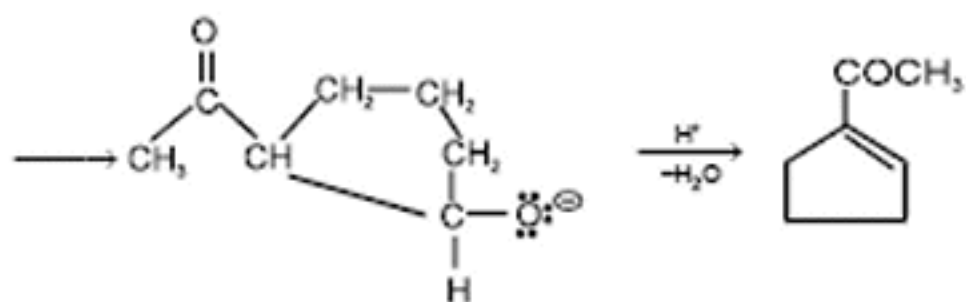
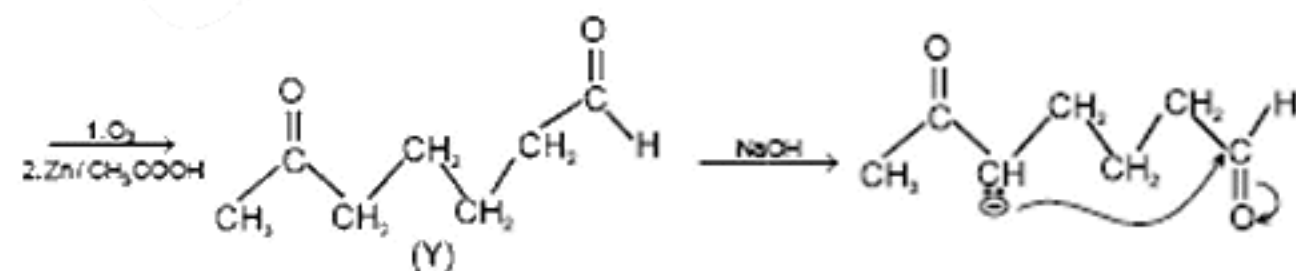
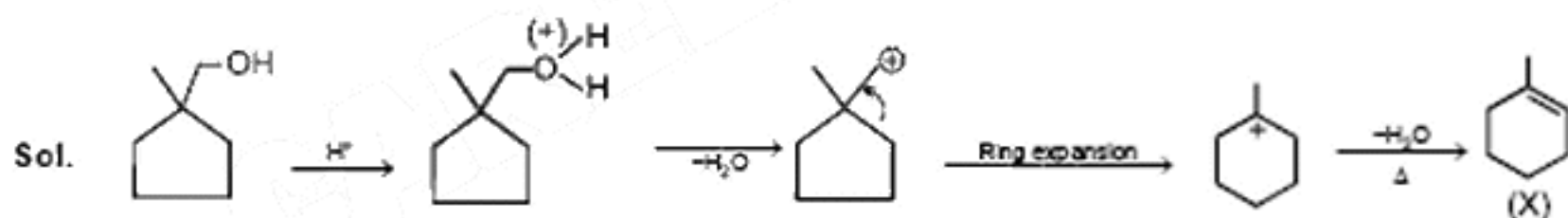
$\therefore$  Moles of CaO is equal to 18

$$W_{CaO} = 18 \times 56 = 1008 \text{ gm}$$

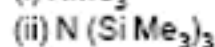


Identify (X) and (Y).

[2]



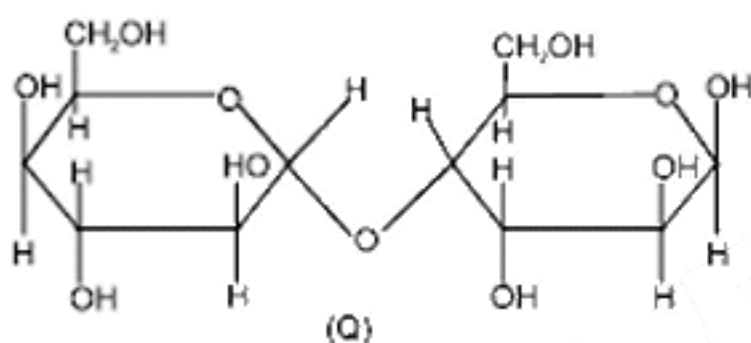
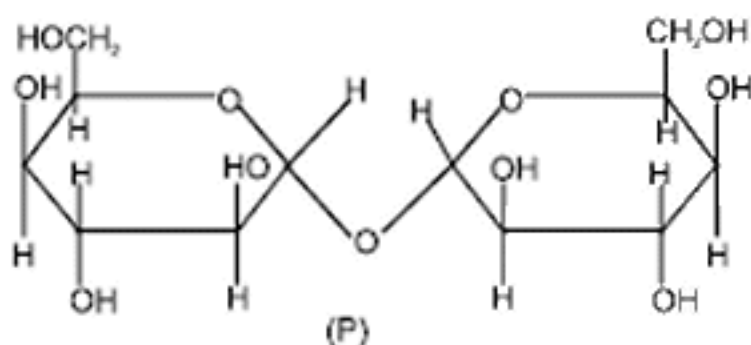
Q.6 Predict whether the following molecules are isostructural or not. Explain your answer.



[2]

Sol.  $\text{N}(\text{Me})_3$  is trigonal pyramidal because of 3 – bond pairs and one lone pair. Because of back bonding ( $\pi$ - $d\pi$  bonding). In  $\text{N}(\text{SiMe}_3)_3$  the shape is trigonal planar.

Q.7 Which of the following disaccharide will not reduce Tollen's reagent ?



[2]

Sol. In structure (Q) one ring is present in the form of hemiacetal. It will hydrolyse and reduce Fehling's solution. In structure (P) both the rings are present in acetyl form it will not hydrolyse in solution hence no reaction with Fehling's solution.

Q.8  $\text{N}_2$  is adsorbed in 20% of the surface sites.  $\text{N}_2$  gas evolved on heating was collected at 0.001 atm and 298 K in a container of volume  $2.46 \text{ cm}^3$ . Find out the no. of surface sites occupied per molecule of  $\text{N}_2$ . If the density of surface sites is  $6.023 \times 10^{14}/\text{cm}^2$  and surface area is  $1000 \text{ cm}^2$ .

[2]

Sol. For nitrogen gas

$$P(\text{N}_2) = 0.001 \text{ atm}$$

$$T = 298 \text{ K}; \quad V = 2.46 \text{ cm}^3$$

Applying ideal gas equation  $PV = nRT$

$$\therefore n(\text{N}_2) = \frac{0.001 \times 2.46 \times 10^{-3}}{0.0821 \times 298} = 1 \times 10^{-7}$$

$$\text{N}_2 \text{ molecules} = 6.023 \times 10^{23} \times 10^{-7} = 6.023 \times 10^{16}$$

$$\text{Surface sites} = 6.023 \times 10^{14} \times 1000 = 6.023 \times 10^{17}$$

$$\text{Since 20\% of the sites are used to adsorb} = \frac{20}{100} \times 6.023 \times 10^{17} = 12.04 \times 10^{16}$$

$$\Rightarrow \text{Site occupied per molecule} = \frac{12.04 \times 10^{16}}{6.02 \times 10^{16}} = 2$$

Q.9. For developing black and white photographic film, give the balanced chemical equation. Sodium thiosulphate on acidification turns milky. Give the balanced chemical equation.

[4]

Sol. For developing photographic film, reactions are



- Q.10 For a reaction  
 $2X_{(g)} \longrightarrow 3Y_{(g)} + 2Z_{(g)}$   
 the data of partial pressure of X with time is given below (assume ideal gas conditions)

Time (Min)	0	100	200
$P_x$ (mm of Hg)	800	400	200

Calculate -

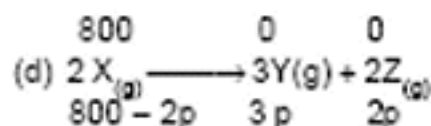
- Order of reaction
- Rate constant
- time required to complete 75% of reaction
- Total pressure of reaction mixture if  $p_x = 700$  mm

[4]

- Sol.  $2X_{(g)} \longrightarrow 3Y_{(g)} + 2Z_{(g)}$   
 (a)  $t_{1/2}$  is independent of initial conc. of X, hence reaction is first order. ( $t_{1/2} = 100$  min)

$$(b) K = \frac{0.693}{t_{1/2}} = \frac{0.693}{100} = 6.93 \times 10^{-3} \text{ min}^{-1}$$

$$(c) \text{ Time required} = 2 t_{1/2} = 2 \times 100 = 200 \text{ min.}$$



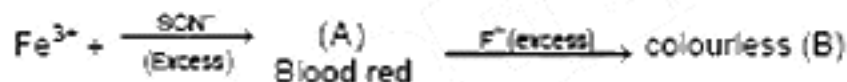
$$800 - 2p = 700$$

$$2p = 100$$

$$p = 50 \text{ mm}$$

$$\text{Total pressure } (P_T) = 800 + 3p = 950 \text{ mm.}$$

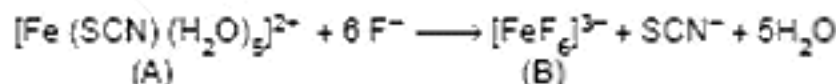
- Q.11 In the given reaction sequence. Identify (A) and (B)



- Write the IUPAC name of (A) and (B)
- Find out the spin only magnetic moment of B.

[4]

- Sol.  $Fe^{3+} + \xrightarrow[\text{(excess)}]{SCN^-} [Fe(SCN)(H_2O)_5]^{2+}$



(A)

(B)

(Blood Red)

(Colourless)

- IUPAC name of

(A) is Pentaquathiocyanato iron (III) ion

(B) is Hexafluoroferrate (III)

$$(b) \text{ Magnetic moment} = \sqrt{n(n+2)}$$

$$= \sqrt{35} = 5.92 \text{ B.M.}$$

Where  $n = 5$ 

(No. of unpaired electron).

- Q.12
  - For first orbit of hydrogen atom, calculate the velocity of electron ( $r = a_0 = 0.529 \text{ \AA}$ )
  - Calculate the de-broglie wavelength of electron in first Bohr orbit
  - Calculate the orbital angular momentum of 2p orbital in terms of  $h/2\pi$  units

[4]

- Sol.
  - $V = 2.18 \times 10^8 \times Z/n \text{ cm/sec} = 2.18 \times 10^8 \text{ cm/sec}$
  - $2\pi R = n\lambda$ .

$$\lambda = \frac{2\pi R}{n} = 2\pi \times 0.529 \text{ \AA}$$

$$= 3.3 \text{ \AA}$$

(c) for 2p,  $\ell = 1$

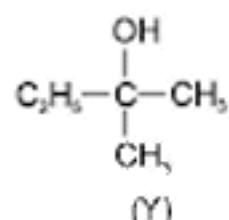
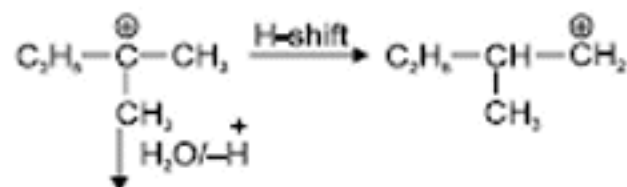
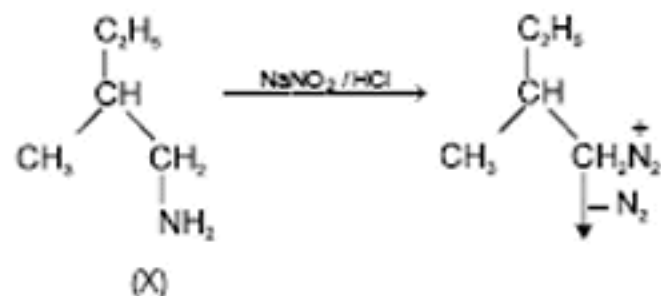
$$\text{orbital angular momentum} = \frac{h}{2\pi} \sqrt{\ell(\ell+1)} = \sqrt{2} \times \frac{h}{2\pi}$$

Q.13  $C_5H_{13}N \xrightarrow[-N_2]{NaNO_2/HCl}$  Tertiary alcohol + other products

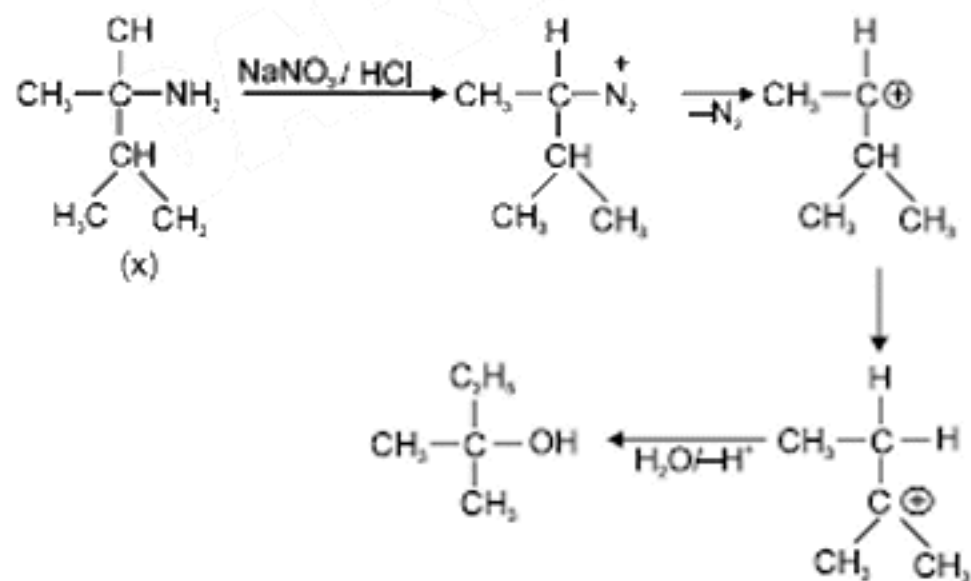
X is optically active. Find X and Y. Is Y optically active? write all intermediate steps.

[4]

Sol. There are 2-possibilities of X.



(Y is optically inactive)



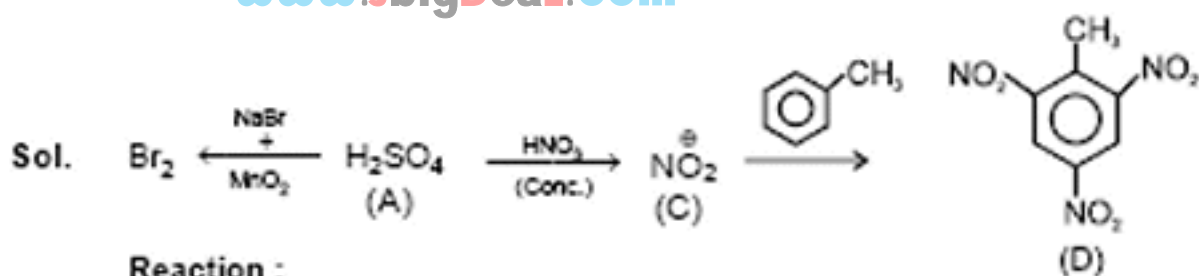
Q.14 (B)  $\xleftarrow[+MnO_2]{NaBr}$  (A)  $\xrightarrow{Conc. HNO_3}$  (C)  $\xrightarrow{\text{Benzene ring with } CH_3}$  (D) (Explosive Product)

(Brown fumes & Pungent smell)

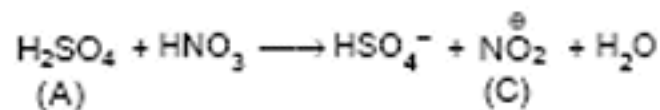
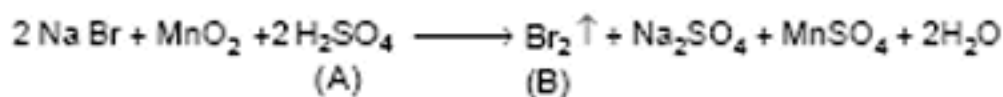
(Intermediate)

Identify the missing compounds. Give the equation from A to B and A to C.

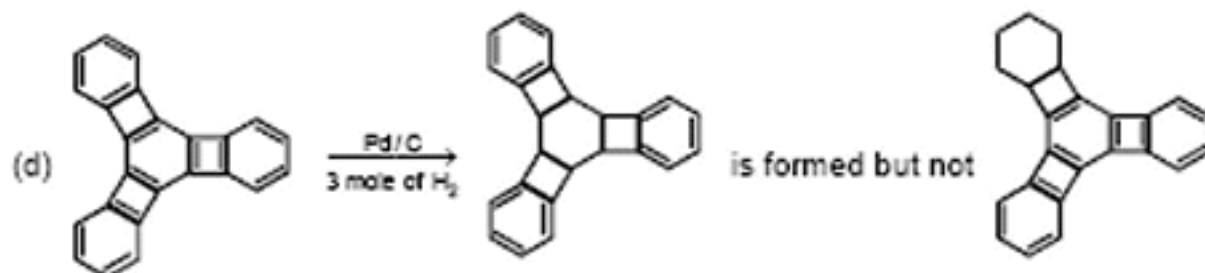
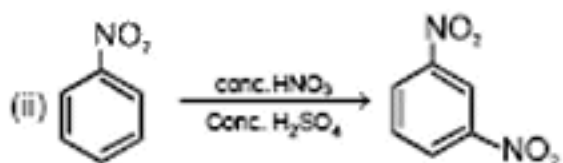
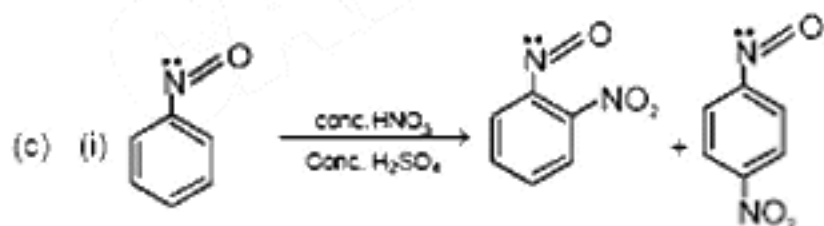
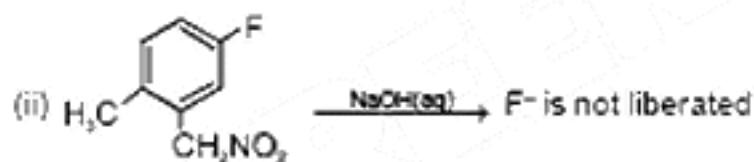
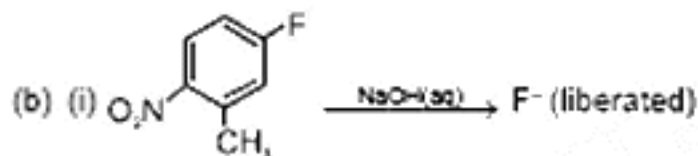
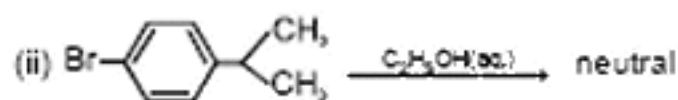
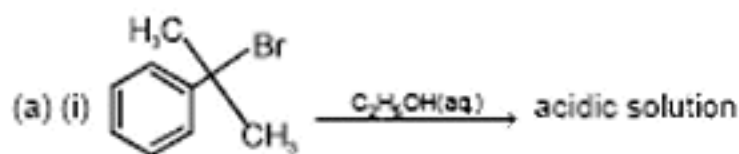
[4]



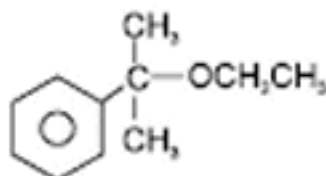
Reaction :



Q.15 Give reasons :



Sol. (a) (i) The products formed are



and HBr by nucleophilic substitution and because of presence of HBr, the solution is acidic.

(ii) There will be no reaction because Br group is directly attached to the Benzene ring (no possibility of  $S_N$  reaction)

(b) (i) will undergo nucleophilic substitution as  $\text{NO}_2$  group makes benzene ring electron deficient and

the product formed B

(ii)  $\xrightarrow{\text{NaOH(aq)}}$   $\text{F}^-$  is not liberated because the ring does not become electron deficient and will not

undergo  $\text{SN}^2$  reaction

(c) (i) Because of presence of lone pair of electrons, the ring gets attacked and gives ortho and para products.

(ii) Because of  $-I$  effect,  $\text{NO}_2$  is strongly deactivating group, hence m-director.

(d) Three- four membered

Anti aromatic rings becomes stable due to the reduction of central ring and only on antiaromatic ring can be stabilized on reduction of terminal ring.

Q.16 (B)  $\xrightarrow{\text{Zn}}$  (A)  
 (white fumes pungent smell) (M = transition colourless) (Purple colour)  
 Identify the metal M and  $\text{MCl}_4$   
 Explain the colour difference of  $\text{MCl}_4$  and (A).

[4]

Sol.  $\text{TiO}_2$   $\xleftarrow{\text{Moist air}}$   $\text{TiCl}_4$   $\xrightarrow{\text{Zn}}$   $(\text{Ti}(\text{H}_2\text{O})_6)^{3+}$   
 (B) (A)  
 (Purple colour)

d - d transition of single electron of Ti (III) will cause color change and Ti (IV) contains no d- electrons.

Q.17 (a)  $\mu_{\text{observed}} = \sum \mu_i x_i$

where  $\mu_i$  is the dipole moment of stable conformers and  $x_i$  is mole fraction of that conformer.

(i) Draw the Newman's projection for stable

conformers of  $\text{Z}-\text{CH}_2-\text{CH}_2-\text{Z}$ .

(ii) If  $\mu_{\text{observed}} = 1.0$  D and mole fraction of anti form = 0.82, find  $\mu_{\text{gauche}}$

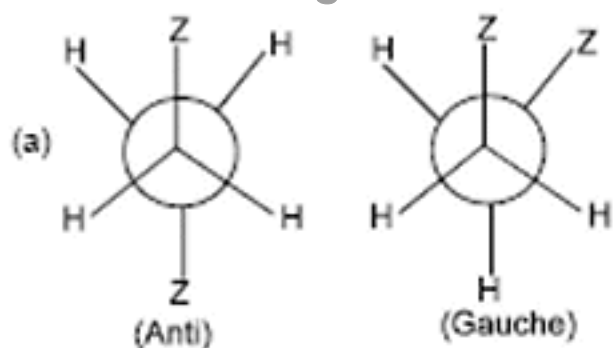
(b) Draw most stable meso conformer of

if (i)  $\text{Y} = \text{CH}_3$  about  $\text{C}_2 - \text{C}_3$  rotation and

(ii)  $\text{Y} = \text{OH}$  about  $\text{C}_1 - \text{C}_2$  rotation

[6]

Sol.



(ii)

$$X_{\text{anti}} = 0.82$$

$$X_{\text{gauche}} = 0.18$$

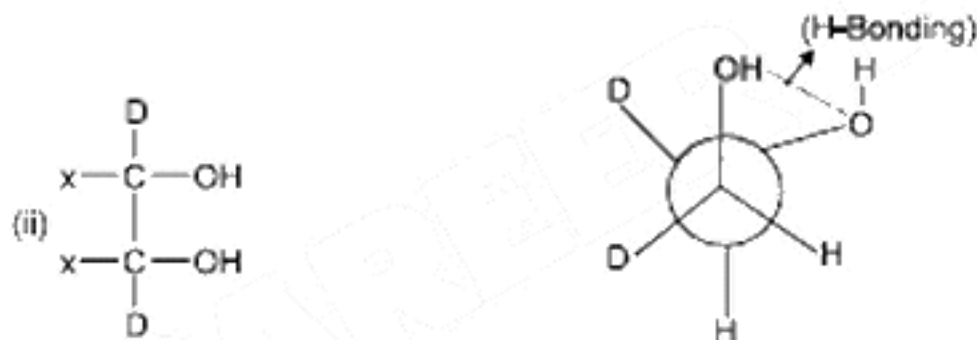
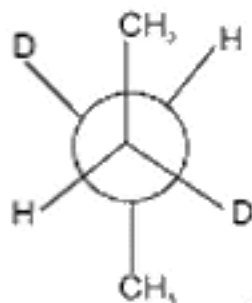
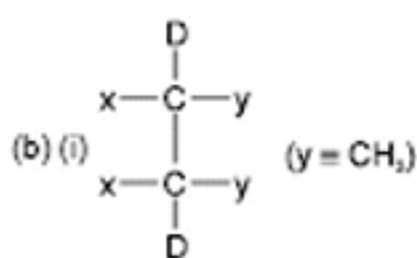
$$\mu_{\text{observed}} = \mu_{\text{anti}} \times 0.82 + \mu_{\text{gauche}} \times 0.18$$

$$\mu_{\text{anti}} = 0 \text{ (due to symmetry)}$$

$$\therefore 1 = \mu_{\text{gauche}} \times 0.18$$

$$\mu_{\text{gauche}} = 1/0.18$$

$$= 5.55 \text{ D}$$



Q.18 (a) (i) Represent the following reaction in the form of a cell



(ii) Calculate  $\Delta G^\circ$  of the above reaction from the following data :

$$\Delta G_f^\circ (\text{AgCl}) = -109 \text{ kJ/mol}$$

$$\Delta G_f^\circ (\text{Cl}^-) = -129 \text{ kJ/mol}$$

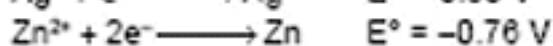
$$\Delta G_f^\circ (\text{Ag}^+) = 77 \text{ kJ/mol}$$

(iii) Calculate  $E^\circ$  of the cell.

(iv) Calculate  $\log_{10} K_{sp}$  for AgCl

(b)  $6.539 \times 10^{-2}$  g of metallic Zn (65.39 amu.) was added to 100 ml of saturated solution of AgCl. Calculate

$$\log_{10} \frac{[\text{Zn}^{2+}]}{[\text{Ag}^+]^2}, \text{ given}$$

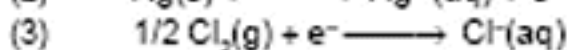
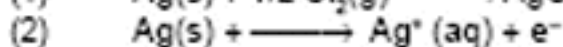
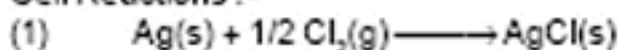


Also find how many moles of Ag will be formed.

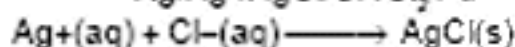
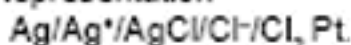


Sol.

Cell Reactions:-



(i) Cell Representation



(ii)  $\Delta G^\circ = \sum \Delta G^\circ(\text{P}) - \sum \Delta G^\circ(\text{R})$

$= (-109) - (-129 + 77) = -57 \text{ kJ}$

(iii)  $\Delta G^\circ = -nFE^\circ$  ( $n = 1, F = 96500$ )

$E^\circ = \frac{-57 \times 1000}{96500 \times 1} = 0.59 \text{ volts}$



$\Delta G^\circ = -2.303 RT \log K_{\text{eq}}$

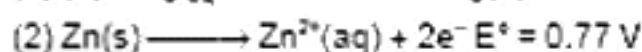
$-57 = -2.303 RT \log K_{\text{eq}}$

$\log K_{\text{eq}} = \frac{57000}{2.303 \times 8.314 \times 298} = 10$

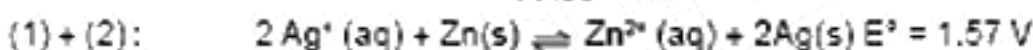
$K_{\text{eq}} = 10^{10} = \frac{1}{[\text{Ag}^+][\text{Cl}^-]}$

$K_{\text{sp}} = 10^{-10}$

$K_{\text{sp}} = s^2 = 10^{-10} \Rightarrow s = 10^{-5} \text{ mol/L}$



moles of Zn added =  $\frac{6.539 \times 10^{-2}}{65.39} = 10^{-3} \text{ moles}$

(from  $\Delta G^\circ = \Delta G_1^\circ + \Delta G_2^\circ$ ) $10^{-5} \text{ moles } 10^{-3} \text{ moles.}$  $n = 2$ at equilibrium  $E_{\text{cell}} = 0$ 

$E_{\text{cell}}^\circ = \frac{0.059}{n} \log \frac{[\text{Zn}^{2+}]}{[\text{Ag}^+]^2}$

$\log \frac{[\text{Zn}^{2+}]}{[\text{Ag}^+]^2} = \frac{1.57 \times 2}{0.0591} = 52.8.$