CBSE Delhi 2013

Chemistry (Theory)

Time: 3 Hrs **Max. Marks: 70**

General Instructions:

(a) *All questions are compulsory.*
(b) *Question numbers 1 to 8 are very short answer questions and carry 1 mark each.*
(c) *Question numbers 9 to 18 are short answer questions and carry 2 marks each.*
(d) *Question numbers 19 to 27 are also short answer questions and carry 3 marks each.*
(e) *Question numbers 28 to 30 are long answer questions and carry 5 marks each.*
(f) *Use Log Tables, if necessary. Use of calculators is not allowed.*

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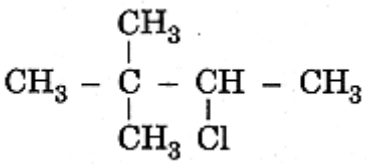
1. Of physisorption and chemisorption, which has a higher enthalpy of adsorption?
Solution:
Chemisorption has a higher enthalpy of adsorption.

2. Name the method used for refining of copper metal.
Solution:
The method used for refining of copper metal is electrolytic refining

3. Name two poisonous gases which can be prepared from chlorine gas.
Solution:
The two poisonous gases are tear gas and phosgene.

4. Write the IUPAC name of the following compound:



Solution:
The IUPAC name is 2-chloro-3,3-dimethylbutane.

5. Rearrange the following compounds in the increasing order of their boiling points:

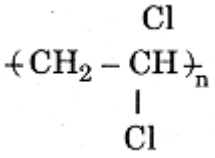
$$CH_3-CHO,\ CH_3-CH_2-OH,\ CH_3-CH_2-CH_3$$

Solution:
Increasing order of boiling points: CH_3–CH_2–CH_3, CH_3–CHO, CH_3–CH_2–OH.

6. Write the structure of *N*-methylethanamine.
Solution:
Structure of *N*-methylethanamine is H_3C–NH–CH_2–CH_3.

7. What are the products of hydrolysis of sucrose?
Solution:
Products of hydrolysis of sucrose are α-D(+) glucose and β-D(−) fructose.

8. Is the following compound a homopolymere or a copolymer?



Solution:

It is a homopolymer.

9. Account for the following:
(i) Schottky defects lower the density of related solids.
(ii) Conductivity of silicon increases on doping it with phosphorus.
Solution:
(i) In Schottky defect, equal number of cations and anions disappear from the lattice, resulting in vacancies, and thus lower the density of related solids.
(ii) When phosphorus is doped in Si, an extra electron enters the lattice because P is a Group 15 element and Si is a Group14 element. The conductivity is increased by the movement of this free mobile electron resulting in an *n*-type semiconductor.

10. Aluminium crystallizes in an fcc structure. Atomic radius of the metal is 125 pm. What is the length of the side of the unit cell of the metal?
Solution:
We know that for fcc, $Z = 4$ and $r = 125$ pm. The edge length, a, is found out as follows:

$$r = \frac{a}{2\sqrt{2}} \Rightarrow a = 2\sqrt{2}r$$

Substituting values, we get $a = 2 \times 1.14142 \times 125 = 354\,\text{pm}$

11. The standard electrode potential (E^{o}) for Daniell cell is + 1.1 V. Calculate the ΔG^{o} for the reaction

$$\text{Zn(s)} + \text{Cu}^{2+}\text{(aq)} \rightarrow \text{Zn}^{2+}\text{(aq)} + \text{Cu(s)}$$

(where 1 F = 96500 C mol^{-1}).
Solution:
For the reaction $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$, we have $E^{o}_{\text{cell}} = 1.1\text{V}$ and $n = 2$. Therefore, ΔG^{o} is

$$\Delta G^{o} = -nFE^{o}_{\text{cell}} = -2 \times 96500 \times 1.1 = -212300\,\text{J mol}^{-1} = -212.3\,\text{kJ mol}^{-1}$$

12. (a) For a reaction A + B → P, the rate law is given by

$$r = k[\text{A}]^{1/2}[\text{B}]^{2}$$

What is the order of this reaction?
(b) A first order reaction is found to have a rate constant $k = 5.5 \times 10^{-14}$ s^{-1}. Find the half-life of the reaction.
Solution:
(a) For the reaction A + B → P, $r = k[\text{A}]^{1/2}[\text{B}]^{2}$

$$\text{Order of this reaction} = \frac{1}{2} + 2 = \frac{5}{2} = 2.5$$

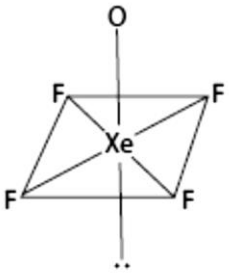
(b) Given that $k = 5.5 \times 10^{-14}$ s^{-1}. Therefore, half-life can be calculated as

$$t_{1/2} = \frac{0.693}{5.5 \times 10^{-14}} = 0.126 \times 10^{14}\ \text{s}$$

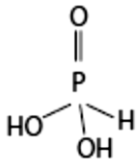
13.
(a) Name the method used for removing gangue from sulphide ores.
(b) How is wrought iron different from steel?
Solution:
(a) Method used for removing gangue from sulphide ores is froth floatation.
(b) (i) Wrought iron has a very low carbon content (0.2–0.5%), whereas steel has a high carbon content (0.15–1.5%).
(ii) Wrought iron is used for making magnets and dynamos for electric motors, in the manufacture of nails, bolts, chains, etc. Steel and various alloy steels like stainless steel, nickel steel are used for making utensils, automobile parts, drilling machines, etc.

14. Draw the structures of the following molecules: (a) $XeOF_4$ and (b) H_3PO_3.
Solution:
The structures are as follows:

(a) $XeOF_4$ (b) H_3PO_3



Square pyramidal
(Octahedral with one position unoccupied)
Xenon oxyfluoride
$XeOF_4$



15. How are interhalogen compounds formed? What general compositions can be assigned to them?
Solution:
Interhalogen compounds are formed by direct combination of halogens under specific conditions. For example,

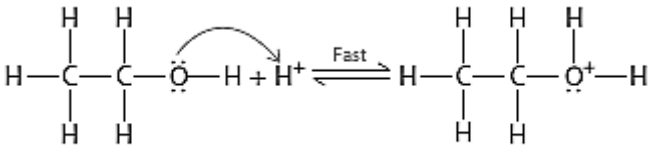
$$\underset{\text{(Equal volumes)}}{Cl_2 + F_2} \xrightarrow{437\ K} 2ClF$$

General composition assigned to interhalogen compounds are XX', XX'_3, XX'_5, XX'_7 where X is the halogen of larger size and X will be of smaller size.

16. Explain the mechanism of the following reaction:

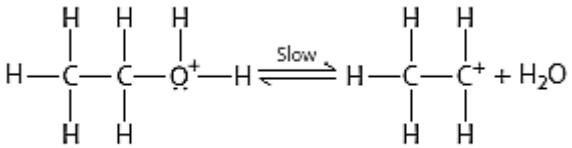
$$CH_3 - CH_2 - OH \xrightarrow[443\ K]{H^+} CH_2 = CH_2 + H_2O$$

Solution:
For the reaction, the mechanism is as follows:
Step 1: Formation of protonated alcohol



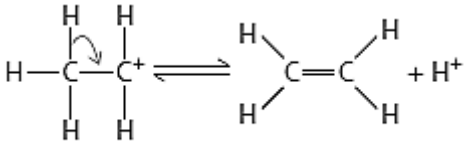
Ethanol Protonated alcohol

Step 2: Formation of carbocation



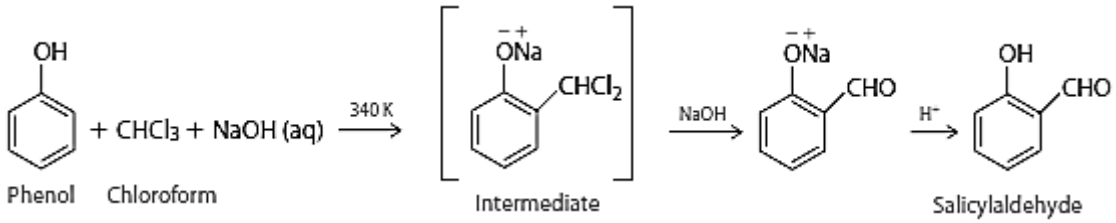
Carbocation

Step 3: Formation of ethene by elimination of a proton



Ethene

17. Write the equations involved in the following reactions:
(a) Reimer–Tiemann reaction (b) Williamson's ether synthesis
Solution:
(a) Reimer-Tiemann reaction



(b) Williamson's ether sythesis

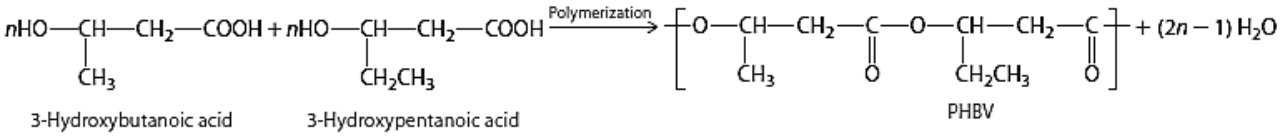
$$\underset{\text{Ethyl bromide}}{C_2H_5Br} + \underset{\substack{\text{Sodium}\\\text{Ethoxide}}}{C_2H_5ONa} \rightarrow \underset{\text{Diethyl Ether}}{C_2H_5 - O - C_2H_5} + NaBr$$

18. Define thermoplastic and thermosetting polymers. Give one example of each.

Solution:
Thermoplastic polymers are polymers in which the intermolecular forces lie in between that of elastomer and fiber. They can be moulded again and again.
Thermosetting polymers are polymers in which the intermolecular forces are the strongest. Once set, they cannot be remoulded again because of the presence of few cross-links. For example, bakelite and melamine.

OR

What is a biodegradable polymer? Give an example of a biodegradable aliphatic polyester?
Solution:
Polymers which are degraded by micro-organisms within a suitable period so that they do not cause any serious effect to the environment are called biodegradable polymers. PHBV(poly-β-hydroxybutyrate-co-β-hydroxy-valerate) is a biodegradable aliphatic polyester:



19. The rate of a reaction becomes four times when the temperature changes from 293 K to 313 K. Calculate the energy of activation (E_a) of the reaction assuming that it does not change with temperature. [Given that R = 8.314 J K^{-1} mol^{-1}, log 4 = 0.6021]
Solution:

Given that $k_2 = 4\,k_1$, T_1 = 293 K, T_2 = 313 K, E_a = ?. Using the formula $\log\frac{k_2}{k_1} = \frac{E_a}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$, we get

$$\log\frac{4k_1}{k_1} = \frac{E_a}{2.303\times 19.14}\left(\frac{1}{293} - \frac{1}{313}\right)$$

$$\log 4 = \frac{E_a}{19.14}\left(\frac{1}{293} - \frac{1}{313}\right) \Rightarrow 0.6020 = \frac{E_a}{19.14}\left(\frac{313-293}{293\times 313}\right)$$

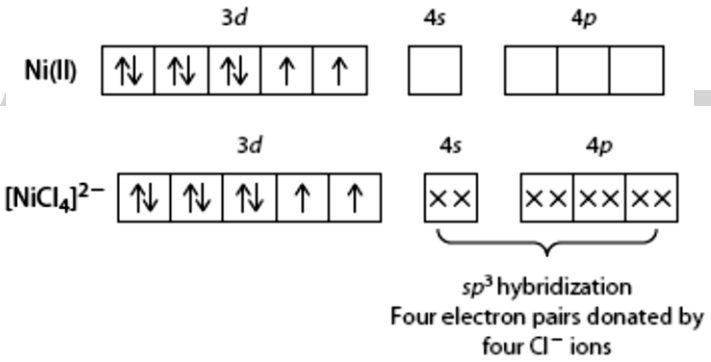
or $$E_a = 52834.8\ \text{J mol}^{-1} = 52.83\ \text{kJ mol}^{-1}$$

20. What are the characteristics of the following colloids? Give one example of each.
(a) Multimolecular colloids (b) Lyophobic sols (c) Emulsions
Solution:
The characteristics of colloids are as follows:
(a) Multimolecular colloids: In multimolecular colloids, the colloidal particles are an aggregate of atoms or small molecules with a diameter of less than 1 nm. The molecules in the aggregate are held together by van der Waals forces of attraction. Examples of such colloids include gold sol and sulphur sol.
(b) Lyophobic sols: The colloidal solutions in which the particles of dispersed phase have no affinity for dispersion medium are called lyophobic colloids. For example, colloidal solutions of Ag and Au, hydroxides such as $Al(OH)_3$ and $Fe(OH)_3$.

(c) Emulsions: The colloidal solutions in which both dispersed phase and dispersion medium are liquids. They are stabilized by the presence of certain substances called emulsifiers or emulsifying agents. For example, milk, butter, etc.

21. Give reasons for the following:
(a) $R_3P{=}O$ exists but $R_3N{=}O$ does not, where R is an alkyl group.
(b) $PbCl_4$ is more covalent than $PbCl_2$.
(c) At room temperature, N_2 is much less reactive.
Solution:
(a) $R_3P{=}O$ exists but $R_3N{=}O$ does not because N does not have *d*-orbital and cannot form $d\pi$–$p\pi$ bonds, which phosphorus is able to form.
(b) Due to inert pair effect; ns^2 electron of Pb cannot be easily released for bond formation, and it is difficult to form (E^{4+}) ion than E^{2+} ion. Under these circumstances, if all the four valence electrons are to be involved in the bond formation, the compounds which show +4 oxidation state must be of covalent nature.
(c) N_2 exists as N≡N; hence, its bond dissociation energy is very high and thus it is least reactive.

22. For the complex $[NiCl_4]^{2-}$, write
(a) the IUPAC name (b) the hybridization type. (c) the shape of the complex.
(Atomic no. of Ni = 28.)
Solution:
For $[NiCl_4]^{2-}$,
(a) IUPAC name is tetrachloronickelate(II) ion
(b) Hybridization is sp^3.
Ni (ground state configuration) $[Ar]^{18}\ 4s^2\ 3d^8$
Ni^{2+} (excited state configuration) $[Ar]^{18}\ 3d^8$



In case of $[NiCl_4]^{2-}$, Cl^- ion is a weak field ligand. Therefore, it does not lead to the pairing of unpaired 3*d* electrons and Ni^{2+} undergoes sp^3 hybridization.
(c) It forms a complex with tetrahedral geometry.

OR

What is meant by crystal field splitting energy? On the basis of crystal field theory, write the electronic configuration of d^4 in terms of t_{2g} and e_g in an octahedral field when (a) $\Delta_o > P$ and (b) $\Delta_o < P$.
Solution:
The degenerate *d*-orbitals (in a spherical field environment) split into two levels, that is, e_g and t_{2g} in the presence of ligands. The splitting of the degenerate levels due to the presence of ligands is called the crystal-field splitting while the energy difference between the two levels (e_g and t_{2g}) is called the crystal-field splitting energy. It is denoted by Δ_o. After the orbitals have split, the filling of the electrons takes place.

For d^4 configuration, after 1 electron (each) has been filled in the three t_{2g} orbitals, the filling of the fourth electron takes place in two ways. It can enter the e_g orbital (giving rise to $t_{2g}^3\ e_g^1$ like electronic configuration) or the pairing of the electrons can take place in the t_{2g} orbitals (giving rise to $t_{2g}^4\ e_g^0$ like electronic configuration).
(a) If the Δ_o value of a ligand is less than the pairing energy (*P*), then the electrons enter the e_g orbital.
(b) If the Δ_o value of a ligand is more than the pairing energy (*P*), then the electrons enter the t_{2g} orbital.

23. Give reasons for the following:
(a) Ethyl iodide undergoes S_N2 reaction faster than ethyl bromide.
(b) (±)2-Butanol is optically inactive.

(c) C–X bond length in halobenzene is smaller than C–X bond length in CH_3–X.

Solution:

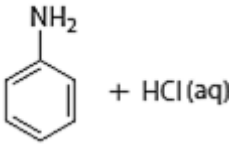
(a) This is because I^- is a strong Nu^- than Br^- as the order of nucleophilicity of halides is $I^- > Br^- > Cl^-$ because of their sizes.

(b) (±)2-Butanol is optically inactive as it is a racemic mixture and contains both enantiomers in equal amounts due to which their optical rotations are cancelled out, and so it becomes optically inactive.

(c) This is because in halobenzene, hybridization of C bearing X will be sp^2 and in haloalkane it will be sp^3. In sp^2 hybridization %*s* character is more, so C will be more electronegative which causes shortening of C–X bond length in halobenzene.

24. Complete the following reactions:

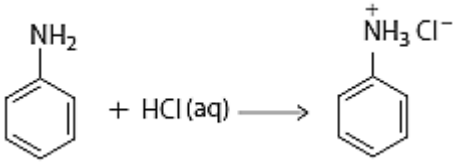
(a) $CH_3CH_2NH_2 + CHCl_3 + \text{alc. KOH} \rightarrow$ (b) $C_6H_5N_2^+Cl^- \xrightarrow[\text{(room temp.)}]{H_2O}$

(c) 

Solution:

(a) $CH_3CH_2NH_2 + CHCl_3 + 3KOH(alc) \rightarrow CH_3CH_2N \overset{\rightarrow}{=} C + 3KCl + 3H_2O$

(b) $C_6H_5N_2^+Cl^- \xrightarrow[\text{(room temp.)}]{H_2O} C_6H_5OH$ This reaction takes place slowly at room temperature, and takes place readily at elevated temperatures.

(c) 

25.

(a) What class of drug is Ranitidine ?

(b) If water contains dissolved Ca^{2+} ions, out of soaps and synthetic detergents, which will you use for cleaning clothes?

(iii) Which of the following is an antiseptic: 0.2% phenol, 1% phenol?

Solution:

(a) Ranitidine is antihistamine (antacid).

(b) Synthetic detergents.

(c) 0.2% phenol is antiseptic, while 1% is a disinfectant.

26. Calculate the emf of the following cell at 25°C:

$$Ag(s)\,|\,Ag^+(10^{-3}M)\,||\,Cu^{2+}(10^{-1}M)\,|\,Cu(s)$$

Given $E^o_{cell} = +0.46\,V$ and $\log 10^n = n$.

Solution:

$Ag\,|\,Ag^+(10^{-3}M)\,||\,Cu^{2+}(10^{-1}M)\,|\,Cu$; $E^\circ_{cell} = 0.46$ V $\quad E_{cell} = ?$

Anode half-reaction: $Ag \rightarrow Ag^+ + e^-]\times 2$

Cathode half-reaction: $Cu^{2+} + 2e^- \rightarrow Cu$

Net equation: $2Ag + Cu^{2+} \rightarrow 2Ag^+ + Cu$

Applying Nernst equation, we get

$$E_{cell} = E^\circ_{cell} - \frac{2.303RT}{nF}\log Q$$

where $$\log Q = \log\frac{[\text{Products}]}{[\text{Reactants}]} = \log\frac{[Ag]^2}{[Cu^{2+}]} = \log\frac{(10^{-3})^2}{10^{-1}} = \log 10^{-5}$$

or $Q = -5$. Therefore, emf of the cell is

$$E_{cell} = 0.46 - \frac{0.0591}{2} \times (-5) = 0.46 - 0.0295(-5) = 0.46 + 0.1475 = 0.6075 \text{ V}$$

27. Shanti, a domestic helper of Mrs. Anuradha, fainted while mopping the floor. Mrs. Anuradha immediately took her to the nearby hospital where she was diagnosed to be severely "anaemic". The doctor prescribed an iron rich diet and multivitamins supplement to her. Mrs. Anuradha supported her financially to get the medicines. After a month, Shanti was diagnosed to be normal.
After reading the above passage, answer the following questions:
(a) What values are displayed by Mrs. Anuradha?
(b) Name the vitamin whose deficiency causes "pernicious anaemia".
(c) Give an example of a water soluble vitamin.
Solution:
(a) Values displayed by Mrs. Anuradha
(i) She is kind-hearted
(ii) She has respect for mankind
(iii) She gave timely medical aid
(b) Vitamin B_{12} deficiency causes pernicious anaemia.
(c) Example of water soluble vitamin is Vitamin C.

28.
(a) State the Raoult's law for a solution containing volatile components. How does Raoult's law become a special case of Henry's law?
(b) 1.00 g of a non-electrolyte solute dissolved in 50 g of benzene lowered the freezing point of benzene by 0.40 K. Find the molar mass of solute. (K_f for benzene = 5.12 K kg mol^{-1})
Solution:
(a) Raoult's law states that the partial vapor pressure of a volatile component present in a solution is directly proportional to the mole fraction of that component at a given temperature.
For example, for a volatile component A present in a solution,

$$p_A \propto x_A \Rightarrow p_A = p_A^o \times x_A$$

Raoult's law is a special case of Henry's law. This can be explained as follows:
According to Raoult's law, $p_A = p_A^o \times x_A$
According to Henry's law, $p_A = K_H \times x_A$
If we compare the two expressions, we find that in both the cases, partial vapor of the volatile component or gas is directly proportional to its mole fraction in the solution. However, proportionality constants, p_A^o and K_H are different. Thus, Raoult's law may be regarded as a special case of Henry's law in which K_H becomes equal to p_A^o.

(b) Given that mass of solute (w_B) = 1 g, mass of solvent (w_A) = 50 g, ΔT_f = 0.4 K, K_f for benzene = 5.12 K kg mol^{-1}. We need to find the molar mass of benzene (M_B). Substituting the given values in the expression for ΔT_f, we get

$$\Delta T_f = K_f \times \frac{w_B}{M_B} \times \frac{1000}{w_A}$$

or
$$0.4 = 5.12 \times \frac{1}{M_B} \times \frac{1000}{50} \Rightarrow M_B = \frac{5120}{20} = 256 \text{ g mol}^{-1}$$

OR

(a) Define the following terms: (i) ideal solution, (ii) azeotrope, (iii) osmotic pressure.
(b) A solution of glucose ($C_6H_{12}O_6$) in water is labelled as 10% by weight. What would be the molality of the solution? (Molar mass of glucose = 180 g mol^{-1}.)
Solution:
(a) (i) Ideal solution is the solution which obey Raoult's law at all concentrations and temperatures. If A and B are the two components of solution then according to Raoult's law, we have

$$p_A = p_A^o x_A \qquad p_B = p_B^o x_B \qquad p_T = p_A + p_B$$

In an ideal solution, the magnitude of A–B interactions is the same as that of A–B and B–B interactions.
(ii) Azeotrope is a constant boiling mixture, that is a liquid mixture which boils at the same temperature without undergoing any change in composition.

(iii) Osmotic pressure is the external pressure that has to be applied on the solution to prevent the inflow of solvent into it through a semipermeable membrane.
(b) Given that mass of solute (w_B) = 10 g, mass of solvent (w_A) = 90 g, molar mass of solute (M_B) = 180 g, then molality is

$$m = \frac{w_B}{M_B} \times \frac{1000}{w_A} = \frac{10}{180} \times \frac{1000}{90} = \frac{10000}{16200} = 0.617 \text{ molal}$$

29.
(a) Give reasons for the following:
(i) Mn^{3+} is a good oxidizing agent.
(ii) $E^{o}_{M^{2+}/M}$ values are not regular for first row transition metals (3*d* series).
(iii) Although F is more electronegative than O, the highest Mn fluoride is MnF_4; whereas the highest oxide is Mn_2O_7.
(b) Complete the following equations:
(i) $2CrO_4^{2-} + 2H^+ \rightarrow$
(ii) $KMnO_4 \xrightarrow{\text{Heat}}$
Solution:
(a) (i) Mn^{3+} is a good oxidizing agent as it has tendency to undergo reduction and get converted into Mn^{2+}, which is more stable due to its half-filled configuration $[Ar]^{18}\,3d^5$.
(ii) $E^{o}_{M^{2+}/M}$ values are not regular for first row transition metals because of the following exceptions:
$E^{o}_{Mn^{2+}/Mn}$ and $E^{o}_{Zn^{2+}/Zn}$ are more negative due to their more stable half-filled (d^5) and fully filled (d^{10}) orbitals, respectively. $E^{o}_{Ni^{2+}/Ni}$ is more negative because of highly negative hydration energy in Ni. $E^{o}_{Cu^{2+}/Cu}$ is positive because the sum of its ionization energies is not balanced by its hydration energy.
(iii) This is because oxygen has tendency to form multiple bonds.

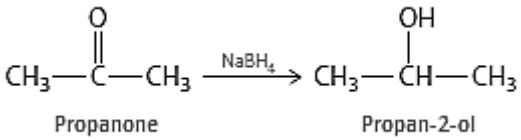
(d) Complete the equations:
(i) $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$
(ii) $2KMnO_4 \xrightarrow{\text{Heat}} K_2MnO_4 + MnO_2 + O_2$

OR

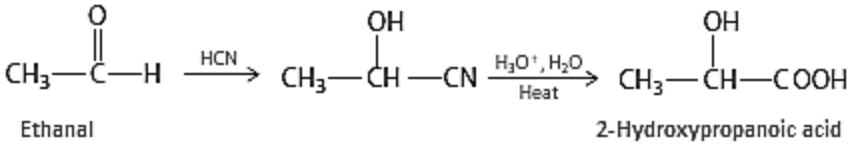
(a) Why do transition elements show variable oxidation states?
(i) Name the element showing maximum number of oxidation states among the first series of transition metals from Sc (Z = 21) to Zn (Z = 30).
(ii) Name the element which shows only +3 oxidation state.
(b) What is lanthanoid contraction? Name an important alloy which contains some of the lanthanoid metals.
Solution:
(a) Transition elements show variable oxidation states because of the participation of both *ns* and $(n-1)d$ orbitals, owing to the small energy difference between them.
(i) (manganese (Mn) shows the maximum number of oxidation states among first series of transition metals.
(ii) Scandium (Sc) shows only +3 oxidation state.
(b) Lanthanoid contraction is the decrease in the ionic (as well as atomic radii) of the elements of lanthanoid series on moving from left to right. It caused by poor shielding of 4*f* electrons.
An important alloy which contains 95 % lanthanoid metal and 5% Fe along with traces of S, C, Ca and Al is mischmetal.

30. (a) How will you convert the following:
(i) Propanone to Propan-2-ol (ii) Ethanal to 2-hydroxypropanoic acid (iii) Toluene to benzoic acid

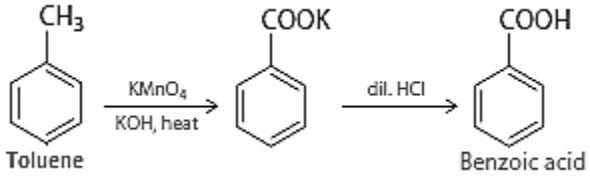
(b) Give simple chemical test to distinguish between:
(i) Pentan-2-one and Pentan-3-one (ii) Ethanal and Propanal
Solution:
(a) The conversions are as follows:
(i) Propanone to Propan-2-ol



(ii) Ethanal to 2-hydroxy propanoic acid

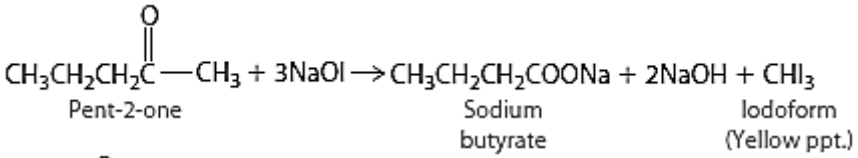


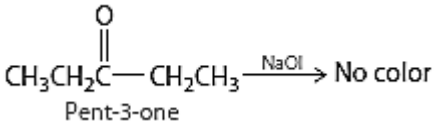
(iii) Toluene to benzoic acid



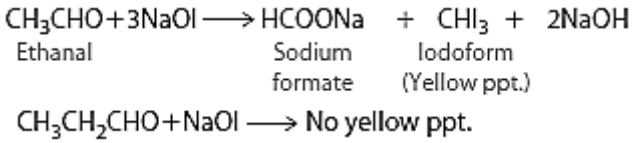
(b) Test to distinguish

(i) Pentan-2-one and Pentan-3-one: Pentan-2-one will give the iodoform test, whereas pentan-3-one will not.



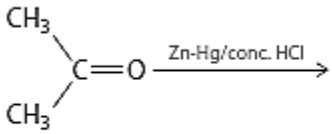


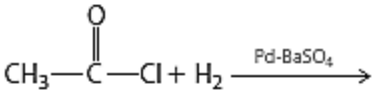
(ii) Ethanal and Propanal: Ethanal will give iodoform test, whereas propanal will not.

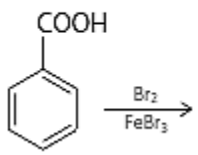


OR

(a) Write the products of the following reactions:

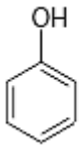
(i) 

(ii) 

(iii) 

(b) Which acid of each pair shown here would you expect to be stronger?

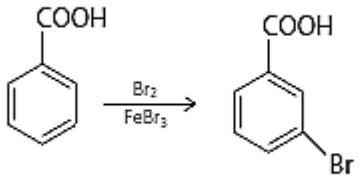
(i) F–CH_2–COOH or Cl–CH_2–COOH

(ii)  or CH_3COOH

Solution:
(a) Write the products.

(i) $(CH_3)_2C{=}O \xrightarrow{Zn\text{-}Hg/conc.\ HCl} (CH_3)_2CH_2 + H_2O$
Propene

(ii) $CH_3{-}C(=O){-}Cl + H_2 \xrightarrow{Pd\text{-}BaSO_4} CH_3CHO + HCl$
Ethanal

(iii) 

m-Bromobenzoic acid

(b) (i) F-CH_2COOH. The electron-withdrawing inductive effect (–I effect) decreases for halogens in the order F > Cl > Br > I. Therefore, the acidic strength of α-haloacids also decreases in the same order.
(ii) CH_3COOH is more acidic than phenol. The carboxylate ion is much more resonance stabilized than phenoxide ion. Thus, the release of a proton from carboxylic acid is much easier than from phenols. Hence, carboxylic acids are stronger acids than phenols.