525/2

S6 CHEMISTRY

Exam 14

PAPER 2

DURATION: 2 HOUR

INSTRUCTIONS TO THE CANDITATES

Attempt any four numbers

1. (a) Describe the extraction of aluminium from a named ore. (10mmarks)

Steps in extraction of Aluminium from bauxite ($Al_2O_{3.x}H_2O$)

(i) The ore is heated
- to remove water and,
- To convert iron salts to iron III oxide

(ii) Removal of Iron impurities
The powdered ore is heated with concentrated sodium hydroxide to dissolve aluminium oxide and silica such that the insoluble iron oxide is filtered off.
Aluminium oxide form aluminate

$Al_2O_3\,(s) + 2NaOH\,(aq) + 7H_2O\,(l) \rightarrow 2Na[Al(OH)_4(H_2O)_2]\,(aq)$

Or the ionic form

$Al_2O_3\,(s) + OH^-(aq) \rightarrow 2AlO_2^-(aq) + H_2O(l)$

Silica also dissolves forming sodium silicate.

$SiO_2\,(s) + 2NaOH\,(aq) \rightarrow Na_2SiO_3(aq) + H_2O\,(l)$

(iii) Separation of aluminium hydroxide from silicon impurities
To the filtrate a little aluminium hydroxide is added to precipitate Aluminium hydroxide,(seeding).
$NaAlO_2(aq) + 2H_2O(l) \rightarrow NaOH(aq) + Al(OH)_3(s)$

Alternatively carbon dioxide bubbled through the filtrate to precipitate aluminium hydroxide as follows

$2NaAl(OH)_4(aq) + CO_2(g) \rightarrow 2Al(OH)_3(s) + Na_2CO_3(aq) + H_2O(l)$

(iv) Recovering pure aluminium oxide
The precipitated aluminium hydroxide is filtered off, washed and ignited to give pure aluminium oxide (alumina).
$2Al(OH)_3(s) \rightarrow Al_2O_3(s) + 3H_2O\ (g)$

(v) Extraction of aluminium from aluminium oxide by electrolysis
Aluminum is obtained from aluminium oxide by electrolysis.
Cryolite, Na_3AlF_6, is added to aluminum oxide

- lower the melting point of alumina from2050^0C to 900^0C
- and improve conductivity of aluminium oxide

At the cathode (carbon) aluminium is liberated

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

At the anode (carbon) oxygen is liberated

$2O^{2-} - 4e \rightarrow O_2\ (g)$

The anode is eaten up by oxygen

$C + O_2\ (g) \rightarrow CO_2\ (g)$

(b) Write equations to show the reaction between

(i) aluminum and sodium hydroxide (2marks)

$2Al(s) + 2^-OH(aq) + 6H_2O(l) \rightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

(ii) aluminium oxide and sodium hydroxide (2marks)

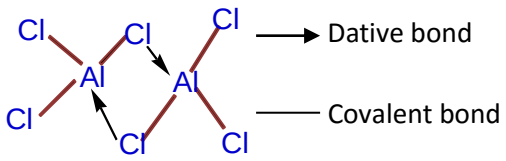
$Al_2O_3\ (s) + OH^-(aq) \rightarrow 2AlO_2^-(aq) + H_2O(l)$

(b) Aluminium reacts with chloride to form a compound of molecular mass; 267.

(i) Write equation between aluminium and chlorine (1mark)

$2Al(s) + 3Cl_2(g) \rightarrow Al_2Cl_6(s)$

(ii) Draw the structure of the product in (b)(i) indicating the types of bonds in it. (2marks)



(c) State and explain what is observed when a few drops of aluminum chloride solution are added to sodium carbonate solution. (3marks)

Al^{3+} hydrolyze in solution to produce acidic solution that reacts with carbonate ions to liberate carbon dioxide

$Al^{3+}(aq) + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3H^+(aq)$

Then

$2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$

Or

$2Al^{3+}(aq) + 3H_2O(l) + 3CO_3^{2-}(aq) \rightarrow 2Al(OH)_3(s) + 3CO_2(g)$

2. (a) Chromium and iron are transition elements.

State three properties of transition elements (1½ mark)

- Forms colored compounds; for instance Cr^{3+} is green
- Has variable oxidation states; +2, +3, +4, +5, +6.
- Forms complexes, e.g. $Cr(NH_3)_6^{3+}$.
- has catalytic properties: for instance
- Cr_2O_3 + ZnO catalyzes formation of methanol from CO and hydrogen.

$CO(g) + 2H_2(g) \rightarrow CH_3OH$

(b) The atomic numbers of chromium and iron are 24 and 26 respectively

(i) Write the electron configuration of chromium and iron atoms (2mark)

$[Ar]4s^1 3d^5$

(ii) State why iron (III) compounds are more stable than iron (II) compounds (1marks)

Oxidation state Fe^{3+} ($[Ar]3d^5$) is more stable than F^{2+} ($[Ar]4s^1 3d^5$) because Fe^{3+} has stable half full electron configuration.

(c) Using equations to illustrate your answer, describe how chromium reacts with:

(i) water (2½ mark)

Chromium does not react with cold water but at red heat with steam is to form chromium III oxide

$2Cr(s) + 3H_2O(g) \rightarrow Cr_2O_3(s) + 2H_2(g)$

(ii) dilute hydrochloric acid (2marks)

In the absence of air, dil. HCl chromium II chloride

$Cr(s) + 2HCl(aq) \rightarrow CrCl_2(s) + H_2(g)$

(d) State what would be observed and write equations for the reactions that would take place when sodium hydroxide solution is added drop wise until in excess to aqueous solution of

(i) chromium (III) sulphate (4marks)

Cr^{3+} forms a green precipitate soluble in excess

$Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$

$Cr(OH)_3(s) + OH^-(aq) \rightarrow Cr(OH)_4^-(aq)$

(ii) iron (II) sulphate (4marks)

Fe^{2+} forms a green ppt. insoluble in excess but rapidly turns brown on standing or oxidation to brown iron III hydroxide by air

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

$4Fe(OH)_2 + 2H_2O(l) + O_2(g) \rightarrow 3Fe(OH)_3$

(e) Write equation to show how iron (II) chloride can be converted to iron (III) chloride. (1mark)

$2FeCl_2\ (aq) + Cl_2(g) \rightarrow 2FeCl_3(aq)$

(f) A solution of sodium hydrogen carbonate was added to aqueous iron (III) chloride. Write equation for the reaction that took place. (2marks)

$2Fe^{3+(}aq) + 3H_2O(l) + 3CO_3^{2-}(aq) \rightarrow 2Fe(OH)_3(s) + 3CO_2(g)$

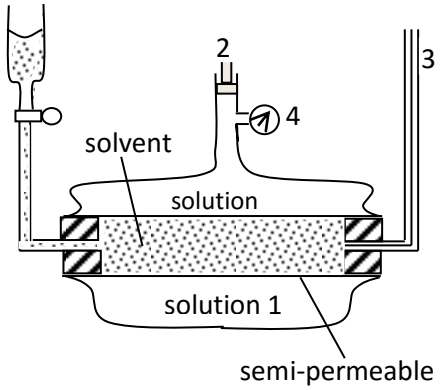
3. (a) Define the term *osmotic pressure* (2 marks)

The osmotic pressure of the solution is the minimum pressure which must be applied to the solution to balance the tendency of the solvent to flow from the solvent to the solution side of the semi-permeable membrane.

(b) (i) Describe an experiment to determine the molecular mass of a substance using osmotic method (5marks)

Method of determination of Relative formula mass of a substance by osmotic pressure method

Working Diagram



1. cylindrical tube between the solvent and solution is porous/semi-permeable
2. Pressure is applied to the solution and adjusted until there no flow of solvent into solution.
3. Capillary tube indicates movement of solvent into the solution.
4. Osmotic pressure, P (Pascal) obtained from the pressure gauge and temperature T^0C of the solution is determined

Results

Suppose the concentration of the solution is m gdm^{-3}

From PV = nRT = $\frac{m}{Mr}RT$ where V is the volume in m^3, R = constant = 8.31, Mr= required molecular mass, T is Kelvin temperature

Mr = $\frac{mRT}{P(10^{-3})} = \frac{1000mRT}{P}$

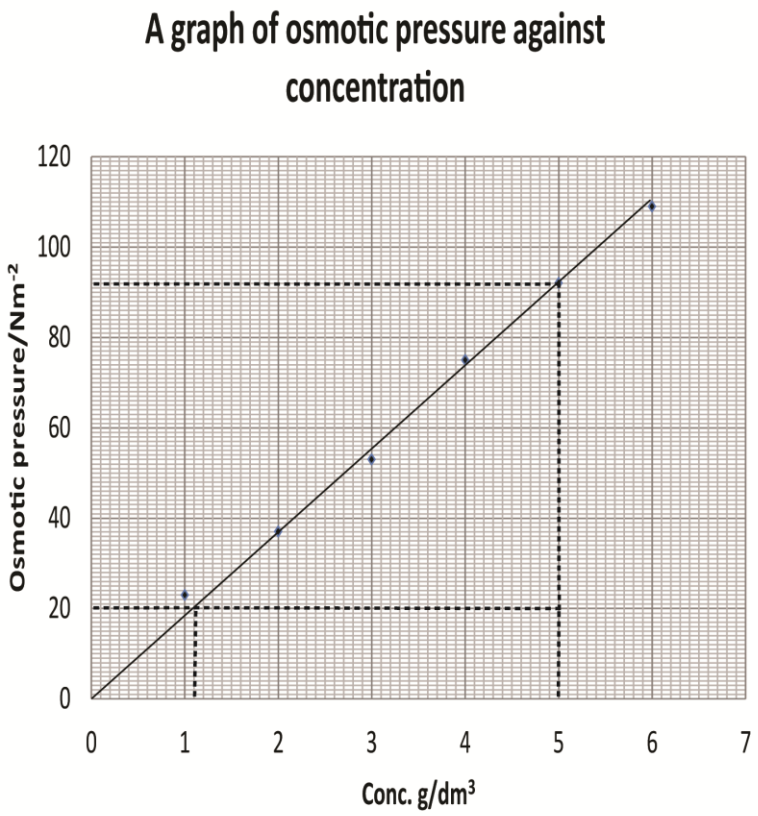
(ii) State any two assumption in (b)(i) (2marks)

- the solution must be dilute
- the solute should not dissociate or associate in solution
- the solute should not react with the solvent
- the temperature should not be very high of very low.

(c) The osmotic pressure of various concentration of a solute in methylbenzene at 20^0C are given in the table below

Conc. g/dm^3	1.0	2.0	3.0	4.0	5.0	6.0
Osmotic pressure/Nm^{-2}	23	37	53	75	92	109

(i) Plot a graph of osmotic pressure against concentration (5marks)



(ii) Use the graph you have drawn to determine the molecular mass X (R =8.314JK^{-1}mol^{-1}) (4 marks)

Slope = $\frac{92-20}{5-1.1} = \frac{72}{3.9}$= 18.462 Nm^{-2}dm^{3}g^{-1}

PV = $\frac{m}{Mr}RT$

PV= $\frac{m}{V}\frac{1000RT}{Mr}$

⇨ $\frac{1000RT}{Mr} = 18.462$

$Mr = \frac{1000\ x8.314\ x\ (273+20)}{18.462} = 131{,}947$g

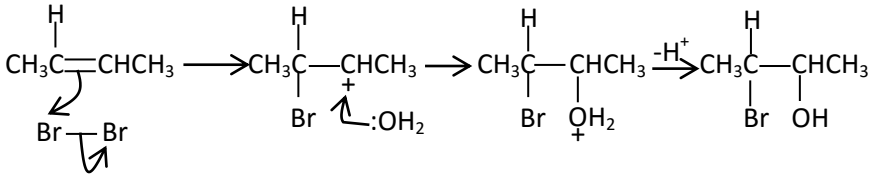
(d) Explain why the freezing point depression method is not suitable for determining the molecular mass of a polymer (2mks)

Dilute solutions of polymers give negligible freezing point depression

4. Complete the following equations and in each case outline the mechanism for the reaction

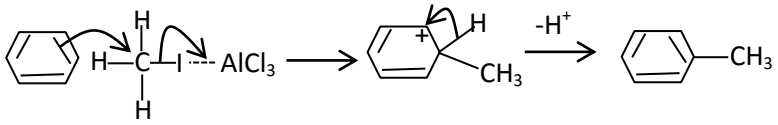
a) $CH_3CH=CHCH_3 \xrightarrow{Br_2/H_2O} CH_3CH(OH)-CHCH_3(Br)$ (4marks)

Mechanism

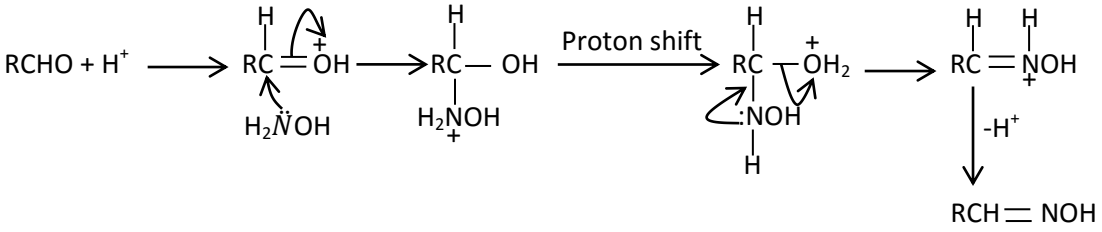


b) $C_6H_6 + CH_3I \xrightarrow{AlCl_3} C_6H_5CH_3$ (4marks)

Mechanism

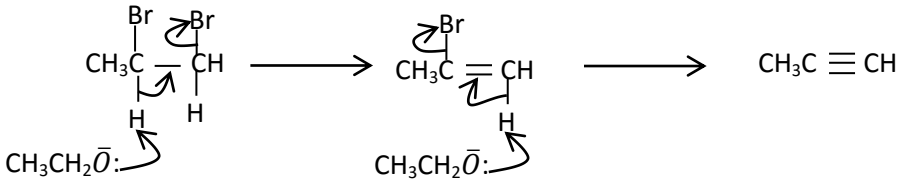


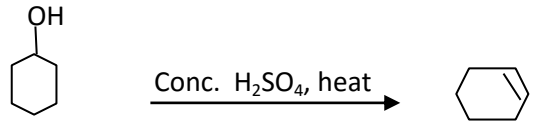
c) $RCHO + H_2N\text{-}OH \xrightarrow{H^+} RCH=NOH$ (5½ mark)



d) $CH_3CHBrCH_2Br \xrightarrow{CH_3CH_2O^-Na^+/CH_3CH_2OH,\ heat} CH_3C\equiv CH$ (3marks)

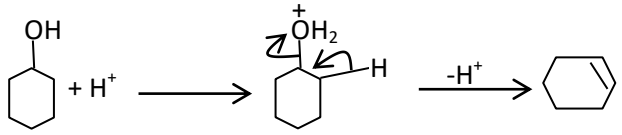
Mechanism



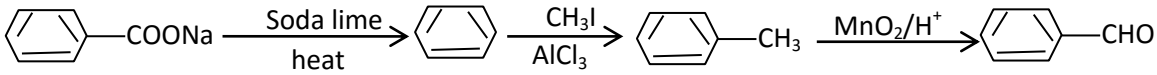
e) 

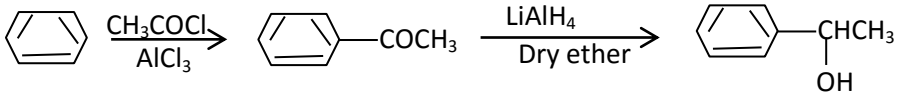
(3½ marks)

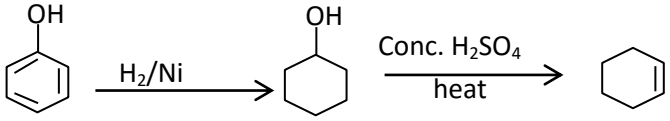
Mechanism

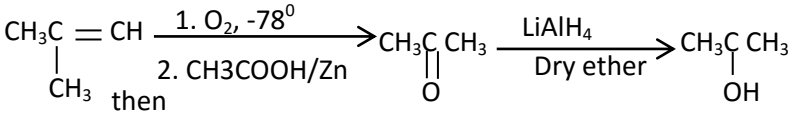


5. Write equation to show how the following compounds can be synthesized

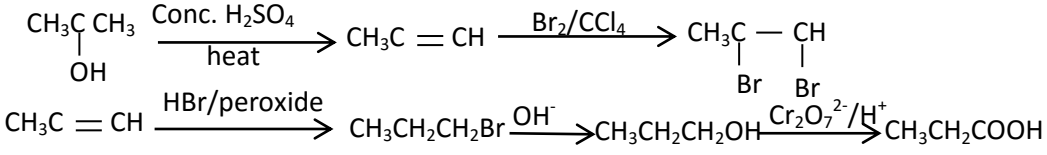
(a) 

(b) 

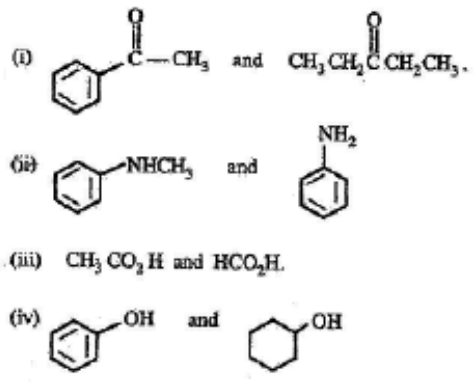
(c) 

(d) 

(e)

(f) 

6. For each of the following pairs of compounds:



Name one reagent which

(a) when reacted with each member of the pair will show similar observation. (8marks)

(i) both form yellow ppt. with Brady's reagent

(ii) both decolorize bromine water

(iii) both form effervescence with sodium hydrogen carbonate

(iv) both produce a gas with sodium

(b) can be used to distinguish between the members of each pair.

(i) Phenylmethylketone (1st one) forms a yellow ppt. with iodine in sodium hydroxide while pentan-3-one does not

(ii) Phyenylmethylamine (1st one) forms a yellow oily ppt with sodium nitrite, hydrochloric acid at zero degrees while phenylamine shows no observable change with the same reagent.

(iii) Methanoic acid (2d one) forms a black ppt./silver mirror with Tollen's reagent (ammoniacal silver nitrate) while ethanoic acid does not

(iv) Phenol (1st one) forms a purple solution with neutral iron (III) chloride solution while cyclohexanol does not.

In each case state would be observed when each member of the pair is reacted with the reagent you have named **END**