525/2
S6 CHEMISTRY

Exam 13 guide

PAPER 2

DURATION: 2 HOUR 30 MINUTES

INSTRUCTIONS

- Answer five questions including three fron section A and two from section B
- Where necessary use C = 12, O = 16, H = 1, S = 32, 1F = 96500C

SECTION A

Attempt three questions from this section

1. (a) Define the term isotopes (01 mark)

   Isotopes are atoms of the same element having the same atomic number but different number of neutrons and thus different atomic mass.

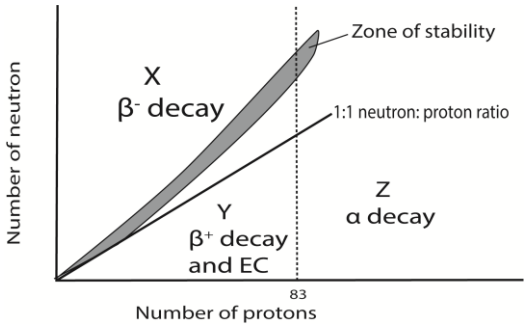
   (b) One of the factors that affect the stability of the isotopes is neutron to proton ratio

   (i) State the other factor (01 mark)

   - *Even and odd number of protons (p) and neutrons (n):* nuclides with even proton and even neutrons tend to be more stable than those with even protons and odd neutrons or odd protons-even neutrons than those with odd proton and odd neutrons.
   - *Magic number of protons and/or neutrons*
   - Mass defect

   (ii) Sketch a graph of number of neutrons versus number of protons and on it indicate

   - The line in which n/p = 1
   - The stability region
   - Three points in the unstability region (3½ marks)



(c) Describe briefly how the isotopes in the unstability region in the three points indicated in (b) can gain stability (04marks)

At X an element is unstable because it has too many neutrons, the element disintegrates by loss of beta particle or conversion of a neutron in to a proton e.g. $^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-}\beta$

At Y an element is unstable because it has too many Protons, the element disintegrates by positron emission or electron capture. e.g, $^{11}_{6}C \rightarrow {}^{11}_{5}B + {}^{0}_{1}e$ and $^{1}_{1}H + {}^{0}_{-1}e(electron) \rightarrow {}^{1}_{0}n$

At Z an element is unstable because it has too many neutrons and protons, the element disintegrates by alpha radiation. e.g. $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

(d) Gallium has two isotopes of mass number 69 and 71 in the ratio x:y. If the relative atomic mass of gallium is 69.8, determine the values of x and y. (03marks)

Solution

y = 100 – x

69x + 71(100 – x) = 69.8 x 100

69x – 71x + 7100 = 6980

2x = 120

x = 60

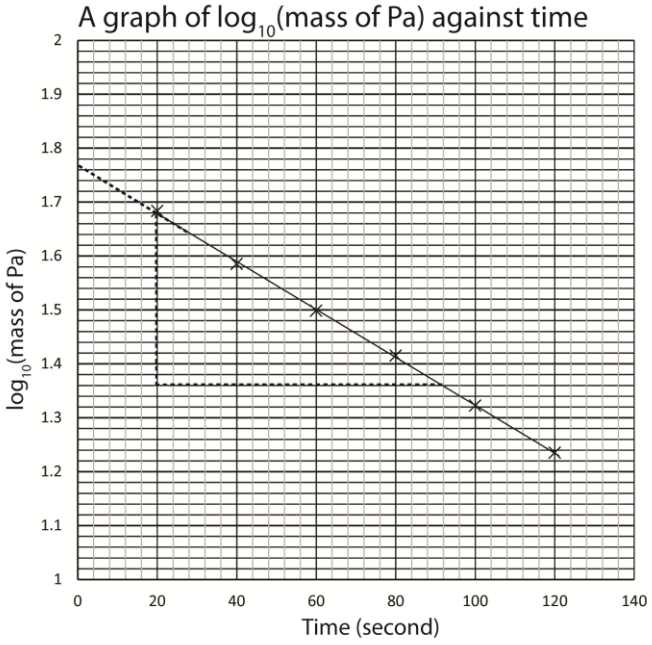
y = 40

x:y = 3:2

(e) The table below shows the results of the radioactive decay of $^{234}_{91}Pa$

Time (seconds)	20	40	60	80	100	120
Mass of $^{234}_{91}Pa$ (g)	48.2	38.5	31.5	26.0	21.0	17.2
$\log_{10}(mass)$	1.683	1.585	1.498	1.415	1.322	1.235

Plot a graph of $\log_{10}(mass)$ against time and use it to determine the



(i) Initial mass of $^{234}_{91}Pa$ (01mark)

Log (initial mass) = 1.77

Initial mass = 58.88g

(ii) Decay constant of $^{234}_{91}Pa$(02marks)

Decay constant, k = $-\frac{2.303slope}{2.303}=-\frac{2.303(1.68-1.36)}{20-92}$ = $0.01s^{-1}$

(iii) Half-life of $^{234}_{91}Pa$ (02marks)

Half-life $\frac{In2}{K}=\frac{0.693}{0.01}=69.3s$

2. (a) Define the terms

(i) Electrolytic conductivity (01 mark)

It is a reciprocal of resistivity of solution between electrodes each 1 unit squared and 1unit apart.

(ii) Molar conductivity (01mark)

It the conductivity of a solution containing 1 mole of an electrolyte.

(b) Conductivity measurement is one of the methods of determining solubility product of a sparingly soluble salt.

(i) Describe how the method is carried out (05marks)

Resistance R of a saturated solution placed between electrodes each A cm^2 and l cm apart

Electric conductivity K is calculated from $K=\frac{1}{R}\times\frac{l}{A}$

If Λ_0AgCl is the molar conductivity at infinite dilution of AgCl, then

C = $\frac{K}{\Lambda_0 AgCl}molcm^3=\frac{1000K}{\Lambda_0 AgCl}moldm^3$

(ii) The electrolytic conductivity of a saturated solution of calcium phosphate at 25^0C is $3.1219 \times 10^{-5}\Omega^{-1}cm^{-1}$. The molar ionic conductivities of calcium ions and phosphate ions at infinity dilution at 25^0C are $119.0\Omega^{-1}cm^2mol^{-1}$ and $240.0\ \Omega^{-1}cm^2mol^{-1}$ respectively.

Calculate the solubility product of calcium phosphate at 25^0C and state its units (05 marks)

Solution

$\Lambda_0\ Ca_3(PO_4)^2 = 3\lambda_0Ca^{2+} + 2\ \lambda_0PO_4^{3-}$

$= 3 \times 119 + 2 \times 240$

$=837\ \Omega^{-1}cm^2mol^{-1}$

$\Lambda_0\ Ca_3(PO_4)^2 = \frac{K}{C}$

C = $\frac{3.1219 \times 10^{-5}}{837}=3.73\ x\ 10^{-8}molcm^{-3}=3.73\ x\ 10^{-5}moldm^{-3}$

$[Ca^{2+}] = (3\ x\ 3.73\ x\ 10^{-5})moldm^{-3}$

$[PO_4^{3-}] = (2\ x\ 3.73\ x\ 10^{-5})moldm^{-3}$

Solubility product Ks = $[Ca^{2+}]^3[PO_4^{3-}]2$

$=(3\ x\ 3.73\ x\ 10^{-5})^3(2\ x\ 3.73\ x\ 10^{-5})^2$

$= 7.8 \times 10^{-21}mol^5dm^{-15}$

(c) Explain each of the following observations

(i) In the conductimetric titration of copper (II) sulphate solution against ammonia solution, the electrolytic conductivity of the mixture decreases to minimum value and then increases gradually and finally almost levels of with excess ammonia (04marks)

Conductivity decreases to a minimum because copper ions are removed from solution as insoluble copper hydroxide.

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

Then increases because copper hydroxide reacts with excess ammonia to form conducting ions of tetraaminocopper II ions and hydroxide ions.

$Cu(OH)_2\ (s) + 4NH_3\ (aq) \rightarrow Cu(NH_3)_4^{2+}(aq) + 2OH^-(aq)$

(ii) The molar conductivity decrease with increase in concentration for both ethanoic acid and sodium chloride (04 marks)

Molar conductivity of ethanoic acid decreases as the concentration of ethanoic acid increases due to decrease in percentage ionization of the acid with increasing concentration.

Molar conductivity of sodium chloride decreases as concentration increases because at high concentration, high density of ions lead ion interaction which reduce mobility of ions which lowers molar conductivity.

3. An organic compound P on complete combustion yielded 8.8g of carbon dioxide and 1.8g of water. 0.1g of P vaporized at 273^0C and 734mmHg occupied a volume of $4.46 \times 10^{-2}dm^3$

(a) Calculate

(i) the empirical formula of P (02marks)

Mass of carbon = $\frac{8.8\ x\ 12}{44}\ 2.4g$

Mass of hydrogen = $\frac{1.8\ x\ 2}{18}\ 0.2g$

Elements	C	H
Mass	2.4	0.2
RAM	12	1
moles	0.2	0.2
Mole ratio	1	1
Empirical formula	CH	

(ii) molecular formula of P (04marks)

volume V at stp

$\frac{760V}{273} = \frac{734\ x\ 4.46\ x\ 10^{-2}}{(273+273)}$

$V = 0.021537 dm^3$

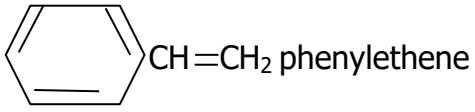
Formula mass = $\frac{22.4\ x\ 0.1}{0.021537}$ = 104

⇨ n(CH) = 104

n = 8

∴molecular formula C_8H_8

(b) Write the structure and IUPAC name of P (01 mark)

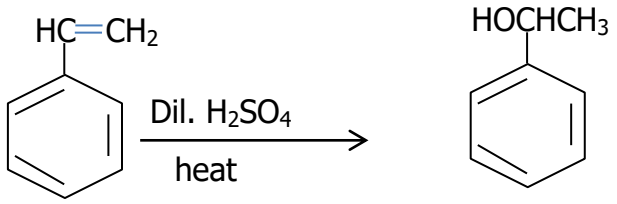


phenylethene

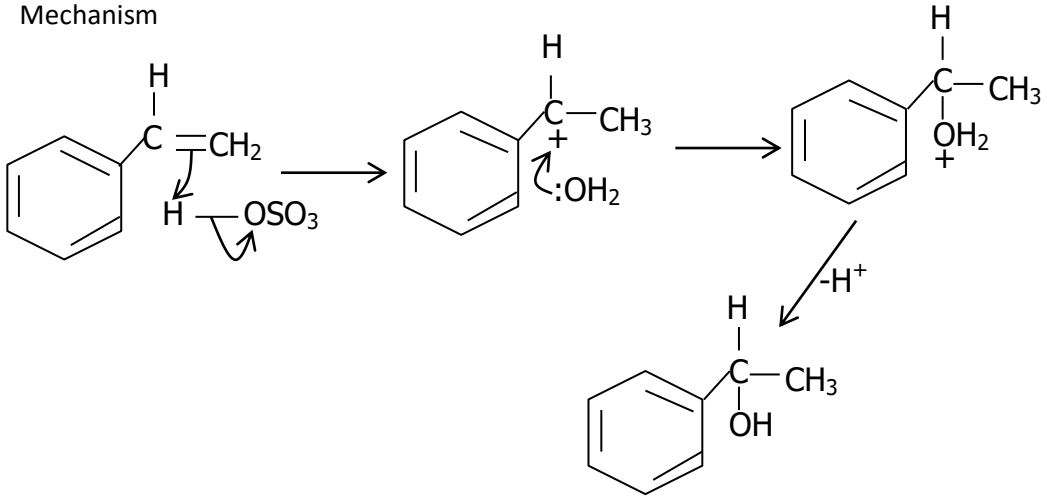
(c) Discuss the reactions of P with

(i) Sulphuric acid

It reacts with dilute sulphuric acid to form 1-phenylethanol

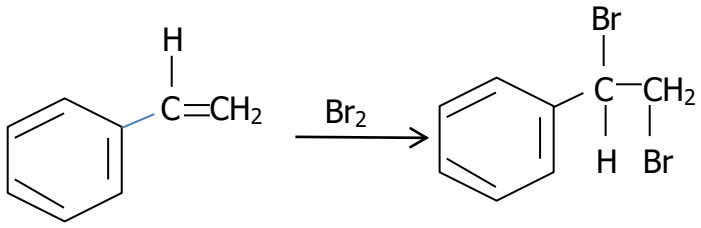


Mechanism

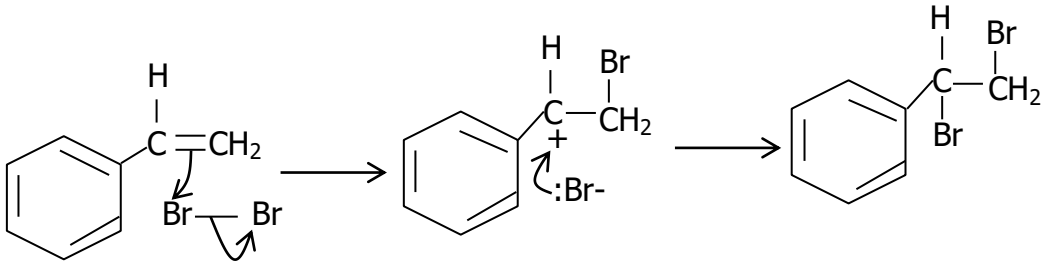


(ii) Bromine (08marks)

P reacts with bromine to form1,2-dibromo-1-phenylethane

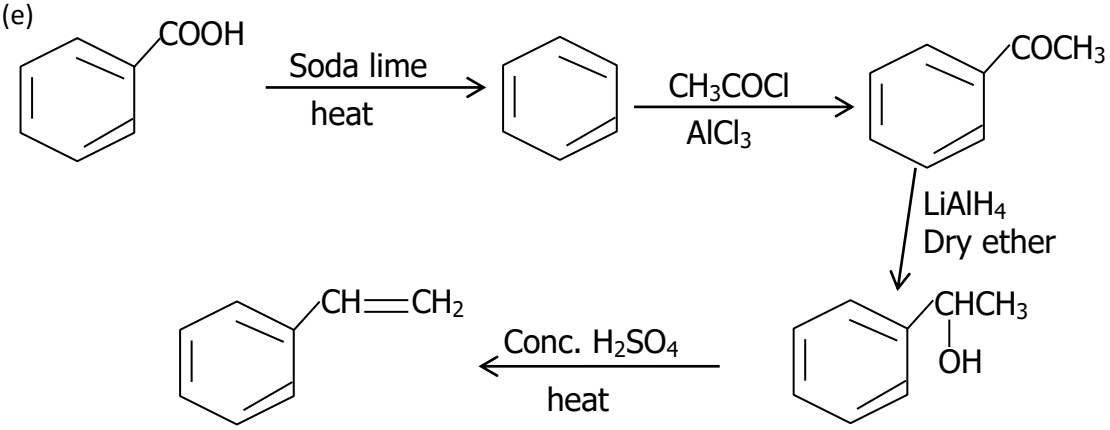


Mechanism



(d) Using equations shows conditions for synthesis of P from benzoic acid (05marks)

(e)



4. (a) Write the outermost electronic configuration of group (IV) elements. (01 marks)

ns^2np^2

(b) Describe the reaction of:

(i) Carbon, silicon, tin and lead with water (6½ marks)

Carbon does not react with cold water but reacts with steam to form water gas

$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$

Silicon, germanium and Tin do not react with water up to 100^0C because they are protected by thin layer of oxide. But they react with steam at very high temperatures to form dioxides

$Ge(s) + 2H_2O(g) \rightarrow GeO_2(s) + 2H_2(g)$

Lead reacts with soft water (water that contains oxygen) to form lead II hydroxide.

$Pb(s) + 2H_2O(g) + O_2(g) \rightarrow Pb(OH)_2(s)$

(ii) Lead with ethanoic acid (2½ marks)

Pb reacts ethanoic acid in presence of air giving lead II ethanoate and water

$Pb(s) + 4CH_3COOH(aq) + O_2(g) \rightarrow Pb(CH_3COO^-)_2(aq) + 2H_2O(l)$

(iii) Chlorides of lead with sodium hydroxide solution (04marks)

Lead II chloride reacts with sodium hydroxide solution to form lead (II) hydroxide which dissolves in excess sodium hydroxide to form sodium plumbate (II)

$PbCl_2(s) + 2OH^-(aq) \rightarrow Pb(OH)_2(s) + 2Cl^-(aq)$

Then

$Pb(OH)_2(s) + 2OH^-(aq) \rightarrow Pb(OH)_4^{2-}(aq)$

Lead(IV) chloride react with sodium hydroxide to produce lead(IV) oxide, sodium chloride and water. Sodium hydroxide - diluted solution.

$PbCl_4 + 4NaOH \rightarrow PbO_2 + 4NaCl + 2H_2O$

The compound PbO_2 reacts with the sodium hydroxide to produce the hexahydroxoplumbate (IV) ion $[Pb(OH)_6]^{2-}$, soluble with the water.

$PbO_2 + 2NaOH + 2H_2O \rightarrow Na_2[Pb(OH)_6]$

(iv) Silicon with acids (03 marks)

Silicon reacts with concentrated nitric acid to form silicon dioxide

Silicon does not react with most acids under normal conditions but is dissolved by hydrofluoric acid, HF, to form fluorosilicic acid, a reaction apparently driven by the stability of the Si(IV) fluoride complex $[SiF_6]^{2-}$.

$Si(s) + 6HF(aq) \rightarrow 2H_2(g) + H_2SiF_6$ (aq) (fluorosilicic acid)

(c) Carbon does not react with chlorine but reacts readily with fluorine.
Explain this observation. (03 marks)

Fluorine is a stronger oxidizing agent than chlorine, has very low F-F bond energy and form stronger C-F bond the C-Cl bond, these factors promote reaction of fluorine with carbon.

SECTION B

Answer two questions from this section

5. (a) Describe an experiement that can be used to determine the enthalpy of displacemnt reaction between zinc and copper sulphate (09marks)

Procedure

- Pipette $25cm^3$ of 0.1M copper II sulphate into a plastic cup
- Insert a thermometer and measure the initial temperature $T_0\,^0C$
- Add excess zinc Powder (6g) to the cup, stir and determine the highest temperature $T\,^0C$ of the mixture.
- Assuming the density of the solution is 1g per cm^3 calculate the amount of heat liberated is calculated from

$\Delta H = m\ c\ \Delta T$

$= 25 \times 4.18\ (T - T_0)$ joules

- Moles of copper displaced = $\frac{25\ x\ 0.1}{1000}$ = 0.0025moles
- Displacement of 0.0025mole of copper II ions produce = $25 \times 4.18\ (T - T_0)]$ joules
- Displacement of 1 mole of copper II ions would produce joule = $\frac{[25 \times 4.18\ (T - T_0)]}{0.0025}$joules

∴Enthalpy of displacement reaction between zinc and copper sulphate = $\frac{[25 \times 4.18\ (T - T_0)]}{0.0025}$joules

(b) State what would be observed and write equation for the reaction when

(i) Copper metal is added to silver nitrate solution (03marks)
The solution turns blue with the formation of black ppt.
$2Ag^+(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$

(ii) Aluminium metal is added to iron (III) sulphate solution (2 ½ marks)
A brown solution turns colorless
$Al(s) + Fe^{3+}(aq) \rightarrow Al^{3+}(aq) + Fe(s)$

(c) Calculate the Gibbs free energy in (c)(ii) above given that the standard reduction potential of aluminium half cell is -1.66V and that of iron (III) half cell is +0.77V. (03marks)

$E^0_{cell} = E_{reduction} - E_{oxidation}$

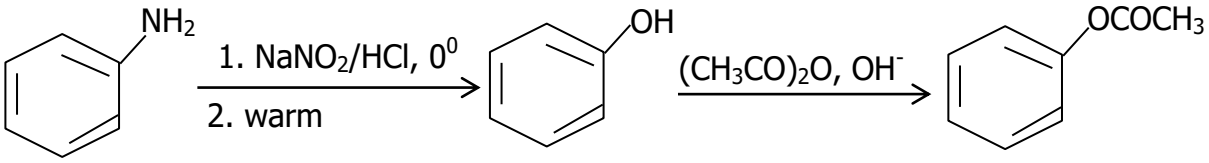
= 0.77 – (-1.66)
= 2.43V

$\Delta G = -nFE^0$

=3 x 96500 x 2.43
= 703,485J

(d) Write the cell notation for the cell formed by combining the half cells in (d) above (1 ½ marks)
$Al(s)/Al^{3+}(aq)//Fe^{3+}(aq)/Fe(s)$

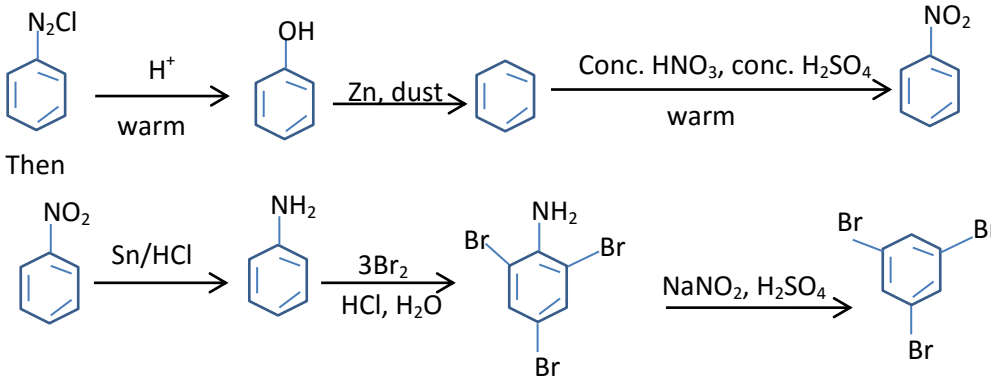
6. Using equations only show the following compounds can be synthesized
(a) Phenylethanoate from aminobenzene (04marks)



(b) 2,2-dichloropropane from propan-1-ol (04marks)

$CH_3CH_2CH_2OH \xrightarrow{\text{Conc. } H_2SO_4/\text{heat}} CH_3CH{=}CH_2 \xrightarrow{HCl} CH_2CCl_2CH_3$

(c) 1,3,5-tribromobenzene from benzene diazonium chloride (04markks)



(d) $CH_3CH{=}NOH$ from but-2-ene (04marks)

$CH_3CH{=}CHCH_3 \xrightarrow{\text{1. } O_3,\ 78^0,\ \text{2. } CH_3CH_2OH/Zn} CH_3CHO \xrightarrow{H_2NOH,\ H^+} CH_3CH{=}NOH$

(e) Ethylamine from propanoic acid (04marks)

$CH_3CH \quad CHCH_3 \xrightarrow{\text{1. } O_3,\ 78^0,\ \text{2. } CH_3CH_2OH/Zn} CH_3CHO \xrightarrow[\text{Dry ether}]{LiAlH_4} CH_3CH_2OH$

Then

$CH_3CH_2OH + PCl_3 \longrightarrow CH_3CH_2Cl + NH_3 \longrightarrow CH_3CH_2NH_2$

7. Explain the following observations

(a) When potassium iodide solution was added to copper (II) sulphate solution; white precipitate and brown solution were formed, however, when potassium bromide solution was used there was no observable change (05marks)

Iodide ions are strong reducing agents that reduce copper II to whitie precipitates of copper I iodide and iodine

$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$

While bromde ions are not strong reducing agent to reduce copper II ions

(b) When concentrated hydrogen peroxide solution was added to lead (II) sulphide, the black solid turned to white solid (03marks)

Hydrogen peroxide oxidises lead sulphide to lead sulphate

$PbS(s) + 4H_2O_2(aq) \rightarrow PbSO4(s) + 4H_2O(l)$

(c) When concentrated ammonia solution was added to cobalt (II) chloride solution, blue precipitate was formed which dissolved in excess ammonia solution to form a pale brown solution (05marks)

With Concentrated ammonia forms a blue precipitate of cobalt (II) hydroxide soluble in excess to give pale yellow solution; the solution turns brown on standing.

$[Co(H_2O)_6]^{2+}(aq) + 2OH^{-}(aq) \rightarrow Co(OH)_2(s)$
pink — blue ppt

$Co(OH)_2(s) + 6NH_3(aq)\ s \rightarrow [Co(NH_3)_6]^{2+}(aq)$
red-brown

$[Co(NH_3)_6]^{2+}(aq) \xrightarrow{\text{Oxidation}} Co(NH_3)_6]^{3+}(aq)$
red-brown — yellow solution

(d) When 60g of urea, $(NH_2)_2CO$ and 128g of naphthalene ($C_{10}H_8$) were separately added to ethanol, both solutions boil at the same temperature and pressure (04marks)

Because both 60g of urea and 128g of mathaene are equal to 1 moles each, contain the same number of particles and since boiling point of solution is a colligative property, they boil at the same temperature.

(e) A solution of hydrogen chloride gas in methylbenzene has no effect on litmus papers hower in an aqueous solution of hydrogen chloride turns blue litmus paper red. (03marks)

In methylbenzene HCl is covalent and does not ionize while in aqueous solution it ionizes into hydrogen ions that turn blue limus paper red.

8. (a) Discuss the chemical properties of aluminium and iron showing

(i) Similarity

Both form ions in oxidation state +3

Both have vacant orbital and their form compounds with dative bonds

(ii) Differences (12marks)

Iron has variable oxidation states of +2, +3 and +6 while aluminium has one oxidation state of +3

Iron forms colored compound i.e. Fe^{2+} -green while Fe^{3+} is brown while aluminium compounds are white

Iron has catalytic properties while aluminium lacks catalytic propertiex

Iron form complex ions such $Fe(CN)_6^{3-}$ while aluminium does not

(b) Explain the following observations

(i) the melting points of aluminium and iron are 66^0C and 1537^0C respectively (04marks)

Iron has heavy nucli and use many electrons in formation metallic bond (involves the participation of both the 4s- and 3d-electrons); while Aluminium has light nuclei and used few electrons in formation of metallic bonds. Thus metallic bonds is iron are stronger than those of aluminium

(iii) Hydrogen chloride gas cannot be used to prepare anhydrous iron (III) chloride, however, hydrogen chloride gas is suitable for preparation of anhydrous aluminium chloride (04marks)

When HCl is reacted with iron Hydrogen produced prevents oxidation of Fe^{2+} ions to Fe^{3+} ions whereas aluminium is a strong reducing agent to reduce H^+ ions to hydrogen

END