



**GRAND A'LEVEL  
CHEMISTRY SEMINAR  
AT  
ST. JOSEPH'S S.S.S  
NAGGALAMA**

**28<sup>TH</sup> SEPTEMBER 2024**

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**SOLUTIONS**

SOLUTIONS TO THE A'LEVEL CHEMISTRY SEMINAR HELD ON 28<sup>TH</sup> SEPTEMBER, 2024.

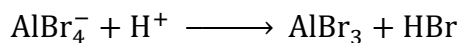
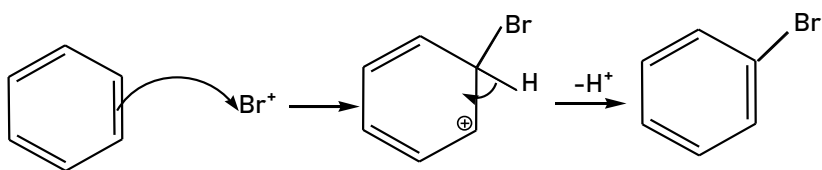
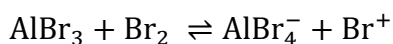
1. (a) There is an increase in atomic radii and decrease in electronegativity from chlorine to iodine. The bonding pair of electrons in the hydrogen – halogen bond becomes less strongly attracted from hydrogen chloride to hydrogen iodide. This leads to increase in bond length and hence decrease in bond strength from hydrogen chloride to hydrogen iodide, thus increasing the ease of the hydrogen halides to dissociate and release hydrogen ions in the solution from hydrogen chloride to hydrogen iodide.

(b) The ethyl group in ethylamine has positive inductive effect and increases on the electron density on nitrogen atom. This makes the lone pair of electrons on nitrogen atom to be more easily available to accept proton from water molecules and produce more hydroxide ions in the solution.

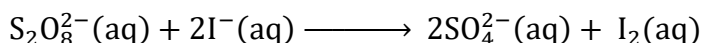
In 1-amino-2-bromo ethane,  $[H_2CBrCH_2NH_2]$ , the bromine atom has a negative inductive effect and reduces the electron density on nitrogen atom. This makes the lone pair of electrons less available to accept proton from water molecules and therefore produces less number of hydroxide ions in the solution.

(c) There is increase in ionic radius and decrease in charge density from magnesium ion to strontium ion. The bromide ions become less polarized by the group(II) cations from magnesium ions to strontium ions. This makes the bonds to become ionic from magnesium bromide to barium bromide. As such the strength of the ionic bonds increases from magnesium bromide to strontium bromide.

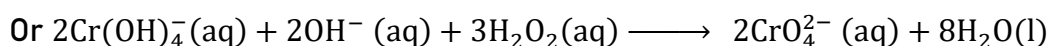
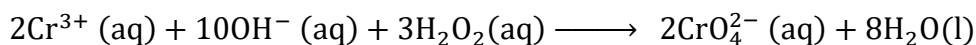
(d) Aluminium ion in Aluminium bromide has a small ionic radius and high charge, therefore high charge density and high polarizing power, it greatly polarizes the bromide ion resulting into formation of predominantly covalent character whereby there is sharing of electrons between Aluminium and bromine, by doing so Aluminium will lack two electrons to achieve its octet structure and thus reaction with halogens forms a stable complex and electrophile which attacks the benzene ring.



e) Peroxosulphate(VI) ion is a strong oxidizing agent which oxidizes iodide ions to iodine and itself reduced to sulphate ions.



f) Hydrogen peroxide oxidizes chromate(III) ions to chromate(VI) ions



g) Down the group, cationic radius increases.

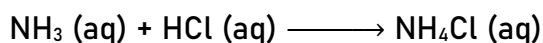
For hydroxides, both lattice energy and hydration energy decrease, however, lattice energy decreases more than hydration energy and thus enthalpy of solution is negative and this makes the hydroxides increase in solubility down the group.

For sulphates, hydration energy decreases more than lattice energy and thus the enthalpy of solution is positive. Solubility of sulphates thus decrease down the group.

2.a)i) Distribution coefficient is the ratio of concentrations of a solute in two immiscible solvents in contact at a given temperature.

ii) A known volume of an aqueous ammonia of known concentration is added to a known volume of trichloromethane in a separating funnel/flask. The mixture is shaken and allowed to stand at a constant temperature

A known volume of the aqueous layer is pipetted and titrated with a standard solution of hydrochloric acid and the concentration of ammonia determined. Ammonia reacts with hydrochloric acid according to the equation.



The concentration of ammonia in the organic layer is obtained by subtraction. The distribution coefficient of ammonia between water and trichloromethane is calculated using the expression;

$$K_D = \frac{[\text{NH}_3]_{\text{aq}}}{[\text{NH}_3]_{\text{organic}}}$$

b) Organic layer.

$$\text{Moles of HCl} = \frac{0.05 \times 23.10}{1000}$$

$$[\text{NH}_3] = \frac{0.05 \times 23.10}{1000} \times \frac{1000}{20} = 0.0578\text{M}$$

$$K_D = \frac{[\text{NH}_3]_{\text{aq}}}{[\text{NH}_3]_{\text{organic}}}$$

$$K_D = \frac{1.442}{0.0578} = 25$$

Alternatively

Organic layer

$$\text{Moles of HCl} = \frac{0.05 \times 23.10}{1000}$$

$$\text{Moles of Ammonia in } 20 \text{ cm}^3 = \frac{0.05 \times 23.10}{1000}$$

$$\text{Moles of NH}_3 \text{ in } 50 \text{ cm}^3 = \frac{0.05 \times 23.10}{1000} \times \frac{50}{20}$$

$$= 2.9 \times 10^{-3}$$

Aqueous Layer

$$[\text{NH}_3]_{\text{aq}} = 1.5 - 0.0578$$

$$= 1.442\text{M}$$

Aqueous layer

$$\text{Initial Moles of NH}_3 = \frac{1.5 \times 50}{1000} = 0.075$$

Moles remaining in aqueous layer.

$$= 0.075 - 2.9 \times 10^{-3}$$

$$= 0.072$$

$$[\text{NH}_3]_{\text{aq}} = \frac{0.072}{50} \times 1000.$$

$$[\text{NH}_3] \text{CHCl}_3 = \frac{2.9 \times 10^{-3}}{50} \times 1000.$$

$$K_D = \frac{0.072 \times 1000 / 50}{2.9 \times 10^{-3} \times 1000 / 50}$$

$$= 25$$

c) Organic layer.

$$\text{Moles of HCl in } 12.5 \text{ cm}^3 = \frac{12.5 \times 0.1}{1000}$$

$$[\text{NH}_3] = \frac{12.5 \times 0.1 \times 1000}{1000 \times 50} = 0.025 \text{ moles}$$

$$\frac{[\text{NH}_3]_{\text{CHCl}_3}}{[\text{NH}_3]_{\text{free}}} = 0.04$$

$$[\text{NH}_3]_{\text{Free}} = \frac{0.025}{0.04} = 0.625 \text{ M}$$

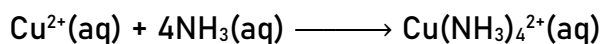
Aqueous layer

$$\text{Moles of HCl in } 20 \text{ cm}^3 = \frac{20 \times 1}{1000}$$

$$[\text{NH}_3]_{\text{aq}} = \frac{20 \times 1 \times 1000}{1000 \times 25} = 0.8 \text{ M}$$

$$[\text{NH}_3]_{\text{complex}} = 0.8 - 0.625$$

$$0.175 \text{ M}$$



$$[\text{Cu}^{2+}] = \frac{0.175}{4} = 0.0438 \text{ M}$$

$$\text{d) Mass of silver in crude sample; } = \frac{2 \times 150}{100} = 3 \text{ g}$$

Let the mass extracted be Xg

$$\frac{x/10}{3-x/150} = 300$$

$$X = 2.857 \text{ g}$$

$$\text{Mass remaining; } = [3 - 2.857] = 0.143 \text{ g}$$

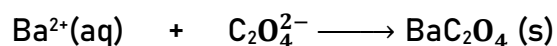
$$\% \text{ of silver remaining; } = \frac{0.143}{3} \times 100$$

$$= 4.77\%$$

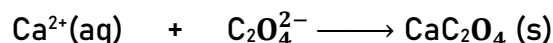
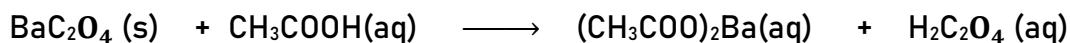
3.(a) Dilute nitric acid followed by ammonium oxalate solution and ethanoic acid.

$\text{BaCO}_3$  – white precipitate soluble in ethanoic acid

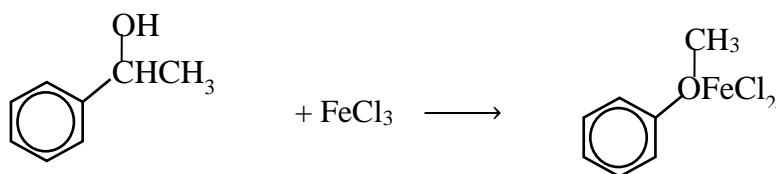
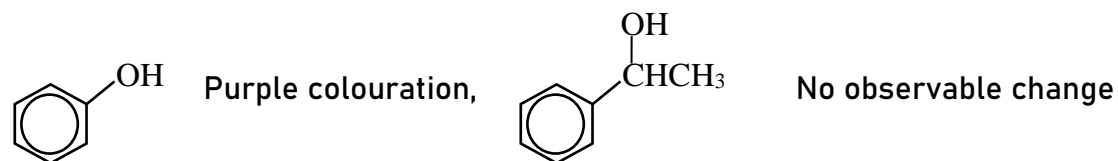
$\text{CaCO}_3$  – white precipitate insoluble in ethanoic acid



Then,



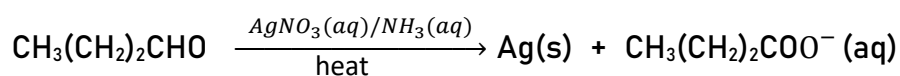
(b) Neutral iron (III) chloride



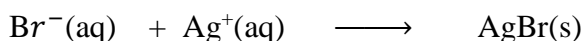
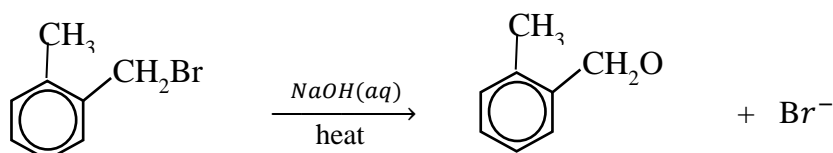
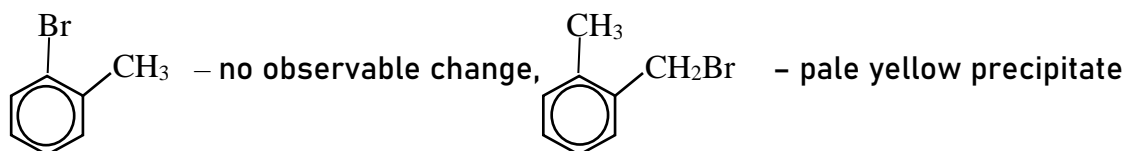
(c) Ammoniacal silver nitrate solution and heat



(or Ammoniacal copper(I) chloride solution and heat or warm



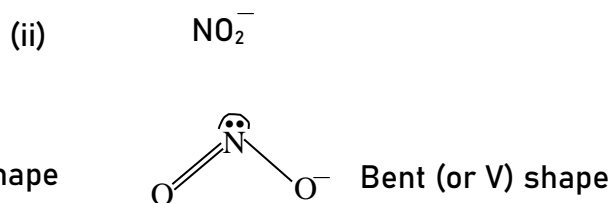
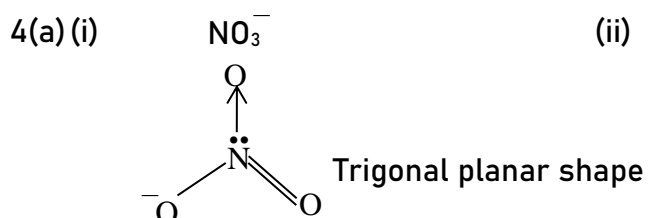
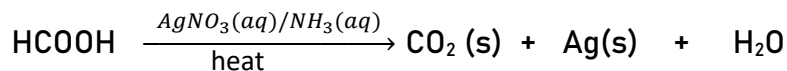
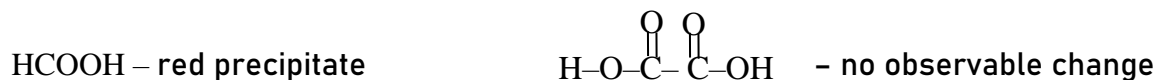
(d) Hot sodium hydroxide solution, dilute nitric acid and silver nitrate solution.



(e) Ammoniacal silver nitrate solution and heat.



Or, Fehlings solution and heat



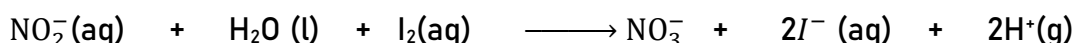
(b) The bond angle in  $\text{NO}_3^-$  is bigger than that in  $\text{NO}_2^-$

This is because in nitrate ion the nitrogen atom has three bond pairs and no lone pair. The bond pairs repel each other until minimum repulsion occurs amongst them. This occurs when the bonded species symmetrically arrange themselves around the nitrogen atom.

In nitrite ion, the nitrogen atom has one lone pair and two bond pairs. The lone pair exerts greater repulsion on the two bond pairs. This makes the bond pairs get closer to each other hence making the bond angle in nitrite ion being smaller than that in nitrate ion.

(c)(i) Nitrite ion ( $\text{NO}_2^-$ )

ii) The nitrite ion reduces iodine to iodide ions and the nitrite ion is oxidized to nitrate ion

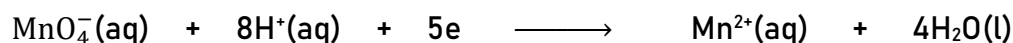


5.(a)(i) Acidified solution of manganate(VII) ions

(ii) Aqueous solution of vanadium (II) ions

(b) (i)  $\text{Pt}(\text{s})/\text{V}^{2+}(\text{aq}), \text{V}^{3+}(\text{aq}) // \text{MnO}_4^-(\text{aq}), \text{H}^+(\text{aq}) \text{Mn}^{2+}(\text{aq})/\text{Pt}(\text{s})$

(ii) At positive terminal



At the negative terminal



$$\begin{aligned} \text{iii) } E^\theta_{\text{cell}} &= E^\theta_{\text{right}} - E^\theta_{\text{left}} \\ &= +1.52 - (-0.27) \text{ V} \\ &= +1.79 \text{ V} \end{aligned}$$

$$\Delta G = -nEF$$

$$= (-5 \times 1.79 \times 96500) \text{ J}$$

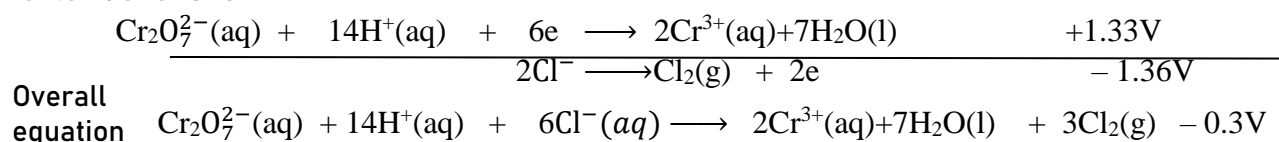
$$= 863675 \text{ J/mol or } 863.675 \text{ KJ/mol}$$

(c)i)  $\text{Pt(s)}, 2\text{Cl}^-(\text{aq}) / \text{Cl}_2(\text{g}) // \text{PbO(s)} / \text{H}^+(\text{aq}), \text{Pb}^{2+}(\text{aq}) / \text{Pt}$

$$\begin{aligned} \text{ii)} \quad E^\theta_{\text{cell}} &= E^\theta_{\text{right}} - E^\theta_{\text{left}} \\ &= (1.46 - 1.36) \\ &= +0.10 \text{ V} \end{aligned}$$

The E.m.f for the overall cell rotation is positive indicating that the cell produce electric current.

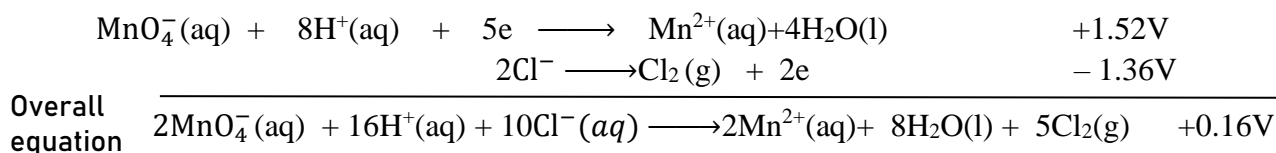
The e.m.f for the overall cell reaction between acidified potassium dichromate and chloride ions is



The E.m.f for the overall cell reaction is -0.03V

This means that the acidified potassium dichromate cannot oxidize the chlorine ions to chlorine since the E.m.f value has a negative sign. Therefore potassium dichromate can be acidified using dilute hydrochloric acid.

Overall cell reaction for the reaction between acidified potassium permanganate and dilute hydrochloric acid is obtained as



Since the E.m.f value for the overall cell reaction has a positive sign, this means that the manganate (VII) ions can oxidize chloride ions to chlorine.

Therefore the manganate(VII) ions cannot be acidified using dilute hydrochloric acid.

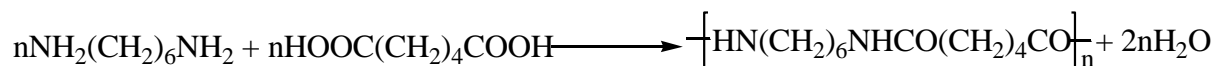
6.a). Addition polymerisation is the process by which small unsaturated molecules or molecules that contain carbon-carbon double bond combine to form a large molecule without loss of other small molecules.

Condensation polymerisation is the process by which many bifunctional molecules combine to form a large molecule accompanied by loss of other small molecules.

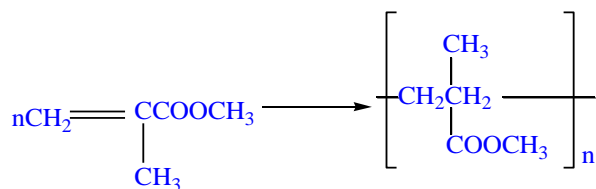
b)i) Hexane-1,6-dioic acid and Hexane-1,6-diamine

ii) Methyl-2-methylpropenoate

c) Nylon-6,6



Perspex



d)i) Nylon-6,6

Monomers are bifunctional

Perspex

Monomers contain carbon-carbon double bond

ii) In formation of nylon-6,6, there is loss of some molecules

In formation of perspex, there is no loss of some molecules and the polymer is a multiplier of the monomer

e) Nylon-6,6; For making clothes, threads and fishing nets

Perspex; For making aircraft, windows and rulers.

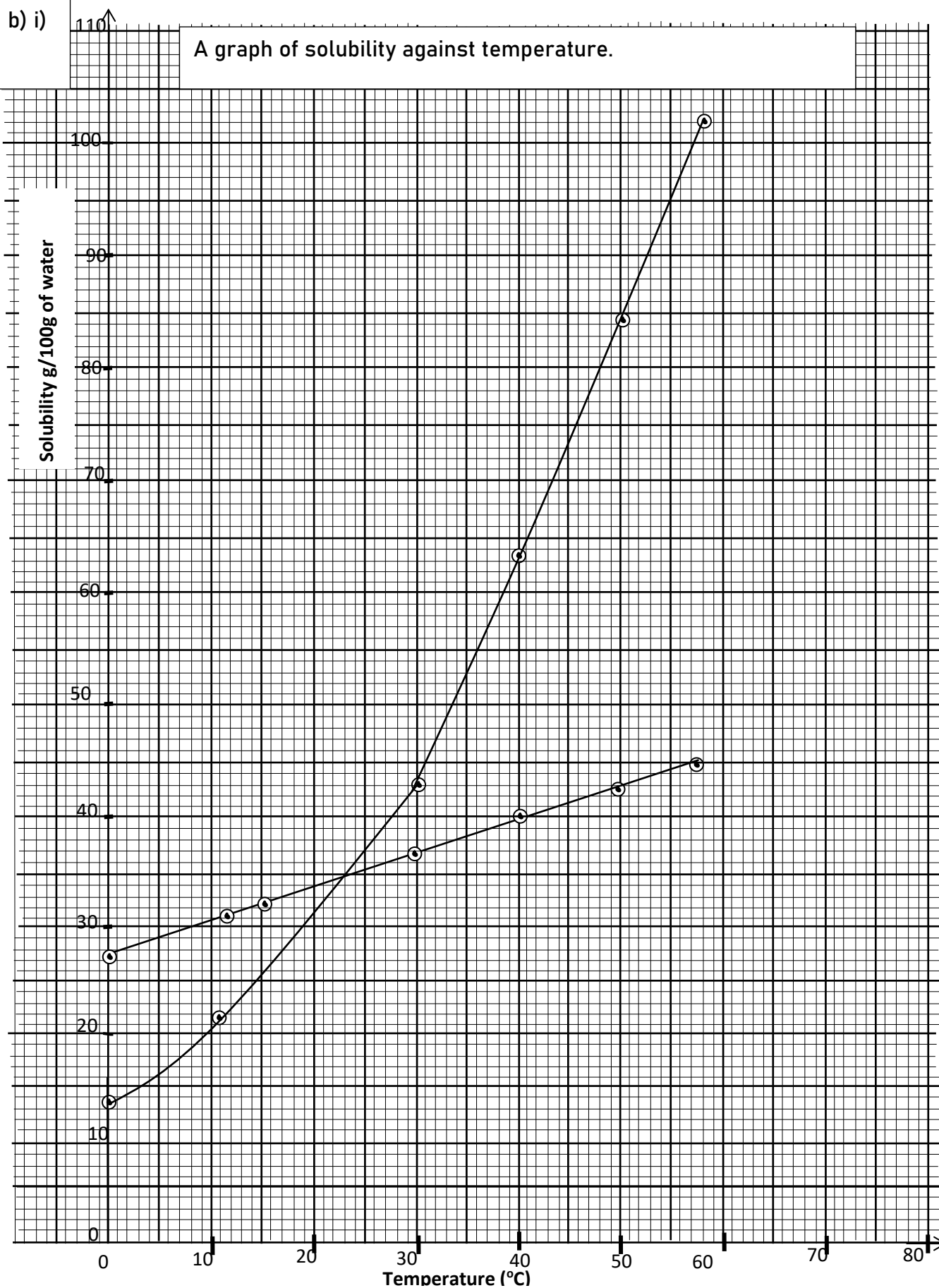
7. a)i) Solute is a substance that dissolves in a solvent to form a uniform solution.

ii) Saturated solution is one that cannot dissolve any more solute in the presence of undissolved solute at a given temperature.



b) i)

A graph of solubility against temperature.



ii) Potassium chloride

iii) At 23.5°C, the solubilities are equal.

iv) Solubility of potassium nitrate at 30°C in 43.0g/ 100g of water.

Solubility of potassium nitrate at 5°C is 17g / 100g of water.

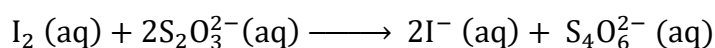
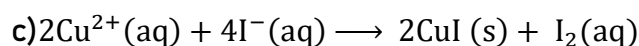
Mass of potassium nitrate that crystallized = 43 – 17

$$= 26\text{g}$$

RFM of potassium nitrate ( $\text{KNO}_3$ ) =  $39 + 14 + 16 \times 3 = 101$

$$\text{Number of moles of } \text{KNO}_3 \text{ that crystallized} = \frac{26}{101}$$

$$= 0.25743 \text{ moles}$$



$$\text{Number of moles } \text{S}_2\text{O}_3^{2-} = \frac{33.5 \times 0.118}{1000}$$

$$= 3.953 \times 10^{-3} \text{ moles}$$

Mole ratio  $\text{S}_2\text{O}_3^{2-} : \text{I}_2 = 2 : 1$

$$\text{Number of moles of } \text{I}_2 \text{ liberated} = \frac{1}{2} \times 3.953 \times 10^{-3}$$

$$= 1.9765 \times 10^{-3} \text{ moles}$$

Mole ratio  $\text{I}_2 : \text{Cu}^{2+} = 1 : 2$

$$\text{Number of moles of } \text{Cu}^{2+} = 1.9765 \times 10^{-3} \times 2$$

$$= 3.953 \times 10^{-3} \text{ moles}$$

RFM of  $\text{CuSO}_4 = 64 + 32 + 16 \times 4 = 160$

25cm<sup>3</sup> of diluted solution contain  $3.953 \times 10^{-3}$  moles of copper(II) sulphate

$$200\text{cm}^3 \text{ of diluted solution contain } \left( \frac{3.953 \times 10^{-3} \times 200}{25} \right) \text{ moles}$$

$$= 0.031624 \text{ moles}$$

Mass of  $\text{CuSO}_4$  in the saturated solution =  $0.031624 \times 160$

$$= 5.05984\text{g}$$

Mass of water in the saturated solution =  $25.2 - 5.06$

$$= 23.14\text{g}$$

23.14g of water dissolve 5.06g of  $\text{CuSO}_4$

100g of water dissolve  $\left(\frac{5.06 \times 100}{23.14}\right)\text{g}$

Solubility of  $\text{CuSO}_4$  = 21.87g/ 100g of water.

d) i) By boiling off most of the water such that the same solute is dissolved in less amount of water.

ii) By increasing the temperature of the solution.

e) i) Fractional crystallization is the process of separating two or more crystalline solids from their aqueous solution due to difference in their solubilities.

ii) 175g of saturated solution at  $100^\circ\text{C}$  contain 75g of  $\text{CuSO}_4$

$\therefore$  50g of saturated solution contain  $\left(\frac{75 \times 50}{175}\right)\text{g}$

$$= 21.43\text{g}$$

125g of saturated solution of  $\text{CuSO}_4$  at  $30^\circ\text{C}$  contain 25g of  $\text{CuSO}_4$

50g of saturated solution of  $\text{CuSO}_4$  at  $30^\circ\text{C}$  contain  $\left(\frac{25 \times 50}{125}\right)\text{g}$

$$= 10\text{g}$$

$\therefore$  Mass of  $\text{CuSO}_4$  that crystallized =  $21.43 - 10$

$$= 11.43\text{g}$$

iii) Stir copper(II) sulphate into hot water until no more will dissolve. Pour the solution into a jar and wait for a few days for the crystals to grow. If one of the crystals is tied on the thread and is suspended in a hot saturated solution of copper(II) sulphate for several days. The crystal grows larger as the solution slowly evaporates.

8) a) i)  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -\text{ve}$

ii) Temperature of  $450^\circ\text{C}$ .

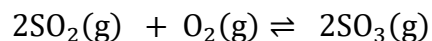
Use of Vanadium pentoxide as a catalyst

Pressure of 2 atmosphere

b) i) When temperature is increased to  $800^\circ\text{C}$ , the position of the equilibrium will shift from the right to the left since the forward reaction is an exothermic reaction and the temperature adjusted is beyond the optimum temperature.

ii) Acidified potassium permanganate reacts with sulphur dioxide, and reduces its concentration and as such the equilibrium position shifts from the right to the left.

c) Let the moles of oxygen which reacted be X



Initial moles;	1.8	2.0	0
Reacted moles;	2X	X	2X
Equilibrium moles;	1.8-2X	2-X	2X

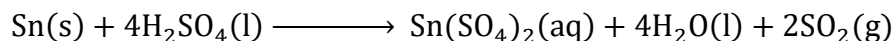
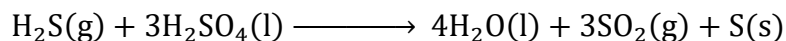
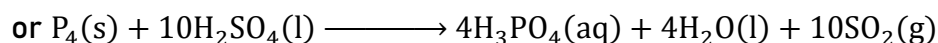
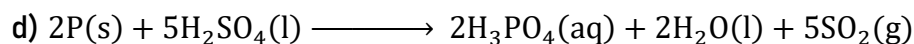
$$\text{Moles of oxygen that reacted;} = \frac{26}{100} \times 2 = 0.52$$

$$\text{Hence } X = 0.52$$

Equilibrium concentration;

$$[\text{SO}_2] = \frac{1.8 - (2 \times 0.52)}{2} = 0.38\text{M}; \quad [\text{O}_2] = \frac{2 - 0.52}{2} = 0.74\text{M} \quad [\text{SO}_3] = \frac{2 \times 0.52}{2} = 0.52\text{M}$$

$$\begin{aligned} K_c &= \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]} \\ &= \frac{0.52^2}{0.338^2 \times 0.74} \\ &= 2.53 \end{aligned}$$

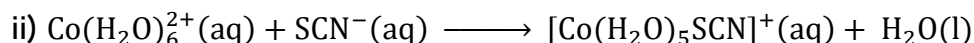


9. a)i) A metal which is capable of forming at least one of its stable ions with a partially filled 3d subshell.

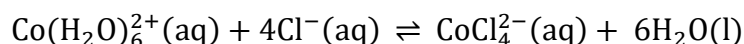
ii) Complex ion is either a positively charged or negatively charged ion in which the central ion is bonded to several other ligands.

b) They form cations with high charge density which are able to attract themselves. Their ions or atoms possess partially filled or vacant orbitals in which the ligands are able to donate their lone pair of electrons and form dative bonds.

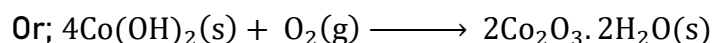
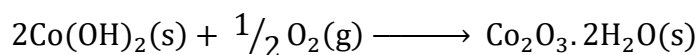
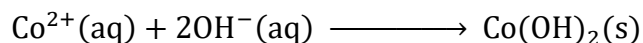
c)i)  $\text{Co}(\text{H}_2\text{O})_6^{2+}$ ; Hexaaquacobalt(II) ions



d)i) Pink solution turns blue;



ii) A blue precipitate insoluble in excess and turns brown on standing

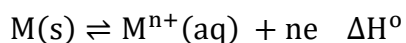


10.i) Standard electrode potential is the electrode potential of an electrode which is the measure with respect to a standard hydrogen electrode under standard conditions.( 298K, 1Atm, 1M concentration of ions)

ii) it is impossible to measure an absolute standard electrode potential because it is necessary to have a second electrode as a reference electrode which also has a potential difference with respect to a solution

We can only measure relative values of standard electrode potentials using a second electrode. E.g. standard hydrogen electrode whose potential difference is arbitrarily taken to be zero (0.00v)

iii) When a metal is dipped in a solution containing its ions, the metal M dissolves so as to establish an equilibrium,



The value of standard electrode potential will depend on the overall enthalpy change. For the reaction above, it will depend on;

Atomization/ sublimation energy.  $M(s) \rightleftharpoons M(g) \quad \Delta H_{\text{atm}}$

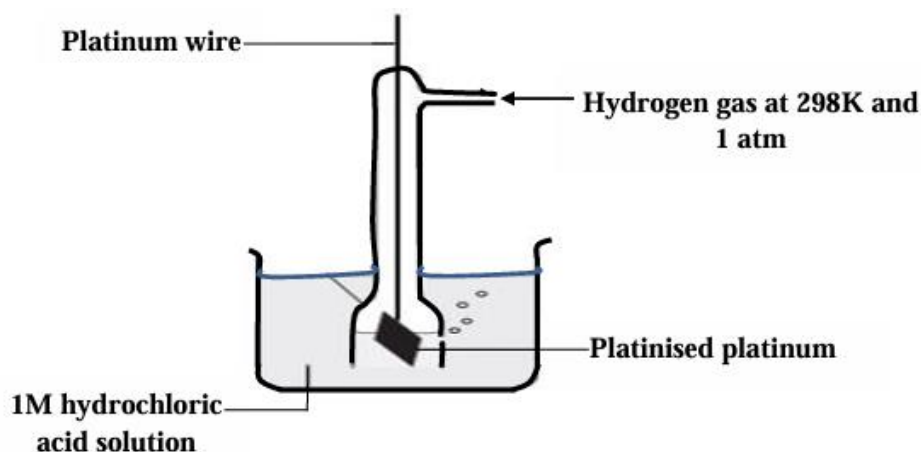
Ionization energy.  $M(g) \rightleftharpoons M^{+}(g) + e \quad \Delta H_{\text{I.E}}$

Hydration energy  $M^{+}(g) \rightleftharpoons M^{+}(aq) \quad \Delta H_{\text{Hyd}}$

The overall heat change,  $\Delta H^{\circ} = \Delta H_{\text{Hyd}} + \Delta H_{\text{I.E}} + \Delta H_{\text{atm}}$

Both atomization and ionization energy are endothermic processes, hydration energy is an exothermic process. For large negative values of the electrode potentials, enthalpies of atomization and ionization should be small and the hydration energy should be large

b) A standard hydrogen electrode consists of hydrogen gas at 298K, and 1 Atm bubbling over a platinized platinum electrode suspended in 1M solution of hydrogen ions.



c) A silver plate is dipped in 1M solution of silver nitrate solution and connected to a standard hydrogen electrode via a voltmeter.

The two half cells are internally connected via a salt bridge

The E.m.f read off from the voltmeter is taken as the standard electrode potential of silver since the electrode potential of standard hydrogen electrode is arbitrarily taken to be zero volts.

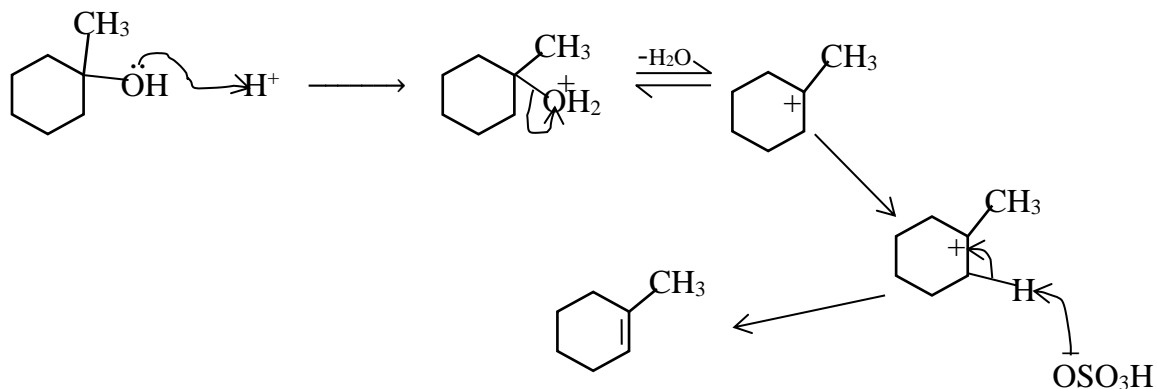
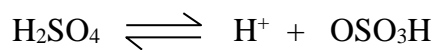
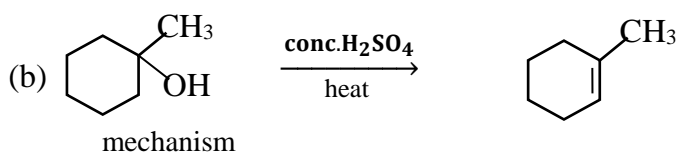
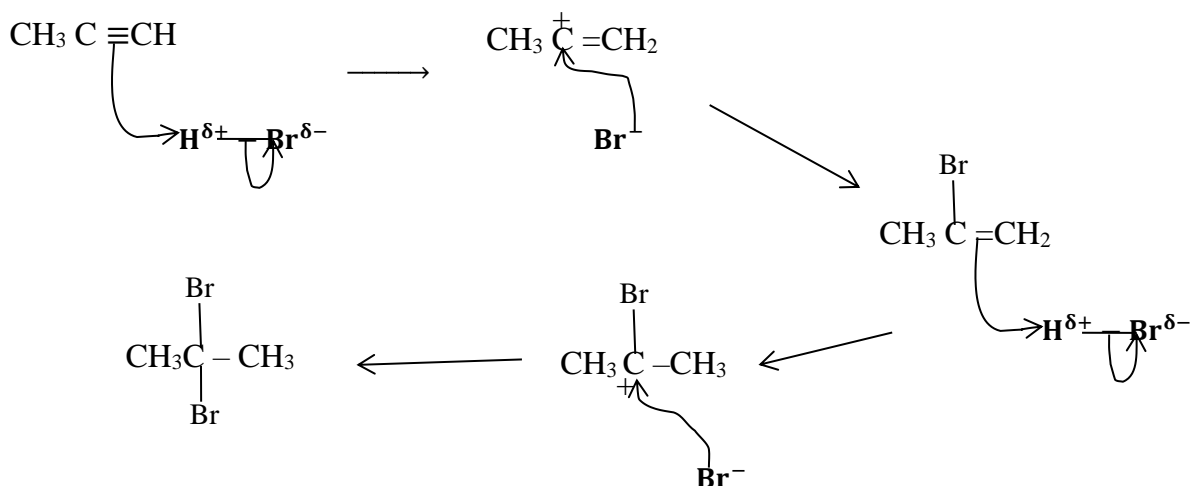
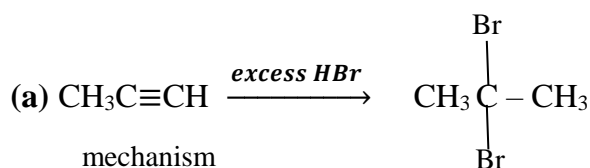
d)i)  $E_{\text{cell}} = E_R - E_L$

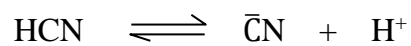
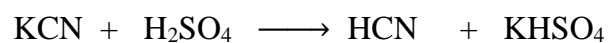
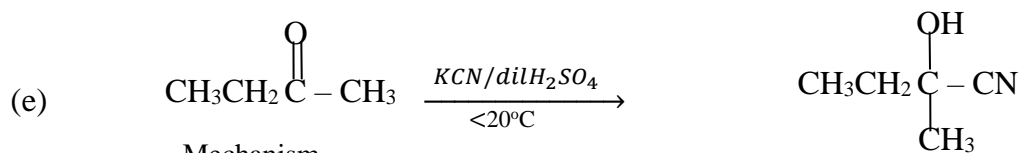
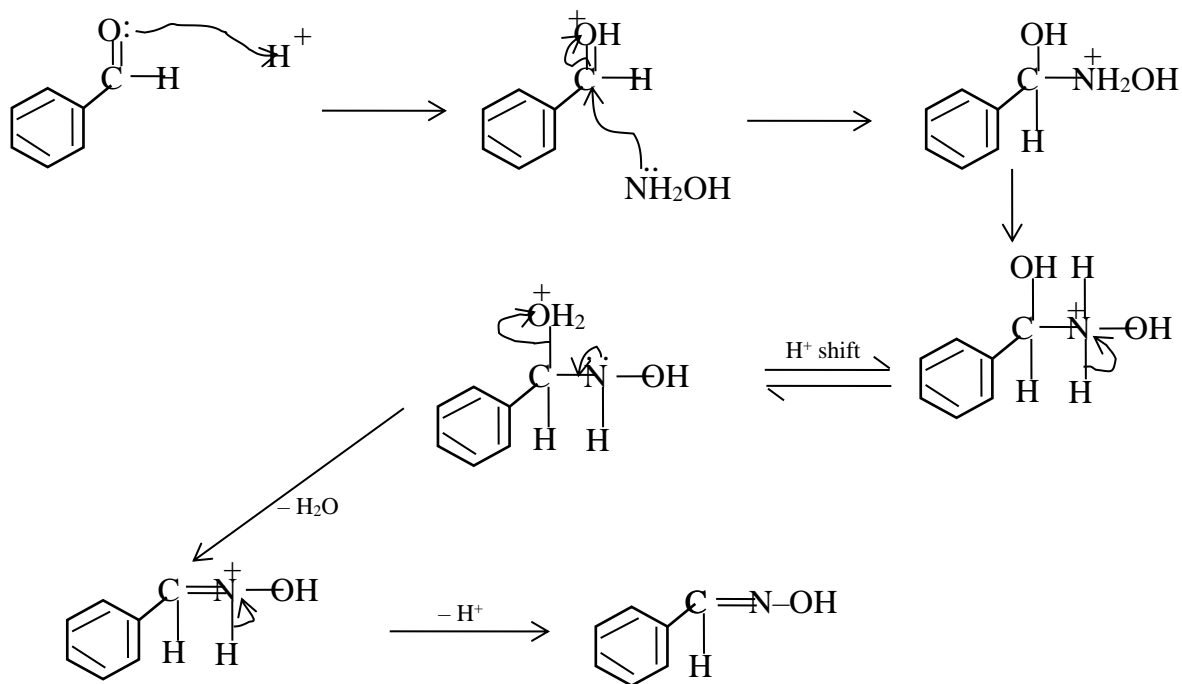
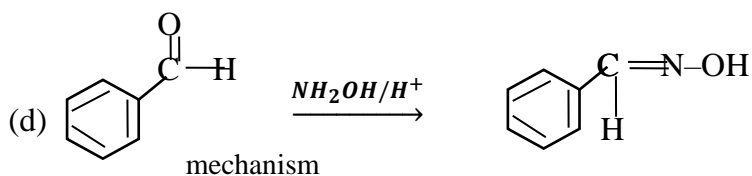
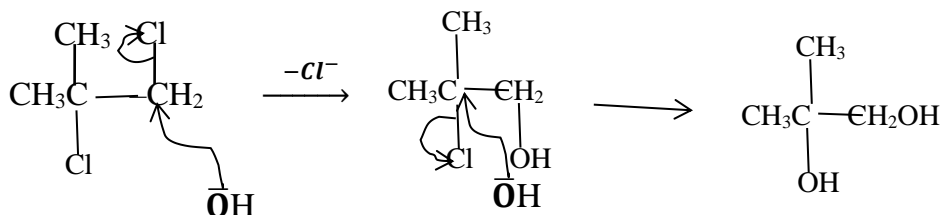
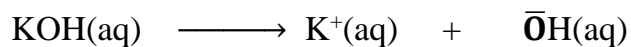
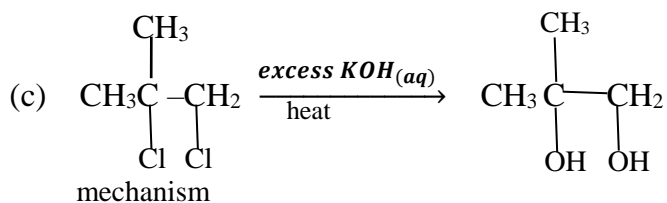
$$= -2.87 - (-2.37)$$

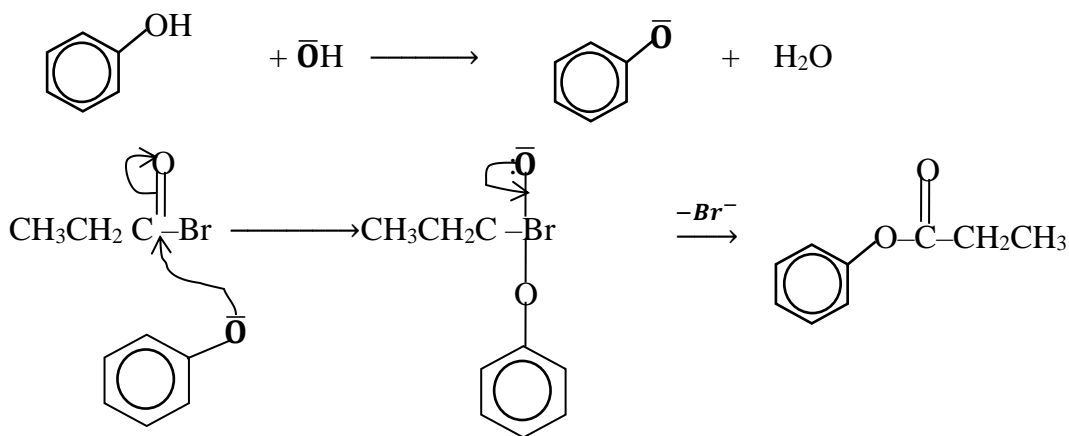
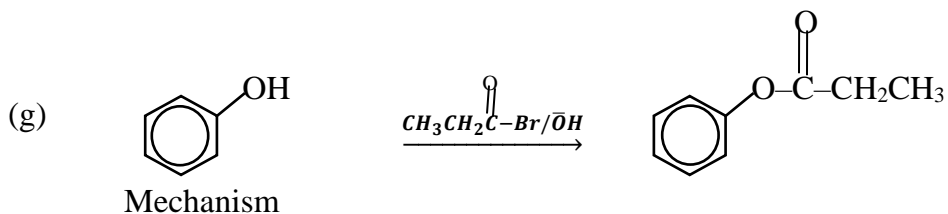
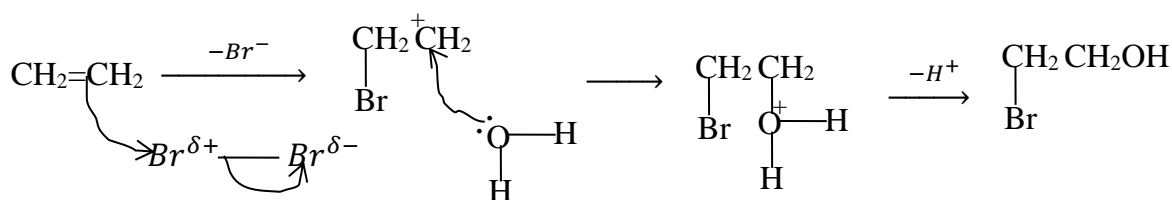
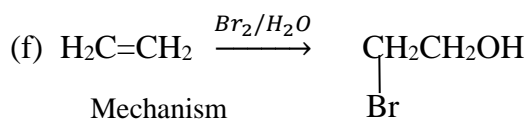
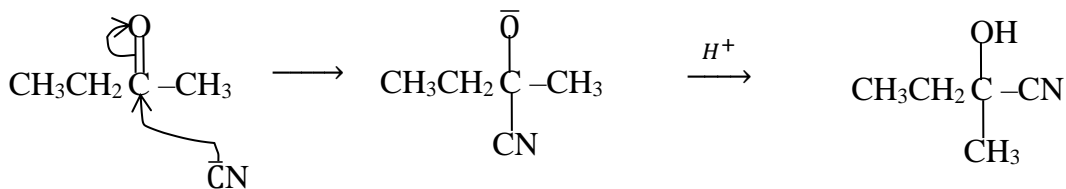
$$= -0.5V$$

ii) The cell reaction is not feasible since the E.m.f of the cell is negative.

11.







12. a) Relative atomic mass of an element is the ratio of the mass of its atom to a twelfth of the mass of carbon atom of carbon-12 isotope.

b) A vaporized sample of an element allowed to enter the ionization chamber where it is subjected to a beam of electrons from an electron gun

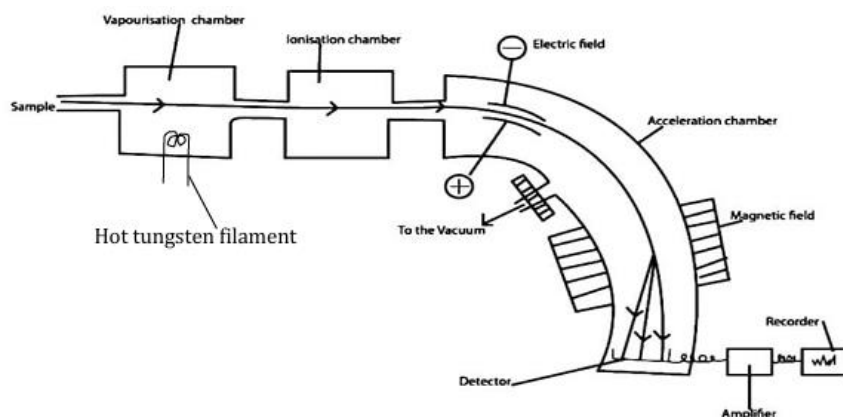
Positively charged ions are formed, they are accelerated to the same velocity by an electric field towards the magnetic field. In the magnetic field, the ions are deflected according to their charge/mass ratio

By varying both electric and magnetic field strengths, a particular set of ions is focused onto the detector



In the detector, the ions create electric impulse in form of detector current, the magnitude of each detector current proportional to the intensity of the ion producing it

The detector currents are recorded on a photographic plate as a series of lines or peaks called mass spectrum



c)i) Relative intensity is the proportion or ratio or fraction of each isotope in a given sample

$$\text{ii) R.A.M} = \frac{(24 \times 8) + (25 \times 1) + (26 \times 1)}{9 + 1 + 1}$$

$$= 24.3$$

iii) W has three isotopes,  $^{24}\text{W}$ ,  $^{25}\text{W}$ ,  $^{26}\text{W}$

d) It produces accurate relative atomic mass

It uses very small amount of the sample

e)  $2.303 \log \left( \frac{N_0}{N} \right) = Kt$

$$2.303 \log \left( \frac{680}{125} \right) = K350$$

$$K = 4.84 \times 10^{-3} \text{ s}^{-1}$$

iii)  $t_{1/2} = \frac{0.693}{k}$

$$t_{1/2} = \frac{0.693}{4.84 \times 10^{-3}}$$

143.2 seconds

13. a)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$  – 1-bromobutane

$(\text{CH}_3)_2\text{CHCH}_2\text{Br}$  – 1-bromo-2-methylpropane

$\text{CH}_3\text{CH}_2\text{CHBrCH}_3$  – 2-bromobutane

$(\text{CH}_3)_3\text{CBr}$  – 2-bromo-2-methylpropane

b)i) 1-bromobutane has the highest boiling point

ii) 2-bromo-2-methylpropane has the lowest boiling point

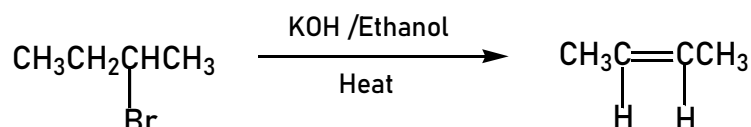
c) 1-bromobutane is a straight chain isomer and the molecules are closer to each other and this increases the intermolecular forces of attraction and thus more heat is required to break them

2-bromo-2-methylpropane is a branched isomer and increased branching gives the molecule a more spherical shape, this reduces the extent of contact between the neighboring molecules, consequently the attractive forces are reduced and therefore less energy is required to break the forces.

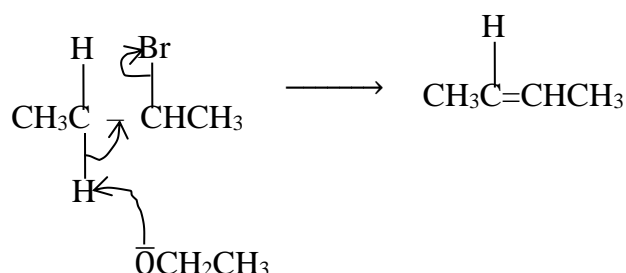
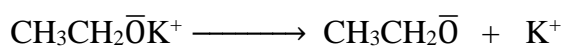
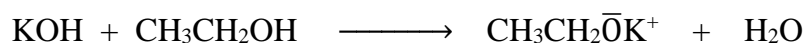
d) S- 2-bromobutane

T- Butan-2-ol

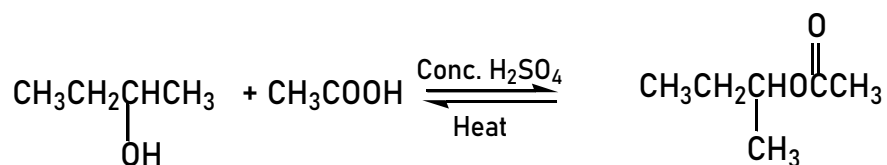
e)i)



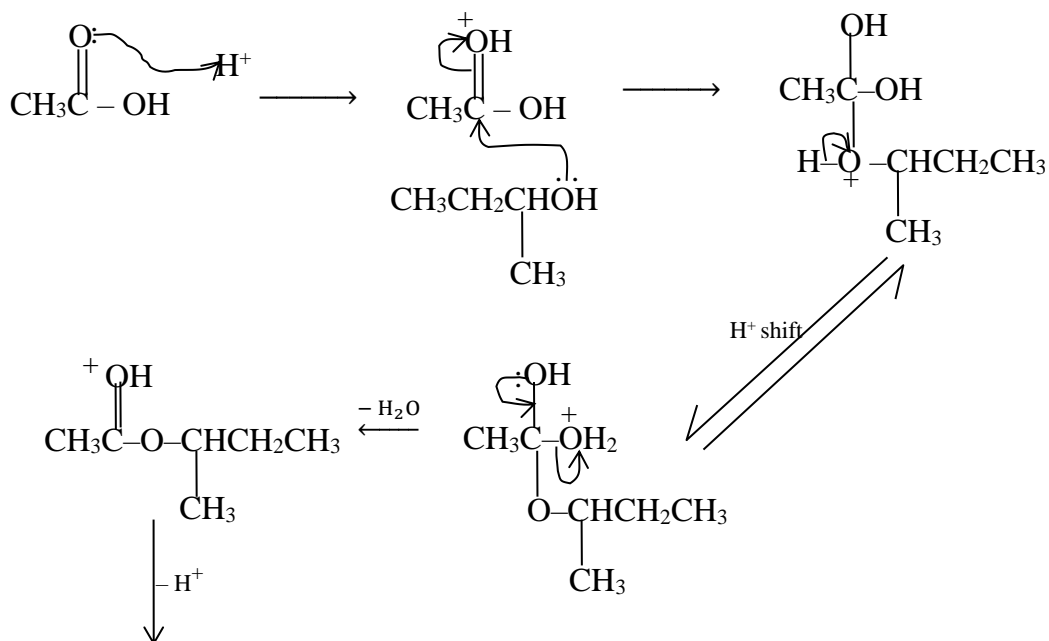
Mechanism



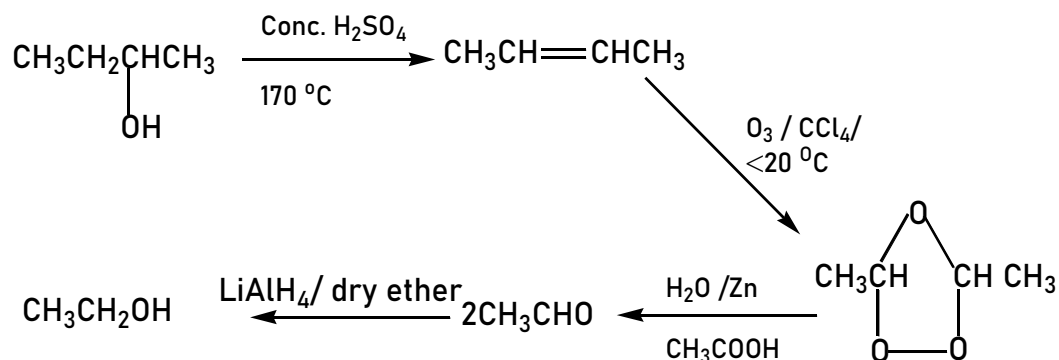
ii)



Mechanism

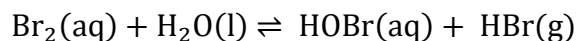
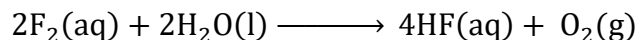


f)

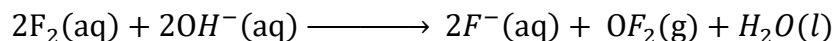


14. a)  $n\text{S}^2 n\text{P}^5$

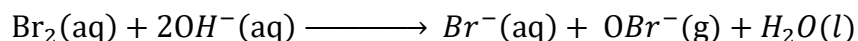
b)i) Fluorine reacts with water vigorously to form hydrofluoric acid and oxygen gas while bromine reacts with water slightly or slowly to form hypobromous acid and hydrobromic acid



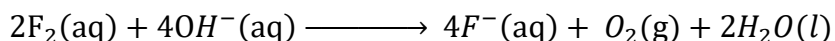
ii) Fluorine reacts with cold dilute potassium hydroxide to form potassium fluoride, oxygen difluoride and water



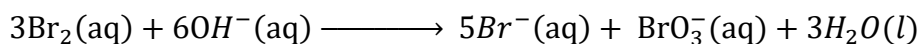
Bromine reacts with cold dilute potassium hydroxide to form potassium hydroxide to form potassium bromide, potassium hypobromite (bromate(I)) and water.



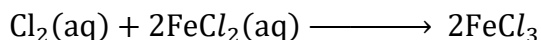
Fluorine reacts with hot concentrated potassium hydroxide solution to form potassium fluoride, oxygen gas and water



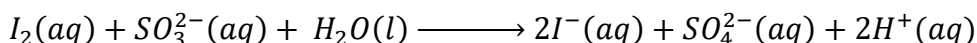
Bromine reacts with hot concentrated potassium hydroxide, potassium bromate, potassium bromide and water.



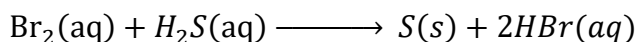
c)i) Pale green solution turned to brown solution



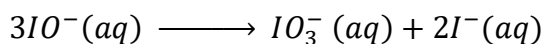
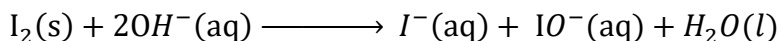
ii) Brown solution turned to colorless



iii) Yellow precipitate



iv) Grey solid dissolves to form pale yellow solution which turns colorless on standing



15. a)i) Ionic product is the product of the molar concentrations of the ions that form a sparingly soluble salt raised to appropriate powers

Solubility product is the product of the molar concentrations of the ions of a sparingly soluble salt raised to appropriate powers when a solution is saturated at a given temperature.

ii) Ionic product is not affected by temperature because the ions are already in solution. However, solubility product is affected by temperature since solubility of a sparingly soluble salt is an endothermic process, increase in temperature increases the kinetic energy of the particles of the solute and thus ions can easily break off from their lattice and this increases the concentration of the ions in solution and thus solubility product increases.

b) Excess of solid Lead(II) iodide is mixed with a known volume of distilled water. The mixture is shaken vigorously for some time until equilibrium is established at a particular temperature. The mixture is filtered to obtain a filtrate which is saturated at a given temperature. The electrolytic conductivity of the filtrate is measured using conductivity meter.

The electrolytic conductivity of pure water is also determined which can be used to determine the electrolytic conductivity of Lead(II) iodide from the formula,

$$K_{\text{solute}} = K_{\text{solution}} - K_{\text{water}}$$

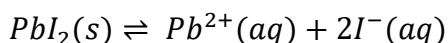
The molar conductivity of the ions of lead(II) iodide at infinite dilution are obtained from the tables in the data books and can be used to determine the molar conductivity of Lead(II) iodide at infinite dilution from the formula,

$$\Lambda^\infty PbI_2 = \Lambda^\infty Pb^{2+} + 2\Lambda^\infty I^-$$

The solubility of Lead(II) iodide can be obtained from formula,

$$\Lambda \propto \frac{K_{PbI_2}}{C}$$

If C is the solubility of Lead(II) iodide, then solubility product is obtained as;

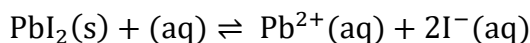


$$\begin{aligned} K_{sp} &= [Pb^{2+}][I^{-}]^2 \\ &= C(2C)^2 \\ &= 4C^3 \text{ Mol}^3\text{dm}^{-9} \end{aligned}$$

$$c) \text{ Mass of } PbI_2 = 207 + 127 \times 2 = 461.$$

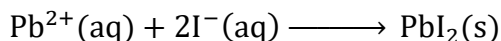
$$\text{Mass of } PbI_2 \text{ that dissolved} = \frac{11.62}{100} \times 2.5 = 0.2905 \text{ g}$$

$$[PbI_2] = \frac{0.2905}{461} = 6.3015 \times 10^{-4} \text{ mol dm}^{-3}$$



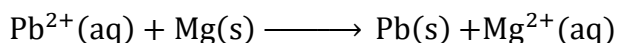
$$\begin{aligned} K_{sp} &= [Pb^{2+}][I^{-}]^2 \\ &= 6.3015 \times 10^{-4} \times (2 \times 6.3015 \times 10^{-4})^2 = 1.0003 \times 10^{-9} \text{ mol}^3\text{dm}^{-9} \end{aligned}$$

d)i) The percentage of Lead(II) iodide that dissolved would be less than 11.62% because ammonium iodide is a strong electrolyte and its addition increases the concentration of the iodide ions. The excess iodide ions will react with the few Lead(II) ions to form insoluble lead(II) iodide and the equilibrium position shifts to the left



This is done to keep the solubility product of Lead(II) iodide constant at a particular temperature, hence its solubility reduces.

ii) The solubility will be more 11.62%, because magnesium ribbon reduces the lead(II) ions to lead metal.

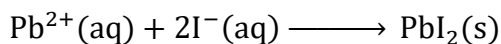


The concentration of the lead(II) ions in solution reduces, thus more lead(II) iodide dissolves to restore the concentration of lead(II) ions to keep the  $K_{sp}$  for lead(II) iodide constant.

$$e)i) \text{ Total volume of solution} = 500 + 500 = 1000 \text{ cm}^3$$

$$[Pb^{2+}] = \frac{0.025}{1000} \times 1000 = 0.025 \text{ M}$$

$$[I^{-}] = \frac{0.01325}{1000} \times 1000 = 0.01325 \text{ M}$$



$$\begin{aligned} \text{Ionic product} &= [Pb^{2+}][I^{-}]^2 \\ &= 0.025 \times [0.01325]^2 = 4.3891 \times 10^{-6} \text{ mol}^3\text{dm}^{-9} \end{aligned}$$

ii) Precipitation will occur because the ionic product has exceeded the solubility product.

$$f) K_{sp} \text{ for } Ag_2CrO_4 = [Ag^+]^2[CrO_4^{2-}]$$

$$1.3 \times 10^{-12} = [\text{Ag}^+]^2 \times 0.005$$

$$[\text{Ag}^+] = \sqrt{\frac{1.3 \times 10^{-12}}{0.005}} = 1.61245 \times 10^{-5} \text{ mol dm}^{-3}$$

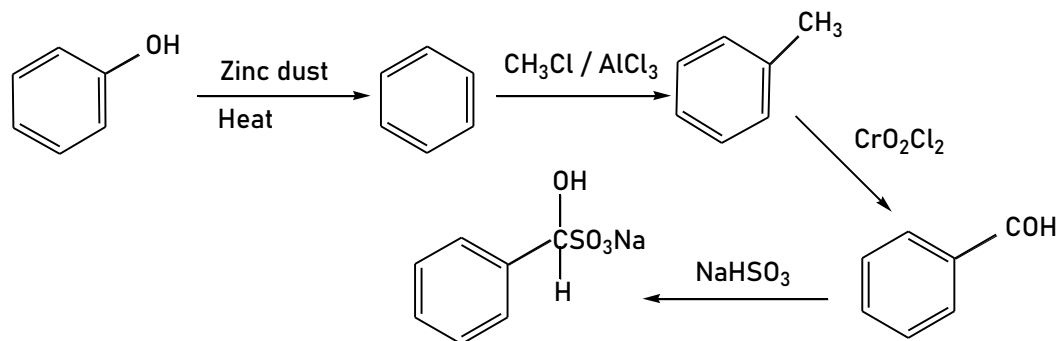
$$K_{sp} \text{ for AgCl} = [\text{Ag}^+][\text{Cl}^-]$$

$$1.8 \times 10^{-10} = [\text{Ag}^+] \times 0.005$$

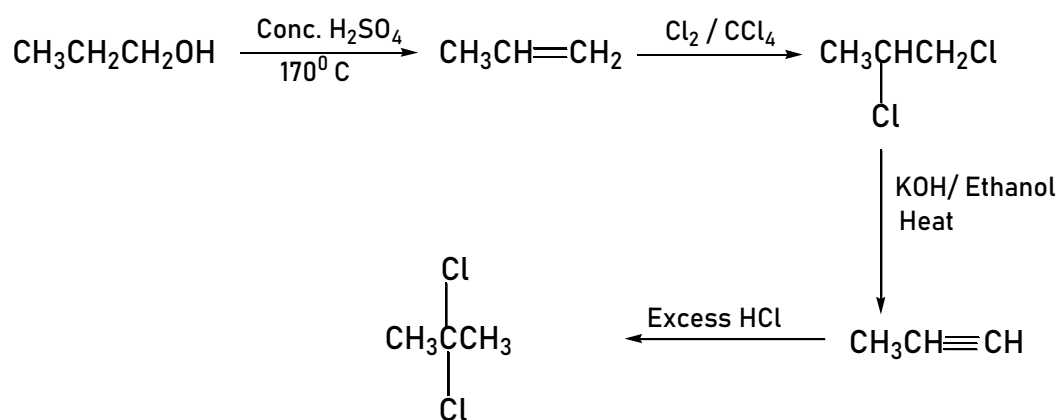
$$[\text{Ag}^+] = \frac{1.8 \times 10^{-10}}{0.005} = 3.6 \times 10^{-8} \text{ mol dm}^{-3}$$

Silver chloride precipitates first because it requires a much smaller amount of silver ions to precipitate.

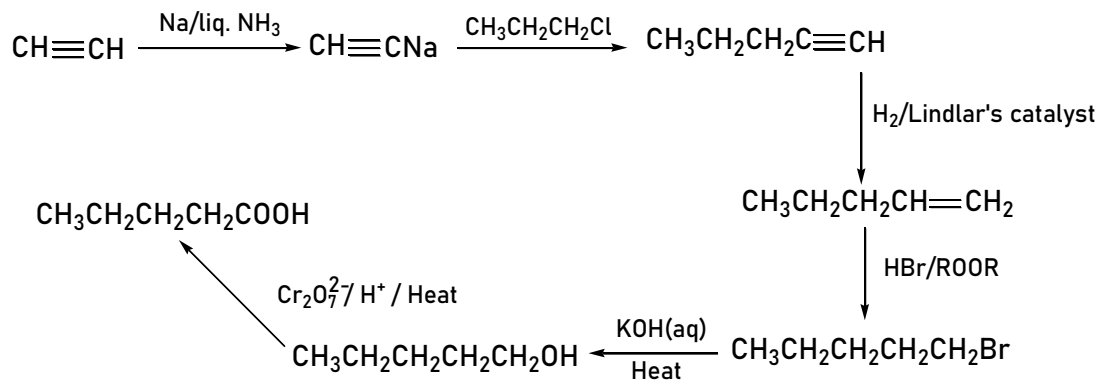
16.



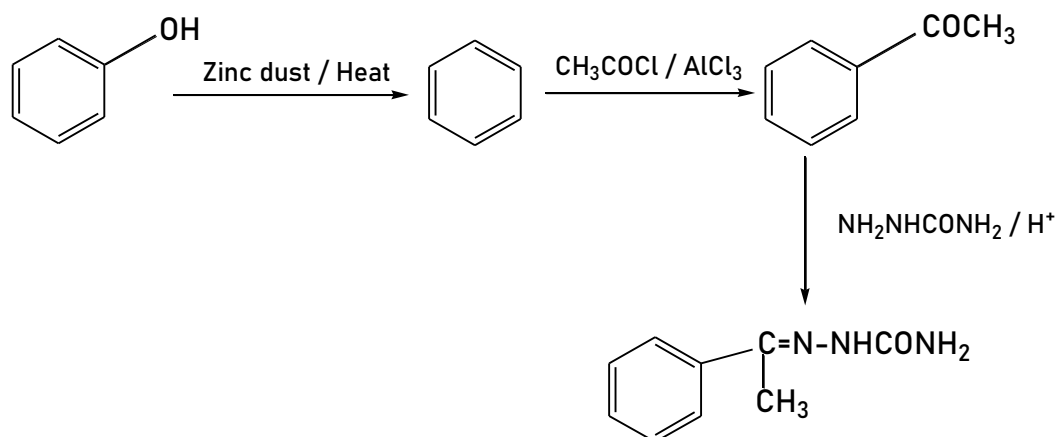
b)



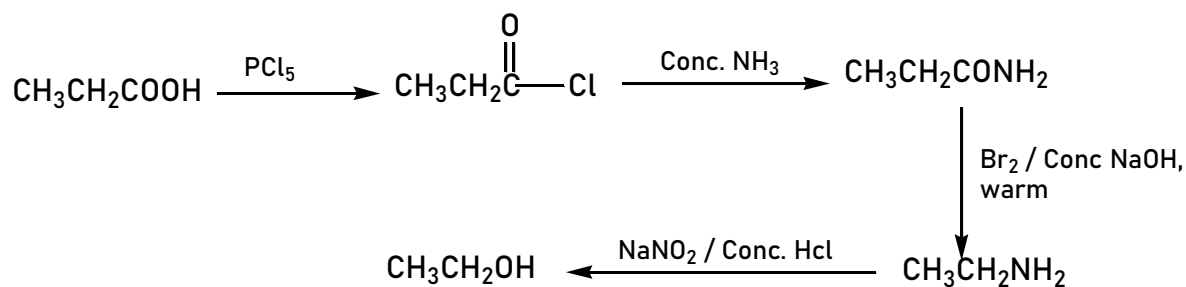
c)



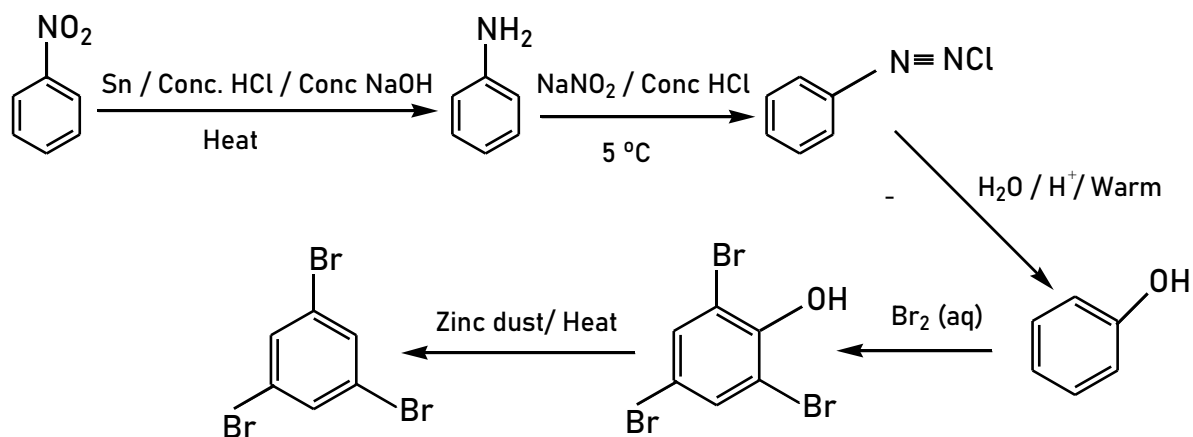
d)



e)



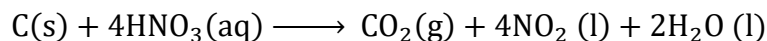
f)



17a)i) +2 and +4

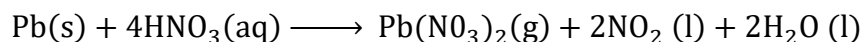
ii) +2 oxidation state increases down the group while stability of +4 oxidation decreases down the group due to inert pair effect which increases with increases in atomic radius.

b)i) Carbon, germanium and tin react with hot concentrated nitric acid to form dioxides, nitrogen dioxide and water.



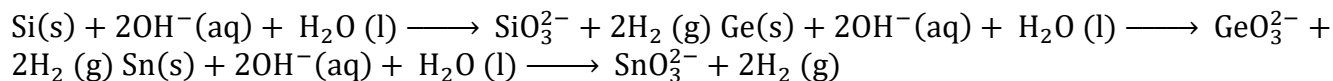
Silicon does not react with nitric acid under any conditions

Lead reacts with hot concentrated nitric acid to form Lead(II) nitrate, nitrogen dioxide and water

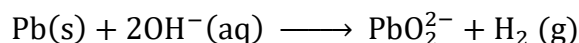


ii) Carbon does not react sodium hydroxide under any condition

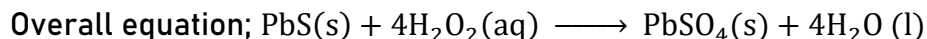
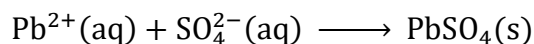
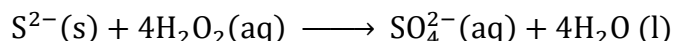
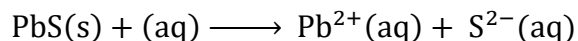
Silicon, germanium, and tin react with hot concentrated sodium hydroxide to form silicate(IV), germinate(VI) and stannate(VI) together with hydrogen gas



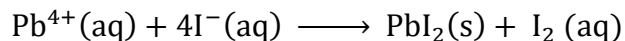
Lead reacts with hot concentrated sodium hydroxide solution to form plumbate(II) and hydrogen gas



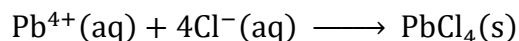
c)i) Hydrogen peroxide oxidizes sulphide ions to sulphate ions which react with lead(II) ions to form lead(II) sulphate.



ii) Iodide ions have a bigger ionic radius than chloride ions, iodide ions act as strong reducing agent which reduces lead(IV) ions to lead(II) ions and iodide ions oxidized to iodine



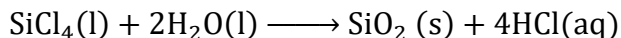
Lead(IV) oxide does not form, instead lead(II) iodide forms. The chloride ions are weaker reducing agents and thus cannot reduce lead(IV) ions to Lead(II) ions. Therefore Lead(IV) chloride can be formed from Lead(IV) ions and chloride ions.



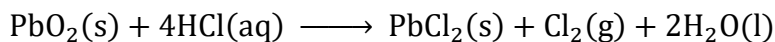
iii) Carbon atom in tetrachloromethane has a smaller atomic radius than silicon in silicon tetrachloride, carbon does not have accessible empty d-orbitals to accommodate lone pairs of electrons from water molecules while silicon has accessible empty d-orbitals to accommodate



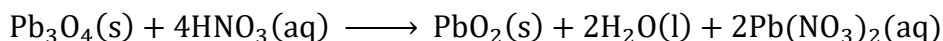
lone pairs of electrons from water molecules thus silicon(IV) chloride reacts with water to form silicon(IV) oxide and hydrochloric acid.



iv) Lead(IV) oxide is a strong oxidizing agent which oxidizes hydrochloric acid to chlorine and itself reduced to Lead(II) chloride which is insoluble in cold solution



v) Trileadtetraoxide is a mixed oxide containing lead(II) oxide and lead(IV) oxide, lead(IV) oxide being acid in nature does not react with nitric acid instead it is released in the solution to form insoluble solid while lead(II) oxide being basic reacts with nitric acid to form lead(II) nitrate which is a soluble compound.



18.a) i) Order of reaction is the sum of the powers to which the molar concentration terms of the reactants are raised in an experimentally determined rate equation.

ii) Molecularity is the number of chemical species taking part in the rate determining step of the reaction mechanism.

iii) Activation energy is the minimum amount of energy possessed by the reactants for the reaction to take place.

b) i) Rate =  $K[\text{H}_2\text{O}_2]$

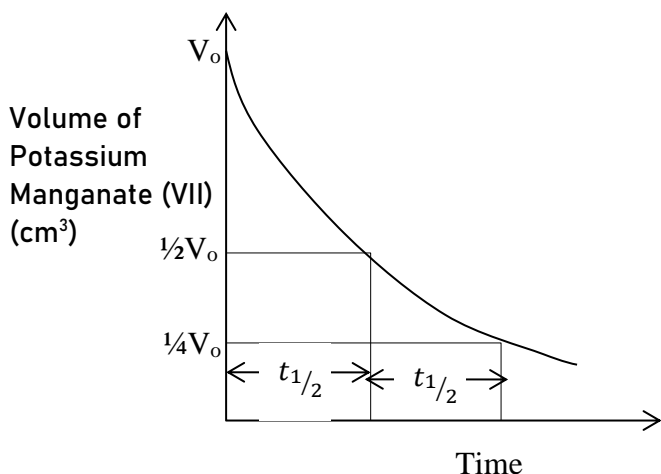
ii) A known volume of hydrogen peroxide of known concentration is placed in a flask.

A small amount of Iron(III) chloride solution is added followed by a small amount of sodium hydroxide solution and a stop clock is simultaneously started.

The mixture is shaken and allowed to stand at a constant temperature. After specific intervals of time, known volumes of the reaction mixture are pipetted into other conical flasks containing dilute sulphuric acid. The base in the reaction mixture is neutralized and the reaction stops.

The mixtures are titrated against standard potassium permanganate solution. The volumes of potassium permanganate solution are directly proportional to the concentration of hydrogen peroxide remaining in the reaction mixture.

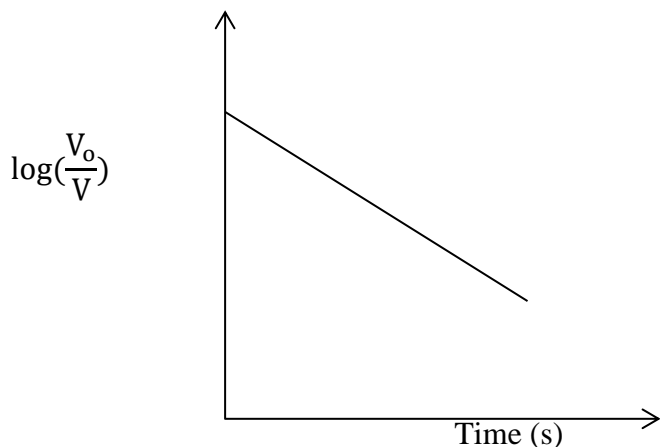
A graph of volume of potassium permanganate solution against time is plotted.



From the graph, half-lives are equal, implying that the reaction is first order kinetics.

Or

A graph of  $\log\left(\frac{V_0}{V}\right)$  against time is plotted.



A straight line graph with negative gradient implies that the reaction is first order.

iii) Increase in temperature increases the rate of decomposition of hydrogen peroxide. Increase in temperature increases the kinetic energy of the molecules and this increases the frequency of collision of molecules. The number of molecules acquiring activation energy increases.

c)

$[H_2O_2]$ (mol dm <sup>-3</sup> )	0.0013	0.00076	0.00036	0.00014	0.0001
Time (min)	5	12	20	33	40
Log $[H_2O_2]$	-2.89	-3.12	-3.44	-3.85	-4.0

On graph paper.

d)i) Initial concentration of  $H_2O_2 = 10^{-2.7} = 0.001995 \text{ mol dm}^{-3}$

$$\text{ii) Slope} = \frac{-4.2 - (-2.55)}{42.5 - 1.5}$$

$$= -0.04024 \text{ min}^{-1}$$

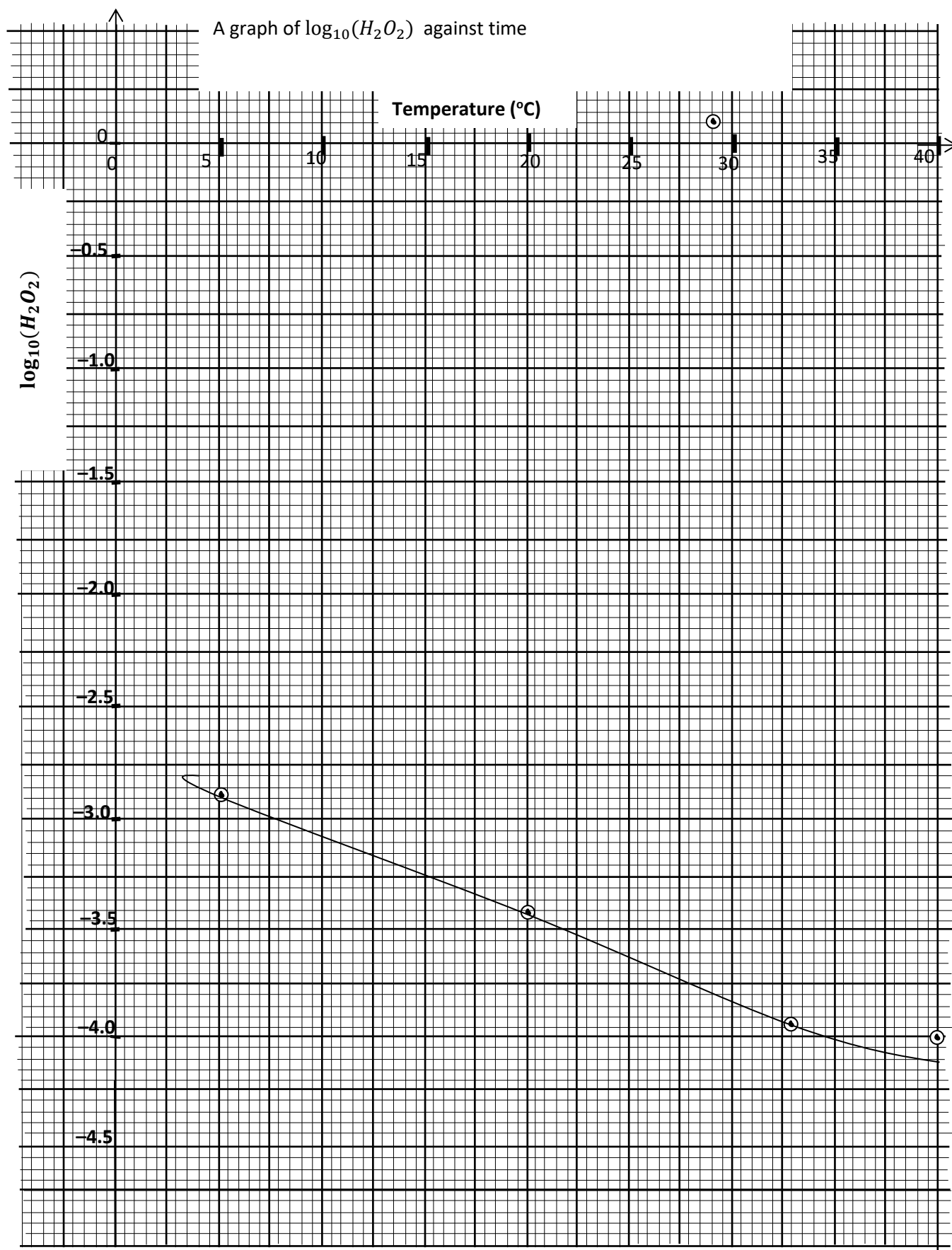
$$\text{Slope} = \frac{-k}{2.303}$$

$$K = 0.092682 \text{ min}^{-1}$$

$$\text{Half-life, } t_{\frac{1}{2}} = \frac{0.693}{k}$$

$$= \frac{0.693}{0.092682}$$

$$= 7.48 \text{ minutes.}$$



19. a)i) A buffer solution is a solution which resists change in pH when a small amount of an acid or a base are added to it.

ii) Salt hydrolysis is the reaction of a salt with water to produce products that affect the pH of the water.

$$\begin{aligned} \text{b) i)} \quad [H^+] &= \alpha C \\ &= 0.025 \times 0.02 = 5.25 \times 10^{-4} \text{ mol dm}^{-3} \\ \text{pH} &= -\log[H^+] \\ &= -\log(5.25 \times 10^{-4}) = 3.28 \end{aligned}$$

$$\begin{aligned} \text{ii)} \quad K_a &= \frac{C\alpha^2}{1-\alpha} \\ &= \frac{0.021 \times 0.025^2}{1 - 0.025} \\ &= 1.346 \times 10^{-5} \text{ mol dm}^{-3} \end{aligned}$$

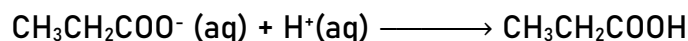
$$\begin{aligned} \text{c)i) New pH} &= 3.28 + 2.34 \\ &= 5.62 \end{aligned}$$

$$\begin{aligned} \text{pH} &= \text{p}K_a + \log\left[\frac{[\text{salt}]}{[\text{acid}]}\right] \\ 5.62 &= -\log 1.346 \times 10^{-5} + \log\left[\frac{[\text{salt}]}{0.021}\right] \\ [\text{Salt}] &= 0.11782 \text{ mol dm}^{-3} \end{aligned}$$

$$\text{RFM of CH}_3\text{CH}_2\text{COOK} = (12 \times 3) + (1 \times 5) + (16 \times 2) + (39 \times 1) = 112$$

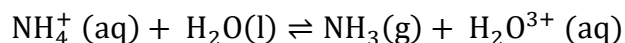
$$\text{Mass of CH}_3\text{CH}_2\text{COOK} = 112 \times 0.11782 = 13.1958 \text{ g}$$

ii) Addition of potassium propanoate increases the concentration of propanoate ions since potassium propanoate is a strong electrolyte. The excess propanoate ions react with hydrogen ions from the partial ionization of propanoic acid. This is done to keep the  $K_a$  the same.



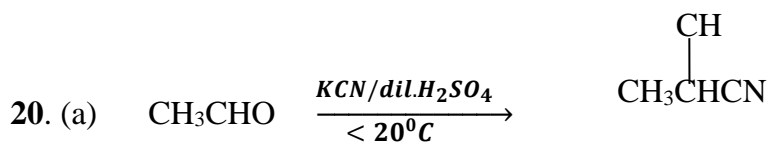
The concentration of the hydrogen ions in solution reduces resulting into increase in pH

d)i) Ammonium ions undergo hydrolysis in aqueous solution to produce hydroxonium ions that react with magnesium ribbon to produce hydrogen gas.

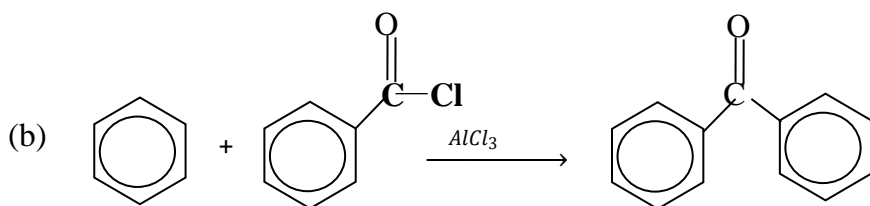
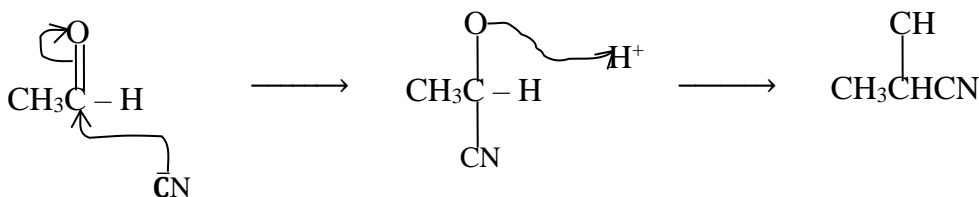
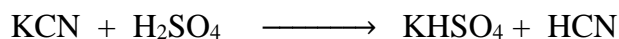


ii) In benzoic acid, the carbonyl functional group is attached directly to the benzene ring. The delocalized pi electrons of the benzene ring exerts a negative inductive effect which weakens the oxygen-hydrogen bond. In aqueous solution, benzoic acid can easily donate protons and a solution has a relatively high concentration of hydrogen ions.

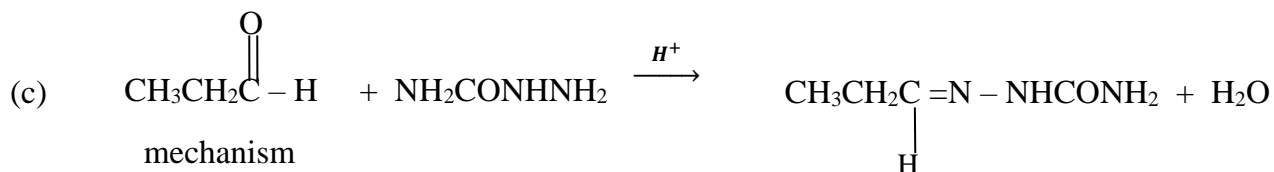
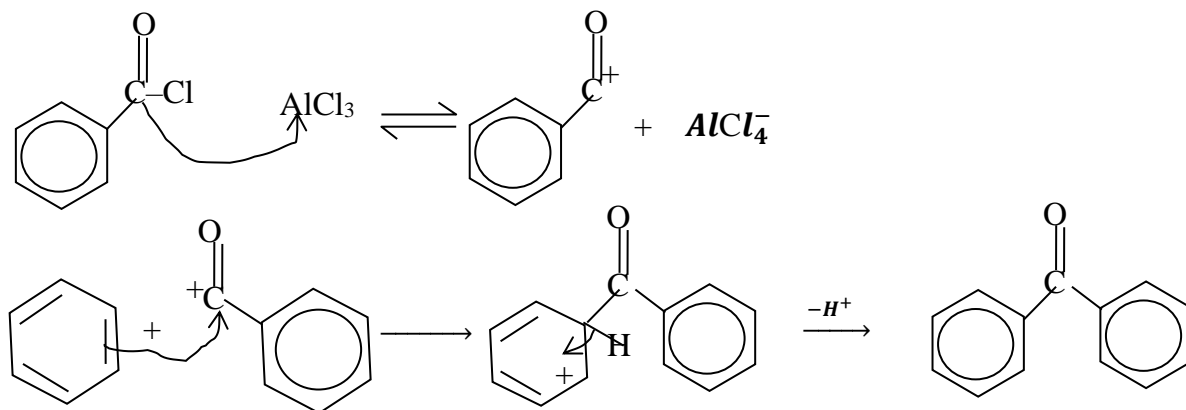
In propanoic acid, the ethyl group attached to the carboxyl group exerts a positive inductive effect which strengthens the oxygen-hydrogen bond and the aqueous solution of propanoic acid has a relatively low concentration of hydrogen ions.

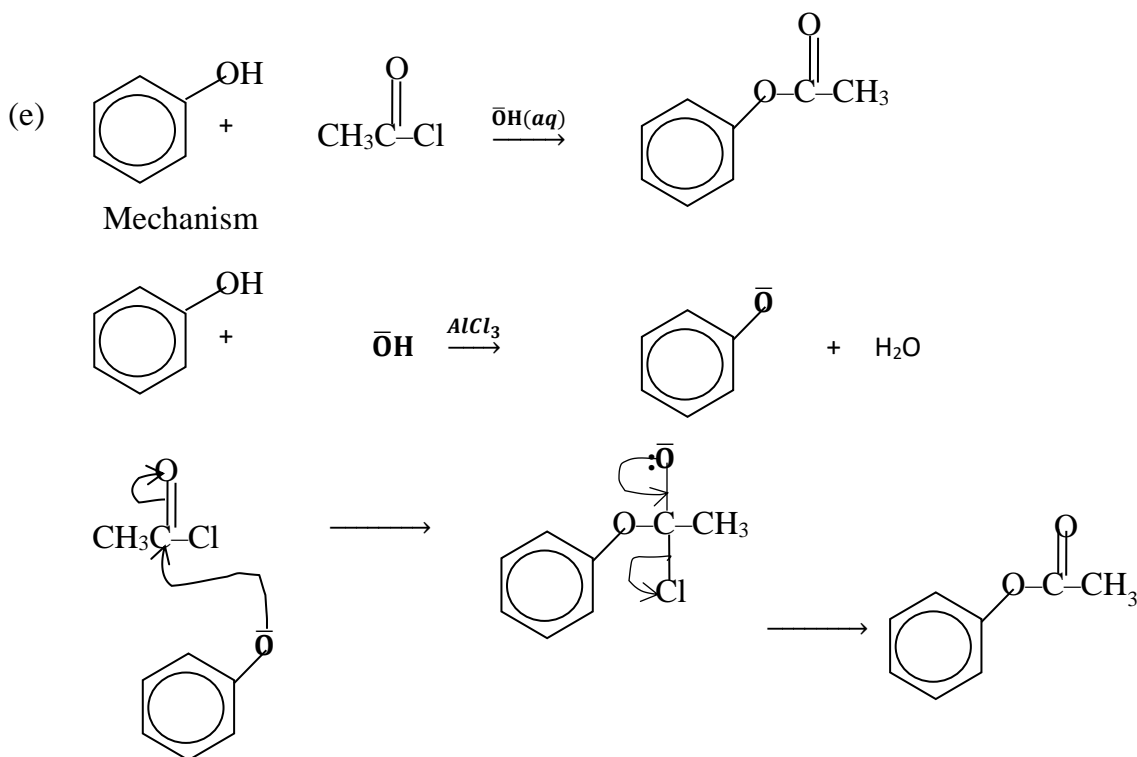
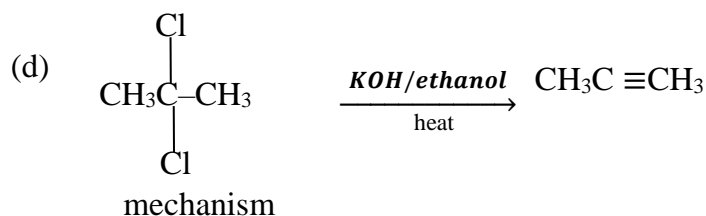
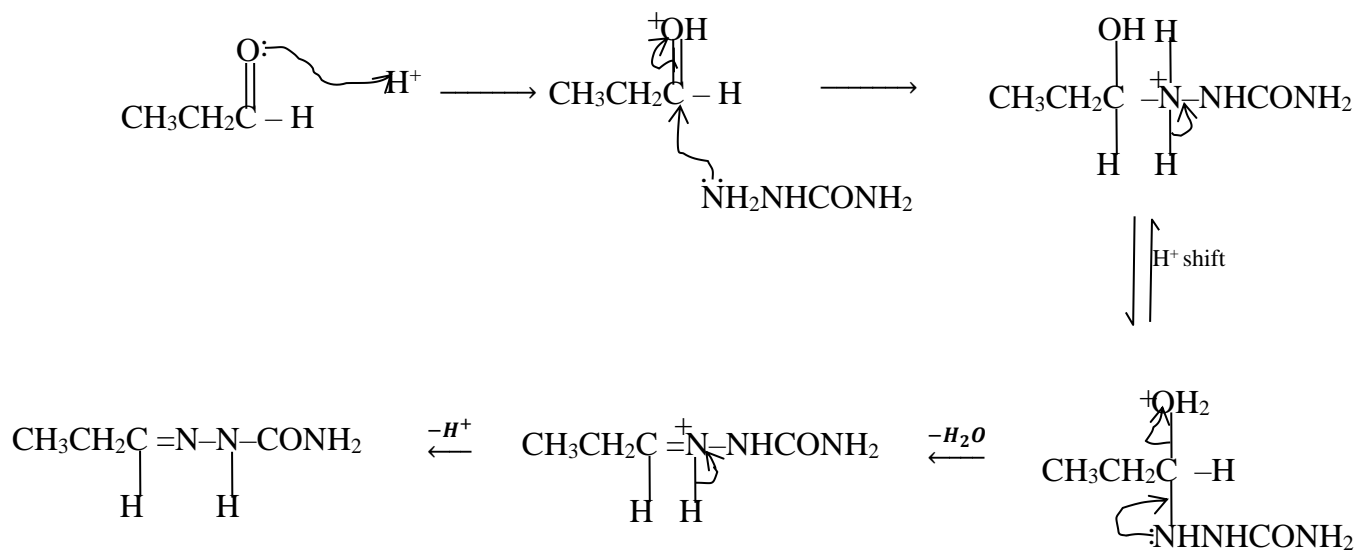


mechanism



Mechanism





21. a) Steam distillation is a technique of separation of a volatile component which is immiscible with water from a mixture containing a nonvolatile impurities by passing steam through the mixture at a temperature below the boiling point of water.

b) The principle is that when an immiscible mixture of two liquids is heated, each liquid will vaporize independent of each other and the vapour pressure above the mixture is the sum of the

individual vapour pressures. The total vapour pressure can easily reach external atmospheric pressure and the mixture boils at temperature below the boiling points of either liquids.

c)i) The component to be steam distilled must be immiscible with water

The components to be steam must be volatile.

The impurities must be nonvolatile.

The component should have high relative molecular mass such that much of it is isolated in the distillate.

The components should exert high vapour pressure near the boiling point of water.

ii) The component is isolated in much purer state.

Decomposition of the component near its boiling point is avoided.

d)

Temperature (°C)	40	50	60	70	80	90	100	110	120
Vapour pressure of phenylamine (mmHg)	10	20	25	32	40	50	55	65	80
Vapour pressure of water(mmHg)	629	632	645	655	670	690	710	730	760
Total vapour pressure of mixture(mmHg)	639	652	670	687	710	740	765	795	840

i) On graph paper.

ii) At 760 mmHg,  $P^{\circ}\text{H}_2\text{O} = 705 \text{ mmHg}$  and  $P^{\circ}\text{amine} = 55 \text{ mmHg}$ .

$$\frac{\text{Mass of phenylamine in distillate}}{\text{Mass of water in distillate}} = \frac{V.P \times \text{RMM of amine}}{V.P \times \text{RMM of water}}$$

RMM of Phenylamine = 93                  RMM of water = 18.

$$\frac{\text{Mass of phenylamine in distillate}}{\text{Mass of water in distillate}} = \frac{55 \times 93}{705 \times 18}$$

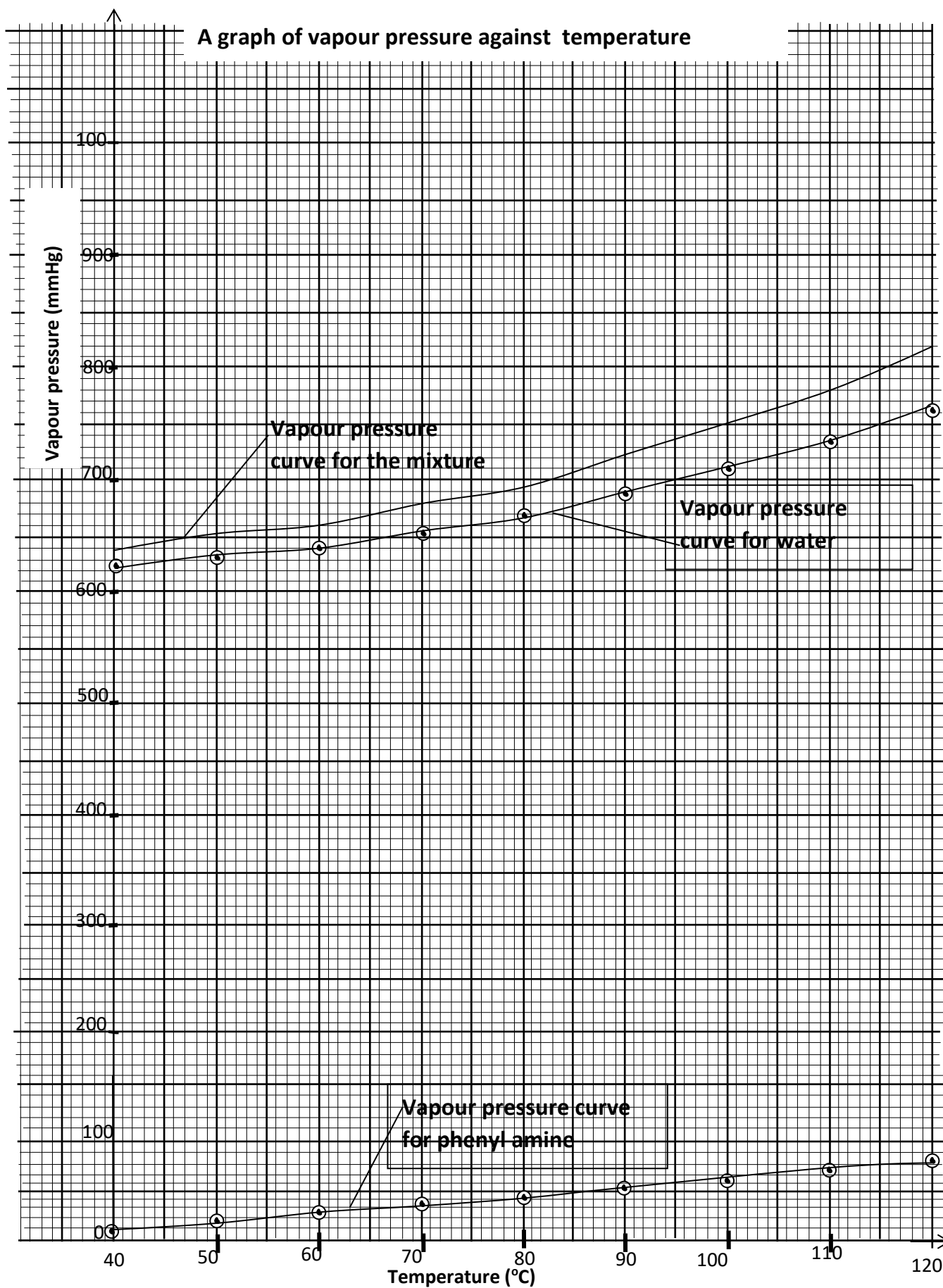
$$= 0.40307$$

The ratio of ammine to water is 0.40307:1

$$\text{Percentage of phenylamine} = \frac{0.4037}{1.40307} \times 100$$

$$= 28.73\%$$

A graph of vapour pressure against temperature





e) Let the mass extracted by 100 cm<sup>3</sup> of ether be X g

$$K_D = \frac{[Q]_{\text{Ether}}}{[Q]_{\text{Water}}}$$

$$2.0 = \frac{x}{100} \times \frac{10-x}{50}$$

$$X = 8 \text{ g}$$

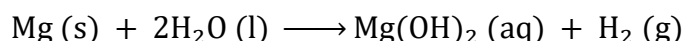
Mass that remained in the aqueous layer;  $10 - 8 = 2 \text{ g}$

$$\text{Percentage of Q extracted by the ether layer} = \frac{8}{10} \times 100 = 80\%$$

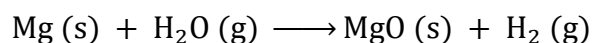
$$\text{Percentage that remained in the aqueous layer} = \frac{2}{10} \times 100 = 20\%$$

22. a) Electropositivity of group(II) elements increases down the group. Down the group, both screening effect and nuclear charge increase due to addition of an extra shell of electrons and more protons to the nucleus respectively. However, increase in screening effect outweighs increase in nuclear charge. Thus, effective nuclear attraction decreases, and the outer electrons are not strongly attracted to the nucleus, therefore the outermost electrons can easily be lost.

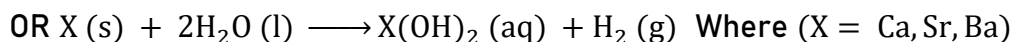
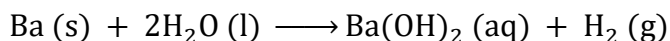
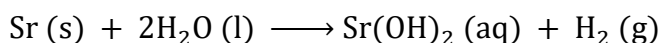
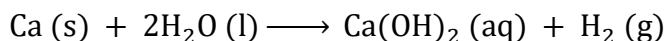
b)(i) Beryllium does not react with water under any condition. Magnesium reacts slowly with cold water forming magnesium hydroxide and hydrogen gas.



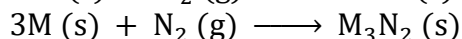
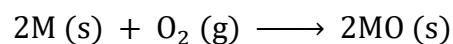
However, heated magnesium reacts vigorously with steam to form magnesium oxide and hydrogen gas.



The rest of the elements react with cold water vigorously to form hydroxides and hydrogen gas.



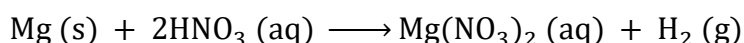
(ii) All group (II) metals react with dry air when heated to form monoxides (normal oxides) and nitrides.



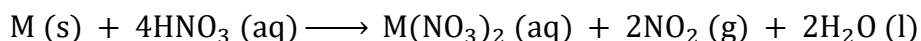
Where M = Be, Mg, Ca, Sr, Ba

(iii) Beryllium does not react with nitric acid under any condition.

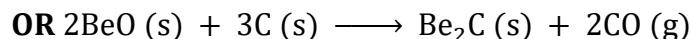
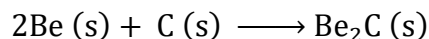
Magnesium reacts with very cold dilute nitric acid to form magnesium nitrate and hydrogen gas.



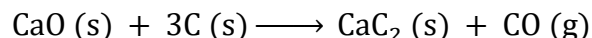
The rest of the metals including magnesium react with hot concentrated nitric acid to form metal nitrate, nitrogen dioxide gas and water.



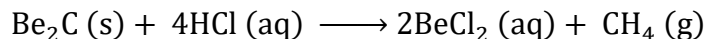
c)(i) Beryllium carbide is formed when beryllium is mixed with carbon and the mixture heated strongly at 950°C. It may also be prepared by reduction of beryllium oxide with carbon at a temperature above 1500°C.



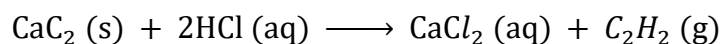
Calcium carbide is prepared by heating a mixture of calcium oxide (lime) and coke in an electric furnace at 2200 °C.



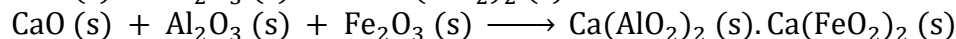
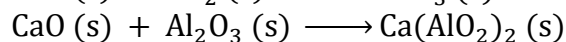
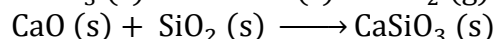
(ii) Beryllium carbide reacts with dilute hydrochloric acid to form beryllium chloride and methane.



Calcium carbide reacts with dilute hydrochloric acid to form calcium chloride and ethyne.

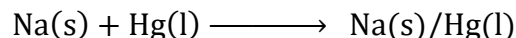
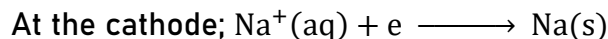
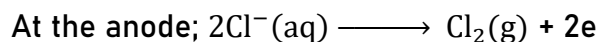


d)(i) Cement is manufactured is manufactured from limestone, silica, alumina and iron ore. Silica, alumina and iron ore come from clay. These substances are mixed, and the mixture crushed into fine powder. The fine powder is heated in a kiln at 2000 °C. Other ingredients such as ash (powdered coal) and gypsum (magnesium sulphate) are added to the mixture to obtain good quality cement. Gypsum delays setting of cement.

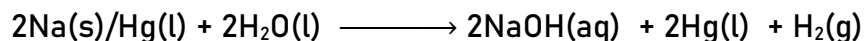


(ii) Concrete is a mixture of cement, sand, stones (gravel) and water. It becomes very hard on standing.

23. A concentrated solution of sodium chloride is electrolyzed using graphite anode and flowing mercury as the cathode.

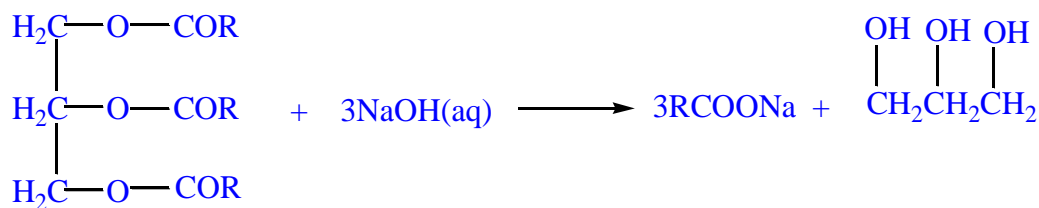


The sodium amalgam is dissolved in water to form sodium hydroxide solution.



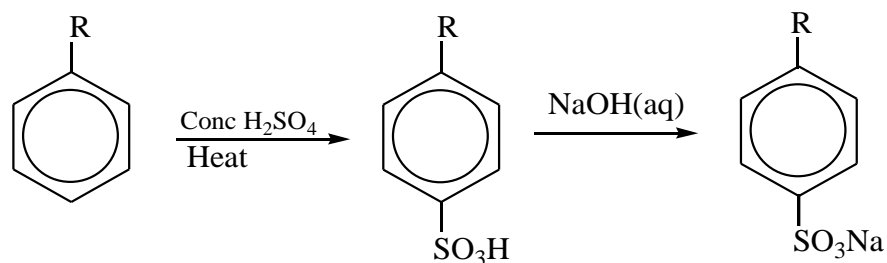
b)i) Animal fat or vegetable oil and sodium chloride

ii) The animal fat or vegetable oil is heated strongly with concentrated sodium hydroxide while stirring the mixture. The liquid mixture is removed from heat source and then concentrated sodium chloride solution is added while stirring the mixture in order to precipitate out the soap. The mixture is allowed to cool and the soap formed is removed then washed.



c) The soap lowers the surface tension between the dirt and the water. As soap is rubbed on a dirty fabric or as the dirty material is agitated with soap in the presence of water, the hydrophobic part attaches to the dirt and removes it. The hydrophilic part of soap dissolves in water. The hydrophobic part forms globules with dirt which is repelled and dispersed by water molecules hence the material being cleansed.

d)i)



d)ii) Sodium sulphate; increases the bulk of the powder making it economically profitable to the manufacturer

Sodium triphosphate; helps to form soluble calcium salts by reacting with calcium ions

Sodium perborate; gives the detergent the bleaching action.

e) Advantages.

Do not form scum with hard water

Form almost neutral aqueous solutions since they are derived from fairly strong acids and strong bases.

24. a) Temperature above which a vapour of a substance cannot be liquefied by increasing pressure

b)i) F-Solid

G- Solid

H- Vapour

ii) B-Transition temperature

C- Tripple point

D- Critical point

c) The vapor phase changed to liquid phase and volume decreased.

# PRACTICAL.

Number 1

Volume of pipette used = .....25.0 cm<sup>3</sup>

Final burette reading (cm <sup>3</sup> )	16.20	32.20	48.20
Initial burette reading (cm <sup>3</sup> )	0.00	16.20	32.20
Volume of FA1 used (cm <sup>3</sup> )	16.20	16.00	16.00

(a)(i) 16.00, 16.00

(ii)  $\frac{16.00+16.00}{2} = 16.00$

## Questions

(b)(i) (Na = 23, S = 32, O = 16)

Molar mass of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> = 2x23+32x2+16x3 = 158g

158g of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> contains 1 mole of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions

18.96g of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> contains  $\frac{18.96}{158} = 0.12$  mole of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions

1000cm<sup>3</sup> of FA1 contains 0.12 moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions

16.00cm<sup>3</sup> of FA1 contains  $\frac{0.12 \times 16}{1000} = 1.92 \times 10^{-3}$  moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions

2 moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions react with 1 mole of iodine

$1.92 \times 10^{-3}$  moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions react with  $\frac{1}{2} \times 1.92 \times 10^{-3} = 9.6 \times 10^{-4}$  moles of iodine

Moles of iodine that reacted with thiosulphate ions =  $9.6 \times 10^{-4}$

(ii) 5moles of iodine are liberated or produced by 2 moles of MnO<sub>4</sub><sup>-</sup>

$9.6 \times 10^{-4}$  moles of iodine are produced by  $\frac{2}{5} \times 9.6 \times 10^{-4} = 3.84 \times 10^{-4}$  moles of MnO<sub>4</sub><sup>-</sup>

25cm<sup>3</sup> of FA3 contains  $3.84 \times 10^{-4}$  moles of MnO<sub>4</sub><sup>-</sup>

100cm<sup>3</sup> of FA3 contains  $\frac{3.84 \times 10^{-4} \times 100}{25} = 1.536 \times 10^{-3}$  moles of MnO<sub>4</sub><sup>-</sup>.

(b) Moles of MnO<sub>4</sub><sup>-</sup> in 100cm<sup>3</sup> of FA3 = moles of MnO<sub>4</sub><sup>-</sup> in 65 cm<sup>3</sup> of FA2

65cm<sup>3</sup> of FA2 contains  $1.536 \times 10^{-3}$  moles of MnO<sub>4</sub><sup>-</sup>.

1000cm<sup>3</sup> of FA2 contains  $\frac{1.536 \times 10^{-3} \times 1000}{65} = 0.24$  moles of MnO<sub>4</sub><sup>-</sup>.

## Part II

Mass of weighing bottle +T = .....35.0g

Mass of weighing bottle alone = .....33.5g

Mass of T used = .....1.5g

## Part III

Volume of pipette used = ..... 25cm<sup>3</sup> ( $\frac{1}{2}$  mark)

Final burette reading (cm <sup>3</sup> )	21.00	41.80	20.80
Initial burette reading (cm <sup>3</sup> )	0.00	21.00	0.00
Volume of FA2 used (cm <sup>3</sup> )	21.00	20.80	20.80

(a)(i) 20.80, 20.80

(ii)  $\frac{20.80+20.80}{2} = 20.80$

(b)(i) 1000cm<sup>3</sup> of FA2 contain 0.024 moles of MnO<sub>4</sub><sup>-</sup>

20.80cm<sup>3</sup> of FA2 contain  $\frac{0.024 \times 20.80}{1000} = 4.99 \times 10^{-4}$  moles of MnO<sub>4</sub><sup>-</sup>.

(ii) Manganate (VII) reacts with both Fe<sup>2+</sup> and C<sub>2</sub>O<sub>4</sub><sup>2-</sup> in the ratio 1:2

Moles of MnO<sub>4</sub><sup>-</sup> that reacted with Fe<sup>2+</sup> =  $\frac{1}{3} \times 4.99 \times 10^{-4} = 1.66 \times 10^{-4}$

1 Moles of MnO<sub>4</sub><sup>-</sup> react with 5 moles of Fe<sup>2+</sup>

$1.66 \times 10^{-4}$  Moles of MnO<sub>4</sub><sup>-</sup> react with  $5 \times 1.66 \times 10^{-4} = 8.3 \times 10^{-4}$  moles of Fe<sup>2+</sup>

(iii) Moles of MnO<sub>4</sub><sup>-</sup> that reacted with C<sub>2</sub>O<sub>4</sub><sup>2-</sup> =  $4.99 \times 10^{-4} - 1.66 \times 10^{-4} = 3.33 \times 10^{-4}$

2 Moles of MnO<sub>4</sub><sup>-</sup> react with 5 moles of C<sub>2</sub>O<sub>4</sub><sup>2-</sup>

$3.33 \times 10^{-4}$  Moles of MnO<sub>4</sub><sup>-</sup> react with  $\frac{5 \times 3.33 \times 10^{-4}}{2} = 8.3 \times 10^{-4}$  moles of C<sub>2</sub>O<sub>4</sub><sup>2-</sup>

(b )i) Values x and y in solid T

$$\begin{array}{cc} \text{Moles Fe}^{2+} & \text{C}_2\text{O}_4^{2-} \\ 8.3 \times 10^{-4} & 8.3 \times 10^{-4} \\ 8.3 \times 10^{-4} & 8.3 \times 10^{-4} \\ \hline 8.3 \times 10^{-4} & 8.3 \times 10^{-4} \\ & 1:1 \end{array}$$

X= 1, Y=1

ii) (Fe = 56, C = 12, O = 16, H = 1)

Moles of Moles Fe<sup>2+</sup> = C<sub>2</sub>O<sub>4</sub><sup>2-</sup> = FeC<sub>2</sub>O<sub>4</sub>.nH<sub>2</sub>O =  $8.3 \times 10^{-4}$

25cm<sup>3</sup> of FA4 contains  $8.3 \times 10^{-4}$  moles FeC<sub>2</sub>O<sub>4</sub>.nH<sub>2</sub>O

250cm<sup>3</sup> of FA4 contains  $\frac{250}{25} \times 8.3 \times 10^{-4} = 8.3 \times 10^{-3}$  moles FeC<sub>2</sub>O<sub>4</sub>.nH<sub>2</sub>O

$8.3 \times 10^{-3}$  moles FeC<sub>2</sub>O<sub>4</sub>.nH<sub>2</sub>O weighs 1.5g

1 moles FeC<sub>2</sub>O<sub>4</sub>.nH<sub>2</sub>O weighs  $\frac{1.5}{8.3 \times 10^{-3}} = 180.7$ g

Molar mass of FeC<sub>2</sub>O<sub>4</sub>.nH<sub>2</sub>O = 180.7g

$56 + 2 \times 12 + 4 \times 16 + 18n = 180.7$

$144 + 18n = 180.7$

n=2

Number 2

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Heat two spatula end-ful of L in a dry test tube strongly until no further change.	White powdery solid reddish brown residue hot yellow on cooling colourless gas, turns moist blue litmus red and forms a white precipitate with calcium hydroxide solution colourless condensate turn anhydrous copper(II) sulphate blue	non-transition metal ions present PbO formed CO <sub>2</sub> evolved CO <sub>32-</sub> , C <sub>2</sub> O <sub>42-</sub> suspected present hydrated salt

<p>(b) To two spatula end-ful of L in a test tube add about 10cm<sup>3</sup> of distilled water shake strongly</p> <p>Filter, keep both the filtrate and the residue.</p> <p>Divide the filtrate into four portions.</p>	<p>partly soluble</p> <p>white residue</p> <p>colourless filtrate</p>	<p>non-transition metal ions /Al<sup>3+</sup>, Ba<sup>2+</sup>, Zn<sup>2+</sup> present</p> <p>non-transition metal ions /Al<sup>3+</sup>, Ba<sup>2+</sup>, Zn<sup>2+</sup> present</p>
<p>(i) . To the first portion of the filtrate, add 2-3 drops of Barium nitrate solution followed by dilute nitric acid.</p>	<p>white precipitate soluble in nitric acid</p>	<p>PO<sub>4</sub><sup>3-</sup> C<sub>2</sub>O<sub>4</sub><sup>2-</sup> , SO<sub>3</sub><sup>2-</sup></p> <p>Suspected present</p>
<p>(b)(ii) . To the second portion of the filtrate, add 2-3 drops of lead (II) nitrate solution followed by dilute nitric acid.</p>	<p>white precipitate soluble in nitric acid</p>	<p>PO<sub>4</sub><sup>3-</sup> C<sub>2</sub>O<sub>4</sub><sup>2-</sup> , SO<sub>3</sub><sup>2-</sup></p> <p>Suspected present</p>
<p>(b)(iii) To the third portion of the filtrate, add 1-2 drops of silver nitrate solution followed by dilute ammonia solution.</p>	<p>white precipitate soluble in ammonia</p>	<p>C<sub>2</sub>O<sub>4</sub><sup>2-</sup> SO<sub>3</sub><sup>2-</sup></p> <p>Suspected present</p>
<p>(b)(iii) Use the fourth portion of the filtrate to carry out your own test to confirm the anion in the filtrate</p> <p>Test</p> <p>To the test solution I added acidified potassium manganate solution the warmed</p>	<p>purple solution turned colourless on warming</p>	<p>C<sub>2</sub>O<sub>4</sub><sup>2-</sup></p> <p>confirmed present</p>
<p>(c) Dissolve then residue in dilute nitric acid. (warm to dissolve) To the resultant solution add dilute sodium hydroxide solution drop- wise until in excess.</p> <p>Filter and keep both the filtrate and residue.</p>	<p>white residue dissolves on warming forming a colourless solution with effervescence of a colourless gas that forms a white precipitate with calcium hydroxide solution white precipitate insoluble in excess white residue colourless filtrate</p>	<p>non-transition metal ions /Pb<sup>2+</sup>, Ba<sup>2+</sup>, Zn<sup>2+</sup> present</p> <p>CO<sub>2</sub> evolved</p> <p>CO<sub>3</sub><sup>2-</sup> confirmed present</p> <p>Mg<sup>2+</sup>, Ba<sup>2+</sup> or Ca<sup>2+</sup></p> <p>Mg<sup>2+</sup>, Ba<sup>2+</sup> or Ca<sup>2+</sup></p> <p>Zn<sup>2+</sup>, Pb<sup>2+</sup> or Al<sup>3+</sup></p>

(d). To the filtrate from part (c) add dilute nitric acid drop wise until the solution is just acidic.  Divide the resultants into three parts.	white precipitate soluble in excess dilute nitric acid	$\text{Zn}^{2+}$ , $\text{Pb}^{2+}$ or $\text{Al}^{3+}$  suspected
(d)(i) To the first portion of acidified filtrate, add dilute sodium hydroxide solution drop-wise until in excess.	white precipitate soluble in excess dilute nitric acid	$\text{Zn}^{2+}$ , $\text{Pb}^{2+}$ or $\text{Al}^{3+}$  suspected
(d)(ii) To the second part of acidified filtrate add dilute ammonia solution drop-wise until in excess.	white precipitate insoluble in excess ammonia solution	$\text{Pb}^{2+}$ or $\text{Al}^{3+}$  suspected
(d)(iii). Use the third part of acidified filtrate to carry out a test of your own choice to confirm one of the cation in the filtrate  Test  To the test solution I added potassium iodide solution	yellow precipitate	$\text{Pb}^{2+}$ confirmed present
(e ). Dissolve the residue from part (c) in minimum amount of nitric acid. Divide the resultant solution into three parts.	white residue dissolves to form a colourless solution	$\text{Mg}^{2+}$ , $\text{Ba}^{2+}$ or $\text{Ca}^{2+}$ suspected present
(i) To the first part add 2-3 drops dilute sulphuric acid	white precipitate	$\text{Ba}^{2+}$ or $\text{Ca}^{2+}$ suspected present
(ii). To the second part, add dilute ammonia solution drop wise until in excess.	no observable change	$\text{Ca}^{2+}$ suspected present
(iv) Use the third part of to carry out a test of your own choice to confirm the second cations in L  Test  To the test solution I added ammonium oxalate solution followed by ethanoic acid	white precipitate insoluble in ethanoic acid	$\text{Ca}^{2+}$ confirmed present

(f) Identify the

(i) Cations in L  $\text{Pb}^{2+}$  and  $\text{Ca}^{2+}$

(ii) Anions in L  $\text{C}_2\text{O}_4^{2-}$  and  $\text{CO}_3^{2-}$

Number 3.

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Burn a small amount of R on a spatula end	white powdery solid melts and burns with yellow sooty flame	aromatic compound with high carbon content
(b) To about 1 spatula end-ful of R in a test – tube, add about 10 cm <sup>3</sup> of distilled water. Shake strongly and test the mixture with litmus paper. Heat the mixture and Divide the resultant solution into 7 parts.	sparingly soluble in cold water turns blue litmus red dissolves on heating forming a colourless solution	polar aromatic compound acidic compound present
(i) To the first part of the solution, add 2 – 3 drops of acidified potassium dichromate (VI) and warm	No observable change	Primary alcohols secondary alcohol Aldehydes absent
(ii) To the second part of the solution add 2-3 drops of 2,4-dinitrophenylhydrazine solution	No observable change	Ketones absent
(iii) To the third part of the solution add 2 – 3 drops of iron (III) chloride solution	No observable change	Benzoic acid absent
(iv) To the fourth part of the solution add 1cm <sup>3</sup> of ethanoic acid followed by 3drops of concentrated sulphuric acid and heat to boiling	No sweet fruity smell	Tertiary alcohols absent
(v) To the fifth part of the solution add little solid magnesium powder	effervescence of a colourless gas	aromatic carboxylic acids present
(vi) To the six part add 2-3 drops acidified potassium manganate(VII)	purple solution turns colourless	un-saturated compound present
(vii) To the seventh part add 2-3 drops of bromine water and shake strongly	Reddish brown solution turns colourless	un-saturated compound present
(c ) Dissolve one spatula end-ful of R in about 3cm <sup>3</sup> of ethanol, add 3 drops of concentrated sulphuric acid and heat pour the resultant solution on a Petri-dish containing some water	Sweet fruity smell	esters formed carboxylic acid confirmed present

(e) Comment on the nature of R. Aromatic unsaturated carboxylic acid

END