

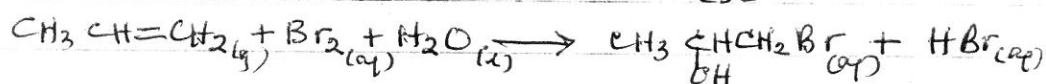
A'LEVEL CHEMISTRY SEMINAR
AT
OLD KAMPALA SENIOR
SECONDARY SCHOOL
ON
SATURDAY, 5TH, OCTOBER 2024

GUIDE

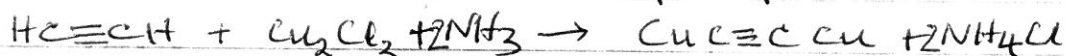
No.1

1

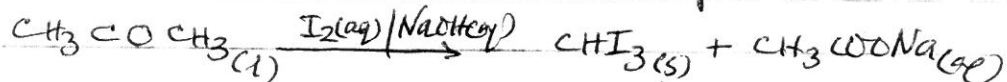
(a) Reddish brown solution turn colourless
or Brown solution turn colourless



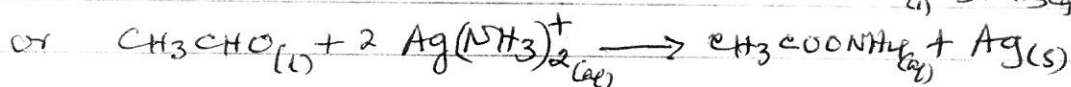
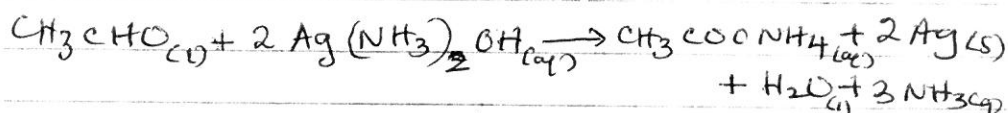
(b) Red solid or red precipitate



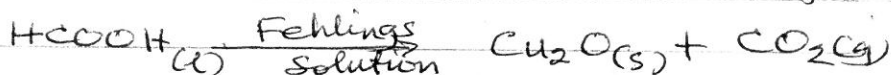
(c) Yellow solid or yellow precipitate



(d) Silver mirror



(e) Red or Reddish-brown solid formed.

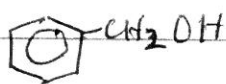


No.2

6. a) Neutral Iron(III) Chloride Solution



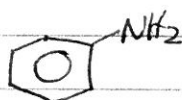
gives a Violet colouration/solution
or purple colouration/solution.



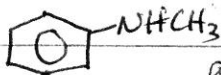
gives no observable change

b) Sodium nitrite solution and concentrated hydrochloric acid at 0°C (range 0-10°C)

or Sodium nitrite and ice cold concentrated hydrochloric acid



give no observable change
or colourless solution



gives a yellow oil or yellow oily liquid.

(c) Fehling Solution and heat

HCOOH gives a red or reddish brown solid.

$\begin{matrix} \text{COOH} \\ | \\ \text{COOH} \end{matrix}$ gives no observable change.

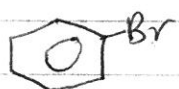
OR Ammoniacal Silver nitrate solution.

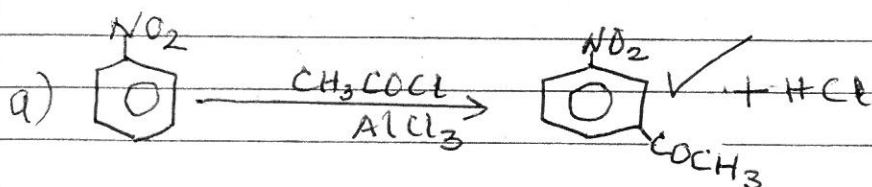
HCOOH forms a Silver mirror

$\begin{matrix} \text{COOH} \\ | \\ \text{COOH} \end{matrix}$ NO observable change.

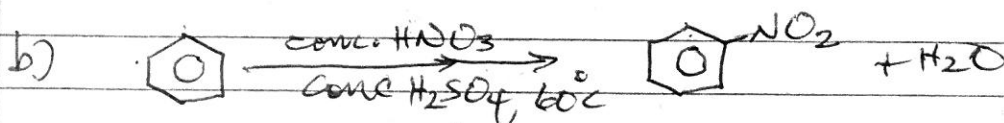
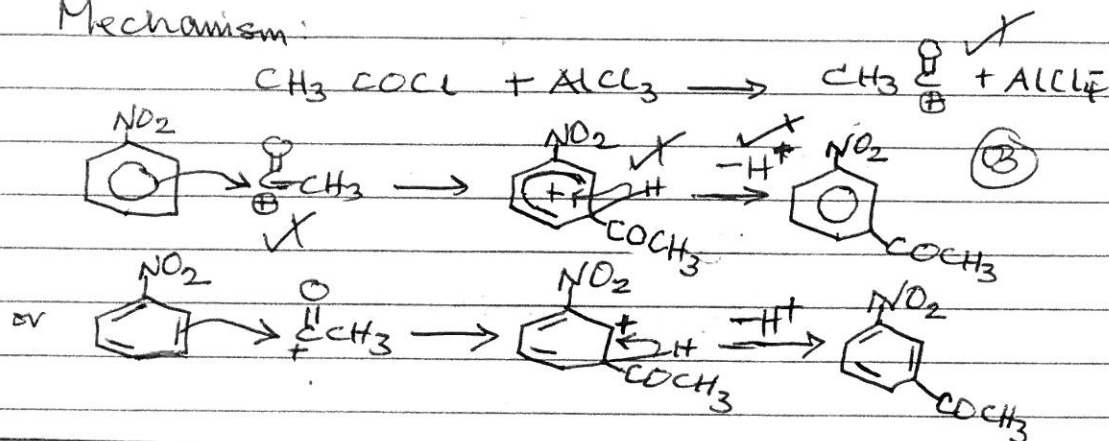
(d) Hot aqueous Sodium hydroxide solution followed by dilute nitric acid and silver nitrate solution.

 forms a Pale yellow solid

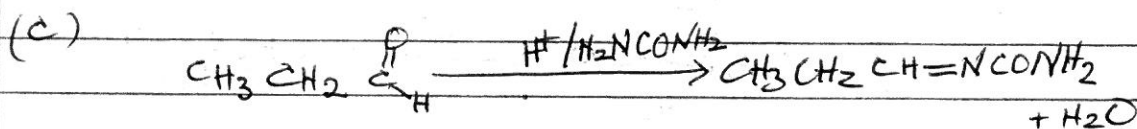
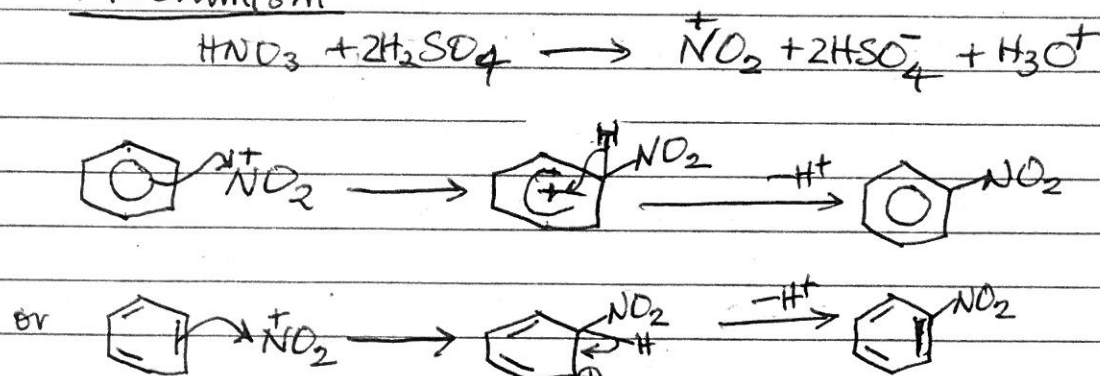
 NO observable change



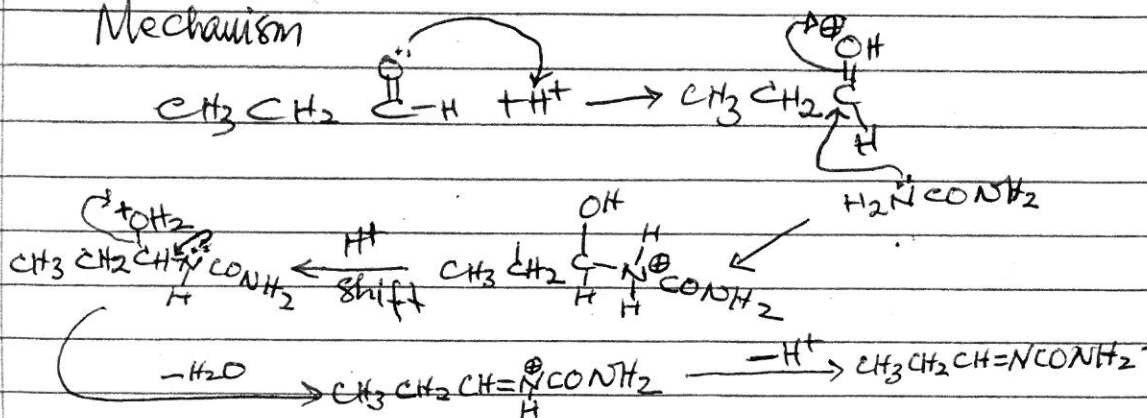
Mechanism:

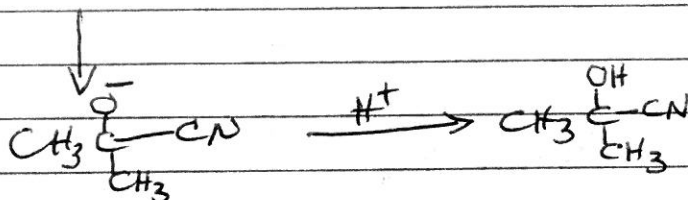
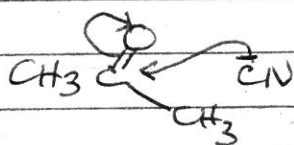
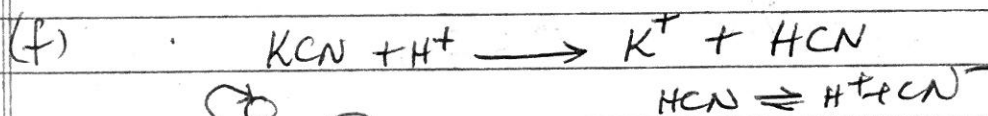
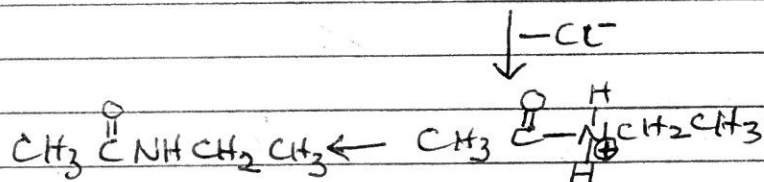
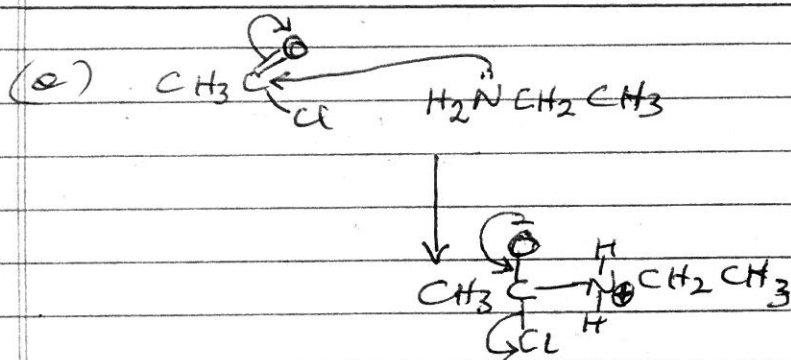
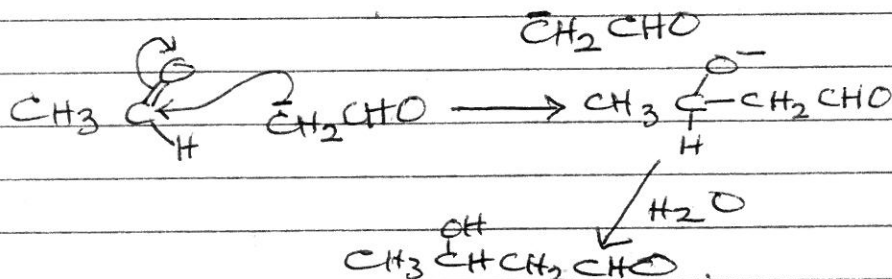
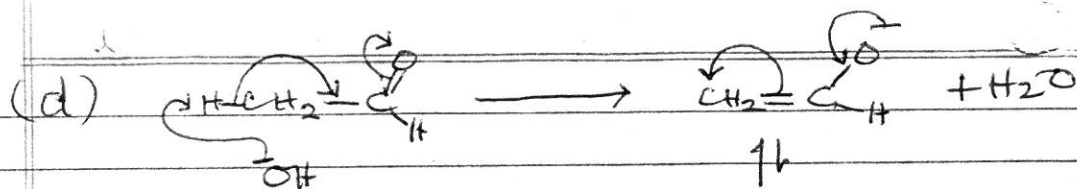


Mechanism



Mechanism

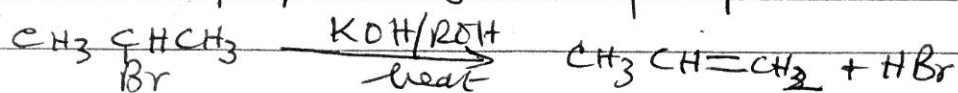




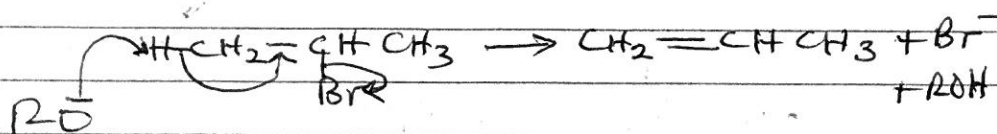
(a) Elimination reaction is one in which a Saturated organic compound loses atoms or group of atoms to form an unsaturated organic compound.

eg. Haloalkanes react with hot alcoholic Potassium hydroxide to form alkenes

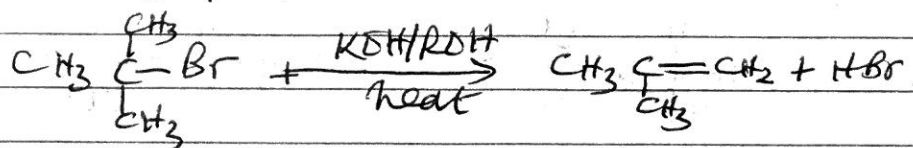
eg. 2-Bromopropane forms propene



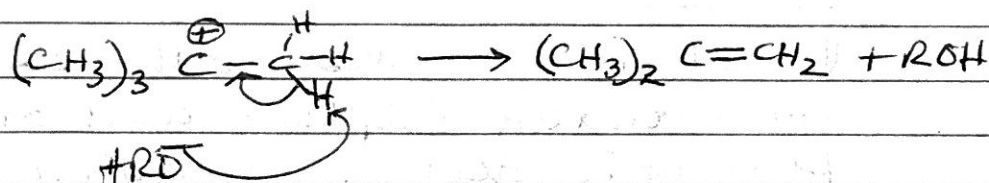
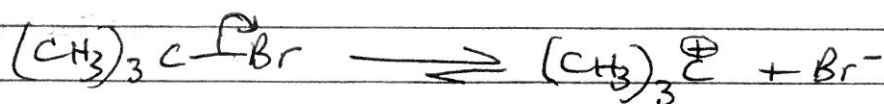
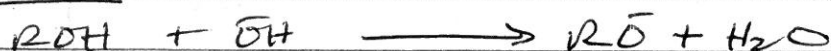
Mechanism E2



2-bromo-2-methylpropane forms 2-methylpropene

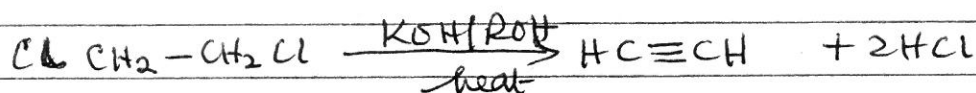


Mechanism E1

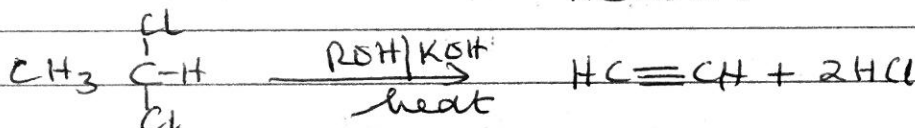
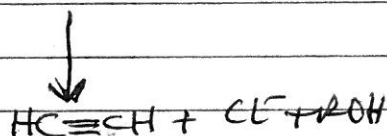
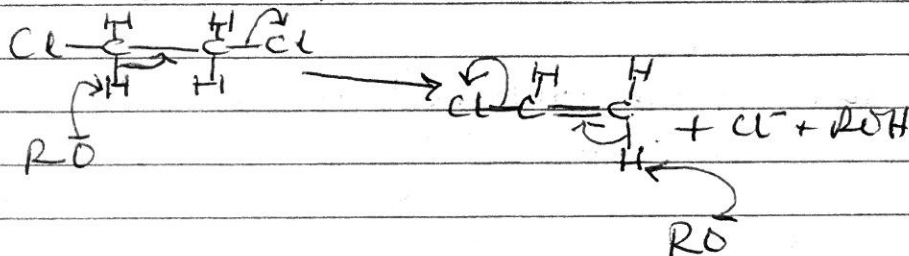


Gem-dihalides and Vicinal dihalides are heated with alcoholic Potassium hydroxide to form alkynes.

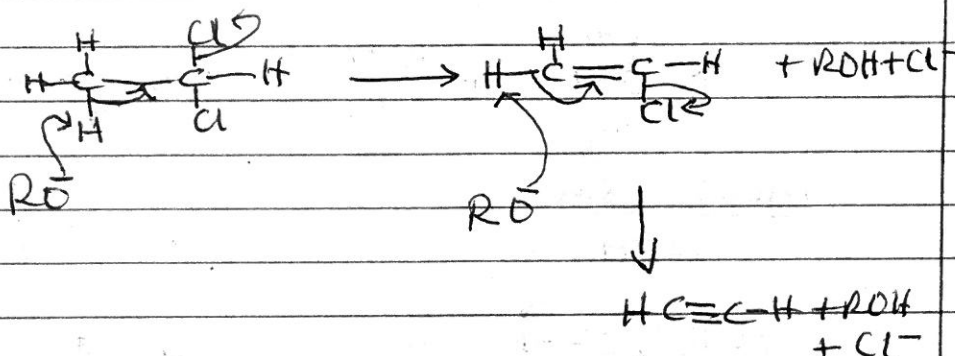
1,2-dichloroethane forms ethyne



Mechanism

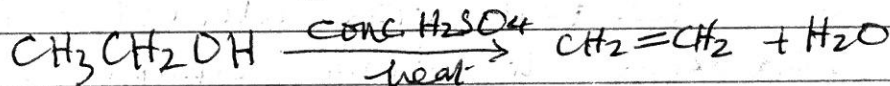


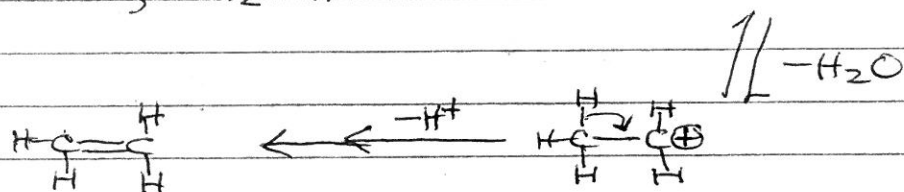
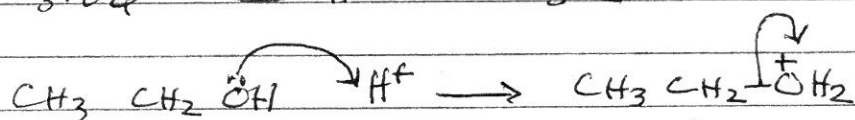
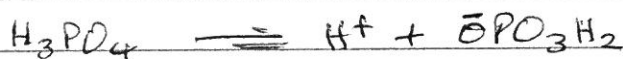
Mechanism



Alcohol is heated with excess concentrated Sulphuric acid or phosphoric acid or aluminium oxide to form alkenes.

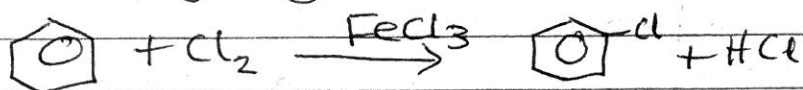
Ethanol forms ethene



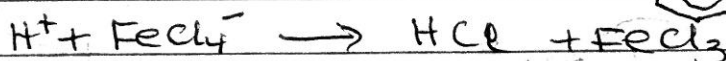
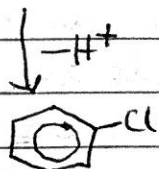
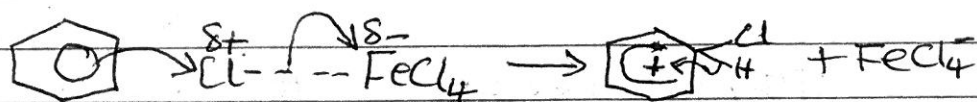
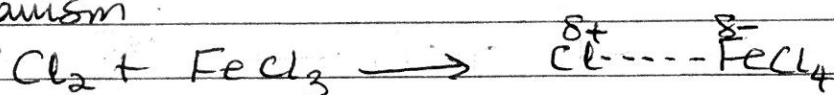


(b) Electrophilic Substitution is a reaction in which a hydrogen atom in the benzene ring is replaced by an electron deficient atom or group of atoms.

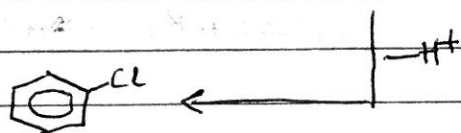
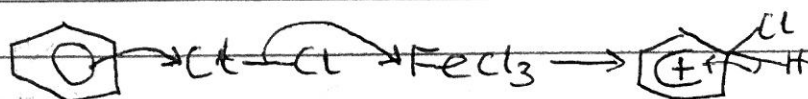
eg Benzene reacts with chlorine gas in the presence of Iron(III) Chloride to form chlorobenzene and hydrogen chloride



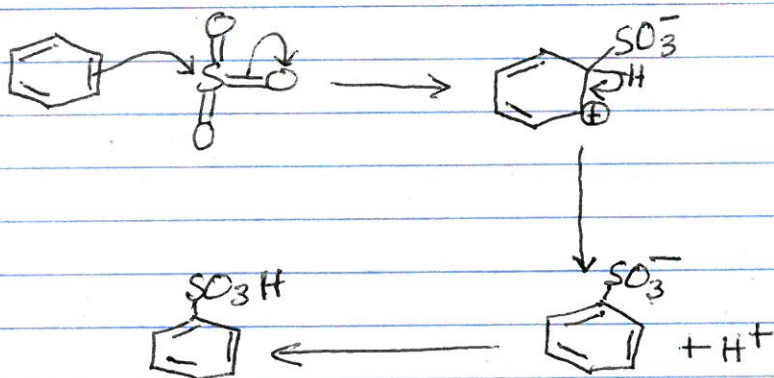
Mechanism



Allowed -

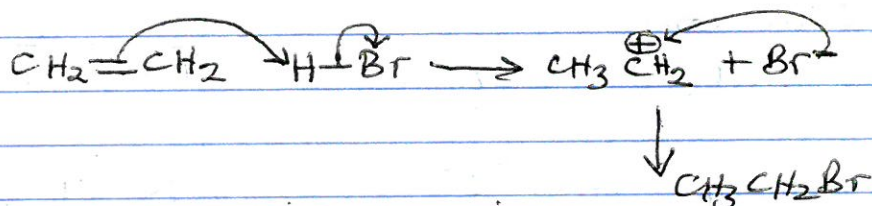


or

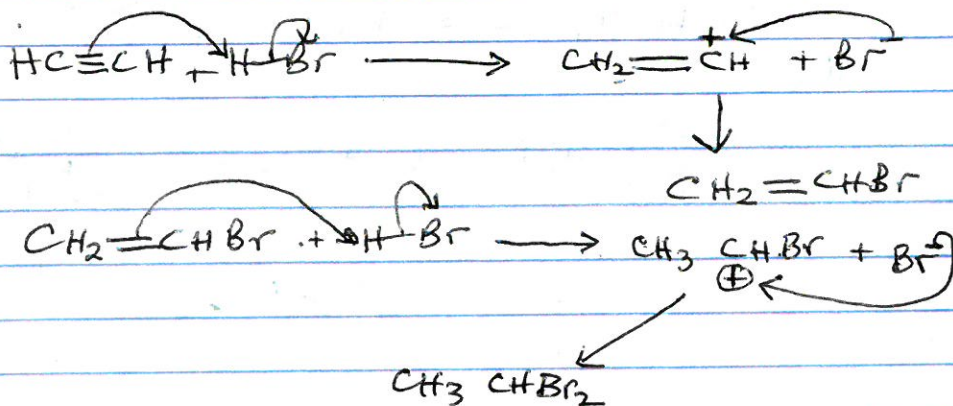


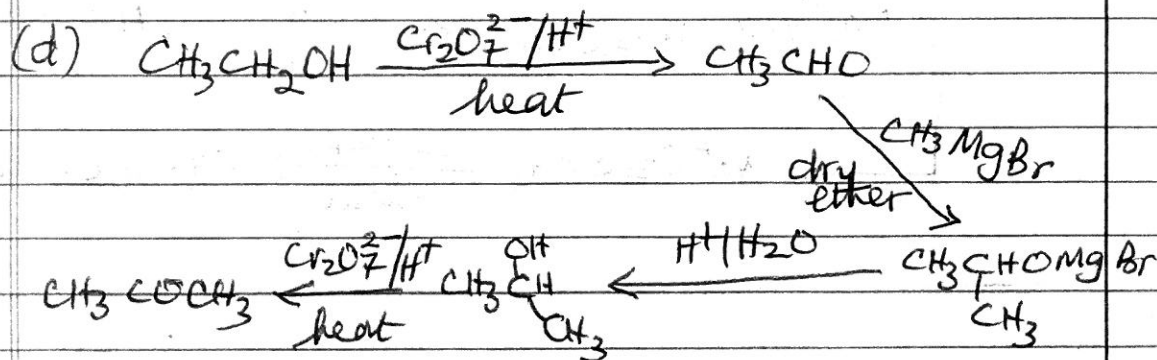
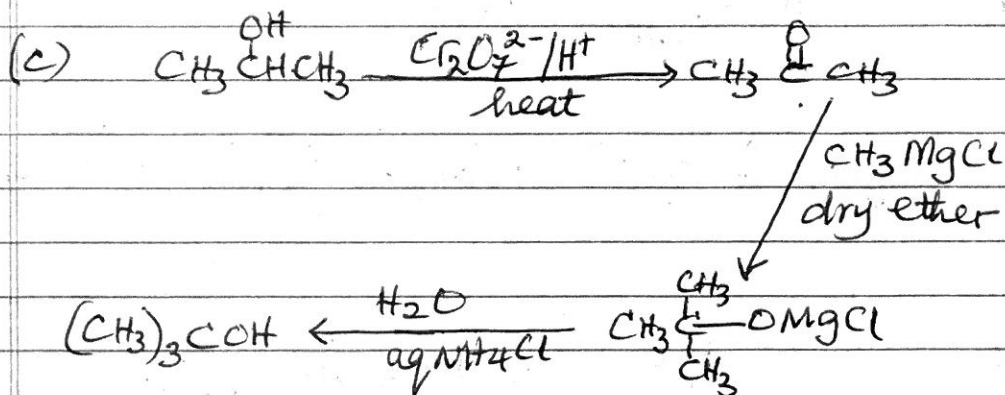
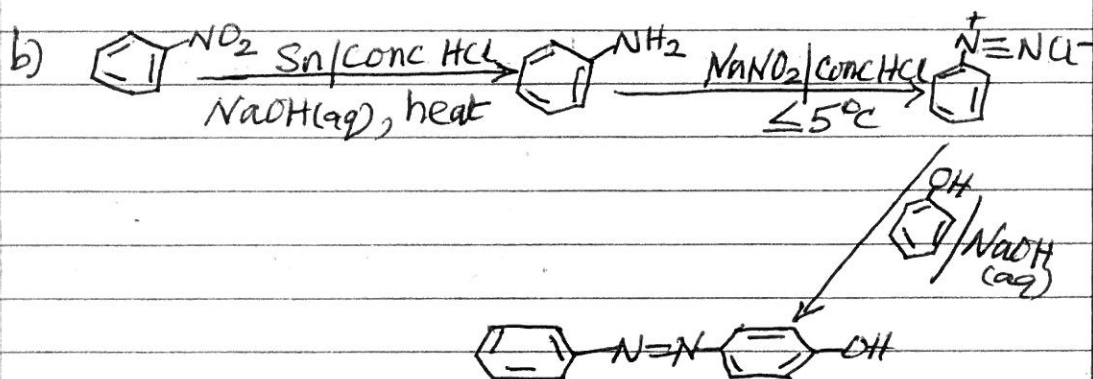
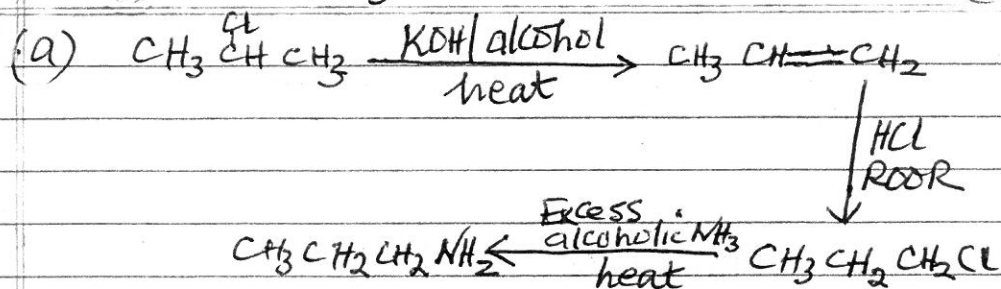
c) Electrophilic addition is a reaction of alkenes and alkynes with electrophilic reagents to form single products.

Ethene reacts with hydrogen bromide to form bromoethane

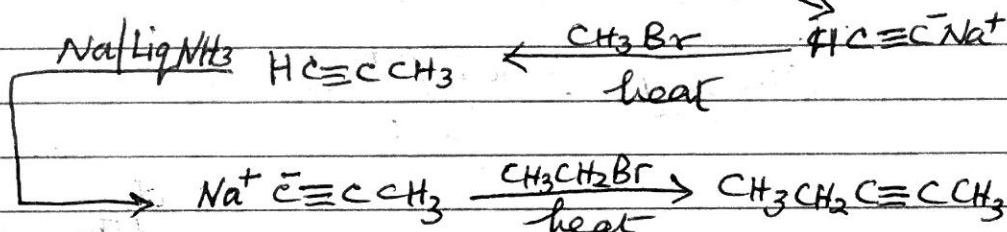
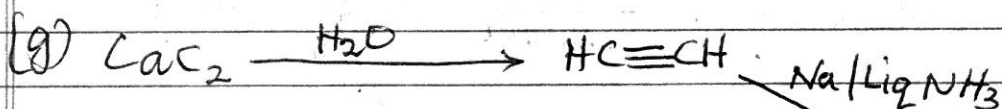
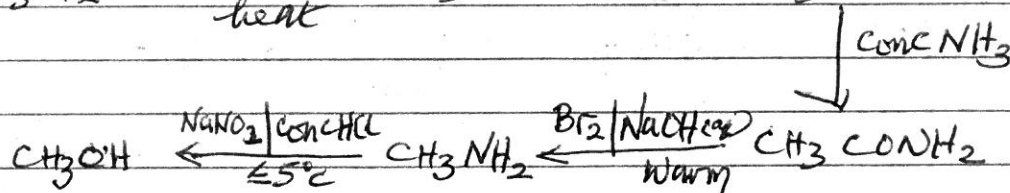
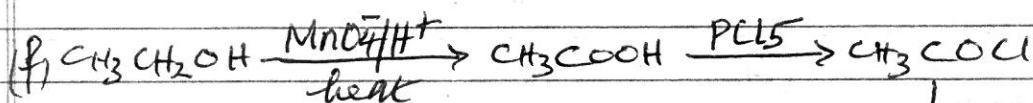
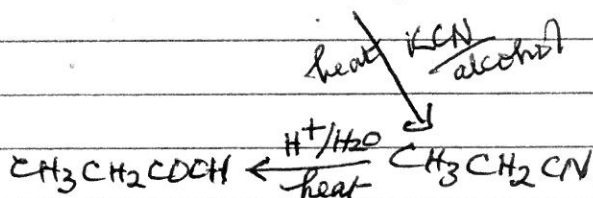
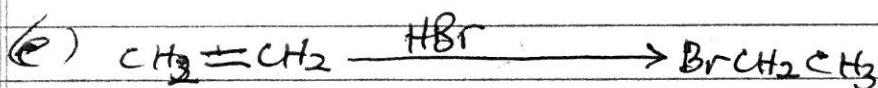
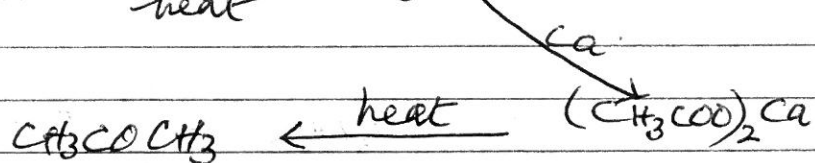
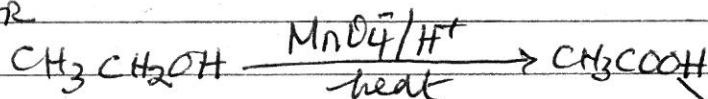


Ethyne reacts with excess hydrogen bromide to form 1,1-dibromoethane.





or

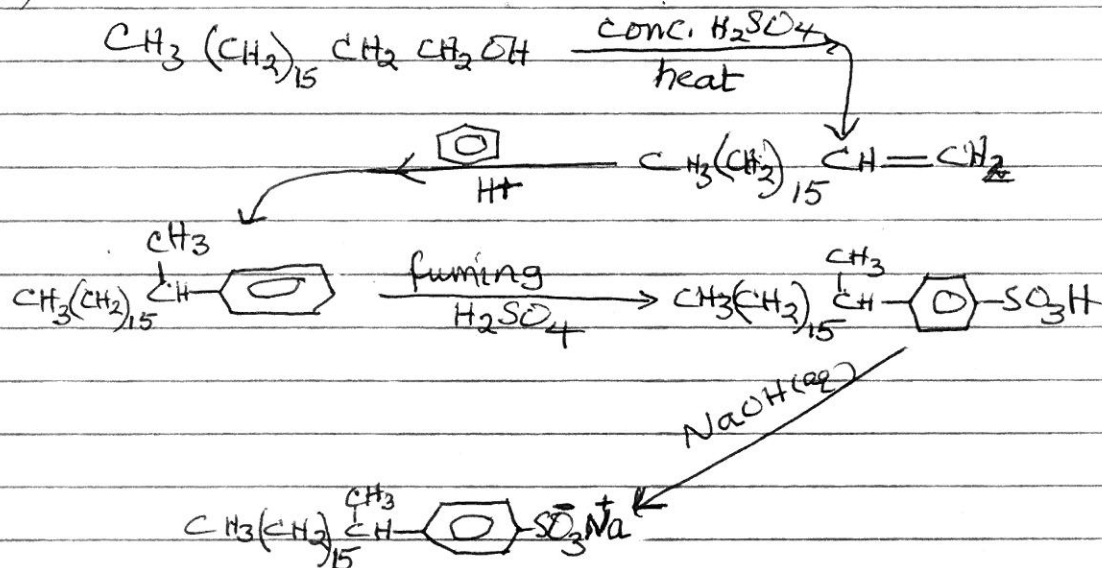


(a) Soap is a Sodium salt of a long chain carboxylic acid.

Soapless detergent

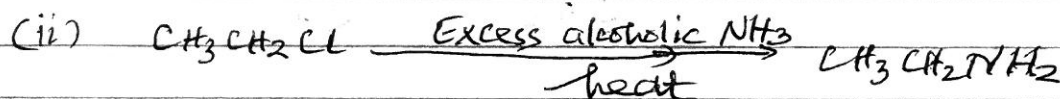
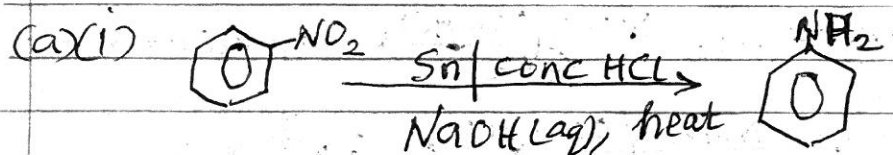
Soapless detergent is a salt of a long chain sulphonic acid or of alkyl benzene sulphonic acid.

(b)



(i) The polyphosphates form soluble complexes with calcium ions and magnesium ions in hard water which would interfere with the cleansing action. They therefore soften the hard water thus enhancing the cleaning power of the detergents.

(ii) Sodium sulphate is used as a filler in powdered detergents and keep detergents dry.



(b) Ethylamine is a stronger base than Phenylamine.

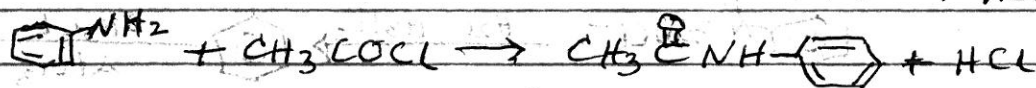
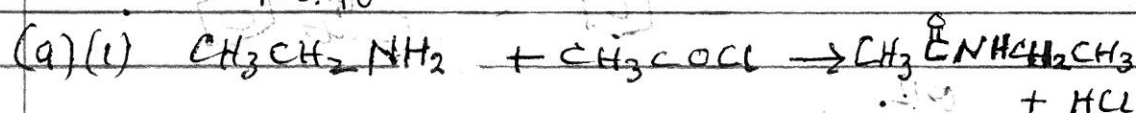
The strength of a base depends on the availability of the lone pair of electrons on nitrogen atom to a proton from water.

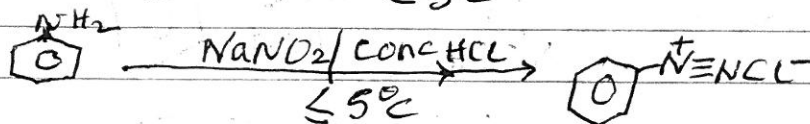
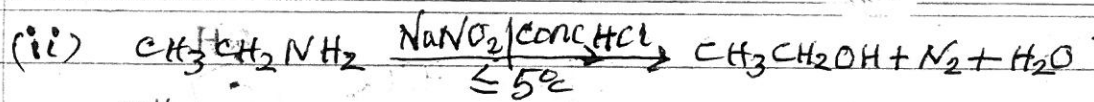
Ethylamine has an ethyl group which has a positive inductive effect.

The ethyl group therefore pushes electrons towards the nitrogen atom and this increases the electron density on nitrogen atom making the lone pair of electrons more available for reaction with a proton from water.

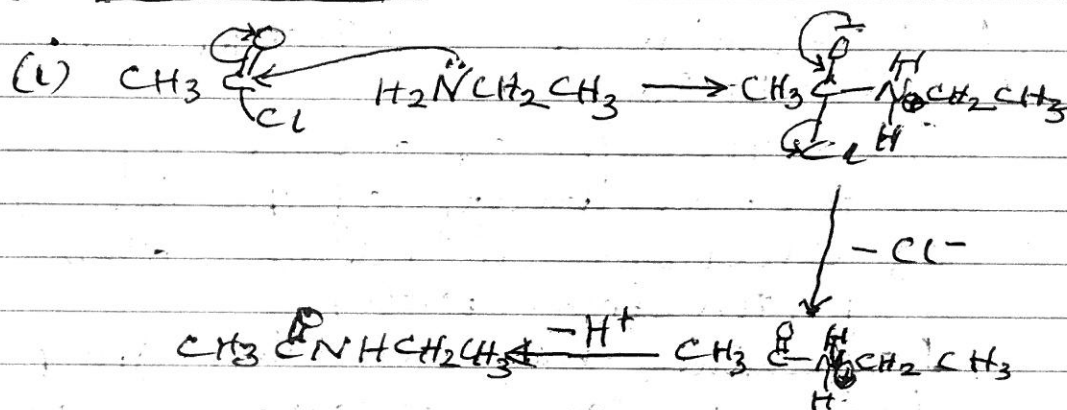
Phenylamine is a weaker base than ethylamine because the lone pair of electrons on the nitrogen atom interacts with the π -electrons of the benzene ring and is less available for reaction with a proton from water.

NO.10





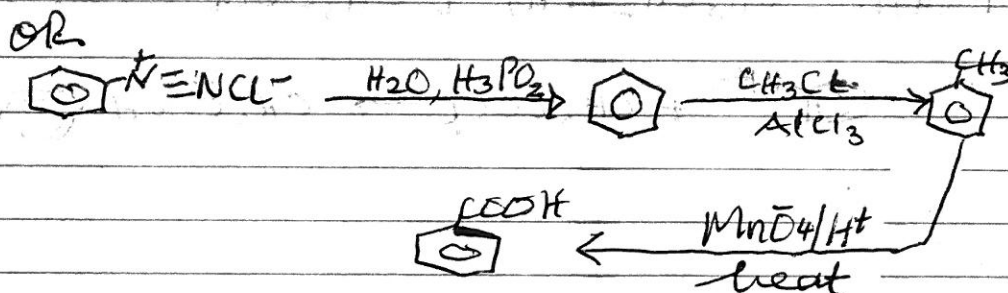
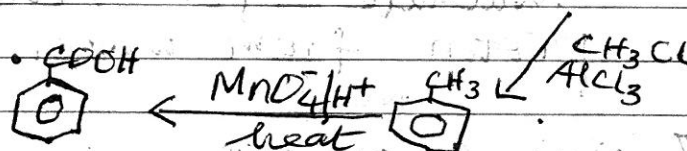
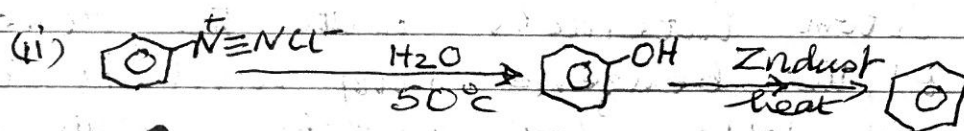
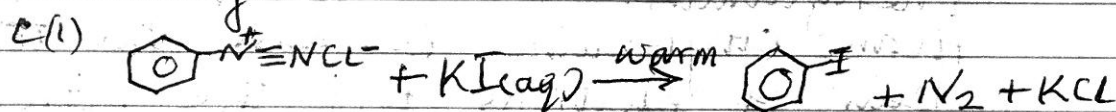
(b) Mechanism.

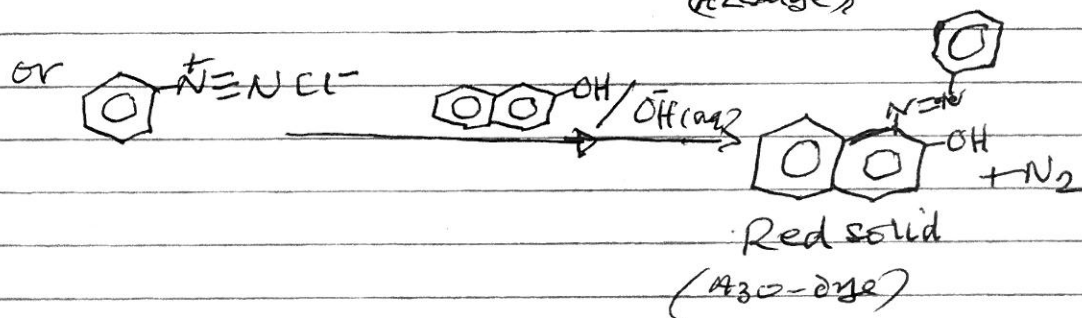
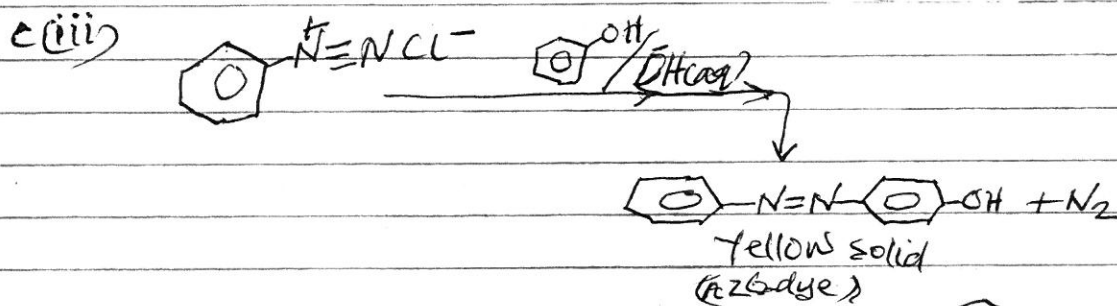


(ii) The reaction in (i) can be used to distinguish ethylamine and phenylamine.

Ethylamine give a colourless solution and bubbles of a colourless gas.

Phenylamine gives no observable change.





(a) Propan-1-ol is heated with acidified Potassium manganate(VII) solution to form propanoic acid.

Propanoic acid is reacted with Phosphorus Pentachloride or thionyl Chloride to form propanoyl Chloride.

Propanoyl Chloride is reacted with concentrated ammonia to form propanamide. The propanamide is warmed with bromine and concentrated Sodium hydroxide to form ethylamine.

Ethylamine is reacted with a solution of Sodium nitrite and concentrated hydrochloric acid to form ethanol.

b) Ethyne is heated with organo-nickel Catalyst to form benzene. Benzene is reacted with Chloromethane in presence of aluminium Chloride Catalyst to form Methyl benzene.

Methyl benzene is heated with acidified Potassium manganate(VII) to form benzoic acid.

(c) Butanoic acid is reacted with Lithium aluminium hydride in dry ether to form butan-1-ol.

Butan-1-ol is heated with concentrated Sulphuric acid at about 180°C to form but-1-ene.

But-1-ene is then reacted with hydrogen chloride to form 2-chlorobutane which is heated with aqueous sodium hydroxide to form butan-2-ol.

(d) Ethanol is reacted with Phosphorous Pentachloride to form Chloroethane.

Chloroethane is heated with alcoholic Potassium cyanide to form propanonitrile.

Propanonitrile is heated with a dilute mineral acid to form propanoic acid.

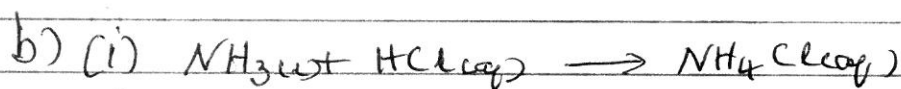
Propanoic acid is reacted with Lithium aluminium hydride in dry ether to form propan-1-ol.

Propan-1-ol is heated with Concentrated Sulphuric acid at 180°C to form

propene which is warmed with dilute Sulphuric acid to form propan-2-ol

(a) Partition Coefficient is the ratio of the concentration of a solute in a solvent to the concentration of the same solute in another solvent when the two solvents are immiscible and present in the same container at a given temperature.

OR It is the ratio of the concentration of a solute dissolved in two immiscible solvents in contact when equilibrium has been established at constant temperature.



$$\text{moles of HCl that reacted} = \frac{0.025 \times 12.5}{1000} = 3.125 \times 10^{-4}$$

$$\text{mole of NH}_3 \text{ in } 25\text{cm}^3 \text{ of CCl}_4 = 3.125 \times 10^{-4}$$

$$\text{moles of NH}_3 \text{ in } 1000\text{cm}^3 \text{ of CCl}_4 = \frac{3.125 \times 10^{-4} \times 1000}{25} = 0.0125 \text{ M}$$

$$\frac{[\text{NH}_3] \text{ in CCl}_4}{[\text{NH}_3] \text{ in H}_2\text{O}} = 0.04$$

$$[\text{NH}_3] \text{ free in water} = \frac{0.0125}{0.04} = 0.3125 \text{ M}$$

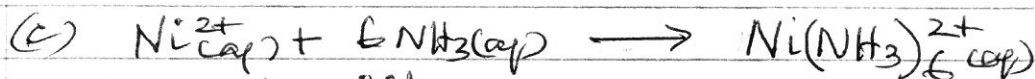
(ii) For complexed NH_3 .

$$\begin{aligned} \text{Moles of NH}_3 \text{ in } 12.5\text{cm}^3 \text{ of aqueous layer} &= \text{moles of HCl} = \frac{0.025 \times 20}{1000} \\ &= 5 \times 10^{-3} \end{aligned}$$

$$\begin{aligned} \text{moles of NH}_3 \text{ in } 1000\text{cm}^3 \text{ of aqueous layer} &= \frac{5 \times 10^{-3} \times 1000}{12.5} \\ &= 0.4 \text{ M} \end{aligned}$$

$$\text{Moles of Complexed } \text{NH}_3 = 0.4 - 0.3125$$

$$= 0.0875 \text{ M}$$



$$\text{Moles of } \text{Ni}^{2+} \text{ ions} = \frac{1}{6} \times 0.0875$$

$$= 0.01458$$

$$\text{Mass of Nickel} = 0.01458 \times 58.7$$

$$= 0.856 \text{ g}$$

$$\text{Mass of impure nickel(II) sulphide}$$

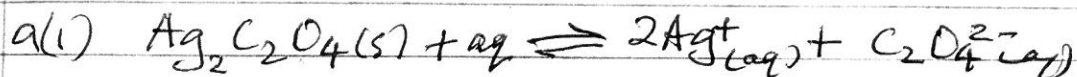
$$\text{in 1 litre} = \frac{4.5}{500} \times 1000$$

$$= 9.0 \text{ g}$$

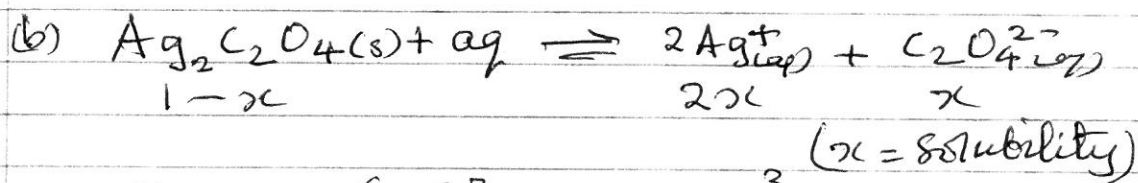
$$\% \text{ of Ni in Nickel(II) sulphide}$$

$$= \frac{0.856}{9.0} \times 100$$

$$= 9.5\%$$



$$(ii) \quad K_{sp} = [\text{Ag}^+]^2 [\text{C}_2\text{O}_4^{2-}]$$



$$K_{sp} = (2x)^2 x = 4x^3$$

$$x = \sqrt[3]{\frac{5.3 \times 10^{-3}}{4}} = 0.1098 \text{ M}$$

$$[\text{Ag}^+] = 2x = 2 \times 0.1098 = 0.2196 \text{ M}$$

$$[\text{C}_2\text{O}_4^{2-}] = 0.1098 \text{ M}$$

$$(c) \quad \text{New } [\text{C}_2\text{O}_4^{2-}] = \frac{1}{3} \times 0.1098 = 0.0366 \text{ M}$$

$$K_{sp} = [\text{Ag}^+]^2 [\text{C}_2\text{O}_4^{2-}]$$

$$5.3 \times 10^{-3} = [\text{Ag}^+]^2 \times 0.0366$$

$$\text{New } [\text{Ag}^+] = \sqrt{\frac{5.3 \times 10^{-3}}{0.0366}} = 0.3805 \text{ M}$$

$$\begin{aligned} \text{Moles of Ag}^+ \text{ required} &= 0.3805 - 0.2196 \\ &= 0.1609 \text{ M} \end{aligned}$$

$$\text{RFM of AgNO}_3 = 108 + 14 + 48 = 170$$

$$\begin{aligned} \text{Mass of silver nitrate} &= 170 \times 0.1609 \\ &= 27.353 \text{ g} \end{aligned}$$

(i) Order of a reaction is the Sum of the powers to which the concentrations of the reactants are raised in the experimental rate equation.

OR

Consider the equation for the reaction between A and B where $A + B \rightarrow \text{Products}$.

$$\text{Rate} = k[A]^x[B]^y$$

$$\text{Order of a reaction} = x + y$$

(ii) $\text{Rate} = k[\text{CH}_3\text{COCH}_3]$

(iii) A Known volume of iodine is transferred into a conical flask.

A Known volume of propanone followed by a known volume of dilute sulphuric acid are added into the conical flask and a stop clock is simultaneously started.

The mixture is shaken and allowed to stand at room temperature. After specific time intervals a known volume of the reaction mixture is pipetted into a flask to which sodium hydrogen carbonate solution or sodium carbonate solution has been added to quench (stop) the reaction. The reaction mixture is titrated against a standard solution of sodium thiosulphate using starch as indicator.

A graph of volume of sodium thiosulphate against time is plotted. Since the volume of sodium thiosulphate is proportional to the concentration of iodine left, the graph is a straight line with a negative gradient implying that the reaction is zero order with respect to iodine.

(9) The boiling points decrease from Sodium Chloride to Silicon(IV) Chloride.

OR

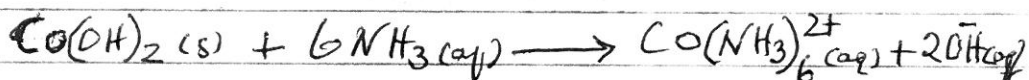
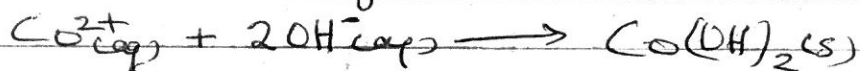
The boiling points decrease in the order $\text{NaCl} > \text{MgCl}_2 > \text{Al}_2\text{Cl}_6 > \text{SiCl}_4$.

(b) Sodium Chloride and Magnesium Chloride have a giant ionic structure, composed of oppositely charged ions held by strong ionic bonds. Magnesium ion has a smaller ionic radius and a higher charge density than sodium ion, so magnesium ion polarises the chloride ion more than the sodium ion, making Magnesium Chloride less ionic and has a weaker ionic bonds than Sodium Chloride. Hence

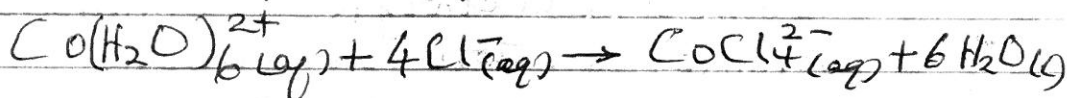
Magnesium chloride has a lower boiling point than Sodium chloride.

Aluminium Chloride and Silicon tetrachloride have a simple molecular structure, their molecules are held by weak van der Waals forces whose strength decreases with decrease in molecular mass from aluminium chloride to silicon tetrachloride. Hence boiling point of silicon tetrachloride is lower than that of aluminium chloride.

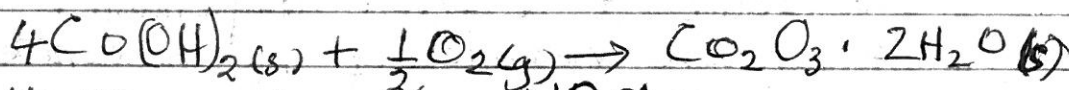
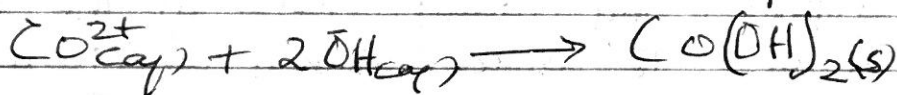
(a) with Concentrated ammonia, Cobalt(II) Chloride forms a blue precipitate which dissolves in excess to give a red-brown solution.



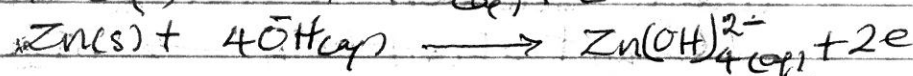
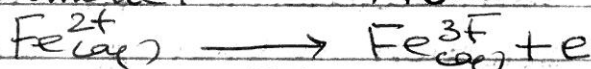
b) with Concentrated hydrochloric acid, Cobalt(II) Chloride solution changes from pink to blue



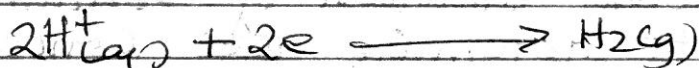
(c) with aqueous sodium hydroxide, Cobalt(II) chloride forms a blue precipitate which is insoluble and turns brown on standing



Q. 11 At the anode: NO. 21



(ii) At the cathode



(b) (i) $\text{Pt}(\text{s}) | \text{Fe}^{2+}(\text{aq}), \text{Fe}^{3+}(\text{aq}) || \text{H}^{+}(\text{aq}) | \text{H}_2(\text{g}) | \text{Pt}(\text{s})$

$\text{Zn}(\text{s}) | \text{OH}^{-}(\text{aq}), \text{Zn}(\text{OH})_4^{2-}(\text{aq}) || \text{BrO}_3^{-}(\text{aq}), \text{Br}^{-}(\text{aq}), \text{OH}^{-}(\text{aq}) | \text{Pt}(\text{s})$

I signifies separation of phases

II signifies Salt bridge

Pt is platinum

Signifies separation of species in the same phase.

(a) Solubility product - is the product of the molar concentration of the ions of a sparingly soluble ionic compound raised to the appropriate powers in a saturated solution at a given temperature.

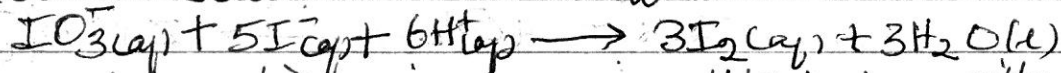
(ii) Common ion effect - is the precipitation of a sparingly soluble ionic compound (electrolyte) from its saturated solution by adding a solution of a more soluble electrolyte containing a similar cation or anion.

(b) Determining the solubility product of copper(II) iodate:

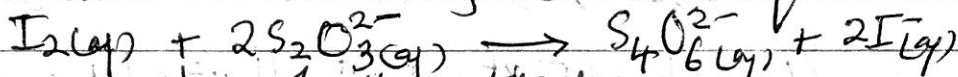


A saturated solution of copper(II) iodate is prepared by adding excess of the copper(II) iodate to water, shaken and then allowing to settle at a fixed temperature.

A known volume of the saturated solution is pipetted, acidified and Potassium iodide solution added to liberate iodine.



The liberated iodine is titrated with a standard solution of sodium thiosulphate to determine the concentration of iodine according to the equation



The results of the titration are used to determine the concentration of iodine. If the concentration of iodine

is $x \text{ mol dm}^{-3}$, that of iodate ions is $\frac{1}{3}x \text{ mol dm}^{-3}$ and of copper(II) ions

is $\frac{1}{2} \times \frac{1}{3}x$ or $\frac{1}{6}x \text{ mol dm}^{-3}$

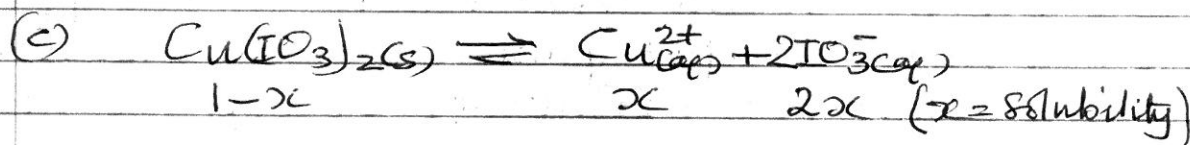
b)

$$K_{sp} = [Cu^{2+}][IO_3^-]^2$$

(continued)

$$= \frac{x}{6} \times \left(\frac{1}{3}x\right)^3$$

$$= \frac{x^4}{54} \text{ mol}^3 \text{ dm}^{-9}$$



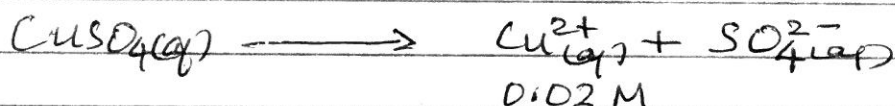
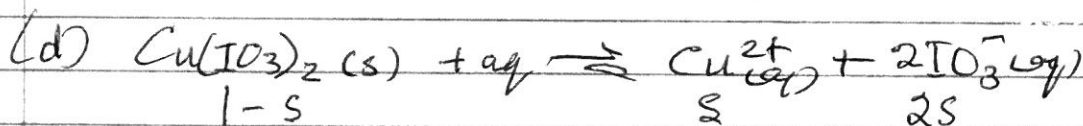
$$K_{sp} = [Cu^{2+}][IO_3^-]^2$$

$$= x(2x)^2$$

$$= 4x^3$$

$$= 4(8.33 \times 10^{-3})^3$$

$$= 2.31 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$$



$$[Cu^{2+}] = 0.02 + s; [IO_3^-] = 2s$$

$$K_{sp} = [Cu^{2+}][IO_3^-]^2; \Rightarrow 2.31 \times 10^{-6} = (0.02 + s)(2s)^2$$

Assumption: $[Cu^{2+}] \approx 0.02M$ Since s is very small compared to $0.02M$.

$$\therefore 2.31 \times 10^{-6} = 0.02(2s)^2 = 0.08s^2$$

$$\therefore s = \sqrt{\frac{2.31 \times 10^{-6}}{0.08}}$$

$$s = 5.37 \times 10^{-3} M$$

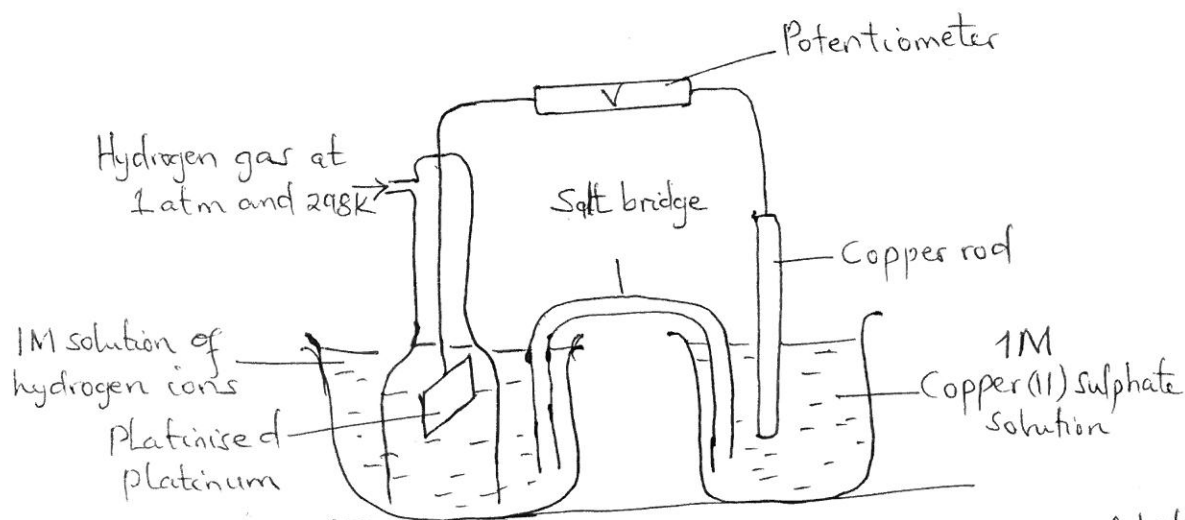
(e)(i) Addition of concentrated ammonia solution to saturated Copper(II) iodate solution increases the solubility of Copper(II) iodate. This is because ammonia reacts with Copper(II) ions to form a soluble complex. This reduces the concentration of Copper(II) ions. Therefore copper(II) iodate dissolves

to replace the copper(II) ions and
maintain the value of K_{sp}

(ii) Addition of Potassium iodate solution increases the concentration of iodate ions which then react with copper(II) ions to precipitate copper(II) iodate. Therefore, solubility of copper(II) iodate decreases.

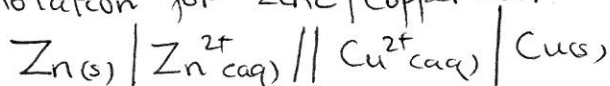
(a) standard electrode potential is the potential difference established when a metal electrode is dipped in a 1 molar solution of its ions measured relative to the standard hydrogen electrode at 25°C at 1 atmosphere.

(b)



- A Copper rod is dipped in a 1 molar solution of Copper(II) sulphate.
- The iron half cell is connected externally by electric wires to a standard hydrogen electrode via a potentiometer to measure the emf of the cell.
- The iron half-cell is connected to the standard electrode internally by means of a salt bridge to allow exchange of ions without mixing of the two solutions in the half-cells. The temperature of the solution is maintained at 298K .
- Since the standard hydrogen electrode has a standard electrode potential of 0.00V , the reading on the potentiometer is the standard electrode potential of the Copper electrode.

(c) Cell notation for zinc/copper cell



$$E_{\text{cell}}^{\ominus} = E_{\text{RHE}} - E_{\text{LHE}}$$

$$= +0.3 - -0.76$$

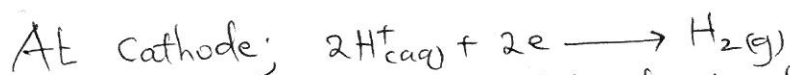
$$E_{\text{cell}}^{\ominus} = +1.06\text{V}$$

- (d)
- The electrolytic cell converts electrical energy into chemical energy, whereas an emf cell converts chemical energy into electrical energy.
 - In electrolytic cell, anode is positive and cathode is negative whereas in emf cell, anode is negative and cathode is positive.

(e)

$$I = 2A, t = 30\text{min}$$

$$Q = It = 2 \times 30 \times 60 = 3600C$$



2 moles of electrons liberate 1 mole of H_2 .
 $(2 \times 96500)C$ of charge liberate 1 mole of H_2
 $3600C$ liberate $\left(\frac{1 \times 3600}{2 \times 96500}\right)$ moles of H_2
 $= 0.0187$ moles of H_2 .

$$PV = nRT.$$

$$V = \frac{nRT}{P} = \frac{0.0187 \times 8.314 \times (23+273)}{100 \times 1000}$$

$$= 4.528 \times 10^{-4} m^3$$

$$= 4.528 \times 10^{-4} \times 10^6 cm^3$$

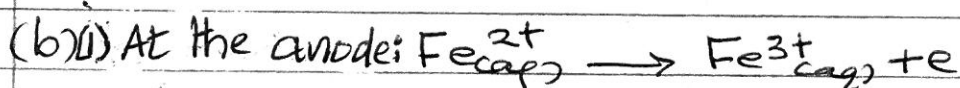
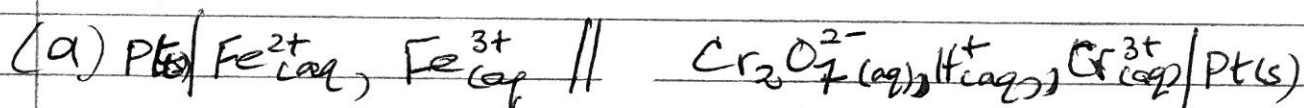
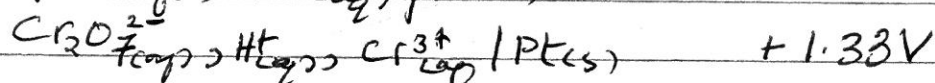
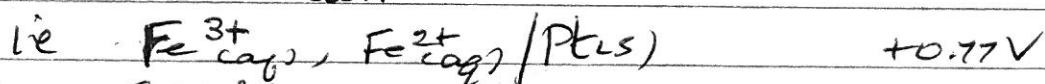
$$= 4.528 \times 10^2 cm^3$$

$$V = \underline{452.8 cm^3}$$

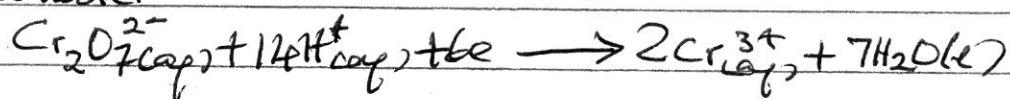
(f) Applications of standard electrode Potentials

- Predicting feasibility of a reaction
- Calculating emf of electrochemical cells.
- Determining Solubility of sparingly soluble salt.

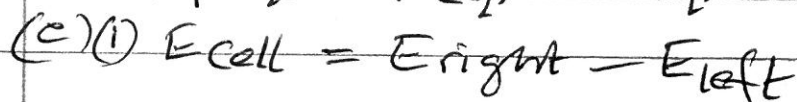
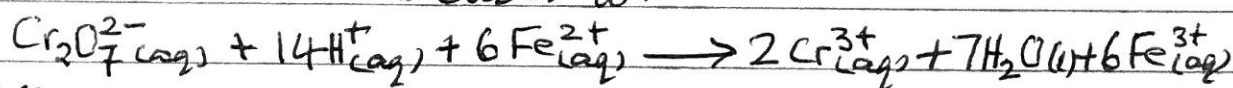
These are oxidation potentials, first change them to reduction potentials before writing a cell notation



At the Cathode:



(ii) overall cell reaction is:



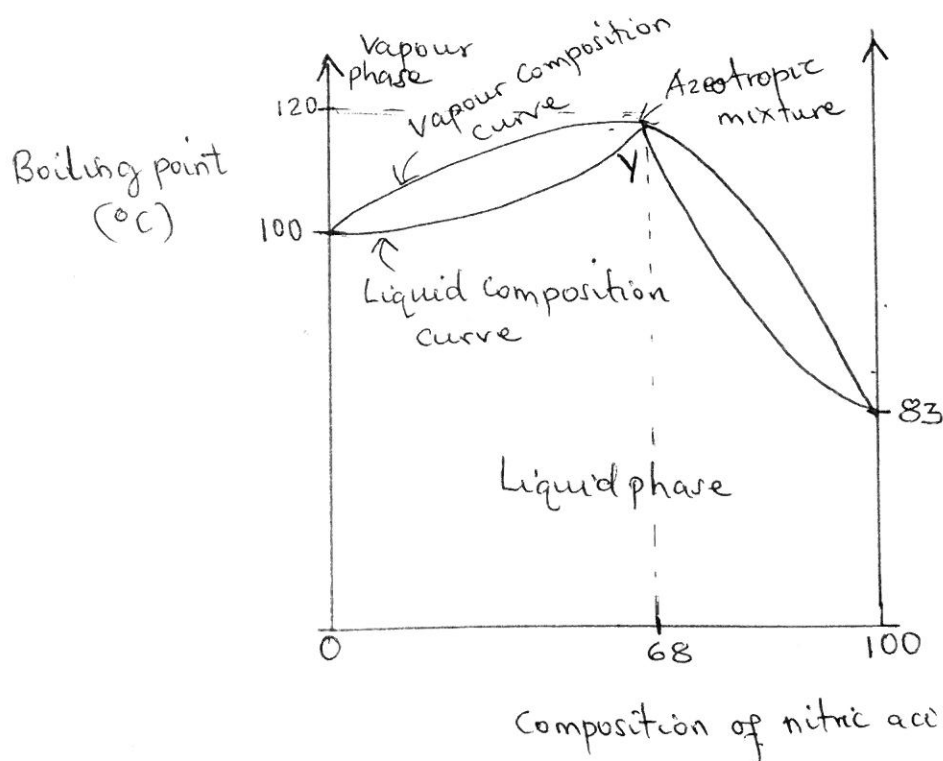
$$= 1.33 - 0.77$$

$$= +0.56\text{V}$$

(ii) The reaction is feasible. Because the e.m.f of the cell is positive.

(a) (i) A constant boiling mixture is a mixture whose liquid boils at constant temperature at a given pressure to give a vapour of the same composition.

(ii) Boiling point-composition diagram for the mixture of nitric acid and water.



- (i) The phase diagram shows that addition of nitric acid to water results into an increase in boiling point up to ~~to~~ point Y where the composition of nitric acid is 68%, and the mixture boils at a constant maximum temperature, 120°C.
- Similarly, addition addition of water to nitric acid results into an increase in boiling point of mixture up to 68% of nitric acid where the mixture boils at a constant maximum temperature of 120°C.
 - This is due to the formation of strong intermolecular forces between the components in the mixture and hence the escaping tendency of the molecules from the solution into vapour phase decreases such that the exerted vapour ^{Pressure} becomes equal to the external atmospheric pressure at a higher temperature corresponding to higher boiling points.

- When a mixture containing less than 60% nitric acid was fractionally distilled, it boils to give a vapour which is richer in water than the original liquid mixture.
- Cooling this vapour produces a liquid mixture of the same composition which when heated produces a vapour richer in water than itself.
- Repeated heating and cooling finally produces pure water as distillate and the azeotropic mixture as the residue.

6) Moles of HNO_3 in 1L of 2M $\text{HNO}_3 = \frac{1000 \times 2}{1000} = 2$.

$$\text{Mr of } \text{HNO}_3 = 1 + 14 + (16 \times 3) = 63 \text{g}.$$

1 mole of HNO_3 weighs 63g.

$$2 \text{ moles of } \text{HNO}_3 \text{ weigh } (63 \times 2) = 126 \text{g}.$$

But a constant boiling mixture of HNO_3 and water contains 68% HNO_3 .

Let the total mass of the constant boiling mixture containing 126g of HNO_3 be x .

$$\frac{126}{x} \times 100 = 68$$

$$x = 185.2941 \text{g}.$$

$$\text{Density of the mixture} = 1.42 \text{gcm}^3.$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

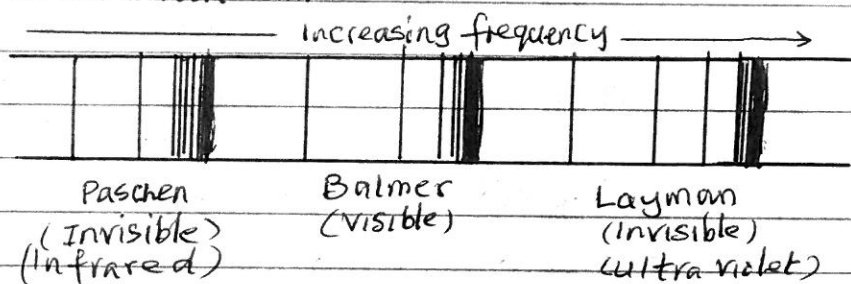
$$\begin{aligned} \text{Volume of nitric acid} &= \frac{185.2941}{1.42} \\ &= \underline{\underline{130.49 \text{cm}^3}} \end{aligned}$$

26 (a)

The hydrogen spectrum consists of a group or series of lines. The group or series of lines are found both in the visible and invisible parts of electromagnetic radiation. (The series or groups of lines in the visible region are called Balmer series, the series of lines in the invisible region(s) are the Lyman series in the ultra-violet region, the Paschen series in the infrared region).

The lines in each group or series come closer to each other towards the higher frequency or lower wavelength.

At the end of each group or series there is a continuum.



(b) When electricity is passed through a discharge tube containing hydrogen gas at low pressure (or when heated) many of the molecules break up into single atoms.

The atoms get excited to different extents by electrons absorbing energy and moving (or jumping) from a lower energy level to a higher energy level. In the excited state, the atom is unstable therefore the electron falls back to the lower energy level and emits energy in form of radiation of specific wavelength or frequency.

The emitted radiation if analysed using a spectroscope gives rise to an emission or line spectrum.

26(b)(ii) How the hydrogen spectrum provides evidence for the existence of energy levels

- ① The hydrogen atom has one electron yet its spectrum has many lines
- 2) There are a group or series of lines in the hydrogen spectrum eg Balmer series electrons drop from higher energy levels to energy level number 2. Lyman series, electrons drop from higher energy levels to energy level number 1.
3. The spacing between adjacent lines in each series differ.
4. There is a continuum at the end of each group of lines or series signifying convergency of energy levels
- 5 The number of lines within each series in the spectrum increases with increase in resolving power of the Spectroscope signifying that within a given energy level there are sublevels which differ in energy and electron transitions from these levels give rise to these lines
6. Each line has a definite frequency or wavelength corresponding to the energy emitted when an electron drops from a higher energy level to a lower energy level.

(c)

$$E = hf$$

(h = plank's constant)
 f = frequency

$$= 6.6 \times 10^{-34} \times 3.28 \times 10^{15} \text{ J per electron}$$

$$= 6.6 \times 10^{-34} \times 3.28 \times 10^{15} \times 6.02 \times 10^{23} \text{ J mol}^{-1}$$

$$= 1303209.6 \text{ J mol}^{-1}$$

$$= 1303.2096 \text{ kJ mol}^{-1}$$

- (a) Relative atomic mass of an element is the average mass of its atoms on a scale on which one atom of the Carbon-12 isotope of carbon has a mass of 12 units.
- (b)
- The apparatus is evacuated of air.
 - The vapourised sample of the substance is introduced into the ionising chamber.
 - The sample collides with fast moving electrons to form positive ions.
 - The ions are accelerated by a strong electric field so that the ions which enter the magnetic field will be of the same kinetic energy.
 - The ions are then subjected to a magnetic field that deflects them according to their mass-charge ratio.
 - The strength of the magnetic field and electric field are varied so that ions of a given mass are received at the detector or collector.
 - When the ions strike the collector they produce an electric current, the magnitude of which is proportional to the abundance of the isotope which gives rise to the ions.
 - The detector currents are recorded as a series of lines or peaks corresponding to the relative abundance of the ions of a particular mass falling on the collector at that instant.
- The relative atomic mass is calculated as the average mass of the isotopes according to their abundances using the formula,

$$RAM = \frac{\sum \% \text{ abundance} \times \text{atomic mass of isotopes}}{100}$$

(i) Total current = $0.16 + 2.72 + 2.50 + 5.92 = 11.3 \text{ mA}$

Isotope 204; $\frac{0.16}{11.3} \times 100 = 1.42\%$

Isotope 206; $\frac{2.72}{11.3} \times 100 = 24.07\%$

Isotope 207; $\frac{2.50}{11.3} \times 100 = 22.12\%$

Isotope 208; $\frac{5.92}{11.3} \times 100 = 52.39\%$

$$\begin{aligned}\text{Relative atomic mass} &= \frac{\sum \% \text{ abundance} \times \text{Isotopic mass}}{100} \\ &= \frac{(204 \times 1.42) + (206 \times 24.07) + (207 \times 22.12) + (208 \times 52.39)}{100} \\ &= \underline{207.24}\end{aligned}$$

- (a) Order of reaction is the sum of the Powers of the Concentration of the reactants in the rate equation.
Half life of a reaction is the time taken for the quantity of the reactant to reduce by half.

(b)

Time (minutes)	2.0	4.0	7.0	10.0	14.0	20.0
Concentration of B (mol l^{-1}), [B]	0.820	0.670	0.490	0.372	0.24	0.141
$\log_{10} [B]$	-0.086	-0.174	-0.310	-0.429	-0.620	-0.851

- (c) (i) Order of the reaction is 1 because a plot of $\log_{10} [B]$ against time produces a straight line with a negative gradient.

- (ii) Rate constant, K .

$$\begin{aligned}\text{Slope} &= \frac{-0.851 - -0.086}{20.0 - 2} \\ &= \frac{-0.765}{18} \\ &= -0.0425 \text{ min}^{-1}\end{aligned}$$

$$\text{From, slope} = \frac{-K}{2.303}$$

$$\begin{aligned}K &= -\text{slope} \times 2.303 \\ &= 0.0425 \times 2.303\end{aligned}$$

$$K = 0.0979 \text{ min}^{-1}$$

- (iii) Half life, $t_{1/2}$

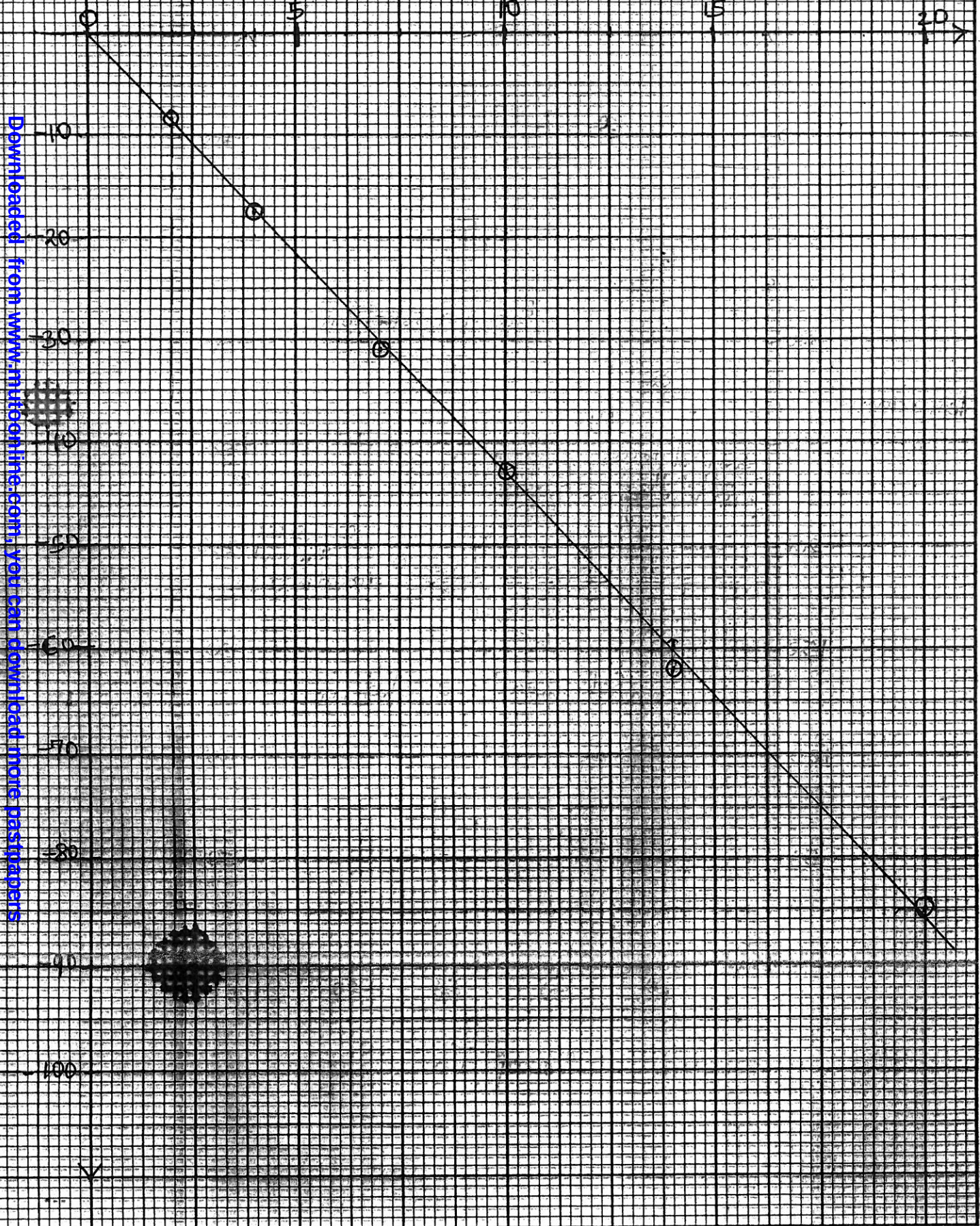
$$t_{1/2} = \frac{\ln 2}{K}$$

$$= \frac{\ln 2}{0.0979}$$

$$t_{1/2} = 7.08 \text{ minutes}$$

A graph of $\log_{10} [B]$ against time.

Time (minutes)



NO. 30

(a) This is the method used to separate a volatile component, which is immiscible with water, from other non-volatile impurities by passing steam through the impure sample, and boiling occurs below 100°C .

b(i) The substance should be immiscible with water

- The substance should exert a high vapour pressure at the boiling point of water.

- The substance should have a fairly high relative molecular mass.

(ii) - The substance should be immiscible with water so that at a given temperature each of the components produces vapour independent of their proportions in the mixture and hence boil at a much lower temperature than the boiling point of the volatile component.

- The substance should have a high relative molecular mass so that much of it is got in the distillate.

- The substance to be purified should be more volatile than the impurities so that it exerts a higher vapour pressure near the boiling point of water so that the mixture boils at a temperature below 100°C and also so that much of it is obtained in the distillate.

(iii) Advantages of Isolating Substances by steam distillation.

- Distillation occurs at a lower temperature than the boiling point of any of the components of the distillate.

- It enables purification of substances that decompose at temperatures close to their boiling points.

(c) From the graph at 97°C and 1 atm,

$$VP_A = 0.62 \text{ atm}, \quad VP_{\text{H}_2\text{O}} = 0.385 \text{ atm}.$$

$$Mr_{\text{H}_2\text{O}} = (1 \times 2) + (1 \times 16) = 18$$

$$\frac{\text{Mass of A in distillate}}{\text{Mass of H}_2\text{O in distillate}} = \frac{VP_A \times Mr_A}{VP_{\text{H}_2\text{O}} \times Mr_{\text{H}_2\text{O}}},$$

$$\frac{4.3}{1.1} = \frac{0.62 \times Mr_A}{0.385 \times 18}$$

$$Mr_A = \underline{43.694}$$

(a) Λ ($\Omega^{-1}\text{cm}^2\text{mol}^{-1}$)	238	230	224	217	210	202	
$\sqrt{\text{concentration}}$ ($\text{mol}^{1/2}\text{dm}^{-3/2}$)	0.1	0.2	0.3	0.4	0.5	0.6	

(i) See graph.

(ii) Molar Conductivity decreases with increase in concentration. At low concentration, ions are far apart and their mobility is high. As the concentration of the ions increases, ions get closer to each other and ionic interference increases leading to decrease in the mobility of the ions hence molar conductivity decreases.

(iii) Molar conductivity at infinite dilution = $245\Omega^{-1}\text{cm}^2\text{mol}^{-1}$

(i) Using KCl.

$$K_{\text{KCl}} = \frac{\text{Cell constant}}{R}$$

$$\text{Cell constant} = K \times R$$

$$= 0.01164 \times 24.96$$

$$= 0.2905 \text{ cm}^{-1}$$

(ii) For BrCH_2COOH

$$\Lambda_{0.1} = \frac{1000K}{C}$$

$$\text{But } K_{\text{BrCH}_2\text{COOH}} = \frac{\text{Cell constant}}{R}$$

$$= \frac{0.2905}{66.5}$$

$$K = 0.004367 \Omega^{-1}\text{cm}^{-1}$$

$$\Lambda_{0.1} = \frac{1000 \times 0.004367}{0.1}$$

$$\Lambda_{0.1} = 43.6894 \Omega^{-1}\text{cm}^2\text{mol}^{-1}$$

$$(iii) \alpha = \frac{\Lambda_c}{\Lambda_0}$$

$$= \frac{43.6894}{389}$$

$$\alpha = 0.1123$$

$$K_a = C\alpha^2$$

$$K_a = 0.1 \times (0.1123)^2$$

$$K_a = 1.2614 \times 10^{-3} \text{ mol dm}^{-3}$$

$$K_a = \frac{[\text{H}^+]^2}{C}$$

$$[\text{H}^+] = \sqrt{K_a \times C}$$

$$= \sqrt{1.2614 \times 10^{-3} \times 0.1}$$

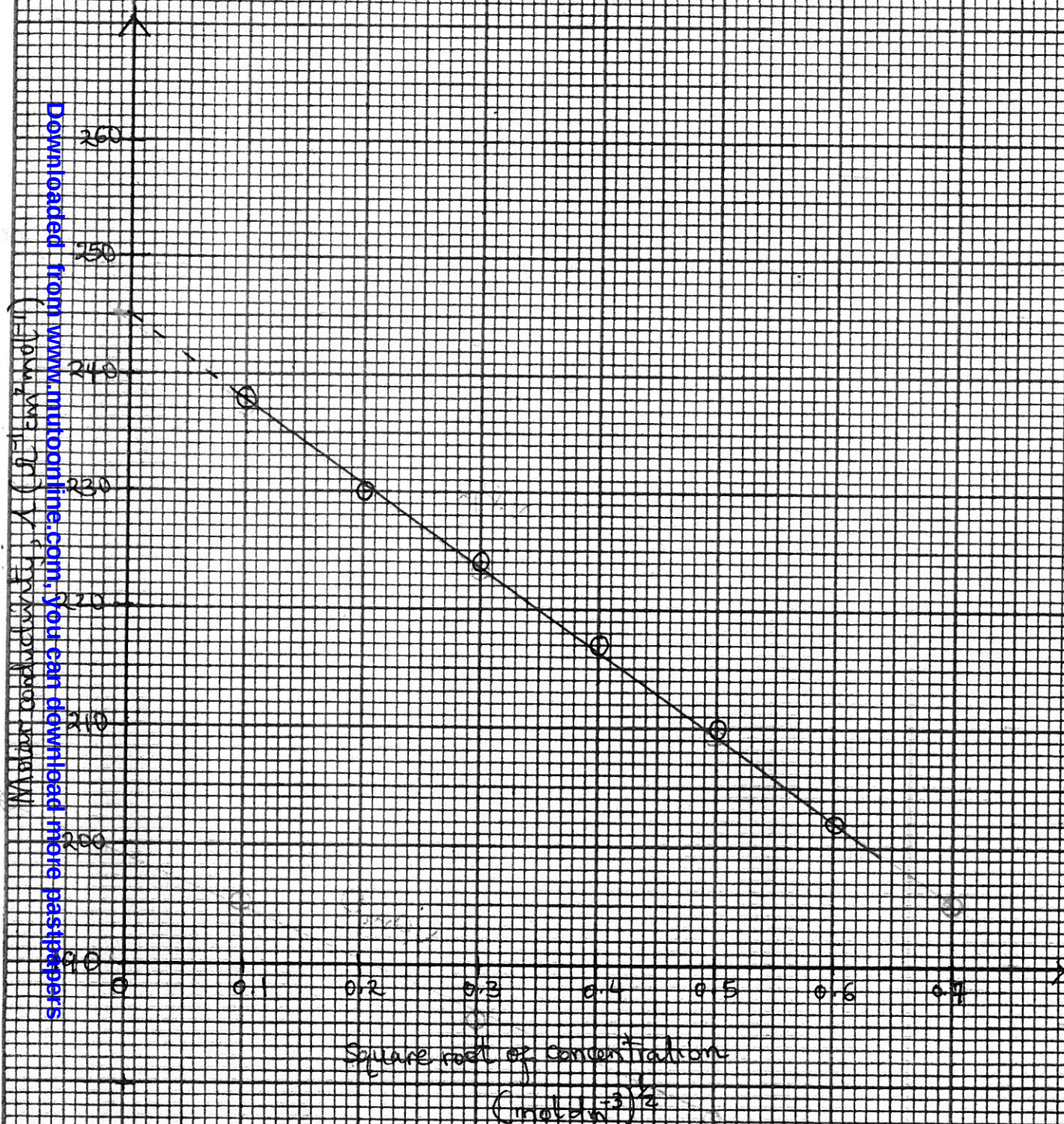
$$[\text{H}^+] = 0.01123 \text{ mol dm}^{-3}$$

$$\text{pH} = -\log [\text{H}^+]$$

$$= -\log (0.01123)$$

$$\text{pH} = 1.95$$

A graph of molar conductivity against square root of concentration



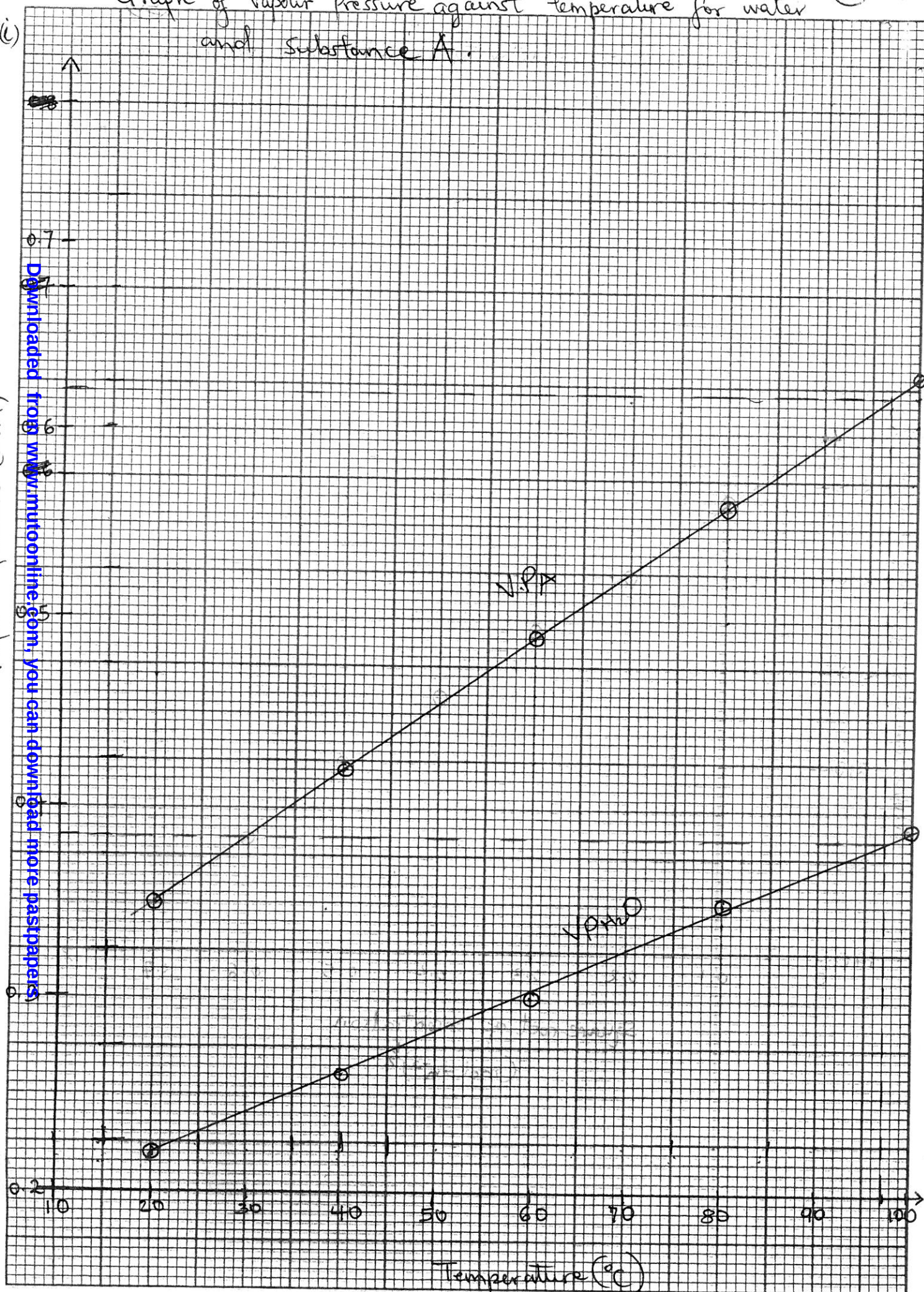
NO. 30

Graph of Vapour Pressure against temperature for water and Substance A.



(i)

Vapour Pressure (atm)



(ii)

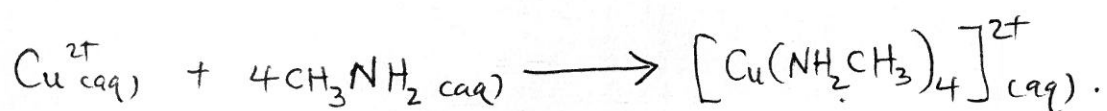
Intercept = 0.4 moles

0.1 moles of Cu^{2+} complexed with 0.4 moles of CH_3NH_2

$$\begin{aligned} \text{1 mole of } \text{Cu}^{2+} \text{ complexed with } & \left(\frac{0.4}{0.1} \right) \\ & = \underline{4 \text{ moles}} \end{aligned}$$

$$n = 4.$$

(b)



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(To be fastened together with other answers to paper)

UACE

Candidate's Name

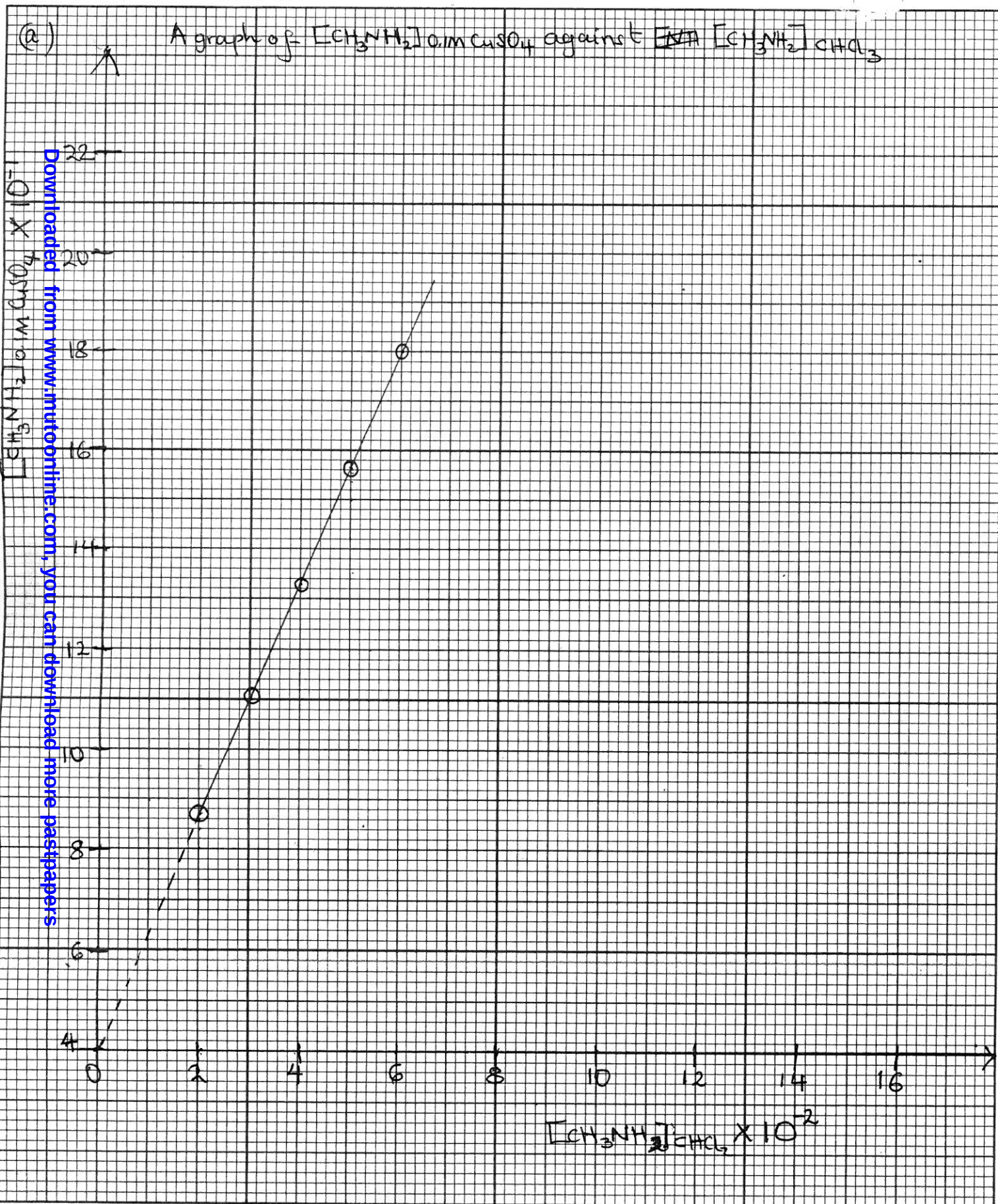
Signature

Subject Name NO. 32 Paper code /

Random No.	41		
Personal Number			

(a) A graph of $[CH_3NH_2] \times 10^{-2}$ against $[CH_3NH_2]CHCl_3$

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(i) See graph. Page 14

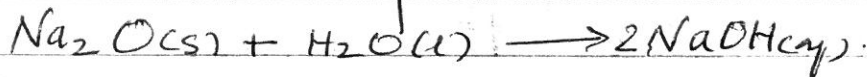
(ii) The melting point increases from Sodium oxide to Magnesium oxide then reduces up to dichlorine heptoxide.

Sodium oxide, Magnesium oxide and aluminium oxide have giant ionic structure.

The ions are held together by strong ionic bonds. The melting point increases from Sodium oxide to Magnesium oxide due to increase in Charge density of the cation; from Magnesium oxide to aluminium oxide it decreases due to very high charge density of aluminium ion which polarises the oxide ion making aluminium partly covalent (less ionic).

Silicon dioxide has a giant covalent structure. Its atoms are held by strong covalent bonds, the rest of the oxides have simple molecular structures. Molecules are held by weak van der Waals forces whose strength decreases with decrease in Polarity of the molecules as a result of decrease in difference of electronegativity of bonding atoms.

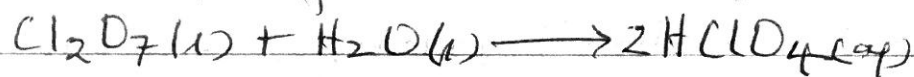
b) (i) Sodium oxide reacts with cold water to give sodium hydroxide



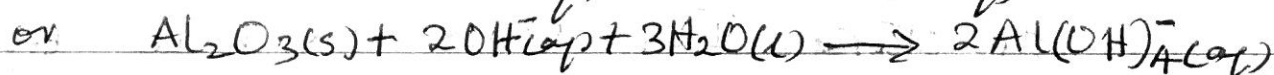
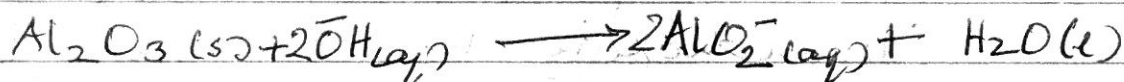
• Magnesium reacts with hot water or on heating to form magnesium hydroxide



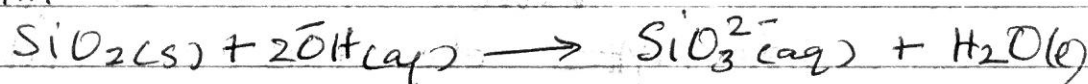
• Dichlorine heptoxide reacts with cold water to form chloric(VII) acid.



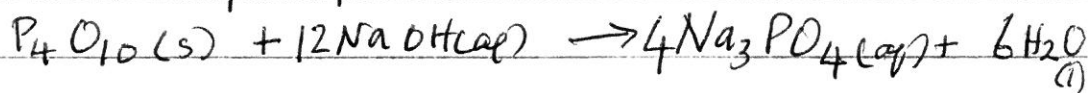
(ii) Aluminium oxide reacts with concentrated sodium hydroxide solution to form an aluminate.



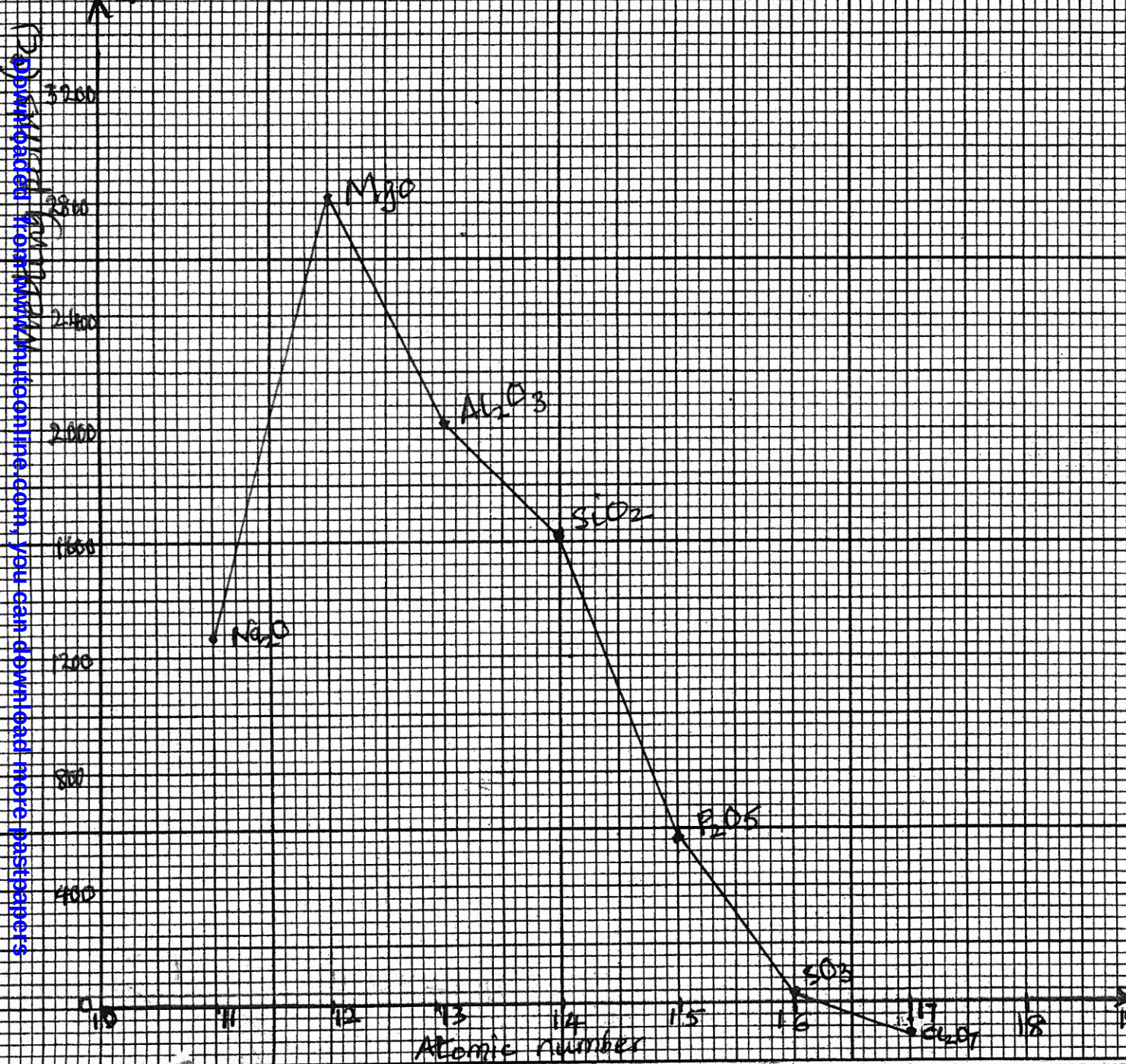
• Silicon(IV) oxide reacts with hot concentrated sodium hydroxide to form a silicate



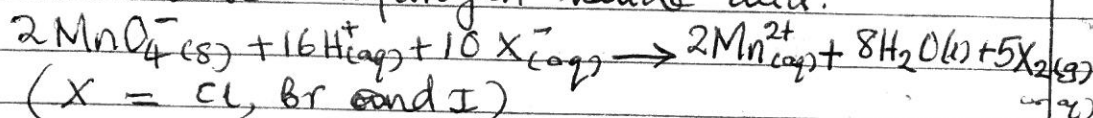
• Phosphorus(V) oxide reacts with cold aqueous sodium hydroxide to form sodium phosphate(V) and water



A graph of Melting points of the oxides against atomic number of the elements.

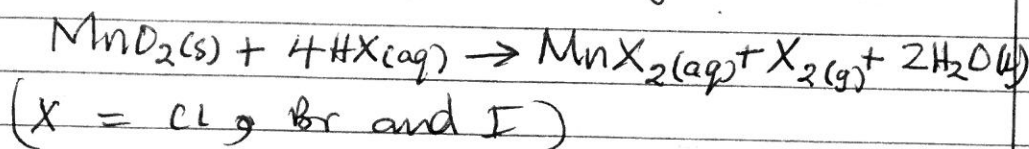


- (a) The halogens can be prepared by reacting Potassium manganate(VII) with a concentrated hydrogen halide acid.

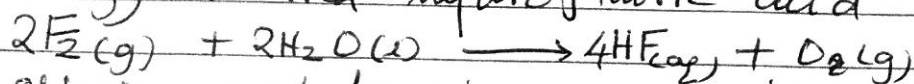


OR

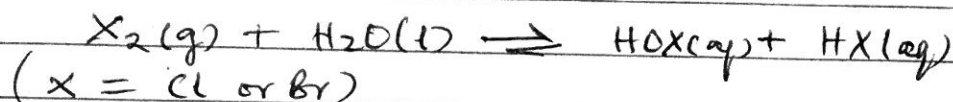
Heating Manganese(IV) oxide with a concentrated solution of a hydrogen halide.



- (b) (i) Fluorine reacts with water to form oxygen and hydrofluoric acid

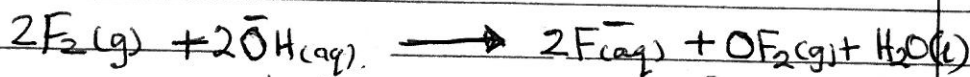


Chlorine and bromine react with water to form hypohalous and hydrogen halide acids

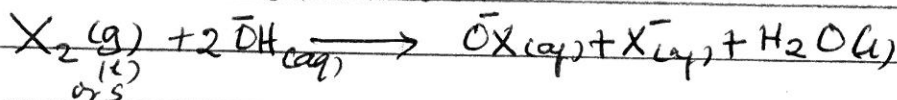


Iodine does not react with water

- (ii) Fluorine reacts with cold dilute Sodium hydroxide to form Sodium fluoride, oxygen difluoride gas and water

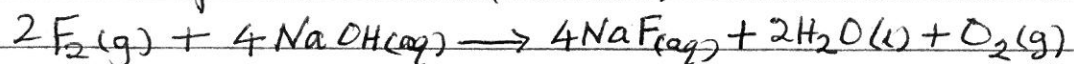


The other halogens react with cold dilute Sodium hydroxide to form halate(⁵), a halide and water

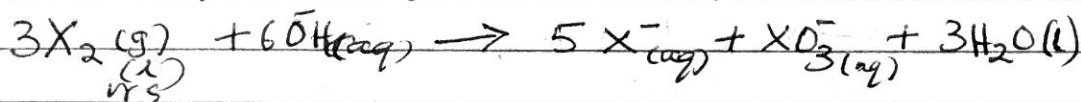


Fluorine reacts with hot concentrated Sodium hydroxide solution to give oxygen,

Sodium fluoride and water.



The other halogens react with hot concentrated sodium hydroxide solution to give a halide, halate and water



(X = Cl, Br, and I)

(a) The boiling point of the hydrides decrease from hydrogen fluoride to hydrogen chloride and increase from hydrogen chloride to hydrogen Iodide. The boiling point of hydrogen fluoride is abnormally high because hydrogen fluoride molecules are associated via hydrogen bonding. Hydrogen bonds are strong and need a lot of energy to break. Fluorine has a small atomic radius and high electronegativity hence hydrogen-fluorine bond is highly Polar leading to formation of hydrogen bonds. Hydrogen chloride, hydrogen bromide and hydrogen Iodide molecules have weak van der Waals forces between their molecules and these forces become stronger as molecular mass increases in the order $\text{HCl} < \text{HBr} < \text{HI}$.

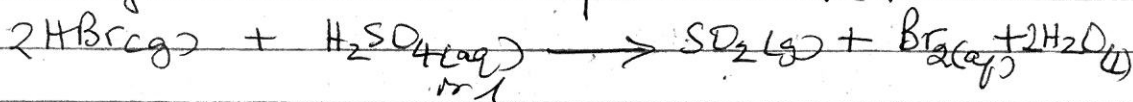
(b) The strength of the acids is in the order hydrogen fluoride $<$ hydrogen Chloride $<$ hydrogen bromide $<$ hydrogen Iodide

OR The Acid strength increases from hydrogen fluoride to hydrogen chloride to hydrogen bromide to hydrogen Iodide.

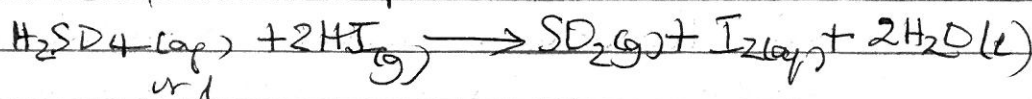
The strength of the acid depends on the ease of release of a proton which depends on both the bond strength and bond energy of the hydrogen-halogen bond and the atomic radius of the halogen. The larger the atom, the weaker the hydrogen-halogen bond and the stronger the acid. The bond length is in the order $\text{H-F} < \text{H-Cl} < \text{H-Br} < \text{H-I}$ and bond strength is in the order $\text{H-F} > \text{H-Cl} > \text{H-Br} > \text{H-I}$.

- (c) Concentrated sulphuric acid has no effect on hydrogen fluoride and hydrogen chloride. This is because hydrogen fluoride is not reducing and hydrogen chloride is a weak reducing agent.

Concentrated sulphuric acid oxidises hydrogen bromide to bromine and is itself reduced to sulphur dioxide.



concentrated sulphuric acid oxidises hydrogen iodide to iodine and is itself reduced to sulphur dioxide.



- d) (i) The strength of the acids is in the order. $\text{HClO} < \text{HClO}_2 < \text{HClO}_3 < \text{HClO}_4$.

Increase in acid strength is due to increase in number of oxygen atoms attached to chlorine.

Oxygen has a greater electronegativity than chlorine such that it withdraws electrons away from the chlorine atom. This withdrawal is transmitted through the chlorine atom to the oxygen-hydrogen bond ($\text{O}-\text{H}$), causing an increase in the partial positive charge of the hydrogen atom. The

oxygen-hydrogen bond therefore is weakened and a proton can be easily lost. The magnitude of the partial positive

charge on the hydrogen atom and weakening of the oxygen-hydrogen bond increases with increase in number of oxygen atoms attached to the chlorine atom. ($\text{H}-\text{O}-\text{Cl}$)

(a) Carbon and Silicon do not react with cold water.

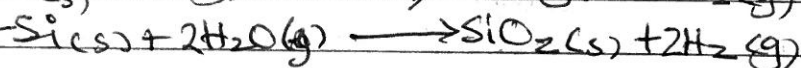
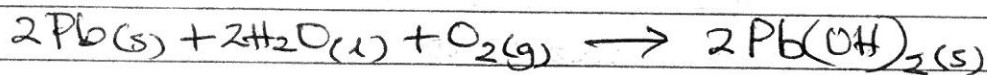
Carbon reacts with steam on heating to form Carbon monoxide and hydrogen.

Silicon reacts with steam on heating to give Silicon (IV) oxide and hydrogen.

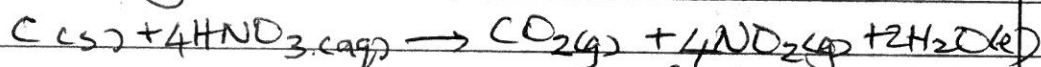
Germanium does not react with water or steam.

Tin does not react with water or steam.

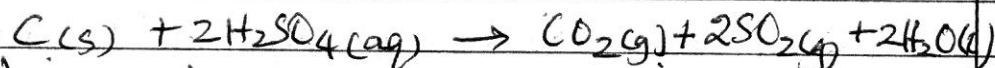
Lead reacts with soft water containing dissolved oxygen (aerated soft water) to form Lead(II) hydroxide



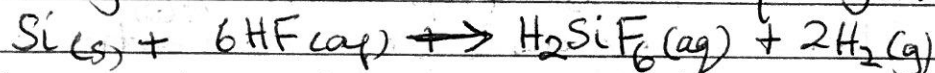
(b). Carbon reacts with hot concentrated nitric acid forming carbon dioxide, nitrogen dioxide and water



Carbon is oxidised by hot concentrated sulphuric acid to carbon dioxide and acid is reduced to sulphur dioxide and water

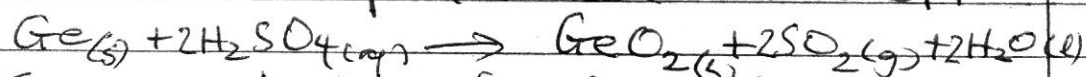


Silicon does not react with acids except concentrated hydrofluoric acid with which it reacts to form hexafluorosilicic acid and hydrogen

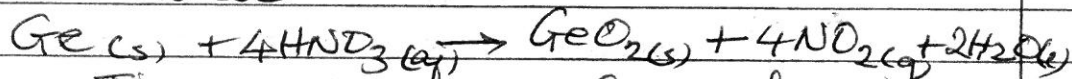


Germanium is oxidised by hot concentrated sulphuric acid to form germanium(IV) oxide, and the acid is

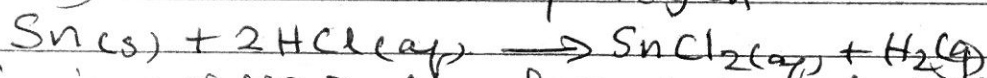
reduced to sulphur dioxide and water.



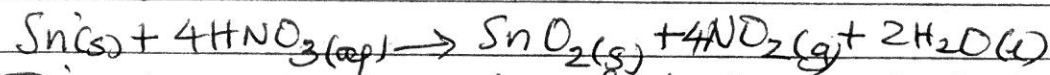
Germanium is oxidised by hot concentrated nitric acid to germanium(IV) oxide and the acid is reduced to nitrogen dioxide and water.



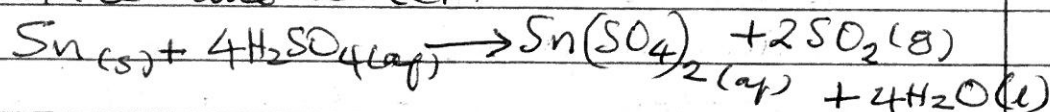
Tin reacts with concentrated hydrochloric acid to form tin(II) chloride and hydrogen.



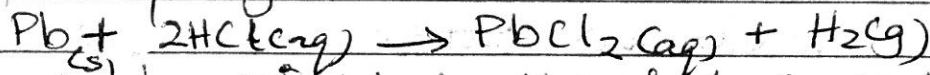
Tin is oxidised by hot concentrated nitric acid to form tin(IV) oxide and the acid is reduced to nitrogen dioxide and water.



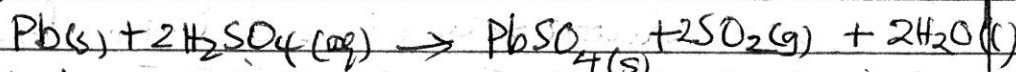
Tin is oxidised by hot concentrated sulphuric acid to tin(IV) sulphate and the acid is reduced to sulphur dioxide and water.



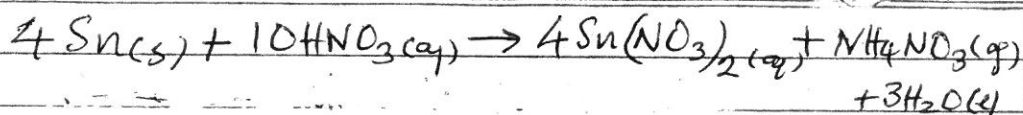
Lead reacts with hot concentrated hydrochloric acid to form Lead(II) chloride and hydrogen.



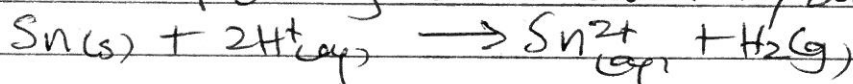
Lead is oxidised by hot concentrated sulphuric acid to Lead(II) sulphate and the acid is reduced to sulphur dioxide and water.



Lead is oxidised by concentrated nitric acid (cold) to Lead(II) nitrate and the acid is reduced to nitrogen dioxide and water.

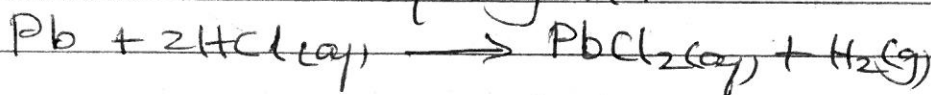


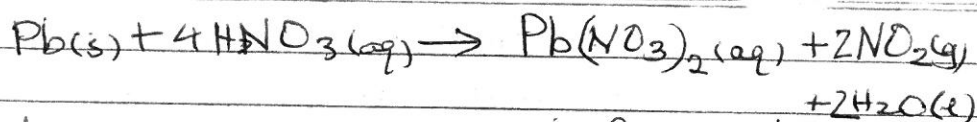
Tin reacts with dilute hydrochloric acid dilute sulphuric acid to form a corresponding salt and hydrogen.



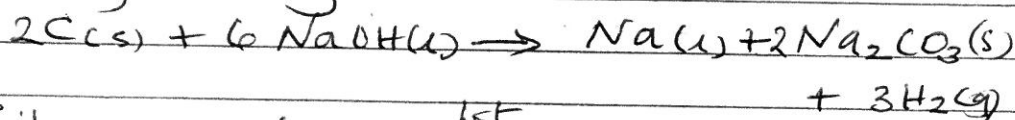
Lead is rendered passive by dilute hydrochloric and dilute sulphuric acid due to formation of an insoluble chloride and sulphate respectively.

Lead reacts with dilute hydrochloric acid on heating to form Lead(II) chloride and hydrogen.

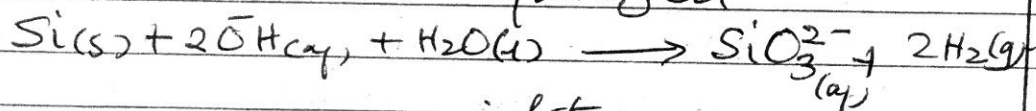




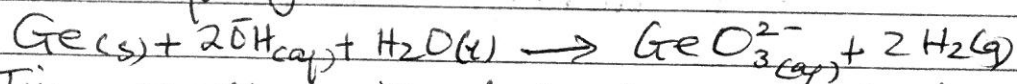
(c) Carbon reduces sodium hydroxide to Sodium metal and Sodium carbonate on strong heating



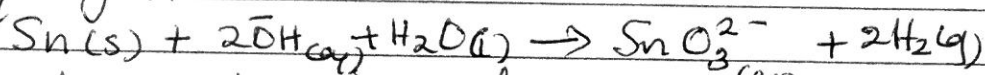
Silicon reacts with ^{hot} concentrated Sodium hydroxide solution to form a silicate and hydrogen



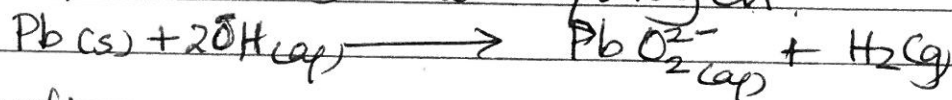
Germanium reacts with ^{hot} concentrated Sodium hydroxide solution to form a germanate(IV) and hydrogen.



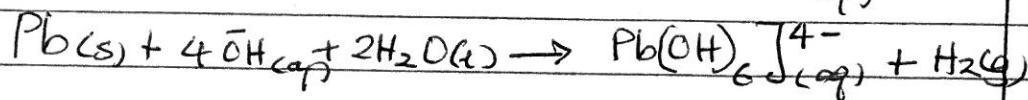
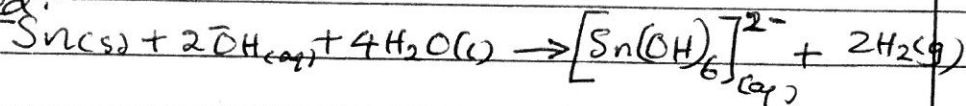
Tin reacts with hot concentrated Sodium hydroxide to form stannate(IV) and hydrogen



Lead reacts with hot concentrated Sodium hydroxide solution to form a plumbate(II) and hydrogen.

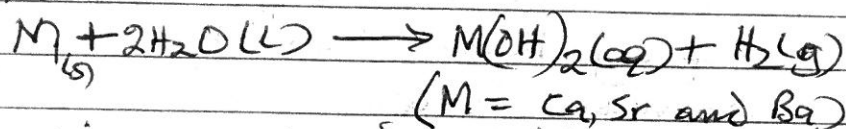
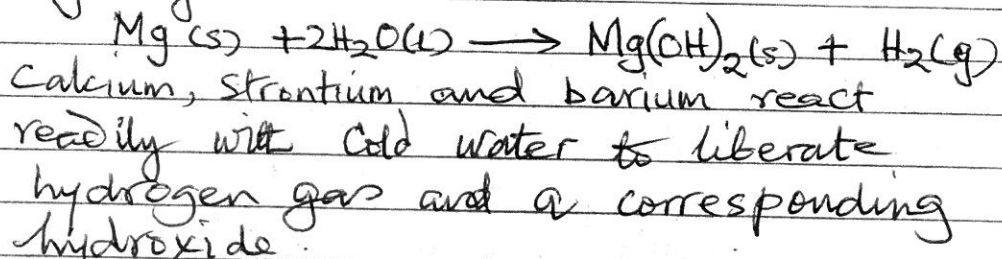


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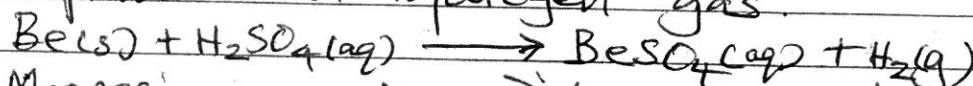


(d) Carbon, silicon and germanium do not react with dilute acids
Tin reacts with cold dilute nitric acid to give tin(II) nitrate, ammonium nitrate and water

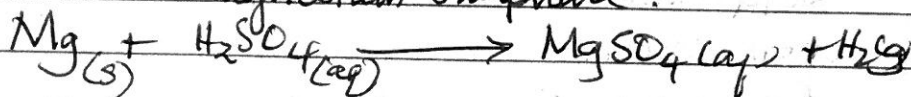
- (a)(i) Beryllium does not react with water. Magnesium reacts slowly with cold water to give Magnesium hydroxide and hydrogen.



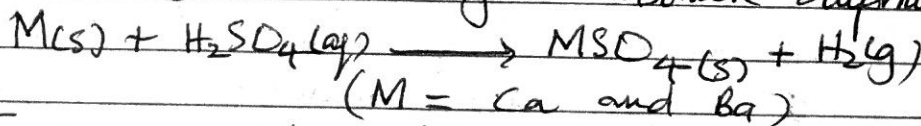
- (ii) Beryllium reacts with dilute sulphuric acid on warming to form beryllium sulphate and hydrogen gas.



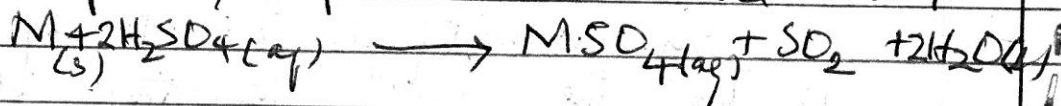
Magnesium reacts readily with cold dilute sulphuric acid to form hydrogen gas and Magnesium sulphate.



Calcium and barium react slowly with cold dilute sulphuric acid and soon stops due to formation of an insoluble sulphate.



They react with hot concentrated sulphuric acid to form a metal sulphate, sulphur dioxide and water.



- (b)(i) Solubility of the hydroxides increase down the group. This is because as cation radius increase down the group, both lattice and hydration energy decrease.

But lattice energy decrease more rapidly than hydration energy. The solution process becomes more exothermic down the group, favouring solubility down the group.

(ii) For the Sulphates, solubility decreases because, down the group, both lattice energy and hydration energy decrease but lattice energy decreases less rapidly than hydration energy. The solution process becomes less exothermic down the group hence the decrease in solubility of the sulphates down the group.