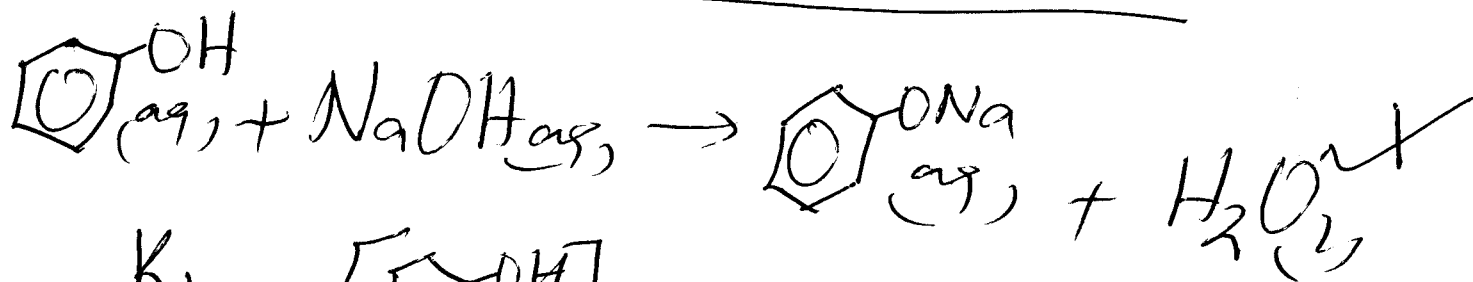


Q. (a) When a solute ~~substance~~ is shaken in two immiscible solvents and left to settle to attain equilibrium at constant temperature, its self such that the ratio of concentration of solute in one solvent to its concentration in the other solvent is constant provided that the solute is in the same molecular state in both solvents.

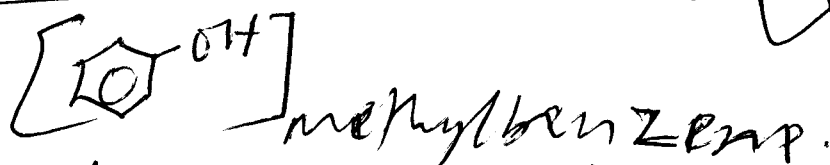
(b) A known volume of water is added to a known volume of methylbenzene followed by a known mass of phenol, the mixture shaken and allowed to stand to attain equilibrium at constant temperature. At equilibrium, a fixed volume of aqueous layer is pipetted and titrated with a standard solution of sodium hydroxide using phenolphthalein indicator to determine the concentration of phenol in aqueous layer.

Also a known volume of ^{methyl benzene} ~~organic~~ layer is fitted and titrated with a standard solution of sodium hydroxide using phenolphthalein indicator or to determine the concentration of phenol in organic layer

TREATMENT OF RESULTS



$$K_D = \frac{[\text{C}_6\text{H}_5\text{OH}]_{\text{aqueous layer}}}{[\text{C}_6\text{H}_5\text{OH}]_{\text{methylbenzene}}}$$



- (C) - When temperature is constant ↓
 - when solvents are immiscible ↓
 - when solute is soluble in both solvents. ✓ (2)
 - when solute is neither dissociate nor associates in solvents.

(d) 100 cm³ contains 0.05 moles HCl

23 cm³ contains $\frac{23 \times 0.05}{100}$

$= 1.15 \times 10^{-3} \text{ moles.}$

$\text{NH}_3 \text{ aq} + \text{HCl} \text{ aq} \rightarrow \text{NH}_4\text{Cl} \text{ aq}$

20 cm³ contains 1.15×10^{-3} mols of NH_3

molar ratio $\text{HCl} : \text{NH}_3 = 1 : 1$

mols of NH_3 in $\text{CHCl}_3 = 1.15 \times 10^{-3}$

original mols of NH_3 in H_2O ,

1000 cm³ contains 1.5 mols of NH_3

50 cm³ contains $\left(\frac{50 \times 1.5}{1000} \right)$

$= 0.075$ mols of NH_3

NH_3

~~mols of NH_3 that remained in H_2O~~

~~$= 0.075 - 1.15 \times 10^{-3}$~~

mols of NH_3 that remained in H_2O

$= 0.075 - 1.15 \times 10^{-3}$

$= 0.072125$ mols

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

$= \frac{0.072125}{1.15 \times 10^{-3}}$

$K_D = 25.1$

(c) 1000 cm³ contains 0.062 mols of HCl

30 cm³ contains $\left(\frac{30 \times 0.062}{1000} \right)$

$= 1.86 \times 10^{-3}$ mols HCl

mol ratio is $\text{HCl}:\text{NH}_3 = 1:1$

moles of $\text{NH}_3 = 1.86 \times 10^{-3}$ moles of NH_3 ✓

50 cm³ contains 1.86×10^{-3} moles NH_3

1000 cm³ contains $\left(\frac{1000 \times 1.86 \times 10^{-3}}{50} \right)$

1/12

$= 0.0372 \text{ M}$ ✓

(ii)

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

organic layer

1/2

$$2.5 = \frac{[\text{NH}_3]_{\text{org}}}{0.0372}$$

$$[\text{NH}_3]_{\text{org}} = 2.5 \times 0.0372 = 0.093 \text{ M}$$

(iii) Original $[\text{NH}_3]_{\text{aq}}$

1000 cm³ contains 0.5 moles HCl

40 cm³ contains $\left(\frac{40 \times 0.5}{1000} \right)$ ✓

$= 0.02$ moles HCl

1/2

mol ratio of $\text{HCl}:\text{NH}_3 = 1:1$

moles of $\text{NH}_3 = 0.02$ moles ✓

(5)

20 ml contains 0.02 moles NH_3

$$1000 \text{ ml contains } \left(\frac{1000 \times 0.02}{20} \right) \\ = 1 \text{ M} \checkmark$$

$$[\text{NH}_3]_{\text{complexed}} = [\text{NH}_3]_{\text{total}} - [\text{NH}_3]_{\text{free}} \\ = 1 - 0.93 = 0.07 \text{ M} \checkmark$$

In the complex $\text{Zn}(\text{NH}_3)_4^{2+}$

~~$A = \frac{[\text{NH}_3]_{\text{complexed}}}{[\text{Zn}^{2+}]}$~~

$$A = \frac{0.07}{[\text{Zn}^{2+}]}$$

$$[\text{Zn}^{2+}] = \frac{0.07}{4} = 0.0175 \text{ M} \checkmark$$

$$\text{mass of Zn in the sol} = 0.0175 \times 65 = 1.1375 \text{ g}$$

$$\% \text{ purity} = \frac{1.1375}{1.5} \times 100 = 75.83\% \checkmark$$

20

② ^(a) %g of O = $100 - 40 - 6.67 = 53.33\%$ ✓

Elements present C H O

Comp by mass 40 6.67 53.33

no. of moles

$$\frac{40}{12} \quad \frac{6.67}{1} \quad \frac{53.33}{16}$$

$$= 3.33 \quad 6.67 \quad 3.33$$

ratio

$$\frac{3.33}{3.33} \quad \frac{6.67}{3.33} \quad \frac{3.33}{3.33}$$

$$= 1 : 2 : 1$$

Empirical formula is CH_2O ✓

(b) 250 cm³ water contains 28.145 g of

1000 cm³ of water contains $\frac{1000 \times 28.145}{250}$ ✓

$$= 112.58 \text{ g}$$

Depression in fpt = $0 - 3.49 = -3.49^\circ\text{C}$ ✓

3.49°C is drop in fpt caused by 112.58 g of

1.86°C is drop in fpt caused by $\frac{1.86 \times 112.58}{3.49}$ ✓

$(\text{CH}_2\text{O})_n = 60$

$12n + 2n + 16n = 60$

$30n = 60$

$n = 2$ ✓

$= 60 \text{ g}$ ✓

Molecular formula is $\text{C}_2\text{H}_4\text{O}_2$ ✓

(ii) CH_3COOH Ethanoic Acid. (2)
 HCOOCH_3 methylmethanoate.

(c) methylmethanoate (1/2)

(i) $\text{CH}_3\text{Br} \xrightarrow{\text{NaOH(aq)}}$ $\text{CH}_3\text{OH} \xrightarrow{\text{HCOOH, H}^+}$ HCOOCH_3 (1/2)

(d) $\text{HCOOCH}_3 + \text{H}_2\text{O} \xrightarrow{\text{OH}^-}$ $\text{HCOO}^- + \text{CH}_3\text{OH}$ (1/2)
 $\text{H}-\text{C}(=\text{O})-\text{OCH}_3 \rightarrow \text{H}-\text{C}(\text{OH})(\text{O}^-)-\text{OCH}_3 \xrightarrow{-\text{CH}_3\text{O}^-} \text{H}-\text{C}(=\text{O})-\text{OH}$

(e) Saponification (1/2)
 - used in manufacture of soap
 $\text{H}-\text{C}(=\text{O})-\text{O}^- + \text{CH}_3\text{OH} \rightarrow$

(f) $\text{HC}\equiv\text{CH} \xrightarrow[\text{FeSO}_4/\text{heat}]{\text{catalyst, } 60^\circ\text{C, satn}}$ $\text{C}_6\text{H}_5\text{C}\equiv\text{CH} \xrightarrow[\text{H}^+]{\text{CH}_3\text{CH}=\text{CH}_2}$ $\text{C}_6\text{H}_5\text{C}(\text{CH}_3)=\text{CH}_2$ (1/2)
 $\downarrow \text{conc H}_2\text{SO}_4, \text{heat}$

(g) $(\text{CH}_3)_2\text{C}(\text{H})-\text{C}_6\text{H}_4-\text{SO}_3\text{Na} \xrightarrow{\text{NaOH(aq)}}$ $(\text{CH}_3)_2\text{C}(\text{H})-\text{C}_6\text{H}_4-\text{SO}_3\text{H}$ (1/2)
 (ii) - Formation of Sulfonated Detergent (1/2)

Advantage

- forms a lather immediately with hard water to avoid wastage
- can be used in acidic medium

DISADVANTAGE

non-biodegradable

(a) Copper pyrites

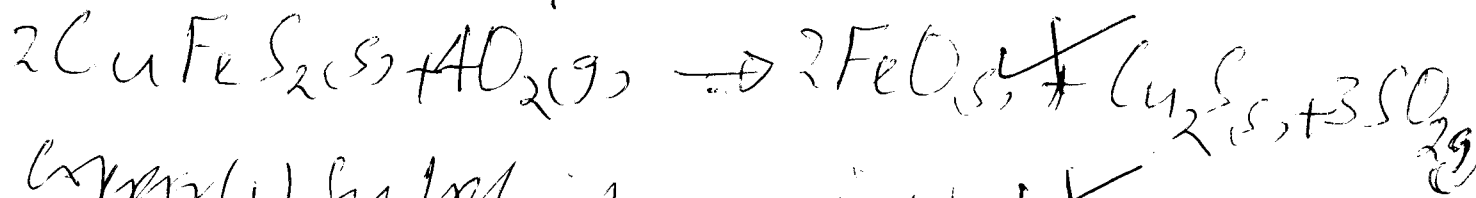
(ii) - Concentration by Froth Flotation

The ore is crushed into powder and dissolved in water which with its impurities and lumps with them to the bottom. The mixture is made alkaline by adding slaked lime and a frothing agent like pine oil is added which wet the ore and floats with it to the surface. Air is blown through the mixture to agitate it while air bubbles rise to the surface with most ore concentrated in the ~~float~~ froth which is skimmed off, broken with an acid, the ore filtered off, washed and dried.

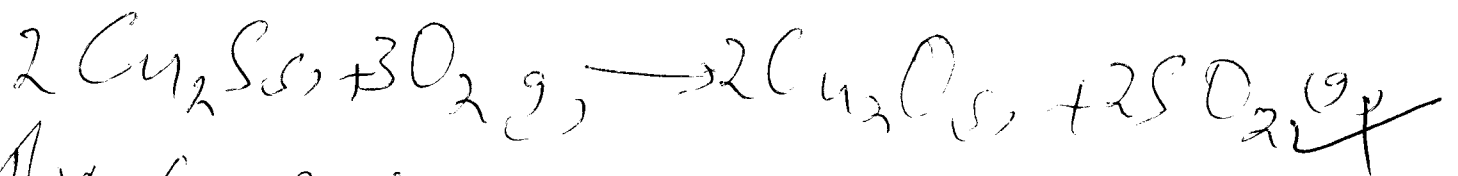
- OXIDATION / REDUCTION / SMELTING

The ore is mixed with silica

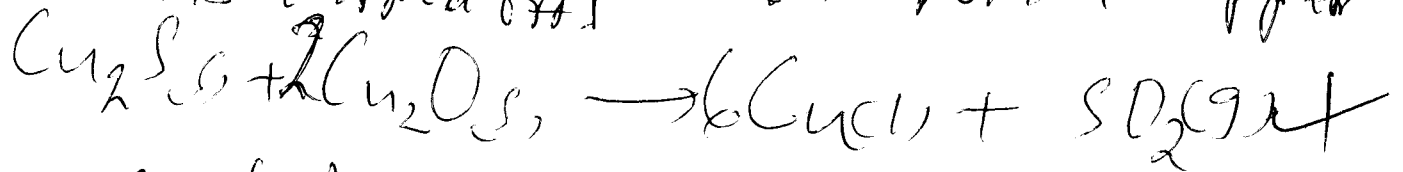
and feed into a furnace. ~~Air is blown~~
~~into~~ Air is blown into the furnace
 which oxidises iron pyrites to iron(II)
 oxide and sulphur dioxide and forming
 copper(I) sulphide.



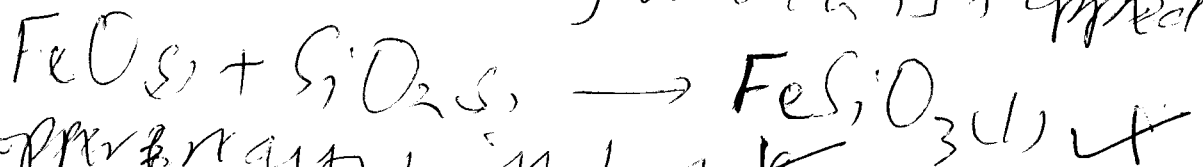
Copper(I) sulphide is oxidised to copper
 (I) oxide



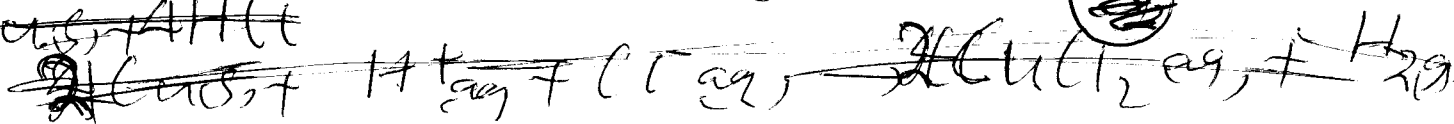
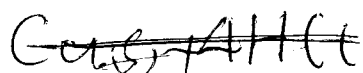
The copper(I) oxide reacts with the remain-
 ing copper sulphide to form copper
 which is tapped off.



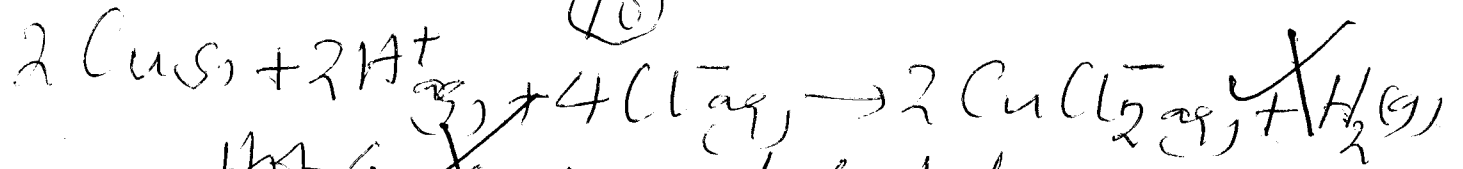
The iron(II) oxide combines with silica
 to form iron(II) silicate which is
 removed as slag which is tapped off.



(b) Copper reacts with hot concentrated
 Hydrochloric acid to form dilute copper
 (II) giving off Hydrogen gas



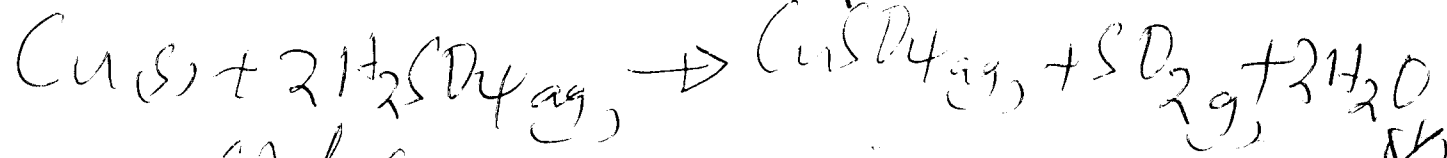
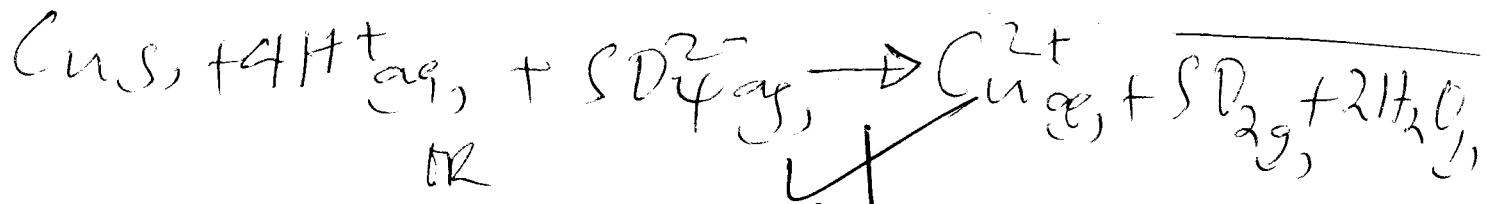
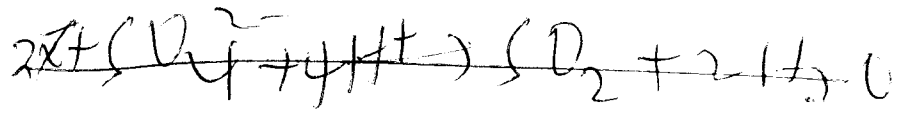
(10)



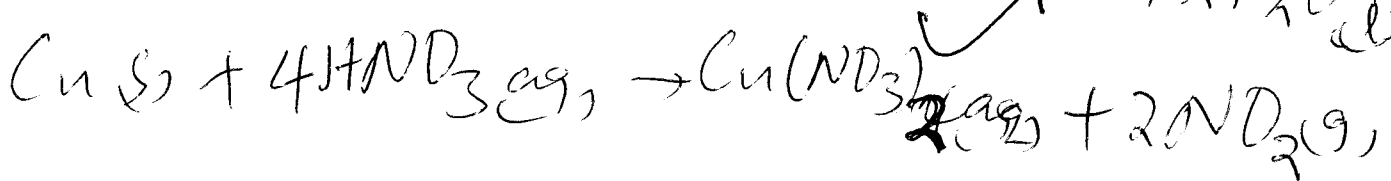
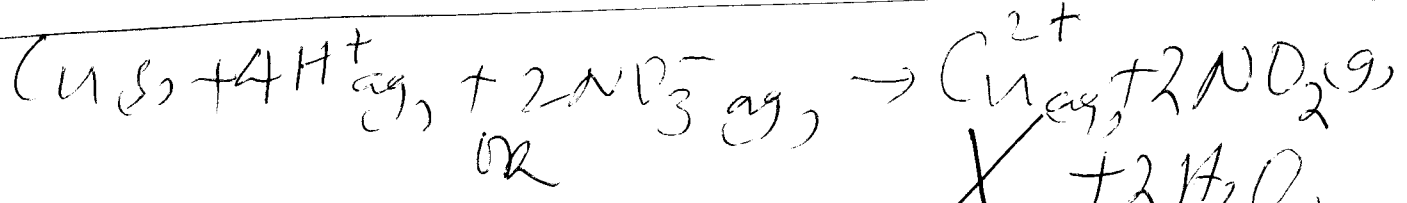
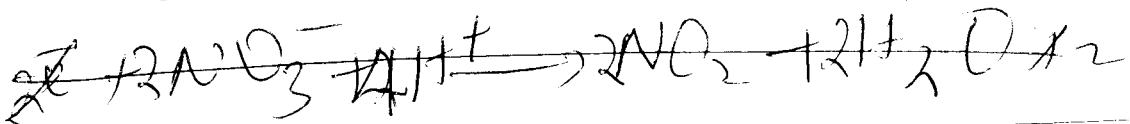
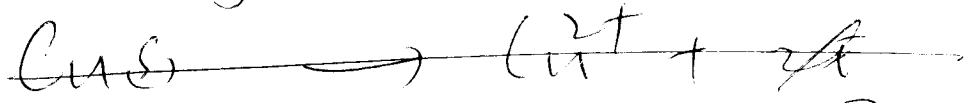
Hot concentrated sulphuric acid oxidises copper to copper(II) sulphate its self reduced to sulphur dioxide gas.



8

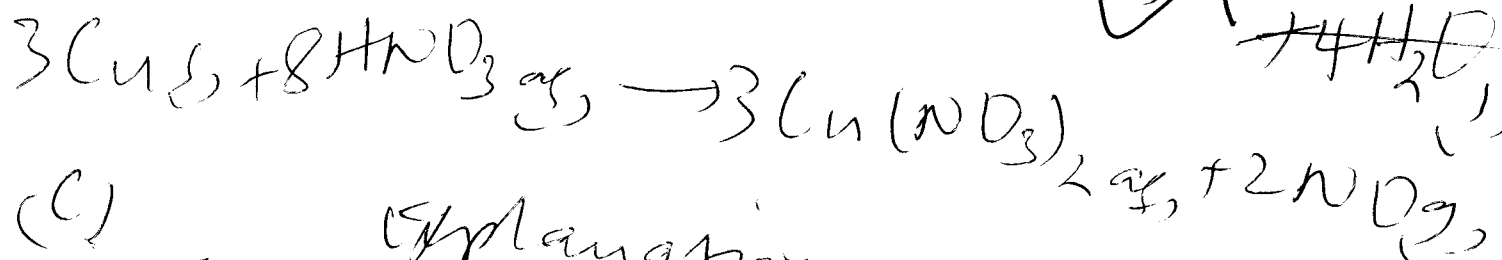
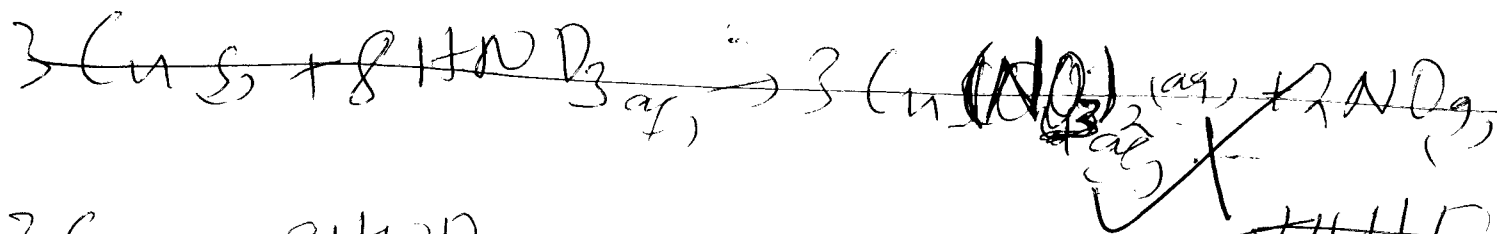
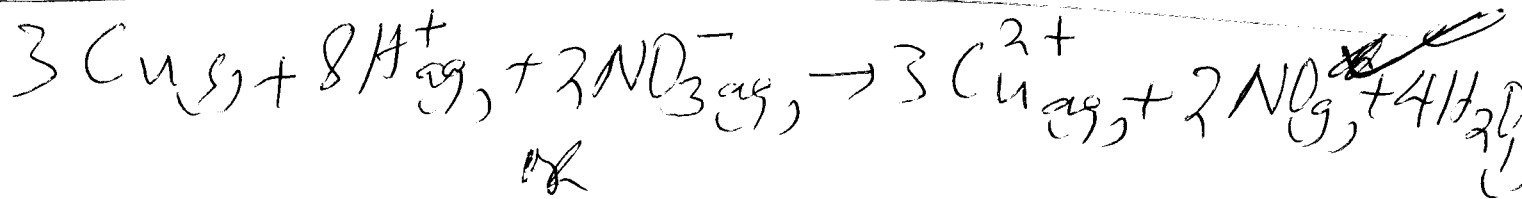
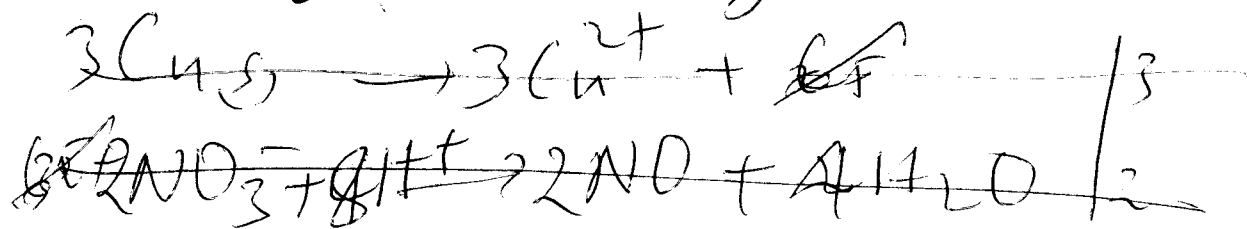


Cold concentrated nitric acid oxidises copper to copper(II) nitrate its self reduced to nitrogen dioxide gas.

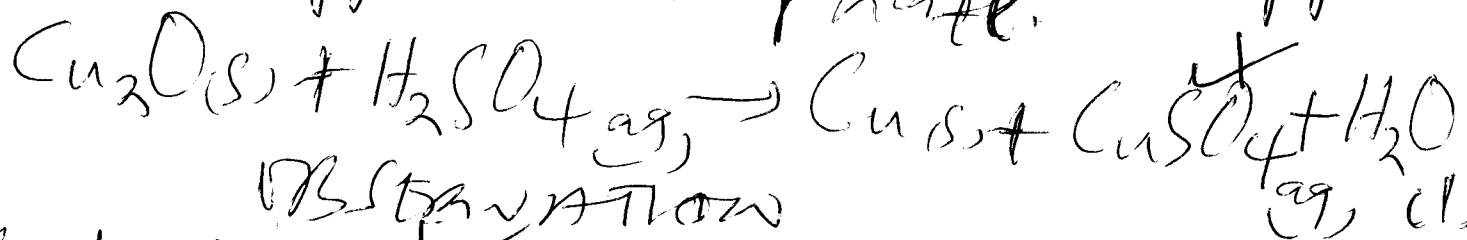


Cold dilute nitric acid oxidises copper to copper(II) nitrate its self

reduced to nitrogen monoxide gas. (11)



(C) Explanation
 (1) Copper(I) Oxide reacts with sulphuric acid to form copper(I) sulphate which ~~under~~ is unstable undergoing disproportionation to form copper and copper(II) sulphate.



OBSERVATION

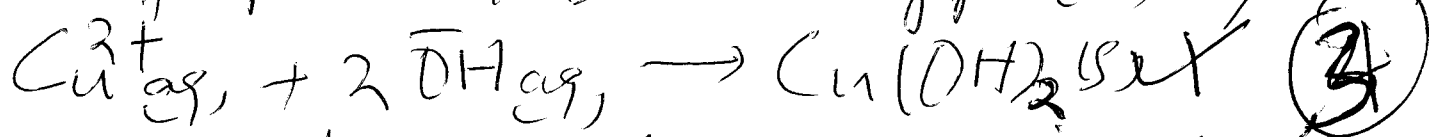
Red solid dissolves to form blue solution and brown solid deposits.

(ii) OBSERVATION

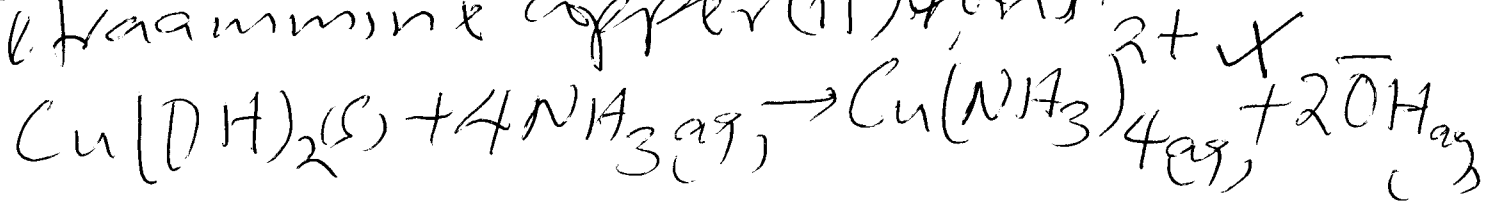
Blue ppt soluble in excess to form deep blue solution.

Explanation; (12)

Copper(II) ions react with hydroxide ions to form insoluble ~~Copper(II)~~ hydroxide



Copper(II) hydroxide reacts with excess ammonia to form a soluble complex Tetraammine copper(II) ions.



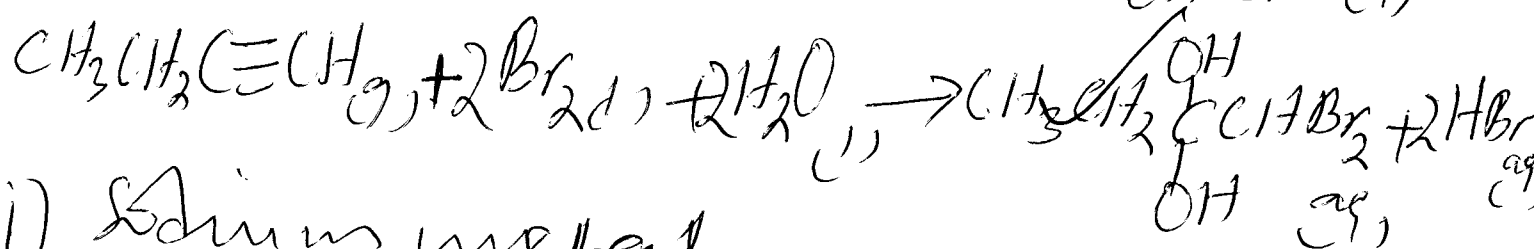
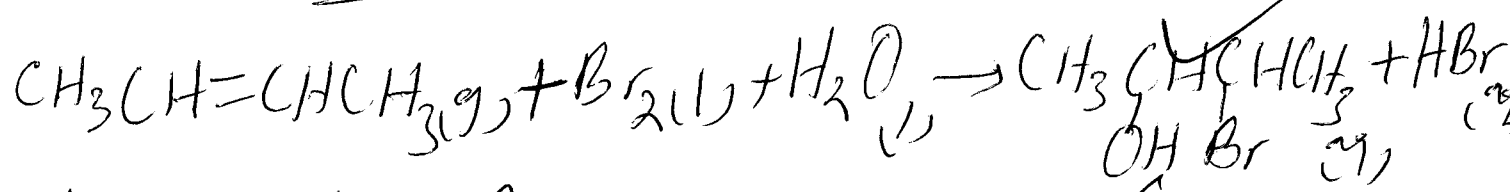
(4) (a) is Reagent, Bromine water ✓

OBSERVATIONS

Reddish brown solution turns to colourless

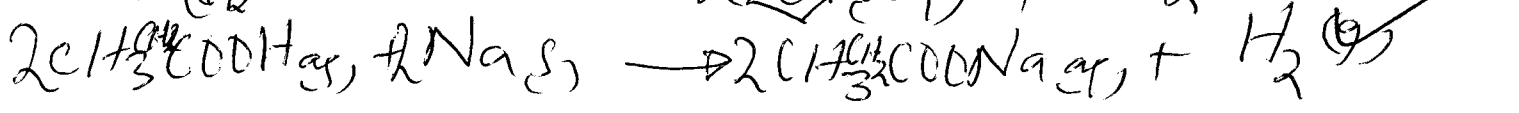
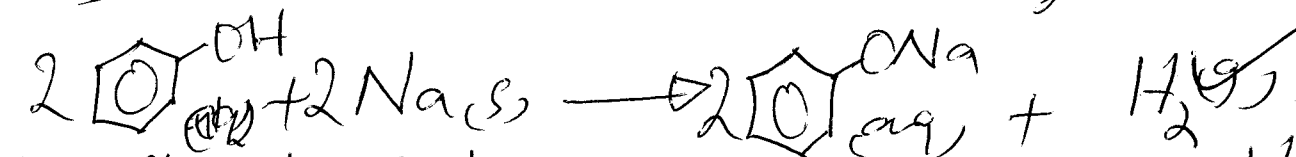
Equations

(14)

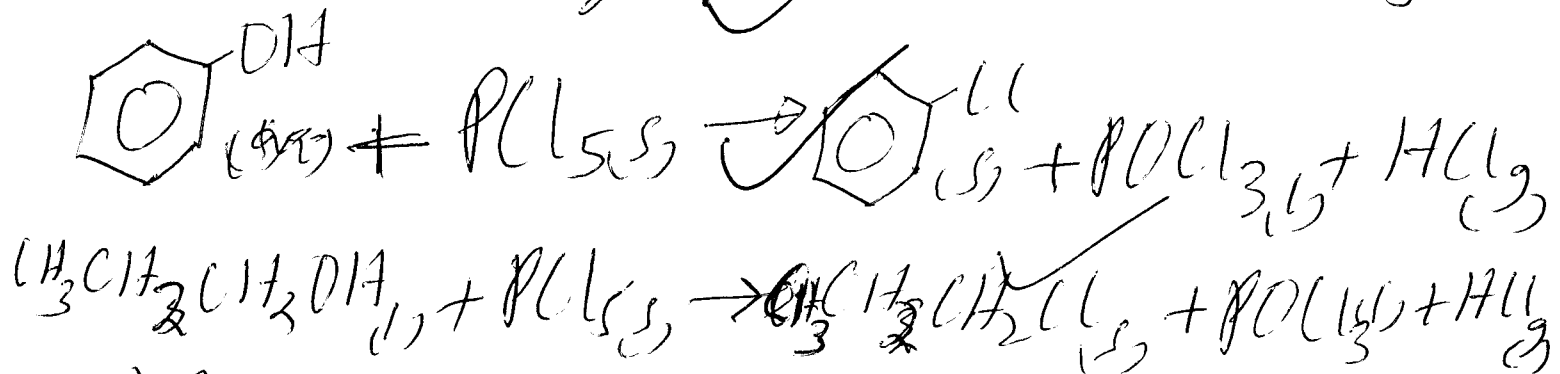


ii) Sodium metal

~~with~~ Bubbles of colourless gas.

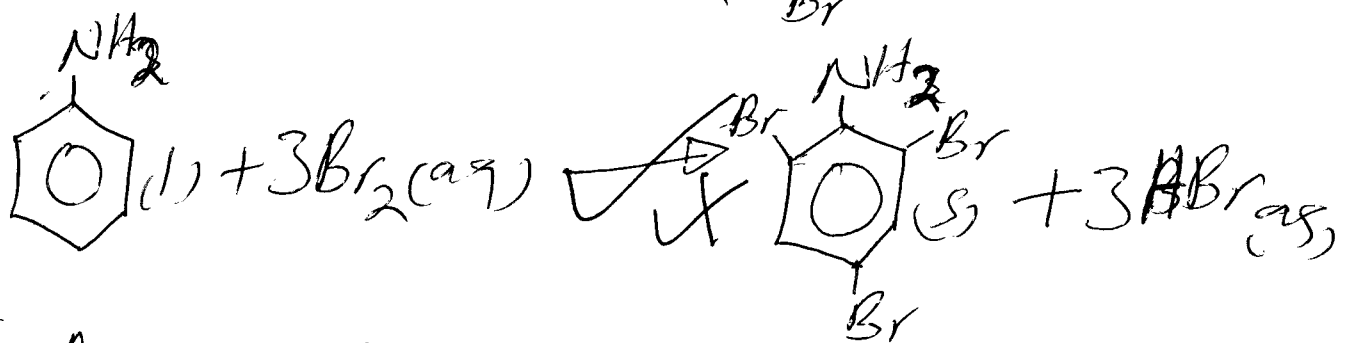
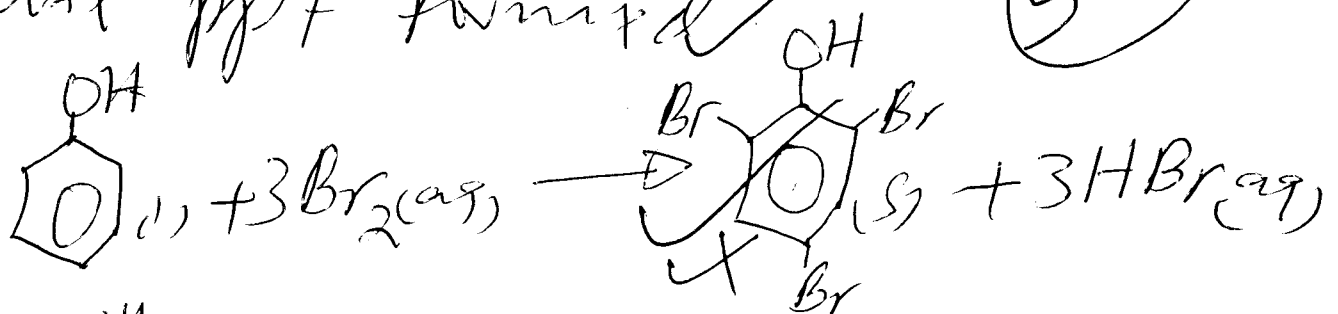


OR (13) Phosphorus
Phosphorus pentachloride (V) chloride
white fumes given off on heating.

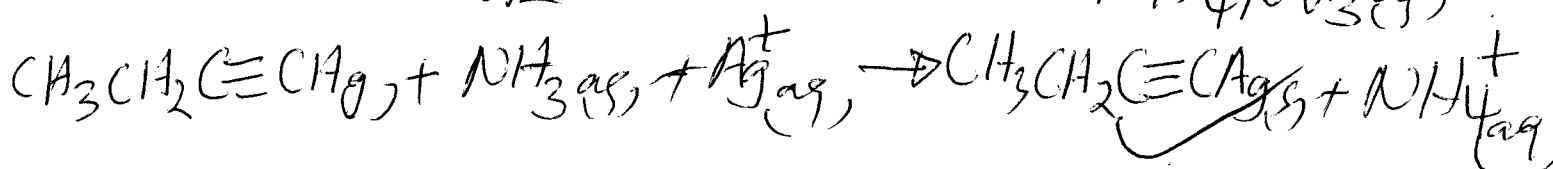
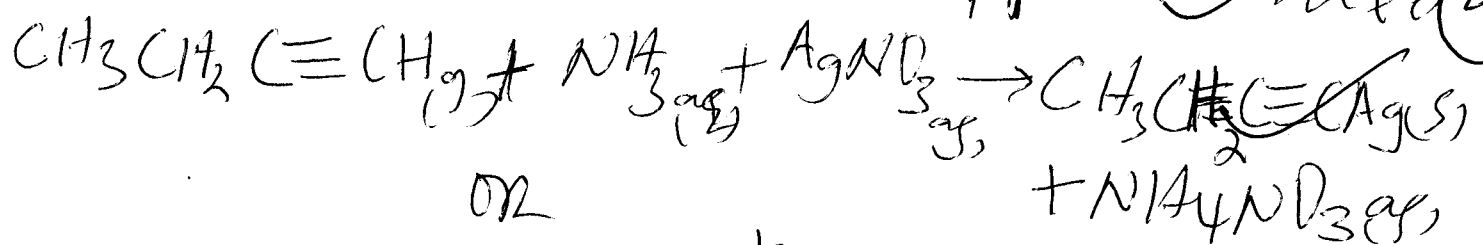



(ii) Bromine water ✓

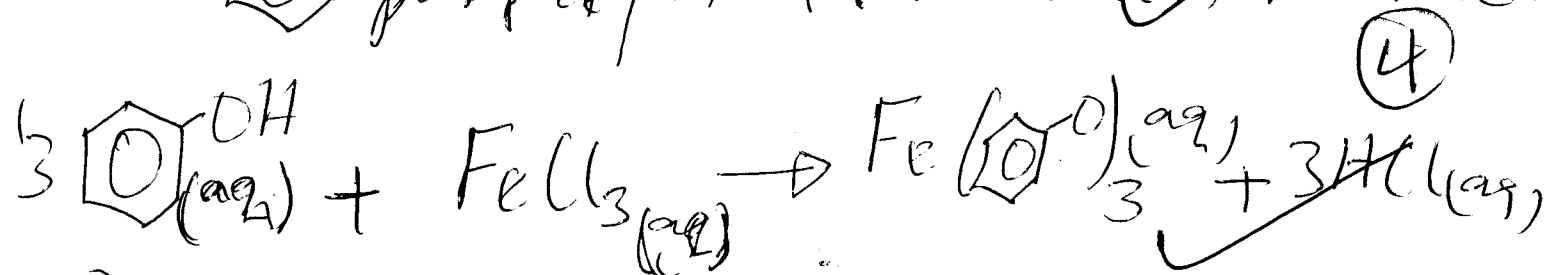
white ppt formed ✓



(b) i) Ammoniacal silver nitrate solution
with $\text{CH}_3\text{CH}=\text{CHCH}_3$ NO observable change
with $\text{CH}_3\text{CH}_2\text{C}\equiv\text{CH}$ white ppt formed (4)




(ii) Neutral iron (iii) chloride solution
 with $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ NO observable change
 with  purple/violet solution formed. (14)



~~(iii) (same with (ii))~~
~~IX~~

~~sodium nitrite solution, carbon tetrachloride
 hydrochloric acid at $(0^\circ \text{ to } 5^\circ)\text{C}$
 with~~

~~ NO observable change.~~

⑤ (a) - Faraday's first law;

The Quantity / amount of substance formed / deposited / liberated at the electrode is directly proportional to the current and the time for which it is passed through the electrolyte.
 - Faraday's second law;

The Quantity of charge required to deposit one mole of substance at the electrode is directly proportional

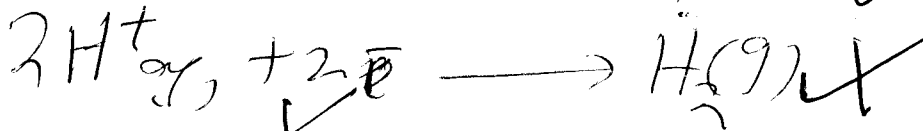
(15)

to the charge on the ion being discharged
 (b) $101.325 \text{ kN m}^{-2} = 19 \text{ mm}$

$$120 \text{ kN m}^{-2} = \frac{120 \times 1}{101.325} = 1.1843 \text{ atm}$$

$$Q = It; t = 20 \times 60 = 1200 \text{ s}$$

$$= 3 \times 1200 = 3600 \text{ C}$$



$(2 \times 96500) \text{ C}$ deposit 1 mole of H_2

$$3600 \text{ C deposit } \left(\frac{3600 \times 1}{2 \times 96500} \right)$$

$$= 0.018653 \text{ moles of } \text{H}_2$$

$$PV = nRT$$

$$1.1843 \times V = 0.018653 \times 0.0821 \times 298$$

$$V = \frac{0.018653 \times 0.0821 \times 298}{1.1843} = 0.42 \text{ L}$$

$$\text{OR } 400 \text{ cm}^3$$

$$\text{OR}$$

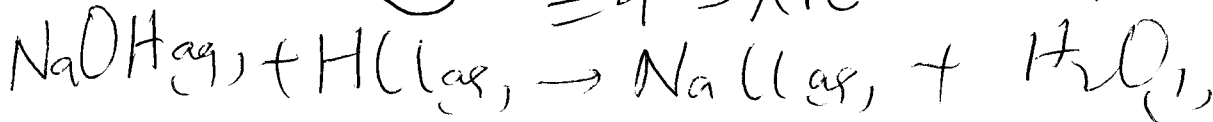
$$4 \times 10^{-4} \text{ m}^3$$

(ii) 1000 cm³ contains 1 mole NaOH

$$4.5 \text{ cm}^3 \text{ contains } \left(\frac{4.5 \times 1}{1000} \right) \text{ moles of } \text{NaOH}$$

(2)

$$= 4.5 \times 10^{-3} \text{ moles of } \text{NaOH}$$



molar ratio $\text{NaOH} : \text{HCl} = 1 : 1$

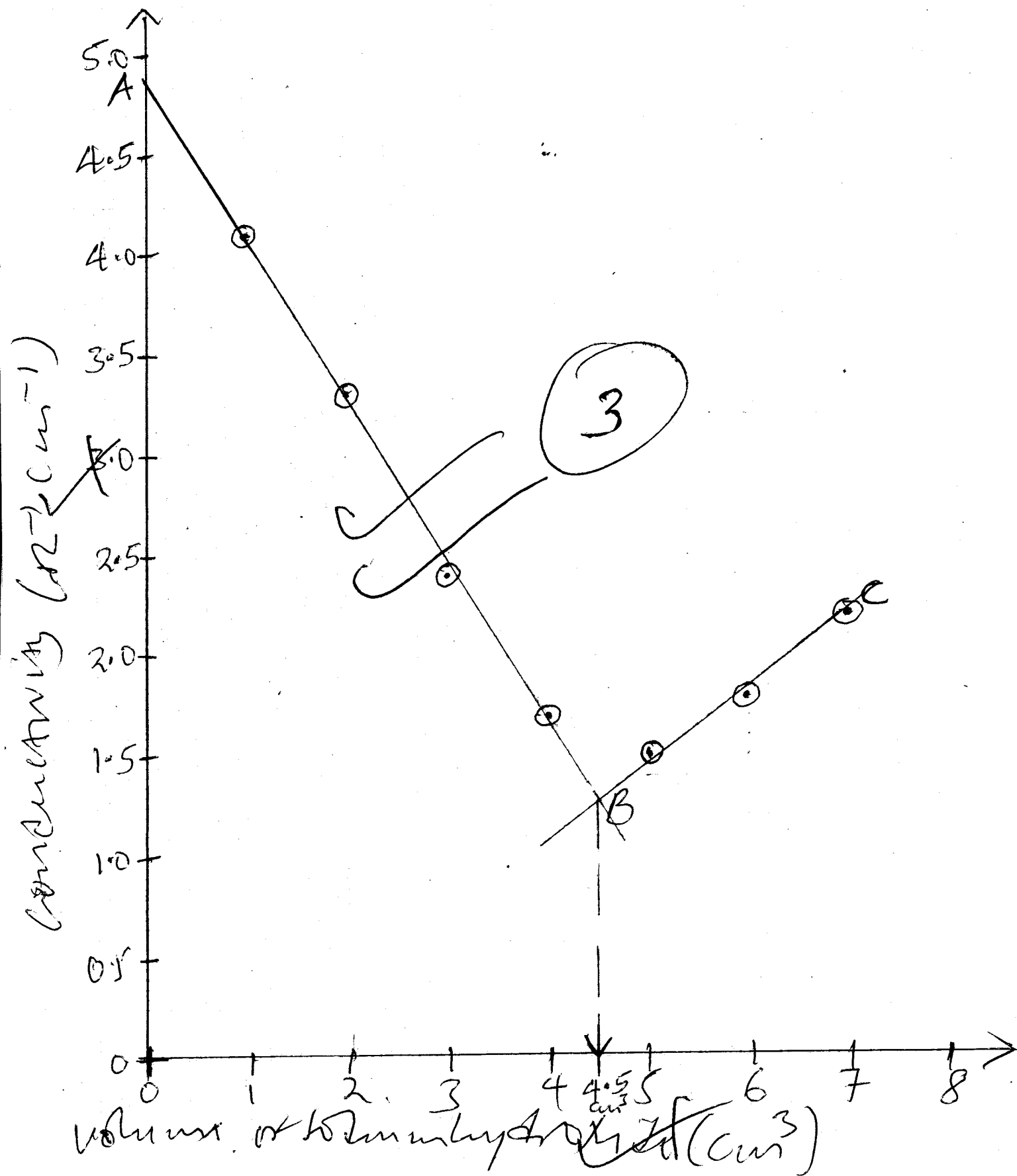
moles of $\text{HCl} = 4.5 \times 10^{-3}$ moles of HCl ✓

50 cm^3 contains 4.5×10^{-3} moles HCl

1000 cm^3 contains $\left(\frac{1000 \times 4.5 \times 10^{-3}}{50} \right)$

$= 0.09 \text{ M}$ ✓

(iii) Initially conductivity is high at A due to many conducting Hydrogen ions and Chloride ions in the strong Hydrochloric acid which is completely dissociated. Conductivity then reduces along AB due to neutralisation of H^+ ions of the acid with hydroxide ions of the base $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ ✓
At B endpoint is reached and conductivity is only due to sodium ion and chloride ions of the salt. Conductivity then increases along BC due to excess conducting Hydroxide ions added after the endpoint. excess base ✓



(17)

$$\text{d) Rfm ZnCl}_2 = 64.5 + 35.5 = 100$$

$$[\text{ZnCl}_2] = C = \frac{2.72}{100} = 0.0272 \text{ Mol dm}^{-3}$$

$$\Lambda_c^{\text{ZnCl}_2} = \frac{\kappa_{\text{ZnCl}_2}}{C} \times 10^3$$

(3/2)

$$= \frac{5.175 \times 10^{-3} \times 10^3}{0.0272}$$

$$\Lambda_c^{\text{ZnCl}_2} = 190.3 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\Lambda_{\infty}^{\text{ZnCl}_2} = \Lambda_{\infty}^{\text{Zn}^{2+}} + \Lambda_{\infty}^{\text{Cl}^{-}} \times 2$$

$$190.3 = 106 + \Lambda_{\infty}^{\text{Cl}^{-}} \times 2$$

$$\frac{\Lambda_{\infty}^{\text{Cl}^{-}} \times 2}{2} = \frac{84.3}{2}$$

$$\Lambda_{\infty}^{\text{Cl}^{-}} = 42.1 \text{ S cm}^2 \text{ mol}^{-1} \quad \underline{\underline{20}}$$

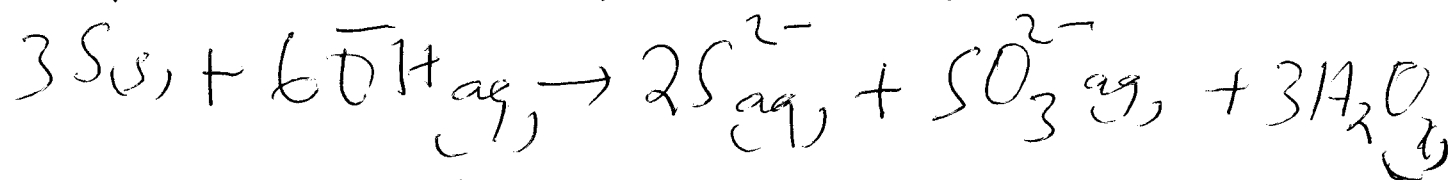
Q (a) (i) Generally boiling point increase from phosphorus to sulphur and reduces from sulphur to Argon because they have simple molecular structure with van der Waals forces of attraction which

(18) ~~stronger~~ with in ~~with~~ in molecular weight ~~than~~ the group.

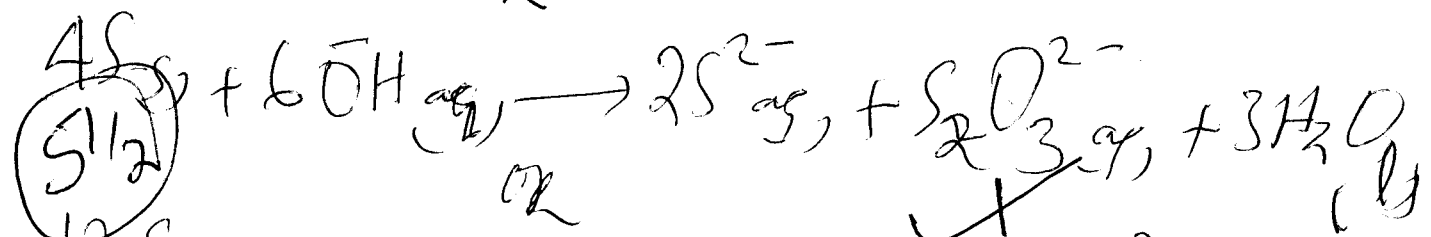
Sulphur is diatomic (S_8) with high molecular weight, strong Vander Waals' forces of attraction hence higher boiling point than Phosphorus which is tetraatomic (P_4) with ⁽³²⁾ relatively low molecular weight, relatively weaker Vander Waals' forces of attraction hence lower boiling point. Chlorine is diatomic (Cl_2) with low molecular weight, weak Vander Waals' forces of attraction and low boiling point. Argon is monoatomic (Ar) with very low molecular weight, very weak Vander Waals' forces of attraction hence very low boiling point.

(b) (i) Phosphorus reacts with hot concentrated sodium hydroxide to form phosphine $P_4 + 3OH^- + 3H_2O \rightarrow 3H_2PO_2^- + PH_3$
- Sulphur reacts with hot ~~concentrated~~ sodium hydroxide to form sodium sulphite / sodium trisulphate / sodium

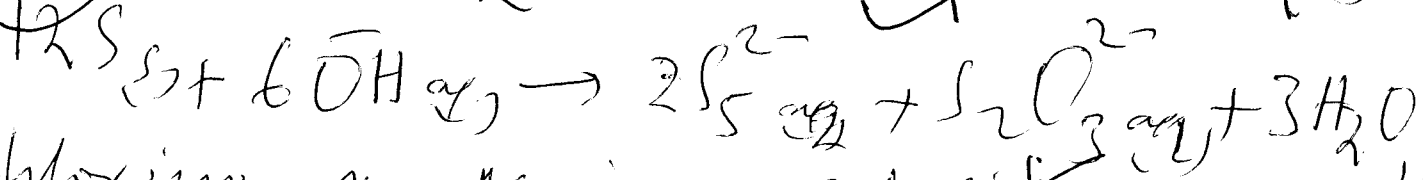
Sulphide / Sulfide pentahydrate



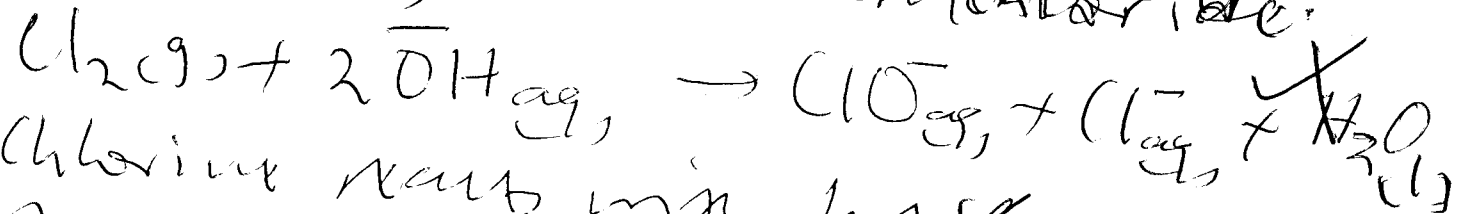
OR



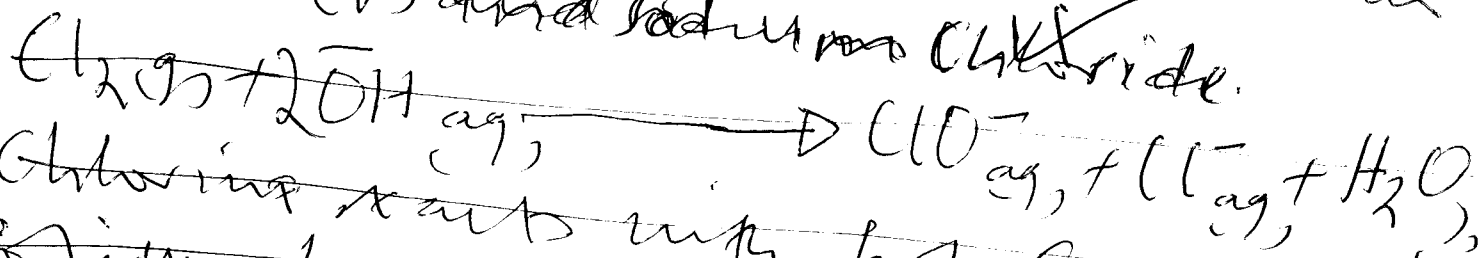
OR



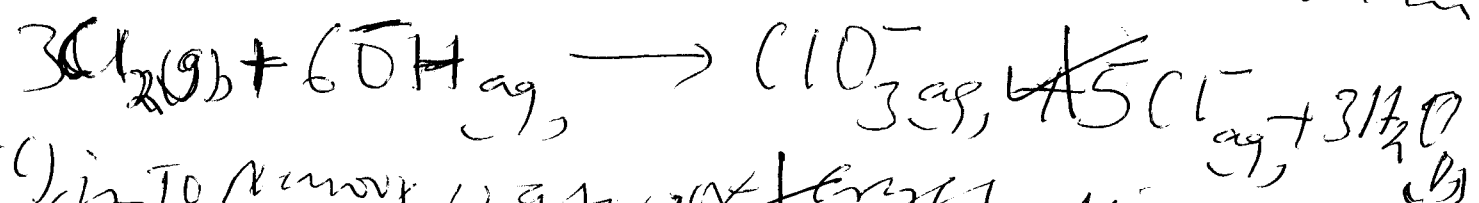
- Chlorine reacts with cold dilute sodium hydroxide to form sodium chlorate(I) and sodium chloride.



- Chlorine reacts with hot concentrated sodium hydroxide to form sodium chlorate(V) and sodium chloride.

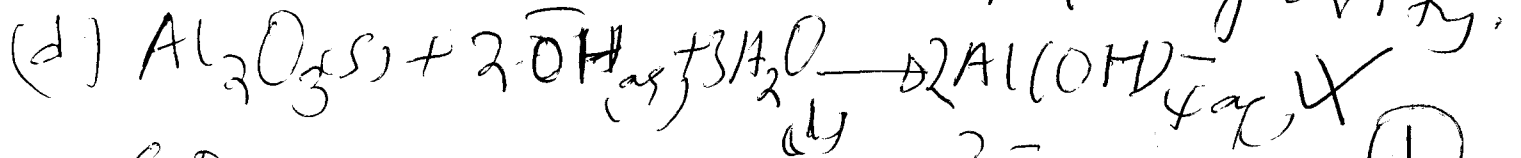


~~Chlorine reacts with hot concentrated sodium hydroxide to form sodium chlorate~~

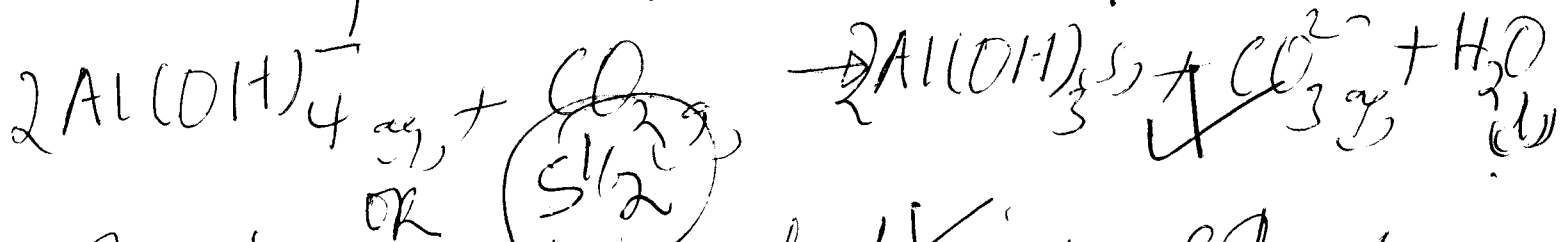


(1) is to remove water by crystallisation to obtain anhydrous aluminium oxide - to oxidise iron(II) to iron(III) oxide.

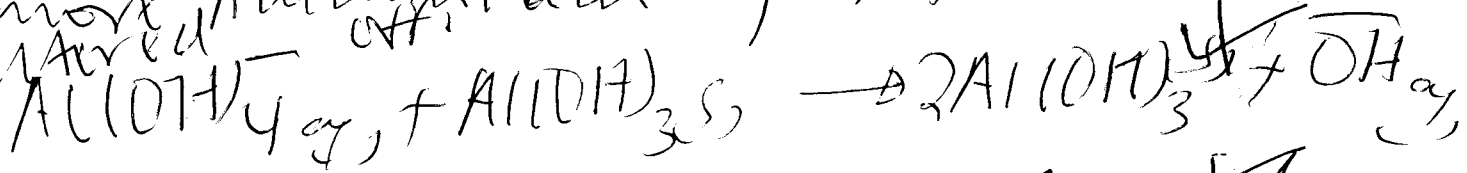
(ii) To remove Fe^{2+} Oxide impurity.



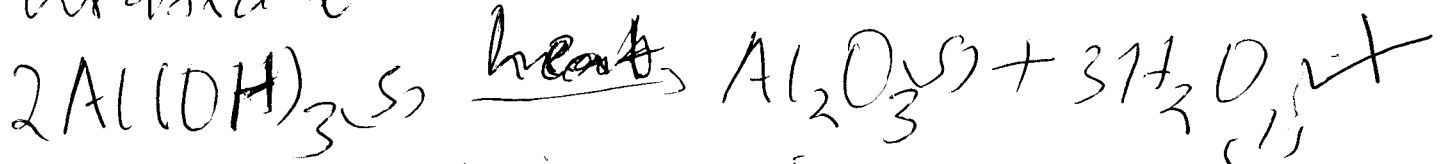
(e) Carbon dioxide is bubbled through the filtrate to precipitate Aluminium hydroxide.



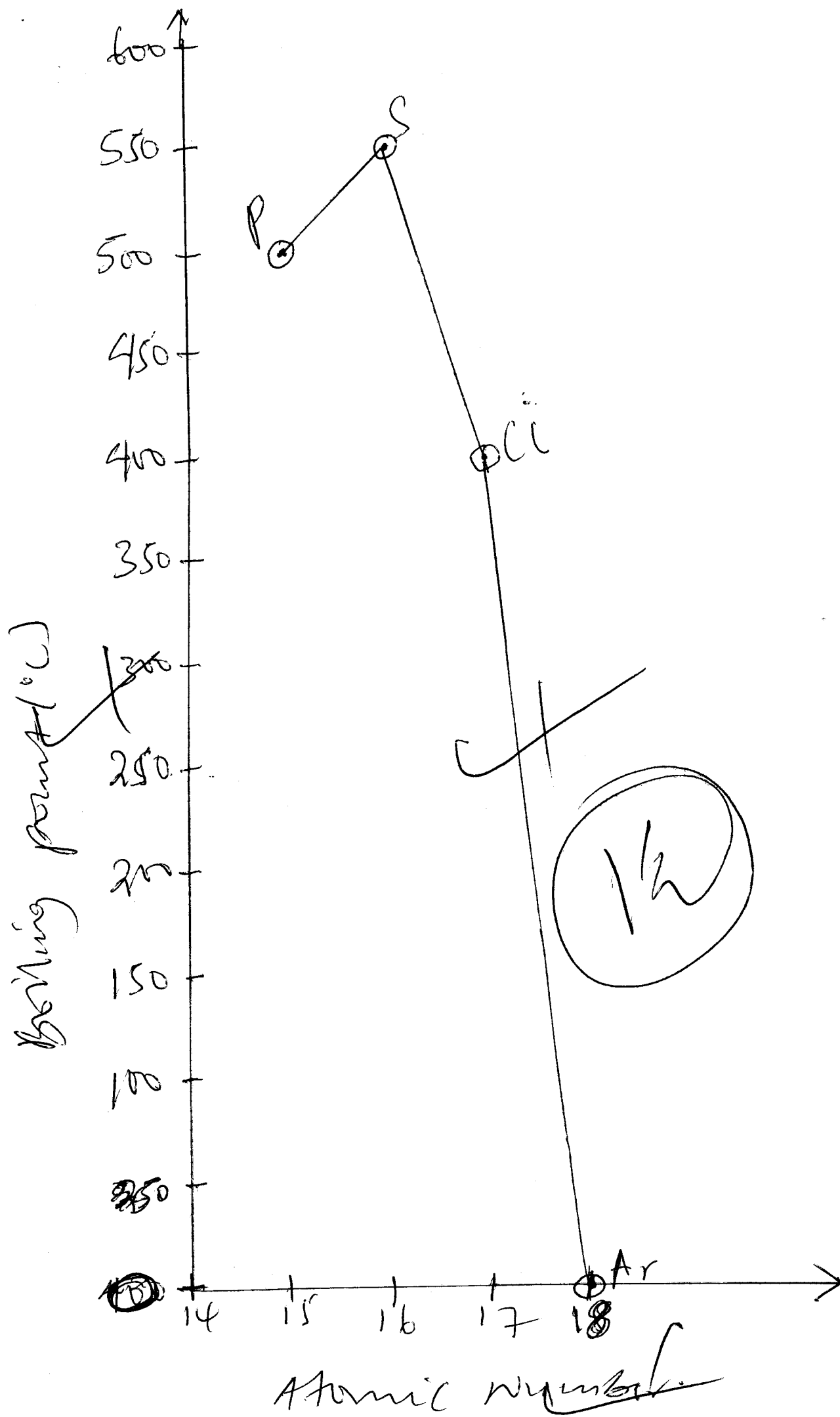
The filtrate is heated with solid Aluminium hydroxide to precipitate more Aluminium hydroxide which is filtered off.

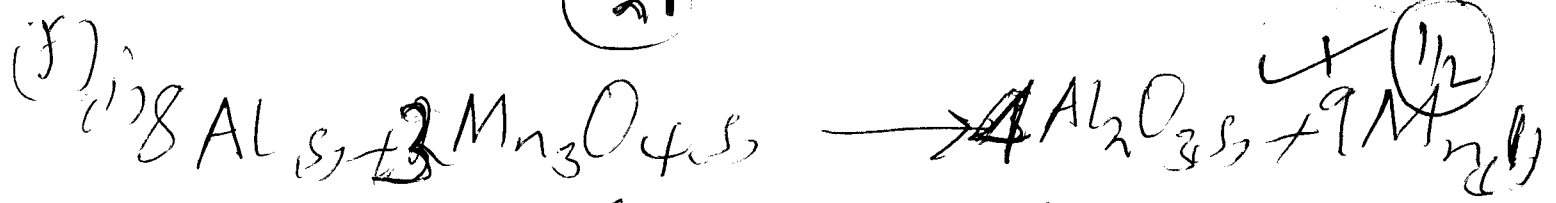


Aluminium hydroxide is strongly heated to obtain Aluminium oxide.

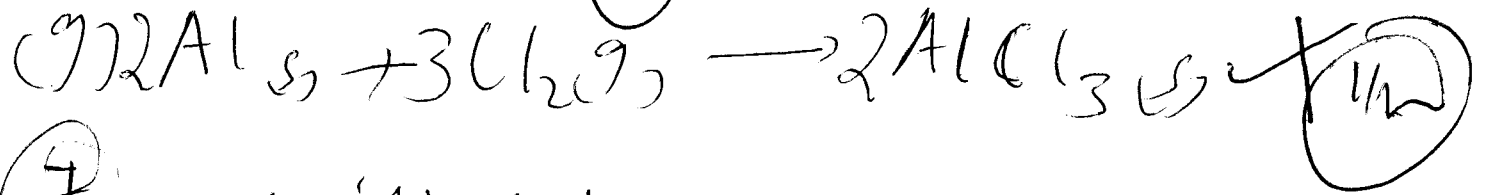


Aluminium oxide is electrolysed between graphite electrodes in presence of molten cryolite to lower melting point of Aluminium oxide. Aluminium is obtained as the cathode $\text{Al}^{3+}_{(aq)} + 3e^- \rightarrow \text{Al}(s)$

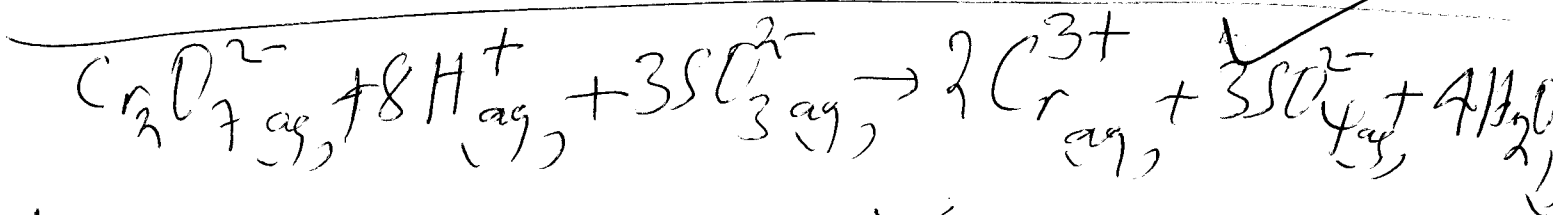
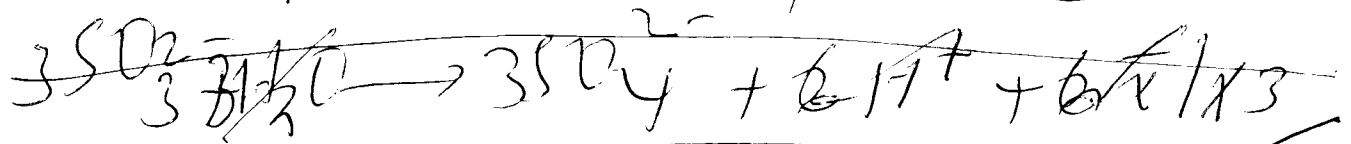
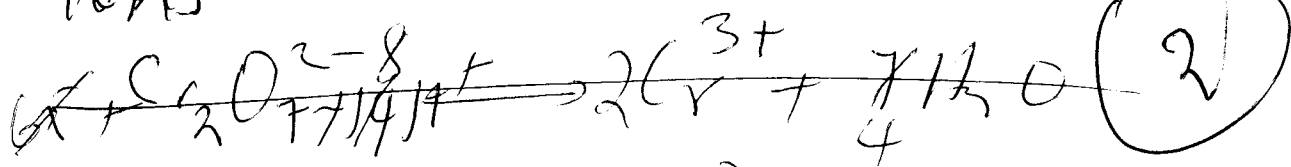




(ii) Thermite process or reduction.



(7) (a) Acidified potassium dichromate (vi) oxidise sulphite ions to sulphate ions & itself reduced to chromium (iii) ions

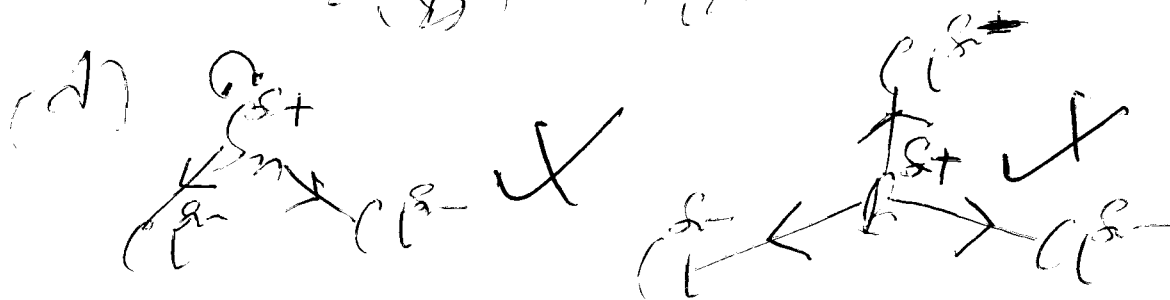
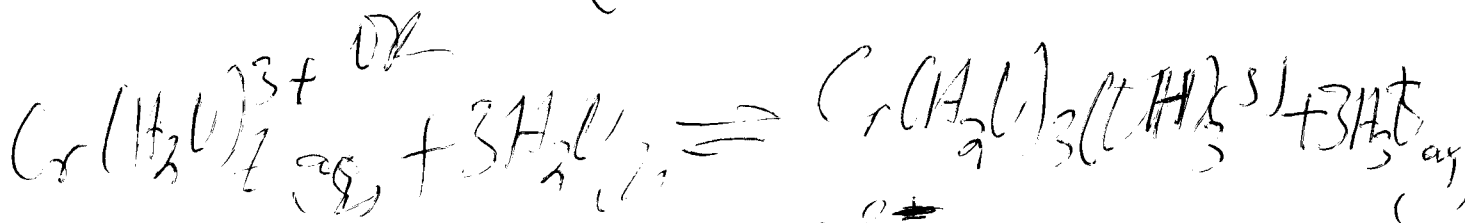
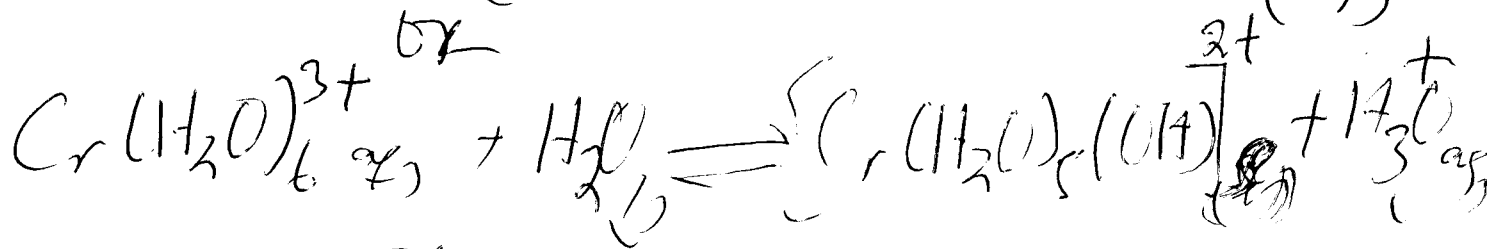
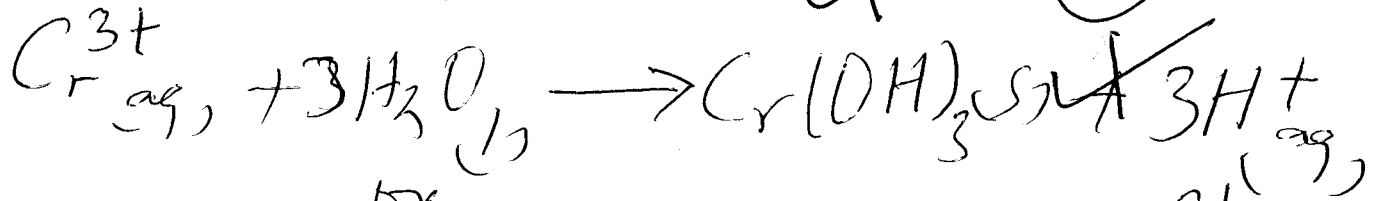


(b) Fluorine is highly electronegative making H-F highly polar and its molecules are held together by strong hydrogen bonds that keeps them close to each other. Hydrogen chloride has simple molecular structure with weak van der Waals forces of attraction that are easily

(22)

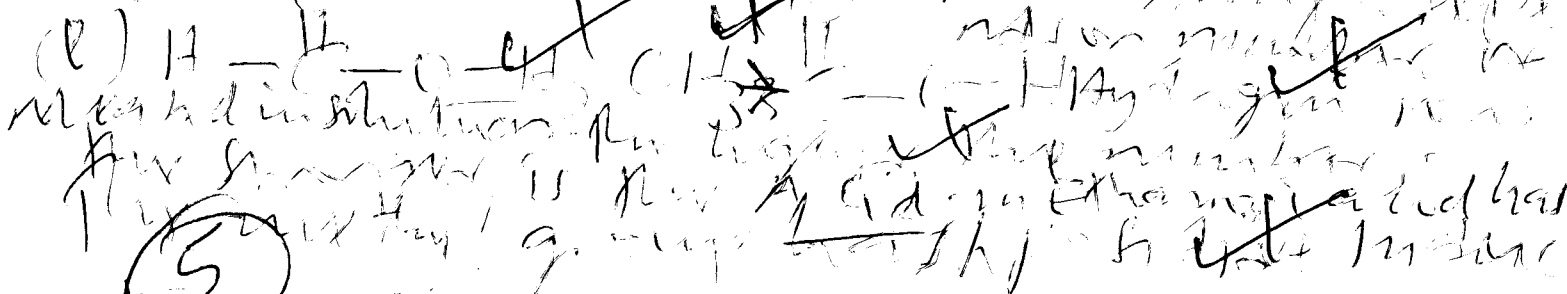
broken at room temperature to keep the molecules far from each other.

(c) Chromium(III) ions have high charge density, undergo hydrolysis releasing hydrogen ions making the solution acidic. (24) Making



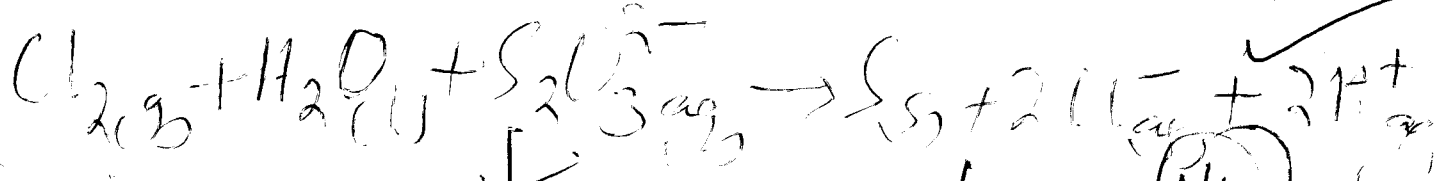
Chlorine is more electronegative than the other and hence, by making the Sn-Cl and B-Cl bonds polar. Boron trichloride is trigonal planar and symmetrical, the hydro-dipole moments in one direction are cancelled out by dipole-dipole moments in opposite direction while

Formaldehyde is V-shaped, not symmetrical with permanent dipole -

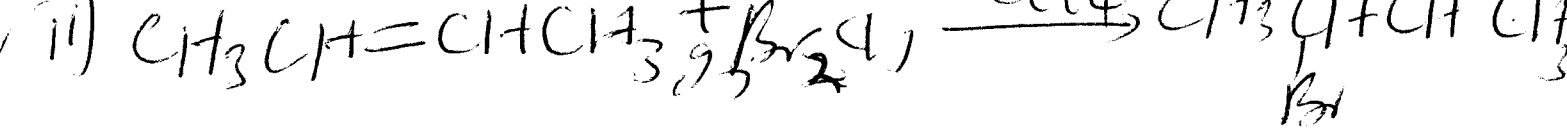


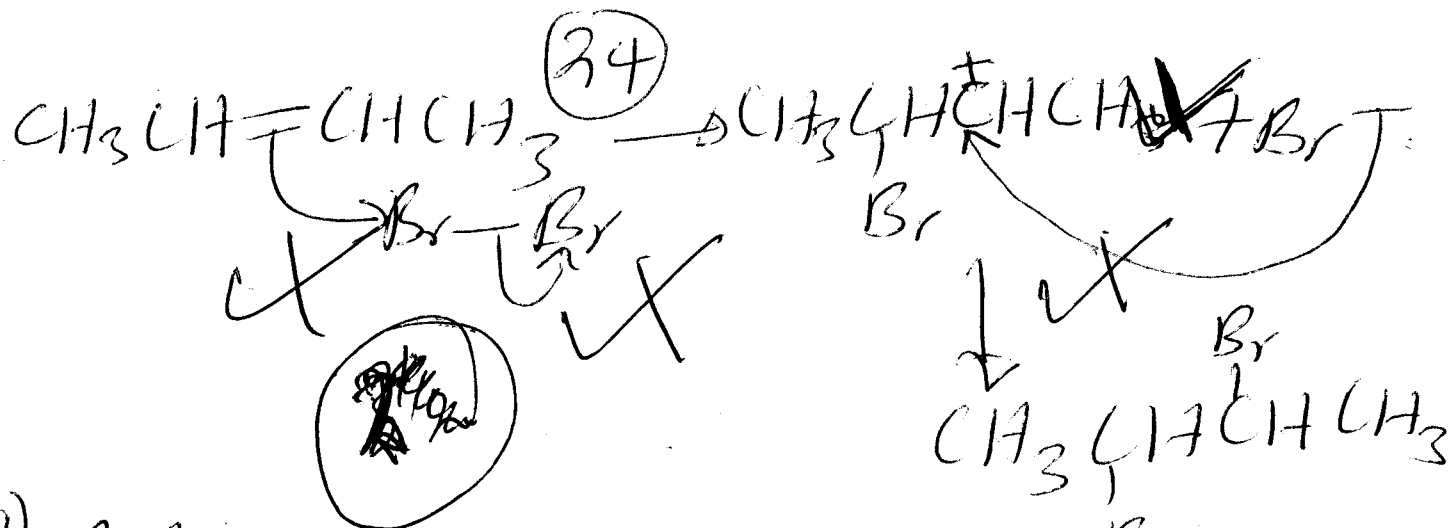
(5) effect of C-H bond making it stronger and breaking it to release hydrogen ions. In methane, Acid, hydrogen atom is in a negative position making it a weak C-H bond in it is broken and breaks to release a methyl anion ion.

(6) Sodium dichromate undergoes disproportionation in an aqueous solution (2 1/2) Chlorine to form sulphur and sulphate ions.



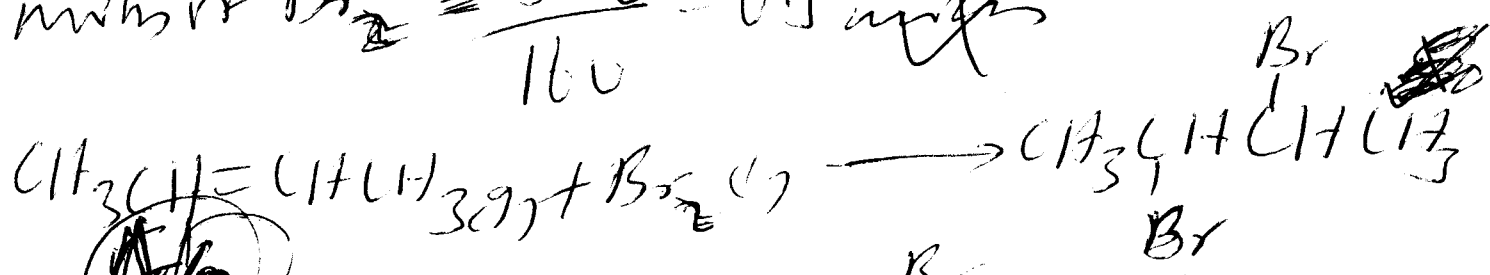
(8) Reddish brown liquid turns to colourless. (1 1/2)





(iii) $\text{Mol wt of Br}_2 = 80 \times 2 = 160$

$\text{mols of Br}_2 = \frac{80}{160} = 0.5 \text{ mols}$



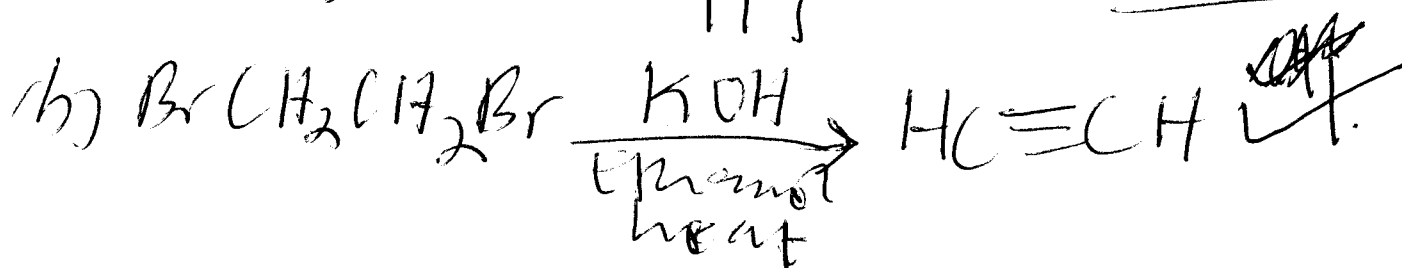
$\text{mols of CH}_3\text{CH}(\text{Br})\text{CH}(\text{Br})\text{CH}_3 = 0.5 \text{ mols}$

$\text{Mm of CH}_3\text{CH}(\text{Br})\text{CH}(\text{Br})\text{CH}_3 = (12 \times 4) + (1 \times 18) + (80 \times 2)$

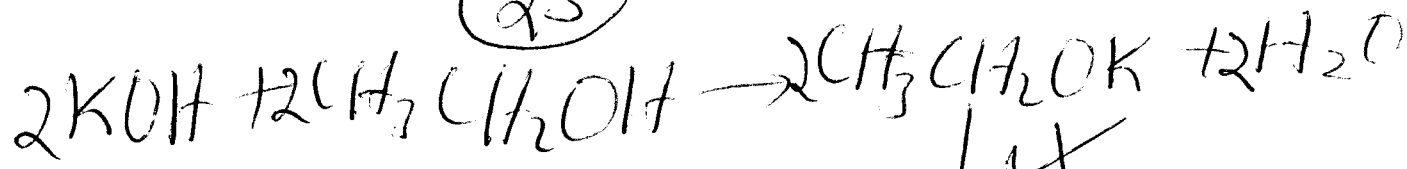
$= 226$

$\text{mass of CH}_3\text{CH}(\text{Br})\text{CH}(\text{Br})\text{CH}_3 = 0.5 \times 226 = 113 \text{ g}$

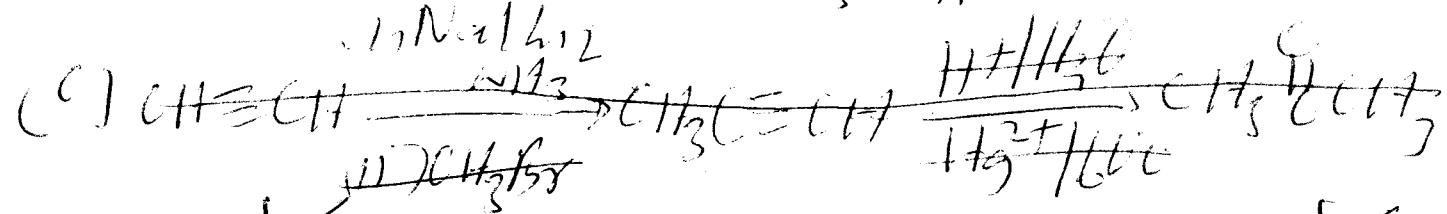
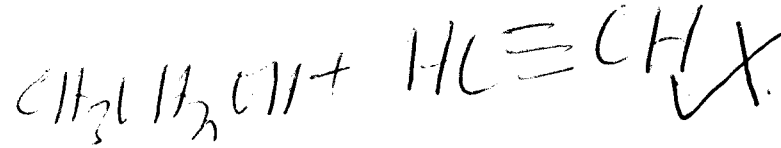
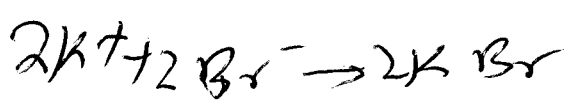
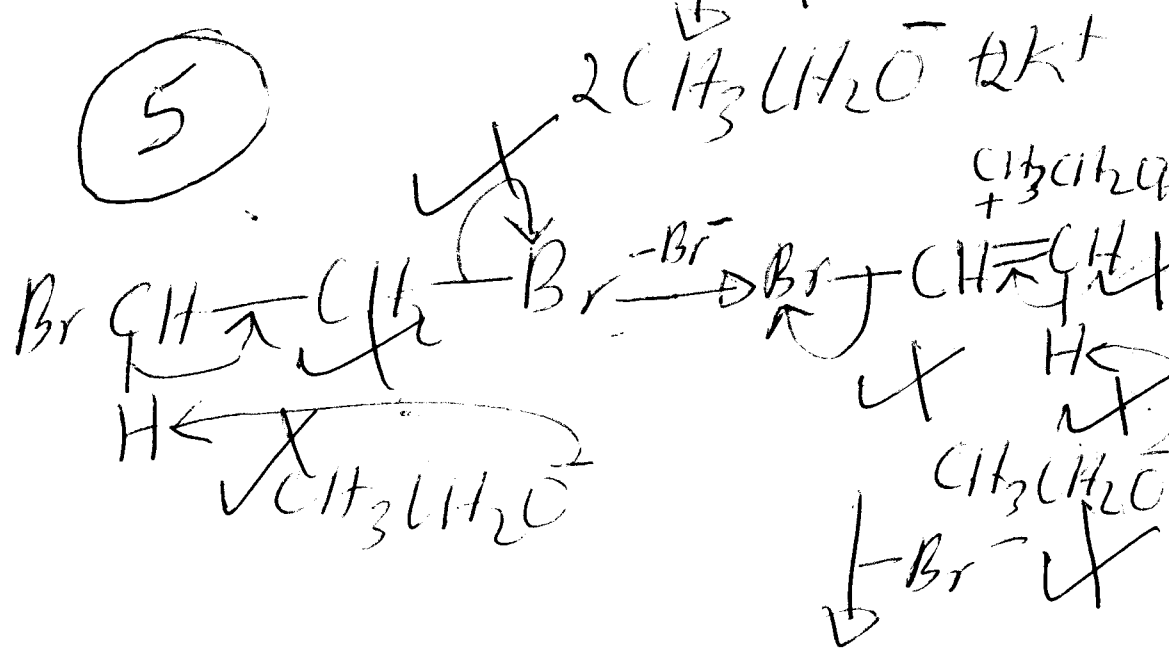
(iv) $\% \text{ yield} = \frac{43.2}{113} \times 100 = 38.2\%$



(25)



(5)



Ethyne is reacted with sodium metal in presence of liquid ammonia followed by bromomethane to form propyne which is reacted with dilute sulphuric acid or concentrated sulphuric acid in presence of water or acidified water in presence of mercuric sulphate catalyst at 60°C to form propanone.