SUGGESTED MARKING GUIDE

Name..... Centre & Index No.....

Signature .....

P525/1
CHEMISTRY
(THEORY)
Paper 1
July /August 2023
2 ¾ Hours

ASSHU ANKOLE JOINT MOCK EXAMINATIONS 2023
Uganda Advanced Certificate of Education
CHEMISTRY
(THEORY)
Paper 1
2 Hours 45 Minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** questions in section A and **six** questions in B

All questions **must** be answered in the spaces provided.

The periodic table; with relative atomic masses is supplied.

Mathematical tables (3 figure tables) are adequate or non-programmable scientific electronic calculators may be used.

Illustrate your answers with equations where applicable.

Where necessary, use the following

Molar gas constant, R $= 8.31 Jk^{-1}Mol^{-1}$

Molar volume of gas at s.t.p is 22.4 litres

Standard temperature $= 273k$

Standard pressure $= 101325 Nm^{-2}$.

For Examiner's Use only																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
25	05	4½	4½	5½	4½	06	06	07	09	09	09	09	09	09	09	09	

SECTION A (46 MARKS)

Answer all questions from this section

1. The standard electrode potentials for some half-cell reactions are given below.

	E^{θ}/V
$Cl^-(aq) \longrightarrow \frac{1}{2}Cl_2(g) + e$	-1.36
$Mn^{2+}(aq) + 2H_2O(l) \longrightarrow M_nO_2(s) + 4H^+(aq) + 2e$	− 1.53

(a) Write the;

i) cell notation for the cell formed when the two half cells are combined. (1 mark)

$Pt_{(s)}|Cl^-_{(aq)}|Cl_{2(g)}||MnO_{2(s)}|H^+_{(aq)}|Mn^{2+}_{(aq)}$ ✓ ✓ ✓

ii) equation for the overall cell reaction. (1 ½ marks)

$MnO_{2(s)} + 4H^+_{(aq)} + 2Cl^-_{(aq)} \longrightarrow Mn^{2+}_{(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$ ✓ ✓ (1½)

(b) Calculate the e.m.f of the cell in (a) (i) (1 ½ marks)

$E^{\theta}_{cell} = E^{\theta}_{right} - E^{\theta}_{left}$ ✓

$= 1.53 - 1.36$ ✓ (1½)

$= +0.17V$

(c) State whether the cell reaction is feasible or not. Give a reason for your answer. (1 mark)

The cell reaction is feasible since e.m.f of the cell is positive ✓ (1)

2. (a)(i) Explain what is meant by the term first electron affinity.

Accept: Enthalpy change

OR: Heat given out when an electron is added to a gaseous atom to form a univegatively charged gaseous ion (1 mark)

Is the heat given off when one mole of electrons is added to one mole of gaseous atoms to form one mole of univegatively charged gaseous ions ✓ (1)

(ii) Write an equation to represent the first electron affinity of Sulphur. (1 mark)

$S_{(g)} + e \longrightarrow S^-_{(g)}$ ✓ (1)

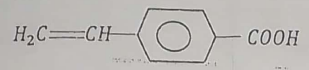
(b) Explain why the value for the first electron affinity of Sulphur is negative whereas the value for the second electron affinity is positive.

(3 marks)

The first electron is added to a neutral gaseous atom thus it receives stronger nuclear attraction than it is repelled ;
& The second incoming electron receives strong repulsion from the negatively charged gaseous ion and therefore, energy must be absorbed to overcome this repulsion in order to add the second electron.

03

3. An organic compound Z has the structure



(a) Name the functional groups in the structure of Z. (1 mark)

Carbon to carbon double bond
Carboxyl group

01

Ref: Double bond, Alkene, Carboxylic

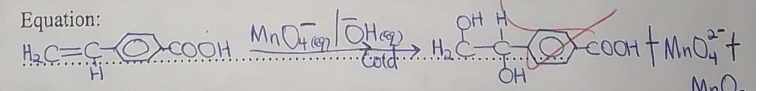
(b) State what is observed and write equation for the reaction in each case that takes place when Z is

(i) treated with a cold aqueous alkaline solution of potassium manganate (VII) (2 marks)

Observation:
A purple solution turns to a green solution and a brown solid is formed

02

Equation:



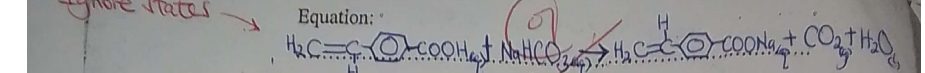
(ii) added aqueous sodium hydrogen carbonate solution (1½ marks)

Observation:
Bubbles / effervescence of a colourless gas

01½

Ignore states →

Equation:



Accept: $HCO_{3(aq)}^- + H^+_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$

4. (a) Define the term electrolytic conductivity. (1 mark)

Accept: Is the reciprocal of electrolytic resistivity

Is the conductance of an electrolyte placed between two parallel electrodes of unit cross-sectional area separated by unit length.

(b) The electrolytic conductivity of a 0.0634 molar solution of a weak acid HA at 25°C is 1.138×10^{-3} scm^{-1} and its molar conductivity at infinite dilution is 338.5 $scm^2 Mol^{-1}$. Calculate the :

i) degree of ionization of HA (2 marks)

$\Lambda_c(HA) = 1000K$

$= \frac{1000 \times 1.138 \times 10^{-3}}{0.0634}$

$= 17.9495\ scm^2 mol^{-1}$

$\alpha = \frac{\Lambda_c}{\Lambda_\infty}$

$= \frac{17.9495}{338.5}$

$= 0.053$

ii) acid dissociation constant, Ka at 25°C (1½ marks)

$K_a = \alpha^2 c$

$= 0.0634(0.053)^2$

$= 0.000178\ mol dm^{-3}$

Accept

$K_a = \frac{c\alpha^2}{1-\alpha}$

$= \frac{0.0634(0.053)^2}{(1-0.053)}$

$= 0.00018\ mol dm^{-3}$

5. (a) Write equation for the reaction between chlorine and;

i) cold dilute sodium hydroxide solution (1 ½ marks)

$Cl_{2(g)} + 2OH^-_{(aq)} \rightarrow Cl^-_{(aq)} + OCl^-_{(aq)} + H_2O_{(l)}$

$Cl_{2(g)} + 2NaOH_{(aq)} \rightarrow NaCl_{(aq)} + NaOCl_{(aq)} + H_2O_{(l)}$

ii) Potassium iodide solution (1 ½ marks)

$Cl_{2(g)} + I^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + I_{2(aq)}$

$Cl_{2(g)} + KI_{(aq)} \rightarrow 2KCl_{(aq)} + I_{2(aq)}$

(b) State what:

i) would happen if the resultant mixture in (a) (i) was heated.

(1½ marks)

Sodium chlorate(I) would decompose to sodium chlorate(V) and sodium chloride

$3ClO^-_{(aq)} \rightarrow ClO_3^-_{(aq)} + 2Cl^-_{(aq)}$

ii) happened in (a) (ii) (1 mark)

Chlorine oxidised iodide ions to iodine while iodide ions reduced chlorine to chloride ions.

6. (a) Nylon – 6, 6 is formed by the reaction between hexane -1, 6 – diamine and hexane -1, 6 – dioic acid.

i) Write equation for the formation of nylon -6, 6. (1½ marks)

Rej $H_2N-(CH_2)_6-NH_2$

$HO-C(=O)-(CH_2)_4-C(=O)-OH$

$nH_2N(CH_2)_6NH_2 + nHOC(=O)(CH_2)_4C(=O)OH \rightarrow [-C(=O)(CH_2)_4C(=O)-N(H)(CH_2)_6N(H)-]_n + 2nH_2O$

ii) State the type of polymerization involved in the formation of nylo -6, 6. (½ mark)

Condensation polymerisation

(b)(i) The osmotic pressure of a solution containing $2gdm^{-3}$ of nylon-6,6 at 25°C was $20308Nm^{-2}$. Calculate the relative molecular mass of nylon 6, 6. (2 marks)

$\Pi V = nRT$

$M_r = \frac{2 \times 8.31 (25+273)}{20308 \times 1 \times 10^{-3}}$

$= 243.9$

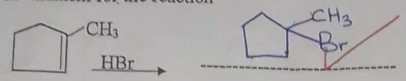
Rej: Ans if units are put.

(ii) State one use of nylon 6, 6 (½ mark)

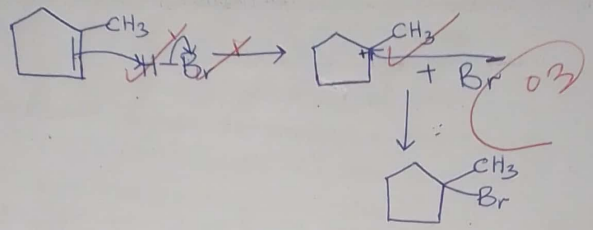
Used to make fishing nets

Used to make;
- Tents
- Clothes / fabrics
- Conveyor belts

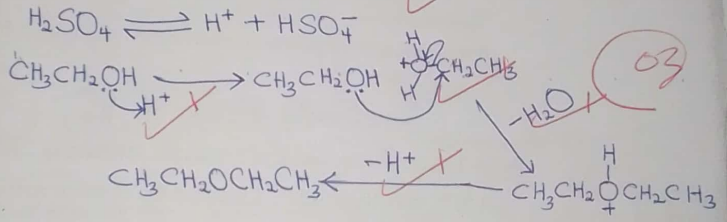
7. (a) Complete the following equations and in each case, outline the mechanism for the reaction



(3 marks)



(b) $CH_3CH_2OH \xrightarrow[140^oC]{Conc.H_2SO_4} CH_3CH_2OCH_2CH_3$ (3 marks)



8. Write equation for the dissolution of each of the following salts in water. State whether the resultant solution is neutral, basic or acidic.

a) Potassium chloride (2 marks)

$KCl_{(s)} + (aq) \longrightarrow K^+_{(aq)} + Cl^-_{(aq)}$

The resultant solution is neutral

b) Aluminium chloride (2 marks)

$[Al(H_2O)_6]^{3+}_{(aq)} + 3H_2O_{(l)} \rightarrow Al(H_2O)_3(OH)_{3(s)} + 3H_3O^+_{(aq)}$

OR $Al^{3+}_{(aq)} + 3H_2O_{(l)} \rightarrow Al(OH)_{3(s)} + 3H^+_{(aq)}$

Resultant solution is acidic

c) Sodium propanoate (2 marks)

$CH_3CH_2COO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3CH_2COOH_{(aq)} + OH^-_{(aq)}$

The resultant solution is basic

9. Various concentrations of **A** and **B** were reacted at a constant temperature. The table below shows the initial concentrations of **A** and **B** and their initial rates for the reaction.

Experiment	[A] ($Moldm^{-3}$)	[B] ($Moldm^{-3}$)	Initial rate ($Moldm^{-3}s^{-1}$)
1	0.4	0.4	7.0×10^{-4}
2	0.8	0.8	2.8×10^{-3}
3	1.6	0.8	1.12×10^{-2}

Accept 2 0

(a) State the order of reaction with respect to A and B.

A. Second order reaction (½ mark)

B. Zero order reaction (½ mark)

(b) Give a reason for your answer in (a) (2 marks)

Accept:
- Increases by four times
- multiplies initial rate by four times

Reject: Increases by four

For A; Doubling the initial concentration of A keeping that of B constant quadruples the initial rate.

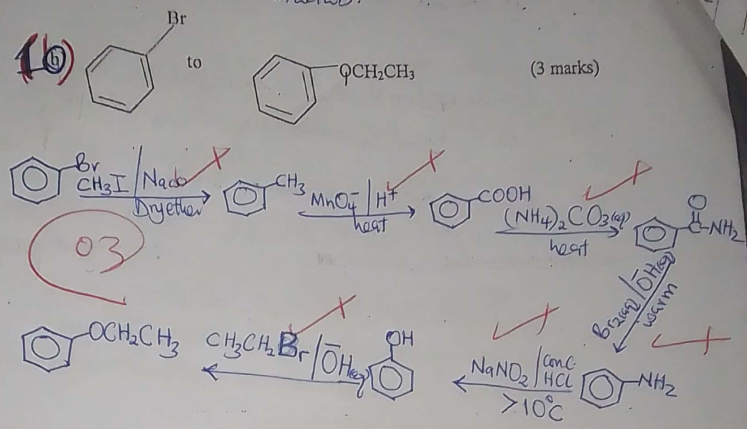
For B, Doubling the initial concentration of both A and B quadruples the initial rate.

(c) Determine the overall order of the reaction. (1 mark)

Overall order = 2 + 0

= 2

(b) USING EQUATIONS, SHOW HOW THE CONVERSION BELOW CAN BE EFFECTED.



03

11.(a) When ammonium dichromate was heated a green solid R was forme

Write equation for the reaction that took place. (1 ½ marks)

$(NH_4)_2Cr_2O_7(s) \longrightarrow Cr_2O_3(s) + N_2(g) + 4H_2O(l)$

(b) R was heated with potassium hydroxide in contact with air.

i) State what was observed (1 mark)

A green solid turned to a yellow solid.

ii) Write the equation for the reaction that took place. (1 ½ marks)

$2Cr_2O_3(s) + 8OH^-(s) + 3O_2(g) \longrightarrow 4CrO_4^{2-}(s) + 4H_2O(l)$

OR $2Cr_2O_3(s) + 8KOH(s) + 3O_2(g) \longrightarrow 4K_2CrO_4(s) + 4H_2O(l)$

(c) The compound formed in (b); when treated with water gave a yellow solution. The yellow solution turned orange when acidified with dilute sulphuric acid . Identify;

i) the ion that gives the yellow solution its colour. (½ mark)

CrO_4^{2-}

Accept Chromium(VI) ion ½

ii) the ion that gives the orange solution its colour. (½ mark)

$Cr_2O_7^{2-}$

Accept Dichromate(VI) ion ½

iii) Write ionic equation for the reaction leading to the formation of the orange colour. (1 ½ marks)

$2CrO_{4(aq)}^{2-} + 2H^+_{(aq)} \longrightarrow Cr_2O_{7(aq)}^{2-} + H_2O_{(l)}$ 1½

(d) The resultant solution in (c)(iii) was added to excess sodium hydroxide solution

(i) State what was observed. (1 mark)

An orange solution turns to a yellow solution 1

(ii) Write equation for the reaction that took place (1 ½ marks)

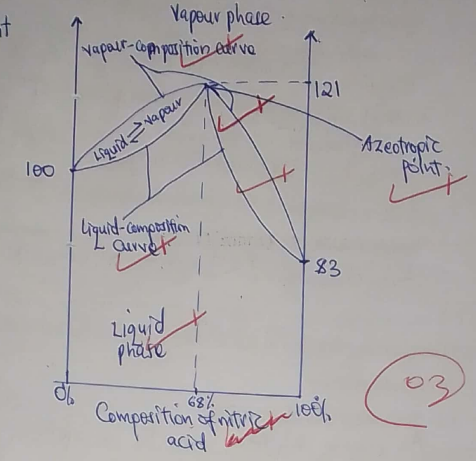
$Cr_2O_{7(aq)}^{2-} + 2OH^-_{(aq)} \longrightarrow 2CrO_{4(aq)}^{2-} + H_2O_{(l)}$ 1½

12. (a) Nitric acid and water are miscible in all proportions. They form a constant boiling point mixture having a boiling point 121°C, composition 68% by mass of nitric acid and density 1.42gcm^{-3}.

i) Define the term constant boiling point mixture (1 mark)

Is the binary liquid mixture which at constant pressure boils at constant temperature forming vapour of the same composition as the liquid mixture 1

ii) Sketch a labelled diagram of the boiling point – composition for nitric acid and water system. (The boiling point of water and nitric acid are 100°C and 83°C respectively) (3 marks)



03

iii) Describe what would happen when 20% nitric acid is fractionally distilled. (2 marks)

~~When a liq~~ It boils at constant temperature forming vapour richer in the more volatile component, nitric acid. Condensation of the vapour gives a liquid having the same composition as the vapour. Repeated heating and boiling yields pure nitric acid in the distillate and the azeotropic mixture in the residue.

02

Rej without pure

(b) Explain why nitric acid and water form a constant boiling point mixture. (1 mark)

The solution exerts lower vapour pressure than the vapour pressure of pure water and pure nitric acid.

01

(c) Calculate the molarity of the boiling point mixture (2 marks)

$1cm^3$ of solution contain 1.42g of HNO_3

$1000cm^3$ of solution contain (1.42×1000) g

$= 1420$ g

mass of $HNO_3 = \frac{68}{100} \times 1420$

$= 965.6$ g

$Mr(HNO_3) = 1 + 14 + 16(3) = 63$

63g of HNO_3 contain 1 mole

965.6g of HNO_3 contain $\left(\frac{965.6}{63}\right)$ moles

$= 15.3M$

13. 0.0291g of compound P containing carbon, hydrogen and oxygen gave 0.0581g of carbon dioxide and 0.0239g of water on combustion.

a) Calculate the empirical formula of P (3 marks)

mass of $C = \frac{12}{44} \times 0.0581$

$= 0.0158$g

Mass of $H_2 = \frac{2}{18} \times 0.0239$

$= 0.0027$g

Mass of $O_2 = 0.0291 - (0.0158 + 0.0027)$

$= 0.0106$g

Element	C	H	O
mass	0.0158	0.0027	0.0106
moles	$\frac{0.0158}{12}$	$\frac{0.0027}{1}$	$\frac{0.0106}{16}$
	0.0013	0.0027	0.00066
mole ratio	$\frac{0.0013}{0.00066}$	$\frac{0.0027}{0.00066}$	$\frac{0.00066}{0.00066}$
	2	4	1

Empirical formula is C_2H_4O

b) When 0.14g of P was vapourised at 20°C and 740 mmHg pressure, it occupied a volume of $39.5cm^3$.

i) Determine the molecular formula of P (2 marks)

$PV = nRT$

$Mv = 0.14 \times 8.31(20 + 273)$

$\left(\frac{740 \times 101325}{760}\right) \times 39.5 \times 10^{-6}$

$= 87.5$

$(C_2H_4O)n = 87.5$

$[(12 \times 2) + 4 + 16]n$

$n = \frac{87.5}{44}$

$n \approx 2$

∴ Molecular formula of P is $C_4H_8O_2$

ii) P reacted with sodium hydrogen carbonate with effervescence. Write the structural formulae and IUPAC names for all the possible isomers of P (2 marks)

$CH_3CH_2CH_2COOH$ Butanoic acid

$CH_3CH(CH_3)COOH$ 2-Methylpropanoic acid

02

(c) Write equation to show how one of the isomers of P can be converted to 1-Chloro-2-methylpropane (2 marks)

$CH_3CH(CH_3)COOH \xrightarrow[\text{Dry ether}]{LiAlH_4} CH_3CH(CH_3)CH_2OH \xrightarrow{PCl_5} CH_3CH(CH_3)CH_2Cl$

02

14. State what would be observed and write equations for the reactions that would take place when:

a) Potassium iodide is added to acidified potassium manganate (VII) solution. (2 ½ marks)

Observation

A purple solution turns to a brown solution

02½

Equation

$2MnO_4^-(aq) + 16H^+(aq) + 10I^-(aq) \rightarrow 5I_2(aq) + 2Mn^{2+}(aq) + 8H_2O(l)$

b) Dilute hydrochloric acid is added to sodium thiosulphate solution (2 ½ marks)

Observation

Bubbles of a colourless gas and a yellow solid is formed.

02½

Equation

$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow SO_2(g) + S(s) + H_2O(l)$

c) 2 or 3 drops of 2, 4 – dinitrophenylhydrazine is added to a dilute solution of propanone. (1 ½ marks)

Observation

A yellow precipitate is formed

Equation

$CH_3COCH_3 + C_6H_3(NHNH_2)(NO_2)_2 \rightarrow C_6H_3(NHN{=}C(CH_3)_2)(NO_2)_2 + H_2O$

d) Tin (II) chloride is added to Iron (III) sulphate solution . (2 ½ marks)

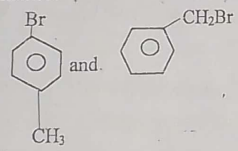
Observation

A brown solution turns to a green solution

Equation

$2Fe^{3+}_{(aq)} + Sn^{2+}_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + Sn^{4+}_{(aq)}$

15. Name one reagent that can be used to distinguish the following pairs of organic compounds and in each case state what would be observed when each compound of the pair is separated treated with the reagent you have named.

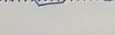
a)  and (3 marks)

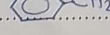
Reagent

Hot sodium hydroxide solution, dilute nitric acid and silver nitrate solution

Rej: without solution, without heat, wrong order

Observation

with  : No observable change

with  : Pale yellow precipitate

b) $CH_3\overset{O}{\overset{\|}{C}}-\bar{O}Na^+$ and $Na^+\bar{O}-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-\bar{O}Na^+$

Reagent (3 marks)

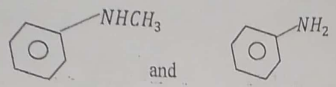
Ref: without heat, acidified

Acidified potassium manganate(VII) solution and heat

Observation

with $CH_3COO\bar{N}a^+$: No observable change

with $Na^+\bar{O}-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-\bar{O}Na^+$: Purple solution turns colourless with bubbles of a colourless gas

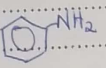
c)  and (3 marks)

Reagent

Sodium nitrite solution and Concentrated hydrochloric acid at 0°C

Observation

with  : Yellow oily liquid

with  : No observable change

16. Sulphur dichloride dioxide, SO_2Cl_2, decomposes at high temperature, according to the following equation

$$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$$

When 13.5g of SO_2Cl_2 was placed in a 2 litre vessel and heated at a pressure of 2 atmospheres; 1.5g of chlorine was formed at equilibrium.

(a) Write the expression for the equilibrium constant, Kp. (1 mark)

$$Kp = \frac{P_{SO_2} \times P_{Cl_2}}{P_{SO_2Cl_2}}$$

(b) Calculate the value of Kp and state its units (5 marks)

moles of $SO_2Cl_2 = \frac{13.5}{32+(16\times2)+(35.5\times2)}$

$= 0.1$

Equilibrium moles of $Cl_2 = \frac{1.5}{35.5\times2} = 0.02113$

$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$

Initial moles: 0.1 mole 0 0

If α dissociates: -0.1α $+0.1\alpha$ $+0.1\alpha$

Equilibrium moles: $0.1(1-\alpha)$ 0.1α 0.1α

But $0.1\alpha = 0.02113$

$\alpha = (0.02113) \div 0.1 = 0.2113$

Total equilibrium moles $= 0.1(1-\alpha) + 0.2\alpha$

$= 0.1(1-0.2113) + 0.2(0.2113)$

$= 0.12113$

$P_{SO_2Cl_2} = \frac{0.1(1-0.2113)\times2}{0.12113} = 1.30224$ atm

$P_{SO_2} = P_{Cl_2} = \frac{0.02113\times2}{0.12113} = 0.34888$ atm

$K_p = \frac{(0.34888)^2}{1.30224} = 0.0935$ atmospheres.

(c) State what would happen to the position of equilibrium when;

(i) Pressure is reduced (½ marks)

The equilibrium position would shift to the right.

(ii) Sulphur dioxide is removed from the equilibrium mixture. (½ marks)

The equilibrium position would shift to the right.

(iii) Chlorine is added to the equilibrium mixture. (½marks)

The equilibrium position would shift to the left.

(d) Explain your answer in c(iii) above. (1 ½ marks)

Addition of chlorine increases the partial pressure of Chlorine in the equilibrium mixture. To restore the equilibrium, more chlorine reacts with Sulphur dioxide to form sulphur dichloride dioxide.

17.(a)(i) Write the formula and name of main ore of Zinc. (1 mark)

ZnS, Zinc blende.

(ii) State the method which can be used to concentrate the ore you have named in (a) (i). (½ mark)

Froth flotation ✓ ½ Reg flotation

(b) The concentrated ore in (a) (ii) was converted to zinc oxide.

i) State how the conversion was carried out. (½ mark)

By roasting the concentrate ore in air ✓ ½

ii) Write an equation for the reaction that led to the formation of zinc oxide. (1 ½ marks)

$2ZnS_{(s)} + 3O_{2(g)} \longrightarrow 2ZnO_{(s)} + 2SO_{2(g)}$ ✓ ✓ 1½

(c) The zinc oxide in (b) was mixed with coke and limestone; the mixture put in a blast furnace and hot air blown into the furnace.

i) State the purpose of adding coke (½ mark)

To reduce zinc oxide to zinc ✓ ½

ii) Write equation for the reaction that takes place leading to the formation of Zinc. (1 mark)

$ZnO_{(s)} + C_{(s)} \longrightarrow Zn_{(g)} + CO_{(g)}$ ✓ or

Accept $ZnO_{(s)} + CO_{(g)} \longrightarrow Zn_{(g)} + CO_{2(g)}$

(d) Zinc powder was added to dilute sodium hydroxide solution.

i) State what was observed. (1 ½ marks)

A grey solid dissolves forming a colourless solution and bubbles of a colourless gas ✓ ✓ 1½

ii) Write equation for the reaction that took place. (1 ½ marks)

$Zn_{(s)} + 2OH^-_{(aq)} + 2H_2O_{(l)} \longrightarrow Zn(OH)^{2-}_{4(aq)} + H_{2(g)}$ ✓

OR $Zn_{(s)} + 2OH^-_{(aq)} \longrightarrow ZnO^{2-}_{2(aq)} + H_{2(g)}$ ✓ 1½

(e) Explain why it is advantageous to have a sulphuric acid manufacturing plant near a zinc extraction plant (1 mark)

Sulphur dioxide gas from extraction of zinc from zinc blende is a raw-material in the manufacture of sulphuric acid (Contact process) ✓

END