~~Student's~~ Teacher's Name: Noelmijita

Signature: ..... Combination.....

P525/1
CHEMISTRY
Paper 1
2 ¾ hours

KIBUBURA GIRLS' SECONDARY SCHOOL
Uganda Advanced Certificate of Education
S.5 EOT II EXAMINATIONS 2024
CHEMISTRY
Paper 1
2 hours 45 minutes

INSTRUCTIONS:
Answer all questions in section A and section B
All questions must be answered in the spaces provided

The Periodic Table, with relative atomic masses, is provided.

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 = 8.314 JK^{-1} mol^{-1}
Molar volume of a gas at s.t.p is 22.4 litres.
Standard temperature = 273 K
Standard pressure = 101325 N m^{-2}

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
06	7½	04	05	04	4	4½	6	05	09	09	09	09	09	09	100

Section A (46 marks)

Attempt all questions in this section

1. Name the reagent that you would use to distinguish between the following pairs of compounds. In each case state what you would observe when the reagent is treated with each member of the pair.

a) $CH_3CH_2CH=CH_2$ and $CH_3CH_2CH_2CH_3$ *(2 marks)*

Reagent:

Acidified potassium manganate (VII) solution ✓

rej – no acidified

Accept: bromine water.

Observations:

purple solution turns colourless – $CH_3CH_2CH=CH_2$ 02

No observable change – $CH_3CH_2CH_2CH_3$

Accept: Brown solution turns colourless – $CH_3CH_2CH=CH_2$

No observable change – $CH_3CH_2CH_2CH_3$

b) CH_3CH_2OH and CH_3OH *(2 marks)*

Reagent:

Iodine solution and sodium hydroxide solution ✓

rej Iodine

Observations:

Yellow precipitate – CH_3CH_2OH 02

No observable change – CH_3OH

c) $CH_3CH_2C\equiv CH$ and $CH_3C\equiv CCH_3$ *(2 marks)*

Reagent:

Ammoniacal silver nitrate solution ✓

Accept: Ammoniacal copper(I) chloride solution

Observations:

white precipitate with $CH_3CH_2C\equiv CH$ 02

No observable change with $CH_3C\equiv CCH_3$

Accept: Red precipitate with $CH_3CH_2C\equiv CH$

No observable change with $CH_3C\equiv CCH_3$

2. An alkyne X has molecular formula C_4H_6. Write the names and structural formulae of all possible isomers of X. (2 marks)

$CH_3CH_2C\equiv CH$ But-1-yne

$CH_3C\equiv CCH_3$ But-2-yne 02

(b) X reacts with an ammoniacal solution of silver nitrate.

(i) State what is observed. ($\frac{1}{2}$ mark)

A white precipitate $\frac{1}{2}$

(ii) Write the equation for the reaction that takes place. (1 mark)

$CH_3CH_2C\equiv CH_{(g)} + AgNO_{3(aq)} + NH_{3(aq)} \longrightarrow CH_3CH_2C\equiv CAg_{(s)} + NH_4NO_3$ 01

(c) Write equations to show how X can be synthesized from ethane. (4 marks)

$CH_3CH_3 + SO_2Cl_2 \xrightarrow{40-80^\circ C} CH_3CH_2Cl$

$CH_3CH_2Cl \xrightarrow[\text{heat}]{KOH|CH_3CH_2OH} CH_2=CH_2$

$CH_2=CH_2 + Cl_2|CCl_4 \longrightarrow CH_2ClCH_2Cl$

$CH_2ClCH_2Cl \xrightarrow[\text{heat}]{\text{excess } KOH|CH_3CH_2OH} HC\equiv CH \xrightarrow[\text{liquid}]{\text{(i) Na|NH}_3\text{(l)}\ \text{(ii) } CH_3CH_2Cl} CH_3CH_2C\equiv CH$ 04

3. The enthalpies of some reactions are given below:

(i). $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$ -393.5 KJ/mol

(ii). $H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)}$ -285.9 KJ/mol

(iii). $C_6H_5OH_{(s)} + 7O_{2(g)} \longrightarrow 6CO_{2(g)} + 3H_2O_{(l)}$ -3009 KJ/mol

(a) Calculate the standard enthalpy of formation of phenol, C_6H_5OH from its elements. (03 marks)

Required equation $6C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \longrightarrow C_6H_5OH(s)$ $\Delta H_f^\theta = ?$

$= 6(i) + 3(ii) - (iii)$ ✓

$= 6(-393.5) + 3(-285.9) - -3009$ ✓

$= -209.7\ KJmol^{-1}$ ✓ (03)

(b) (i) From your answer in (a) above state whether phenol is a stable compound or not. ($0\frac{1}{2}$ mark)

Phenol is a stable compound + ($\frac{1}{2}$)

(ii) Give a reason for your answer in (b) (i) above. ($0\frac{1}{2}$ mark)

Its standard enthalpy of formation is negative, ($\frac{1}{2}$) exothermic

4(a) State Raoult's law of relative lowering of vapour pressure. (1mark)

It states that the relative lowering of vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of the solute in the solution at a given temperature (01)

(b)(i) Calculate the vapour pressure of a solution containing 18g of glucose ($C_6H_{12}O_6$) in 50g of water at 60°C (The vapour pressure of pure water is 150mmHg.) (2 $\frac{1}{2}$ marks)

Molar mass of glucose ($C_6H_{12}O_6$)

$= (12\times6) + (1\times12) + (16\times6)$

$= 180$ ✓

Molar mass of $H_2O = (16\times1) + (1\times2) = 18g$ ✓ (01)

$\frac{P^o_{solvent} - P_{solution}}{P^o_{solvent}} = \frac{\text{mass of glucose} \times \text{Mr water}}{\text{Mr of glucose} \times \text{mass of water}}$ ✓

$\frac{150 - P_{solution}}{150} = \frac{18}{180} \times \frac{18}{50}$ ✓

$= 144.6$ mmHg.

$\therefore$ Vapour pressure of solution $= 144.6$ mmHg ✓ (1½)

(ii) State any three assumptions made in b(i) (1 ½ marks)

Glucose doesnot associate or dissociate in the solution

The solution is dilute ✓

Glucose is non volatile ✓ (½) rej - solute, rej - solvent

There is no chemical reaction between glucose and water

Deny ½ mark for any extra assumption given.

5. Polonium $^{216}_{84}Po$ undergoes radioactive decay to give elements X and Y according to the equation below.

$$^{216}_{84}Po \longrightarrow X + \alpha \longrightarrow Y + \beta$$

(a) Write the:

(i) Atomic numbers of elements X and Y (@0½ mark)

82 ✓

83 ✓ (01)

(ii) Mass numbers of elements X and Y. (@0½ mark)

212 ✓

212 ✓ (01)

(b) Calculate the half-life of element Y. (02 marks)

[The decay constant = $6.54 \times 10^{-4} min^{-1}$]

$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$ ✓

$t_{\frac{1}{2}} = \frac{0.693}{6.54 \times 10^{-4}}$ ✓ (02)

$t_{\frac{1}{2}} = 1059.63$ minutes ✓ Deny ½ for no unit

6. A solution containing Xg of cane sugar [R.M.M = 342] in 105g of water at a pressure of 101.3Pa boiled at 100.06°C. Determine X. [Kb for water = 0.52°C/mol/1,000g] (04½ marks)

Boiling point elevation = 100.06 − 100 = 0.06°C

0.52°C is the elevation in boiling point caused by 342g

0.06°C is the elevation in boiling point caused by $\frac{342 \times 0.06}{0.52}$ g

$= 39.46154$ g

1000g of water dissolves 39.461549 of X

105g of water dissolves $\frac{39.46154 \times 105}{1000}$ g of X

$= 4.14359$ g of X

04

7. Excess ethane reacts with chlorine in presence of sunlight to form chloroethane.

(a) Write equation for the reaction that took place. (01 mark)

$CH_3CH_3(g) + Cl_2(g) \longrightarrow CH_3CH_2Cl + HCl$ (excess)

01

(b) Outline the mechanism for the reaction. (03½ marks)

$Cl-Cl \longrightarrow \dot{Cl} + \dot{Cl}$

$CH_3CH_2-H + \dot{Cl} \longrightarrow CH_3\dot{C}H_2 + HCl$

$CH_3CH_2-Cl + \dot{Cl} \longrightarrow CH_3CH_2Cl + \dot{Cl}$

$\dot{Cl} + \dot{Cl} \longrightarrow Cl_2$

03½

8. (a) State three factors that can affect electron affinity. (1½ marks)

- Nuclear charge
- Electronic configuration
- Screening effect
- Atomic radius

1½

Deny ½ for any extra factor given

(b) Write equation for the first electron affinity of sulphur. (01 mark)

$S(g) + \bar{e} \longrightarrow S^-(g)$

01

(c) The first and second electron affinities of sulphur are −200 and $+649\ kJ\ mol^{-1}$ respectively. Explain the difference in the electron affinities of sulphur. (04 marks)

The first electron affinity of sulphur is negative because heat is given out when an electron is added to neutral gaseous sulphur atom to form uninegatively charged gaseous sulphur ion. This incoming electron experiences a greater attraction by the nucleus than it is repelled. There is however repulsion when an electron is being added to the negatively charged gaseous ion. Energy must be absorbed to add this electron such that the repulsion is overcome. This makes the second electron affinity positive

9. The mass spectrometer of chlorine shows peaks at mass 70, 72 & 74. The heights of the peaks respectively are in the ratio of 9:6:1.Calculate:

(a) The average atomic mass of chlorine. (03 marks)

Relative percentage abundances of isotopes $= \frac{9}{16} \times 100 = 56.25$ at 70

$= \frac{6}{16} \times 100 = 37.5$ at 72

$= \frac{1}{16} \times 100 = 6.25$ at 74

$R.A.M = \sum \frac{(\text{Relative percentage abundance} \times \text{mass of isotope})}{100}$

$= \frac{(56.25 \times 70)}{100} + \frac{(37.5 \times 72)}{100} + \frac{(6.25 \times 74)}{100} = 71$ 03

Average atomic mass of chlorine $= \frac{71}{2} = 35.5$

(b) The relative abundance of ^{35}Cl and ^{37}Cl. (02 marks)

Let the relative abundance of ^{35}Cl be x

Let the relative abundance of ^{37}Cl be $100-x$

$R.A.M = \sum \frac{(\text{Relative percentage abundance} \times \text{mass of isotopes})}{100}$

$35.5 = \frac{35 \times x}{100} + \frac{(100-x)37}{100}$ 02

$x = 75\%$

∴ The relative abundance of chlorine 35 is 75% and chlorine-37 is 25%.

Section B (54 marks)

Attempt all questions in this section

10. The table below shows the tests carried out on a solution of substance Z and the following observations were made.

	Tests	Observations
(i)	To a solution of Z was added dilute sodium hydroxide solution drop wise until in excess	White precipitate soluble in excess sodium hydroxide to form a colourless solution.
(ii)	To a solution of Z was added aqueous ammonia solution drop wise until in excess	White precipitate insoluble in excess ammonia solution.
(iii)	To a solution of Z was added acidified potassium manganate (VII) solution	A purple solution turns colourless
(iv)	To a solution of Z was added dilute nitric acid followed by silver nitrate solution, then ammonia solution drop wise until in excess	White precipitate dissolves in excess ammonia to form a colourless solution.

(a) Name and write the symbol of the: (@01 mark)

(i) Cation in substance, Z: Sn^{2+} ; Tin(II) ion ✓+

(ii) Anion in substance, Z: Cl^- ✓+ chloride ion ✓+

02

(b) Write an ionic equation(s) for the reaction leading to formation of the;

(i) a white precipitate and colourless solution in test (i) (3 marks)

$Sn^{2+}_{(aq)} + 2\bar{O}H_{(aq)} \longrightarrow Sn(OH)_{2(s)}$ ✓+

$Sn(OH)_{2(s)} + 2\bar{O}H_{(aq)} \longrightarrow Sn(OH)_4^{2-}{}_{(aq)}$ ✓+

03

(ii) a colourless solution in test (iii) (1½ marks)

$2MnO_4^-(aq) + 5Sn^{2+}(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5Sn^{4+}(aq) + 8H_2O(l)$ 1½

(iii) white precipitate in test (iv) (01½ marks)

$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ 1½

(c) Write the formula of the compound Z. (01 mark)

$SnCl_2$ 01

11. One of the limitations of the method of determining relative molecular mass by freezing point depression method is that the solute should not associate or dissociate in solution.

(a) State three other limitations of determining molecular mass by freezing point depression method. (01½ marks)

The solution is dilute

The solute is non volatile

There is no chemical reaction between the solute and the solvent. 1½

(b) Explain how association or dissociation of a solute in solution affect the molecular mass determined by freezing point depression method. (@02 marks)

Association:

Association reduces the number of particles of a solute in solution and thus decreases lowering the colligative property and increasing the molecular mass. 02

Dissociation:

Dissociation increases the number of particles in solution, thus increasing the colligative property and reducing the molecular mass of the solute.

(c) A solution containing 0.142g of naphthalene in 20.25g of benzene caused a lowering of freezing point of 0.284°C. Calculate the molar mass of naphthalene. [Cryoscopic constant of C_6H_6, K_f = 5.12°C/mol/kg] (03½ marks)

20.25 g of benzene dissolves 0.142 g of Naphthalene

1000 g of benzene dissolves $\frac{0.142 \times 1000}{20.25}$ g of Naphthalene

$= 7.01235$ g

0.284 °C is a depression in freezing point caused by 7.01235 g of Naphthalene

5.12 °C is a depression in freezing point caused by $\frac{7.01235 \times 5.12}{0.284}$ g of Naphthalene

∴ The molar mass of Naphthalene = 126.429 g mol⁻¹

12. Complete the following equations and in each case outline a mechanism for the reaction.

(a) $(CH_3)_3C\text{-}Br \xrightarrow[CH_3CH_2OH,\ heat]{CH_3CH_2O^-Na^+} (CH_3)_2C{=}CH_2 + NaBr$ (3 marks)

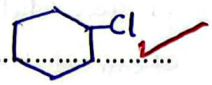
$CH_3CH_2\bar{O}Na^+ \longrightarrow CH_3CH_2\bar{O} + Na^+$

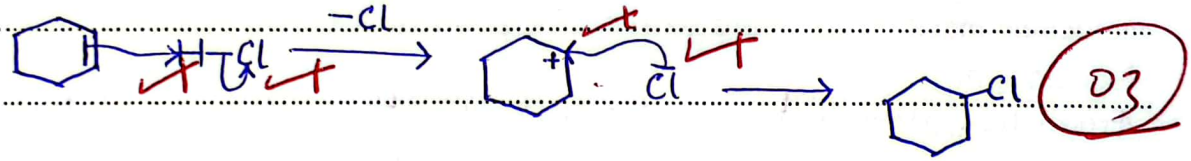
$(CH_3)_3C\text{-}Br \rightleftharpoons (CH_3)_2\overset{+}{C}\text{-}CH_3 + Br^-$

$CH_3\overset{+}{C}(CH_3)CH_2 \longrightarrow CH_3C(CH_3){=}CH_2$ (H abstracted by $:\bar{O}CH_2CH_3$)

$Na^+ + Br^- \longrightarrow NaBr$

03

(b)  + HCl ⟶  (3 marks)



03

(c) $HC{\equiv}CH \xrightarrow[2.\ CH_3CH_2Br]{1.\ Na/\ NH_3(l)} CH_3CH_2C{\equiv}CH + NaBr$ (3 marks)

$Na + NH_3 \longrightarrow NaNH_2$

$HC{\equiv}CH + NaNH_2 \longrightarrow HC{\equiv}CNa + NH_3$

$HC{\equiv}CNa \longrightarrow HC{\equiv}C^- + Na^+$

$CH_3CH_2\text{-}Br \longrightarrow CH_3CH_2C{\equiv}CH + Br^-$

03

$Na^+ + Br^- \longrightarrow NaBr$

13. State what was observed and write equation for the reaction that would take place when

(a) Sulphur dioxide gas is bubbled through a solution of potassium manganate (VII) (02 marks)

Observation

Purple solution turns colourless

Equation

$2MnO_4^-(aq) + 5SO_2(g) + 2H_2O(l) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 4H^+(aq)$

02

(b) Aqueous ammonia is added drop wise until in excess to aqueous copper (II) sulphate solution. (02½ marks)

Observation

Blue precipitate soluble to form a deep blue solution

Equation

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

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

$2\frac{1}{2}$

(c) Ethyne is bubbled through ammoniacal copper (II) chloride solution. (2½mks)

Observation

A red precipitate

01

Equation

$HC\equiv CH(g) + 2CuCl(aq) + 2NH_3(aq) \longrightarrow CuC\equiv CCu(s) + 2NH_4Cl(aq)$ (1½)

(d) Hydrogen peroxide is added to acidified potassium manganate (VII) solution. (02 marks)

Observation

Purple solution turns colourless and bubbles of a colourless gas evolved.

Equation

$2MnO_4^-(aq) + 5H_2O_2(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5O_2(g) + 8H_2O(l)$ (02)

14(a) Define the term osmotic pressure. (01 mark)

Osmotic pressure is the minimum pressure applied to the solution side to balance the tendency of solvent molecules to move from the solvent side to the solution side through a semi-permeable membrane. (01)

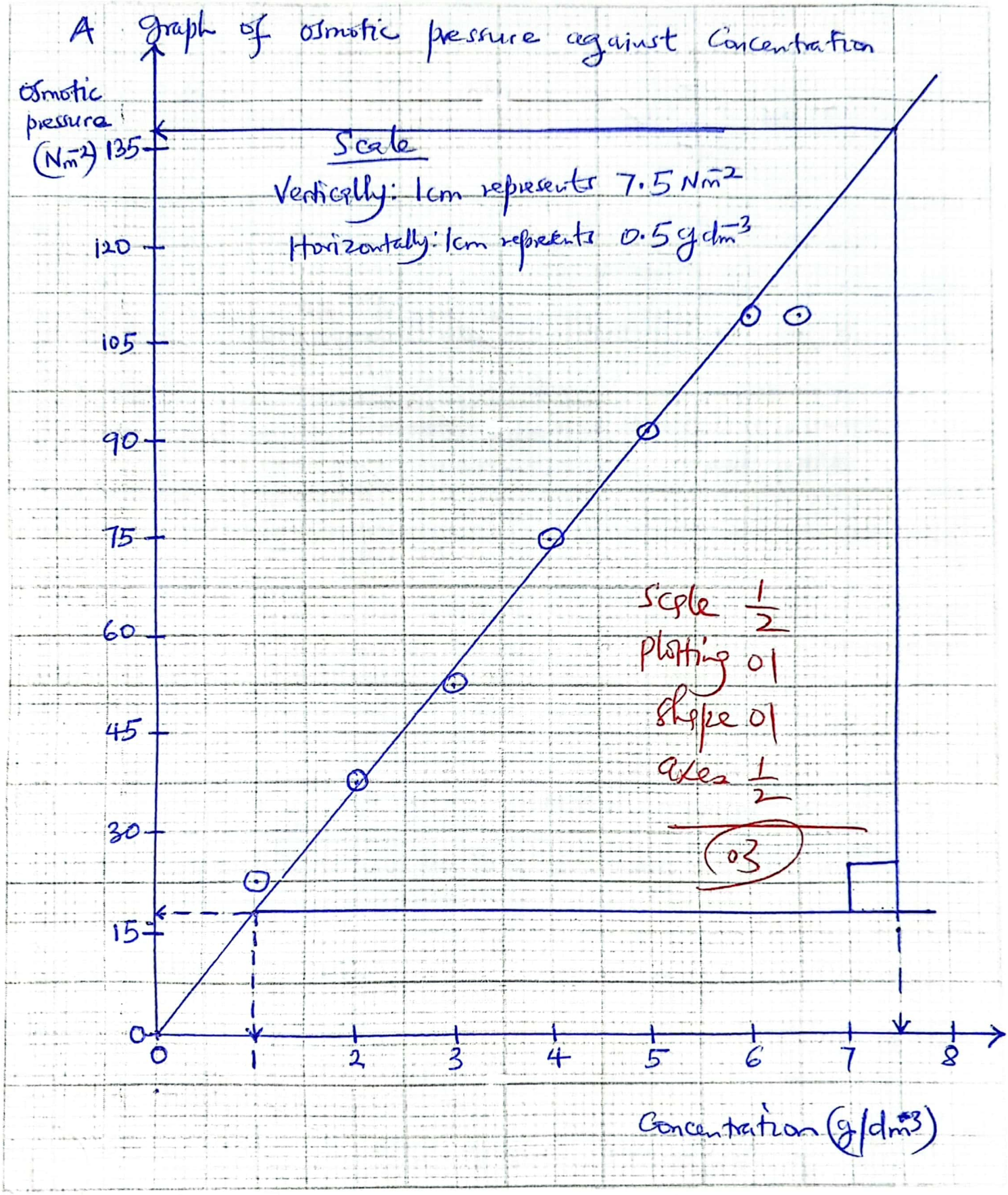
(b) Explain why determination of molar mass of polymer, osmotic pressure is preferred than boiling point elevation method. (01 mark)

Polymers have high relative molecular masses and in dilute solutions, they give few dissolved particles. In dilute solutions of polymers have reasonable and accurately measurable osmotic pressures at room temperature. (01)

(c) The Osmotic pressure of various concentrations of solute X in methylbenzene at 25°C are given in the table below.

Concentration (g/dm^3)	1.0	2.0	3.0	4.0	5.0	6.0
Osmotic pressure (Nm^{-2})	23	37	53	75	92	109

(i) Plot a graph of osmotic pressure against concentration. (03 marks)



(ii) Use the graph to determine the molecular mass of X.[Universal gas constant, R = 8.314J/K/mol] (04 marks)

$slope = \frac{RT}{Mr}$ ✓

$slope = \frac{138 - 18}{75 - 1}$ ✓ ✗

$slope = 18.4615\ Nm^{-2}\ g^{-1}\ dm^3$ Deny $\frac{1}{2}$ for no units.

$\Rightarrow 18.4615 = \frac{8.314 \times (25+273)}{Mr}$ ✓ ✗ 04

Molecular mass of X = 134.20g.

15(a) $10.0cm^3$ of a solution of ammonium iron (II) sulphate-6-water, $(NH_4)_2SO_4FeSO_4.6H_2O$ of unknown concentration was pipetted into a conical flask. To it was added an equal volume of 2M sulphuric acid and then titrated against a solution of 0.02M potassium manganate(VII) . $9.90cm^3$ of the permanganate solution was required for complete reaction.

(i) Write an ionic equation for the reaction between manganate(VII) ions and iron(II) ions. ($1^1/_2$ marks)

$5Fe^{2+}_{(aq)} + MnO_4^-{}_{(aq)} + 8H^+_{(aq)} \longrightarrow Mn^{2+}_{(aq)} + 5Fe^{3+}_{(aq)} + 4H_2O_{(l)}$ ✓ ✓ ✓ $1/2$

(ii) Calculate the molar concentration of the solution of ammonium iron(II) sulphate-6-water. ($1^1/_2$ marks)

$1000\ cm^3$ of solution contain 0.02 moles of MnO_4^- ions

$9.90\ cm^3$ of the solution contain $\left(\frac{0.02 \times 9.90}{1000}\right)$ moles of MnO_4^- ions

$= 0.000198$ moles of MnO_4^- ions ✓

1 mole of MnO_4^- ions reacts with 5 moles of Fe^{2+} ions

0.000198 moles of MnO_4^- ions react with $\left(\frac{5 \times 0.000198}{1}\right)$ moles of Fe^{2+} ions ✓

$= 0.00099$ moles of Fe^{2+} ions

molar Concentration of Fe^{2+} $= \left(\frac{0.00099 \times 1000}{10}\right)$ moles

$= 0.099 \text{ mol dm}^{-3}$ ½

(b) 0.5g of an impure solid potassium chlorate, $KClO_3$ was accurately weighed and put in a beaker. 100 cm^3 of distilled water was added and the mixture stirred to dissolve. The resultant solution was transferred into a 250cm^3 volumetric flask and the solution was made up to the mark with distilled water. 10.0cm^3 of this solution was pipetted into a conical flask and to it was added 35.0 cm^3 of the same ammonium iron(II) sulphate-6- water solution used in (a) followed by an equal volume of 2M sulphuric acid. The mixture was heated to about 85°C and then cooled in cold water for 3 minutes and the cold mixture titrated with the same permanganate solution used in (a). 25.20 cm^3 of the permanganate was required for complete reaction. (Given that 1mole of chlorate (V) ions react with 6moles of iron (II) ions)

Calculate the number of moles of:

(i) excess iron(II) ions that reacted with manganate (VII) ions. ($1^1/_2$ marks)

Moles of MnO_4^- = $\frac{25.2 \times 0.02}{1000}$ = 0.000504 moles

Moles of Fe^{2+} = (5×0.000504) = from the equation; mole ratio is 1:5

= 0.00252 moles of Fe^{2+} ½

(ii) iron(II) ions that reacted with the 10 cm^3 of chlorate(V) ions. ($1^1/_2$ mark)

moles of Fe^{2+} in 35.0 cm^3 = $\frac{35 \times 0.099}{1000}$

= 0.003465 moles of Fe^{2+}

moles of Fe^{2+} ions that reacted = (0.003465 − 0.00252) moles

= 0.000945 moles of Fe^{2+} ½

(iii) Percentage purity of the potassium chlorate. (K=39, Cl=35.5, O=16) (3 mks)

Moles of $KClO_3$ = $\frac{(1 \times 0.000945)}{6}$ moles

= 0.0001575 moles of ClO_3^-

10 cm^3 of solution contain 0.0001575 moles of ClO_3^-

250 cm^3 of solution contain $\frac{(0.0001575 \times 250)}{10}$ moles of ClO_3^-

= 0.0039375 moles of ClO_3^-

Molar mass of $KClO_3$ = (39x1) + (35.5x1) + (16x3)

= 122.5g

1 mole of $KClO_3$ weighs 122.5g

0.0039375 moles of $KClO_3$ weigh $\frac{(122.5 \times 0.0039375)}{1}$ g 03

= 0.48234375g

Percentage purity of $KClO_3$ = $\frac{0.48234375 \times 100}{0.5}$

= 96.5%

THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 TI 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
227 Ac 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

END-MTN