Candidate's Name: ..... J.J.K .....

Signature: .....

| Random No. | Personal No. |
|---|---|
| 0782601038 | 0753247098 |

*(Do not write your School /Centre Name or Number anywhere on this booklet.)*

**P525/1**
**CHEMISTRY**
**Paper 1**
**(Theory)**
**Nov./Dec. 2024**
2¾ hours

# UGANDA NATIONAL EXAMINATIONS BOARD

## Uganda Advanced Certificate of Education

CHEMISTRY

**Paper 1**
**(Theory)**

2 hours 45 minutes

**INSTRUCTIONS TO CANDIDATES:**

*This paper consists of* **two** *Sections;* **A** *and* **B**.

*Section* **A** *is* **compulsory**. *Attempt* **six** *questions from Section* **B**. *Any additional question(s) attempted will* **not** *be marked.*

*All questions* **must** *be answered in the spaces provided. Use* **blue** *or* **black** *ink. Any work done in pencil,* **except** *drawings, will not be marked.*

*The Periodic Table, with relative atomic masses, is attached at the end of the paper.*

*Mathematical tables (3-figure tables) are adequate or silent 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 = 273 K.*
*Standard pressure = $101325\ Nm^{-2}$.*

| For Examiners' Use Only | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | Total |
| 5 | 5 | 4½ | 6 | 4 | 5½ | 6 | 5 | 5 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 100 |

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Accept: e.m.f of a cell in which the electrode on the left is a standard hydrogen electrode and that on the right is the standard electrode in question under standard conditions

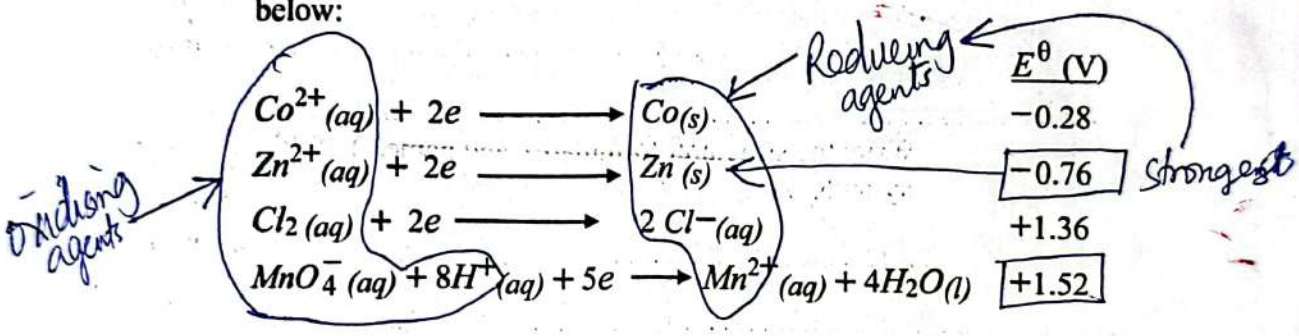
## SECTION A: (46 MARKS)

*Answer* **all** *the questions in this section.*

**1.** **(a)** **Define the term standard electrode potential.** *(01 mark)*

The potential difference or reduction potential (or electrode potential) established when a metal electrode is placed in a 1 molar solution of its ions measured relative to the standard hydrogen electrode at 25°C (298K) and 1 atmosphere. Accept standard conditions (25°C, 1atm, 1M) ✓

**(b)** **The standard electrode potentials of some half cells reactions are given below:**




**(i)** **Identify the strongest reducing agent and the strongest oxidising agent.** *(01 mark)*

reject wrong symbols ✓

Strongest reducing agent: Zn ✓ Accept Zinc metal (01)

Strongest oxidising agent: $MnO_{4(aq)}^-$ ✓ Accept aqueous manganate (VII) ion or permanganate ion

reject (II), (VII), (VII)

**(ii)** **Write the cell notation of the cell constructed by combining the half cells $Co^{2+}(aq) / Co(s)$ and $Zn^{2+}(aq) / Zn(s)$.** *(01 mark)*

Emphasize physical states

$Zn(s) / Zn^{2+}(aq) \,||\, Co^{2+}(aq) / Co(s)$ ✓ (1) reject CO, Zn and other wrong symbols.

**(iii)** **Write the equation for the overall cell reaction for the cell in b(ii).** *(01 mark)*

$Zn_{(aq)} + Co^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Co_{(s)}$ ✓ (1)

**(iv)** **Calculate the e.m.f. of the cell in b(ii).** *(01 mark)*

$E^{\theta}_{cell} = E^{\theta}_{right} - E^{\theta}_{left} = -0.28 - (-0.76) = +0.48V$ ✓✓ (1)

Deny mark if (+) or (V) missing.

05

2. Nylon 6, 6 $\left[ \overset{H}{\underset{|}{N}}-(CH_2)_6-\overset{H}{\underset{|}{N}}-\overset{O}{\overset{\|}{C}}(CH_2)_4\overset{O}{\overset{\|}{C}} \right]_n$ is formed by condensation polymerisation.

(a) State the meaning of the term condensation polymerisation. *(01 mark)*

The process by which many molecules of two different bifunctional monomers joint together to form a large molecule with loss of other small molecules. ✓ (1)

(b) (i) Write the structural formula(e) and name(s) of the monomers of nylon 6, 6. *(03 marks)*

$H_2N(CH_2)_6NH_2$ ✓ Hexane-1,6-diamine ✓ reject amine

$HOOC(CH_2)_4COOH$ ✓ Hexane-1,6-dioic acid ✓

or $ClOC(CH_2)_4COCl$ — Hexane-1,6-dioyl dichloride ✓ Accept hexanedioyl dichloride (3)

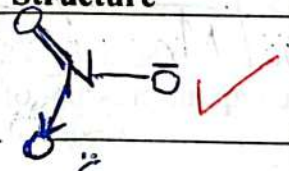
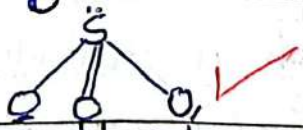
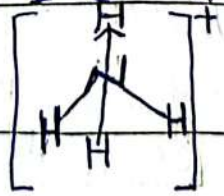
(ii) State **one** use of nylon 6, 6. *(01 mark)*

Making fishing nets, tarpaulins, ropes, clothing etc. ✓ (1)

−1 for @ extra wrong answer — any one.

3. Draw the structure and name the shape of each of the following ions in Table 1: *(4½ marks)*

**Table 1**

| Ion | Structure | Name of shape |
|---|---|---|
| $NO_3^-$ |  ✓ | Trigonal planar ✓ ½ |
| $SO_3^{2-}$ |  ✓ | Trigonal pyramidal ✓ 1½ |
| $NH_4^+$ |  ✓ | Tetrahedral ✓ 1½ |

reject; hanging bonds, wrong symbols, missing arrows

Consider appropriate bond angles

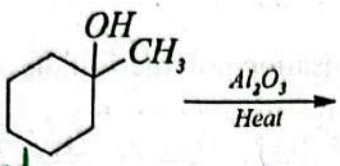
Structure must be correct to award shape.

09½

4. Complete the following equations and name the major organic product:

(a) $CH_3COOH \xrightarrow{PCl_5} CH_3COCl + HCl + POCl_3$ ..... (1½ marks)

Name ..... Ethanoyl chloride ..... ½

(b)  ..... (1½ marks)

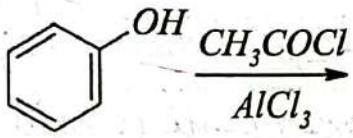
−½ if one of underlined pdcts is missing

Name ..... 1-methylcyclohexene ..... ½

repeat methylcyclohexene

(c) $(CH_3COO)_2Ca \xrightarrow{Heat} CH_3COCH_3 + CaCO_3$ ..... (1½ marks)

Name ..... Propanone ..... ½

(d)  ..... (1½ marks) ½

Name ..... 4-hydroxyphenylethanone

5. The vapour pressure of propanone is 37330 $Nm^{-2}$ at 30 °C. When 33.4 g of cane sugar were dissolved in 120 g of propanone, the vapour pressure reduced by 1760 $Nm^{-2}$. $M_r$ of $CH_3COCH_3 = (3\times12)+(6\times1)+(16\times1) = 58$

(a) Calculate the molar mass of cane sugar. (2½ marks)

$\frac{\Delta P}{P_{solvent}} = \frac{m_{solute}}{M_{r\,solute}} \Big/ \frac{m_{solvent}}{M_{r\,solvent}} \Rightarrow \frac{1760}{37330} = \frac{33.4 \times 58}{M_{r\,solute} \times 120}$ ..... 2½

(b) Explain why the vapour pressure of the solution is lower than that of propanone. (1½ marks)

Cane sugar is a non-volatile solute. Cane sugar particles occupy some of the surface of the solution, reducing the escaping tendency of propanone particles into vapour phase ..... 1½

$M_{r\,solute} = \frac{37330 \times 33.4 \times 58}{1760 \times 120} = 342.4\,g.$ ..... 10

Deny ½ if answer has no units.

6. (a) State what would be observed and write an equation for the reaction that takes place when dilute hydrochloric acid is added to aqueous potassium manganate(VI) solution.

**Observation:** (1½ marks)

Green solution turns purple and a brown precipitate / solid deposited. ½

**Equation:** (1½ marks)

$3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$

or $3K_2MnO_4(aq) + 4HCl(aq) \rightarrow 2KMnO_4(aq) + MnO_2(s) + 2H_2O(l) + 4KCl(aq)$

(b) Explain why potassium manganate(VII) is **not** acidified using hydrochloric acid. (2½ marks)

Potassium manganate(VII) oxidises hydrochloric acid to chlorine and itself reduced to manganese(II) ions 2½

emphasize correct roman numerals and symbols for eqns.

$2MnO_4^-(aq) + 16H^+(aq) + 10Cl^-(aq) \rightarrow 2Mn^{2+}(aq) + 5Cl_2(g) + 8H_2O(l)$

or $2KMnO_4(aq) + 16HCl(aq) \rightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$

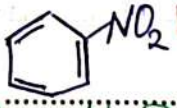
7. Complete the following equations and in each case write the mechanism for the reaction(s):

(a) $CH_3CH_2OH \xrightarrow[180\ ^\circ C]{Conc.H_2SO_4} H_2C{=}CH_2 + H_2O$ ½ 分 $H_2O$ missing (3½ marks)

**Mechanism:** $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$ 3½

$CH_3CH_2\ddot{O}H + H^+ \rightarrow CH_3CH_2\overset{+}{O}H_2 \xrightarrow{-H_2O} H_2C{-}\overset{+}{C}H_2 \xrightarrow{-H^+} H_2C{=}CH_2$

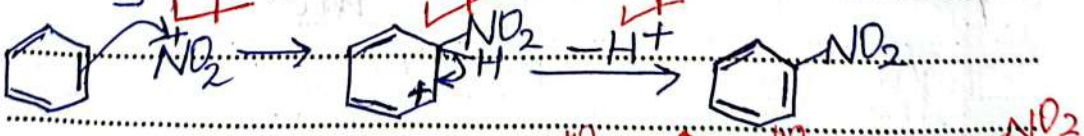
Acc: $CH_3CH_2OH + H{-}OSO_3H \rightarrow$

(b)  $\xrightarrow{Conc.\ HNO_3/Conc.H_2SO_4}$  Accept  (2½ marks)

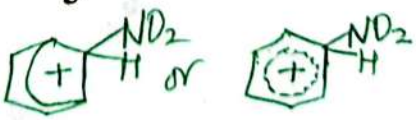
Accept $HNO_3 + H_2SO_4 \rightleftharpoons NO_2^+ + H_2O + HSO_4^-$ 2½

**Mechanism:**

$HNO_3 + 2H_2SO_4 \rightleftharpoons NO_2^+ + H_3O^+ + 2HSO_4^-$



Acc 

reject Benzene missing the Kind  etc. reject 

**8.** (a) Write an equation for the reaction that takes place when methylamine is dissolved in water. *(1½ marks)*

$CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftharpoons CH_3\overset{+}{N}H_{3(aq)} + \bar{O}H_{(aq)}$ ✓✓ 1½

reject $\bar{O}H$ Accept $OH^-$

(b) The hydrogen ion concentration of a 1M methylamine solution is $2.5 \times 10^{-13}$ *mol* $l^{-1}$. Calculate the base dissociation constant $K_b$, of methylamine. *(3½ marks)*

*(The ionic product of water, $K_w = 10^{-14}$ mol$^2$ $l^{-2}$)*

$K_w = [H^+][\bar{O}H] = 10^{-14} \Rightarrow [\bar{O}H] = \frac{10^{-14}}{2.5 \times 10^{-13}}$ ✓✓

$[\bar{O}H] = 4 \times 10^{-2}$ M ✓

$K_b = \frac{[CH_3\overset{+}{N}H_3][\bar{O}H]}{[CH_3NH_2]}$ ✓

But at equilibrium;

$[\bar{O}H] = [CH_3\overset{+}{N}H_3]$ ✓

$[CH_3NH_2] = 1M$ (remains the same)

$K_b = \frac{[\bar{O}H]^2}{[CH_3NH_2]} = \frac{(4 \times 10^{-2})^2}{1}$ ✓✓

$K_b = 1.6 \times 10^{-3}$ mol dm$^{-3}$. ✓ 3½

**9.** The first ionisation energies and atomic radii for some elements of group(II) of the Periodic Table are given in Table **2**.

**Table 2**

| **Element** | Beryllium | Magnesium | Calcium | Strontium | Barium |
|---|---|---|---|---|---|
| **First ionisation energy (kJ mol$^{-1}$)** | 899 | 738 | 590 | 550 | 503 |
| **Atomic radius (nm)** | 0.089 | 0.136 | 0.174 | 0.191 | 0.198 |

(a) State how the first ionisation energy varies with atomic radius. *(01 mark)*

First ionisation energy decreases with increase in atomic radius. ✓



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(b) Explain your answer in (a). **(04 marks)**

From one element to another, screening effect increases due to addition of an extra energy level completely filled with electrons, Nuclear charge also increases due to more protons added to the nucleus. However, increase in screening effect is more rapid outweighs increase in nuclear charge hence effective nuclear charge decreases atomic radius increases and the distance of the outermost electron from the nucleus increases and weakly attracted hence easily removed. (4)

reject subenergy level Subshell

reject a proton is added

## SECTION B: (54 MARKS)

*Answer any* **six** *questions from this section.*
*Any additional question(s) answered will* **not** *be marked.*

**10.** The molecular formula of a compound ***P*** is $C_3H_6Cl_2$.

(a) Write the structural formulae of all the possible isomers of ***P***. **(02 marks)**

$CH_3CH_2\underset{Cl}{\overset{Cl}{C}}H$ ✓ $CH_3\underset{Cl}{\overset{Cl}{C}}CH_3$ ✓ (2)

$CH_3\underset{Cl}{C}HCH_2Cl$ ✓ $ClCH_2CH_2CH_2Cl$ ✓

Deny marks if names included

$CH_3CH_2\underset{Cl}{\overset{Cl}{C}}H$

$CH_3CH_2CHCl_2$

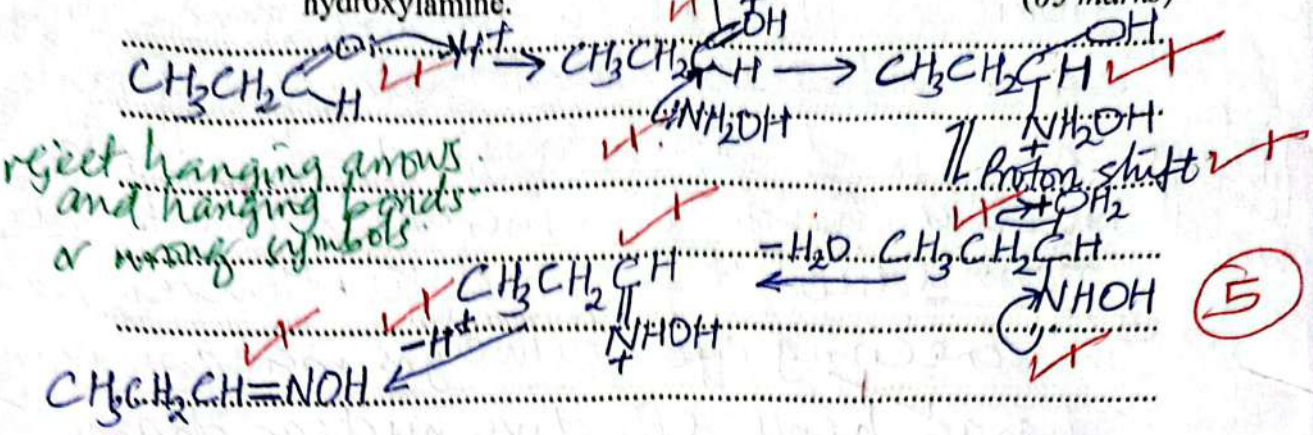
(b) When ***P*** was boiled with aqueous sodium hydroxide, a compound ***R*** which reacted with hydroxylamine ($NH_2OH$) in the presence of an acid and reduced Fehling's solution, was formed.

(i) Identify compounds ***P*** and ***R***. **(02 marks)**

P is $CH_3CH_2\underset{Cl}{\overset{Cl}{C}}H$ ✓ Accept $CH_3CH_2CHCl_2$ reject 1,1-dichloropropane

R is $CH_3CH_2CHO$ ✓ (2)

(ii) Write a mechanism for the reaction between ***R*** and hydroxylamine. *(05 marks)*



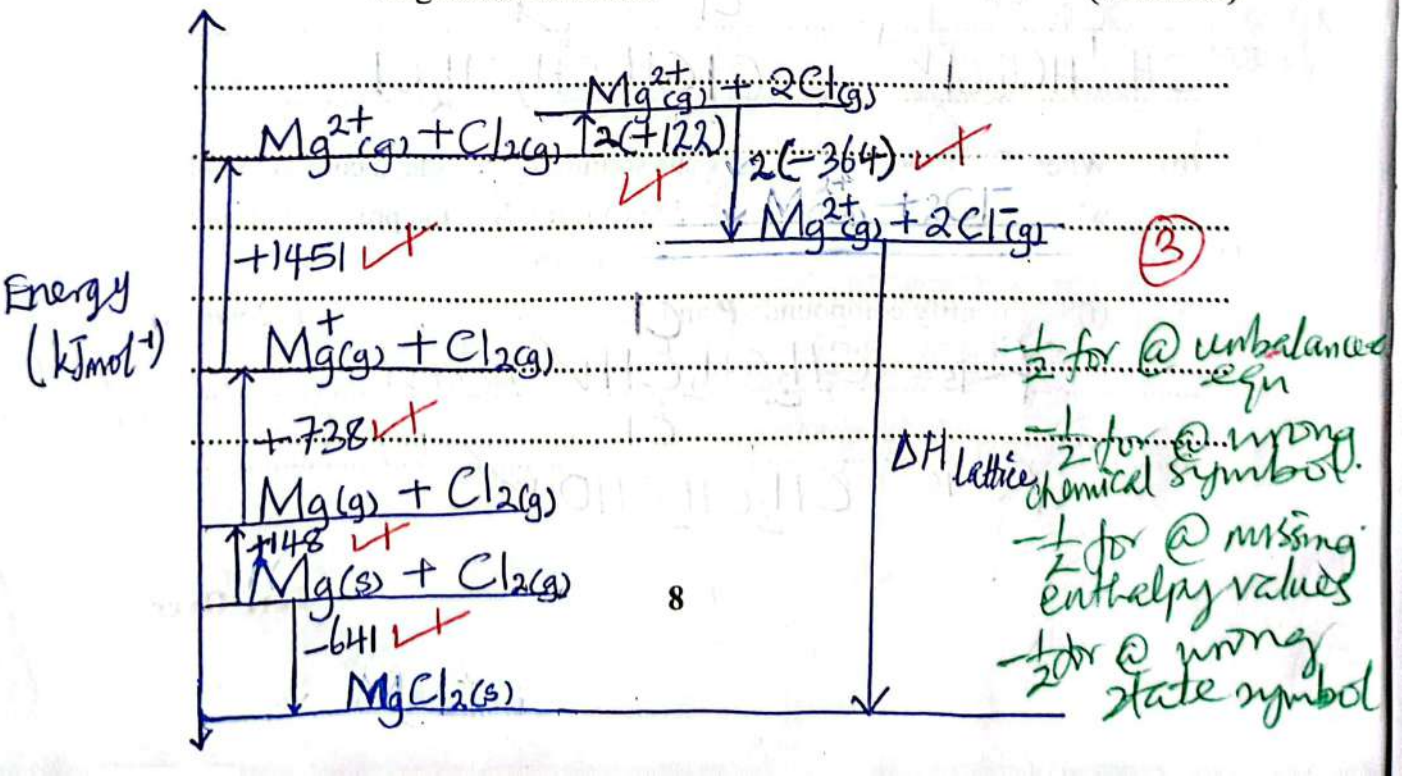

**11.** (a) State **two** factors which affect the magnitude of lattice energy. *(01 mark)*

Ionic charge ✓
Ionic radius ✓

(b) Some thermochemical data are shown below:

Enthalpy of atomisation of chlorine = +122 kJ mol$^{-1}$.
Enthalpy of atomisation of magnesium = +148 kJ mol$^{-1}$. ✓
First ionisation energy of magnesium = +738 kJ mol$^{-1}$ ✓
Second ionisation energy of magnesium = +1451 kJ mol$^{-1}$. ✓
Enthalpy of formation of magnesium chloride = −641 kJ mol$^{-1}$ ✓
First electron affinity of chlorine = −364 kJ mol$^{-1}$.

(i) Construct an energy level diagram for the formation of magnesium chloride. *(03 marks)*



(ii) Determine the lattice energy of magnesium chloride. (02 marks)

$+148+738+145(+2(+122)+2(-364)+\Delta H_{lattice} = -641$

$\Delta H_{lattice} = -641 - 1853$

$= -2,494\ kJmol^{-1}$ ✓ (2) reject KJmol (-½)

Apply consequential error marking if (b) is faulted

(iii) Calculate the enthalpy of solution of magnesium chloride. (03 marks)

(*The hydration energies of magnesium ions and chloride ions are −1891 and −381 kJ mol$^{-1}$ respectively.*)

$\Delta H_{hydration\ of\ MgCl_2} = \Delta H_{hydration\ of\ Mg^{2+}} + 2(\Delta H_{hydration\ of\ Cl^-})$

$= -1891 + 2(-381) = -2653\ kJmol^{-1}$

$\Delta H_{solution} = \Delta H_{hydration\ of\ MgCl_2} + \Delta H_{lattice}$

$= -2,653 + 2494$

$= -159\ kJmol^{-1}$ (3)

**12.** (a) One of the characteristics of transition elements, is formation of complexes. Explain how transition metal ions form complexes. (1½ marks)

The ions have high charge densities hence attracting very many ligands. The ions also have vacant or partly filled d-orbitals in which ligands donate electrons to form coordinate bonds. (1½)

(b) The formulae of some complex ions are shown in Table 3. Write the name of the complex ion, its oxidation state and the co-ordination number of the central metal ion. (03 marks)

**Table 3** (3)

| Complex ion | Name of ion | Oxidation state | Co-ordination number |
|---|---|---|---|
| $[(Co(SCN)_4]^{2-}$ | Tetrathiocyanatocobaltate(II) | +2 | 4 |
| $[Cr(NH_3)_4Cl_2]^{+}$ | Tetraamminedichlorochromium(III) | +3 | 6 |

Accept four, reject +4

reject (II), (ii) — emphasize spellings — no space — reject 2, two

(c) The molecular mass of a salt, $Cu(NH_3)_xCl_y \cdot ZH_2O$ is 276.

When a solution containing 1.38 g of salt was reacted with excess silver nitrate solution, 2.87 g of silver chloride was formed.

Calculate the number of moles of chloride ions in 1 mole of the salt. (02 marks)

reject: Dichlorotetraammine (alphabetical order)



$12 = +15$

$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

Molar mass of $AgCl = 108 + 35.5 = 143.5$ g. Acc: RFM but ✗ no unit

Moles of AgCl precipitated $= \frac{2.87}{143.5} = 0.02$

Mole ratio of $AgCl : Cl = 1:1$

Moles of $Cl^-$ that reacted $= 0.02$

1.38g of salt contain 0.02 moles of $Cl^-$

276g of salt contain $\frac{276 \times 0.02}{1.38}$

$= 4$ moles of $Cl^-$

(2)

Accept other correct logical approach & award accordingly.

(d) When a solution containing 1.38g of the salt was mixed with aqueous sodium hydroxide and heated, the ammonia liberated completely neutralised 10 $cm^3$ of a 1.0 M hydrochloric acid.

Calculate the number of moles of;

(i) ammonia molecules in 1 mole of the salt. *(1½ marks)*

Moles of HCl neutralised $= \frac{10 \times 1.0}{1000} = 0.01$

$NH_{3(aq)} + HCl_{(aq)} \rightarrow NH_4Cl_{(aq)}$

mole ratio of $HCl : NH_3 = 1:1$

moles of $NH_3$ that reacted $= 0.01$

1.38g of salt liberate 0.01 mole of $NH_3$

276g of salt liberate $\frac{276 \times 0.01}{1.38}$

$= 2$ moles of $NH_3$ molec

(1½)

(ii) water in 1 mole of the salt. *(01 mark)*

$Cu(NH_3)_2Cl_4 \cdot zH_2O = 276$

$63.5 + 28 + 6 + (4 \times 35.5) + 18z = 276$

$18z = 36.5$

$z = 2$

number of moles of water = 2

(1)

**13.** Write the equations to show how the following compounds can be synthesised and in each case, indicate the conditions for the reaction.

(a) $CH_3CH_2CH_2Br$ from propanone. *(04 marks)*

$CH_3COCH_3 \xrightarrow[\text{dry ether}]{LiAlH_4} CH_3CHCH_3$ (OH)

or $H_2/Ni$ 150°C or Na/Ethanol or $NaBH_4/CH_3OH$

$CH_3CHCH_3$ (OH) $\xrightarrow[180^\circ C \text{ or heat}]{\text{Conc. } H_2SO_4} CH_2CH=CH_2$

or Conc $H_2PO_4$ heat

$CH_3COCH_3 \xrightarrow{PCl_5} CH_3CCH_3$ (Cl, Cl)

$CH_3CCH_3$ (Cl, Cl) $\xrightarrow[\text{heat}]{\text{Alcoholic KOH}} CH_3C \equiv CH$

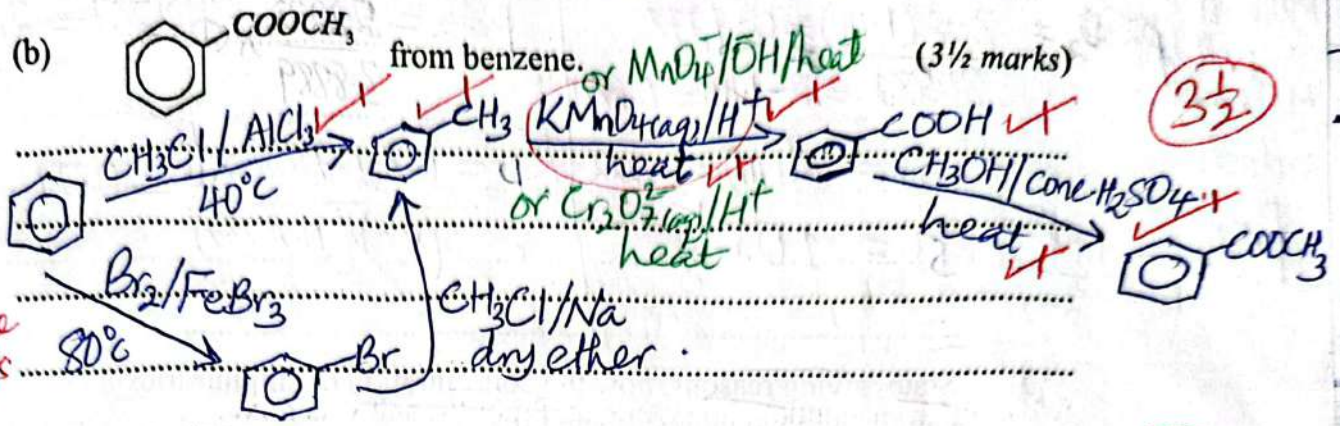
$CH_3C \equiv CH \xrightarrow[\text{Lindlar's catalyst}]{H_2} CH_2CH=CH_2$

$CH_2CH=CH_2 \xrightarrow[\text{organic peroxide}]{HBr} CH_3CH_2CH_2Br$

reject $H_2O_2$

Deny if more

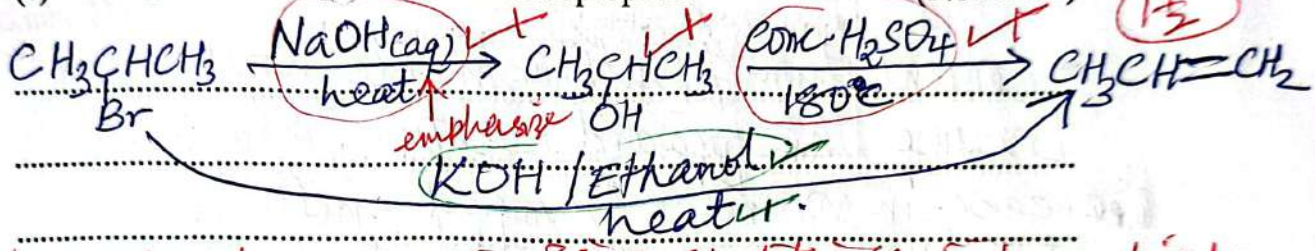
(4)

(b) 

(3½ marks)

reject wrong benzene rings

(c) $CH_3CH=CH_2$ from 2–bromopropane. (1½ marks)




Marking 2 stops for wrong or missing condition(s), intermediate, reagent

**14.** Sulphur dioxide and oxygen can react to form sulphur trioxide according to the following equation:

$2\,SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2\,SO_{3\,(g)}$; $\Delta H$ is negative.

3 moles of sulphur dioxide and 2 moles of oxygen were heated at 450 °C in a 1 $dm^3$ vessel at 50 atmospheres. At equilibrium the vessel contained 20 % sulphur dioxide.

(a) (i) Write the expression for the equilibrium constant, $K_p$. (½ mark)

reject $k_p=$

$K_p = (P_{SO_3})^2 / (P_{SO_2})^2 (P_{O_2})$ ✓

reject [ ]

(ii) Calculate the value of the equilibrium constant, $K_p$ for the reaction at 450 °C. (04 marks)

Let moles of $O_2$ that reacted be $x$

| | $2SO_{2(g)}$ | + $O_{2(g)}$ | $\rightleftharpoons$ | $2SO_{3(g)}$ |
|---|---|---|---|---|
| Initial moles | 3 | 2 | | 0 |
| moles reacted/formed | $2x$ | $x$ | | $2x$ |
| Equilibrium moles | $(3-2x)$ | $(2-x)$ | | $2x$ ✓ |



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But $3-2x+2x+2-x = 5-x$

Also $\frac{3-2x}{5-x} = \frac{20}{100} \Rightarrow x = 1.1111$ at equilibrium

Total moles $= 5 - 1.1111 = 3.8889$

Moles of $SO_2$ at equilibrium $= 3-2(1.1111) = 0.7778$

Moles of $O_2$ at equilibrium $= 2-1.1111 = 0.8889$

Moles of $SO_3$ at equilibrium $= 2(1.1111) = 2.2222$

$P_{SO_2} = \frac{0.7778}{3.8889} \times 50 = 10$ atm

$P_{O_2} = \frac{0.8889}{3.8889} \times 50 = 11.4287$ atm

$P_{SO_3} = 50 - 10 - 11.4287 = 28.5713$ atm

$K_p = \frac{(28.5713)^2}{(10^2)(11.4287)} = 0.7143$ atm$^{-1}$ (4)

(b) State, giving reasons, how the concentration of sulphur trioxide at equilibrium would be affected if;

(i) pressure is increased. (1½ marks)

Concentration of sulphur trioxide would increase, because the forward reaction which occurs by a decrease in volume is favoured shifting equilibrium position to the right. (1½)

(ii) temperature is increased. (1½ marks)

Concentration of sulphur trioxide would decrease because the backward reaction which is endothermic is favoured shifting equilibrium position to the left. (1½)

(iii) an inert gas is added at constant pressure. (1½ marks)

Concentration of sulphur trioxide would decrease because the total volume of the system increased shifting equilibrium to the right so as to increase the number of moles. (1½)

15. (a) State the meaning of the term **bond energy**. reject covalent bond. (01 mark)

The energy given out when one mole of covalent bonds is formed from free gaseous atoms. ✓

or Energy required to break one mole of covalent bonds to form free gaseous atoms

(b) The bond dissociation energies of fluorine, chlorine, bromine and iodine are 158, 242, 193 and 151 kJ mol$^{-1}$ respectively.

(i) State the trend in the bond dissociation energies of the elements. (1½ marks)

reject fluorine has weakest BDE

Bond dissociation energy increases from fluorine molecule to chlorine molecule and then decreases to iodine molecule. ✓ ½

Accept Bond dissociation energy generally decreases from fluorine molecule to iodine molecule with that of fluorine being abnormally lower than chlorine

(ii) Explain your answer in (b)(i). (3½ marks)

Fluorine has the smallest atomic radius hence the fluorine atoms in the molecule are closest resulting into repulsion between non-bonding electrons hence weakening the fluorine–fluorine bond. From chlorine to iodine, atomic radius increases, bond length increases and bond strength decreases. 3½

(c) Write an equation to show how cold dilute sodium hydroxide solution reacts with;

(i) fluorine. (1½ marks)

$2F_{2(g)} + 2OH^-_{(aq)} \rightarrow OF_{2(g)} + 2F^-_{(aq)} + H_2O_{(l)}$ ✓✓

or $2F_{2(g)} + 2NaOH_{(aq)} \rightarrow OF_{2(g)} + 2NaF_{(aq)} + H_2O_{(l)}$ 1½

(ii) chlorine. (1½ marks)

$Cl_{2(g)} + 2OH^-_{(aq)} \rightarrow Cl^-_{(aq)} + ClO^-_{(aq)} + H_2O_{(l)}$ ✓✓ 1½

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



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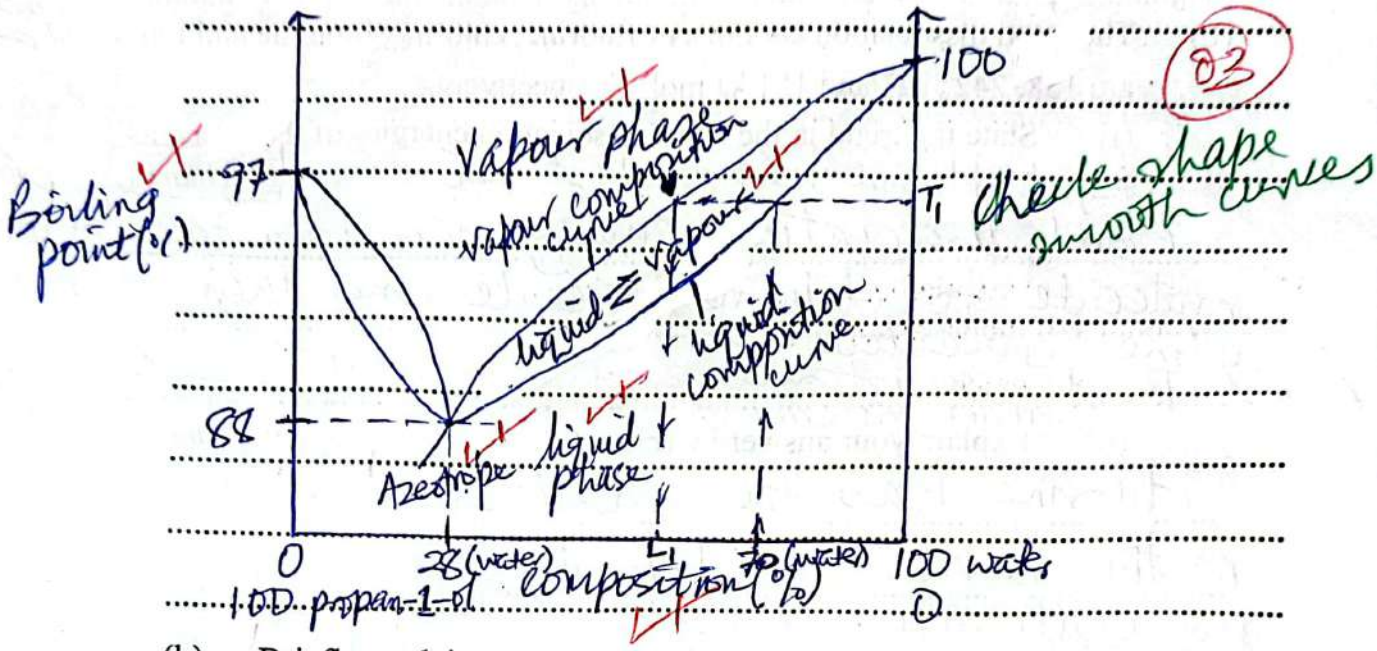
16. Propan-1-ol (boiling point 97 °C) and water (boiling point 100 °C) are miscible in all proportions. A mixture of the two liquids containing 72 % propan-1-ol boils at 88 °C.

(a) Sketch a labelled boiling point–composition diagram for the mixture of propan-1-ol and water. *(03 marks)*




(b) Briefly explain;

(i) why propan-1-ol and water form a minimum boiling point mixture. *(04 marks)*

The mixture deviates positively from Raoults law because the forces of attraction (hydrogen bonds) between propan-1-ol molecules and water molecules are on average weaker than forces of attraction (hydrogen bonds) between individual water molecules and forces between individual propan-1-ol (hydrogen bonds) molecules. This increases the tendency for molecules to vapourise from the mixture resulting in a maximum vapour pressure than would be predicted by Raoults law. 4

(ii) what would happen when a mixture containing 30 % propan–1–ol is fractionally distilled. (02 marks)

The mixture boils when heated, at a constant temperature, T, greater than 88°C, to yield a vapour V, that contains a lower amount of water than the original solution. When the vapour is condensed, it forms a liquid L, of the same composition as the vapour. Successive evaporation and condensation yields the azeotrope as distillate and pure water as residue.

reject filtrate for distillate

2

**17.** Tin and lead are elements in group(IV) of the Periodic Table. Describe the reactions of the elements with;

(a) cold water. (03 marks)

Tin does not react with cold water

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

$2Pb(s) + 2H_2O(l) + O_2(g) \rightarrow 2Pb(OH)_2(s)$

3

(b) sodium hydroxide solution. (3½ marks)

Accept alternative correct eqns.

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

$Sn(s) + 2OH^-(aq) + H_2O(l) \rightarrow SnO_3^{2-}(aq) + 2H_2(g)$

3½

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

$Pb(s) + 2OH^-(aq) \rightarrow PbO_2^{2-}(aq) + H_2(g)$

(c) hot concentrated sulphuric acid. (2½ marks)

Tin reacts with hot concentrated sulphuric acid to form tin(IV) sulphate, sulphur dioxide and water.

$Sn(s) + 4H_2SO_4(aq) \rightarrow Sn(SO_4)_2(aq) + 2SO_2(g) + 4H_2O(l)$

Lead reacts with hot concentrated sulphuric acid to form Lead(II) sulphate, sulphur dioxide and water.

$Pb(s) + 2H_2SO_4(aq) \rightarrow PbSO_4(aq) + SO_2(g) + 2H_2O(l)$

Accept ionic eqns

2½



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# 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 | 35.5 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 Bl 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

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