Candidate's Name: MUNICEL 0782/0752 792750

Signature: .....

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P525/1
CHEMISTRY
(Theory)
Paper 1
Nov./Dec. 2020
2¾ hours

UGANDA NATIONAL EXAMINATIONS BOARD

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 from section* **B**.

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

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

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

Illustrate your answers with equation(s) 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 l.
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
4	6	4	6	4½	3½	8	5	5	9	9	9	9	9	9	9	9	100%

SECTION A (46 MARKS)

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

1. The standard reduction potentials for some half cell reactions are shown below.

$Sn^{4+}_{(aq)} + 2e^- \longrightarrow Sn^{2+}_{(aq)}$ +0.15V.

$PbO_{2(s)} + 4H^+_{(aq)} + 2e^- \longrightarrow Pb^{2+}_{(aq)} + 2H_2O_{(l)}$ +1.46V.

(a) Write the overall equation for the cell reaction that would occur when the half cells are combined. *(1½ marks)*

$Sn^{2+}_{(aq)} + PbO_{2(s)} + 4H^+_{(aq)} \longrightarrow Pb^{2+}_{(aq)} + 2H_2O_{(l)} + Sn^{4+}_{(aq)}$ ✓✓

- symbols - state symbols.
- Balancing

(b) (i) Calculate the e.m.f of the cell. *(1½ marks)*

$E_{mf} = E_{right} - E_{left}$ ✓ (1½)

$= +1.46 - 0.15$ ✓ $= +1.31V$ ✓ deny mark if +ve is missing.

(ii) State whether the reaction is feasible or not and give a reason for your answer. *(01 mark)*

Reaction is feasible ✓ because emf is positive ✓

* Allow Gibbs free energy is negative if it has been calculated and worked out correctly.

2. Figure 1 shows the structure of compound G. [04]

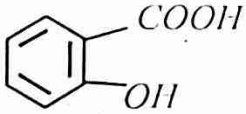


Fig.1

(a) Identify the functional groups in G. *(02 marks)*

Hydroxyl group ✓(1) Accept —OH eg: hydroxy, hydroxo, OH

Carboxyl group ✓(1) —COOH eg: carboxylic group, COOH

accept enol-group $-\overset{|}{C}=C-$

(b) Name the reagent(s) that can be used to identify each of the functional groups you have identified in (a). *(02 marks)*

Hydroxyl group - Neutral Iron(III) chloride solution ✓(1)

Carboxyl group - Sodium carbonate solution ✓(1)

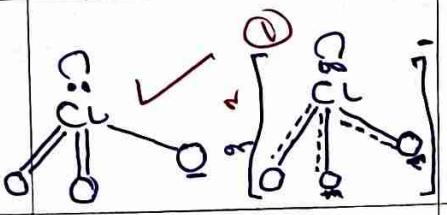
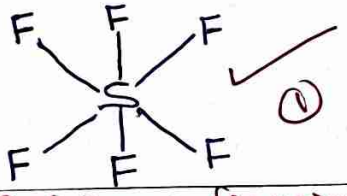
reject without solution, eg: solid sodium hydroxide, carbonate

(c) State what would be observed when **C** is treated separately with the reagent(s) you have named in (b). *(02 marks)*

Neutral iron (III) chloride - Violet/purple coloration (1)
Sodium carbonate solution - Bubbles of a colorless gas (1)
- Award if reagent in (b) are correct.
[06]

3. Draw the structure and name the shape of each of the following species: *(4½ marks)*

- Bond angle, Hybrid bond.

Species	Structure	Shape
CrO_4^-	Ignore due to error; mark transferred	
ClO_3^-	 (1)	Trigonal pyramidal (1)
SF_6	 (1)	Octahedral or square bipyramidal (1)

[04]

Deny marks for wrong shape & structure.

4. (a) Define the term **standard enthalpy of formation.** *(01 mark)*

This is the enthalpy change that occurs when one mole of a compound is formed from its constituent elements in their standard states under standard conditions. (1)

emphasize element not component.
Accept. Normal physical states
- 25°C, 1 Atm as stated conditions.

(i) $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$ $\Delta H = -393$

(ii) $H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)}$ $\Delta H = -286$

(iii) $3C_{(s)} + 4H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow C_3H_8O$ $\Delta H = -2010$

$\Delta H_f = 3x_{eqn(i)} + 4x_{eqn(ii)} - eqn(iii)$

$\Delta H_f = (3x-393) + (4x-286) - (-2010)$

$= -313\ kJmol^{-1}$ (03½)

(b) The standard enthalpies of combustion of *propan–1–ol, carbon* and *hydrogen* are: –2010, –393 and –286 kJ mol^{-1} respectively.

Calculate the standard enthalpy of formation of *propan–1–ol.*

(03 marks)

$3C_{(s)} + \frac{1}{2}O_{2(g)} + 4H_{2(g)} \xrightarrow{\Delta H_f} CH_3CH_2CH_2OH$

$3O_{2(g)}$ $(3x-393)$ $2O_{2(g)}$ $(4x-286)$ $\frac{9}{2}O_{2(g)}$ -2010

$3CO_{2(g)} + 4H_2O_{(l)}$

$\Delta H_f = (-393 \times 3) + (-286 \times 4) + 2010$

$= -313\ kJmol^{-1}$

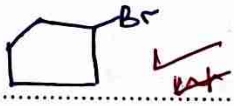
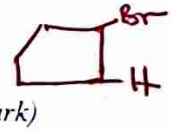
- equations must be balanced (03½)

- ignore units - deny when –ve

(c) Comment on the stability of *propan–1–ol.* *(1½ marks)*

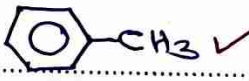
Propan-1-ol is stable because the enthalpy of formation is negative or reaction is exothermic (1½) [06

5. Complete the following equations and in each case name the main organic product.

(a)  + HBr ⟶  accept  *(1½ mark)*

- ignore Completion deny name

Name of the product Bromocyclopentane

(b)  $CH_3I/AlCl_3$ ⟶  *(1½ marks)*

Name of the product Methylbenzene reject: Toluene. methy benzene.

(c) $CH_3CH = CH_2$ 1. H_2SO_4 2. $H_2O/warm$ ⟶ CH_3CHCH_3 (OH) *(1½ marks)*

Name of the product Propan-2-ol [04½

or

$CH_3CH_2CH_2OH_{(l)} + \frac{9}{2}O_{2(g)} \longrightarrow 3CO_{2(g)} + 4H_2O_{(l)}$

$\Delta H_{Rxn} = \sum \Delta H_f^{\ominus}{}_{products} - \sum \Delta H_f{}_{reactants}$

$-2010 = [(3x-393) + (4x-286)] - \Delta H_f^{\ominus}{}_{C_3H_8O} + 0$ (03½)

$\Delta H_f^{\ominus} = (3x-393) + (4x-286) + 2010$

$= -313\ kJmol^{-1}$

6. (a) Determine the oxidation state of chromium in each of the following species: – show the computation.

(i) Cr_2O_3 *(01 mark)*

$2x + -6 = 0$ ✓ (01)

$x = +3$ ✓

(ii) CrO_4^{2-} *(01 mark)*

$y + (4x-2) = -2$ ✓ (01)

$y = +6$ ✓

(b) Write an equation to show the reaction between;

(i) Cr_2O_3 and excess sodium hydroxide solution. *(1½ marks)*

$Cr_2O_{3(s)} + 6\bar{O}H_{(aq)} + 3H_2O_{(l)} \longrightarrow 2Cr(OH)_6^{3-}{}_{(aq)}$ ✓✓

$Cr_2O_{3(s)} + 2\bar{O}H_{(aq)} + 3H_2O_{(l)} \longrightarrow 2Cr(OH)_4^{-}{}_{(aq)}$

(ii) ~~$Cr_2O_4^{2-}$ and hydrogen peroxide solution.~~ (Ignored) *(1½ marks)*

$Cr_2O_{3(s)} + 2\bar{O}H_{(aq)} \longrightarrow 2CrO_2^{-}{}_{(aq)} + H_2O_{(l)}$

$Cr_2O_{3(s)} + 6\bar{O}H_{(aq)} \longrightarrow 2CrO_3^{3-}{}_{(aq)} + 3H_2O_{(l)}$ [03½]

7. Ammonium chloride was added to 1.0 dm^3 of a 0.1 M aqueous ammonia to make a solution of pH 8.7. Calculate the;

(a) (i) concentration of hydroxide ions in the solution. *(02 marks)*

($K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6})

$pH = -\log[H^+]$ ✓

$8.7 = -\log[H^+]$ ✓

$[H^+] = 1.99 \times 10^{-9}$ M ✓

$K_w = [H^+][\bar{O}H]$ ✓

$[\bar{O}H] = \left(\frac{1.0 \times 10^{-14}}{1.99 \times 10^{-9}}\right)$ ✓

$= 5.0 \times 10^{-6}$ mol dm^{-3}

OR

$pOH = pK_w - pH$ ✓

$= (14 - 8.7) = 5.3$ ✓

$pOH = -\log[\bar{O}H]$

$[\bar{O}H] = 10^{-5.3}$ ✓

$= 5.0 \times 10^{-6}$ mol dm^{-3} ✓

– Allow alternative correct computations

(ii) mass of ammonium chloride used. *(03 marks)*

(K_b for aqueous ammonia = 1.8×10^{-5} mol dm^{-3})

$K_b = \frac{[NH_4^+][\bar{O}H]}{[NH_3]}$ ✓

Assumption: $[NH_4^+] = [NH_4Cl] = [salt]$ ✓

$[salt] = \frac{K_b[NH_3]}{[\bar{O}H]}$

rej: $K_b = \frac{[NH_4^+][\bar{O}H]}{[NH_4OH]}$

$= \left(\frac{1.8 \times 10^{-5} \times 0.1}{5.0 \times 10^{-6}}\right)$ ✓

$= 0.36$ mol dm^{-3} ✓

Molar mass $NH_4Cl = 14 + 4 + 35.5 = 53.5$ g

Mass NH_4Cl added $= (53.5 \times 0.36)$ ✓

$= 19.26$ g ✓

(03)

or

$pOH = -pK_b + \log \frac{[salt]}{[base]}$ ✓+

$-\log(5.0\times10^{-6}) = -\log(1.8\times10^{-5}) + \log \frac{[salt]}{0.1}$ ✓+

Assuming $[NH_4^+] = [salt]$ ✓+

$[NH_4Cl] = 0.36M$ ✓+ (02)

Pfm $NH_4Cl = 14+4+35.5 = 53.5$ ✓+

Mass $NH_4Cl = (53.5 \times 0.36) = 19.26g$. ✓+ ✓+ Allow alternative correct computations

(b) (i) State what would happen to the pH of the solution in (a) if a small amount of dilute sodium hydroxide solution is added to it.

(½ mark)

pH remains constant ✓+

(ii) Give a reason for your answer in (b),(i). ✓+ *(01 mark)*

- emphasize the source of the ions

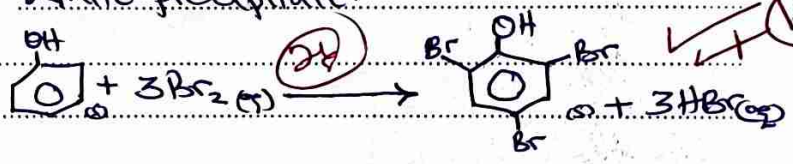
The hydroxide ions added from sodium hydroxide reacts with ammonium ions from ammonium chloride to form water and ammonia (aqueous ammonia) that pH remains constant. (1+) [08]

reg: ammonium hydroxide

8. State what would be observed and write an equation for the reaction that would take place when each of the following compounds is mixed with bromine water.

(a) C_6H_5OH *(2½ marks)*

Observation: White precipitate ✓ (1) allow solid

Equation:  (2+) (1+) (½)

$C_6H_5OH_{(aq)} + 3Br_{2(aq)} \longrightarrow C_6H_2Br_3OH_{(s)} + 3HBr_{(aq)}$.

(b) $CH_3CH = CH_2$ *(2½ marks)*

Observation: Reddish brown solution turns colourless ✓+ ✓+.

Accept brown solution

(2+)

Equation:

$CH_3CH=CH_{2(g)} + Br_{2(aq)} + H_2O_{(l)} \longrightarrow CH_3\overset{OH}{C}HCH_2Br_{(aq)} + HBr_{(aq)}$ ✓+

CXBZH-

- Balanced
- correct state
- deduct ½ mark for wrong state

[05]

9. (a) State the trend in the acidity of the hydrides of elements in group VII of the Periodic Table. *(01 mark)*

The acidity of the hydrides of elements of group VII increases from hydrogen fluoride to hydrogen iodide. ✓ (1)

(b) Explain your answer in (a). accept HF < HCl < HBr < HI. *(04 marks)*

Down the group atomic radius of halogens increases; as a results bond length of hydrogen - halogen bond increases and thus bond strength decreases. ✓ Therefore the ease of release of a proton increases ✓ leading to the increase in acid strength. ✓

* specific statement
* emphasize halogens; deny elements.
* Bond length hydrogen - halogen.
reg. - hydrogen - halide
- bonic or anionic radius.
- deny symbols and formulae in explanation

[05

SECTION B (54 MARKS)

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

10. Compound *A* consists of carbon, 62.1% hydrogen 10.3%, the rest being oxygen. The vapour density of the compound is 29.

(a) Determine the:

percentage of oxygen = (100 − 72.4) = 27.6% ✓

(i) empirical formula of *A*. *(02 marks)*

C	H	O	
$\frac{62.1}{12}$	$\frac{10.3}{1}$	$\frac{27.6}{16}$	Empercal formular
5.175	10.3	1.725 ✓	C_3H_6O ✓
$\frac{5.175}{1.725}$	$\frac{10.3}{1.725}$	$\frac{1.725}{1.725}$	(02)
3	6	1 ✓	reg: 3 : 5.971 : 1

(ii) molecular formula of *A*. but continue awarding *(01 mark)*

Molecular mass = (2 × V.D) = (2 × 29) = 58 ✓

$(C_3H_6O)_n = 58$

$n = 1$ ✓ (1½)

Molecular formular is C_3H_6O ✓

(b) Write the structural formula of all the possible isomers of *A*. *(01 mark)*

CH_3CH_2CHO ✓ (01)

CH_3COCH_3 ✓

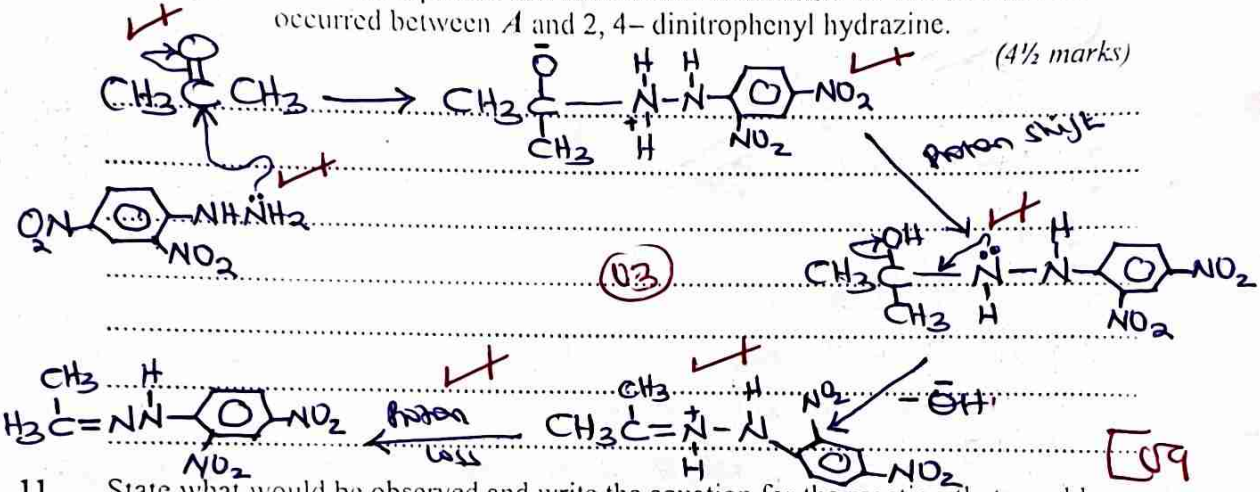
$H_2C=CHCH_2OH$ award any two.

(c) Compound *A* reacted with 2, 4– dinitrophenyl hydrazine to give an orange solid but did not react with ammoniacal silver nitrate solution.

(i) Identify *A*. *(½ mark)*

CH_3COCH_3 ✓ ½ reject propanone unless when indicated above in brackets.

(ii) Write the equation and indicate the mechanism for the reaction that occurred between *A* and 2, 4– dinitrophenyl hydrazine. *(4½ marks)*



11. State what would be observed and write the equation for the reaction that would take place if;

(a) propyne is bubbled through ammoniacal copper(I) chloride solution. *(02 marks)*

Observation: Red precipitate ✓ ✓ (02)

$CH_3C\equiv CH_{(g)} + CuCl_{(aq)} + NH_{3(aq)} \longrightarrow CH_3C\equiv CCu_{(s)} + NH_4Cl_{(aq)}$

Equation: $CH_3C\equiv CH_{(g)} + Cu^+_{(aq)} + NH_{3(aq)} \longrightarrow CH_3C\equiv CCu_{(s)} + NH_4^+{}_{(aq)}$

$CH_3C\equiv CH_{(g)} + Cu(NH_3)_2Cl_{(aq)} \longrightarrow CH_3C\equiv CCu_{(s)} + NH_4Cl_{(aq)} + NH_{3(g)}$

eg: $CH_3C\equiv C-Cu$.
physical states (½ mark)
ignore balancing
* Cu^+ } must be present as reactants.
* NH_3 }

(b) Fehling's solution is added to methanoic acid. *(02 marks)*

Observation: Reddish brown precipitate ✓ ✓ (02)

$2Cu^{2+}_{(aq)} + 4\bar{O}H_{(aq)} + HCOOH_{(aq)} \longrightarrow Cu_2O_{(s)} + CO_{2(g)} + 3H_2O_{(l)}$

Equation: ignore balancing ; deduct ½ for physical state

* Cu^{2+} } both
* $\bar{O}H$ } present in equation as reactants.

Cu_2O } present as product in eqn
CO_2 }

Accept:

$HCOOH_{(l) \text{ or } (aq)} \xrightarrow{Cu^{2+}_{(aq)};\ \bar{O}H_{(aq)}} Cu_2O_{(s)} + CO_{2(g)}$

(c) dilute sodium hydroxide solution is added drop-wise until in excess to aqueous nickel(II) ions. *(02 marks)*

Observation: Green precipitate insoluble in excess

Equation $Ni^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Ni(OH)_{2(s)}$ (1)

equation relates to the observation.

(d) silver nitrate solution is added to aqueous iron(II) sulphate. *(03 marks)*

Observation: Green solution turns to brown / yellow and a grey precipitate formed. (02)

Equation $Fe^{2+}_{(aq)} + Ag^+_{(aq)} \longrightarrow Fe^{3+}_{(aq)} + Ag_{(s)}$

or White precipitate formed: award corresponding to the observation.

$2Ag^+_{(aq)} + SO_4^{2-}_{(aq)} \longrightarrow Ag_2SO_{4(s)}$ [04]

12. (a) Define the term **distribution coefficient**. *(01 mark)*

Ratio of concentration of a solute in a solvent to the concentration of the same solute in another solvent when the two solvents are immiscible and in contact at a given temperature at equilibrium. (1)

– Allow alternative Correct Statement { – immiscible solvent, – contact, – temperature, – equilibrium.

(b) 1.5 g of an impure ore of zinc was dissolved in a 0.02 M ammonia and the resulting solution shaken with trichloromethane. After the layers had settled, 50 cm^3 of the trichloromethane layer needed 30 cm^3 of a 0.062 M hydrochloric acid for neutralisation. 20 cm^3 of the aqueous solution were neutralized by 40 cm^3 of a 0.5 M hydrochloric acid. If the partition coefficient of ammonia between water and trichloromethane at 25 °C is 25.0 and the reaction ratio between zinc(II) ions and ammonia is 1:4. Calculate the molar concentration of;

(i) ammonia in the trichloromethane layer. *(02 marks)*

$30cm^3$ of hydrochloric acid contains $\left(\frac{0.062 \times 30}{1000}\right) = 1.86 \times 10^{-3}$ moles

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

$50cm^3$ of trichloromethane contains 1.86×10^{-3} moles

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

eg: $NH_4OH_{(aq)} + HCl \longrightarrow NH_4Cl_{(aq)} + H_2O$ $= 0.0372M$ Turn Over

(1½ mark

(ii) free ammonia in the aqueous layer.

$K_D = \frac{[NH_3]_{free}}{[NH_3]_{complex}}$ ✓

$[NH_3]_{free} = (25 \times 0.0372)$ ✓ ✓ (1½)

$= 0.93M$.

(iii) complexed ammonia in the aqueous layer. (02 marks)

$40cm^3$ of solution of HCl contains $\left(\frac{0.5 \times 40}{1000}\right) = 2 \times 10^{-2}$ mole HCl ✓

$20cm^3$ of aqueous layer contains 2×10^{-2} mole NH_3 ✓

$1000cm^3$ of aqueous layer contains $\left(\frac{2 \times 10^{-2} \times 1000}{20}\right) = 1M$ ✓ (02)

$[NH_3]_{complexed} = (1 - 0.93) = 0.07M$ ✓

(c) Determine the percentage of zinc in the ore. (2½ marks

$\frac{[NH_3]_{complexed}}{[NH_3Zn^{2+}]} = 4$ ✓ $\therefore [Zn^{2+}] = \left(\frac{0.07}{4}\right) = 0.0175M$ ✓

Mass of $Zn^{2+} = (0.0175 \times 65.7) = 1.1498_5$ ✓

% $Zn = \left(\frac{1.1498}{1.5} \times 100\right)$ ✓ (02½)

$= 76.65\%$ ✓

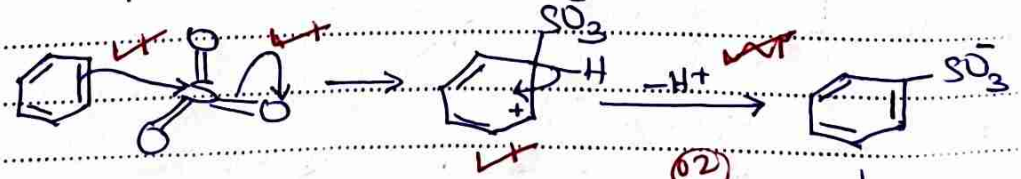
- Allow first mark for calculation.

UG

13. Write a mechanism to show how each of the following conversions can be effected:

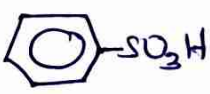
(a)  to  SO_3H (03 marks

$2H_2SO_4 \rightleftharpoons SO_3 + HSO_4^- + H_3O^+$ ✓ (1) - must be balanced.

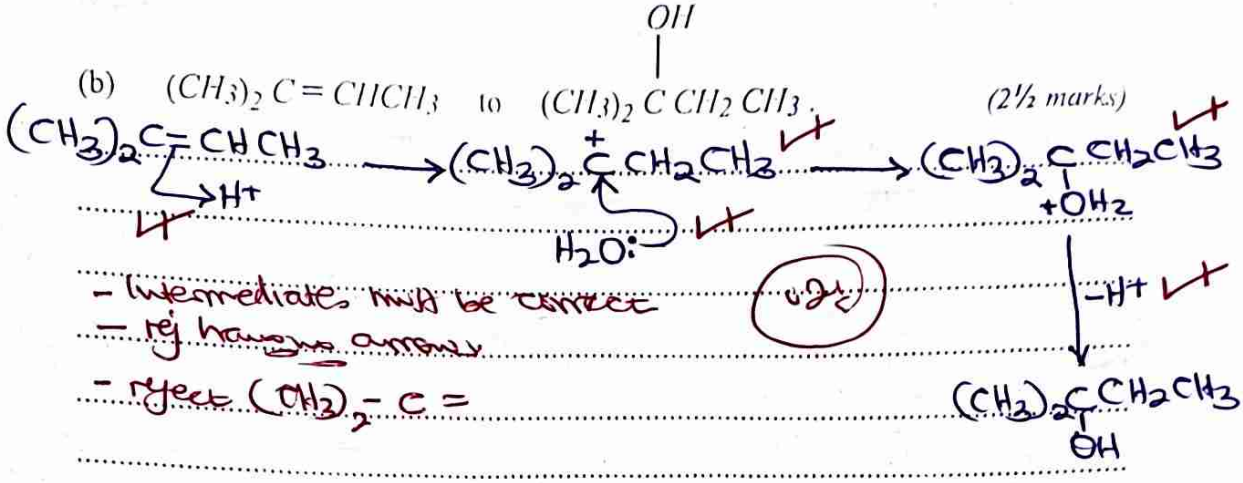


(02)

$+H^+$ ✓



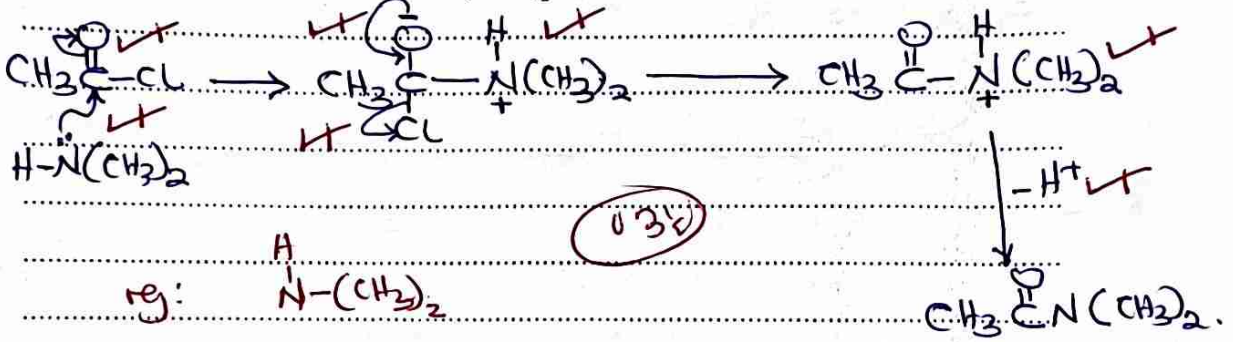
(b) $(CH_3)_2C=CHCH_3$ to $(CH_3)_2C(OH)CH_2CH_3$. *(2½ marks)*



- Intermediate must be correct
- reg hanging arrows
- reject $(CH_3)_2-C=$

(02)

(c) CH_3COCl to $CH_3CON(CH_3)_2$. *(3½ marks)*



reg: $CH_3CO\overset{H}{N}(CH_3)_2$

(03)

14. Compound *Z* contains 25.6% copper, 12.8% sulphur, 25.6% oxygen and the rest being water. [05]

$\%H_2O = (100-64) = 36\%$

(a) (i) Calculate the empirical formula of *Z*. *(02 marks)*

Cu	S	O	H_2O	Empirical formular
$\frac{25.6}{63.5}$	$\left(\frac{12.8}{32}\right)$	$\left(\frac{25.6}{16}\right)$	$\frac{36}{18}$	$CuSO_4 \cdot 5H_2O$
0.403	0.4	1.6	2	
$\frac{0.403}{0.4}$	$\frac{0.4}{0.4}$	$\frac{1.6}{0.4}$	$\frac{2}{0.4}$	
1	1	4	5	

(02)

(deny if decimals given)

(ii) Determine the molecular formula of *Z*. (*The formula mass of Z =250*). *(1½ marks)*

$(CuSO_4 \cdot 5H_2O)_n = 250$

$n(63.5 + 32 + 64 + 90) = 250$

$n = 1$

Molecular formular

$CuSO_4 \cdot 5H_2O$ (1½)

(b) Concentrated hydrochloric acid was added drop-wise to aqueous Z until in excess.

(i) State what was observed. *(1½ marks)*

Blue solution turned green then yellow (1½)

(ii) Write the equation for the reaction that took place. *(1½ marks)*

$Cu(H_2O)_6^{2+}_{(aq)} + 4Cl^-_{(aq)} \longrightarrow CuCl_4^{2-}_{(aq)} + 6H_2O_{(l)}$ ✓✓

$Cu(H_2O)_4^{2+}_{(aq)} + 4Cl^-_{(aq)} \longrightarrow CuCl_4^{2-}_{(aq)} + 4H_2O_{(l)}$

accept ⇌; reject Cu^{2+}, award ½ and exchange concept only.

(c) To an aqueous solution of Z was added dilute nitric acid followed by barium nitrate solution.

(i) State what was observed. *(01 mark)*

White precipitate. ✓(1) accept solid or ppt

(ii) Write the equation for the reaction that took place. *(1½ marks)*

$Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \longrightarrow BaSO_{4(s)}$ ✓✓ (1½)

[09

15. (a) Carbon and lead are elements in group IV of the Periodic Table.

Write the equations to show how carbon dioxide and lead(IV) oxide can react with sodium hydroxide. *(03 marks)*

$CO_{2(g)} + 2\bar{O}H_{(aq)} \longrightarrow CO_3^{2-}{}_{(aq)} + H_2O_{(l)}$ ✓✓

or $CO_{2(g)} + \bar{O}H_{(aq)} \longrightarrow HCO_3^-{}_{(aq)}$

$PbO_{2(s)} + 2\bar{O}H_{(aq)} + 2H_2O_{(l)} \longrightarrow Pb(OH)_6^{2-}{}_{(aq)}$ ✓✓

or $PbO_{2(s)} + 2\bar{O}H_{(aq)} \longrightarrow PbO_3^{2-}{}_{(aq)} + H_2O_{(l)}$

(b) Write an equation for the reaction between lead(IV) oxide with warm concentrated solution of;

(i) hydrochloric acid. dry(1) *(1½ marks)*

$PbO_{2(s)} + 4HCl_{(aq)} \longrightarrow PbCl_{2(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$ ✓✓ (1½)

$PbO_{2(s)} + 4H^+_{(aq)} + 2Cl^-_{(aq)} \longrightarrow Pb^{2+}_{(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$

(ii) sulphuric acid. *(1½ marks)*

$2PbO_{2(s)} + 2H_2SO_{4(l/aq)} \longrightarrow 2PbSO_{4(s)} + O_{2(g)} + 2H_2O_{(l)}$ ✓✓ (1½)

allow

(c) Lead(IV) oxide was strongly heated.

(i) State what was observed. *(1½ marks)*

Dark brown/brown solid turned to reddish brown/orange when hot and then yellow when cold.

– Temperature changes should be emphasised and tied to colours.

(ii) Write the equation for the reaction that took place. *(1½ marks)*

$2PbO_{2(s)} \longrightarrow 2PbO_{(s)} + O_{2(g)}$

[US]

16. The boiling point of pure water is 100 °C at 760 mmHg pressure. At the same pressure, a solution containing 1.576 g of potassium chloride in 100 g of water boils at 100.11 °C.

(a) Calculate the boiling point constant, K_b for water. *(3½ marks)*

Boiling point elevation $\Delta T = (100.11 - 100) = 0.11°C$

1mole of KCl = (39+35.5) = 74.5

1.576g of KCl in 100g water raises bpt by 0.11°C

74.5g KCl in 100g water raises bpt by $\left(\frac{0.11 \times 74.5}{1.576}\right)°C$

74.5g KCl in 1000g water raises bpt by $\left(\frac{0.11 \times 74.5 \times 100}{1.576 \times 1000}\right)$

– allow alternative logical approaches

– If formula is used, award 1mark for final answer if unit included or else award ½ mark.

$= 0.52°C\ mol^{-1}kg^{-1}$.

units

(03½)

(b) Explain why;

(i) the boiling point of potassium chloride solution is higher than that of pure water. *(2½ marks)*

Potassium chloride is a non-volatile solute; it covers part of the water surface, and reduces the escaping tendency of water molecules into vapor phase. The solution therefore exerts a low vapor pressure than pure water and must be heated to a higher temperature to raise the vapor pressure to that of the atmosphere in order to boil.

(2½)

Turn Over

(ii) a 0.1 M potassium chloride solution boils at the same temperature as a 0.2 M glucose solution. *(03 marks)*

Potassium chloride is a strong electrolyte which completely dissociates in solution to give potassium and chloride ions. The resultant solution contains potassium ions and chloride ions each of 0.1M making the total number of moles of particles in solution equal to 0.2M. Glucose is a non electrolyte which doesn't dissociate in solution. Therefore a solution of glucose has exactly 0.2 moles of particle. Thus the two solutions have the same number of particles leading to the same boiling point. [04] (03)

17. Both chlorine and sodium hydroxide are manufactured by electrolysis of concentrated sodium hydroxide (chloride) solution.

(a) Name the substance used as the;

(i) cathode. *(½ mark)*

Mercury or steel or Nickel

(ii) anode. *(½ mark)*

Graphite or Titanium

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

(i) chlorine. *(01 mark)*

$2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$ ✓ (1) – states.

(ii) sodium hydroxide. *(2½ marks)*

Graphite Hg cathode

$Na^+_{(aq)} + e^- \longrightarrow Na_{(s)}$

$Na_{(s)} + Hg_{(l)} \longrightarrow NaHg_{(l)}$

$2NaHg_{(l)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)} + 2Hg_{(l)}$ (02½)

When steel or Nickel is used

Steel or Nickel

$2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$

$Na^+_{(aq)} + OH^-_{(aq)} \longrightarrow NaOH_{(aq)}$

or $H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$

$2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$

$Na^+_{(aq)} + OH^-_{(aq)} \longrightarrow NaOH_{(aq)}$

– award correspondingly to the cathode named.

(c) State what would be observed and write the equation(s) for the reaction(s) that would take place if chlorine is bubbled through;

(i) sodium iodide solution. *(1½ marks)*

Colourless solution turns brown ✓✓

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

(ii) hot concentrated sodium hydroxide solution. *(02 marks)*

Greenish yellow gas dissolves to give a colourless solution. ✓✓

$6OH^-_{(aq)} + 3Cl_{2(g)} \longrightarrow 5Cl^-_{(aq)} + ClO_3^-{}_{(aq)} + 3H_2O_{(l)}$ ✓✓

(d) Give a reason for your answer in (c) (i). *(01 mark)*

✓ ①

Chlorine oxidise iodide ions to iodine which form a brown solution. - award the oxidation concept - reject displacement.

[09

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