

Candidate's Name:

MARKINER ERIC

Signature:

Gerald Peter

Random No.	Personal No.
P 5 2 5 1	0 2 2

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

PS2S/1
CHEMISTRY
Paper 1
Nov./Dec. 2018
2½ hours



UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

CHEMISTRY

Paper 1

2 hours 45 minutes

INSTRUCTIONS TO CANDIDATES:

Answer all questions in Section A and six questions in 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 equations where applicable.

Where necessary, use the following:

Molar gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$.

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

Standard temperature = 273 K.

Standard pressure = 101325 N m^{-2} .

For Examiners' Use Only

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
06½	x	06	06	4½	6	6	6	5	9	9	9	9	9	9	9	9	100

SECTION A: (46 MARKS)
Answer all questions in this section.

1. Various concentrations of X and Y were reacted at a constant temperature. The table below shows the initial concentrations of X and Y and their initial rates for the reaction.

06½

Experiment	[X] (mol dm ⁻³)	[Y] (mol dm ⁻³)	Initial rate (mol s ⁻¹)
1	0.2	0.2	3.5×10^{-4}
2	0.4	0.4	1.4×10^{-3}
3	0.8	0.4	5.6×10^{-3}

- (a) State the order of reaction with respect to X and Y.

- (i) X 2 ✓ (01) (½ mark)
(ii) Y 0 ✓ (01) (½ mark)

- (b) Give reasons for your answers in (a).

Doubling the Conc_n of X while Keeping the [Y] Constant, the rate goes up four times implying order 2 w.r.t X. or; by (02)
Doubling the [Y] and [X], the rate goes up four times implying zero order w.r.t Y. or; by cal_n; $3.5 \times 10^{-4} = K(0.2)^2(0.2)$

- (c) Determine the overall order of the reaction. $1.4 \times 10^{-3} = K(0.4)^x(0.4)^y$

$$2 + 0 = 2 \quad \text{✓} \quad (01) \quad (ii) \div (i); \quad 4 = 4 \times 2^y \quad \text{✓}$$

- (d) Calculate the value for the rate constant for the reaction. $K = (2^y)^{-1} = (2^0)^{-1} = 1$ (½ marks)

Using expt 1; Rate = $K[X]^2$ ✓
 $3.5 \times 10^{-4} = K(0.2)^2$ ✓ (01½)
 $K = 8.75 \times 10^{-3}$ ✓ Ignore units

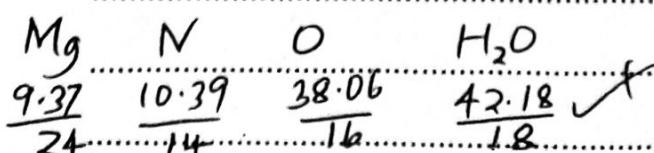
2. (a) A solid Q contains 9.37% by mass of magnesium, 10.39% nitrogen and 42.18% water.

(Ignore) Information missing
(i) Calculate the empirical formula of Q. (02 marks)

$$\% \text{ of Oxygen} = 100 - (9.37 + 10.39 + 42.18)$$

$$= 38.06\% \quad \text{✓}$$

∴ Empirical formula is $MgN_3O_6(H_2O)_6$. (02½)



$$0.39 : 0.781 : 2.38 : 2.34$$

$$\frac{0.39}{0.39} : \frac{0.781}{0.39} : \frac{2.38}{0.39} : \frac{2.34}{0.39} \quad \text{✓}$$

$$1 : 2 : 6 : 6 \quad \text{✓}$$

- (i) Determine the molecular formula of Q .
(RFM of $Q = 256$)

(01 mark)

$$24n + 28n + 16 \times 6n + (18 \times 6)n = 256$$

$$256n$$

$$= 256$$

$$= 1$$

(01)

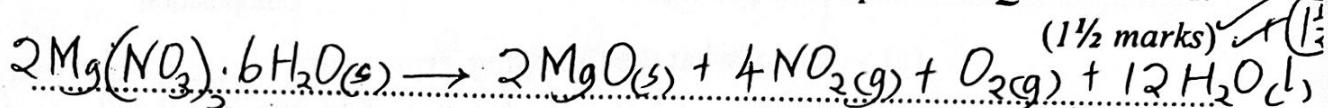
Molecular formula is $MgN_2O_6(H_2O)_6$ or $MgN_2O_6 \cdot 6H_2O$

- (b) Solution of Q reacts with iron(II) sulphate in the presence of concentrated sulphuric acid to form a brown ring. Identify Q .

(0½ mark)

Magnesium nitrate hexahydrate or $Mg(NO_3)_2 \cdot 6H_2O$.

- (c) Write equation for the reaction that would take place if Q was heated.



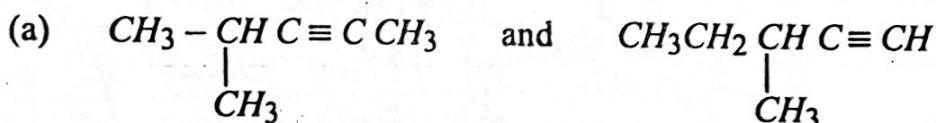
(1½ marks)

3.

- Name a reagent that can be used to distinguish between the following pairs of compounds.

06

In each case, state what would be observed if each member of the pair was treated with the reagent you have named.

**Reagent**

Ammoniacal Silver nitrate Solution or Tollen's reagent

(01 mark)

Accept: Ammoniacal Copper(II) Chloride Solution

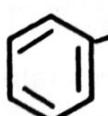
Observation

With $CH_3CH(CH_3)C \equiv CCH_3$, no observable change.

(02 marks)

With $CH_3CH_2CH(CH_3)C \equiv CH$: white precipitate

(b)



CHO

and

 CH_3CHO

> spelling of the reagents
should be correct.
> Rej. symbol or formulae

Reagent

Iodine Solution and Sodium hydroxide Solution.

(01 mark)

Observation

With , no observable change.

(02 marks)

With CH_3CHO , yellow ppt.

(03)

or Fehlings Solution.

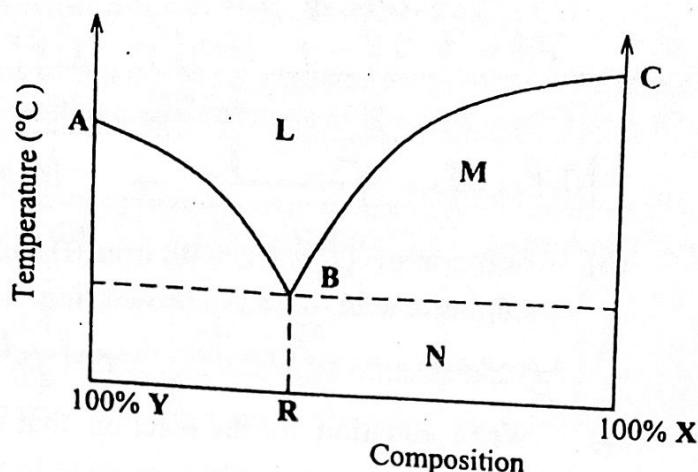
With , no observable change

CH_3CHO : reddish Brown ppt.

Turn Over

4. The temperature - composition diagram for a system containing two components X and Y is shown below.

06



- (a) State what the following represents:

- (i) Regions: L Liquid (mixture) rej. solution
 M Solid X and liquid (mixture) (1/2 ma)
 N Solid X and Solid Y or solid mixture (1/2 ma)

- (ii) Points: A Melting or Freezing pt or Soln. (1/2 ma)
 B Eutectic point (1/2 ma)
 C Melting point of pure X. (1/2 ma)

- (iii) Curves: AB Melting point of Y as X is added.
 BC Freezing point of X as Y is added (1/2 ma)
 or Variation of freezing pt (1/2 ma)

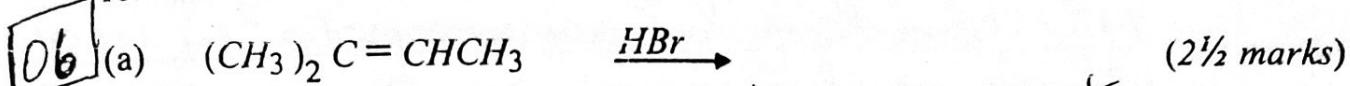
- (b) State what would happen when a mixture of composition R is heated.

The solid mixture melts at B to a liquid mixture of the same composition. or The solid mixture melt.

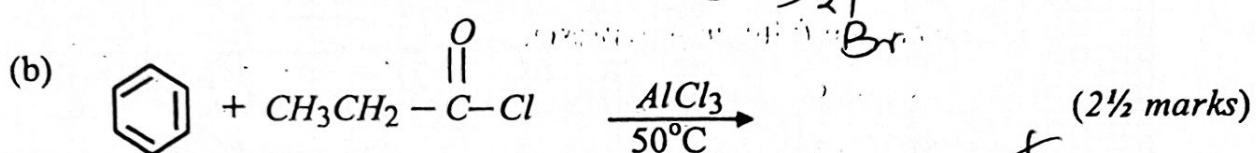
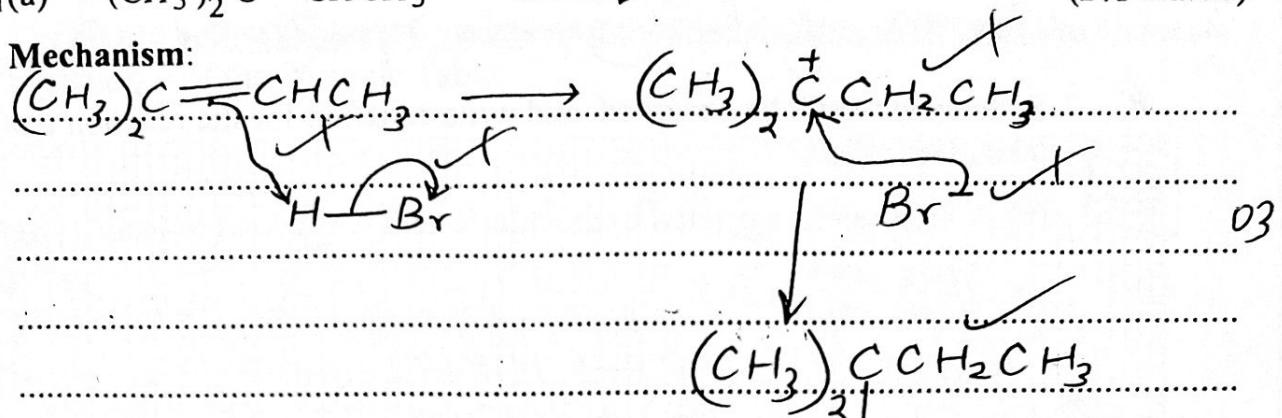
5. Write equation for the reaction between aqueous sodium hydroxide and

- D42 (a) chromium(III) oxide. $\text{Cr}_2\text{O}_3(\text{s}) + 2\bar{\text{O}}\text{H}(\text{aq}) \rightarrow 2\text{CrO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ (1/2 mark)
- " " $\text{Cr}_2\text{O}_3(\text{s}) + 2\bar{\text{O}}\text{H}(\text{aq}) + 3\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{Cr}(\text{OH})_4^-(\text{aq})$
- (b) beryllium oxide. $\text{BeO}(\text{s}) + 2\bar{\text{O}}\text{H}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Be}(\text{OH})_4^{2-}(\text{aq})$ (1/2 marks)
- (c) tin(II) oxide. $\text{SnO}(\text{s}) + 2\bar{\text{O}}\text{H}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Sn}(\text{OH})_4^{2-}(\text{aq})$ (1/2 marks)
- $\text{SnO}(\text{s}) + 2\bar{\text{O}}\text{H}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{SnO}_2^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- $\text{SnO}(\text{s}) + \bar{\text{O}}\text{H}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Sn}(\text{OH})_3^-(\text{aq})$.

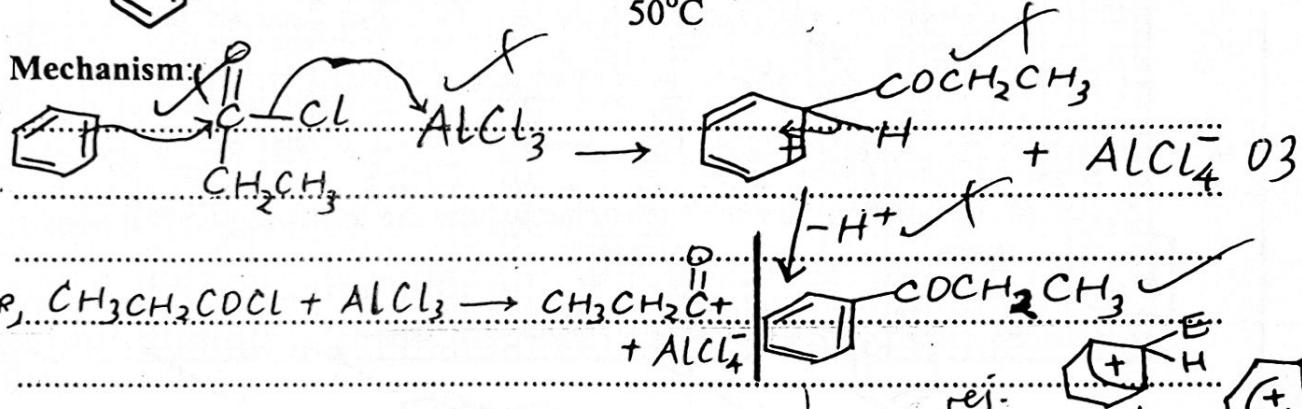
6. Complete the following equations and in each case, write a mechanism for the reaction.



Mechanism:



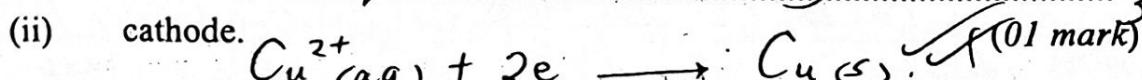
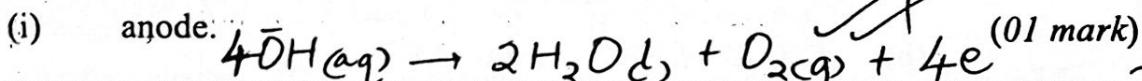
Mechanism:



7. When a current of 0.65 A was passed through copper(II) sulphate solution using platinum electrodes for 35 minutes, 0.0143 g of hydrogen and 0.113 g of oxygen were evolved.

Q6

(a) Write equation for the reaction that took place at the



(b) Determine the quantity of electricity required to evolve 1 mole of gas at each electrode.

(ii) At the anode.

$$\text{Quantity of electricity passed} = 0.65 \times 35 \times 60 = 1365 \text{ C} \quad (02 \text{ marks})$$

$$\text{No of moles of Oxygen evolved} = 0.113/32 = 3.53 \times 10^{-3}$$

3.53×10^{-3} moles of Oxygen are deposited by 1365 C

$$\therefore 1 \text{ mole of Oxygen is deposited by } \left(\frac{1365 \times 1}{3.53 \times 10^{-3}} \right) \text{ C.} \quad O_2$$

(ii) At the cathode. $2H^{+}(aq) + 2e \rightarrow H_2(g)$,
 No. of moles of hydrogen evolved = $0.0143 = 7.15 \times 10^{-3}$ (01 mark)
 7.15×10^{-3} moles of hydrogen are deposited by 1365C
 1 mole of hydrogen is deposited by $1365 = 7.15 \times 10^{-3}$ (01 mark)
 1 mole of hydrogen is deposited by $1365 = 190909C$

8.

State what would be observed and write equation for the reaction that would take place when:

(a) excess concentrated hydrochloric acid was added to lead(II) oxide.

Yellow solid dissolves forming a colourless solution (2½ marks)
 $PbO(s) + 4HCl(aq) \rightarrow H_2PbCl_4(aq) + H_2O(l)$ (03)
 or $PbO(s) + 2HCl(aq) + 2Cl^-(aq) \rightarrow PbCl_4^{2-}(aq) + H_2O(l)$

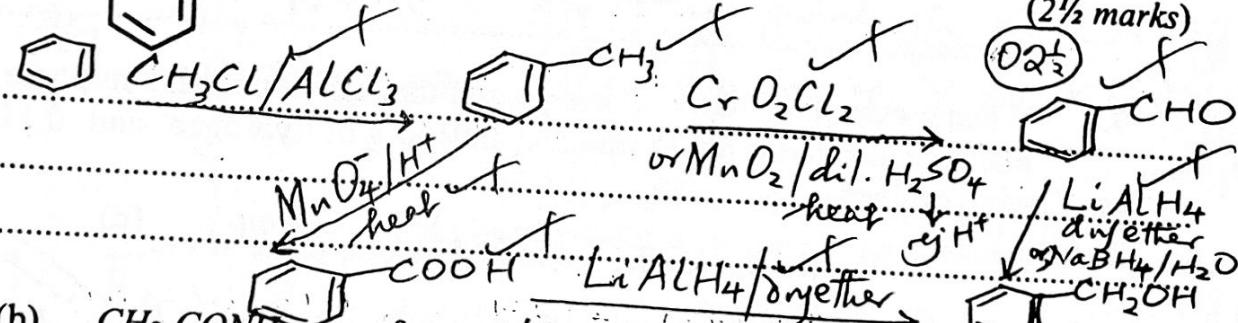
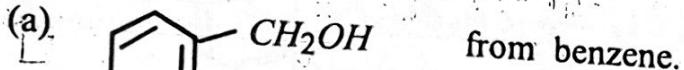
(b) potassium iodide was added to copper(II) sulphate solution. (2½ marks)
 Blue Solution turns to brown and a white solid / ppt is formed.

$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow Cu_2I_2(s) + I_2(aq)$ (03)
 or $2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$

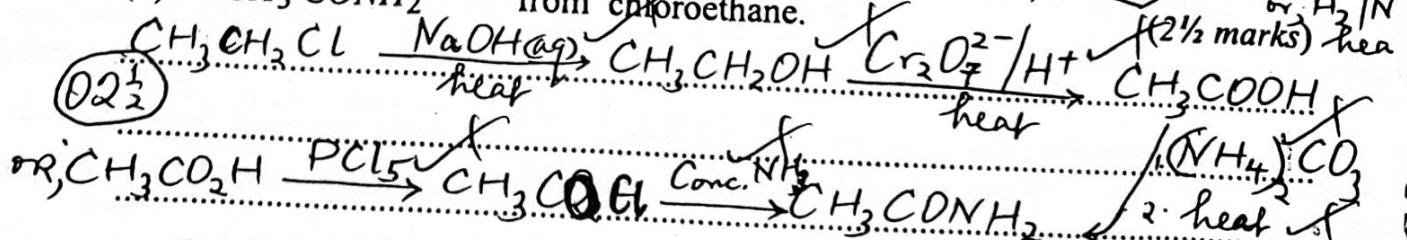
9.

Write equation in each case to show how the following conversions can be effected:

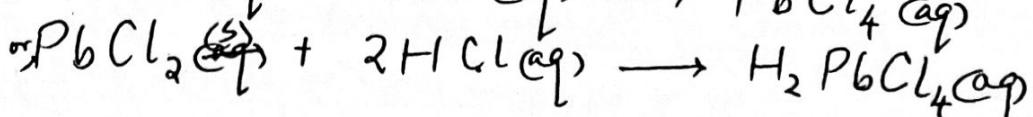
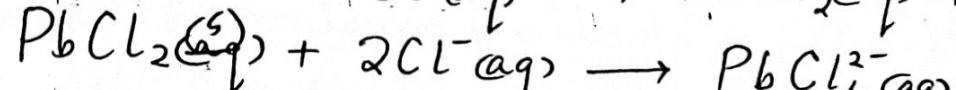
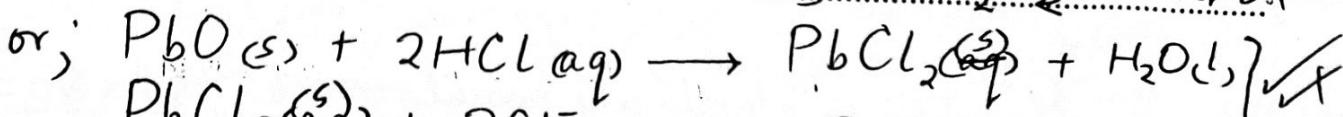
(a)



(b)



or;

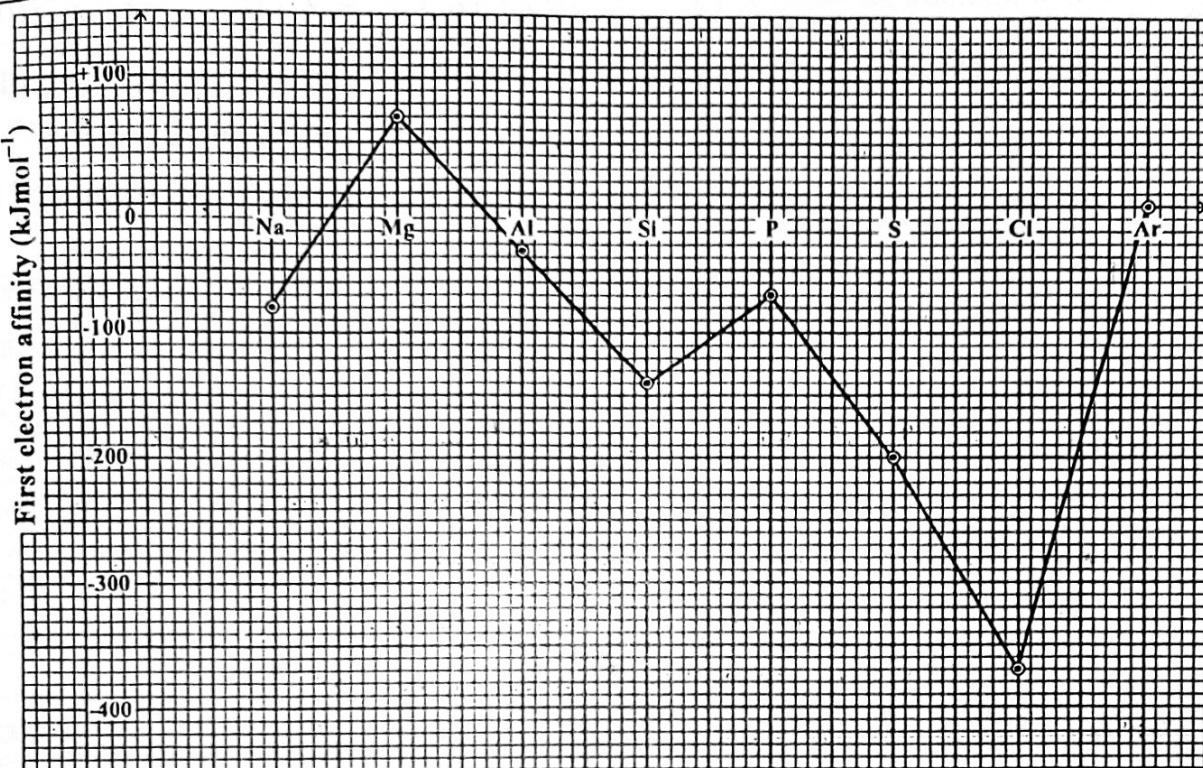


SECTION B: (54 MARKS)

Answer any six questions from this section.

10.
9C 09

The figure below shows the variation of the first electron affinity of the elements in Period 3 of the Periodic Table.



Explain each of the following observations:

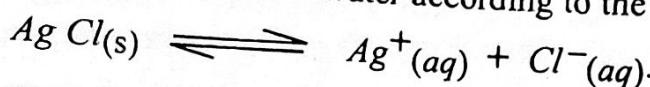
- There is a general increase in the first electron affinity from sodium to argon. Across the period, atomic radius \downarrow and nuclear charge \uparrow , as a result, the nuclear attraction for the incoming electron increases. (1½ marks)
- The first electron affinity of magnesium is higher than that of aluminium. Mg: $1s^2 2s^2 2p^6 3s^2$ Al: $1s^2 2s^2 2p^6 3s^2 3p^1$. Magnesium has fully filled $3s$ subenergy level which is stable. The added electron experiences greater repulsion from the existing electrons than nuclear attraction. Aluminium has one electron in the $3p$ subenergy level which is unstable. Therefore the added electron experiences more attraction. (1½ marks)
- The first electron affinity of phosphorous is less than that of sulphur. P: $1s^2 2s^2 2p^6 3s^2 3p^3$, S: $1s^2 2s^2 2p^6 3s^2 3p^4$. Phosphorous has a half filled $3p$ subenergy level which is energetically stable, the incoming electron experiences more repulsion than nuclear attraction. (3½ marks)

Turn Over

Sulphur has a 3P subenergy level with electrons which is unstable. Therefore the incoming electron experiences greater nuclear attraction than repulsion.

11. (a) Silver chloride dissolves in water according to the following equation.

(09)



Write the expression for the solubility product, K_{sp} of silver chloride.

$$K_{sp} = [Ag^+][Cl^-] \quad (01 \text{ mark})$$

- (b) The electrolytic conductivity of a saturated solution of silver chloride in water at $25^\circ C$ is $3.41 \times 10^{-6} \Omega^{-1} cm^{-1}$ and that of pure water is $1.6 \times 10^{-6} \Omega^{-1} cm^{-1}$. Calculate the solubility product of a saturated solution of silver chloride at $25^\circ C$.

(The molar conductivities at infinite dilution of silver nitrate, potassium nitrate and potassium chloride are 133.4, 145.0 and $149.9 \Omega^{-1} cm^2 mol^{-1}$ respectively at $25^\circ C$).

$$\Lambda_{AgCl} = \Lambda_{AgNO_3} + \Lambda_{KCl} - \Lambda_{KNO_3} \quad (4\frac{1}{2} \text{ marks})$$

$$= 133.4 + 149.9 - 145.0 = 138.3 \Omega^{-1} cm^2 mol^{-1}$$

$$K_{AgCl} = K_{\text{solution}} - K_{\text{water}} \quad \checkmark$$

$$= 3.41 \times 10^{-6} - 1.6 \times 10^{-6}$$

$$= 1.81 \times 10^{-6} \Omega^{-1} cm^{-1} \quad \checkmark$$

$$[AgCl] = \frac{1000K}{\Lambda} = \frac{1.81 \times 10^{-6} \times 1000}{138.3} \quad \checkmark$$

$$\text{or, } C = \frac{K}{\Lambda} \quad \checkmark \quad (04)$$

$$K_{sp} = (1.31 \times 10^{-5})^2 = 1.31 \times 10^{-10} \text{ Mol}^2 dm^{-6} \quad \checkmark$$

$$= 1.72 \times 10^{-10} \text{ Mol}^2 dm^{-6} \quad (\text{Ignore units})$$

- (c) Ammonia solution was added to a solution containing silver chloride.

- (i) State how the solubility of silver chloride was affected.

Solubility increases. \checkmark (01 mark)

- (ii) Explain your answer in (c)(i) above.

Ammonia reacts with Silver ions to form Complex ions which lowers the concentration of Silver ions so more Silver chloride dissolves in order to restore the equilibrium and the K_{sp} value. \checkmark (2½ marks)

023

12. Compound T, C_3H_6O reacts with 2, 4-dinitrophenylhydrazine to form a yellow precipitate.

(a) Write the names and the structural formulae of all possible isomers of T.

Extra wrong one CH_3COCH_3 ✓ Propanone (03 marks)

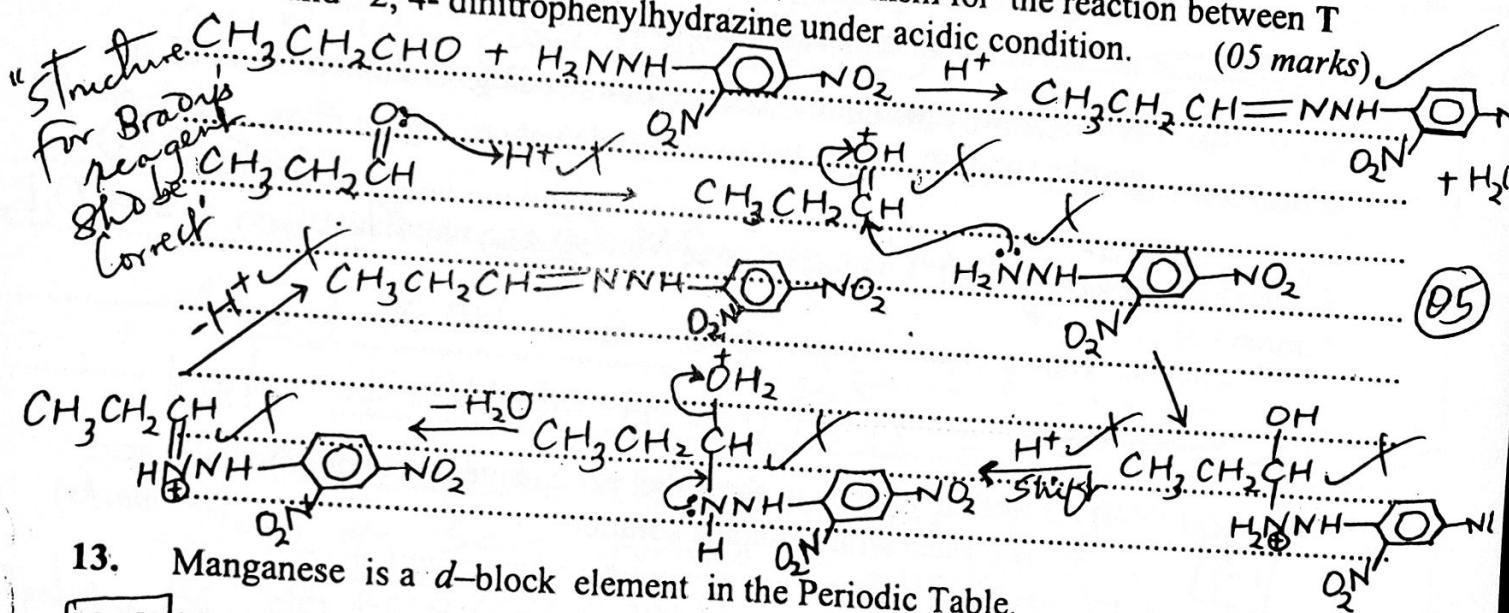
Cancel's CH_3CH_2CHO ✓ Propanal (03)

the correct one CH_3CH_2CHO ✓ Propanal (03)

- (b) T reacts with ammoniacal silver nitrate solution to form silver. Identify T.

CH_3CH_2CHO or propanal (01 mark) (01)

- (c) Write equation and indicate a mechanism for the reaction between T and 2, 4-dinitrophenylhydrazine under acidic condition. (05 marks)



13. Manganese is a d-block element in the Periodic Table.

(a) Define the term d-block element.

Is an element in which the outermost electrons fill the d-sub energy level. (01 mark) (01)

(b) (i) Write the electronic configuration of manganese.

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$. (1/2 mark) (01)

rej; [Ar] $4s^2 3d^5$.

(ii) State the common oxidation states exhibited by manganese in its compounds.

$+2$, $+4$ and $+7$ (1 1/2 marks) (01 1/2)

Any extra wrong one deduct 1/2 mark.

(iii) Write the formulae of oxides of manganese in each of the oxidation states you have stated in (b)(ii).

MnO , Mn_2O_3 , and Mn_3O_7 (1 1/2 marks) (01 1/2)

- (c) A black oxide, Y of manganese was fused with a mixture of potassium hydroxide and potassium nitrate to give a compound which when treated with water gave a green solution.

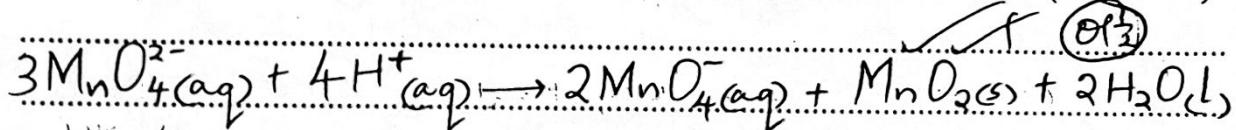
The green solution turned purple when acidified with sulphuric acid.
Identify:

(i) Y MnO_2 or Manganese(IV) oxide
(01 mark)

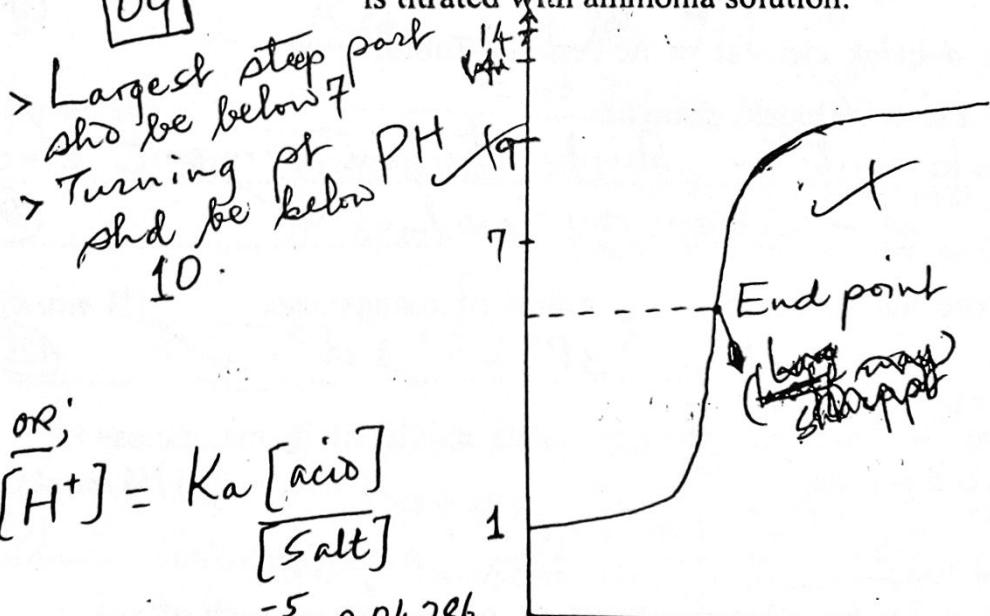
(ii) the ion that gives the green solution its colour. MnO_4^{2-} or Manganate(VI) ion
(01 mark)

(iii) the ion that gives the purple solution its colour. MnO_4^- or Manganate(VII) ion
(01 mark)

(d) Write ionic equation for the reaction leading to the formation of the purple solution.
(1½ marks)



14. (a) (i) Sketch a graph to show the pH change when hydrochloric acid is titrated with ammonia solution. (1½ marks)



$$\begin{aligned} \text{pH} &= \text{pK}_a + \log \frac{\text{salt}}{\text{acid}} \\ &= -\log 1.8 \times 10^{-5} + \log \frac{0.028}{0.0428} \\ &= 4.57 \end{aligned}$$

or,

$$[\text{H}^+] = \frac{\text{Ka} [\text{acid}]}{[\text{salt}]}$$

$$= \frac{1.8 \times 10^{-5} \times 0.04286}{0.0286}$$

$$= 2.7 \times 10^{-5} \text{ Molar}$$

$$\text{pH} = -\log [\text{H}^+]$$

$$= -\log 2.7 \times 10^{-5}$$

Volume of ammonia solution added (cm^3)

Ambrose

After end point, there is a gradual rise in pH due to excess NH_3 solution added which together with the salt (ammonium chloride) form a buffer solution.

(ii) Explain the shape of your sketch graph in (a)(i). (3½ marks)

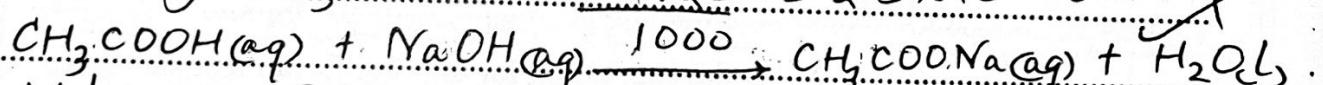
Initially pH is low because the concentration of hydrogen ions is high from a strong acid that completely ionises. The pH then gradually rises as ammonia solution is added because hydrogen ions are being neutralised. This is followed by a sharp rise in pH with little ammonia solution added signifying end point has been reached. The pH at the end point is less than 7 because the salt formed is hydrolysed by water forming hydroxide ions (acidic solution).

(b) Calculate the pH of a resultant solution formed when 10 cm³ of a 0.1M sodium hydroxide solution is added to 25 cm³ of a 0.1M ethanoic acid at 25 °C.

(Dissociation constant of ethanoic acid at 25 °C = 1.8×10^{-5} mol dm⁻³).

Moles of NaOH used = $\frac{0.1 \times 10}{1000} = 1.0 \times 10^{-3}$

Moles of CH_3COOH = $\frac{0.1 \times 25}{1000} = 2.5 \times 10^{-3}$



Moles of Salt formed = 1.0×10^{-3}

Excess acid (CH_3COOH) = $(2.5 - 1.0) \times 10^{-3} = 1.5 \times 10^{-3}$

$[\text{CH}_3\text{COOH}] = \frac{1.5 \times 10^{-3} \times 1000}{1000} = 0.04286 \text{ M}$

$[\text{CH}_3\text{COONa}] = \frac{1.0 \times 10^{-3} \times 1000}{3.5} = 0.0286 \text{ M}$ (04)

15. (a) Beryllium, magnesium, calcium and barium are some of the elements that belong to Group II of the Periodic Table.

State how the elements react with sulphuric acid and give the conditions for the reactions.

"Pds shd be" Beryllium reacts with warm dilute sulphuric acid to form beryllium sulphate and hydrogen gas. Magnesium reacts with cold dilute sulphuric acid to form magnesium sulphate and hydrogen gas. Calcium and Barium react slowly with cold dilute sulphuric acid and the reaction soon stops due to formation of insoluble sulphate.

- (b) (i) State how the solubilities of the sulphates of Group II elements vary down the group. (01 mark)

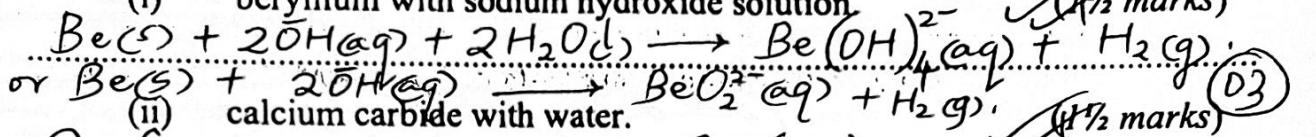
Solubility decreases down the group. (01)

- (ii) Explain your answer in (b)(i). (02 marks)

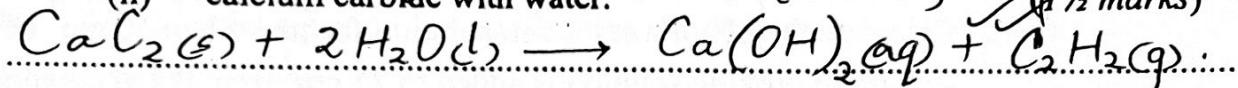
Both lattice and hydration energy decrease down the group due to increase in cationic radii. However hydration energy decreases more rapidly than lattice energy hence leading to a rise in solubility. (02)

- (c) Write equation for the reaction of:

- (i) beryllium with sodium hydroxide solution. (1½ marks)



- (ii) calcium carbide with water. (1½ marks)



16. In the manufacture of ammonia, nitrogen is catalytically hydrogenated to give ammonia according to the following equation.

09



- (a) (i) Name the catalyst used in the reaction. (½ mark)

Iron reg. Symbol. (0½)

- (ii) Write the expression for the equilibrium constant, K_p for the reaction.

$$K_p = \frac{P_{\text{NH}_3}^2}{P_{\text{N}_2} \times P_{\text{H}_2}^3} \quad \text{or} \quad (P_{\text{NH}_3})^2 / (P_{\text{N}_2} \times (P_{\text{H}_2})^3)$$

- (b) State what would happen to the position of the equilibrium if:

- (i) pressure was increased. (01 mark)

Equilibrium position would shift to the right. (01)

- (ii) temperature was increased. (01 mark)

Equilibrium position would shift to the right. (01)

Cont.

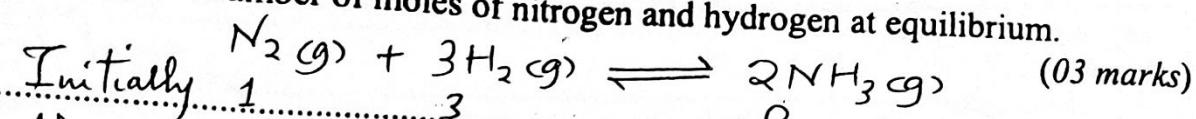
Beryllium reacts with hot concentrated sulphuric acid to form beryllium sulphate, sulphur dioxide and water.

Magnesium reacts with hot conc. sulphuric acid to form magnesium sulphate, SO_2 and water. (03)

Calcium and barium react with hot conc. sulphuric acid to form insoluble sulphates which stops the reaction.

- (c) When 3 moles of hydrogen and 1 mole of nitrogen were mixed and allowed to attain equilibrium at 100 atm and 400°C , the equilibrium mixture contained 25% of ammonia by volume. Calculate the:

- (i) number of moles of nitrogen and hydrogen at equilibrium.



At eqm $\begin{array}{ccc} 1-x & 3-3x & 2x \checkmark \end{array}$
Let x be moles of nitrogen gas that reacted. (03)
Total no. of moles at eqm = $1-x+3-3x+2x=4-2x$.
 $\frac{2x}{4-2x}=\frac{25}{100} \Rightarrow 100-50x=200x \Rightarrow x=0.4 \text{ moles.}$

Moles of nitrogen = $1-0.4=0.6 \text{ moles.}$

(ii) value of the equilibrium constant, K_p at 400°C . (2½ marks)

Moles of hydrogen = $3-3(0.4)=1.8 \text{ moles.}$

$P_{\text{N}_2} = \frac{0.6}{3.2} \times 100 = 18.75 \text{ atm,}$ Total moles = $4-0.8=3.2$

$P_{\text{H}_2} = \frac{1.8}{3.2} \times 100 = 56.25 \text{ atm,}$ $K_p = \frac{(25)^2}{18.75 \times (56.25)^3}$ (02)

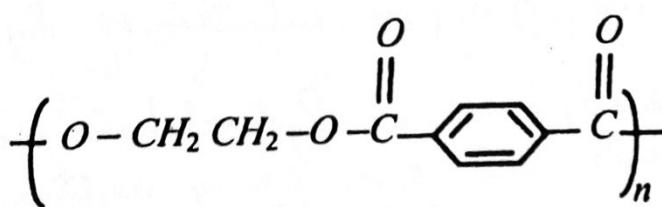
$P_{\text{NH}_3} = \frac{0.8}{3.2} \times 100 = 25 \text{ atm,}$ $= 1.87 \times 10^{-4} \text{ atm}^{-2}$

17. (a) Differentiate between addition and condensation polymers. (02 marks)

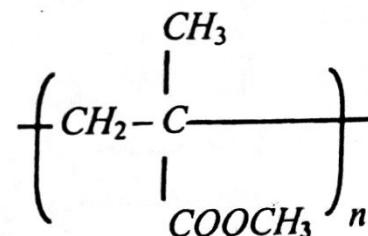
09 Addition polymer is formed when unsaturated monomers combine without loss of small molecules while condensation polymer is one formed when two types of bifunctional monomers combine with loss of small molecules. (02)

- (b) The structural formulae of two polymers R and T are shown below.

R



T



Name the polymer:

(i) R

Terylene

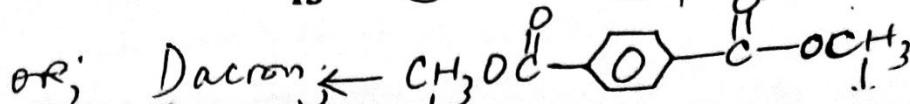
(01 mark)

(ii) T

Perspex
(Polymethyl 2-methylpropenoate)

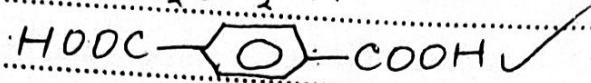
(01 mark)

Turn Over



(c) Write the structural formula(e) of monomer(s) of the polymers R and T respectively.

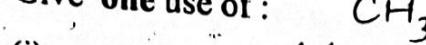
For R; $\text{HOCH}_2\text{CH}_2\text{OH}$ ✓ (0.3 marks)



(0.3)

For T; $\text{CH}_2=\text{C}(\text{COOCH}_3)\text{CH}_3$ ✓ monomer for Dacron

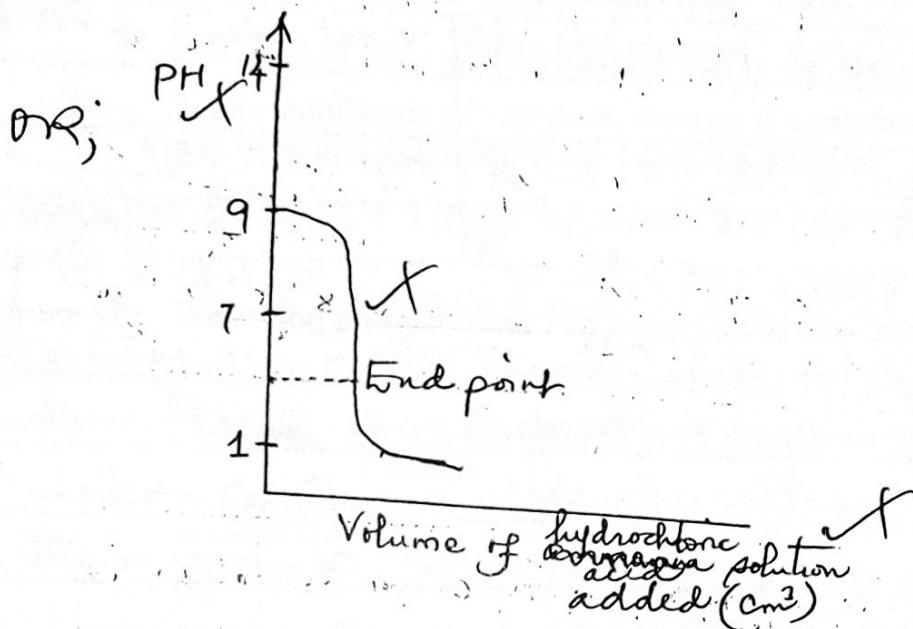
(d) Give one use of:



(i) R Making cloth (Fabric) (0.2)

(ii) T Making windscreen of aircraft (0.1 mark)

Lenses, Corrugated roof lights



Initially the pH is slightly higher than 7 because ammonia solution is a weak base (Concentration of hydroxide ions is low).

The pH then gradually rises as hydrochloric acid is added because hydroxide ions are being neutralised and the remaining ammonia solution together with ammonium chloride form a buffer solution. This is followed by a sharp drop in pH with little hydrochloric acid added signifying end point has been reached.

The pH of the solution at the end point is less than 7 because the salt formed is hydrolysed by water forming hydroxonium ions (acidic solution).

After end pt there is a general decrease in pH

A
Ames

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 Tl 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		

Candidate's Name

Ambrose Kariyo # 2018

Ambrose

Signature: Ambrose Kariyo

Random No.

Personal No.

P	5	2	5	3	0	2	3
---	---	---	---	---	---	---	---

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

P525/3

**CHEMISTRY
(PRACTICAL)**

Paper 3

Nov./Dec. 2018

3½ hours



UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

CHEMISTRY PRACTICAL

Paper 3

3 hours 15 minutes

INSTRUCTIONS TO CANDIDATES:

Answer All questions. Use blue or black ball point pen. Any work done in pencil will not be marked except drawings.

Record your answers on this question paper in the spaces provided.

Mathematical tables and silent non-programmable calculators may be used

Reference books (i.e text books, Books on qualitative analysis, etc.) should not be used.

Candidates are not allowed to start working with the apparatus for the first 15 minutes. This time is to enable candidates read the question paper and make sure they have all the apparatus and chemicals that they may need.

For Examiners' Use Only			
Q.1	Q.2	Q.3	Total
30	32	18	80

I. You are provided with the following:

FA1, which is approximately a 0.1M sodium thiosulphate solution.

FA2, which is a solution containing 2.4 g dm⁻³ of potassium iodate.

Solid Y, which is a salt containing dichromate ions.

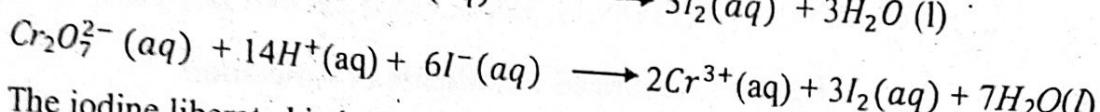
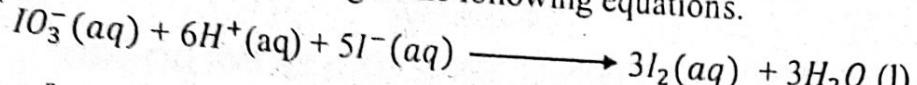
1M sulphuric acid solution.

5% potassium iodide solution.

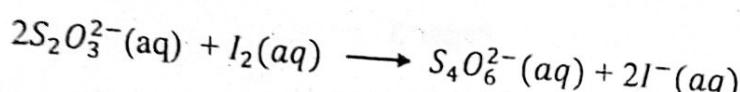
Starch solution.

You are required to standardise FA1 and use it to determine the percentage by mass of chromium in Y.

In acidic solution, iodate and dichromate(VI) ions react with potassium iodide to liberate iodine according to the following equations.



The iodine liberated in both cases reacts with thiosulphate ions according to the following equation



PROCEDURE:

(a) Pipette 25.0 (or 20.0) cm³ of FA2 into a conical flask and add an equal volume of 1M sulphuric acid using a measuring cylinder, followed by 10 cm³ of 5% potassium iodide solution.

Titrate the iodine liberated with FA1, using starch solution as indicator.
Repeat the titration until you obtain consistent results.

(i) Record your results in Table I below.

Results:

Volume of pipette used 25.0 / 25.00 cm³. (½ mark)

Table I

Final burette reading (cm ³)	16.50	33.10	16.10
Initial burette reading (cm ³)	0.00	47.00	0.00
Volume of FA1 used (cm ³)	16.50	16.10	16.10

(ii) Volumes of FA1 used for calculating average volume. (4½ marks)

..... 16.10 and 16.10 cm³ (from table) (½ mark)
..... (check replication)

(iii) Average volume of FA1 used 16.10 cm³. (2½ marks)

Values must be recorded to 2 decimal places with correct subtraction.

Deny ½ mark for values recorded to 1 decimal place up to a maximum of 1½ marks.

Award zero if values are recorded to no decimal place.

Reject any value above 50 cm³.

± 0.1 ✓

± 0.2 ✓

± 0.3 ✓

± 0.4 ✓

08

Questions:

- (a) Calculate the number of moles of iodine liberated by FA2.
(O = 16; K = 39; I = 127)

$$\text{RFM of } \text{KIO}_3 = 39 + 127 + (16 \times 3) = 214 \quad (2\frac{1}{2} \text{ marks})$$

$$\text{Molarity of FA2} = \frac{2.4V}{214} = 0.0112 \text{ M.}$$

1000 cm³ of FA2 contain 0.0112 moles of IO_3^-

25 cm³ of FA2 contain $\frac{(25 \times 0.0112)}{1000} = 2.8 \times 10^{-4}$ moles.

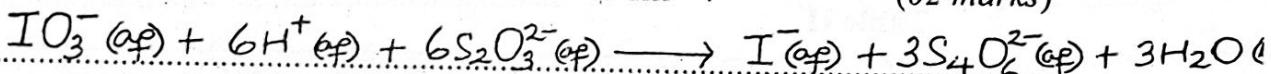
1 mole of IO_3^- liberates 3 moles of I_2 .

2.8×10^{-4} moles of IO_3^- liberate $\frac{(2.8 \times 10^{-4} \times 3)}{1} = 8.4 \times 10^{-4}$ moles of I_2 .

Final answer only affected by RFM of KIO_3 and volume of pipette.

- (b) Determine the concentration of FA1 in mol dm⁻³.

(02 marks)



1 mole of IO_3^- reacts with 6 moles of $\text{S}_2\text{O}_3^{2-}$

2.8×10^{-4} moles of IO_3^- react with $\frac{(6 \times 2.8 \times 10^{-4})}{1}$

(02)

$$= 1.68 \times 10^{-3} \text{ moles of } \text{S}_2\text{O}_3^{2-}$$

16.10 cm³ of FA1 contain 1.68×10^{-3} moles of $\text{S}_2\text{O}_3^{2-}$

1000 cm³ of FA1 contain $\frac{(1.68 \times 10^{-3} \times 1000)}{16.10} = 0.104 \text{ M.}$

OR;

1 mole of I_2 reacts with 2 moles of $\text{S}_2\text{O}_3^{2-}$

8.4×10^{-4} moles of I_2 react with $\frac{(2 \times 8.4 \times 10^{-4})}{1} = 1.68 \times 10^{-3}$ moles.

16.10 cm³ of FA1 contain 1.68×10^{-3} moles of $\text{S}_2\text{O}_3^{2-}$

1000 cm³ of FA1 contain $\frac{(1.68 \times 10^{-3} \times 1000)}{16.10} = 0.104 \text{ M.}$

- Deny mark for molarity if the average volume is outside the accuracy range.

Turn Over

PROCEDURE:

- (b) Weigh accurately about 1.2 g of Y. Dissolve it in a minimum amount of distilled water and transfer the solution into a 250 cm³ volumetric flask. Make the solution up to the mark with distilled water and label it FA3.

Pipette 25.0 (or 20.0) cm³ of FA3 into a conical flask and add an equal volume of 1M sulphuric acid using a measuring cylinder, followed by 10 cm³ of 5% potassium iodide solution.

Titrate the iodine liberated with FA1 using starch as indicator.

Repeat the titration until you obtain consistent results.

- (i) Record your results in table II below.

RESULTS

Mass of weighing bottle + Y	5.20 ✓	X	g. (½ mark)
Mass of empty weighing bottle	4.00 ✓	X	g. (½ mark)
Mass of Y used	1.20 ✓	X	g. (½ mark)
Volume of pipette used	25.0 / 25.00 ✓	cm ³ .	(½ mark)

Table II

Final burette reading (cm ³)	23.10 ✓	46.30 ✓	23.20 ✓
Initial burette reading (cm ³)	0.00 ✓	23.10 ✓	0.00 ✓
Volume of FA1 used (cm ³)	23.10 ✓	23.20 ✓	23.20 ✓

(4½ marks)

- (ii) Volumes of FA1 used for calculating average volume.

23.20 and 23.20 ✓ cm³. (½ mark)

(iii) Average volume of FA1 used..... 23.20 ✓ cm³. (2½ marks)

Questions:

- (a) Calculate the number of moles of iodine liberated by FA3. (02 marks)

$$1000 \text{ cm}^3 \text{ of FA1 contain } 0.104 \text{ moles of } \text{S}_2\text{O}_3^{2-} \quad y_2$$

$$23.20 \text{ cm}^3 \text{ of FA1 contain } \frac{(23.20 \times 0.104)}{1000} \text{ moles} = 2.4128 \times 10^{-3} \text{ moles}$$

Ambone

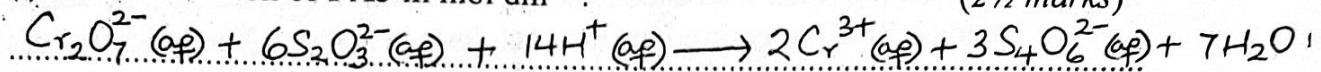
2 moles of $S_2O_3^{2-}$ react with 1 mole of I_2 . ✓ 1½

2.4128×10^3 moles of $S_2O_3^{2-}$ react with $\frac{(2.4128 \times 10^3 \times 1)}{2}$ ✓ 1½

$$= 1.2064 \times 10^3 \text{ mol}$$

(b) Determine the:

(i) concentration of FA3 in mol dm⁻³. (2½ marks)



6 moles of $S_2O_3^{2-}$ react with 1 mole of $Cr_2O_7^{2-}$. ✓ 2½

2.4128×10^3 moles of $S_2O_3^{2-}$ react with $\frac{(2.4128 \times 10^3 \times 1)}{6}$ ✓ 2½

$$= 4.02 \times 10^4 \text{ mol}$$

25.0 cm³ of FA3 contain 4.02×10^4 moles of $Cr_2O_7^{2-}$. ✓ mm.

1000 cm³ of FA3 contain $\frac{(4.02 \times 10^4 \times 1000)}{25.00}$ ✓ X ✓ X = 0.016 M.

OR; 3 moles of I_2 are liberated by 1 mole of $Cr_2O_7^{2-}$.

1.2064×10^3 moles of I_2 are liberated by $\frac{(1.2064 \times 10^3 \times 1)}{3}$ ✓ mm.

Continue as above.

(ii) mass of chromium in Y and hence its percentage. ($Cr = 52$) (3½ marks)

25.0 cm³ of FA3 contain 4.02×10^4 moles of $Cr_2O_7^{2-}$.

250 cm³ of FA3 contain $\frac{(250 \times 4.02 \times 10^4)}{25}$ ✓ X ✓ X = 4.02×10^3 moles

4.02×10^3 moles of $Cr_2O_7^{2-}$ weigh 1.2 g.

1 mole of $Cr_2O_7^{2-}$ weighs $\frac{1.2}{(4.02 \times 10^3)}$ ✓ X = 298.51 g. 3½

Mass of Cr atoms in Cr_2O_7 = (2×52) ✓ X = 104 g.

$$\text{Percentage} = \frac{104}{298.51} \times 100 \checkmark$$

$$= 34.84 \% \checkmark$$

2. You are provided with substance Q, which contains two cations and two anions. You are required to carry out tests below on Q and identify the cations and anions in Q. Identify any gas(es) evolved. (Mixture of CuCO_3 + BaCl_2)

Record your observations and deductions in the table below.

(32 marks)

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Heat two spatula end-fuls of Q strongly in a dry test tube until there is no further change.	<ul style="list-style-type: none"> - Colourless condensate or liquid that turned anhydrous CuSO_4 from white to blue. ✓ - Colourless gas that turned damp blue litmus red, and lime water milky. ✓ - Brown fumes. ✓ - Green solid turned to a black residue. ✓ 	<ul style="list-style-type: none"> - Water of crystallisation hence a hydrated compound. (05) - CO_2 gas, hence CO_3^{2-}, HCO_3^-, $\text{C}_2\text{O}_4^{2-}$ or CH_3COO^-. - NO_2 hence NO_3^- - CuO hence Cu^{2+} NiO, hence Ni^{2+} FeO, hence Fe^{2+}
(b) To about 6 cm ³ of water, add 2 spatula end-fuls of Q and shake well. Filter the mixture and keep both the filtrate and residue.	<ul style="list-style-type: none"> - Colourless filtrate. ✓ - Green residue. ✓ 	<ul style="list-style-type: none"> - Non-transition metal cations (or, Mg^{2+}, Ca^{2+}, Ba^{2+}, Pb^{2+}, Al^{3+}, Zn^{2+}, Sn^{2+} or Sn^{4+}, Cu^{2+}, Fe^{2+}, Ni^{2+})
(c) Divide the filtrate into six parts. (i) To the first part of the filtrate, add dilute sodium hydroxide solution dropwise until in excess	<ul style="list-style-type: none"> A white precipitate insoluble in excess 	<ul style="list-style-type: none"> - Ca^{2+}, Ba^{2+} or Mg^{2+}. ✓

Note: The brown fumes observed on heating could have been to the nitrate formed in preparation of CuCO_3 using HNO_3 as one of the reagents.

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the second part of the filtrate, add dilute ammonia solution dropwise until in excess.	A white precipitate insoluble in excess.	Ba^{2+} or Mg^{2+} . 02
(iii) To the third part of the filtrate, add 2-3 drops of dilute sulphuric acid and heat the mixture.	A white precipitate insoluble on heating	Ba^{2+} 0½
(iv) Use the fourth part of the filtrate to carry a test of your own choice so as to confirm the first cation in Q. To the solution was added potassium chromate (VI) solution followed by dilute NaOH dropwise till in excess. cept; $\text{C}_2\text{O}_4^{2-}$ CH_3COO^-	A yellow precipitate insoluble in dilute Sodium hydroxide. → A white ppt Soluble	Ba^{2+} Confirmed. 2½
(v) To the fifth part of the filtrate add 2-3 drops of lead(II) nitrate solution.	A white precipitate	Cl^- Suspected. Reject: SO_4^{2-} or SO_3^{2-} because of the presence of Ba^{2+} . 01
(vi) Use the sixth part of the filtrate to carry out a test of your own choice so as to confirm the first anion in Q. To the solution was added Silver nitrate solution followed by dilute nitric acid Reject: addition of AgNO_3 followed by ammonia formation as there would be formation of NH_4^+ .	A white precipitate insoluble in nitric acid.	Cl^- Confirmed. 2½

TESTS	OBSERVATIONS	DEDUCTIONS
(d) Add dilute nitric acid in small portions to the residue until there is no further change. Divide the resultant solution into three portions.	- Residue dissolves with effervescence of a colourless gas that turned damp blue litmus red, and lime water milky. - A blue solution formed	CO_3^{2-} gas, hence CO_3^{2-} confirmed Cu^{2+} 6½
(i) To the first portion of the solution, add dilute sodium hydroxide solution dropwise until in excess.	A blue precipitate insoluble in excess.	Cu^{2+} ✓
(ii) To the second portion of the solution, add dilute ammonia solution dropwise until in excess.	A blue precipitate soluble in excess to give a deep blue solution.	Cu^{2+} confirmed 2½
(iii) Use the third portion of the solution to carry out a test of your own choice so as to confirm the second cation in Q. To the solution was added potassium hexacyanoferrate(II) Solution.	A brown precipitate	Cu^{2+} confirmed 02

Questions:

Identify the

- (i) cations in Q..... Ba^{2+} (in c(iv)) and Cu^{2+} (in d(iii)) O_2 13
- (ii) anions in Q..... Cl^- (in C(ii)) and CO_3^{2-} (in d).

Total = 32

3. You are provided with an organic compound W.

You are required to carry out tests below on W and describe the nature of W.

Record your observations and deductions in the table below.

(18 marks)

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Burn a small amount of W on a spatula end or in a dry porcelain dish.	Burns with a yellow non-sooty flame ✓	Aliphatic Saturated Compound. (or cpd with low carbon content or low C : H ratio) 02
(b) To about 0.5 cm^3 of W, add 1 cm^3 of water, shake and test the mixture with litmus paper.	Dissolves / miscible / soluble in water forming a colourless solution which has no effect on litmus paper. ✓	- Polar ✓ Compound of low molecular mass - The compound is neutral probably an alcohol, carbonyl compound or ester. 04
(c) To about 1 cm^3 of W, add 2 - 3 drops of neutral iron(III) chloride solution.	No observable change ✓	Phenol absent ✓ 02
(d) To about 1 cm^3 of W, add 3 - 4 drops of 2,4-dinitrophenylhydrazine.	No observable change ✓	Carbonyl compound absent. ✓ 02
(e) To about 2 cm^3 of W, add 4 - 5 drops of acidified potassium dichromate(VI) solution, heat, allow to cool and use in part (f).	The Solution of acidified potassium dichromate (VI) turns from orange to green ✓	Primary or Secondary alcohol oxidised to a carbonyl compound. ✓ 02

TESTS	OBSERVATIONS	DEDUCTIONS
(f) To the mixture from (e), add 3 - 4 drops of 2,4-dinitrophenylhydrazine.	Yellow precipitate ✓	Carbonyl compound + formed from oxidation of Primary alcohol + or Secondary alcohol. (E)
(g) To about 2 cm ³ of Luca's reagent, add about 1 cm ³ of W.	No observable change ✓	Primary alcohol (02)

(h) Describe the nature of W.

An aliphatic primary alcohol. ✓ ✓ ✓ 12

.....
Total = 18
.....

06

ALTERNATIVES FOR PROCEDURE II b(ii)

Anscombe

$$\Rightarrow 25.0 \text{ cm}^3 \text{ of FA3 contain } 4.02 \times 10^{-4} \text{ moles of } \text{Cr}_2\text{O}_7^{2-}$$

$$250 \text{ cm}^3 \text{ of FA3 contain } \left(\frac{4.02 \times 10^{-4} \times 250}{25.0} \right) \checkmark X$$

$$= 4.02 \times 10^{-3} \text{ moles.}$$

1 mole of $\text{Cr}_2\text{O}_7^{2-}$ contains $(2 \times 52) \text{ g}$ of Cr.

$$4.02 \times 10^{-3} \text{ moles of } \text{Cr}_2\text{O}_7^{2-} \text{ contain } \left(\frac{4.02 \times 10^{-3} \times 104}{1} \right) \checkmark X$$

$$= 0.4181 \text{ g of Cr} \quad (32)$$

$$\text{Percentage of Chromium} = \frac{0.4181}{1.2} \times 100 \checkmark X$$

$$= 34.84 \% \checkmark$$

OR;

$$\Rightarrow 1 \text{ mole of } \text{Cr}_2\text{O}_7^{2-} \text{ contains 2 moles of Cr atoms}$$

$$0.016 \text{ moles of } \text{Cr}_2\text{O}_7^{2-} \text{ contain } \left(\frac{2 \times 0.016}{1} \right) \checkmark X$$

$$= 0.032 \text{ moles of Cr.}$$

$$\text{Mass of Cr in } \text{Cr}_2\text{O}_7^{2-} = (52 \times 0.032) \checkmark X$$

$$= 1.664 \text{ g} \checkmark$$

$$250 \text{ cm}^3 \text{ of FA3 contain } 1.2 \text{ g of } \text{Cr}_2\text{O}_7^{2-}$$

$$1000 \text{ cm}^3 \text{ of FA3 contain } \left(\frac{1000 \times 1.2}{250} \right) \checkmark X$$

$$= 4.8 \text{ g of } \text{Cr}_2\text{O}_7^{2-}$$

$$\text{Percentage of Chromium} = \frac{1.664}{4.8} \times 100 \checkmark X$$

$$= 34.67 \% \checkmark$$