Name...MR. SENTAMU GEOFREY.....Index No...0703-084687.

Signature.....

P525/1

Chemistry

Paper 1

2 ¾ hours

MOST RESOURCEFUL MOCK EXAMINATIONS 2019

UGANDA ADVANCED CERTIFICATE OF EDUCATION

CHEMISTRY

PAPER 1

TIME: 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.*
- *Molar gas constant, $R=8.314Jk^{-1}mol^{-1}$*
- *Molar volume of a gas at stp is 22.4litres*

FOR EXAMINERS USE ONLY																	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
4½	06	04	06	04	06	5½	06	04	09	09	09	09	09	09	09	09	100

SECTION A: (46 MARKS)

1. (a) Bond energies for some bonds are given below:

Bond	Bond energy ($KJmol^{-1}$)
C ≡C	+813
C – C	+346
C – H	+413
H – H	+436

Calculate the enthalpy of hydrogenation of ethyne. (3 marks)

ΔH = Σ Bond Energy for reactants - Σ bond energy for products.

$HC \equiv CH + 2H_2 \longrightarrow$ H–C(H)(H)–C(H)(H)–H

= [1 B.E (C≡C) + 2 B.E(C–H) + 2 B.E (H–H)] – [1 B.E (C–C) + 6 B.E (C–H)]

= [(1 × 813) + (2 × 413) + (2 × 436)] – [(1 × 346) + (6 × 413)]

= 2511 – 2824

= –313 kJ mol^{-1} (Q3)

(b) State whether hydrogenation of ethyne is feasible or not. Give a reason for your answer. (1 ½ marks)

Hydrogenation of ethyne is feasible.

Because enthalpy of hydrogenation is a negative value. (1½)

Accept exothermic.

2. State what is observed and write equation of reaction in each case when the following compounds are mixed. (6 ½ marks)

(a) Methanoic acid and ammoniacal silver nitrate solution heated.

Observation

Silver mirror deposit

Accept grey precipitate.

Equation

$2HCOOH + 2Ag(NH_3)_2^+ OH^- \longrightarrow 2CO_{2(g)} + 2Ag_{(s)} + 4NH_{3(g)} + 2H_2O_{(l)}$

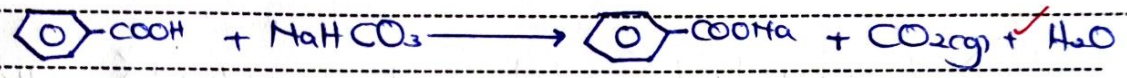
or $HCOOH + 2Ag(NH_3)_{2(aq)}^+ + 2OH^-_{(aq)} \longrightarrow CO_{2(g)} + 2Ag_{(s)} + 4NH_{3(g)} + 2H_2O_{(l)}$

(b) Benzoic acid and aqueous Sodium bicarbonate solution.

Observation

Bubbles of a colourless gas.

Equation



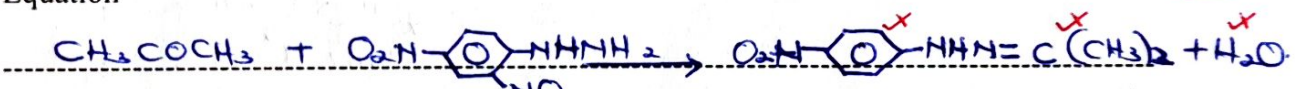
(c) Propanone and Brady's solution

Observation

Yellow precipitate.

Accept orange precipitate.

Equation



Deny ½ for missing H_2O.

3. Calculate the pH of solution formed by mixing 80cm^3 of 0.1M hydrochloric acid with 120cm^3 of 0.1M potassium hydroxide.

Number of moles of $HCl = \frac{80 \times 0.1}{1000}$

$= 0.008$ moles

Number of moles of $KOH = \frac{120 \times 0.1}{1000}$

$= 0.012$ moles

Number of moles of excess KOH

$= 0.012 - 0.008$

$= 0.004$ moles

Total volume of solution $= 80 + 120$

$= 200$cm^3

Molar concentration of excess KOH

$= \frac{0.004 \times 1000}{200}$

$= 0.02$M

$KOH_{(aq)} \longrightarrow K^+_{(aq)} + OH^-_{(aq)}$

Molar of $[OH^-] = 0.02$M.

from $[H^+] = \frac{K_w}{[OH^-]}$

$pH = -\log[H^+]$

$= -\log\left(\frac{1 \times 10^{-14}}{0.02}\right)$

$= 12.3$

4. (a) State three reasons for the difference in properties between fluorine and other group (VII) elements (3 marks)

- Fluorine is the most electronegative halogen atom
- Fluorine molecule has the lowest bond dissociation energy
- Fluorine lacks d - sub shell. ✓ 03
- Fluorine atom has a small atomic radius ✓

(b) Write equation for the reaction that takes place between the following compounds.

(i) Silicon (IV) oxide and hydrofluoric acid (1 ½ marks)

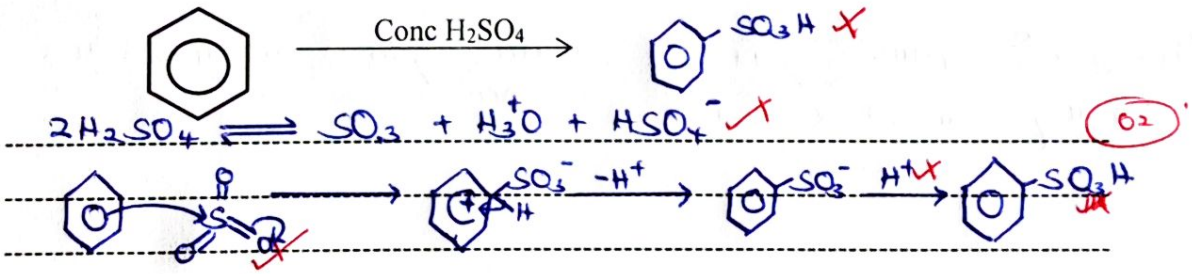
$SiO_{2(s)} + 4HF_{(l)} \longrightarrow SiF_{4(g)} + 2H_2O_{(l)}$ ✓✗

(ii) Fluorine and water. (1 ½ marks) 03

$2F_{2(g)} + 2H_2O_{(l)} \longrightarrow O_{2(g)} + 4HF_{(g)}$ ✓✗

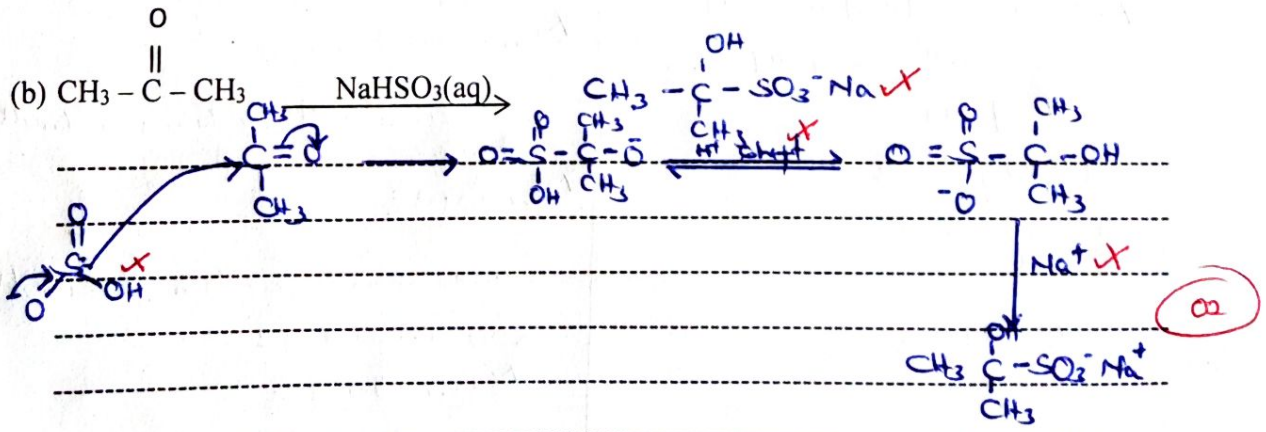
5. Complete the following reactions and write the accepted mechanism.

(a)



02

(b)



02

6. (a) (i) Explain what is meant by the order of a chemical reaction. (1 mark)

This is the sum of the powers to which the concentration terms of the reactants are raised in the experimentally determined rate equation. 01

Reg. without experimental rate equation.

(ii) Name two methods used to determine orders of reactions. (1 mark)

- Inspection of experimental data ✓
- Graphical method ✓ 01
- Calculation ✓ Any two

(b) The results obtained for the Kinetics of the decomposition of nitrogen (V) oxide are given in the table below.

$[N_2O_5]$/ moldm^{-3}	Initial rate/moldm^{-3} S^{-1})
1.6×10^{-3}	0.12
2.4×10^{-3}	0.18
3.2×10^{-3}	X

Calculate the: (4 marks)

(i) Order of reaction

Using experiments 1 and 2.

$\left(\frac{2.4\times10^{-3}}{1.6\times10^{-3}}\right)^n = \left(\frac{0.18}{0.12}\right)$ ✓

$1.5^n = 1.5$ ✓ 02

$n = 1$ ✓ Order is 1

accept first order.

(ii) Value of X.

Using experiments 1 and 3.

$\left(\frac{3.2\times10^{-3}}{1.6\times10^{-3}}\right)^1 = \frac{X}{0.12}$ ✓

$2 = \frac{X}{0.12}$ ✓ 02

$X = 0.24$ ✓ mol dm^{-3} s^{-1} ✓ Deny ½ for no units.

7. (a) Write electronic configuration of;

(i) Nitrogen

$1s^2 2s^2 2p^3$. ✓ ½

(ii) Phosphorus

$1s^2 2s^2 2p^6 3s^2 3p^3 3d^0$. ✓ ½

(b) Explain why nitrogen only forms (NCl_3) whereas phosphorus forms the chlorides PCl_3 andPCl_5. (1 ½ marks)

Nitrogen atom is too small to accomodate five chlorine atoms, it also lacks the 2d orbital to increase receive a number of electrons from donors. Conversely phosphorus atom is large and also contains the 3d orbitals to accept electrons from chlorine atom. 1½

(c) Write equation(s) for the hydrolysis of phosphorus chlorides by water.

(i) Phosphourus (V) Chloride

Equation

$PCl_{5(s)} + 4H_2O \longrightarrow H_3PO_{4(aq)} + 5HCl_{(aq)}$

(ii) Phosphorus (III) Chloride. 03

Equation

$PCl_{3(l)} + 3H_2O \longrightarrow H_3PO_{3(s)} + 3HCl_{(g)}$

Reject unbalanced equation.

8. When $20cm^3$ of a hydrocarbon Z was exploded in $200cm^3$ of Oxygen (excess), it completely burnt with a sooty flame. The volume of residual gas after cooling to room temperature was $160cm^3$.On addition of aqueous Potassium hydroxide to the residual gas, the final volume of gas was $20cm^3$.

(a) Calculate the molecular formula of Z. (3 marks)

$C_xH_{y(g)} + \left(x + \frac{y}{4}\right)O_{2(g)} \longrightarrow x\,CO_{2(g)} + \frac{y}{2}H_2O_{(g)}$

Volume of reacted $O_2 = 200 - 20$

$= 180cm^3$

$20\left(x + \frac{y}{4}\right) = 180$

$x + \frac{y}{4} = 9$

$x + \frac{y}{4} = 90$

$y = 8$

∴ Molecular formula is C_7H_8

Volume of CO_2 produced $= 20x$

$= 160 - 20$

$= 140.$

$20x = 140$

$x = 7$

03

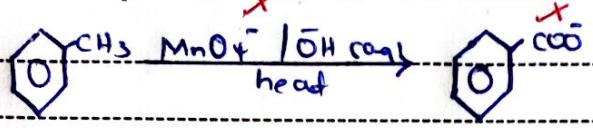
(b) When Z was heated with alkaline Potassium manganate (VII) solution forms a colourless solution which cooled in the presence of dilute sulphuric acid to form a crystalline solid P.

(i) Identify; (1 mark)

Z; Methyl benzene ✓ or 

P; Benzoic acid ✓ or  02

(ii) Write equations to show how P is formed. (1 ½ marks)

 01

9. (a) Explain why diffusion in solution is very much slower than in gases.

Particles in solution are moderately packed due to intermolecular forces ✓ which ✓ reduces their tendency to move freely ✓ and easily. Conversely in gases, the molecules are far apart ✓ due to very weak forces of attraction which increases their ✓ tendency to move freely and easily 02

(b) 141.4cm^3 of gas X diffused through a porous plug in the same time as it took 50cm^3 of Oxygen to diffuse through the same plug under identical conditions.
Calculate the relative molecular mass of X.

$$\frac{\text{Rate of diffusion of } O_2}{\text{Rate of diffusion of X}} = \sqrt{\frac{\text{Relative molecular mass of X}}{\text{Relative molecular mass of } O_2}} \checkmark$$

$$\left(\frac{\frac{50}{t}}{\frac{141.4}{t}}\right) = \sqrt{\frac{M_x}{16\times2}} \checkmark$$

$$\left(\frac{150}{141.4}\right)^2 = \frac{M_x}{32} \checkmark$$

$$M_x = 4 \checkmark$$ 02

SECTION B: (54 MARKS)

10. State what is observed and write equation for the reaction that takes place when;
(a) Potassium iodide is added to acidified hydrogen perioxide solution.

Observation

Brown colouration ✓ accept solution.

Equation (2½)

$2I^-_{(aq)} + 2H^+_{(aq)} + H_2O_{2(aq)} \longrightarrow 2H_2O_{(l)} + I_{2(aq)}$ ✗

(b) Concentrated hydrochloric acid is added dropwise until in excess to aqueous solution containing Cobalt (II) ions.

Observation

Pink ✗ solution turns blue ✗

Equation (2½)

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

(c) Aqueous Sodium hydroxide is added dropwise to aqueous solution containing beryllium (II) ions.

Observation White ✗ precipitate ~~soluble~~ ✗ soluble in excess to form a colourless solution

~~$Be^{2+}_{(aq)} + 2OH^-_{(aq)}$~~

Equation (04)

$Be^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Be(OH)_{2(s)}$ ✓✗

$Be(OH)_{2(s)} + 2OH^-_{(aq)} \longrightarrow Be(OH)_4^{2-}{}_{(aq)}$ ✓✗

11. (a) A compound Y contains by mass 22.86% Oxygen, 8.57% hydrogen and the rest carbon.
(i) Calculate the empirical formula of Y. (2 ½ marks)

Elements present	C	H	O
Percentage composition	68.57	8.57	22.86 ✗
Moles	$\frac{68.57}{12}$	$\frac{8.57}{1}$	$\frac{22.86}{16}$
	5.71	8.57	1.43 ✗
Mole ratio.	$\frac{5.71}{1.43}$ Deny	$\frac{8.57}{1.43}$ ½ for different decimal places	$\frac{1.43}{1.43}$ (2½)
	4	6	1 ✗

Empirical formula of Y is C_4H_6O ✓

(ii) When 0.30g of Y is vapourised at 80°C and 700mmHg pressure, it occupied a volume of 134.77cm^3. Determine the molecular formula of Y. (3 ½ marks)

$PV = \frac{mRT}{M_r}$ ✗

$M_r = \frac{mRT}{PV}$

$= \frac{0.3 \times 8.314 \times 353}{\frac{700 \times 101325}{760} \times 134.77 \times 10^{-6}}$ ✗

$= 70$ ✗

$(C_4H_6O)_n = 70$

$((12\times4)+(6\times1)+(16\times1))_n = 70$

$70n = 70$

$n = 1$ ✗

∴ Molecular formula of Y is C_4H_6O ✗

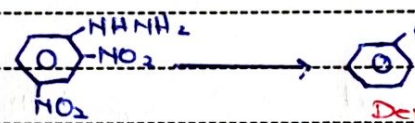
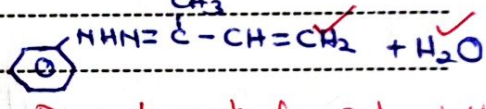
3½

(b) Y forms a yellow precipitate with 2,4 – dinitro phenyl hydrazine and does not react with Tollens' reagent. Identify Y. (1 mark)

$CH_3\overset{O}{\overset{\|}{C}}OCH=CH_2$ ✓

01

(c) Write equation for the formation of a yellow precipitate in (b). (2 marks)

$H_2C=CHCOCH_3 +$  $\longrightarrow$  $+ H_2O$ ✓

02

Deny 1 mark for water missing

12. (a) State three characteristics of chemical equilibrium. (2 ½ marks)

- It is produced only in a closed system ✓
- It is dynamic ✓
- It is reversible. ✓
- At chemical equilibrium, a reaction does not reach completion.

Any three.

1½

(b) Phosphorus (V) chloride when heated decomposed according to the following equation

$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

(i) Write the expression for the equilibrium constant K_C (1 mark)

$K_C = \frac{[PCl_3][Cl_2]}{[PCl_5]}$ ✓

01

(ii) When 1 mole of phosphorus (V) chloride was heated in a closed vessel at 350°C, the equilibrium mixture was found to contain 38.4% of chlorine. Calculate the equilibrium constant, K_C at 350°C. (3 ½ marks)

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

	PCl_5	PCl_3	Cl_2
Initial moles	1	0	0
Equil moles	$1-\alpha$	α	α

Total moles at equilibrium $= 1+\alpha+\alpha-\alpha$

$= 1+\alpha$

$\frac{38.4}{100} = \frac{\alpha}{1+\alpha}$

$0.348 + 0.384\alpha = \alpha$

$\alpha = 0.623$ moles

Let $v\ dm^3$ be volume of the vessel.

$[Cl_2] = \frac{0.623}{v}$ $[PCl_3] = \left(\frac{0.623}{v}\right)$ moldm^{-3}

$[PCl_5] = \left(\frac{0.377}{v}\right)$ moldm^{-3}

$K_C = \frac{[PCl_3][Cl_2]}{[PCl_5]}$

$K_C = \left(\frac{0.623}{v}\right) \cdot \left(\frac{0.623}{v}\right) \div \left(\frac{0.377}{v}\right)$

$= \left(\frac{1.03}{v}\right)$ moldm^{-3} (3½)

(iii) The equilibrium constant at 250°C is 1.54, state whether the reaction is exothermic or endothermic. Give a reason for your answer. (1 ½ marks)

Exothermic

Because the value of k_c increases with decrease in temperature owing to the shift of equilibrium position from left to right (1½)

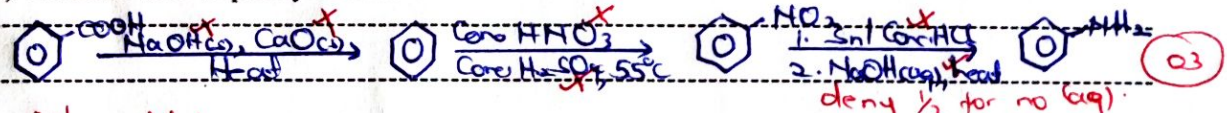
(c) State what would happen to the concentration of chlorine if the pressure in the vessel was decreased while the temperature is maintained at 350°C. Give a reason for your answer. (1 ½ marks)

The concentration of chlorine would increase.

This is because the forward reaction proceeds with increase in volumes. So decrease in pressure shifts equilibrium position from the left to the right which increases the concentration of chlorine (1½)

13. Write equation to show how the following conversions can be effected. [Include conditions for reactions]

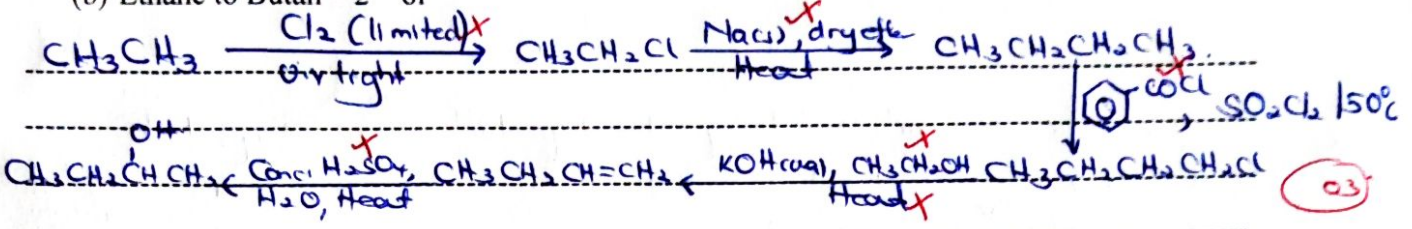
(a) Benzoic acid to phenylamine.



deny ½ for no (aq). (03)

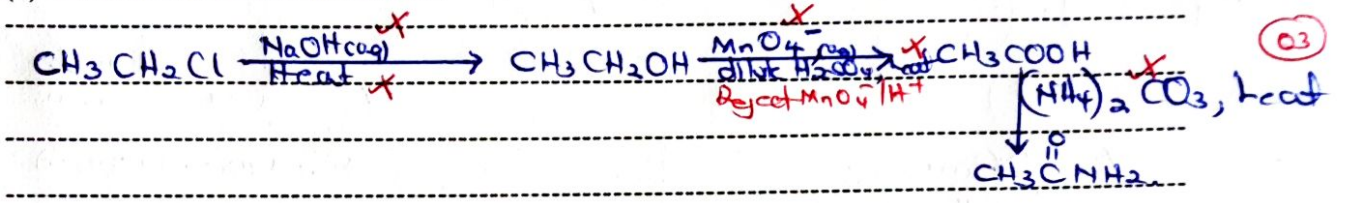
Alternatively

(b) Ethane to Butan – 2 – ol



03

(c) 1-chloro ethane to ethanamide.



03

14. (a) (i) Explain what is meant by an acid-base indicator. (1 mark)

An acid-base indicator is a weak acid or weak base which changes colour depending on the pH of the solution. ✓ 01

accept alkalinity or acidity

(ii) Explain why titration experiments only one or two drops are used. (1 mark)

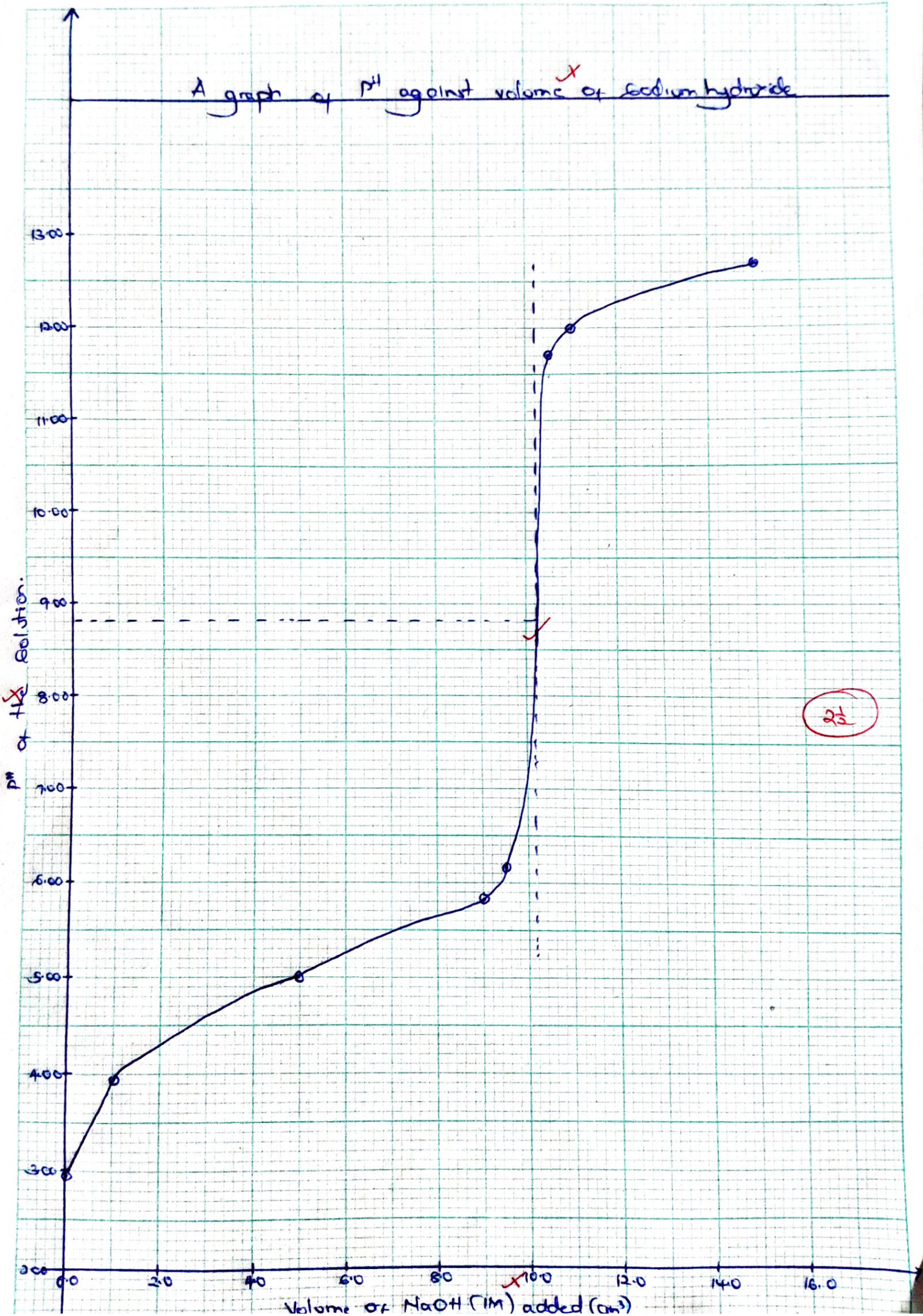
To control the reaction which would be vigorous and yield an unwanted side products. 01

(b) The table below gives data obtained when 100cm^3 of propanoic acid was titrated with 1.0M sodium hydroxide solution

Volume of NaOH (1m) added (cm^3)	0.0	1.0	5.0	9.0	9.5	10.5	11.0	15.0
pH of solution	2.94	3.92	4.87	5.82	6.15	11.70	12.00	12.70

(i) Draw a graph of pH against the volume of sodium hydroxide. (2 ½ marks)

A graph of pH against volume of sodium hydroxide



2½

(ii) Explain the shape of the graph you have drawn in b(i) (2 ½ marks)

Initially pH before addition of any base is low (ie below 7) because propanoic acid is a weak acid. The pH gradually increases because neutralization takes place, which constitutes a buffer solution that resists any further increase in pH. pH sharply increases even when a small amount of NaOH because all the acid has undergone complete neutralization. At end point pH is above 7 pH gradually increased due to excess NaOH added. (2½)

(iii) Determine the pH of the solution at equivalence point (1 mark)

8.80 ✓ (01)

(iv) Which of the following indicators would be suitable for the titration? Give a reason for your answer

Indicator	Methyl red	Bromothymol blue	Phenol red
pH range	4.2 – 6.3	6.0 – 7.6	6.8 – 8.4

Indicator

No suitable indicator. ✗

Reason (01)

Because pH at end point does not lie with in the pH range of any of the given indicator.

15. (a) Compare the following properties of group (II) and group (I) elements. In each case, give a reason for your answer.

(i) First ionization energy

Group II elements have higher first ionization energies than corresponding group I metals. Group (II) metals have fully filled outermost s-subshell hence thermodynamically very stable ns^2 and also the outermost electrons are tightly held owing to their small atomic radius as compared to large atoms of group 1 metals with neither fully filled nor half filled outermost sub-shells. (1½)

(ii) ~~Melting point~~ Electropositivity

Group II element are less electropositive than group I metals. In group II metals, the atoms have a smaller atomic radius compared to group I metals hence greater nuclear charge in group I metal atoms; the electrons in the outermost shell are attracted more strongly and not easily lost which reduces electropositivity (1½)

(iii) ~~Electro positivity~~ Melting point

Group II metals have higher melting point than group 1 metals because of their strong metallic bonds attributed to the strong metallic bonds fact that group II metals contribute two electrons to the charge cloud for metallic bonding, group 1 metals atoms contribute only one electron to the charge cloud for metallic bonding. (1½)

(b) The decomposition temperatures of the carbonates of group (II) elements are given below

Carbonate	$MgCO_3$	$CaCO_3$	$SrCO_3$	$BaCO_3$
Decomposition temperature °C	404	826	1098	1370

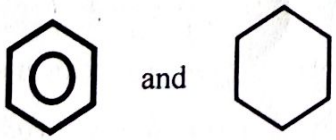
(i) State how the decomposition temperatures vary (1 mark)

Decomposition temperatures d increase from $MgCO_3$ to $BaCO_3$ (01)

(ii) Explain your answer in (b) (i) (3 ½ marks)

From $MgCO_3$ to $BaCO_3$, the charge densities of the metal cations progressively decrease due to an increase in cationic radius so that the metal carbonates become more ionic hence more thermally stable in line with polarising. In addition the oxide is smaller than a carbonate ion hence the decomposition of the metal carbonate becomes less energetically favourable down the group (2½)

16. Name a reagent that can be used to differentiate between the following pairs of compounds. State what would be observed if each compound is treated with reagent you have named.

(a)  and

Reagent Concentrated nitric acid and concentrated sulphuric acid at 55°C

Reject without 55

Observation  pale yellow liquid. ✓

 No observable change ✓ (03)

Accept liquid bromine and aluminium chloride at room temperature.

(b) 

Reagent Hot acidified potassium manganate (VII) solution.

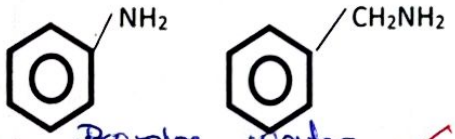
Observation - No observable change ✓ (03)

 - Purple solution to a colourless and bubbles of a colourless gas

Accept ammoniacal silver nitrate solution

 - silver mirror Accept other oxidising agent.

 - No observable change.

(c) 

Reagent Bromine water ✓

Observation  - white precipitate. (03)

 - No observable change.

Accept concentrated hydrochloric acid and sodium nitrite solution

17. Ethanol can be produced by fermentation of molasses.

(a) (i) Name two other raw materials from which ethanol can be produced by fermentation.

Cassava flour (starch), Ripe bananas, millet, sorghum ✓ molasses ✓ and yeast (01)

(ii) Write equations to show how crude ethanol can be obtained from the materials named above (3 marks)

From starch (cassava flour) and yeast

$2C_6H_{10}O_5 + H_2O \xrightarrow{\text{Diastase}} C_{12}H_{22}O_{11}$ ✓

$C_{12}H_{22}O_{11} + H_2O \longrightarrow 2C_6H_{12}O_6$ ✓ (03)

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + CO_2$

Accept other raw material

(b) Describe how 100% (absolute) ethanol can be produced from crude ethanol produced in (a) (ii)

Absolute ethanol can be produced from crude ethanol by distillation of crude ethanol using a third component benzene. When the mixture is distilled, the first azeotrope contains three components, ethanol water and benzene, further distillation yields benzene and ethanol as the second azeotrope and finally the last azeotrope will contain absolute ethanol. (02)

Accept chemical methods of adding calcium oxide, calcium oxide absorbs water leaving out ethanol.

(c) Write equation(s) to show how each of the following compounds could be obtained from ethanol

(i) Polyethene (1 ½ marks)

$CH_3CH_2OH \xrightarrow[+80^oC]{Conc.\ H_2SO_4} H_2C=CH_2$

High temperature
High pressure

(½)

(ii) Ethoxyethane. (1 ½ marks)

$CH_3CH_2OH \xrightarrow[140^oC]{Conc.\ H_2SO_4} CH_3CH_2OCH_2CH_3$ (1½)

or

$CH_3CH_2OH \xrightarrow{CH_3CH_2Cl + Na} CH_3CH_2OCH_2CH_3$

END