

Candidate's Name: **MUNICEL 2022 GUIDE**

Signature: *[Signature]*

Random No.				Personal No.			
0	7	8	2	0	7	5	2
7	9	2	7	5	0		

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

P525/1
CHEMISTRY
 (Theory)
 Paper 1
 Nov./ Dec. 2022
 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 your answers **must** be written 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, $R = 8.31 \text{ JK}^{-1} \text{ mol}^{-1}$.

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
4	4	6	4	6	5	5	5	6	9	9	9	9	9	9	9	9	100

SECTION A (46 MARKS)

Answer all questions in this section.

1. Complete the following nuclear reaction equations:

- Symbols should be correct*
- Atomic masses
- Atomic numbers
- (a) ${}^{30}_{15}\text{P} \longrightarrow {}^{30}_{16}\text{S} + \dots$ *β without figures* *eg: β* (01 mark)
- (b) ${}^{56}_{26}\text{Fe} + {}^2_1\text{H} \longrightarrow \dots$ *${}^{57}_{27}\text{Co}$* *$+ {}^1_0\text{n}$* (01 mark)
- (c) ${}^1_1\text{H} + {}^7_3\text{Li} \longrightarrow \dots$ *${}^8_4\text{Be}$* *eg: ${}^4_2\text{He}$ or 2α* (01 mark)
- (d) ${}^{234}_{90}\text{Th} \longrightarrow \dots$ *${}^{234}_{91}\text{Pa}$* *$+ {}^0_{-1}\text{e}$* (01 mark)

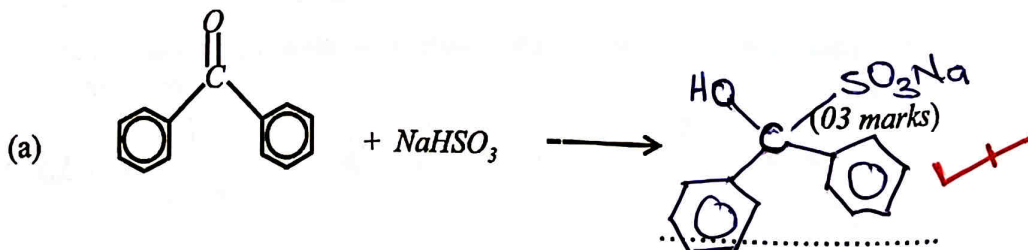
2. Draw the structure and state the shape of each of the following species in table 1.

Table 1

(4½ marks)

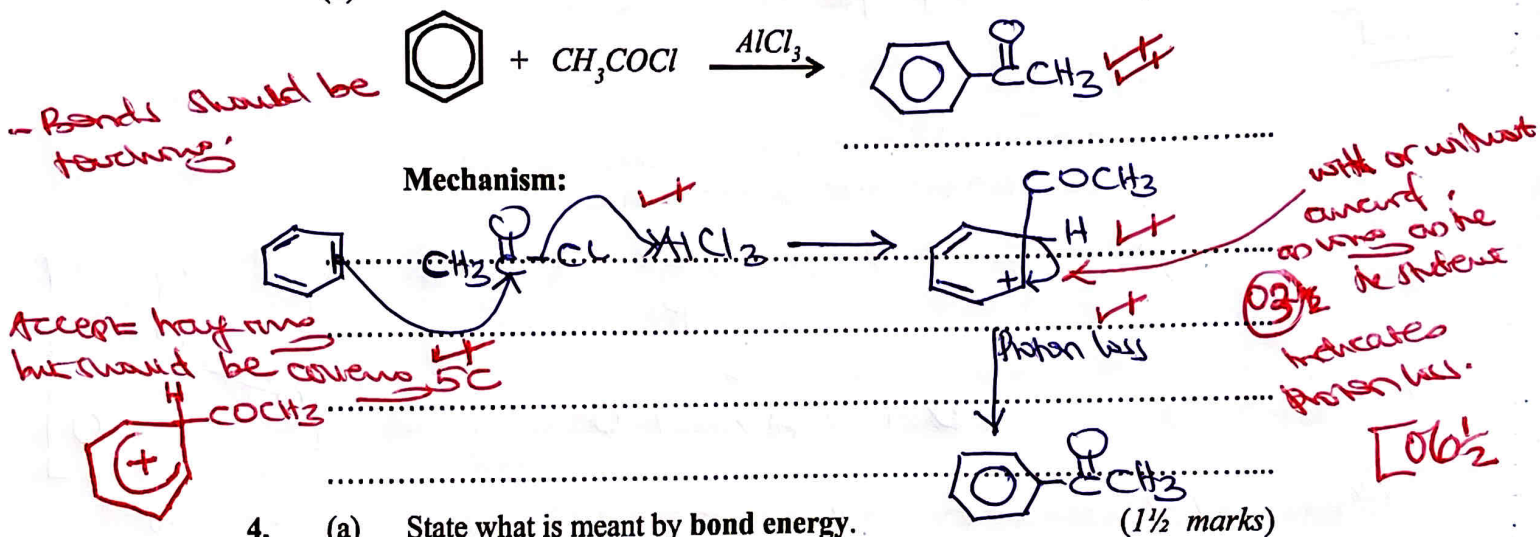
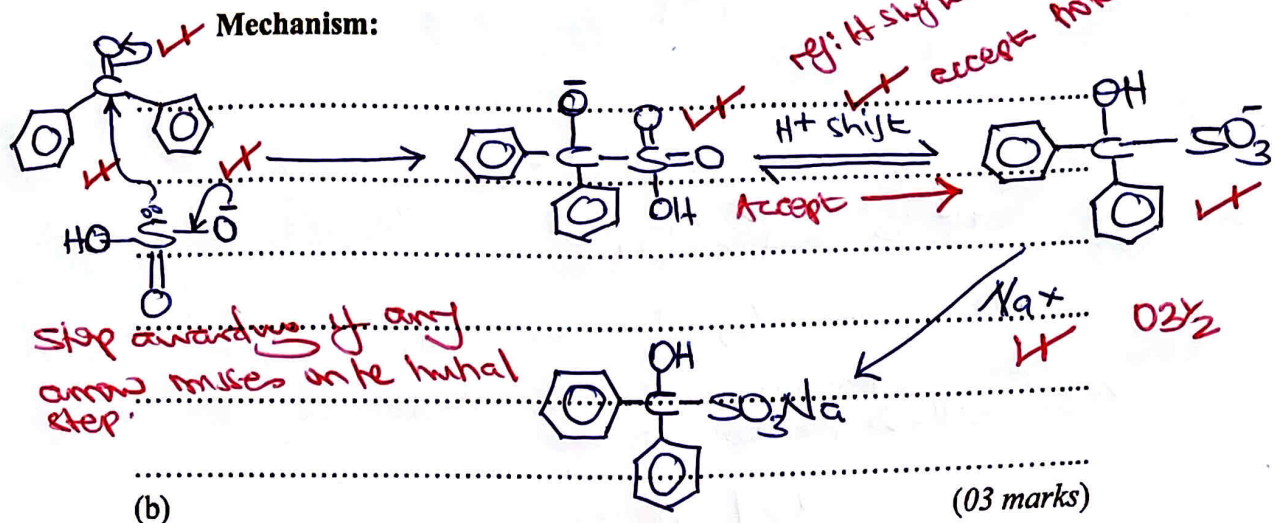
Species	Structure	Shape
SiO_3^{2-}		Trigonal planar
BrO_3^-		Trigonal pyramidal
Cl_2O		Bent or V-shaped

3. Complete the following equations and write a mechanism for the reaction in each case:



2

(Award if it is similar to the product in the mechanism)



4. (a) State what is meant by bond energy.

Amount of heat evolved when one mole of covalent bonds is formed from its free gaseous atoms.

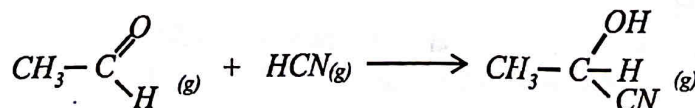
Heat absorbed when one mole of covalent bonds is broken to form free gaseous atoms.

Table 2 shows standard average bond energies for some selected bonds.

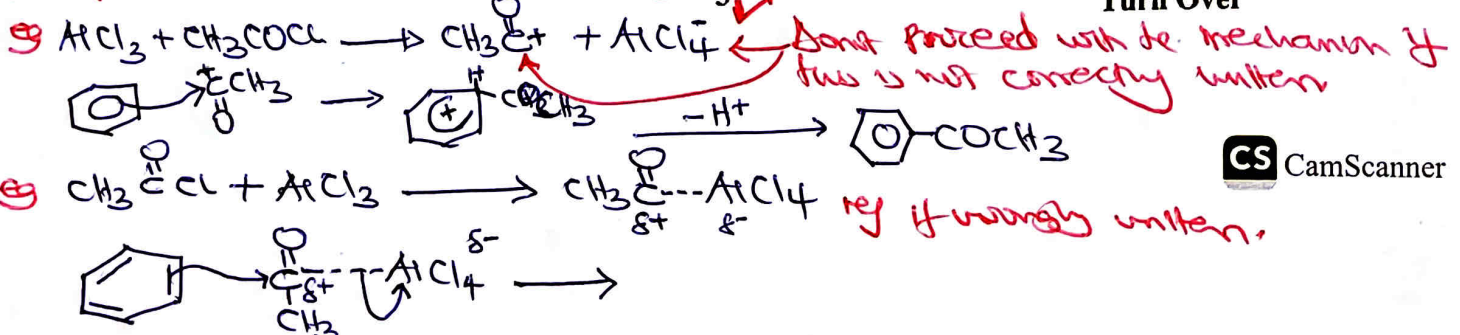
Table 2

Bond	C-C	C-O	C-H	H-O	C=O
Average bond energy (kJmol ⁻¹)	348	360	412	463	743

Use the data in the table to determine the standard enthalpy change of the reaction. (03 marks)



Accept alternative mechanisms (02 marks)



$$\Delta H_{\text{reaction}} = \sum \text{BE of bonds broken} + \sum \text{BE of bonds formed}$$

$$= (742 + 412) + (-360 - 462 - 348)$$

$$= -161 \text{ kJ mol}^{-1}$$

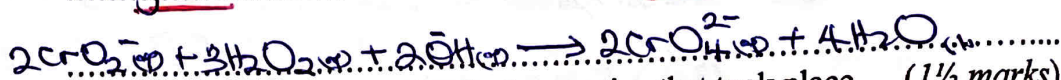
Accept alternative approaches eg
Born Haber cycle

5. (a) To a mixture of chromium(III) sulphate solution and excess sodium hydroxide solution, was added hydrogen peroxide solution and the resultant mixture heated.

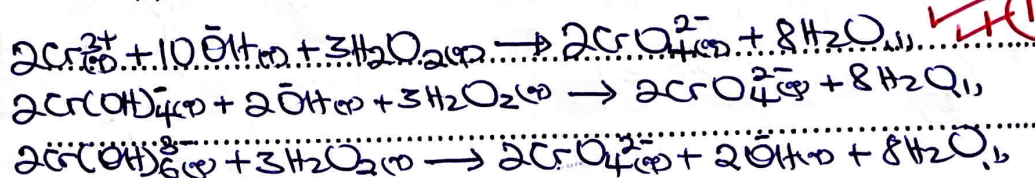
(i) State what was observed.

$\frac{1}{2}$ mark tied to both observations
($\frac{1}{2}$ mark)

A green solution turned yellow



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



(b) The resultant solution in (a) was divided into portions and treated as follows:

(i) To the first portion dilute sulphuric acid was added. State what was observed and write an equation for the reaction that took place.

Observation:

(½ mark)

Yellow solution turned orange

Equation:

(1½ marks)



(ii) To the second portion, a few drops of lead(II) ethanoate solution was added. State what was observed and write an equation for the reaction that took place.

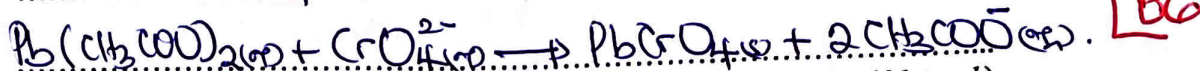
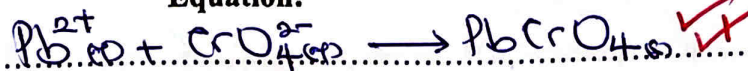
Observation:

(1/2 mark)

Yellow precipitate formed. Also ppt / solid

Equation:

(1 1/2 marks)



6. (a) State what would be observed if benzene was added to water. (01 mark)

Two layers formed

Also: Two liquid layers.

- (b) An organic compound Q is soluble in both water and benzene. 0.5 moles of Q was shaken with a mixture containing 40 cm³ of water and 20 cm³ of benzene and the mixture allowed to stand until equilibrium was attained.

(K_D for Q between benzene and water at 25 °C is 5.)

Calculate the number of moles of Q in the water.

(04 marks)

Let moles of Q in benzene be x

$$[\text{Q}]_{\text{in H}_2\text{O}} = \frac{0.5-x}{40} \quad [\text{Q}]_{\text{in benzene}} = \frac{x}{20}$$

$$K_D = \frac{[\text{Q}]_{\text{in benzene}}}{[\text{Q}]_{\text{in water}}} \quad 5 = \frac{40x}{20(0.5-x)}$$

$$5 = \frac{x/20}{0.5-x/40}$$

$$x = 0.357$$

$$\text{moles of Q in water} = (0.5 - 0.357) = 0.143 \text{ moles}$$

$$K_D = \frac{[\text{Q}]_{\text{H}_2\text{O}}}{[\text{Q}]_{\text{benzene}}} = \frac{1}{5}$$

$$x = 0$$

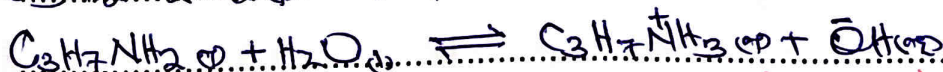
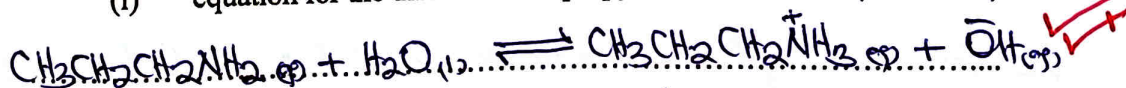
$$\text{Accept } 0.14$$

[05]

7. (a) Propylamine is a weak base.

Write an;

- (i) equation for the dissolution of propylamine in water. (1 1/2 marks)



reversible rxn missing deduct 1/2 mark

Accept: $K_b = \frac{[\text{OH}]^2}{c}$

$$[\text{OH}] = \sqrt{6.918 \times 10^{-4} \times 0.1}, \quad [\text{OH}] = 8.317 \times 10^{-3} \text{ M}$$

$$[\text{OH}] = c\alpha; \alpha = \left(\frac{8.317 \times 10^{-3}}{0.1} \right) = 0.0832$$

(ii) expression for the base dissociation constant, K_b , for propylamine.

(01 mark)

$$K_b = \frac{[\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_3][\text{OH}]}{[\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2]}$$

✓ ①

tried to do
rej. y au wrong

(b) Determine the degree of dissociation of a 0.1 M propylamine solution. (K_b for propylamine 6.918×10^{-4}) (2½ marks)

Accept

$$K_b = \alpha^2 c$$

$$\alpha = \sqrt{\frac{K_b}{c}}$$

$$\alpha = \left(\frac{6.918 \times 10^{-4}}{0.1} \right)^{\frac{1}{2}} = 0.0832$$

$$K_b = \frac{\alpha^2 c}{1-\alpha}, \quad 6.918 \times 10^{-4} = \frac{0.1 \alpha^2}{1-\alpha}$$

$$0.1 \alpha^2 + 6.918 \times 10^{-4} \alpha - 6.918 \times 10^{-4} = 0$$

$$\alpha = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= 0.0799 \approx 0.08$$

[05]

8. The industrial reaction in which sulphur dioxide is converted into sulphur trioxide in the contact process is reversible and exothermic.

(a) Write equation to illustrate the reaction.

(02 marks)



balanced

deduct ½ if missing

must be written before awarding

(b) Giving reason(s) in each case, state the effect on the equilibrium position of the reaction in (a) if;

(i) the temperature was increased.

(1½ marks)

Equilibrium shifts from right to left because the forward reaction is exothermic or because the backward reaction is endothermic

(ii) helium was added to the reaction mixture at constant volume.

(1½ marks)

Addition of helium at constant volume increases the pressure hence equilibrium shifts from left to right because the forward reaction is accompanied by a decrease in volume (or decrease in number of moles)

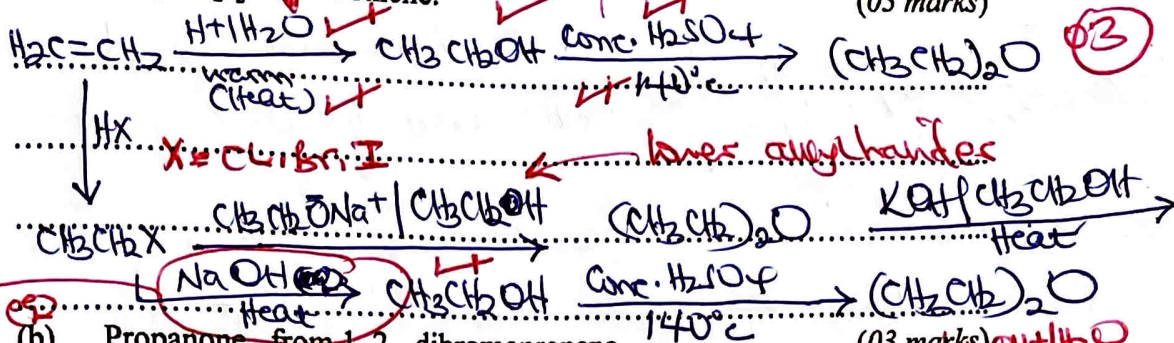
rej: partial pressure

[05]

9. Write equations to show how the following compounds can be synthesized:

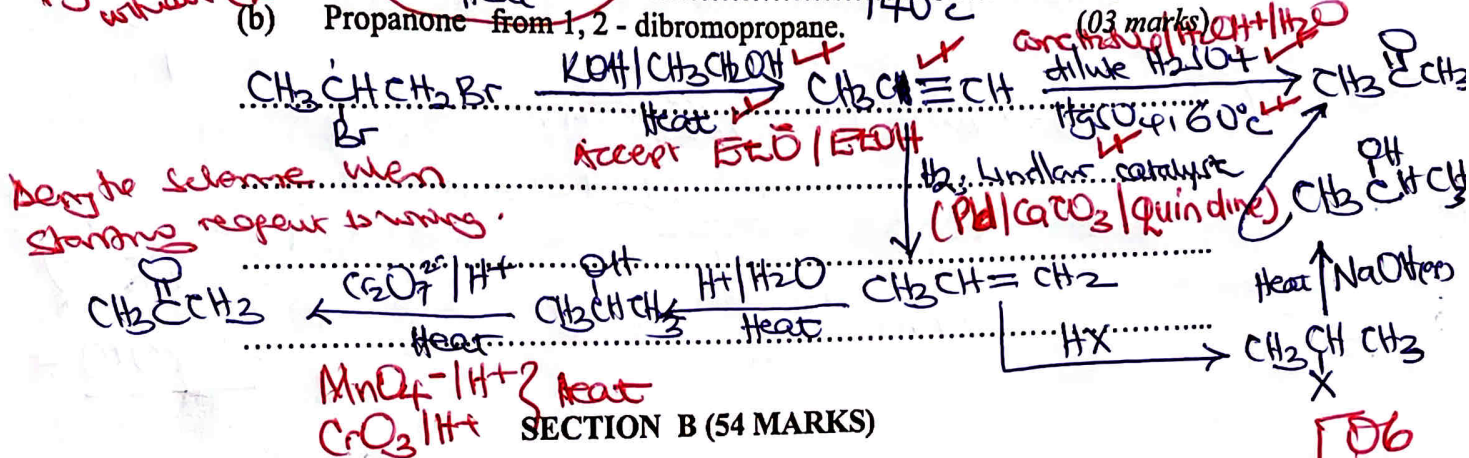
(a) $(CH_3CH_2)_2O$ from ethene.

(03 marks)



(b) Propanone from 1, 2 - dibromopropane.

(03 marks)

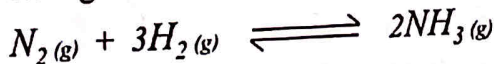


SECTION B (54 MARKS)

Answer six questions from this section.

Any additional question(s) answered will not be marked.

10. Nitrogen reacts with hydrogen according to the following equation:



(a) State the condition(s) that favour formation of ammonia. (1½ marks)

Any wrong condition cancels correct one.

Low temperature or 450-500°C

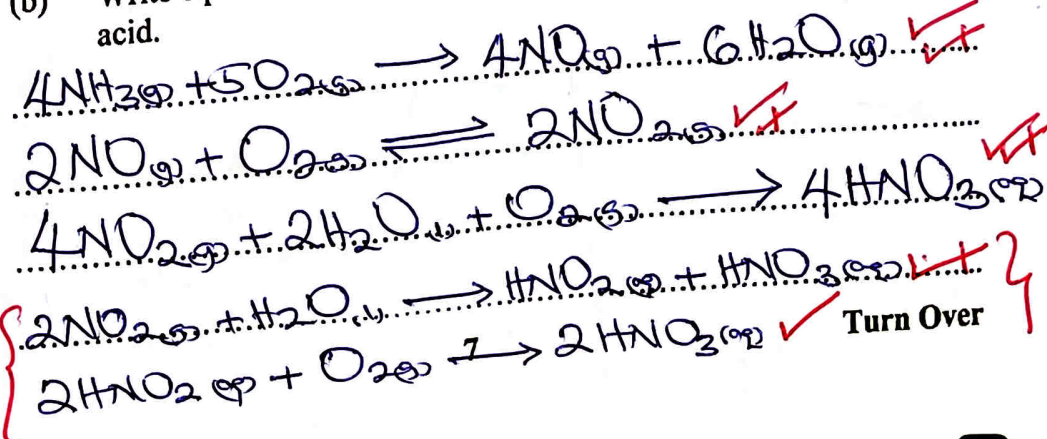
High pressure or 200-1000 atmosphere

Iron catalyst

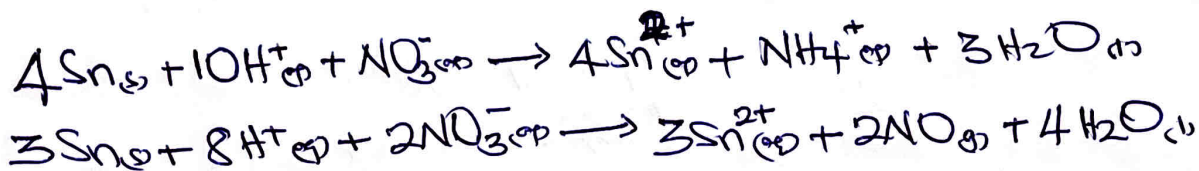
rej: catalyst; iron catalyst

accepts quite correctly phase any temp in range.

(b) Write equation(s) to show how ammonia can be converted to nitric acid. (4½ marks)

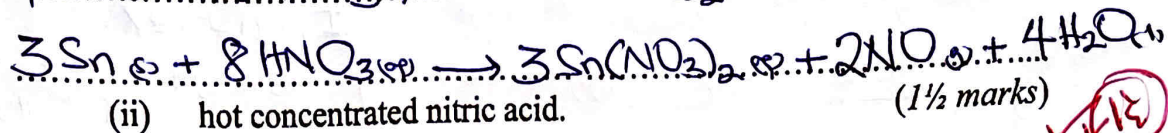
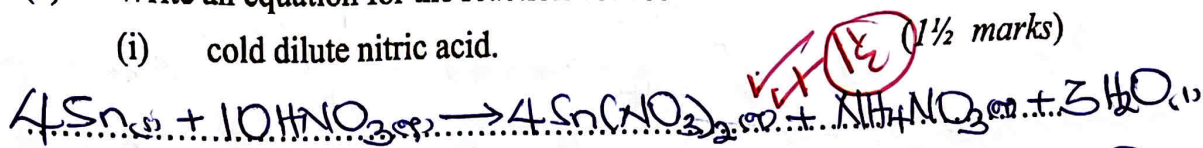


Turn Over

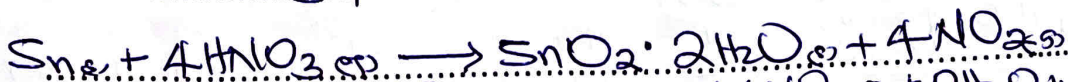


(c) Write an equation for the reaction between tin and

(i) cold dilute nitric acid.



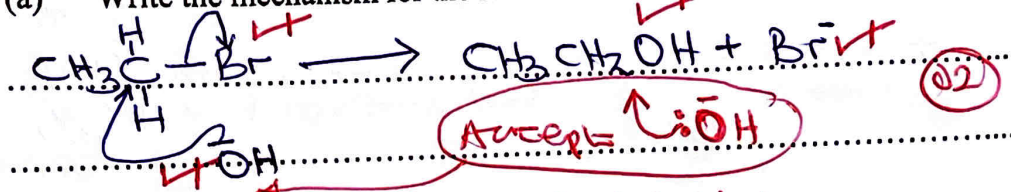
(ii) hot concentrated nitric acid.



11. Ethylbromide reacts with aqueous sodium hydroxide solution according to the following equation:



(a) Write the mechanism for the reaction.



Accept: Bimolecular nucleophilic substitution

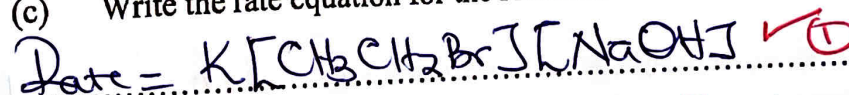
(b) Name the type of mechanism in (a).

Substitution nucleophilic bimolecular

Accept:

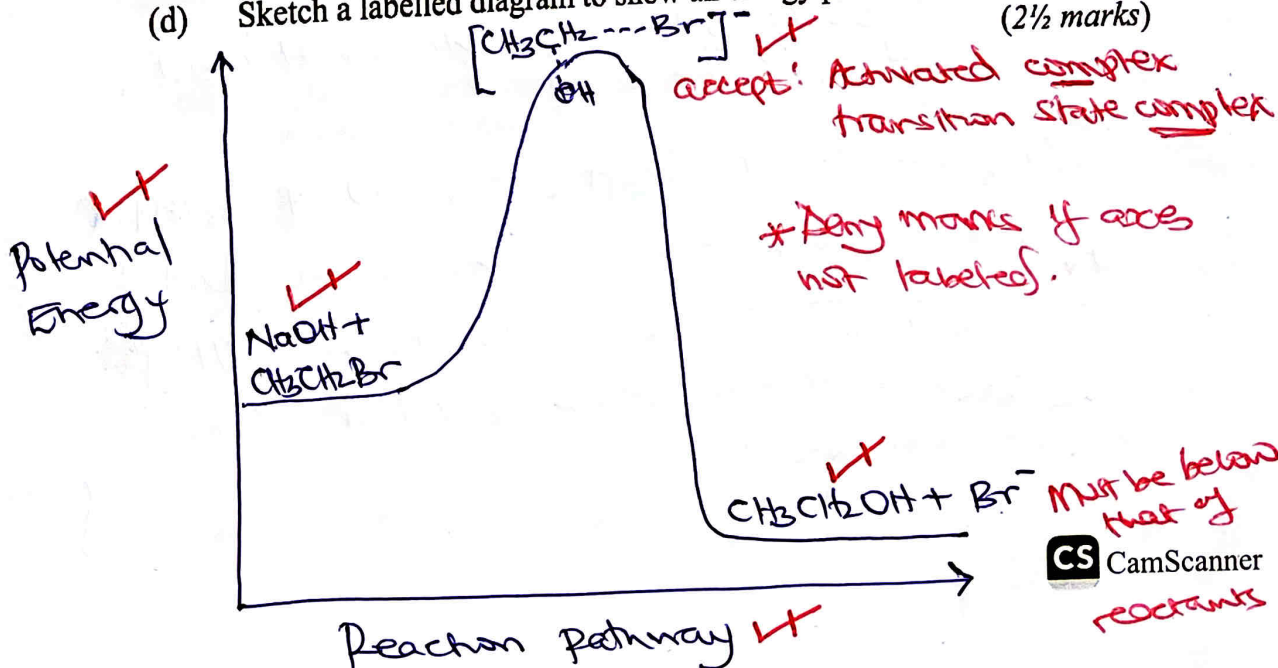
Nucleophilic substitution bimolecular

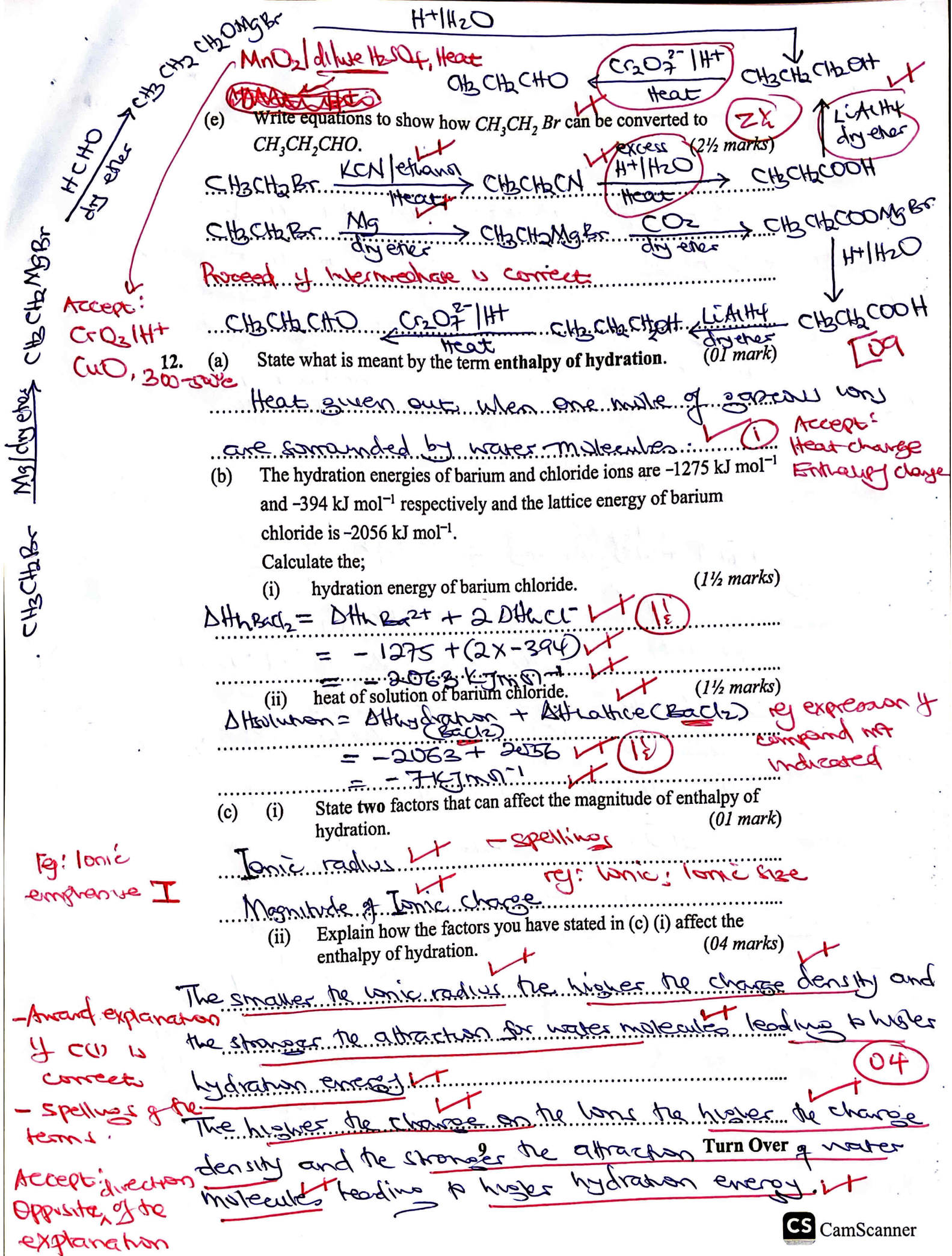
(c) Write the rate equation for the reaction.



Accept: $\text{Rate} = k[\text{CH}_3\text{CH}_2\text{Br}][\text{OH}^-]$

(d) Sketch a labelled diagram to show an energy profile for the reaction.





13. (a) A compound J contains 19.1% nitrogen, 43.6% oxygen by mass, the rest being manganese.

(i) Calculate the empirical formula of J.

(2½ marks)

$$\% \text{Mn} = 100 - (19.1 + 43.6) = 37.3 \quad \checkmark$$

Elements	Mn	:	N	:	O	rel: N_2 : O_2 : Mn
No. g moles	$\frac{37.3}{54.9}$		$\frac{19.1}{14}$		$\frac{43.6}{16}$	$\checkmark$
	0.679		1.364		2.725	
Mole ratio	$\frac{0.679}{0.679}$		$\frac{1.364}{0.679}$		$\frac{2.725}{0.679}$	$\checkmark$ (2½)
	1		2		4	$\checkmark$

Empirical formula of J is MnN_2O_4 $\checkmark$

← symbols must be correct

- (ii) 10 g of J in 1000 g of water lowered the freezing point of water by 0.127°C . Determine the molecular formula of J.

(K_f for water = $1.86^\circ\text{C mol}^{-1} \text{kg}^{-1}$)

(02 marks)

0.127°C is depression in freezing point caused by 10 g J

1.86°C is depression in freezing point caused by (10×1.86)

$$\checkmark \frac{10 \times 1.86}{0.127}$$

$$\checkmark = 146.5$$

$$(\text{MnN}_2\text{O}_4)_n = 146.5$$

$$(54.9 + 28 + 64)n = 146.5 \quad (62)$$

$$146.9n = 146.5$$

$$n = 1 \quad \checkmark$$

Molecular formula of J is MnN_2O_4 $\checkmark$

rel: if it is wrong

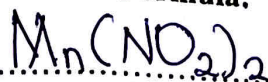
rel: $\text{Mn}(\text{NO}_2)_2$

- (b) When a few drops of concentrated nitric acid were added to a solution of J, followed by a little lead(IV) oxide and the mixture boiled, a purple coloured solution was formed.

Write the;

- (i) formula and name of J. (01 mark)

Formula:

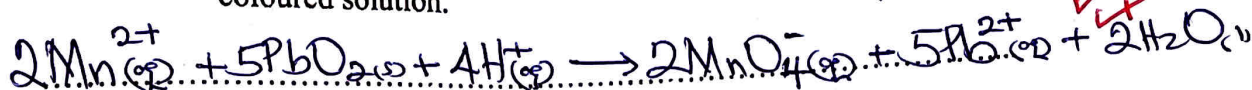


Name:

Manganese(II) nitrite ✓

rej: Manganese(II) nitrate solution.

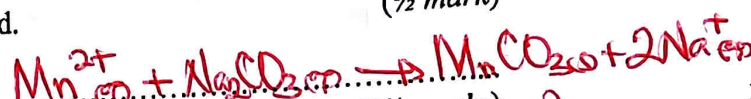
- (ii) equation for the reaction leading to formation of the purple coloured solution. (1½ marks)



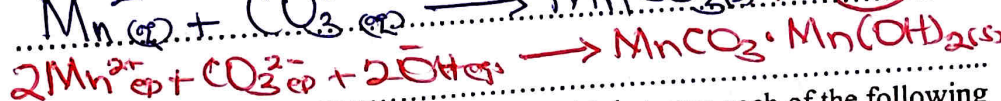
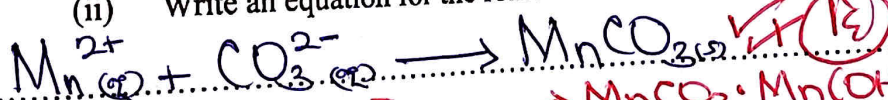
- (c) A few drops of aqueous sodium carbonate was added to a solution of J. (½ mark)

- (i) State what was observed.

White precipitate ✓



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

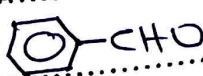


14. Name a reagent that can be used to distinguish between each of the following pairs of compounds. In each case state what would be observed if each member of the pair was separately treated with the reagent you have named. (03 marks)

- (a) C_6H_5CHO and CH_3CHO .

Iodine solution and sodium hydroxide solution ✓

rej: Iodoform

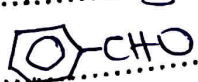


No observable change ✓

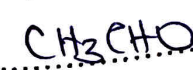


Yellow precipitate ✓

Fehling's solution or Benedict's solution (and heat) ✓



No observable change ✓



Reddish brown precipitate (on heating) ✓

Allow hot Fehling's solution. ✓ accept red precipitate

Turn Over

Accept ppt / solid

Ammoniacal silver nitrate
 Ammoniacal copper(I) chloride solution
 $\text{CH}_3\text{CH}_2\text{C}\equiv\text{CH}$ Red precipitate *rej: (reddish brown ppt.)*
 $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ No observable change
 (b) $\text{CH}_3\text{CH}_2\text{C}\equiv\text{CH}$ and $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$. (03 marks)

Ammoniacal silver nitrate solution *rej: Tollen's reagent*
 $\text{CH}_3\text{CH}_2\text{C}\equiv\text{CH}$ White precipitate *rej: formulae*
 $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ No observable change. (03)

Alkaline: Aqueous ammonia and silver nitrate solution.

(c) $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$ (03 marks)
accept at room temp

rej: After 5 minutes. Anhydrous zinc chloride and concentrated hydrochloric acid
- emphasise range $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ No observable change at room temperature
rej: white precipitate / cloudiness *rej: Lucas reagent.* (03)

$\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$ - Forms cloudy solution / turbid solution / two layers within 5-10 minutes. (04)

15. (a) Briefly explain what is meant by the term **basic buffer**. (02 marks)

A solution of a weak base and its salt from a strong acid that results pH change when a small amount of acid or alkali is added or diluted and has a pH greater than 7. (02)

(b) 500 cm³ of a 1 M solution of ammonia was mixed with 500 cm³ of a 1 M ammonium chloride solution.

Calculate the pH of the resultant solution. (05 marks)

(pK_b of ammonia solution = 4.74)

$$\begin{aligned} \text{p}K_b &= -\log K_b \text{ or } -\log K_b = 4.74 \\ K_b &= 10^{-4.74} \\ &= 1.819 \times 10^{-5} \text{ mol dm}^{-3} \\ K_b &= \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} \\ \text{pOH} &= -\log [\text{OH}^-] \\ &= -\log(1.819 \times 10^{-5}) = 4.74 \\ \text{pH} + \text{pOH} &= 14 \\ \text{pH} &= 14 - 4.74 = 9.26 \end{aligned}$$

$$\begin{aligned} \text{or } \frac{[\text{H}^+]}{[\text{OH}^-]} &= \frac{K_w}{K_b} \\ &= \frac{1.0 \times 10^{-14}}{1.819 \times 10^{-5}} \\ &= 5.49 \times 10^{-10} \end{aligned}$$

$$\begin{aligned} \text{pH} &= -\log [\text{H}^+] \\ &= -\log(5.49 \times 10^{-10}) \\ &= 9.26 \end{aligned}$$

but complete dissociation of NH_4Cl :

$$[\text{NH}_4^+] = [\text{NH}_4\text{Cl}] = \left(\frac{1 \times 500}{1000}\right) \times \frac{1}{1000} \times 1000 = 0.5 \text{ M}$$

$$[\text{NH}_3] = \left(\frac{1}{1000} \times 500 \times \frac{1}{1000} \times 1000\right) = 0.5 \text{ M}$$

$$\begin{aligned} [\text{OH}^-] &= \frac{K_b [\text{NH}_3]}{[\text{NH}_4^+]} = \frac{1.819 \times 10^{-5} \times 0.5}{0.5} \\ &= 1.819 \times 10^{-5} \end{aligned}$$

$$pH = pK_w - pK_b + \lg \frac{[base]}{[salt]}$$

$$pH = -\lg \frac{K_w [salt]}{K_b [base]}$$

Accept alternative approach involving

$$pOH = pK_b - \lg \frac{[base]}{[salt]} ; pK_w =$$

$$pOH = pK_b + \lg \frac{[salt]}{[base]}$$

- (c) Two drops of dilute sodium hydroxide solution were added to the resultant solution in (b). State what happened to the pH of the solution. Give a reason for your answer. (02 marks)

pH remains constant. This is because hydroxyl ions from sodium hydroxide added react with ammonium ions from ammonium chloride to form ammonia solution (aqueous ammonia)

eg: Ammonium hydroxide

[04]

16. (a) State three properties in which cobalt differs from calcium. (1½ marks)

Cobalt forms many complexes

Has variable oxidation states

forms coloured compounds

- (b) To an aqueous solution containing cobalt(II) ions was added concentrated hydrochloric acid dropwise until in excess.

Name the cobalt species present in the solution;

- (i) before addition of hydrochloric acid.

(½ mark)

accept (ii)

Hexaqua cobalt(II) ion or Hexaquo cobalt(II) ion

- (ii) after addition of excess hydrochloric acid.

eg: (2) or 2, 11

(½ mark)

Tetrachlorocobaltate(II) ion

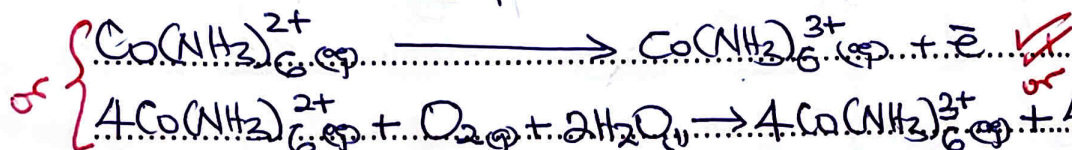
one word

(c) Concentrated ammonia solution was added dropwise until in excess to a solution containing cobalt(II) ions and the mixture allowed to stand.

(i) State what was observed.

Accept
A blue precipitate, soluble in excess to form a dark brown solution which turns reddish-brown on standing.

(ii) Write equation(s) for the reactions that took place. (4½ marks)



17. (a) A 2% solution of a monomer, M has the same osmotic pressure as 11.6 cm³ of a solution containing 1.65 g of a polymer of molecular mass 1040 at 298 K.

Calculate the relative molecular mass of M.

Accept 8.314 (03 marks)

$$\frac{\pi}{M_r} = \frac{nRT}{V} = \frac{1.65 \times 8.314 \times 298}{11.6 \times 10^{-6} \times 1040} = 338695.87 \text{ Nm}^2$$

Accept:
 $\pi = \frac{nRT}{V}$

$$\pi = nRT$$

- Follow the student's logical computation

$$M_r = \frac{nRT}{\pi} = \frac{2 \times 8.314 \times 298}{100 \times 10^{-6} \times 338695.87}$$

$$= 146.23$$

deg marks if units indicated.

$$\pi = \frac{nRT}{V}; \frac{M_A RT}{M_A V_A} = \frac{M_B RT}{M_B V_B}$$

A = Polymer
B = Monomer

$$\frac{1.65 \times 8.314 \times 298}{1040 \times 11.6 \times 10^{-6}} = \frac{2 \times 8.314 \times 298}{100 \times 10^{-6} \times M_B}$$

$$M_B = \frac{146.23 (R=8.314)}{146.32 (R=0.082)}$$

$$\frac{\pi_1}{C_1 T_1} = \frac{\pi_2}{C_2 T_2}$$

$$\frac{\pi_1}{C_1} = \frac{\pi_2}{C_2} \quad \frac{760}{11.6} = \frac{760}{22400}$$

$$\pi_1 = 2541.6 \text{ mmHg}$$

$$\frac{\pi_1}{C_1 T_1} = \frac{\pi_2}{C_2 T_2}$$

$$\frac{2541.6}{22400 \times 298} = \frac{760}{M_r \times 273}$$

CS CamScanner

$$M_r = 146.23$$

- (b) The structural formulae of some monomers are shown in the table 3. Complete the table by writing in the spaces provided; the structural formula of the polymers formed, type of polymerisation and one use of each polymer.

Table 3

(06 marks)

Structural formula of monomer (s)	Structural formula of polymer	Type of Polymerisation	Use of Polymer
(i) $\text{CH}_2=\text{C}(\text{CH}_3)-\text{CH}=\text{CH}_2$	$\left[\begin{array}{c} \text{H} \quad \text{CH}_3 \\ \quad \\ \text{---C---C---} \\ \quad \\ \text{H} \quad \text{H} \end{array} \right]_n$	Addition ① reject without (1) rej. Additional	tyres ✓ shoe soles surgical glove Insulators Condensers gumboots any one
(ii) $\text{HOCH}_2\text{CH}_2\text{OH}$ + $\text{H}-\text{C}(=\text{O})-\text{C}_6\text{H}_4-\text{C}(=\text{O})-\text{H}$	* Wrong polymer deny all marks. Ignored.		
(iii) $\text{CH}_2=\text{CH}-\text{CN}$	$\left[\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{---C---C---} \\ \quad \\ \text{H} \quad \text{CN} \end{array} \right]_n$ ↑ reject without (1)	Addition ✓	clothes / fabric Artificial finger nails carpets ③

17(a) 1.65g of polymer occupies 11.6 cm³ ✓
 1040g of polymer occupies $\frac{(11.6 \times 1040)}{1.65} = 7311.515 \text{ cm}^3$ ✓
 100 cm³ of solution is occupied by 2g of monomer ✓
 7311.515 cm³ solution is occupied by $\frac{2}{100} \times 7311.515$ ✓

$= 146.23$ ✓

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	