UGANDA TEACHERS' EXAMINATION SCHEME

Uganda Advanced Certificate of Education

JOINT MOCK EXAMINATIONS

CHEMISTRY

Paper 1

MARKING GUIDE

SECTION A (46 MARKS)

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

1. (a) (i) The decay ions is written as; $\frac{dN}{dt} = \lambda N.$

State what the following represent; *(1½ marks)*

λ Decay constant

N Number of atom present

$\frac{dN}{dt}$ rate of Elis integration of atomic nuclei in a given element. or Rate of decay of the decay of the atomic nuclei.

(ii) Using the above expression, derive the expression showing the relationship between decay constant and the half life.

(02 marks)

$$-\frac{dN}{dt} = \lambda N$$

$$\frac{1}{N}dN = -\lambda dt \quad \text{at} \quad t = t½, \; N_t = \frac{N_o}{2}$$

$$\int_{No}^{N_t} \frac{1}{N} dN \quad -\lambda \int_{t=0}^{t} dt$$

$$\text{In}\,[N]_{N_o}^{N_t} = -\lambda t$$

$$\text{In}\,\frac{N_t}{N_o} = -\lambda t$$

$$\text{In}\,\frac{N_o}{2/N_o} = -\lambda t½$$

$$\text{In}\,\frac{No}{2} \; x \; \frac{1}{No} = -\lambda t½$$

$$\text{In}\,(½) = -\lambda t½ \quad t½ = \frac{0693}{\lambda}$$

$$\lambda t½ = \text{In}\,2$$

(b) A radio Isotope has a half life of 10 minutes, calculate the percentage of the isotope that remains after 40 minutes. *(2 marks)*

$t½ = 10$ $N_t = ?$ $N_o = 100$ $t = 40$ minutes

$t½ = \frac{0.693}{\lambda}$

$\lambda = \frac{0.693}{t½}$

$= \frac{0.693}{10}$

$0.0693\ min^{-1}$

$N_t = 100 \times 0.062$

$N_t = 6.25$ cowts

$N_t = N_o\, e^{-\lambda t}$

$N_t = 100 \times e^{-0.0693 \times 40}$

$N_t = 6.25\%$

Accept alternative methods $23.3 \log \frac{N_o}{N_t} = \lambda t$

2. (a) State three properties in which beryllium and aluminum are similar. *(1½ marks)*

- Both form chlorides which are mainly covalent / dimerise
- Both metals are rendered ~~passure~~ passive by concentrated nitric acid.
- Both metals react with sodium hydroxide / alkalis to liberate hydrogen gas.
- Both oxides and hydroxides of these metals are amphateric.
- Carbides of both metals produce methane on hydrolysis.

(b) Write the equation(s) for the reaction(s) between the following

(i) Aluminum and Sodium hydroxide *(1½ marks)*

$$2\,Al_{(s)} + 2\overline{O}H_{(aq)} + 6H_2O_{(l)} \longrightarrow 2Al(OH)_4^-{}_{(aq)} + 3H_{2(g)}$$

(ii) Aluminum carbide and water *(1½ marks)*

$$Al_4C_{3(s)} + 12H_2O_{(l)} \longrightarrow 4Al(OH)_{3(s)} + 3CH_{4(g)}$$

3. Complete the following equations, giving the IUPAC name of the main organic product in each case.

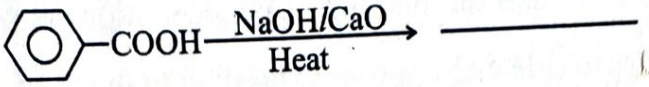
(i) $CH_3CH_2CHICH_3 \xrightarrow[\text{Heat}]{\text{ROH/alcohol}} CH_3CH=CHCH_3 + KI$ *(1½ marks)*

Name of product But-2-ene.

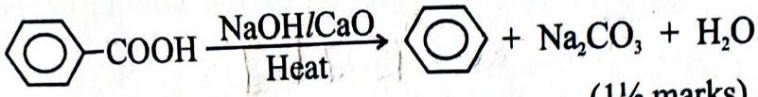
(ii) $CH_3CO_2H + CH_3OH \underset{\text{Heat}}{\overset{H^+}{\rightleftharpoons}} CH_3CO_2CH_3 + H_2O$ *(1½ marks)*

Name of product Methyl ethanoate

(iii)



(1½ marks)



(1½ marks)

Name of product Benzane

4. (a) What is meant by the term "order of reaction". *(02 marks)*

- Is the sum of powers to the concentration terms of all reactants are raised in the rate equation.

(b) Methyl ethanoate is hydrolysed by water in preserve of an acid according to the following equations:

$$CH_3CO_2CH_3 + H_2O \underset{}{\overset{H^+}{\rightleftharpoons}} CH_3CO_2H + CH_3OH$$

(i) State the molecularity of the reaction *(01 mark)*

- Three

(ii) Determine the order of the reaction (Assume that the acid takes part in the reaction). *(01 mark)*

- Second order

(iii) State the condition(s) under which the reaction can be overall first order. *(01 marks)*

When the acid acts as a catalyst and water is in large excess amount making its concentration constant.

5. Sulphurtrioxide decomposes according to the following equation.

$$2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)} \quad \Delta H^{\theta} = +ve.$$

(a) Write the expression for the equilibrium constant, Kc. *(01 mark)*

$$Kc = \frac{[SO_2]^2[O_2]}{[SO_3]^2}$$

(b) (i) 3.4 moles of sulphurtrioxide was decomposed at 60^0C in a $50cm^3$ vessel. When equilibrium was established, the amount of sulphur dioxide formed was found to be 0.06 moles. Calculate the equilibrium constant, Kc for the reaction at 60^0C. *(04 marks)*

$$2SO_{3(l)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$$

Initial moles 3.4 — — $1000cm^3 = 1dm^3$

Moles that reacts 0.06 0.06 0.03 $50cm^3 = {}^{50}/_{1000}\ dm^3$

Moles at equilibrium 3.34 0.06 0.03 $= 50 \times 10^{-3} dm^3$

Concertation at eq=m $\frac{3.34}{50 \times 10^{-3}}$ $\frac{0.06}{50 \times 10^{-3}}$ $\frac{0.03}{50 \times 10^{-3}}$

66.8 1.2 0.6

$$Ke = \frac{(SO_2)^2 (O_2)}{(SO_3)^2}$$

$$= \frac{(1.2)^2 \times 0.6}{(66.8)^2} = 1.936 \times 10^{-4} \text{ moldm}^3$$

(ii) State what would happen to the Kc value if the reaction was carried out at 100^0C. Give a reason for your answer. *(02 marks)*

- The value of the Ke would increase because increase in temperature favours the forward reaction ~~size~~ since the reaction is endothermic.

6. (a) State what would be observed and write equation for the reaction(s) that would take place when the following pairs of compounds are reacted.

(i) Ethyne and silver nitrate in aqueous ammonia. *(02 marks)*

Observation

- A white precipitate.

Equation

$HC \equiv CH + 2Ag(NH_3)_2 + NO_3^- \longrightarrow Ag\ C \equiv CAg^+ + 2NH_4NO_3 + 2NH_3$

OR

$HC \equiv CH + 2AgNO_3 + 2NH_3 \longrightarrow Ag^+ + \overline{C} \equiv \overline{C}Ag^+ + 2NH_4NO_3$

(ii) Ethanal and silver nitrate in aqueous ammonia *(02 marks)*

Observation

- A silver mirror or precipitate of solver mirror

Equation

$CH_3CHO + 2AgNO_3 + 2NO + H_2O \longrightarrow CH_3COO^- + 2NH_4NO_3 + Ag$

OR

$CH_3CHO + Ag(NH_3)_2 + H_2O$ $CH_3COO\_Ag_{(s)} + 2NH_4^+$.

(b) Name a reagent that can be used to distinguish between cyclohexane and cyclohexene, state what would be observed when the compounds are separately treated with the reagent you have named. *(02 marks)*

Reagent

Bromine water or acidified potassium permanganate solution.

Observation

- With cyclohexane no observable change
- With cyclohexane brown liquid / turns colouless with bromine water / purple solution turning colourless with acidifies potassium permanganate.

7. A weak acid, RCOOH has a concentration of 0.04 moldm^{-3}.

(a) Write an expression for the acid dissociation constant , Ka for RCOOH. $RCOOH \rightleftharpoons RCOO^- + H^+$ *(01 marks)*

$$Ka = \frac{[RCOO^-][H^+]}{[RCOOH]}$$

Accept $Ka = \frac{[RCOO^-][H^+]}{[RCOOH]}$.

(b) Calculate its pH given that its Ka = 1.8 x 10^{-5} moldm^{-3} and hence the value of the degree of ionisation. *(04 marks)*

$RCOOH_{(aq)} \rightleftharpoons RCOO^-_{(aq)} + H^+$

$C - \propto C \qquad \propto C \qquad \propto C$

$Ka = \frac{(H^+)^2}{C}$ At eqn $(RCOO^-) = (H^+)$

$(H^+) = \sqrt{KaC}$

$= \sqrt{1.8 \times 10^{-5} \times 0.04}$

$= 8.485 \times 10^{-4}$

$pH = -\log(H^+) = -\log 8.485 \times 10^{4}$

$= 3.07$

$(H^+) = \propto C$

$\propto = \frac{(CH^+)}{C} = \frac{8.485 \times 10^{-4}}{0.04} = 0.02\%$

8. The first ionization energies of the elements Lithium to Neon in $KJmol^{-1}$ are given in the table below.

Li	Be	B	C	N	O	F	Ne
519	900	799	1090	1400	1310	1680	2080

(a) Explain why the ionization energies show an overall tendency to increase across the period. *(03 marks)*

A cross the period atomic number / number of protons increased which increase the effective nuclear charge than the shielding / screening effect thus more energy is required to remove an electron hence increase in ~~ionisation~~ ionisation energy.

(b) Why is the ionization energy of boron lower than that of beryllium. *(02 marks)*

Boron ($1s^2 2s^2 2p^1$) has its electron removed from a partially filled p-suborbital thus easy to remove Beryllium ($1s^2 2s^2$) is removed from fully filled S-orbital which is thermodynamically stable hence difficult to remove.

9. 0.01 mole of a hydrocarbon with molar mass 54 on complete combustion yielded 1.76g of carbondioxide. Determine its molecular formula and hence the structural formulae of two (2) straight chain Isomers of it. *(03½marks)*

Molar mass of $CO_2 = 12 + 32 = 44$

Mass of $C = \frac{12}{44} \times 1.76 = 0.48$

1 mole of hydrocarbon has 54g

0.01 mole of hydrocarbon has 0.01 x 54g = 0.54g

Mass of hydrogen = 0.54 – 0.48 = 0.06g

Element C : H

Mass / RAM	0.48 / 12	: 0.06 / 1
	0.24	: 0.06
Simples ratio	0.04/0.04	0.06/0.04
	(1	1.5) x 2
	2	3

Empirical formula is C_2H_3

$(C_2H_3)_n = 54$

$27n = 54$

$n = 2$

M.F = C_4H_6

⇒ $CH_3CH_2C{\equiv}CH$.

$CH_3C{\equiv}CCH_3$.

SECTION B (54 MARKS)

10. Q (molar mass 86) and R (molar mass 100) form an ideal solution that obeys Raoult's law. At 30^{0}C, the saturated vapour pressures of pure Q and pure R are 30kNm^{-2} and 12kNm^{-2} respectively. The table below shows the variation of partial vapour pressures of Q and R with composition

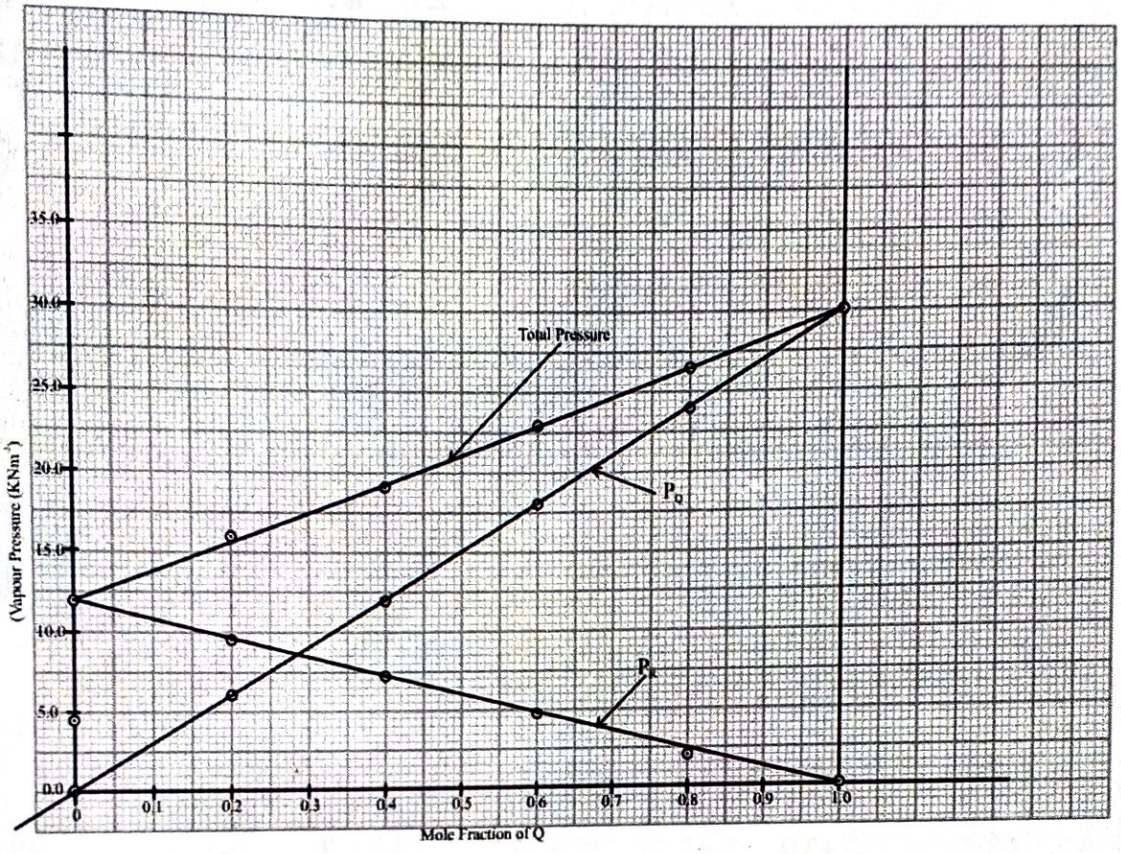
Mole fraction of Q	0.0	0.2	0.4	0.6	0.8	1.0
Partial vapour pressure of Q/kNm^{-2}	0	6	12	18	24	30
Partial vapour pressure of R/kNm^{-2}	12	9.6	7.2	4.8	2.4	0
Total vapour pressure /kNm^{-2}	12	15.6	19.2	22.8	26.4	30

(a) State Raoult's law *(01 mark)*

It states that the vapour pressure of a volatile components of a solution of a liquid mixture is the product of its pure vapour pressure and its mole fraction at constant temperature.

(b) On the same axes, plot a graph of partial vapour pressures and total vapour pressures against composition for Q and R.

Graph of portail vapour pressure of Q and R and dotal vapour pressure against composition.



(c) Use the graph in (b) to determine;

(i) The mole fraction of Q and R from a liquid mixture that produced the same partial vapour pressure *(01mark)*

Mole fraction of Q $= 0.275 \pm 0.1$

Mole fraction of R $= 0.725 \pm 1$

Accept 0.28

0.72

(ii) The mass of Q and R from a liquid mixture whose total vapour pressure is 26kNm^{-2}. *(03 marks)*

Molar masses of Q and R are 86 and 100 respectively

Mole fraction of Q at total pressure of $26KNm^{-2}$

0.635

Molar fraction of R at total pressure of $26KNm^{-2}$

0.365

Mass of Q $= 0.635 \times 86 = 54.61g$ } Left since molar mass

Mass of R $= 0.365 \times 100 = 36.5g$ } where not given in question

11. Cobalt, copper, iron and manganese are d-block elements.

(a) (i) What is meant by the term d-block element? *(01 mark)*

Elements in which the inner d-orbital is in the process of being filled with electrons.

OR

An element which has d-o-bitals as part of its valency shell.

(ii) Write down the electronic configuration of Cu, Fe^{2+} and Mn^{2+}. *(03 marks)*

Cu $15^2 25^2 2p^6 35^2 3p^6 45^2 3d^9$ **OR** $15^2 25^2 3p^6 35^2 45^1 3d^{10}$

Fe^{2+} $15^2 25^2 2p^6 35^2 3p^6 3d^6$.

Mn^{2+} $15^2 25^2 2p^6 25^2 3p^6 3d^5$

(iii) Explain why Fe^{2+} ions are oxidized to Fe^{3+} but Mn^{2+} ions are not readily oxidized to Mn^{3+}. *(02 marks)*

Fe^{2+} with $3d^6$ outer most orbital is easily oxidized to the more stable half filled $3d^5$ orbital,

While

Mn^{2+} has a thermodynamically stable with a half filled $3d^5$ orbital unlike Mn^{3+} which has $3d^4$ thus is not oxidized to higher oxidation state.

(b) Cobalt forms a complex compound of the formula $[Co(NH_3)_4\ Cl_2]^+Cl^-$.

(i) What is the oxidation state of cobalt in this compound?

(01 mark)

+3

(ii) Give the name of the complex ion contained in this compound.

(01 mark)

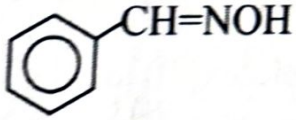
- Dichloratetra ammine cobalt(III) ion

(iii) How many moles of silver chloride would be immediately precipitated from one mole of this compound in aqueous solution by adding an excess of silver nitrates. *(01 mark)*

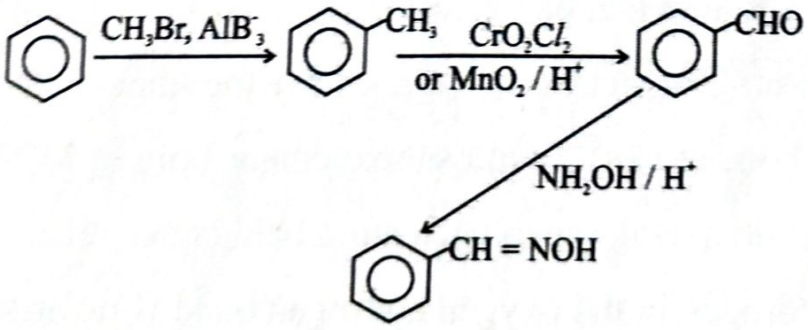
- One mole of silver chloride u_2 precipitated since it has only chloride ion.

12. Write equations to show how the following compounds can be synthesised.

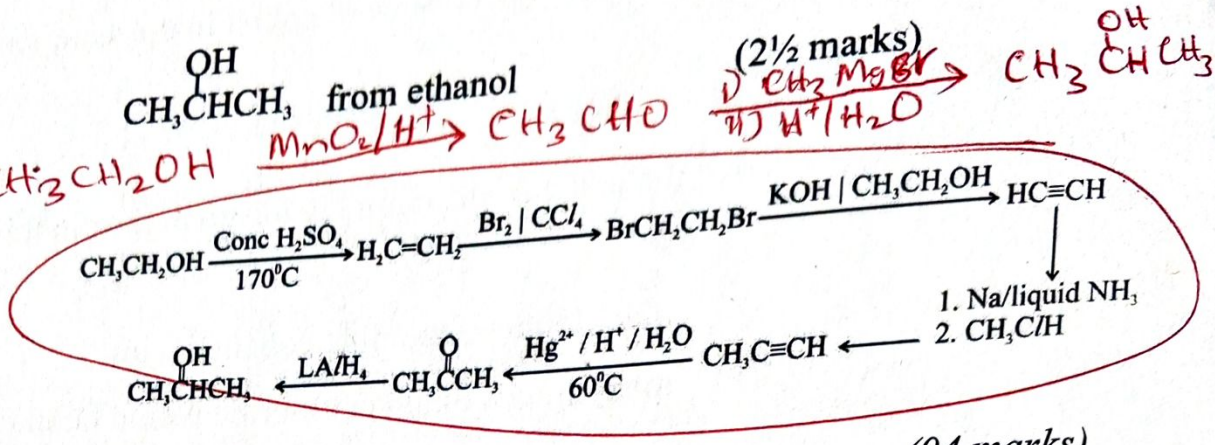
(a)



from benzene (2½ marks)

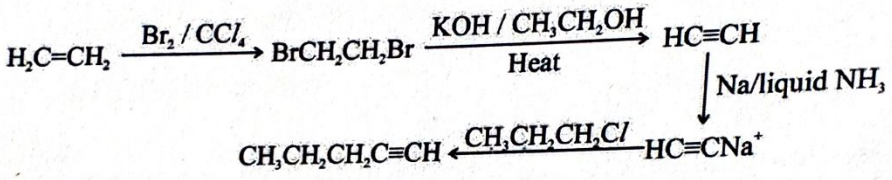


(b) $CH_3\underset{OH}{C}HCH_3$ from ethanol (2½ marks)



(04 marks)

(c) $CH_3CH_2CH_2C{\equiv}CH$ from ethene.



13. Explain each of the following observations

(a) Lead (IV) oxide decomposes when heated to give lead (II) oxide and oxygen but carbondioxide does not. *(02 marks)*

- Lead(IV)oxide is less stable than lead(II)oxide where carbondioxide in the +4 oxidation state is more stable.
- This stability of the +4 oxidation state decreases down the group due to that pair effect.

(b) Butan-2-ol and ethoxyethane have the same molecular mass. Butan-2-ol boils at 124^0C while ethoxyethane boils at 35^0C. *(04 marks)*

In butan-1-ol, the oxygen atom being more electronegative than the hydrogen in the oxygen hydrogen bond U_2polarised this associates via formation of intermolecular hydrogen bonds that require a lot of energy. In ethoxyethane, the molecules are joined by vander wals forces which are easy to break hence low boiling point.

(c) The pH of aqueous ammonium chloride is less than 7 while that of aqueous sodium chloride is 7. *(03 marks)*

Ammonium chloride contains an ammonium ion which undergoes hydrolysis to form hydrogen / hydroxonism ions that make the solution acidic.

$NH^{+}_{4(aq)} + H_2O_{(l)} \rightleftharpoons NH_{3(aq)} + H_3O^{+}_{(aq)}$

Sodium chloride is a salt of a strong acid and strong base which does not undergo hydrolysis.

14. (a) Explain what is meant by

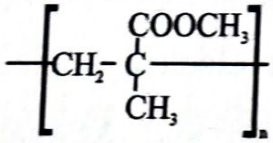
(i) Polymerisation. *(01 mark)*

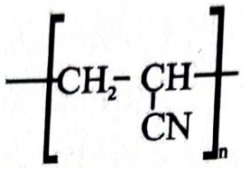
Is the joining / linking together small molecules to form a larger molecule of much higher relative formula mass.

(ii) Copolymer *(01 mark)*

Is a polymer that is formed from two different monomers with elimination of simple molecules.

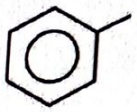
(b) The structural formulae of some monomers are shown in the table below. Complete the table by writing in the spaces provided; the structural formula of the polymers formed; type of polymerization and one use of each polymer. *(04 marks)*

Structural formula of monomer(s)	Structural formula of polymer	Type of polymerization	Use of polymer
		Addition polymerization	Making lenses/ rulers corrugated roof lights/ aeroplan windows

(ii) $CH_2=CH-CN$		Addition polymerization	Sythetic fibre for closing/ separator motive is Lethum-ion used in aeroplan

(d) A sample of polystyrene (polyphenylethene) is found to consist of molecules with an average molecular mass of 12480.

(i) Write down the repeating unit with in polystyrene. *(01 mark)*



or phenylethene

(ii) How many polystyrene monomers are present in each polymeric unit? *(02 marks)*

Molar mass of phenylethane $= (12 \times 8) + (1 \times 8)$

$= 104$

Number of polystyrene moners

$$= \frac{12480}{104} = 120$$

15. (a) Define the term electrolytic conductivity. *(01 mark)*

Is the conductance of an electrolyte placed between electrodes of cross sectional area of $1m^2$ and 1M apart accept unit cross sectional area and unit distance part.

(b) The table below gives the molar conductivity at 298K of an aqueous solution of ethanoic acid.

Concentration ($moldm^{-3}$)	0	0.001	0.01	0.1
Molar conductivity ($\Omega^{-1}cm^2nol^{-1}$)	390	50	16	5

Calculate;

(i) The degree of ionization, ∝ of 0.01M ethanoic acid. *(01 mark)*

$$\alpha = \frac{\Lambda_c}{\Lambda_\infty} = \frac{16}{390} = 0.041 \text{ or } 4\%$$

(ii) The pH when the solution is b (i) is diluted 10 times.

(03 marks)

$$CH_3COOH(aq) \rightleftharpoons \underset{\alpha c}{CH_3COO^-(aq)} + \underset{\alpha c}{H^+}$$
$$\underset{C(1-\alpha)}{}$$

At equilibrium $[H^+] = \alpha c$ $\quad C = 0.001$

$$\alpha = \frac{\Lambda_c}{\Lambda_\infty} \quad \frac{50}{390} = 0.128$$

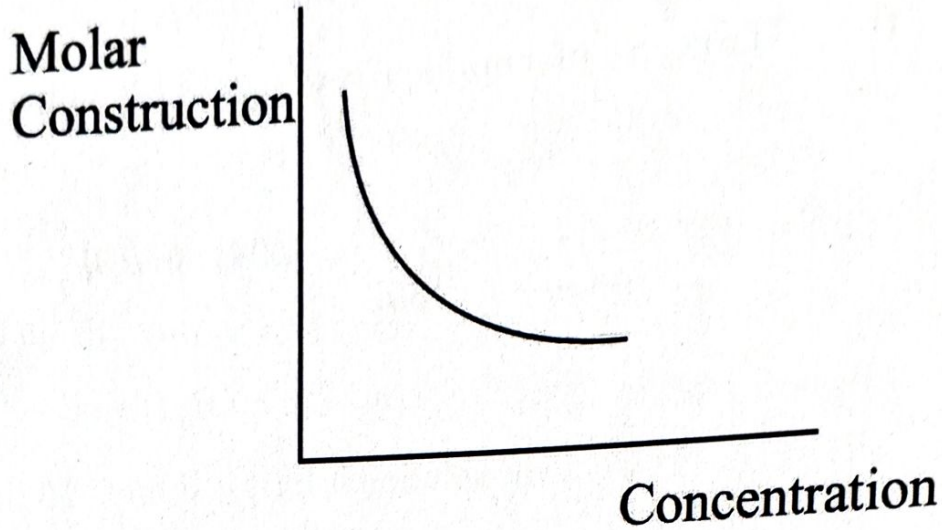
$$[H^+] = \alpha c = 0.128 \times 0.001 = 1.28 \times 10^{-4}$$

$$pH = -\log[H^+] = -\log 1.28 \times 10^{-4}$$

$$pH = 3.89$$

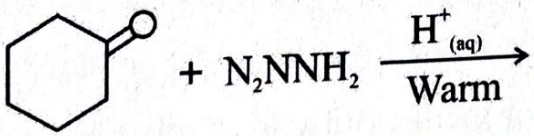
(c) Sketch a graph to show how the molar conductivity varies with concentration for methanoid acid. Explain the shape of the graph.

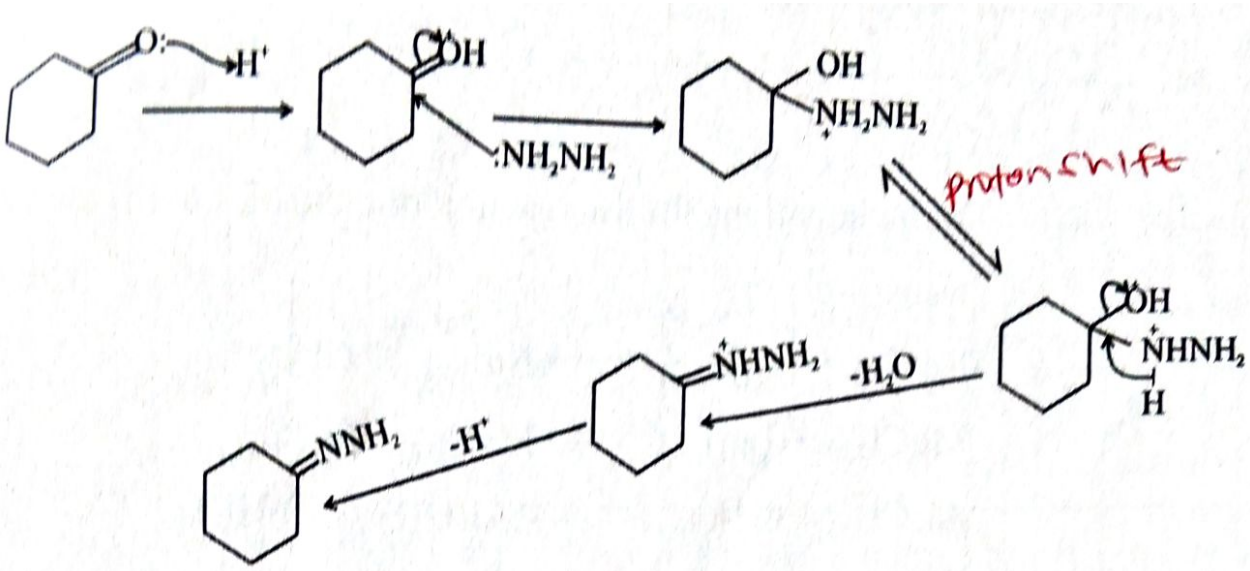
(04 marks)

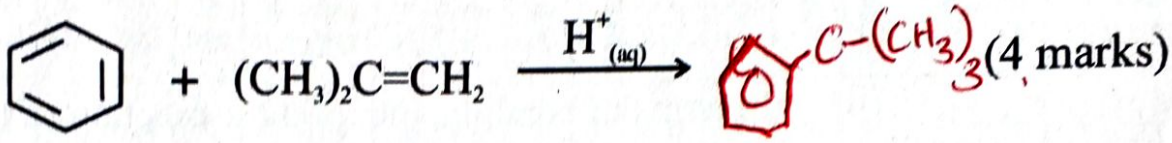


Molar conductivity decrease with increase in concentration. At low concertation, more molecules ionise / degree of ionization is high thus number of ions per unit volume is high hence high conductivity. As concentration increases number of ions per unit volume decreases due to decrease in degree of ionization hence decrease in conductivity.

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

(a)  (5 marks)



(b) 

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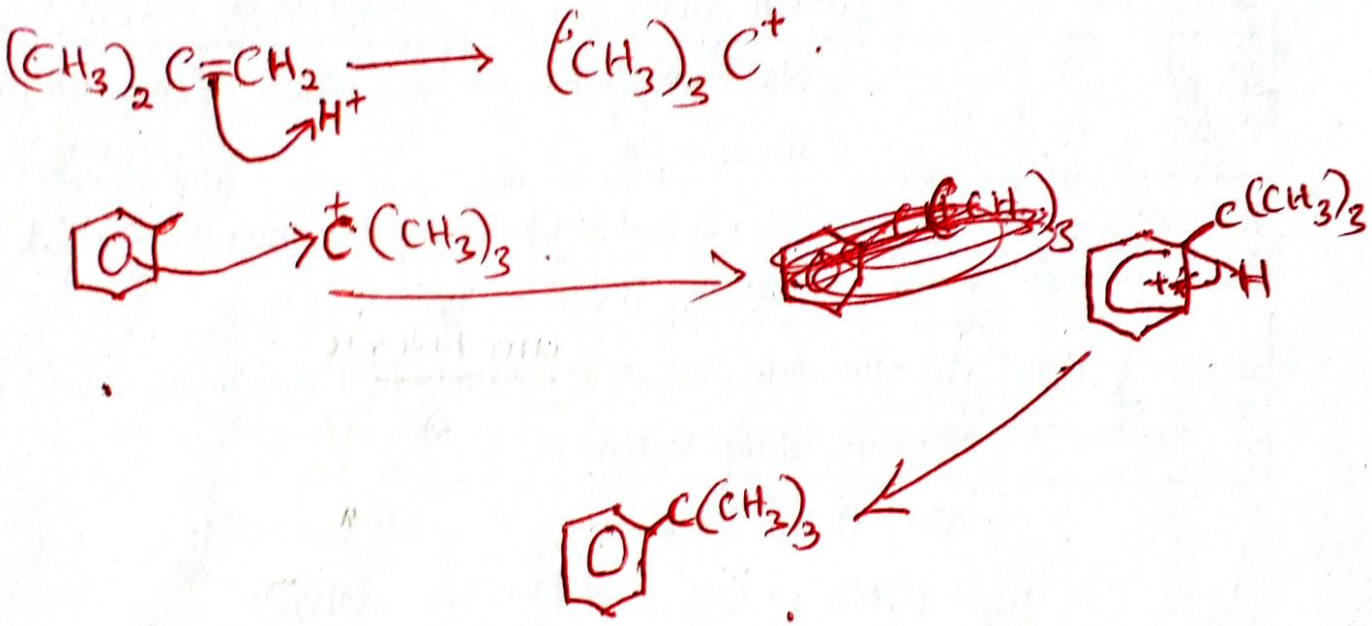

17. (a) Write the formula for the anhydrous chloride of sodium, magnesium, aluminum and silicon. *(02 marks)*

- NaCl
- $MgCl_2$
- Al_2Cl_6
- $SiCl_4$

(b) (i) Write equations for the reaction of chlorides in (a) above with water. (04 marks)

$NaCl_{(s)} + (aq) \longrightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

$MgCl_{2(s)} + (aq) \longrightarrow Mg^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$

$Al_2Cl_{6(s)} + 6H_2O_{(s)} \longrightarrow 2Al(OH)_{3(s)} + 6HCl_{(g)}$

$SiCl_{4(l)} + 2H_2O_{(l)} \longrightarrow SiO_{2(s)} + 4HCl_{(s)}$

OR $SiCl_{(l)} + 3H_2O_{(l)} \longrightarrow H_2SiO_{3(s)} + 4HCl_{(s)}$

(ii) In terms of bonding, interpret the reaction of the chlorides in b (i) with water. (02 marks)

- NaCl and $MgCl_2$ are ionic chlorides since they dissolve in water
- Al_2Cl_6 and $SiCl_4$ are covalent chlorides which are hydrolysed with water.

(c) Aluminum hydroxide is ~~amphaterid~~ amphoteric. Using an equation(s) show the meaning of this statement. (01 mark)

$Al(OH)_{3(s)} + 3H^{+}_{(aq)} \longrightarrow Al^{3+}_{(aq)} + 3H_2O_{(l)}$

$Al(OH)_{3(s)} + OH^{-}_{(aq)} \longrightarrow Al(OH)_4^{-}$