PROPOSED MARKING GUIDE BY EMURIA RONALD (0778422061)

SECTION A-46 MARKS

ATTEMPT ALL QUESTIONS IN THIS SECTION.

1. Complete the following **equations** and outline the **mechanism** for each of the reactions.

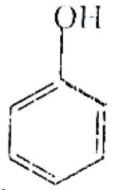
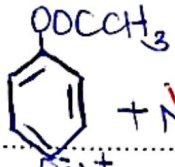
a. $(CH_3)_3CBr \xrightarrow[\text{Heat}]{OH^-_{(aq)}} CH_3C(CH_3)=CH_2 + H_2O + Br^-$ (02½ mark)

Consider major organic product

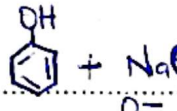
Mechanism: $(CH_3)_3CBr \underset{}{\overset{\text{Ionisation}}{\rightleftharpoons}} (CH_3)_3C^+ + Br^-$

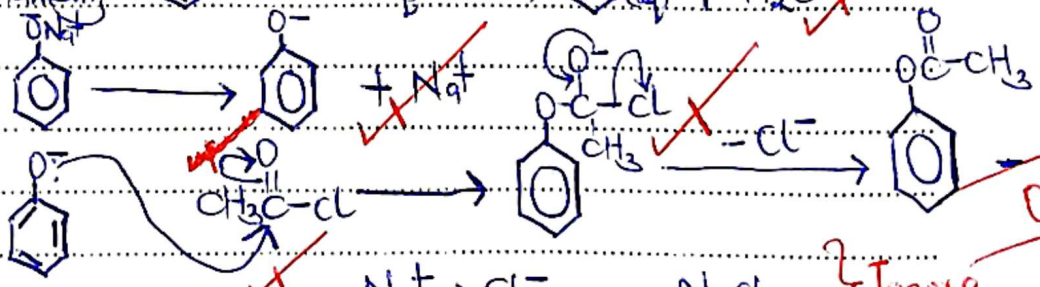
$(CH_3)_2\overset{+}{C}-CH_2 \xrightarrow{-H_2O} (CH_3)_2C=CH_2$

02½

b.  + $CH_3COCl \xrightarrow[\text{Heat}]{NaOH_{(aq)}}$  $+ NaCl$ (03 marks)

Mechanism:





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

03

Ignore

2. Thorium decays according to the following equation.

$^{232}_{90}Th + \alpha \longrightarrow X + \beta \longrightarrow Y + \beta \longrightarrow Z$

a) Identify the following species. (03 marks)

X: $^{233}_{93}Np$

Y: $^{236}_{93}Np$

Z: $^{236}_{92}U$

03

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b) The **half-life** of Thorium-232 is **234 days**. Determine the **time taken** for Thorium to **decay** by **12.5%** of its **original value**.

(03 marks)

$\lambda = \frac{\ln 2}{t_{1/2}}$

$\lambda = \frac{\ln 2}{234}$

$\lambda = 2.962 \times 10^{-3}\ day^{-1}$

From $\ln\left(\frac{N_o}{N_t}\right) = \lambda t$

$N_t = (100 - 12.5)\%$

$N_t = 87.5\%$

$N_o = 100\%$

Also accept $2.303 \log\left(\frac{N_o}{N_t}\right) = \lambda t$

$\ln\left(\frac{100}{87.5}\right) = \lambda t$

$t = \frac{1}{\lambda} \ln\left(\frac{100}{87.5}\right)$

$t = \frac{1}{2.962 \times 10^{-3}} \ln\left(\frac{100}{87.5}\right)$

$t = 45.07$ days

It takes 45 days for Thorium to decay.

Accept $N_o = N_t e^{\lambda t}$

3. Write equations for the reaction between water and: (@01½ marks)

a) Sodium hydride.

$NaH_{(s)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)} + H_{2(g)}$

b) Phosphorus (V) oxide.

$P_2O_{5(s)} + 3H_2O_{(l)} \longrightarrow 2H_3PO_{4(aq)}$

Accept $P_4O_{10(s)} + 6H_2O_{(l)} \longrightarrow 4H_3PO_{4(aq)}$

c) Beryllium carbide.

$Be_2C_{(s)} + 4H_2O_{(l)} \longrightarrow 2Be(OH)_{2(s)} + CH_{4(g)}$

4. **50.0cm³** of a vaporized alcohol **G**, $C_nH_{2n+2}OH$ diffused through a porous plug in **19.85 seconds**. Under the same conditions, the same volume of hydrogen gas diffused through under the same conditions in **21.85 seconds**.

a) (i). Calculate the **molecular mass** of **G**. (02 marks)

From Graham's law of gaseous diffusion

$\frac{\text{Rate of diffusion of G}}{\text{Rate of diffusion of } H_2} = \sqrt{\frac{Mr \text{ of } H_2}{Mr \text{ of G}}}$

$\left(\frac{50}{19.85} \times \frac{21.85}{50}\right) = \sqrt{\frac{2}{Mr \text{ of G}}}$

Error in the Question

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5. The standard electrode potentials for some half-cells are shown below.

$Fe^{3+}_{(aq)}, Fe^{2+}_{(aq)}/Pt_{(s)}$: $^{+}0.77V$	$Sn^{4+}_{(aq)}, Sn^{2+}_{(aq)}/Pt_{(s)}$: $^{+}0.15V$

a) Write the cell convention for the combined cell. (01½ marks)

$Pt_{(s)}/Sn^{2+}_{(aq)}, Sn^{4+}_{(aq)}//Fe^{3+}_{(aq)}, Fe^{2+}_{(aq)}/Pt_{(s)}$ ✓✓ – Deny without Platinum electrodes – Emphasize states

b) Write equation for the: (@01 mark)

i. Reaction at the cathode.

$Fe^{3+}_{(aq)} + e \longrightarrow Fe^{2+}_{(aq)}$ ✓

ii. Reaction at the anode.

$Sn^{2+}_{(aq)} \longrightarrow Sn^{4+}_{(aq)} + 2e$ ✓

iii. Overall cell reaction. (0½ mark)

$2Fe^{3+}_{(aq)} + Sn^{2+}_{(aq)} \longrightarrow 2Fe^{2+}_{(aq)} + Sn^{4+}_{(aq)}$ ✓

c) Calculate the **e.m.f** of the cell. (01 mark)

$E^{\ominus}_{cell} = E^{\ominus}_{cathode} - E^{\ominus}_{anode}$ ✓

$E^{\ominus}_{cell} = (+0.77 - {}^{+}0.15)V$ ✓ Emphasize (+)

$E^{\ominus}_{cell} = +0.62V$ ✓

6. Compare the reactivity of the following elements with water:

a) (i). Fluorine. (0½ mark)

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

(ii).Chlorine. (0½ mark)

$Cl_{2(g)} + H_2O_{(l)} \longrightarrow HOCl_{(aq)} + HCl_{(aq)}$ ✓

(iii).Iodine. (0½ mark)

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$I_{2(aq)} + H_2O_{(l)} \longrightarrow$ No reaction

b) Write equation for the reaction between fluorine and: (@01½ marks)

i. Cold dilute sodium hydroxide solution.

$2F_{2(g)} + 2NaOH_{(aq)} \longrightarrow 2NaF_{(aq)} + OF_{2(g)} + H_2O_{(l)}$

or $2F_{2(g)} + 2\bar{O}H_{(aq)} \longrightarrow 2F^-_{(aq)} + OF_{2(g)} + H_2O_{(l)}$

ii. Hot concentrated sodium hydroxide solution.

$2F_{2(g)} + 4NaOH_{(aq)} \longrightarrow 4NaF_{(aq)} + O_{2(g)} + 2H_2O_{(l)}$

or $2F_{2(g)} + 4\bar{O}H_{(aq)} \longrightarrow 4F^-_{(aq)} + O_{2(g)} + 2H_2O_{(l)}$

04

c) State what would be observed in b(i) and (ii) above. (01 mark)

- Bubbles of a colourless gas given off in b(i)
- Bubbles of a gas in b(ii)

7. Natural rubber has the following structure.

$$-[CH_2\,\underset{\displaystyle CH_3}{\underset{|}{C}}{=}CH - CH_2CH_2\,\underset{\displaystyle CH_3}{\underset{|}{C}}{=}CH\,CH_2]_n-$$

a) Write the **structure** and **name of the monomer** of natural rubber. (02 marks)

$CH_2 = \underset{\displaystyle CH_3}{\underset{|}{C}} - CH = CH_2$

02

Name: 2-methyl-1,3-butadiene Accept Isoprene

b) When **120.0g** of the monomer was polymerized, **3.49 X 10^{-4} moles** of natura; rubber was formed. Calculate the **relative formula mass** of natural rubber. (02 marks)

Molar mass of the isomer $(12\times5)+(8\times1) = 68$ g/mol

3.49×10^{-3} moles of Natural rubber is formed from 120g of monomer

1 mole of Natural rubber is formed from $\left(\frac{120\times1}{3.49\times10^{-3}}\right)$ g of monomer

$= 343,839.5$ g of monomer

02

Value of n $= \left(\frac{343,839.5}{68}\right) = 5,056.5$

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Relative Molecular mass of the polymer $= (5,056\times68)$

$= 343,808$

8. State what would be **observed** and **write equation** for the reaction that would take place if **dilute sulphuric acid** is reacted with:

a) A solution containing iodate ions and iodide ions. (01 mark)

Observations:

Colourless solution turned violet (purple)

Equation: (01½ marks)

$IO_{3(aq)}^{-} + 5I_{(aq)}^{-} + 6H_{(aq)}^{+} \longrightarrow 3I_{2(aq)} + 3H_2O_{(l)}$

b) Aqueous sodium chromate.

Observations: (01 mark)

Yellow solution turned orange

Equation: (01½ marks)

$2CrO_{4(aq)}^{2-} + 2H_{(aq)}^{+} \longrightarrow Cr_2O_{7(aq)}^{2-} + H_2O_{(l)}$

9. a). Define the term '**solubility product**'. (01 mark)

Solubility product is the product of the molar concentrations of the ions of a sparingly soluble electrolyte in a saturated solution raised to their appropriate powers at constant temperature

b).Calculate the **solubility product** of a saturated solution containing **8.35 X 10^{-3}g** of magnesium hydroxide in **1 litre** solution at **25°C**. (03 marks)

$Mg(OH)_{2(s)} + aq \rightleftharpoons Mg_{(aq)}^{2+} + 2OH_{(aq)}^{-}$

Mr of Magnesium hydroxide $= (24) + (16+1)2$ g/mol

$= 58$ g/mol

$[Mg(OH)_2] = [(8.35 \times 10^{-3}) \div 58]$ molL^{-1}

$[Mg(OH)_2] = 1.44 \times 10^{-4}$ mol/L

$K_{sp} = [Mg^{2+}][OH^{-}]^2$ mol^3 dm^{-9}

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Ut [M]$_{Mg}$ $K_{sp} = (1.44 \times 10^{-4})(1.44 \times 10^{-4})^2 \text{ mol}^3\text{l}^{-3}$

$K_{sp} = 2.98 \times 10^{-12} \text{ mol}^3\text{l}^{-3}$

c). State **one application** of solubility product. (01 mark)

But award only ①

Accept:
- To determine the solubility of a sparingly soluble electrolyte.
- Purification of salts - Water softening 01
- Prediction of precipitation

SECTION B-54 MARKS

ATTEMPT ANY SIX QUESTIONS IN THIS SECTION.

10. Freezing point depression is one of the methods of determining the relative molecular mass of a solute or compound.

a) (i). State **four limitations** of determining molecular mass by freezing point depression method. (02 marks)

- The solution should be dilute.
- There should be no association or dissociation of the solute
- There should be no reaction between solute and solvent
- The solute should be non-volatile

02

(ii). Explain how association of solute molecules in a solution affects the molecular mass of determined by freezing point. (03 marks)

Association of solute molecules reduces the number of solute particles in solution this leads to a lower value of the colligative property (freezing point depression). Since the value of colligative property is inversely proportional to its molecular mass there is an increased molecular mass from the actual value.

03

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b) A solution containing **0.142g** of naphthalene in **20.25g** of benzene caused a lowering of freezing point of **0.284°C**.
Calculate the **molar mass** of naphthalene. (04 marks)
(Cryoscopic constant, Kf of benzene $=5.12^0C\ mol^{-1}kg^{-1}$)

20.25g of benzene dissolved 0.142g of Naphthalene
1000g of benzene dissolved $\frac{(1000 \times 0.142)}{20.25}$ g of Naphthalene
$= 7.0123g$
0.284°C was caused by 7.0123g of Naphthalene
5.12°C was freezing point depression caused by $\frac{(5.12 \times 7.0123)}{0.284}$ g
$= 126.4\ g/mol$
Mr of Naphthalene is 126g/mol

04 Emphasize on the units, Deny (01) without units. Ee

11.(a). (i). Write the **electronic configuration** of chromium. (01 mark)
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ Deny $[Ar]\ 4s^1 3d^5$

(ii).State three characteristics of chromium as a transition metal. (01½ marks)
- Chromium has variable oxidation states
- Chromium has catalytic behaviour
- Chromium is paramagnetic
- Chromium forms complex compounds

Deny mark for various oxidation states. Consider only 3 correct ones

(b).Chromium (III) chloride was dissolved in water and the solution tested with litmus paper. State what was observed and explain your answer. (04 marks)
Blue litmus paper turned red.
The resultant solution is acidic (H_3O^+). The Cr^{3+} ion in chromium (III) chloride has empty d-orbitals to accomodate lone pair of electrons from water for hydrolysis.

04

$Cr^{3+}_{(aq)} + 6H_2O_{(l)} \rightarrow Cr(OH)_{3(s)} + 3H_3O^+_{(aq)}$

Accept $Cr(H_2O)^{3+}_{6(aq)} + H_2O_{(l)} \rightleftharpoons [Cr(H_2O)_5OH]^{2+}_{(aq)} + H_3O^+_{(aq)}$

Accept $Cr^{3+}_{(aq)} + 3H_2O_{(l)} \rightleftharpoons Cr(OH)_{3(s)} + 3H^+_{(aq)}$

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(c). Ammonia solution was added drop wise to an aqueous solution of chromium (III) chloride until in excess.

i. State what was observed. (01 mark)

Green precipitate dissolved in the ammonia solution to form a violet solution

ii. Write equation for the reaction that took place. (01½ marks)

Accept two equations

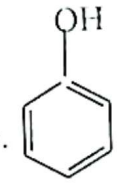
$Cr^{3+}_{(aq)} + 6NH_{3(aq)} \longrightarrow Cr(NH_3)^{3+}_{6(aq)}$ 1½

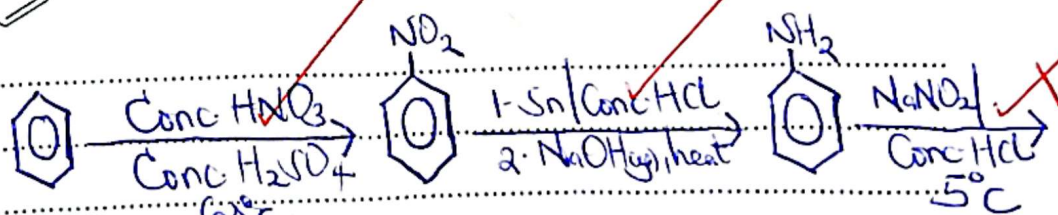
12. Write equations to show how the following compounds can be synthesized. In each case, indicate the reagents and conditions for the reactions.

a. $CH_3CH_2CO_2H$ from Propene (03 marks)

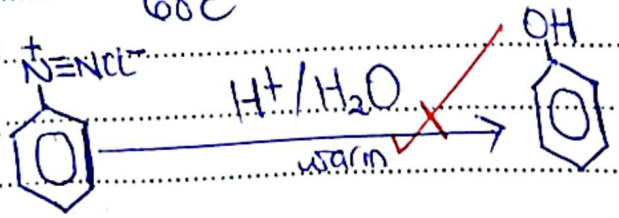
$CH_3CH{=}CH_2 \xrightarrow{HBr/ROOR} CH_3CH_2CH_2Br \xrightarrow[heat]{NaOH_{(aq)}} CH_3CH_2CH_2OH \xrightarrow[heat]{MnO_4^-/H^+} CH_3CH_2COOH$

Accept other correct alternatives and award accordingly or $\xrightarrow[heat]{Cr_2O_7^{2-}/H^+}$ 03

b.  from Benzene (03 marks)



Accept other correct alternatives



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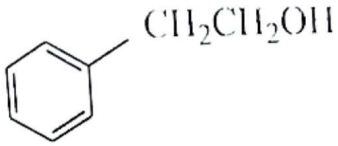
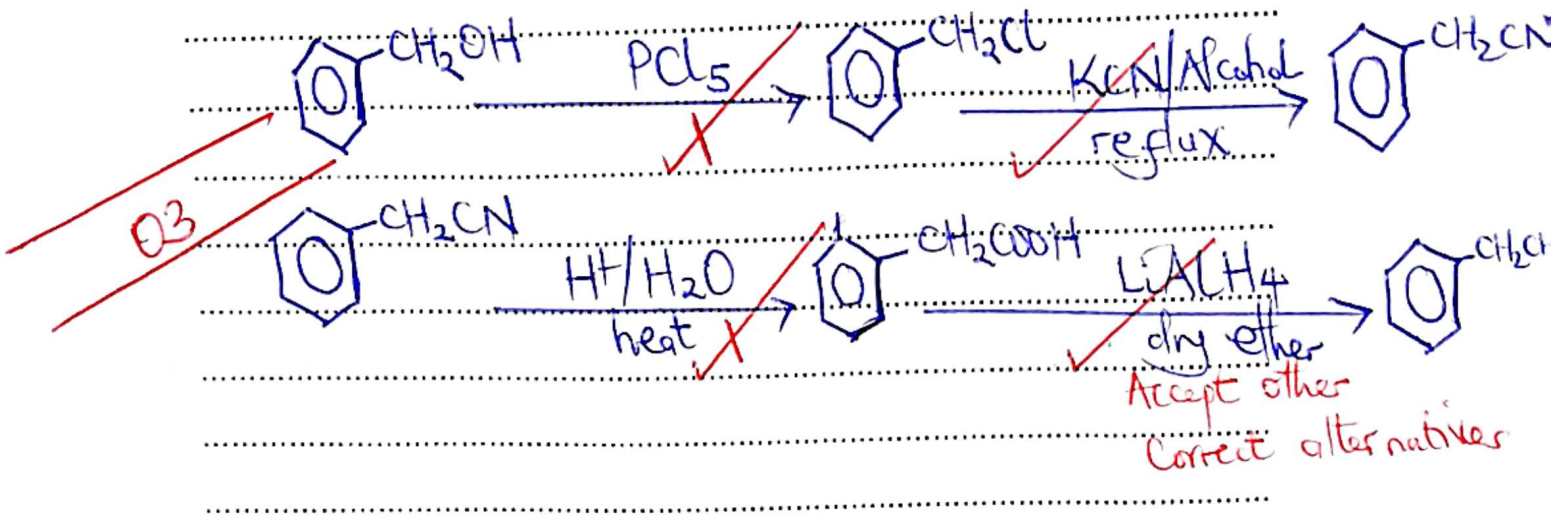
c.  from Phenylmethanol (03 marks)



13. Sodium, aluminium, phosphorus and sulphur are some elements in period 3 of the periodic table.

a) For each element, write the formula and name the structure of the chloride. (04 marks)

Elements	Formula of chloride	structure
Sodium	$NaCl$	Giant ionic structure
Aluminium	$AlCl_3$	Layered molecular structure
Phosphorus	Mark only one PCl_3 or PCl_5	Simple molecular
Sulphur	S_2Cl_2	Simple molecular

Accept Al_2Cl_6 (dimer)

04

b) Write equation for the reaction between water and chloride of:

i. Aluminium. (01½ marks)

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

Accept other correct alternatives

ii. Phosphorus. (01½ marks)

$PCl_{3(aq)} + 3H_2O_{(l)} \longrightarrow H_3PO_{3(aq)} + 3HCl_{(aq)}$

or $PCl_{5(aq)} + 4H_2O_{(l)} \longrightarrow H_3PO_{4(aq)} + 5HCl_{(aq)}$

4½

iii. Sulphur. (01½ marks)

$2S_2Cl_{2(l)} + 3H_2O_{(l)} \longrightarrow 3S_{(s)} + H_2SO_{3(aq)} + 4HCl_{(g)}$

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14.(a). Kohlraush's law of indepent ionic conductivity of ions. (02 marks)

Kolrausch's laws states that the molar conductivity at infinite dilution of an electrolyte is the sum of the molar conductivities of the ions at infinite dilution of that form the electrolyte.

02

Accept another correct definition

(b).Given the following molar conductivities at infinite dilution, Λ_o.

$(CH_3COO)_2Cu$: Λ_o $=195\ ohm^{-1}cm^2mol^{-1}$

$CuCl_2$: Λ_o $=266\ ohm^{-1}cm^2mol^{-1}$

HCl : Λ_o $=426.2\ ohm^{-1}cm^2mol^{-1}$

Calculate the molar conductivity at infinite dilution, Λ_o for ethanoic acid. (03 marks)

$(CH_3COO)_2Cu_{(aq)} + 2HCl_{(aq)} \longrightarrow 2CH_3COOH_{(aq)} + CuCl_{2(aq)}$

From Kolrausch's law of independent migration of ions;

$2\Lambda_o(CH_3COOH) = \Lambda_o(CH_3COO)_2Cu + 2\Lambda_o(HCl) - \Lambda_o CuCl_2$

$\Lambda_o CH_3COOH = \frac{1}{2}\Lambda_o(CH_3COO)_2Cu + \Lambda_o HCl - \frac{1}{2}\Lambda_o CuCl_2$

$\Lambda_o CH_3COOH = [(\frac{1}{2} \times 195) + 426.2 - (\frac{1}{2} \times 266)]\ Ohm^{-1}cm^2mo$

$\Lambda_o CH_3COOH = 390.7\ Ohm^{-1}cm^2mol^{-1}$

03

Accept units in Scm^2mol^{-1}

(c).The ionic radii and ionic mobilities at infinite dilution of some ion are shown in the table below.

Ions	Ionic radius(nm)	Ionic mobility (cm/sec)
Li^+	0.060	4.01×10^{-4}
Na^+	0.095	5.19×10^{-4}
K^+	0.133	7.62×10^{-4}

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Explain the trend in the ionic mobilities. (04 marks)

The ionic mobilities decrease in the order $K^+ > Na^+ > Li^+$, Accept increase in the order $Li^+ < Na^+ < K^+$ The larger the ionic radius, the lower the charge density and the weaker the hydration of the ion. This leads to a lower frictional force experienced by the ion while moving through the solution, leading to higher ionic mobility. K^+ with the highest ionic radius has the highest ionic mobility among the given ions

04

15. State what would be observed and write equation(s) for the reaction(s) that would take place when:

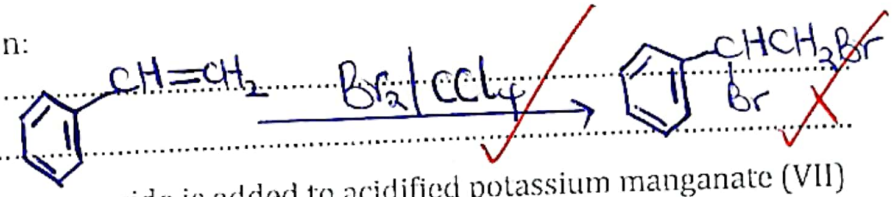
a) Phenylethene is added to a solution of bromine in carbon tetrachloride. (02 marks)

Observations:

Reddish-brown solution turned colourless.

02

Equation:



b) Hydrogen peroxide is added to acidified potassium manganate (VII) solution. (02½ marks)

Observations:

Purple solution turned colourless,
Bubbles of a colourless gas

02½

Equation:

$$2MnO^-_{4(aq)} + 6H^+_{(aq)} + 5H_2O_{2(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 5O_{2(g)} + 8H_2O_{(l)}$$

c) Ethyne is bubbled through ammoniacal silver nitrate solution. (01½ marks)

Obervations:

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Observation: White precipitate

Accept: $HC{\equiv}CH + Ag(NH_3)_2^+ \rightarrow Ag^+C{\equiv}\bar{C}Ag^+_{(s)} + 3NH_4^+$

$HC{\equiv}CH + 2AgNO_{3(aq)} + 2NH_4OH_{(aq)} \rightarrow Ag^+C{\equiv}\bar{C}Ag^+_{(s)} + 2NH_4NO_{3(aq)} + 2H_2O_{(l)}$

1½

d) Hydrogen sulphide is added to acidified sodium dichromate (VI) solution. (03 marks)

Observations:

Orange solution turned green, with a yellow solid/deposit

Equation:

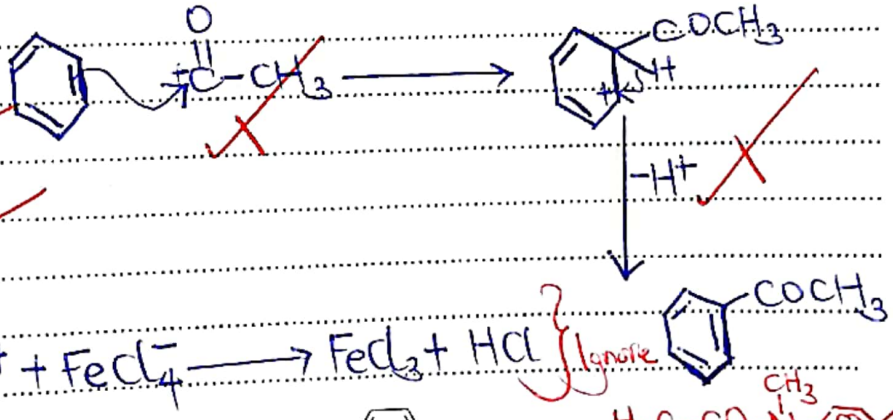
$3H_2S_{(aq)} + Cr_2O_{7(aq)}^{2-} + 8H^+_{(aq)} \rightarrow 2Cr^{3+}_{(aq)} + 3S_{(s)} + 7H_2O_{(l)}$

03

16. Complete the following equations and in each case, write an accepted mechanism for the reaction.

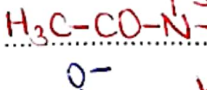
a.  + $CH_3COCl \xrightarrow{FeCl_3}$  + HCl (02½ marks)

$CH_3COCl + FeCl_3 \rightarrow CH_3C^+{=}O + FeCl_4^-$

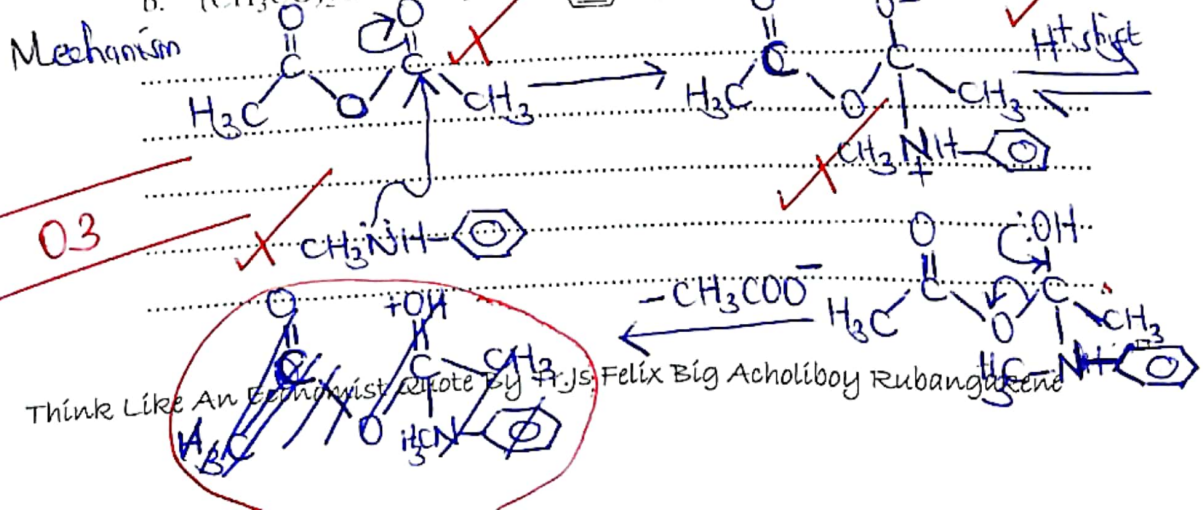


$H^+ + FeCl_4^- \rightarrow FeCl_3 + HCl$ Ignore

02½

b. $(CH_3CO)_2O$ + CH_3NH-  →  + CH_3COO^- (03 marks)

Mechanism



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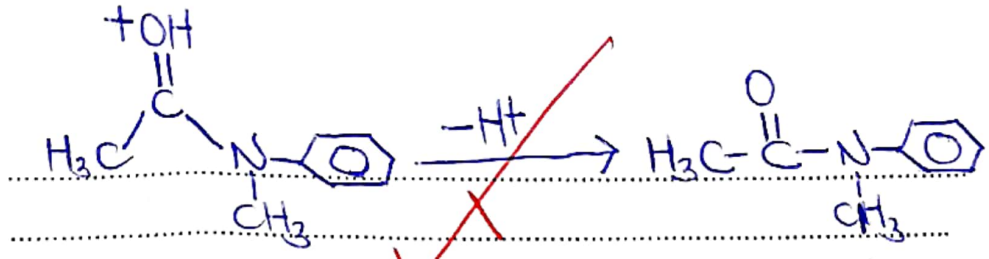
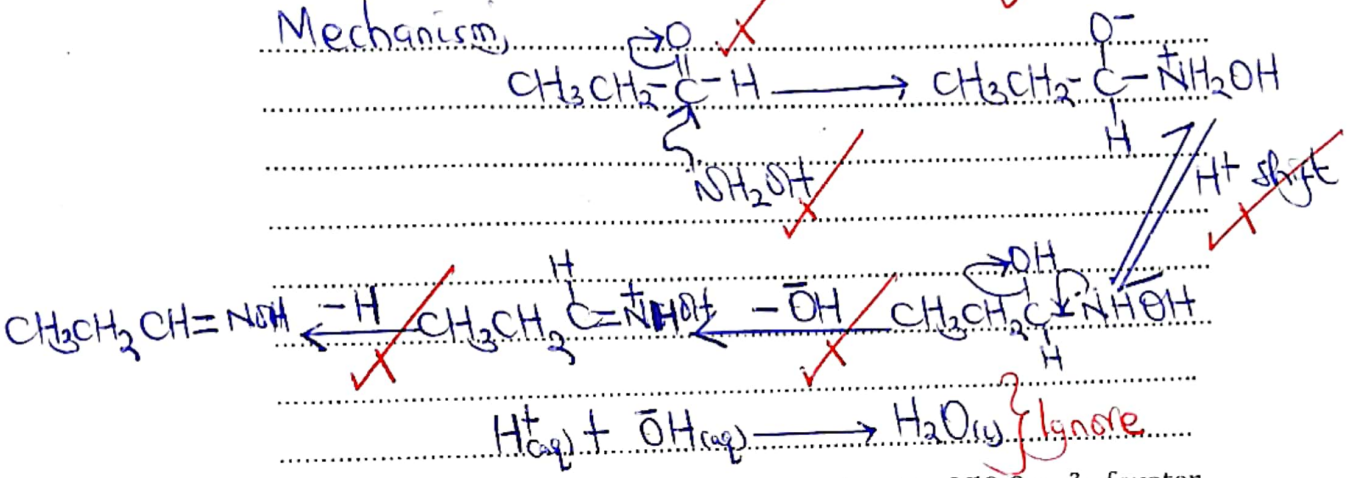


c. $CH_3CH_2CHO \xrightarrow{H_2N\text{-}OH} CH_3CH_2CH{=}NOH$ (03½ marks)

Mechanism



17. **20.0cm³** of **0.50M** hydrochloric acid was added to **250.0cm³** of water.

a) Calculate the **pH** of the resultant solution. (02 marks)

moles of hydrochloric acid $= \left(\frac{20 \times 0.5}{1000}\right)$

$= 0.01$ moles

Total volume of solution $= (20 + 250)\,cm^3 = 270\,cm^3$

$270\,cm^3$ of solution (H^+) contain 0.01 moles

$1000\,cm^3$ of solution (H^+) contain $\left(\frac{0.01 \times 1000}{270}\right)$ moles

$[H^+] = 0.037M$, $pH = -\log[H^+]$

$pH = 1.43$

02

b) Calculate the **mass** of ammonium chloride that should be added to **1dm³** of **0.1M** ammonia solution at **25°C** to give a solution whose **pH** is **8.7**. State any assumption made. (The base dissociation constant for ammonia solution, $K_b = 1.8 \times 10^{-5}$ **mol/dm³** at **25°C**) (05½ marks)

From Henderson-Hasselbalch equation

$pOH = pK_b + \log_{10}\frac{[salt]}{[base]}$, But $pOH = 14 - pH = (14 - 8$

$pOH = 5.3$

$5.3 = -\log(1.8 \times 10^{-5}) + \log_{10}\frac{[salt]}{0.1}$

$5.3 = 4.74 + \log_{10}\frac{[NH_4Cl]}{0.1}$

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$0.56 = \log_{10} \frac{[NH_4Cl]}{0.1}$

$[NH_4Cl] = (10^{0.56} \times 0.1)g$

$[NH_4Cl] = 0.36\ mol/dm^3$

M_r of $NH_4Cl = 53.5g/mol$

Mass of $NH_4Cl = (0.36 \times 53.5)g$

$= 19.26g$

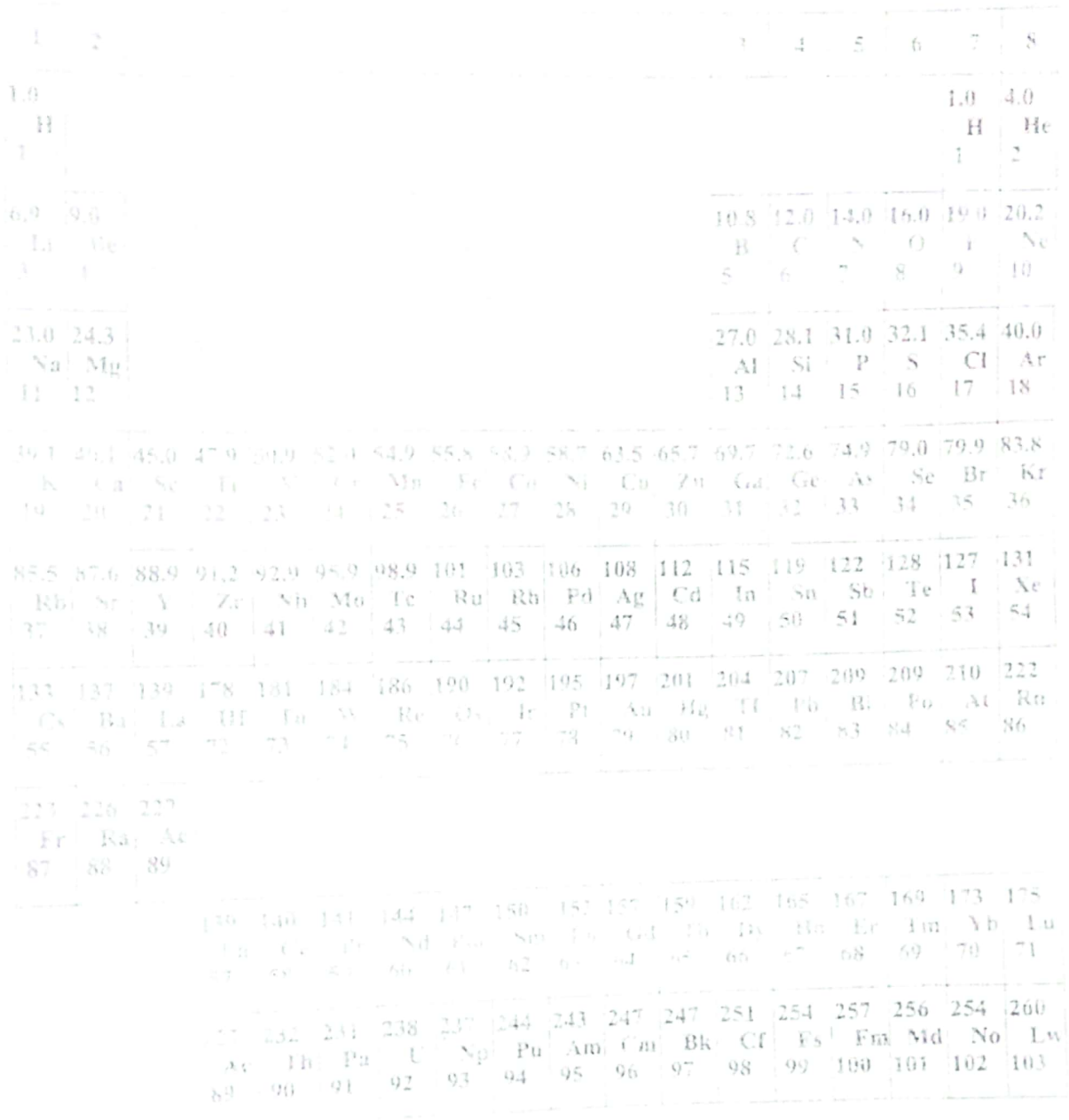
c) Few drops of aqueous sodium hydroxide solution were added to solution in (b).

i. State what happened to the pH of the solution. (0½ mark)

No change in pH

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

The hydroxide ions added react with the ammonium ions (NH_4^+) in the buffer to form ammonia solution. $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(aq) + H_2O(l)$



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