TANZANIA HEADS OF ISLAMIC SCHOOL COUNCIL (TAHISCO)

INTER ISLAMIC MOCK EXAMIMNATION

CHEMISTRY 02

MARKING SCHEME

2026

1. (a) Hydroxide of period 2 (Li, Be, B, C, N) show changes in properties from basic $\rightarrow$ amphoteric $\rightarrow$ acidic as you move toward the right.

- Reaction with water **(04 marks)**

  Lithium basic – very soluble in water

  Li OH(s) $\rightarrow Li^{+}_{(aq)} + OH^{-}_{(aq)}$

  - Beryllium hydroxide ($Be(COH)_2$)

    Amphoteric – insoluble in water

  - Boron hydroxide ($B(OH)_3/H_3BO_3$)

    Weak acid – slightly soluble in water

    $B(OH)_3 + 2H_2O \rightleftharpoons [B(OH)_4]^- + H_3O^+$

- Reaction with acids **(03 marks)**

  - Lithium hydroxide

    Neutralization

    $LiOH + HCl \rightarrow LiCl + H_2O$

  - Beryllium hydroxide

    Does not react with acids

    Act as bare

    $Be(OH)_2 + 2HCl \rightarrow BeCl_2H_2O$

  - Boron hydroxide

    Does not react with acids

- Reaction with bases **(03marks)**

  - Lithium hydroxide
    Already basic – no reaction
  - Beryllium hydroxide
    Act as acid
    $Be(OH)_2 + 2OH^- \rightarrow [Be(OH)_4]^{2-}$
  - Boron hydroxide
    Reacts with basis to form borates $B(OH)_3 + OH^- \rightarrow [B(OH)_4]$

(ii) Chromium (III) hydroxide is amphoteric

- In pure water, it dissolving only slightly due to its low solubility
- When a complex – forming reagent (excess hydroxide ions) is added Cr^{3+} ions from a stable complexion
- This removes Cr^{3+} from solution, shifting the dissolution equilibrium to the right and thereby increasing the solubility of chromium (III) hydroxide. **(1 ½ marks)**

  (1) Limited dissolution in water

  $Cr(OH)_{3(s)} \rightleftharpoons Cr^{3+}_{(aq)} + 3OH^{-}$ **(00 ½ mark)**

  (2) Complex formation in excess base

  $Cr^{3+}_{(aq)} + 6OH^{-}_{(aq)} \rightarrow [Cr(OH)_6]^{3-}_{(aq)}$

  Overall equation

  $Cr(OH)_{3_{(aq)}} + 3OH^{-}_{(aq)} \rightarrow [CrOH_6]^{3-}_{(aq)}$

(b) The methods includes

(i) Gravity separation (Hydraulic washing) **(01mark)**

Property used: Difference in density between metal ore and impurities (gangue)

Explanation: Ore particles with high density will sink while particles will be washed away by water.

Example: Tin stone (SnO_2), Hematite (Fe_2O_3)

(ii) Froth flotation **(01mark)**

Property used: Difference in countability core hydrophobic, gauge hydrophilic)

Explanation: Ore particles attach with air bubble and raise up as froth while gangue remains inside the water

Examples: Sulphide ores like ZnS, PbS, $CuFeS_2$.

(iii) Magnetic separation. **(01 mark)**

Property used: Magnetic vs non-magnetic behaviour

Explanation: Magnetic ore will be attracted by magnetic roller white gangue will fall apart

Example: Magnetic (Fe_3O_4), Chromite ($FeCr_2O_4$)

(c) (i) Factors which are considered in periodic table are

- Atomic number **(01 mark)**
- Physical and chemical properties periodic classification **(01mark)**

(ii) Factors are

- Nuclear charge : The more nuclear charge increase, the stronger attraction between nucleus and bonding pairs of electrons, e.g. C<N<O<F
- Atomic size: The large atomic size the low electronegativity e.g. F>Cl>Br>l

- Shielding effect: Less number of shells of electrons between nucleus electron less shielding effect Li>Na>k
- Electronic configuration: The atom which have fulfilled orbitals in the outermost shell cause

Any three points @ 01 ½ marks = 04 ½ marks

2. (a) (i) The effects of catalyst in an activation energy

- Positive catalysts lower activation energy while negative catalyst increase the activation energy of the reaction **(02 marks)**

(ii) Postulates of collision theory **(02 marks)**

- The collision of molecules posses sufficient kinetic energy to cause reaction **(01 marks)**
- The reaction molecules most collide with proper orientation **(01 marks)**

(b) (i) From the equation

1^{st} order of reaction

$K = \frac{2.303}{t} = log\left(\frac{a}{a-x}\right)$ **(01mark)**

t = 10

a = 34.75, x = 6.3 a-x = 34.75 – 6.3 = 28.45ml

$$K = \frac{2.303}{10}\log\left(\frac{34.75m}{28.45ml}\right)$$

K = 0.02min **(02 marks)**

t = 15 min

ax = 8.95; a-x = 34.75 – 8.95 = 25.8 ml

$\boldsymbol{K = \frac{2.303}{15} log\left(\frac{34.75}{25.8}\right)}$ **(02marks)**

K_2 = 0.01985 min

t = 20

x = 11.40 a-x = 34.75 – 11.40 = 23.35ml

$K = \frac{2.303}{20} log\left(\frac{34.75}{23.35}\right)$ **(02 marks)**

K_2 = 0.01988 min

Since the value of K is fairly constant, it is first order. **(01mark)**

(ii) Rate constant = $\frac{0.020+0.01985+0.01988}{3}$

Rate constant = 0.01991 min **(02 marks)**

(c) (i) Reaction is first order

- Extent of hydraulic after I hour = 25%
- Therefore fraction remaining after 1 hour = 100 – 25 = 75%

  = 0.75

For first order

$K = \frac{2.303}{t} log\left(\frac{a}{a-x}\right)$

Then

$K = \frac{2.303}{60\ min} log\left(\frac{100}{75}\right)$ **(01mark)**

K=4.796 x 10^{-3} min

Then half life

$t\frac{1}{2} = \frac{0.693}{k}$ **(01mark)**

Then

$$t\frac{1}{2} = \frac{0.693}{4.796 \times 10^{-3}}$$

$t\frac{1}{2} = 144.5min$ **(01mark)**

(ii) Given

Reaction is first order

K_2 = 2K

T_1 = 35ºC = 308k

T_2 = 45ºC = 318k

$Log\left(\frac{k_2}{k_1} = \frac{Ea}{2.303R}\left(\frac{T_2-T_2}{T_1T_2}\right)\right)$ **(01mark)**

Then

$Log\left(\frac{2k_1}{k_1}\right) = \frac{Ea}{2.303\times8.314}\left(\frac{318-308}{318\times308}\right)$ **(01mark)**

Ea = 5.65 x 10^4Jmol^{-1} or 56453.6Jmol^{-1} or 56.53kJmol^{-1} **(01mark)**

3. (a) (i) It is immiscible liquid in water

- It has high molecular mass
- It has non-volatile compounds
- It does not decompose at the temperature of stream
- It is temperature sensitive
- It does not react with water
- It has a fairly high vapour pressure at temperature above 100ºC.

(Any five points @ 1 mark = 05 marks)

(ii) Data given

- Total pressure = 100 kPa
- Boiling temperature of mixture = 91ºC
- Vapour pressure of chlorobenze at 91ºC=29kPa
- Vapour pressure of water at 91ºC = (100 – 29) = 71)kPa
- Mass of chlorobenzene in distillate = 100g

Step 1: Mole ratio in the vapour

In steam distillation the mole ratio in the vapour equals the ratio of vapour pressures

$\frac{nc}{nw} = \frac{pc}{pw} = \frac{29}{71}$ **(00 ½ mark)**

Step 2. Mole of chlorobenzene

nc = $\frac{100}{112.5}$ ≈ 0.889 mol **(00 ½ mark)**

Step 3: Moles of water distilled

$nw = \frac{29kPa}{71kR}$ x 0.889mol ≈ 2.17mol **(01mol).**

Step 4: Mass of water

mw = nw x Mrw

= 2.17mol x 18gmol^{-1}

mw = 39.06g **(01mark)**

Step 5: Total mass of distilled

Mass of distilled = mw + mc

Mass of distilled = 39.06g + 100g

Mass of distilled = 139.06g

∴ The mass of the distilled containing 100g of chlorobenzene is approximately 139.06g **(02 marks)**

(b) The temperature affects the distribution coefficient because the temperature affect the solubility of the solute in the solvent. The increase in temperature causes the decrease in solubility which leads to increase in distribution coefficient and vice versa, so temperature must kept constant. **(03marks)**

(c) Formula UND

$\boldsymbol{k}\Delta = \frac{\boldsymbol{Cw}}{\sqrt{\boldsymbol{Ca}}}$ (00 ½ mark)

$k\Delta_1 = \frac{0.094}{0.1865} \approx 0.1865$ **(00 ½ mark)**

$k\Delta_2 = \frac{0.164}{0.761} \approx 0.1879$ **(00 ½ mark)** ∴

$k\Delta_3 = \frac{0.254}{1.850} \approx 0.186$ **(00 ½ mark)**

$k\Delta_4 = \frac{0.436}{5.430} \approx 0.1871$ **(00 ½ mark\)**

∴Phenol associates (dimerizes) in chlorofos solution, whulert main in normal molecular state in acquires solution since the value of KD is constant by using association concept. **(01 ½ marks)**

4. (a) (i) Ester due to presence of -COO-linkage. **(01mark)**

(ii) Main idea

- Methanol is used as a source of methanoic
- Ethanol gives ethyl group **(01mark)**
- Finally, esterification (acid-catalysed) occurs

Step 1: Oxidation of methanol to methanoic acid

Methano is oxidized by acidified potassium dichromate a $kMnO_4$

$CH_3OH+[O] \longrightarrow HCOOH$ **(02 marks)**

Step 2: Esterification of methanoic acid with ethanol in the presence of concentrates H_2SCl_4 (catalyst + dehydrating agent)

$HCOOH + CH_3CH_2OH \xrightarrow{\text{conc}} H_2SO_4\ HCOOCH_2CH_3+H_2O$ **(02 marks)**

(iii) Ethy methanoate **(01mark)**

(iv) $1+COOCH_2CH_3+NaOH \xrightarrow{\Delta} HCOONa + HOCH_2CH_3$ **(01mark)**

(b) (i) Most polymer exhibit resistance to chemical attack. Hence they are used to make clothing gloves.

- Polymers are poor conductors of heat and electricity. They are good thermal electric insulator i.e. electric cables.
- Polymers are very light in weight but with degree of strength. Therefore, they are used to make different fitting in aviation and construction industries.

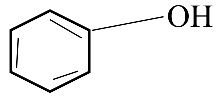
@ 01 ½ marks = 04 ½ marks

(ii) Rubber is tangle of polymeric chains. If sketched with enough external forces, individual chains slip past one another. Thereby causing the rubber to lose most of its electricity. **(01 mark)**

- The solution to this to cross-linked rubber with sulpher (using zinc oxide as a catalyst) to prevent slippage, a process known as vulcanization. **(1mark)**
- Through vulcanization process the rubber become more flexible and its quality improved for many practical work such as making tyres. **(01mark)**

(iii) Cationic polymerization is more favored than anionic polymerization when vinylic monomer electron donating group, because there is the formation stable coronium ion in which the electron donating groups increase the stability b donating the electron pairs to the positive carbon by the inductive affect. **(02)**

(c) (i) Tetrafluro ethane $CF_2{=}CF_2$ **(01 mark)**

(ii) Methanal HCHO and phenol  **(02marks)**

5. (a) (i) Aluminium sulplude is unstable in water and undergoes hydrolysis when its solution is mixed with calcium solution.

Aluminium sulphide reacts with water, producing aluminium hydroxide precipitate and hydrogen sulphide gas.

Calcium chloride does not take post directly in forming the precipitate; it is a spectator in solution **(01mark)**

$Al_2S_{3(s)} + 6H_2O_{(l)} \longrightarrow 2Al(OH)_{(s)} + 3H_2S_{(q)}$`` **(01mark)**

(ii) Copper (II) hydroxide is only slightly soluble in water because there is no strong interaction to remove Cu^{2+} ions from the solid.

In the presence of concentrated ammonia, ammonia acts as a ligand and forms a stable complex ion with Cu^{2+} ions. This complex formation shifts the equilibrium, causing the precipitate to dissolve. **(01mark)**

$Cu(OH)_2 \rightleftharpoons Cu^{2+}_{(aq)} + 2OH^-_{(aq)}$

$Cu^{2+}_{(aq)} + 4NH_{3_{(aq)}} \rightarrow [Cu(NH_3)_4]^{2+}_{(aq)}$

$Cu(OH)_{2_{(aq)}} + 4NH_{3_{(aq)}} \rightarrow [Cu(NH_3)_4]^{2+}_{(aq)} + 2OH^-_{(aq)}$ **(01mark)**

(b) Solution

$[NH_4^+] = 0.2M$

K5 $[NH_4OH] = 1.8 \times 10^5M$

T = 298k **(02marks)**

Kn = $\frac{kw}{kg} = \frac{1.0\times10^{-14}mol^2dm^{-6}}{1.8\times\times10^{-5}moldm^{-3}} = 5.56 \times 10^{-10}moldm^{-3}$

$\therefore$ Hydraulic constant of the salt is $5.56 \times 10^{-10}moldm^{-3}$.

(ii) Degree of hydrolysis

$$h = \sqrt{\frac{kh}{c}}$$

$$h = \sqrt{\frac{5.56 \times 10^{-10}}{0.2}}$$

$= 5.27 \times 10^{-5}$ or 0.00527%

$\therefore$ The degree of hydrolysis is 5.27×10^{-5} or 0.00527% pH of the solution.

$[H^+] = hC$

$[H^+] = 5.27 \times 10^{-6} \times 0.2$

$= 1.05 \times 10^{-5}M.$

$= 1.05 \times 10^{-5}M$

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

$pH = -\log (1.05 \times 10^{-5})$ **(02marks)**

$pH = 4.98$

$\therefore$ The pH of the solution is 4.78.

(c) To calculate the number of moles of NaOH and CH_3COOH.

- Moles of NaOH

  Volume = 20ml = 0.02L

  Molarity = 0.2M

  Moles = Volume x Molarity

  Moles = 4×10^{-3}mol = 4mmol **(00 ½ mark)**

- Moles of CH_3COOH

  Volume = 50ml = 0.05L

  Molarity = 0.2M

  Moles = Volume x Molarity

  Moles = 0.05L x 0.2M/L =

  Moles = 0.01 mol = 10mmol **(00 ½ mark)**

Determine the limiting reactants after the reaction

CH_3COOH + NaOH		CH3COONa + H_2O		
10 mol	4mmol	0	0	t=0
6 mmol		4 mmol		t=t.

Excess

To calculate the concentration of CH_3COOH and CH_3COONa in the 70ml final solution.

The total volume of solution = 20 + 50 = 70ml

$[CH_3COOH] = \frac{6mmol}{70ml} = \frac{6}{70}M$

$[CH3COONa] = \frac{4mmol}{70ml} = \frac{4}{70}M$

Use Henderson Hass/balch equation.

$pH = pKa + log\left(\frac{[CH_3COONa]}{[CH_3COOH]}\right)$ **(00 ½ mark)**

$pH = 4.74 + \log\left(\frac{4/70M}{6/70M}\right) = 4.56$

pH = 4.56 **(01 mark)**

Addition volume of 8g NaOH (0.2M) required to make pH = 4.74
From

$pH = pKa + \log\left(\frac{[CH_3COONa]}{[CH_3COOH]}\right)$ **(00 ½ mark)**

$4.74 = 4.74 + \log\left(\frac{[CH_3COONa]}{[CH_3COOH]}\right)$

$0 = \log\frac{[CH_3COONa]}{[CH_3COOH]}$

$\boldsymbol{\frac{[CH_3COONa]}{[CH_3COOH]}}$

How many moles of NaOH added (Need to calculate)

- Moles present of CH_3COOH and CH_3COONa

- Moles of CH_3COOH = 6mmol
- Moles of CH_3COONa = 4mmol

$CH_3COOH \rightleftharpoons CH_3COO- + H+$

$NaOH \longrightarrow Na^+ + H^-$

But $H^+ + OH^- \longrightarrow H_2O$

$CH_3COONa \longrightarrow Na+ + CH_3COO^-$

$[CH_3COONa] = 6 – x$

$[CH_3COONa] = 4 + x$

Then

$\frac{4+x}{6-x}$

4+x = 6-x

2x = 6-4

$\frac{2x}{2} = \frac{2}{2}$

X = 1mmol

The addition moles of NaOH is 1mmol.

- Volume that contains 1mmol?

  Molarity = $\frac{n\ mole}{Volume}$

  n moles = 1mmol

  Molarity = $\frac{8g}{\frac{4g}{m}/} = 0.2mmol/ml$

  Volume = $\frac{n\ moles}{Molarity} = 1mmol/0.2mol/$ml

  Volume = 5ml **(01mark)**

∴The 5ml of the 0.2M NaOH will be required to in the solution to achieve pH of 4.74.

(d) (i) The ionization of water is an endothermic process true; this is because kw increases from 0.64 x 10^{-4} to 1.0 x 10^{-14} as temperature increases **(1mark)**

(ii) The pH of water is greater at 298k then at 291k $[H^+]=\sqrt{kw}$ Sinr $[OH^-]=[H^+]$, $[H]^2$=kw

$[H+]_{291k} = \sqrt{0.64 \times 10^{-14}} = 0.8 \times 10^{-7}M$ **(00 ½ mark)**

[H+]298k = $\sqrt{1.0 \times 10^{-14}} = 1.0 \times 10^{-7M}$ **(00 ½ mark)**

pH at 291k = log (0.8 x 10^{-7} = 7.10

pH at 298k = -log (1 x 10^{-7} = 7.00

∴The answer is false (not valid) because the pH m creases with temperature.

(iii) From the solution (ii) $[H^+]$ at 271k is 0.8 x 10^{-7}M as $[H^+] = [OH^-]$, then the statement is true. **(01mark)**

(iv) From the solution (ii), pH of water was found to be 7 at 298k, this shows that water is natural at 298. Therefore the statement is true. **(01mark)**

6. (a) Given

Compound A has formula C_8H_6

With dilute H_2SO_4/.$HgSO_4$ $\longrightarrow$ gives B.

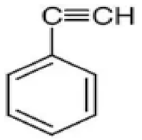
B can also be obtained from benzene + Acid chloride/$AlCl_3$ (Friedel crafts acylation)

B with I_2/aqueous kOH $\longrightarrow$ gives C + yellow compound D

Yellow compound in iodoform test = CHI_3.

Compound A

- Formula : C_8H_6
- Hydration with $HgSO_4/H_2SO_4$ is characteristic of alkynes
- Aromatic alkynes with formula C_8H_6 is : Phenylacetylene (C_6H_5-C≡CH)



(01 ½ marks)

Compound B

From A:

Hydration of phenylacetylenes gives a methyl ketone

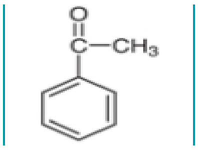
C_6H_5 - C≡CH $\xrightarrow{HgSO_4/+I_2SO_4}$ C_6H_5 – CO – CH_3 **(01 ½ marks)**

From benzene

Fridel – crafts acylation

$C_6H_6 + CH_3COCl \xrightarrow{AlCl_3} C_6H_5COCH_3$ **(01 ½ marks)**

Therefore B is acetophenone ($C_6H_5COCH_3$)



Compound D (yellow compound)

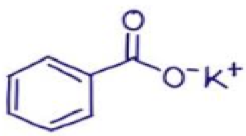
- I_2 /kOH gives iodoform test
- Yellow precipitate = Iodoform

  Therefore D is CHI_3 (Iodoform)

Compound C

- Acetophenone is a methyl ketone
- Iodoform reaction converts the rest into benzoate salts

  $C_6H_5COCH_3 \xrightarrow{I_2/kOH} C_6H_5COOk$ (Potassium benzoate)



(01 ½ marks)

Therefore,

- A: Phenylacetylene (C_6H_5 - C≡CH) **(01 mark)**
- B: Acetophenone ($C_6H_5COH_3$) **(01 mark)**
- C: Potassium benzoate (C_6H_5COOk) **(01mark)**
- Iodoform (CHI_3)

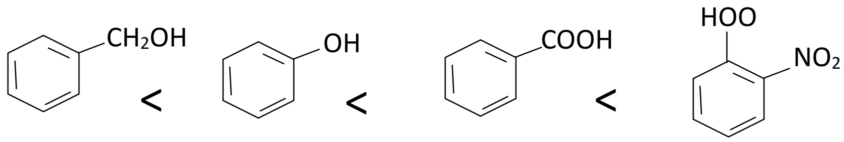
(b) (i) Triphenylamine **(01 ½ marks)**

(ii) N-methylbenzene amine **(01 ½ marks)**

(iii) Phenylamine/ benzeamine **(01 ½ marks)**

(iv) 2-phenylethanoyl hypochlorite (**01 ½ marks)**

(c) (i) Given: phenol, Benzyl alcohol, Benzoic acid, Nitrobenzoic acid. Increasing acidity



Benzyl alcohol < phenol < Benzoic acid < Nitrobenzoic acid

Reason: Electron – withdrawing NO_2 group increases acidity of benzoic acid, while benzyl alcohol is the least acidity due to lack of resonance stabilization of its conjugate base. **(02marks)**

(ii) Given: Ethanoic acid, propanoic acid, methanolic acid, 2-chloroethanoic acid.

2-chloroethanoic acid, 2-methylpropanoic acid.

Increasing acidity:

2-methylporopanoic acid < propanoic acid < Ethanoic acid < Methanoic acid <

2-chloroethanoic acid

Reason: Electron withdrawing groups (like Cl) increase acidity while electron donating groups (like CH_3) decrease it. **(02marks)**