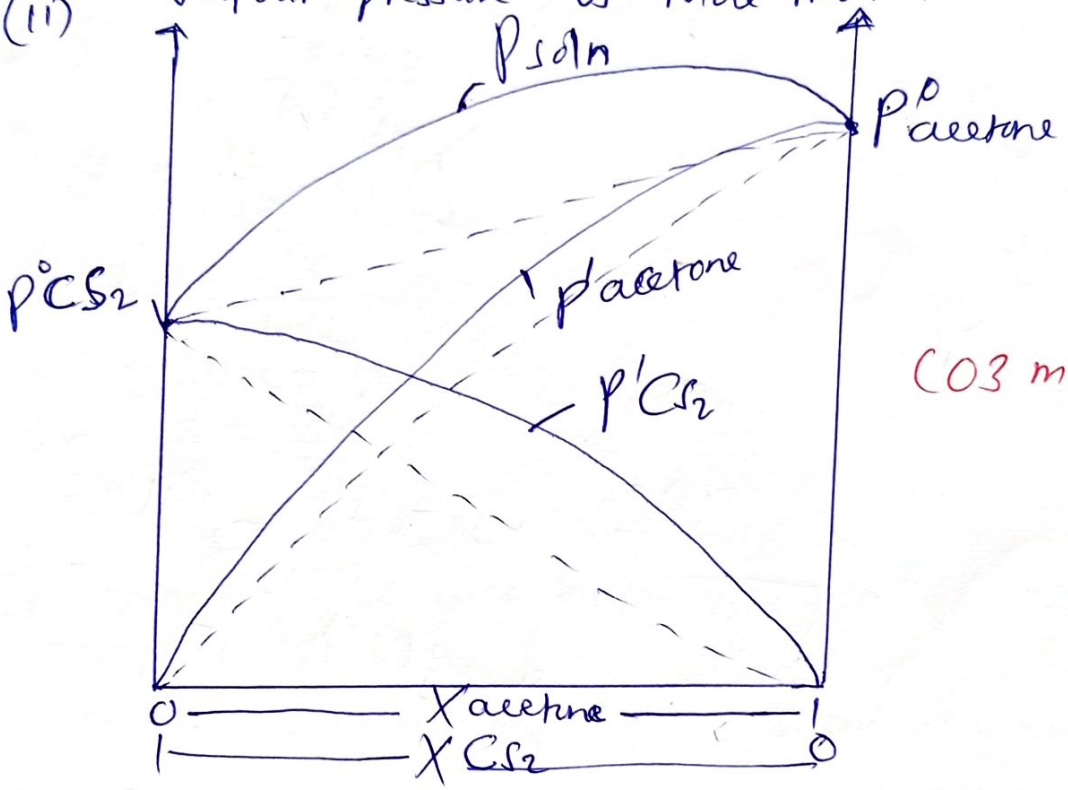
FORM SIX INTERISLAMIC MOCK EXAMINATION (2024)

CHEMISTRY 2

MARKING GUIDE:

01 (a) (i) Positive deviation from Raoult's law because after mixing form weaker intermolecular force of attraction therefore high vapour pressure than expected from Raoult's law. (02 marks)

(ii) Vapour pressure Vs Mole fraction curve diagram.



(03 marks)

(iii) A- Negative deviation ---- 00½
B- Positive deviation ---- 00½

A mixture A differ from solution B by the following properties

- It form lower vapour pressure than expected from Raoult's law
- It's formation is exothermic
- There is decrease in volume upon mixing
- Show stronger intermolecular force of attraction after mixing. (01 mark @ 00½)

(b) Given;

Distribution coefficient (kd) = 2

Mass of organic compound = 1g

Volume of aquous layer = $100cm^3$

Volume of ether layer = $100cm^3$

Required;

(i) Mass extracted by using $100cm^3$ of ether layer

Soln:

$$kd = \frac{[\text{Solute in ether}]}{[\text{Solute in aquous}]} \quad \text{---- 01}$$

$$2 = \frac{x/100}{1-x/100}$$

$$2 = \frac{x}{100} \times \frac{100}{1-x}$$

$$2 = \frac{x}{1-x} \quad \text{---- 01}$$

$$2-2x = x$$

$$\frac{2}{3} = \frac{3x}{3}$$

$$x = 0.67\,g$$

∴ The mass extracted by using $100cm^3$ of ether at once is 0.67g. ---- 01

(ii) mass extracted by using $50cm^3$ of ether twice.

1st extraction.

Soln:

$$kd = \frac{[\text{Solute in ether}]}{[\text{Solute in aquous}]} \quad \text{---- 01}$$

$$2 = \frac{\frac{x}{50}}{\frac{1-x}{100}}$$

$$2 = \frac{x}{50} \times \frac{100^2}{1-x}$$

$$2 = \frac{2x}{1-x}$$

$$2-2x = 2x \quad \text{---- 01}$$

$$\frac{2}{2} = \frac{4x}{2}$$

(b) (ii) $x = 0.5g$.

2nd extraction

Mass remained $= 1 - x = 1 - 0.5 = 0.5g$.

$$Kd = \frac{[\text{Solute in ether}]}{[\text{Solute in aqueous}]} \quad \text{---} \ 01$$

$$2 = \frac{\frac{x}{50}}{\frac{0.5-x}{100}}$$

$$2 = \frac{x}{50} \times \frac{100}{0.5-x}^{2}$$

$$2 = \frac{2x}{0.5-x}$$

$$1 - 2x = 2x$$

$$\frac{1}{4} = \frac{4x}{4}$$

$$x = 0.25g$$

Total mass extracted $= m_1 + m_2$

$= 0.5g + 0.25g$ --- 01

$= 0.75g$

∴ The mass extracted by using $50cm^3$ ether is $0.75g$.

(c) (i) Seperation of crude oil into various components

(ii) Purification of organic compounds

(iii) Extraction of natural compounds

(iv) Manufacturing of chemical in industries. (02 marks any two @ 1 mark)

01 (d) Data given

Vapour pressure of mixture $(P_T) = 760mmHg$

Vapour pressure of pure water $(P_W^\circ) = 733mmHg$

Molar mass of nitrobenzene $(M_{rN}) = 123g/mol$

Required to find proportional of water and Nitrobenzene. --- 01

(d) From, $\frac{M \text{ of organic liquid}}{M \text{ of water}} = \frac{P_{organic} \times Mr \text{ of organic}}{P_{water} \times Mr \text{ water}}$ ---01

$$\frac{M_N}{M_W} = \frac{(760-733) \times 123 g/mol}{733 \times 18 g/mol}$$ ---01

$$= 0.25 = \frac{1}{4} = 4:1$$

∴ The proportion of water and nitrobenzene in a distillate is 4:1. ---01

02 (a) (i) Collision Theory.

- Not all collision between the reactants can result into products only successful collision form the product (01 each 00½ mark)
- The successful collision must have enough energy called activation energy

(ii) Arrhenius Theory;-

- Reacting particles collide each other to attain reaction. (1 mark @ 00½)
- The frequency of collision increase with an increase in temperature.

(b) (i) Given;

$3A + 2B \longrightarrow 4C + D$

$\frac{\Delta[C]}{\Delta t} = 13 \text{ mol/s}$

From equation

$\frac{\Delta[D]}{\Delta t} = \frac{1}{4}\frac{\Delta[C]}{\Delta t}$ ---- 01

$= \frac{1}{4} \times 13 \text{ mol/s}$

$= 3.25 \text{ mol/s}$ ---- 00½

∴ Rate of production of D is 3.25 mol/s

(b) (i) Then;

$$\frac{\Delta[D]}{\Delta t} = -\frac{1}{2}\frac{\Delta[B]}{\Delta t} \quad \text{---- 01}$$

$$\frac{\Delta[B]}{\Delta t} = -2\frac{\Delta[D]}{\Delta t}$$

$$= 2 \times 3.25 \text{ mol/s} \quad \text{--- 01/2}$$

$$= -6.50 \text{ mol/s}$$

∴ The rate of consumption of B is -6.50 mol/s.

(ii) From general formula of half life.

$$\frac{t_1'}{t_2'} = \left(\frac{[NO_2]'}{[NO_2]}\right)^{n-1} \quad \text{---- 01}$$

Where t_1' and t_2' are half life obtained from the data given and $[NO_2]'$ and $[NO_2]$ are the initial concentration.

$$\frac{200}{300} = \left(\frac{0.0065}{0.01}\right)^{n-1} \quad \text{--- 01}$$

$$0.67 = 0.65^{n-1}$$

$$\log 0.67 = n-1 \log 0.65$$

$$-0.174 = (n-1)\,-0.187$$

$$-0.174 = -0.187n + 0.187$$

$$n = 1.93 \approx 2 \quad \text{--- 01}$$

∴ The order of reaction with respect to NO_2 is 2.

(c) (i) Since MnO_4^- is strong oxidizing agent will oxidized HCl to Cl_2 gas therefore not used during redox titration (01 marc)

(ii) Starch is added near the end point of iodometric titration inorder to prevent the formation of starch-iodine complex that will interfere the reaction between iodine and sodium thiosulphate. (01 marc)

(d) (i) $4OH^- \longrightarrow 2H_2O + O_2 + 4e^-$

then, $m = \frac{Mr}{V \cdot F} It$.

$= \frac{32 \times 2A \times 75.39 \times 60sec}{4 \times 96500C}$ --- 01

$= 0.75g$.

At S.T.P,

$32g$ of $O_2 \equiv 22.4dm^3$

$0.75g$ of $O_2 \equiv x$ --- 01

$x = \frac{0.75g \times 22.4dm^3}{32g}$

$= 0.525dm^3$

∴ Volume of O_2 produced is $0.525dm^3$ -- 01

(ii) Deduction of element X in $X_2(SO_4)_3$.

Given mass of $X_2(SO_4)_3$ deposited $= 1.62g$.

then, For Cu;

$m = \frac{Mr\,It}{V \cdot F}$

$= \frac{64 \times 2A \times 75.39 \times 60sec}{2 \times 96500C}$

$= 3g$. --- 01

From Faraday second law

$\frac{m_{Cu}}{m_X} = \frac{E_{Cu}}{E_X}$

but $E_{Cu} = \frac{Mr}{V} = \frac{64}{2} = 32$. -- 01

$E_X = \frac{m_X \cdot E_{Cu}}{m_{Cu}}$

$= \frac{1.62g \times 32}{3g}$

$= 17.28$

— 06 —

(d) (ii) $E_x = 17.28$

then $E_x = \frac{M_x}{v}$ $v = 3$

$M_x = E_x \times v$ -- 01

$= 17.28 \times 3 = 51.82 \simeq 52 g/mol$

∴ From the molar mass the element X will be Chromium.

(e) Given;

$E^{\ominus}_{Ni^{2+}/Ni} = -0.25V$

$E^{\ominus}_{Ag^{+}/Ag} = 0.80V$

$[Ag^+] = 0.1M$

$[Ni^{2+}] = 2.5$

Required the cell e.m.f.

from $E_{cell} = E^{\ominus} + \frac{0.0591}{n} \log \frac{[Reducing]}{[Oxidation]}$ ... 01

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

$= 0.80V - (-0.25V)$

$= 1.05V$

$E_{cell} = 1.05V + \frac{0.0591}{2} \log \frac{(0.1)^2}{(0.25)}$

$= 1.05V + (-0.070V)$ 01

$= 0.979V$ --

∴ The e.m.f of the cell is 0.979V

Then, $K_c = \log^{-1}\left(\frac{n E^{\ominus}_{cell}}{0.0591}\right)$

$= \log^{-1}\left(\frac{2 \times 1.05V}{0.0591}\right)$ -- 01

$= 3.92 \times 10^{35}$ -- 01

∴ The equilibrium constant of cell is 3.92×10^{35}

(a) (i) Due to the formation of the complex compound tetrachloroplumbate (II) ion

i.e $PbCl_2$ + excess HCl (conc) $\longrightarrow [PbCl_4]^{2-}_{(aq)}$ (02 marks)

(ii) This is due to common ion effect which keeps the concentration of OH^- low and therefore prevent the precipitation to occur. (02 marks)

(b) Given:

Concentration of $CaF_2 = 0.0168\ g/dm^3$

Molar Solubility = $\frac{\text{Conc}}{\text{Molar mass}}$

$= \frac{0.0168\ g/dm^3}{78\ g/mol}$ --01

$= 2.15 \times 10^{-4}\ mol/dm^3$

Required to calculate the Ksp for CaF_2.

Consider

$CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$

$x \quad\quad 2x$ --01

$K_{sp} = [Ca^{2+}][F^-]^2$

$= x \cdot (2x)^2$

$= 4x^3$ -- 01

but $x = 2.15 \times 10^{-4}\ mol/dm^3$

$= 4(2.15 \times 10^{-4}M)$

$= 3.99 \times 10^{-11}\ mol^3 dm^{-9}$ --01

∴ The Ksp for CaF_2 is $3.99 \times 10^{-11}\ mol^3 dm^{-9}$ --01

(c) Given;

Molarity of base = 0.15M

Molarity of salt = 0.09M

Pkb for weak base = 4.75 -- 01

Required the pH of buffer solution

from, $pH = pKw - (pKb + \log \frac{[salt]}{[Base]})$ -- 01

03 (c) $= 14 - (4.75 + \log \frac{(0.09)}{(0.15)})$ — 01

$= 14 - (4.75 + (-0.22))$

$= 14 - 4.53$ — — — 01

$= 9.47$

∴ The pH of the basic buffer solution is 9.47. — — — 01

(d) (i) By coating
(ii) By passivation
(iii) By alloying
(iv) By cathodic protection

(06 marks @ 01½).

4. (a) Across the period atomic radii decreases due to increase in nuclear charge and nuclear attractive force which cause more contraction of shells. ——— (01 marks)

Down the groups, atomic radii increases due to increase in number of shells, decrease in nuclear attractive force and screening effects. ——— (01 marks)

(b) Electronegativity generally decreases down the group because of increasing atomic/ionic size that cause the decrease in nuclear attractive power of an atom (02 marks)

(c) Reasons:

(i) Due to small ionic/atomic size for each first member in each group A elements.

(ii) High electronegativity value of the first member in each group.

(iii) Electrical shells are close to the nucleus due to few number of shells acquired by first member in each group. (Any two @ 01 mark)

(d) (i) Both Li and Mg burn in air to form normal oxides.

$$4Li_{(s)} + O_{2(g)} \longrightarrow 2Li_2O_{(s)}$$

$$2Mg_{(s)} + O_{2(g)} \longrightarrow 2MgO_{(s)}$$

(ii) Both Li and Mg combine directly with nitrogen to form nitrides.

$$6Li_{(s)} + N_{2(g)} \longrightarrow 2Li_3N_{(s)}$$

$$3Mg_{(s)} + N_{2(g)} \longrightarrow Mg_3N_{2(s)}$$

(iii) Hydroxides, carbonates and nitrates of both Li and Mg decompose when heated to give oxides:-

4. $2LiOH_{(s)} \xrightarrow{\Delta} Li_2O_{(s)} + H_2O_{(g)}$

$Mg(OH)_{2(s)} \xrightarrow{\Delta} MgO_{(s)} + H_2O_{(g)}$

$MgCO_{3(s)} \xrightarrow{\Delta} MgO_{(s)} + CO_{2(g)}$

$Li_2CO_{3(s)} \xrightarrow{\Delta} Li_2O_{(s)} + CO_{2(g)}$

$2LiNO_{3(s)} \xrightarrow{\Delta} Li_2O_{(s)} + 2NO_{2(g)} + \frac{1}{2}O_{2(g)}$

$Mg(NO_3)_{2(s)} \xrightarrow{\Delta} MgO_{(s)} + 2NO_{2(s)} + \frac{1}{2}O_{2(g)}$

(iv) Carbonates, phosphates and fluorides of both Li and Mg are sparingly soluble in water

(v) Both halides of Li and Mg are partially covalent in ~~both~~ character, hence can dissolve in many organic solvents.

(Any 3 @ 02marks).

(e) (i) The major impurity in the bauxite is silicon dioxide (silica). The ore is heated with carbon at 1000°C under nitrogen (01mark) The following reaction occurs: (01mark)

$Al_2O_{3(s)} + 3C_{(s)} + N_{2(g)} \xrightarrow{1000°C} 2AlN_{(s)} + 3CO_{(g)}$

$SiO_2 + C \xrightarrow{1000°C} Si_{(g)} + CO_{2(g)}$

The silica get reduced to silicon and CO_2 gas. Volatile silicon and CO_2 gas escape leaving behind aluminium nitride. On hydrolysis AlN give $Al(OH)_3$. (01mark).

$AlN_{(s)} + 3H_2O_{(l)} \xrightarrow{1200°C} Al(OH)_{3(s)} + NH_{3(g)}$

The obtained $Al(OH)_3$ is washed and dried and then heated to form pure aluminium oxide

$2Al(OH)_{3(s)} \xrightarrow{\Delta} Al_2O_{3(s)} + 3H_2O_{(g)}$ (01mark)

4. (e) (ii) Pure aluminium oxide (alumina) is melted in a steel container in presence of cryolite and fluospar (CaF_2). The molten aluminium is collected at the bottom and trapped from time to time. Oxygen is liberated at the anode. (01 marks)

The reactions occured:

At cathode:

$$4Al^{3+}_{(aq)} + 12e^- \longrightarrow 4Al_{(s)}$$ (01 marks)

At anode:

$$6O^{2-}_{(aq)} \longrightarrow 3O_{2(g)} + 12e^-$$ (01 marks)

Overall reaction:

$$4Al^{3+}_{(aq)} + 6O^{2-}_{(aq)} \longrightarrow 4Al_{(s)} + 3O_{2(g)}$$ (01 marks)

5. (a) (i) Benzene-1,4-diol

(ii) 4-chlorophenylmethanol

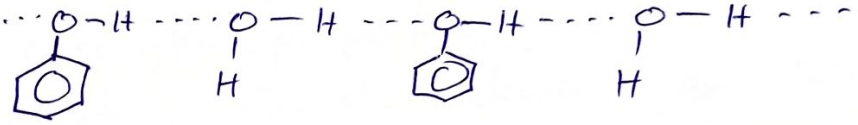
(iii) Butan-2-ol

(iv) Butan-1-ol. (01 mark @)

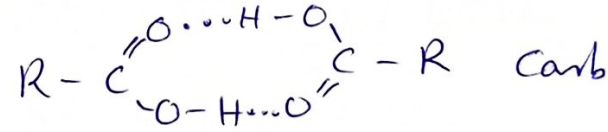
(b) (i) The phenyl group withdraw electrons from the OH group and hence weaken O–H bond. This makes O–H bond easily broken in aqueous solution to release H^+ ions. (02 marks)

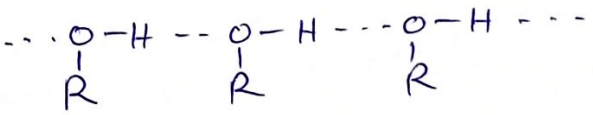
5 (b) (ii) Phenol contain OH group which donate electrons towards benzene by +M-effects.
OH in phenol is a strong activator than CH_3- group in toluene that's why phenol is more reactive than toluene. (02 marks)

(iii) Phenol can form hydrogen bonds with water molecules hence soluble in water but toluene can not form hydrogen bonds with water. (02 marks)

i.e 

(c) (i) Carboxylic acids have higher boiling point than alcohols because they form many hydrogen bonds compared to alcohols i.e carboxylic acids have two sites for H-bonds formation whereas alcohols have only one site. (02 marks)

i.e  Carboxylic acids

 Alcohols.

(ii) Acetone is more polar compared to propanal. The polarity of acetone makes it have more stronger intermolecular forces of attraction. That's why acetone have higher boiling point compared to propanal. (02 marks)

5. (d) (i) $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-H \xrightarrow{KMnO_4/H^+} CH_3CH_2COOH$ · (02 marks)

(ii) $CH_3C\equiv CCH_3 + H_2O \xrightarrow[60^\circ C]{H_2SO_4/HgSO_4} CH_3CH_2\overset{O}{\overset{\|}{C}}-CH_3$ · (02 marks)

(iii) $CH_3C\equiv CCH_3 + O_3 \xrightarrow{H_2O} CH_3COOH + CH_3COOH$ · (02 marks)

6. (a) (i) Variable oxidation states

Transition metals show a wide range of oxidation states due to their ability to loose electrons from both 4s and 3d-orbitals.

(ii) Catalytic properties

- Most of transition elements and their compounds particularly oxides have good catalytic properties. Their catalytic properties are associated with the presence of vacant d-orbitals, the tendency to exhibit variable oxidation states, the tendency to form reaction intermediates with reactants and presence of defects (irregular arrangement of atoms) in their crystal lattices.

(iii) Magnetic properties

The transition elements are paramagnetic with exception of zinc (because of absence of unpaired electron(s)).

(iv) Formation of coloured compounds.

- Transition elements compounds are generally colored. The colour formation is not a characteristic of simple ion but a complex ion of transition elements. The colour formation results due to splitting of d-orbitals into double and treble degenerates. Transition of electrons in these degenerate orbitals cause colour formation. (Any three @ 01 mark)

(b) (i) $[PtCl_2(en)_2]$

(ii) $Na_2[NiCl_4]$

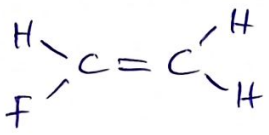
(iii) $(NH_4)_2[Ni(H_2O)_2(C_2O_4)_2]$

(iv) $[Fe(NH_3)_6][Cr(CN)_6]$

(v) $[Co\,H_2O(en)_2\,CN]^{2+}$

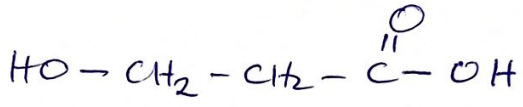
(01 mark @).

(c) (i)



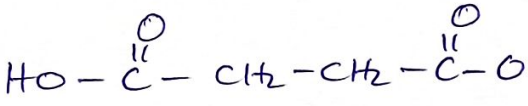
(02 marks)

(ii)

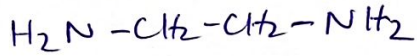


(02 marks)

(iii)

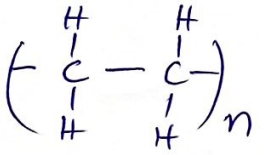


and (01 mark)



(01 mark).

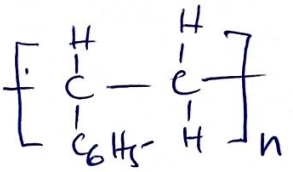
(d) (i)



(01 mark)

- Making plastic bottle containers, plastic bags, pipes and electrical insulators. (Any one) (1 mark)

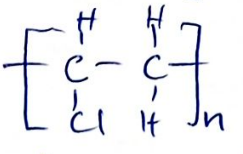
(ii)



(01 mark)

- Used for making household goods, electrical insulators, lacquers, optical lenses and ion exchange resins. (Any one) (01 mark)

(iii)



(01 mark)

- Used for making cable insulation pipes, hoses and packaging materials. (Any one) (01 mark).