Name.....

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Signature.....

P525/1
CHEMISTRY
Paper 1
July/August 2024
2¾ Hours

MASAKA DIOCESAN EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

JOINT MOCK EXAMINATIONS 2024

CHEMISTRY

PAPER 1

2 hours 45 minutes

INSTRUCTION TO CANDIDATES

Answer all questions in section A and only six questions in section B.

All questions must be written in the spaces provided.

The periodic table with relative atomic masses is provided.

Non-programmable scientific calculators may be used.

Illustrate your answers with equations where applicable.

Where necessary, use the following

Molar gas constant, R	=	8.31 $JK^{-1}mol^{-1}$
Molar volume of gas at s.t.p	=	22.4 dm^3
Standard temperature	=	273 K
Standard pressure	=	101325 Nm^{-2}

For examiner's use only																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	TOTAL
5	5	5	5½														

CHEMISTRY 525/1 MARKING GUIDE 2024

SECTION A: (46 Marks)

Attempt all questions in this section.

1. (a) State the principal oxidation state of group II elements. (½ mark)

+2 ✓

(b) Explain why group II elements;

(i) are strong reducing agents. (1½ marks)

second largest atoms in the periodic table. outermost electrons far from the nucleus and less attracted by the nucleus, so easily/readily released/lost

(ii) are harder than group I elements. (1½ marks)

- Contribute two electrons per atom towards metallic bond formation. Increasing the strength of metallic bond compared to group I elements which contribute only one electron.

(c) Describe one property in which beryllium resembles aluminium. (1½ marks)

Both react with cold hot concentrated alkalis to form complex ions. $Be_{(s)} + 2OH^- + 2H_2O \rightarrow Be(OH)_4^{2-}{}_{(aq)} + H_{2(g)}$

- Products formed.

2. (a) An alcohol Q C_4H_9OH reacts with sodium metal liberating hydrogen gas.

(i) Write a general equation for the reaction. (1½ marks)

$C_nH_{(2n+1)}OH + Na_{(s)} \rightarrow C_nH_{(2n+1)}ONa + \frac{1}{2}H_{2(g)}$

OR $RCH_2OH + Na_{(s)} \rightarrow RCH_2ONa + \frac{1}{2}H_{2(g)}$

(ii) Name the chemical nature of the alcohol in the reaction. (½ mark)

Acidic. ✓

(b) (i) Name one reagent that can be used to identify the functional group in the alcohol Q and state what would be observed when the reagent is treated with the alcohol. (1½ marks)

Reagent Phosphorous pentachloride ✓

Observation white fumes / misty fumes

(ii) Write the general equation for the reaction between alcohol Q and the reagent named (1½ marks)

$C_nH_{(2n+1)}OH + PCl_{5(g)} \rightarrow C_nH_{(2n+1)}Cl + HCl + POCl_{3(g)}$

-3(a) $2Fe(OH)_{2(s)} + \frac{1}{2}O_{2(aq)} + H_2O_{(l)} \longrightarrow 2Fe(OH)_{3(s)}$.

(c) Alcohol Q when treated with iodine solution followed by aqueous sodium hydroxide solution at 30°C, a yellow precipitate is formed but no effect with acidified potassium manganate VII solution.

Name Q ....2-methylpropan-2-ol.... (½ mark) 04

3. State what would be observed if the following substances are treated together. In each case write equations for the reaction

(a) Aqueous Iron II sulphate and aqueous sodium hydroxide solution then left standing.

Observation ....pale dirty green precipitate, turns brown on standing.... (1 mark) 01

Equation $Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Fe(OH)_{2(s)}$. (1½ marks) 2

$4Fe(OH)_{2(s)} + O_{2(g)} \rightarrow Fe_2O_{3(s)} + 2H_2O_{(l)} + 4H^+_{(aq)}$

$2Fe^{2+}_{(aq)} + \frac{1}{2}O_{2(g)} + 2H_2O \rightarrow Fe_2O_{3(s)} + 4H^+_{(aq)}$

(b) Aqueous sodium ethanoate solution and copper II sulphate solution.

Observation ....blue precipitate.... (1 mark) 02

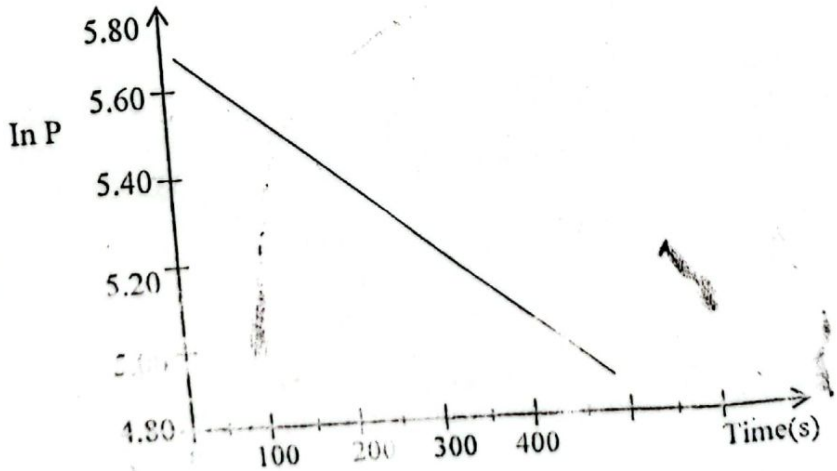
Equation $2CH_3COO^-_{(aq)} + Cu^{2+}_{(aq)} + 2H_2O_{(l)} \rightleftharpoons 2CH_3COOH_{(aq)} + Cu(OH)_{2(s)}$ (1½ marks)

$CH_3COO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + OH^-_{(aq)}$ / $Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Cu(OH)_{2(s)}$ 5

4. (a) The rate of decomposition of azomethane is studied by monitoring the partial pressure of the reactants as a function of time.

$CH_3N{=}NCH_3 \longrightarrow N_{2(g)} + C_2H_{6(g)}$

A sketch of a plot of In P against time for the decomposition of azomethane at 30°C is given below.



(i) State the order of decomposition of azomethane. (½ mark)

first order / 1

(ii) Give a reason for your answer. (1 mark)

the plot of lnP against time is a straight line with a negative slope. ½

(b) Describe how you would use the sketch above to determine;

(i) the original concentration of azomethane. (partial pressure.) (1 marks)

Intercept on y-axis, at time, t=0 gives the natural logarithm of concentration of P and $P_0 = e^{\text{intercept}}$

(ii) half-life of the decomposition of azomethane. (1 mark)

half-life = $\frac{0.693}{\text{slope}}$ ½

(c) The hydrolysis of sucrose is as follows:

$$C_{12}H_{22}O_{11} + H_2O \rightleftharpoons^{H^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

Sucrose — Glucose — Fructose

(i) State two conditions under which the reaction would be first order with respect to the concentration of sucrose overall. (2 marks)

- water is used in large excess.
- ~~in large excess.~~
- Acid as a catalyst

(ii) Write the rate equation for the reaction. (1 mark)

Rate = $K[C_{12}H_{22}O_{11}]$ ½

5. 0.817 g of Iron III chloride when vaporized displaced 56.4 cm^3 of water in the victor Meyer's apparatus maintained at 760 mmHg and standard temperature.

(a) (i) Calculate the relative formula mass of Iron III chloride vapour.

$PV = nRT$

$101325 \times 56.4 \times 10^{-6} = \frac{0.817}{Mr} \times 8.314 \times 273$ ½

$Mr = 324.33$

(ii) Comment about your answer. (1 mark)

The relative formula mass is twice the actual mass of Iron III chloride dimerises in vapour form. ½

(b) Write the structure of vapourised Iron III chloride. (1 mark)

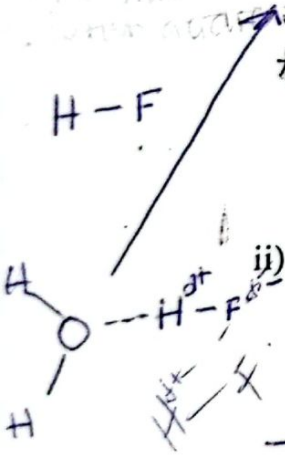
(c) Explain why aqueous solutions of Iron III chloride turn litmus paper red. (02 marks)

Iron III chloride undergoes salt hydrolysis releasing free hydrogen ions that make the solution acidic. ½

$Fe^{3+}_{(aq)} + 3H_2O_{(l)} \rightarrow Fe(OH)_{3(s)} + 3H^+_{(aq)}$ ✓ ½

6. (a) i) Define the term **hydrogen bond.** (1 mark)

- dipole-dipole moment between a hydrogen atom bonded to a more electronegative atom in one molecule and another electronegative atom with atleast a lone pair of electrons in another molecule. ½



ii) State two natural occurrences explained by the existence of hydrogen bonds. (1 marks)

- stability of/in nucleic acids.
- reduced density of ice
- reduction in melting point of ice with increase in pressure.
- increase in surface tension of H_2O / ice in B.P of some liquids e.g H_2O, ice.

(b) 2-nitrophenol and 4-nitrophenol have different solubilities in water and boiling points.

State;

(i) one physical method that can be used to separate the isomers in a mixture basing on their solubilities in water. (1 mark)

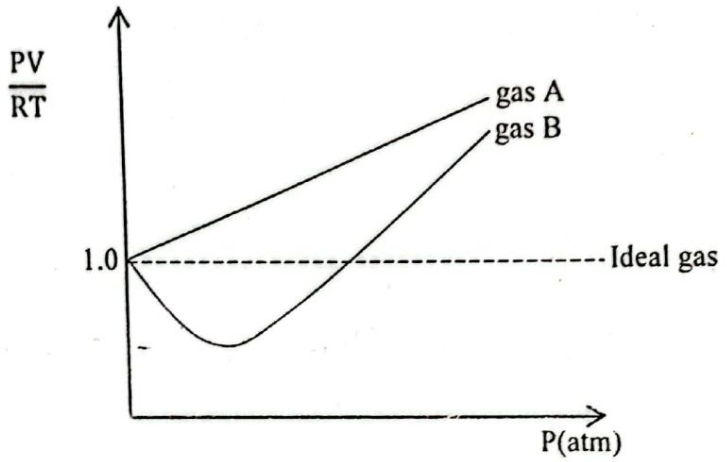
- steam distillation. ½

2-nitrophenol is less volatile in water than 4-nitrophenol.

(ii) why the two isomers differ in boiling points? (3 marks)

In 4-nitrophenol, the hydroxyl group is far from the n... the molecules associate through strong intermolecular hyd... bonds which repuire a lot of heat energy to overcome. In 2-nitro phenol the hydroxyl group is near/close to the nitro group and between the ~~gro~~ groups. Intra molecular hydro... bonds form. Molecules associate through weak van der waal... forces, require low amount of heat energy.

7. (a) The Figure below shows the PV curves of two gases A and B and an ideal gas.



i) Identify which curve represents;

Carbondioxide (½ mark)

B. ✓

Hydrogen gas (½ mark)

A. ✓

ii) Give a reason for your answer in (i) above.

hydrogen gas (A) deviates positively ~~at~~ at all while carbondioxide gas deviates negatively at low pressure and positively at high pressure.

(b) Describe the cause for the observed trend(s) along the curve for;

(i) an ideal gas (1½ marks)

~~the~~ gas obeys Boyles law, ~~the~~ product PV is constant at all pressures. The effect by ~~the~~ change in pressure is counteracted by ~~the opposite~~ change in volume.

(ii) gas B (3 marks)

At low pressure, the gas B obeys boyles law/behaves as an ideal gas. As pressure increases it deviates negatively from ideal behavior; Carbondioxide has high molecular mass deviation due to molecular attraction out weighs deviation due to molecular volume; At high pressure, the gas deviates positively, gas molecules are too close, molecular volume no longer negligable; deviation due to molecular volume out weigh deviation due to molecular attraction.

8. (a) What do you understand by the following:

(i) Effective nuclear charge (1 mark)

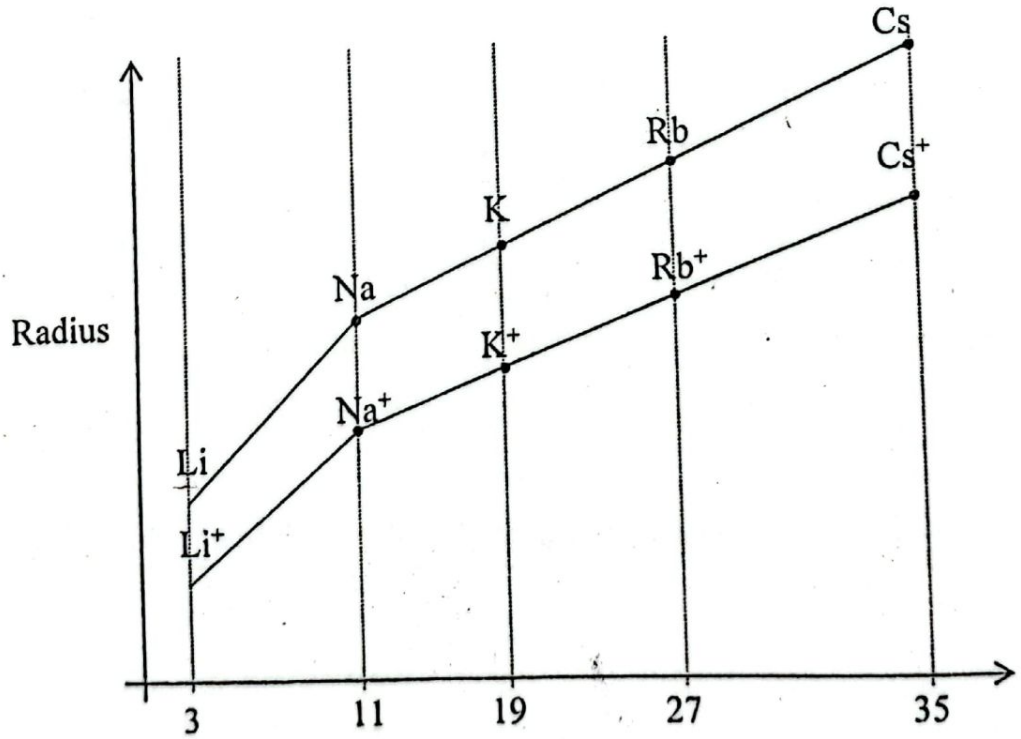
Actual positive nuclear attraction for an electron in multi-electron atom.

Nuclear charge screening effect actual positive.

(ii) Atomic radius (1 mark)

Half the inter-nuclear distance of two closest atoms of the same element in a bonding situation.

(b) The figure below shows the comparison between atomic radius and ionic radii of group I elements.



Explain;

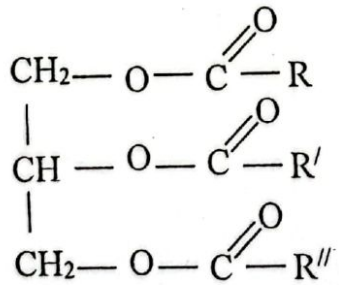
(i) the observed difference in the radii of atoms and ions of group I elements. (2 marks)

Removal of electrons increases ✓ its effective nuclear charge ✓ since its proton: electron ratio is higher than in the atom; this increases ✗ the nuclear attractive force for the remaining electrons, reducing the ~~se~~ size of the ion.

(ii) The variation in the atomic radius of group I elements. (3 marks)

From one element to the next down the group, an extra shell ✓ a full shell of electrons is added to the atom increasing screening effect ✓ at the same time, same number of protons is added to the nucleus, increasing nuclear charge ✓ But increase in screening effect outweigh its increase in nuclear charge ~~outwe~~ decreasing effective nuclear attraction ✓ and the outer electrons become increasingly less attracted ✓ by the nucleus, this increases ✓ the atomic size.

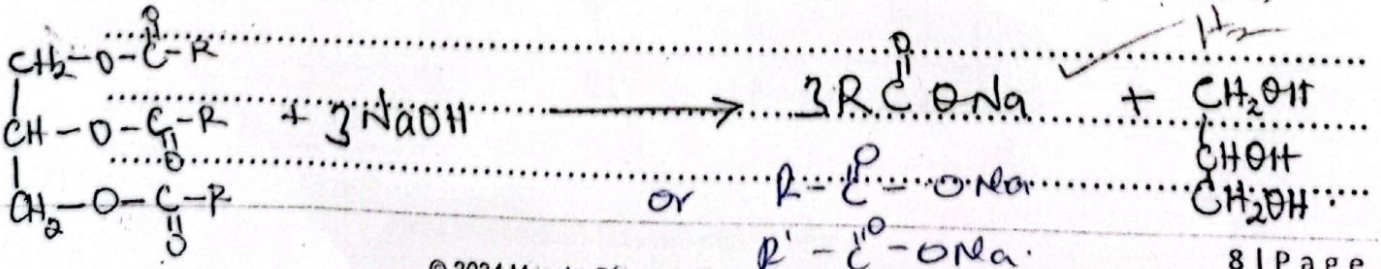
9. Fat and oils are names of the class of compounds called triglycerides which contain three ester groups.



(a) Name the type of reaction that leads to the formation of a triglyceride. (½ marks)

Condensation ✓½ not Condensations

(b) Triglycerides reacts with hot concentrated alkali solution to form soap. Write a general equation for the reaction. (1½ marks)



(c) State two differences between fats and oils. (02 marks)

Oils	fats
-liquids at room temp	-solids at room temperature ✓✓
-produced in/by plants	-produced in/by animals.
Have more unsaturated fatty acids	- Have saturated fatty acids.

(d) Describe briefly how the degree of ~~insalivation~~ unsaturation in the triglyceride can be determined. (2½ marks)

Remove die

-the tri-glyceride is treated with excess standard iodine solution; which reacts with the carbon-carbon double bond. Excess iodine is titrated against standard sodium thiosulphate using starch indicator. Using the mole reacting ratio, the iodine number - number of moles/grams of iodine that react with 100g of ~~the~~ oil is calculated. 6½

SECTION B: (54 Marks)

10. (a) Describe one property in which zinc;

(i) resembles transition elements. (1 mark)

-forms complex ions with hot concentrated alkalis.

~~-is used as a catalyst~~

(ii) differs from transition elements. (1 mark)

-forms ~~complex~~ compounds ~~with~~ using a fixed oxidation state of +2.

-forms non coloured compounds/ions in solution.

(iii) resembles group II elements. (1 mark)

forms c/pds using a fixed oxidation state of +2. ½

- forms ions

(b) Write equation of reaction between concentrated sulphuric acid and;

(i) red lead (Pb_3O_4) (1 mark)

$2Pb_3O_{4(s)} + 6H_2SO_{4(aq)} \rightarrow 6PbSO_{4(s)} + 6H_2O_{(l)} + O_{2(g)}$ ↑

(ii) hydrogen iodide (1 mark)

$14HI + 2H_2SO_{4(aq)} \rightarrow 7I_{2(g)} + H_2S_{(g)} + S_{(s)} + 8H_2O_{(l)}$ ↑

(iii) copper metal (01 mark)

$Cu_{(s)} + 2H_2SO_{4(aq)} \rightarrow CuSO_{4(aq)} + SO_{2(g)} + 2H_2O_{(l)}$

(c) 1.0 g of a mixture of sodium sulphite and sodium sulphate was dissolved in distilled water to make 250 cm³ of solution 25 cm³ of this solution required exactly 23.10 cm³ of 0.01 M acidified potassium manganate VII solution for complete reaction. Calculate the % by mass of sodium sulphate in the mixture (Na = 23, S = 32, O = 16) (03 marks)

$2MnO_{4(aq)}^- + 6H^+_{(aq)} + 5SO_{3(aq)}^{2-} \rightarrow 2Mn^{2+}_{(aq)} + 3H_2O_{(l)} + 5SO_{4(aq)}^{2-}$

moles of MnO_4^- = $\frac{23.1 \times 0.01}{1000}$ ✓

= 2.31×10^{-4} moles ✓

Moles of SO_3^{2-} = $\frac{5}{2} \times 2.31 \times 10^{-4}$ ✓

= 5.775×10^{-4} moles ✓

moles of SO_3^{2-} in 250 cm³ of soln

$\frac{5.775 \times 250}{25} \times 2 = 5.775 \times 10^{-3}$ moles ✓

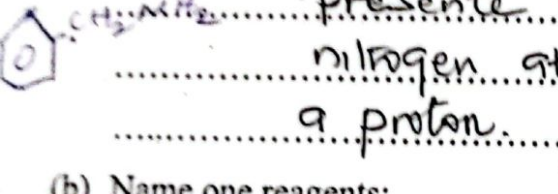
Mass of Na_2SO_3 = $5.775 \times 10^{-3} \times 126$ ✓

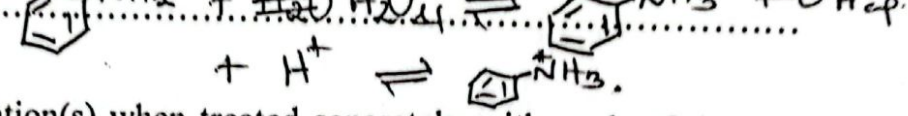
= 0.727g ✓

% by mass = $\frac{0.727}{1} \times 100 = 72.7\%$ ✓

11. (a) Benzylamine is a weak base and phenol is a weak acid. Explain what causes the basic character in benzylamine. (1½ marks) 09

Presence of lone pair of electrons on the nitrogen atom readily available for donation to a proton.





(b) Name one reagents;

(i) that gives similar observation(s) when treated separately with each of the two organic compounds in (a) above. State what would be observed. (2 marks)

Reagent Bromine water ✓ 01

Observation

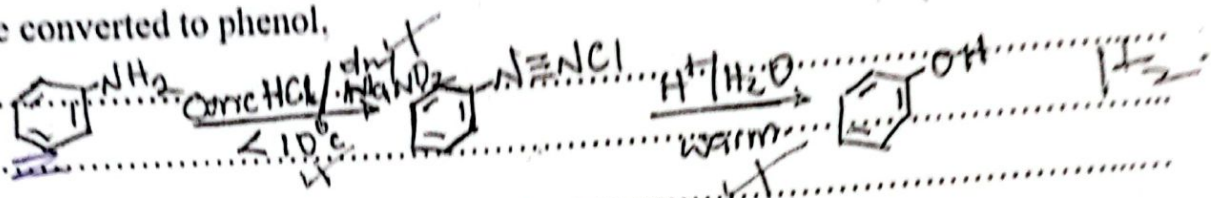
white precipitate ✓ 01

(ii) that can be used to distinguish between the two organic compounds. State what would be observed when the reagent is treated separately with the two organic compounds. (03 marks)

Reagent ~~Neutral~~ Neutral Iron III chloride solution ✓ 01

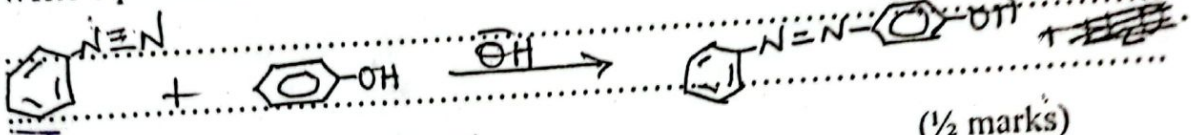
Observation Benzylamine — no observable change. 01
Phenol — purple/violet colouration. 01

(c) Write equation, stating reagents and conditions of reaction to show how benzylamine can be converted to phenol. (1½ marks)



(d) Benzylamine, when treated with cold concentrated hydrochloric acid and dry sodium nitrite, compound Q is formed. Q reacts with phenol in alkaline medium to form an industrial product R.

(i) Write equation for the reaction between Q and phenol. (01 mark)



01

(ii) State the importance of the reaction. (½ marks)

Manufacture of dyes / paints. ½

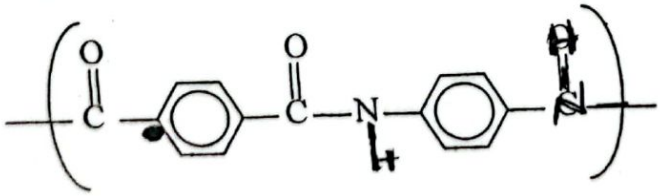
09

12. (a) State two structural differences between addition and condensation polymers. (2 marks)

Addn	Condensation
- no simple molecule lost	- a simple molecule lost
- one	- bi-functional grp
-	

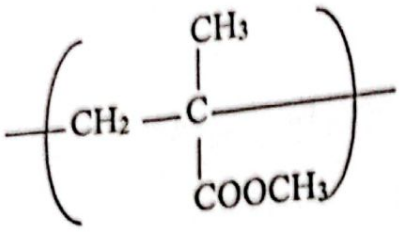
02

(b) Molecular structures of Kevlar and Perspex are show below.



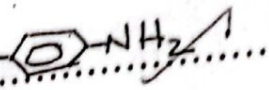
Kevlar

Perspex

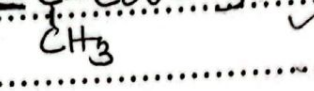


Write down the structural formula(e) of the monomers of; (1½ marks)

(i) Kevlar



(ii) Perspex



State one use of each of the polymers.

(i) Kevlar (1 mark)

Manufacture of bullet proof vests

(ii) Perspex (1 mark)

Manufacture of plastic lenses, plastic car screens, wind. Laboratory plastic ware.

State how;

(i) Vulcanisation of rubber is carried out. (2 marks)

Raw rubber is heated with sulphur (at 140°C). Sulphur atoms cross link at reactive sites of the double bond.

(ii) Vulcanisation improves the properties of natural rubber. (1½ marks)

- Improves/increases the temp working range, toughness elasticity elasticity and bulkness of rubber.

09

13. (a) State:

(i) the distribution law. (1 mark)

A solute distributes its self between two immiscible solvents in contact at the interface such that at equilibrium the ratio of concentration of the solute in the two solvents is constant provided that temp remains constant and the solute remains in its molecular form

(ii) three conditions under which the law is valid. (1½ marks)

- Solute does not form saturate in the two solvents
- temperature remains the same
- solute remains in its molecular form

(b) 1.72 g of potassium iodate was dissolved in water and then excess acidified potassium iodide solution added to make 500 cm³ of solution. This solution was shaken with 200 cm³ of ether 25 cm³ of the organic layer required exactly 23.1 cm³ of 0.1 M sodium thiosulphate solution for complete reaction using starch indicator. Calculate the concentration of iodine at equilibrium in moles per litre of;

(i) the organic layer. (2½ marks)

moles of $S_2O_3^{2-} = \left(\frac{23.1 \times 0.1}{1000}\right) = 2.31 \times 10^{-3}$ moles

$I_{2(aq)} + 2S_2O_{3(aq)}^{2-} \rightarrow 2I^-_{(aq)} + S_4O_6^{2-}{}_{(aq)}$

moles of I_2 reacted $= \frac{1}{2} \times 2.31 \times 10^{-3}$

$= 1.155 \times 10^{-3}$ moles

$[I_2] = \frac{1.155 \times 10^{-3} \times 1000}{25} = 0.0462M$

(ii) the aqueous layer. (2½ marks)

Moles $IO_3^- = \frac{1.72}{214} = 0.008$ moles

eqn $IO_{3(aq)}^- + 6H^+_{(aq)} + 5I^-_{(aq)} \rightarrow 3I_{2(aq)} + 3H_2O_{(l)}$

moles of I_2 liberated:

$(3 \times 0.008) = 0.024$ moles

$[I_2]$ liberated $= \left(\frac{0.024 \times 1000}{500}\right)$

$= 0.048M$

$[I_2]$ in aqueous layer

$= 0.048 - 0.0462 = 0.0018$

127 + 16×3 + 39

(c) Determine the distribution coefficient, k_A of iodine between ether and water. (1½ marks)

$K_D = \frac{[I_2]_{ether}}{[I_2]_{water}} = \frac{0.0462}{0.0018} = 25.667$

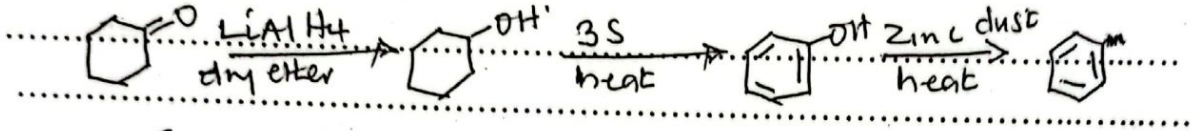
14. Using equations indicating conditions and reagents of reaction show how the following conversions can be effected.

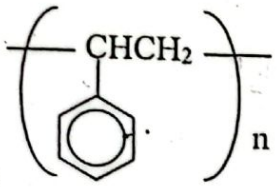
(a) ethene to propanoic acid.

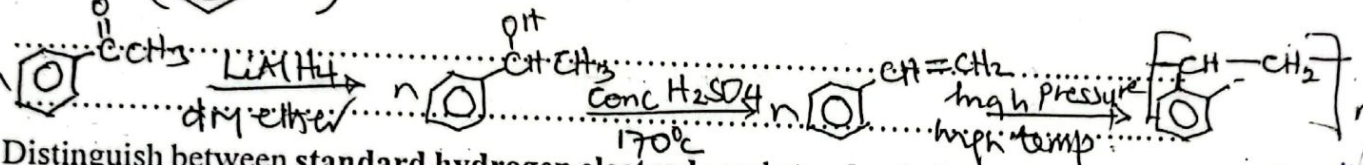
$CH_3CH_2COOH \xrightarrow[\text{dry ether}]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow[180^oC]{Conc\ H_2SO_4} CH_3CH=CH_2 \xrightarrow[ii)\ H^+/H_2O]{i)\ O_3}$

$CH_2=CH_2 \xrightarrow[180^oC]{Conc\ H_2SO_4} CH_3CH_2OH \xleftarrow[\text{dry ether}]{LiAlH_4} CH_3CHO$

(b) benzene from cyclohexanone



(c)  from $C_6H_5COCH_3$



15. (a) Distinguish between **standard hydrogen electrode** and **standard electrode potential.** (2mks)

Standard hydrogen electrode is a set up of hydrogen gas at 25°C and 1atm is bubbling through 1.0M solution of hydrogen ions over platnised platnum.

standard electrode potential is the potential difference when a metal rod is immersed in a 1.0M solution of its ions measured against a standard hydrogen electrode

(b) Below are some half-cell reactions.

		E^θ/V
$SO_3^{2-}(aq) + 2OH^- \longrightarrow$	$SO_4^{2-} + H_2O(l) + 2e^-$	+0.9 V
$2Cr^{3+} + 7H_2O(l) \longrightarrow$	$Cr_2O_7^{2-} + 14H^+ + 6e^-$	−1.33

14(a) $CH_2=CH_2 \xrightarrow{HCl} CH_3CH_2Cl \xrightarrow[\text{ethanol, Heat}]{KCN} CH_3CH_2CN \xrightarrow[\text{Warm}]{H^+/H_2O} CH_3CH_2COOH$

Write;

(i) Cell notation for the cell formed when the two half cells are connected through the salt bridge. (1 mark)

$Pt / SO_3^{2-}(aq), SO_4^{2-}(aq) \,||\, Cr_2O_7^{2-}(aq), H^+(aq), Cr^{3+}(aq) / Pt$ 01

(ii) equation for the reaction at the cathode. (1½ marks)

$3SO_3^{2-}(aq) + Cr_2O_7^{2-}(aq) + 8H^+(aq) \rightarrow 3SO_4^{2-}(aq) + 2Cr^{3+}(aq) + 4H_2O(l)$ 1½

(c) State conditions under which the two half-cells in (b) can give a feasible cell reaction. (01 mark)

- If the emf of a cell has a positive value 01
- when the Gibbs free energy is negative

(d) (i) Chromium plating is applied by electrolysis to objects suspended in a dichromate solution according to the following unbalanced half-reaction equation.

$Cr_2O_7^{2-}(aq) + 12e^- + 14H^+ \longrightarrow 2Cr(s) + 7H_2O(l)$

how long would it take to apply a chromium plating 1.0×10^{-2} mm thick to a car bumper with a surface area of 0.25 m^2 in an electric cell carrying a current of 25.0 A? (3 marks)

(density of Cr is $7.19 gM^3$)

Volume of Cr coating:

$0.25 \times 1.0 \times 10^{-5}$

$= 2.5 \times 10^{-6} M^3$ ✓

Mass of Cr coating:

$2.5 \times 10^{-6} \times 7.19$

$= 1.7975 \times 10^{-5} g$ ✓

104g Cr require (12×96500) c

2.5×10^{-5} g Cr require $\frac{1158.009 \times 1.7975 \times 10^{-5}}{104}$

$= 0.2C$ ✓

$Q = It$ ✓

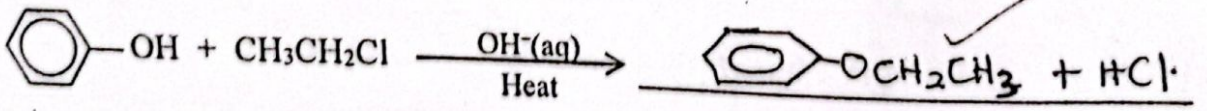
$t = \frac{0.2}{25} = 0.008sec$ ✓ 03

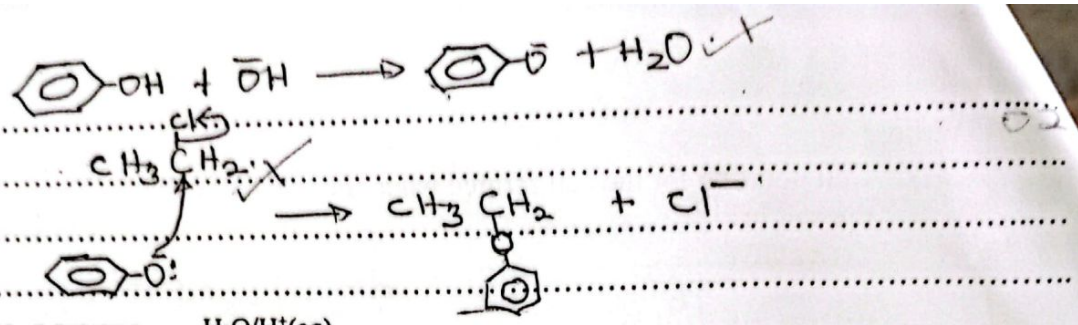
(ii) State three other applications of electrolysis other than electroplating. (1½ marks)

- purification of ores ✓
- Manufacture of chlorine gas ✓
-

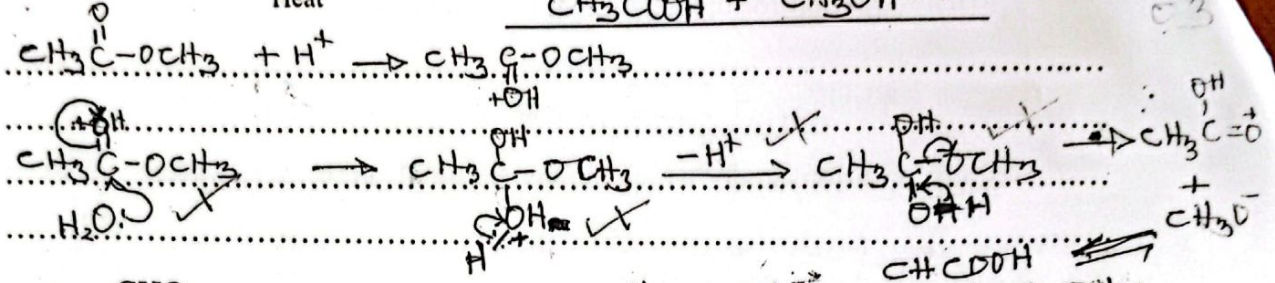
16. Complete the following equations and in each case outline the mechanism for the reaction.

(a)

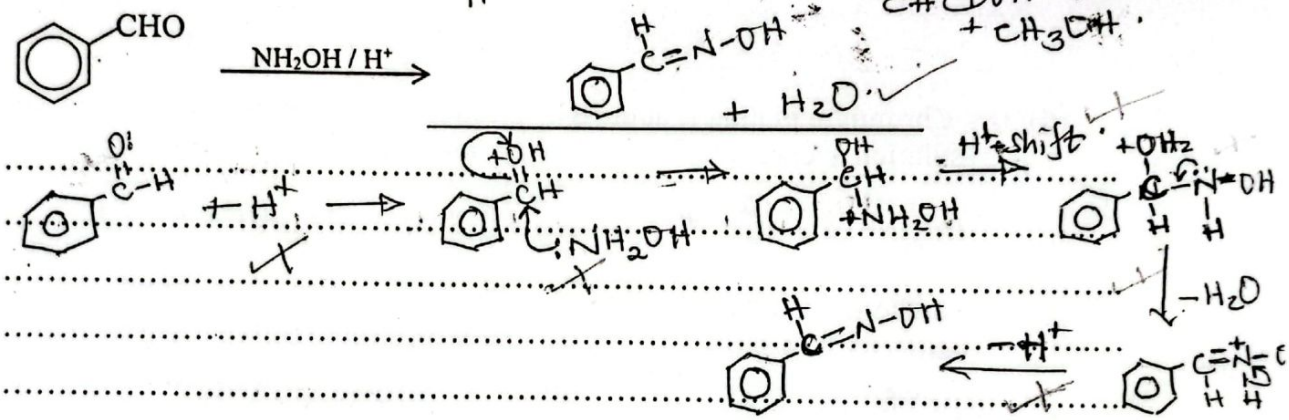




(b) $CH_3COOCH_3 \xrightarrow[\text{Heat}]{H_2O/H^+(aq)} CH_3COOH + CH_3OH$



(c)



17. (a) What do you understand by **freezing point constant**? (01 mark)

- lowering in freezing point of a solvent caused by dissolving one mole of a solute in 1000g of a solvent.

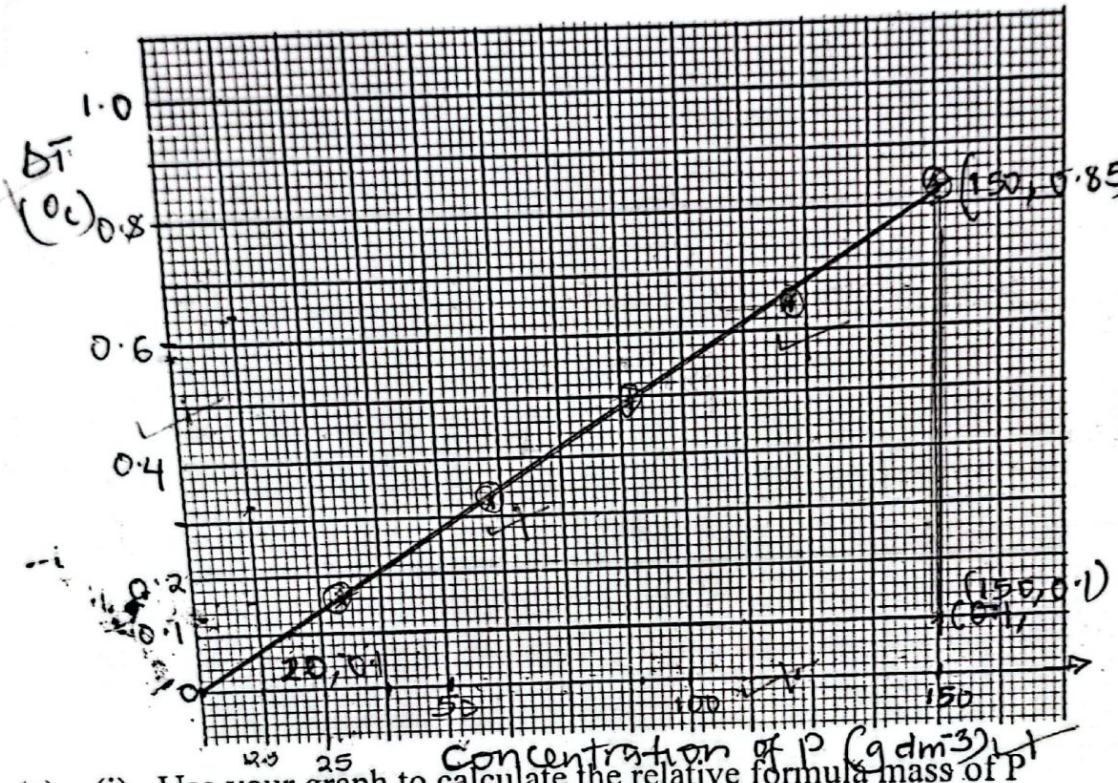
(b) The table below shows the freezing points of various concentrations of a non-volatile solute P in water at 760 mmHg.

Concentration (g dm^{-3})	0	30	60	90	120	150
Freezing point (°C)	0	-0.16	-0.32	-0.49	-0.65	-0.85
Freezing point depression (ΔT_f)	0	0.16	0.32	0.49	0.65	0.85

freezing point of water is 0°C.

(i) Find the freezing point depression for the solution in the table above. (Freezing point of water is 0 °C). (1½ marks)

(ii) Plot a graph of freezing point depression against concentration of P. (3 marks)



03

(c) (i) Use your graph to calculate the relative formula mass of P (Freezing point constant, kf of water is 1.86°C $mol^{-1}kg^{-1}$)

Slope = $\frac{\Delta Y}{\Delta X} = \frac{0.85 - 0.1}{150 - 20} = 0.00577 °C\ g^{-1}\ dm^3$.

$M_r = \frac{K_f}{\Delta T} = \frac{1.86}{0.00577} = 320.6$.

(ii) State one advantage and one disadvantage of using freezing point depression method to determine the relative formula mass of P over other colligative properties. (1 mark)

Advantage

- no heating involved, compounds which decompose on heating are safe with this method.

Disadvantage

- not accurate for compounds with high molecular mass.

*** END ***