GRAND A'LEVEL CHEMISTRY SEMINAR AT ST. JOSEPH'S S.S.S NAGGALAMA

28TH SEPTEMBER 2024

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1. Explain briefly each of the following observations, illustrating your answers with equations where applicable.

(a) The acid strength of the following hydrogen halides are in the order; HI > HBr > HCl

(b) Ethylamine is a stronger base than 1-amino-2-bromoethane

(c) Melting points of the following bromides are in the order; $SrBr_2 < CaBr_2 < MgBr_2$

(d) Aluminium bromide is used as a halogen carrier in the preparation of bromobenzene

(e) When potassium peroxosulphate(VI) solution was added to potassium iodide solution, the colourless solution turned to brown.

(f) To a hot solution of chromium(III) ions containing excess sodium hydroxide solution was added hydrogen peroxide solution , a green solution turned to yellow solution.

(g) Solubility of the hydroxides of group(II) elements increases down the group while the solubility of the sulphates of group(II) elements decreases down the group.

2. a) i) Define the term distribution coefficient

ii) Describe how the distribution coefficient of ammonia between water and trichloromethane can be determined.

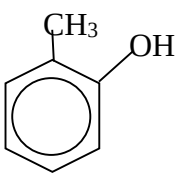
b) 50 cm^3 of 1.5M ammonia solution was shaken with 50 cm^3 of trichloromethane in a separating funnel. After the layers had separated, 20 cm^3 of the trichloromethane layer required 23.10 cm^3 of 0.05M hydrochloric acid for complete reaction. Calculate the distribution coefficient of ammonia between water and trichloromethane

c) A copper ore was dissolved in excess concentrated ammonia and the solution made up to 1 dm^3. The resultant solution was shaken with trichloromethane and left to settle. 50 cm^3 of the organic layer required 12.5 cm^3 of 0.1M hydrochloric acid for neutralization. 25 cm^3 of aqueous layer required 20 cm^3 of 1M hydrochloric acid. Calculate the concentration of copper(II) ions in $moldm^{-3}$.
(The distribution coefficient of ammonia between trichloromethane and water is 0.04)

d) A crude sample of lead contained 2% of silver by mass. Calculate the percentage of silver left in 150 kg of the crude sample of lead if it was thoroughly mixed with 10 kg of zinc at 800°C. The solubility of silver in a given mass of zinc is 300 times its solubility in an equal mass of lead at 800°C.

3. Name the reagents that are used to distinguish between the following pair of compounds. In each case, state the observations made then write equations for the reactions for the stated observable changes

a) $BaCO_3$ and $CaCO_3$

b) 

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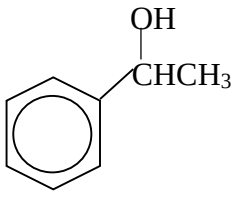
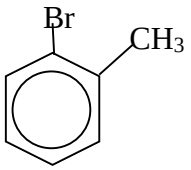
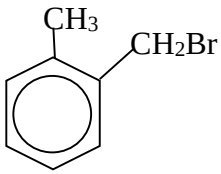


c) $CH_3(CH_2)_2CHO$ and $CH_3CO(CH_2)_2CH_3$

d)  and 

e) HCOOH and HOOCCOOH

4. a) Draw and name the shapes of the following ions

i) NO_3^- ii) NO_2^-

b) Compare the bond angle of the above given ions. Explain your answer.

c) One of the ions in (a) above decolorizes iodine solution

(i) Identify the ion (ii) Explain your answer.

5. The following half-cell reactions are given together with their corresponding standard electrode potential values.

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e \longrightarrow 2Cr^{3+}(aq) + 7H_2O(aq)$ +1.33V

$Cl_2(g) + 2e \longrightarrow 2Cl^-(aq)$ +1.36V

$V^{3+}(aq) + e \longrightarrow V^{2+}(aq)$ -0.27V

$PbO_2(s) + 4H^+(aq) + 2e \longrightarrow Pb^{2+}(aq) + 2H_2O(l)$ +1.46V

$MnO_4^-(aq) + 8H^+(aq) + 5e \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$ +1.52V

a) Name the most;

i) Oxidizing species ii) Reducing species

b) i) Write the cell notation for the cell made by combining the two half-cell reactions for the above mentioned two species in (a) above

ii) Write the equations for the half cell reactions that occur at positive and negative terminals

iii) Calculate the amount of free energy produced by the cell.
[1 Faraday of electricity = 96500C]

c) i) Write the cell convention for the cell made up of two half-cells consisting of acidified lead(IV) oxide and chloride ions.

ii) State whether the cell will produce electric current or not. Explain your answer

d) Using the above given information, explain why potassium dichromate can be acidified using hydrochloric acid whereas potassium permanganate cannot.

6. Nylon-6,6 and Perspex are examples of artificial polymers formed through condensation and addition polymerization processes, respectively

a) Distinguish between the terms addition and condensation polymerisation

b) Name the monomer(s) used in formation of

i) Nylon-6,6 ii) Perspex

c) Write equations leading towards formation of each of the above named polymers

d) State the differences between the structural features of each of the;

i) Monomers used in the formation of the polymers ii) Polymers formed

e) State one use of each of the above named polymers in (a).

7. (a) Define the following terms

(i) solute (ii) saturated solution

(b) The solubilities of potassium chloride and potassium nitrate at a certain temperature are shown in the table below.

Temperature / ^oC	0	11	15	30	40	50	57
Solubility of potassium chloride / g per 100g of water	27.9	31.0	32.0	36.5	40.0	43.0	45.0
Solubility of potassium nitrate /g per 100g of water	14.0	21.5	25.0	43.0	63.0	84.0	102.0

(i) Plot on the same axes, a graph of solubility against temperature for solubilities of potassium chloride and potassium nitrate.

(ii) State which one of the two salts has a solubility which increases less rapidly with increase in temperature.

(iii) Determine the temperature at which the solubilites of the two salts are equal.

(iv) A saturated solution of potassium nitrate at 30^oC was cooled to 5^oC . Determine the number of moles of potassium nitrate crystals formed.
(K = 39 , N= 14 , O = 16)

(c) 25.2g of a solution saturated with copper(II) sulphate at 35^oC was made up to $200cm^3$ with deionized water. $25.0cm^3$ of the diluted solution reacted with excess potassium iodide solution to liberate iodine which was titrated against $33.5cm^3$ of 0.118M sodium thiosulphate solution.
Calculate the solubility of copper(II) sulphate in grams per 100g of water at 35^oC.

(d) Explain how;

(i) Unsaturated solution of a solute can become saturated without adding any more solute

(ii) A saturated solution can become unsaturated without carrying out any dilution.

(e) (i) Define the term fractional crystallization.

(iii) The solubility of copper(II) sulphate is 75g in 100g of water at 100^{o}C and 25g at 30^{o}C. What mass of the salt would crystalize if 50g of a copper(II) sulphate solution saturated at 100^{o}C were cooled to 30^{o}C.

(iv) Explain how you would grow a large crystal of copper(II) sulphate.

8.a) During manufacture of sulphuric acid, sulphur dioxide is catalytically oxidised in an equilibrium reaction to form sulphur trioxide. The reaction is exothermic.

i) Write equation for the reaction.

ii) State the optimum conditions for the reaction

b) State and explain what would happen to the position of equilibrium in the reaction in a(i) above when;

i) Temperature of the reaction is increased to 800^{o}C.

ii) Acidified potassium permanganate solution is added to the vessel of the reaction mixture.

c) 1.8 moles of sulphur dioxide and 2 moles of oxygen were placed in a 2.0 litre vessel. The reaction mixture was heated and when equilibrium was established, 26% of the initial amount of oxygen had reacted. Determine the equilibrium constant for the reaction.

d) Write equation of reaction of warm concentrated sulphuric acid with;

i) Phosphorous. ii) Hydrogen iii) sulphide iv) Tin

9. a) Explain what is meant by the terms;

i) Transition metal ii) Complex ion

b) Explain why transition metals are able to form complexes.

c) Pink solid Q when heated, formed a green solid R and brown fumes, solid R dissolves in dilute hydrochloric acid forming a pink solution T. solution T forms a blue solution with potassium thiocyanate solution.

i) Write the formula and name of the species in solution T.

ii) Write equation for the reaction leading to the formation of the blue solution.

iii) State what will be observed and write equations for the reaction that takes place if to the aqueous solution of solid Q is added to;

(i) Concentrated hydrochloric acid

(ii) Sodium hydroxide solution drop-wise until in excess.

10.a) i) Define standard electrode potential

ii) Why is it not possible to measure standard electrode potential absolutely?

iii) Discuss the factors which affect the value of standard electrode potential

b) Describe a standard hydrogen half cell

c) Describe how the standard electrode potential of a metal electrode can be measured. E.g. silver electrode

d) $Ca^{2+}(aq) + 2e \longrightarrow Ca(s)$ $E^o = -2.87V$

$Mg^{2+}(aq) + 2e \longrightarrow Mg(s)$ $E^o = -2.37V$

A cell was set up as below, $Mg(s)|\ Mg^{2+}(aq)||\ Ca^{2+}(aq)|Ca(s)$

i) Calculate the E.m.f of the cell

ii) What conclusion can you draw from your E.m.f value in d(i) above.

11. Write equation and suggest a mechanism to show how the following compounds are synthesized.

(a) 2,2-dibromopropane

(b) 1-methylcyclohex-1-ene

(c) 2-methylpropane- 1,2- diol

(d) Benzaldehyde oxime

(e) 2-hydroxy-2-methylbutanonitrile

(f) 2-bromoethanol

(g) Phenylpropanoate.

12. a) Define the term relative atomic mass

b) Describe how the relative atomic mass can be determined by the mass spectrometer

c) The mass spectrum of an element W contained three line at mass/charge of 24, 25 and 26 with relative intensities in the ration of 8:1:1 respectively

i) Explain what the term relative intensity means

ii) Calculate the relative atomic mass of W

iii) State why the mass spectrum shows three lines

d) State two advantages of using a mass spectrometer over the depression of freezing point method of determining relative atomic masses

e) The initial count of a radioactive nucleus was 680 per count. After 350 seconds, the count rate was 125 per second.

Calculate the;

i) Decay constant ii) Half-life of the nucleus.

13. A bromoalkane **S**, C_4H_9Br burns with a non-sooty flame.

(a) Write the structural formulae and IUPAC names of all the possible isomers of **S**

(b) Which of the isomers of S in (a) above has the

(i) The highest boiling point

(ii) The lowest boiling point.

(c) Explain your answer in (b) above.

(d) When **S** was refluxed with aqueous potassium hydroxide, compound **T** was formed. Compound **T** formed two layers in 8 minutes when treated with concentrated hydrochloric acid in the presence of anhydrous zinc chloride. Identify **S** and **T**

(e) Write equation and suggest a mechanism for the reaction between

(i) **S** and ethanolic potassium hydroxide and the mixture refluxed.

(ii**)** **T** and ethanoic acid in the presence of few drops of concentrated sulphuric acid and the mixture heated.

(f) Using equations only show how **T** can be converted to ethanol.

14 .Fluorine, Chlorine, bromine and iodine belong to Group (VII) elements of the Periodic Table.

(a)Write the general outermost electronic configuration of the elements.

(b)Discuss the reaction of fluorine and bromine with

(i) Water (ii) Potassium hydroxide

(c) State what would be observed and write equation for the reaction when:

(i) Chlorine gas was bubbled through Iron(II) chloride solution

(ii) Aqueous sodium sulphite solution was added to iodine solution

(iii) Bromine water was added aqueous hydrogen sulphide.

(iv) Iodine was added to cold dilute sodium hydroxide and the mixture allowed to stand.

15 (a)(i) Distinguish between the terms ionic product and solubility product.

(ii)Explain how the two terms in (i) are affected by temperature.

(b) Describe an experiment to determine the solubility product of lead(II) iodide

(c) When 2.5g of lead(II) iodide was shaken with 1 dm^3 of distilled water at 25^oC , 11.62% of the salt had dissolved. Calculate the solubility product of lead(II) iodide at 25^oC.

(d) State and explain whether the percentage of the lead(II) iodide that dissolved would be higher than, less than or equal to 11.62% when the following were added to its saturated solution at 25^oC

(i) Few drops of ammonium iodide solution.

(ii) Two clean pieces of magnesium ribbon.

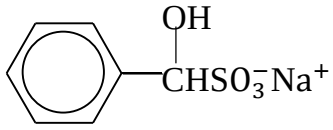
(e) Solution **X** was made by dissolving 0.025 moles of lead(II) ions in 500cm^3 of solution and solution **Y** was made by dissolving 0.01325moles of iodide ions in 500cm^3 of solution.
When the two solution are mixed,

(i) Calculate the ionic product of lead(II) iodide.

(ii) State whether the precipitation of lead(II) iodide will occur or **not**. Give a reason for your answer.

(f) A solution containing silver ions was added to a solution containing 0.005M chromate ions and 0.005M chloride ions. State which of the salts silver chloride or silver chromate will precipitate first? Give a reason for your answer.
(Ksp for Ag_2CrO_4 =1.3x10^{-12}mol^{3}dm^{-9}, Ksp and for AgCl = 1.8 x10^{-10}mol^{2}dm^{-6})

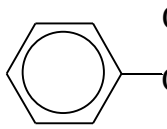
16. Using equations only show how the following conversions can be effected.

(a) 

from phenol

(b) $CH_3CCl_2CH_3$ from propan-1-ol

(c) $CH_3CH_2CH_2\ CH_2\ COOH$ from ethyne

(d) 

from phenol

(e) Ethanol from propanoic acid

(f) 1,3,5-tribromo benzene from nitrobenzene

17. Carbon, silicon, germanium, tin and lead are the elements of **Group(IV)** of the Periodic Table.

(a) (i) State the oxidation states exhibited by the elements.

(ii) Explain how the stability of the oxidation states varies down the group.

(b) Describe the reactions of the elements with

(i) Concentrated nitric acid

(ii) Concentrated sodium hydroxide solution.

(c) Explain the following observations;

(i) When hydrogen peroxide solution is added to lead(II) sulphide, a black solid turned to white solid.

(ii) Lead(IV) chloride exists whereas lead(IV) iodide does not exist.

(iii) Carbon tetrachloride is not hydrolysed by water whereas silicon tetrachloride readily hydrolyses in water.

(iv) When warm concentrated hydrochloric acid was added to lead(IV) oxide, dark brown solid dissolves with effervescence of a greenish yellow gas and white precipitate was formed on cooling.

(v) When dilute nitric acid was added to trileadtetraoxide, red powder turned to dark brown
solid and colourless solution were formed.

18.(a) What is meant by the terms

(i) Order of reaction

(ii) Molecularity of a reaction

(iii) Activation energy of a reaction?

(b) The decomposition of hydrogen peroxide is first order kinetics and proceeds according to the following equation.

$2H_2O_2\ (aq) \longrightarrow 2H_2O\ (l) + O_2(g)$

(i) Write the rate law for the reaction.

(ii) Describe an experiment to show how the order of the above reaction can be determined.

(iii) Explain the effect of temperature on the rate of decomposition of hydrogen peroxide.

(c) The following kinetic data in the table below were obtained for the decomposition of hydrogen peroxide.

Concentration of H_2O_2 ($moldm^{-3}$)	0.0013	0.00076	0.00036	0.00014	0.0001
Time(minutes)	5	12	20	33	40

Plot a graph of $\log_{10}[H_2O_2]$ against time

(d) Using your graph in (c), determine

(i) The initial concentration of hydrogen peroxide

(ii) The half- life of the reaction

19. (a) What is meant by the following terms

(i) Buffer solution. (ii) Salt hydrolysis

(b) A 0.021M propanoic acid solution is 2.5% ionized. Calculate the

(i) pH of the solution

(ii) Acid ionisation constant for the acid.

(c) (i) What mass of potassium propanoate must be added to 1 $dm^3$of 0.021M propanoic acid to increase its pH by 2.34 units

(ii) Why does the pH of propanoic acid increase on addition of the measured mas of

potassium propanoate.

(d) Explain the following observations

(i) When a clean piece of magnesium ribbon was added to an aqueous solution of ammonium nitrate, there was effervescence of a colourless gas.

(ii) Benzoic acid is a stronger acid than propanoic acid.

20. Write equation and suggest a mechanism for the reaction to show how the following conversions can be effected.

(a) 2-hydroxypropanonitrile from ethanal

(b) Diphenylmethanone from benzene

(c) Propanalsemicarbazone from acidified solution semicarbazide. ($NH_2CONHNH_2$)

(d) Propyne from 2,2-dichloropropane.

(e) Phenylethanoate from phenol

21(a)What is meant by the term **steam distillation?**

(b) Explain the principle on which steam distillation is based.

(c) State

(i) the conditions necessary for steam distillation.

(ii) **one** advantage of steam distillation over fractional distillation

(d) The table below shows how the vapour pressure of a mixture of phenyl amine and water varies with temperature.

Temperature (^oC)	40	50	60	70	80	90	100	110	120
Vapour pressure of phenylamine (mmHg)	10	20	25	32	40	50	55	65	80
Vapour pressure of water(mmHg)	629	632	645	655	670	690	710	730	760

(i) On the same axes plot graphs of vapour pressure against temperature for phenylamine , water and the mixture.

(ii) Use the graph to determine the ratio of phenylamine to water and hence the percentage of phenylamine in the distillate. Given that the distillation was carried out at 760mmHg.

(e) The partition coefficient of substance **Q** between ethoxyethane and water is 2.0. A solution containing 10.0g of **Q** in $50cm^3$ of water was extracted with $100cm^3$ of ether. Calculate percentage of **Q** that remained in the aqueous layer.

22. Beryllium, magnesium, calcium, strontium and barium are the elements of group(II) of the Periodic Table.

(a) Describe how the electropositivity of the elements varies down the group.

(b) Discuss the reaction of the elements with

(i) water (ii) dry air (iii) nitric acid

(c) Describe how

(i) Beryllium carbide and calcium carbide can be prepared in the laboratory.

(ii) The carbides in (c)(i) react with dilute hydrochloric acid

(d) Describe how cement is

(i) manufactured (ii) used to make concrete.

23. Sodium hydroxide is used as one of the raw materials in manufacture of soap.

a) Describe briefly how sodium hydroxide can be obtained on a large scale. [No diagram required].

b) i) Name other raw material(s) used together with sodium hydroxide during formation of soap

ii) Briefly describe how a sample of soap can be prepared using the named raw materials

iii) Write equations for the reaction leading towards formation of soap.

c) Explain the cleansing action of soap.

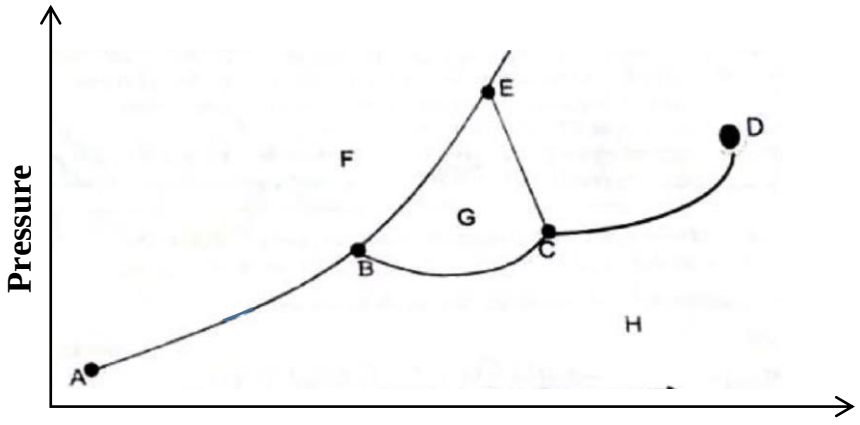
d) i) Write equations to show how a soapless detergent can be prepared starting from an alkylbenzene.

ii) Name some other substances that are added to detergents during their manufacture and state their role.

e) State any two advantages of soapless detergents over soapy detergents.

24. (a) Define the term critical temperature

(b) The phase diagram for a certain substance is shown below



(i) Identify the regions F, G and H

(ii) State what the points B, C and D represent

(c) Describe the changes that took place when pressure was increased at a constant temperature on the phase at H

CHEMISTRY PRACTICAL

QUESTION ONE

You are provided with following;

FA1, which is a solution containing 18.96g of anhydrous sodium thiosulphate in a litre

FA2, which is a solution of manganate (VII) ions of unknown concentration.

SOLID T, which is an iron (II) salt with a formula $\mathbf{Fe_x(C_2O_4)_y.nH_2O}$

10% potassium iodide solution

2.0M sulphuric acid solution

You are required to determine the; (i) Concentration of manganate(VII) ions in FA2 in $moldm^{-3}$

(ii) Valves of **x,y** and **n** in **T**.

Theory

Acidic manganate (VII) ions oxidize iodide ions to iodine according to the following equation.

$2MnO_4^-(aq) + 16H^+(aq) + 10I^-(aq) \longrightarrow 2Mn^{2+}(aq) + 5I_2(aq) + 8H_2O(l)$

The liberated iodine reacts with thiosulphate ions according to the following equation

$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

Acidic manganate (VII) oxidizes both iron (II) ions and ethanedioate ions in solid T according to the following equations.

$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \longrightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$

$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

PART I

Procedure:

Using a measuring cylinder transfer $65cm^3$ of FA2 into a clean $250cm^3$ glass beaker, followed by $35cm^3$ distilled water label the resultant solution **FA3**

Pipette $25.0cm^3$ (or $20.0cm^3$) of **FA3** into a conical flask. Add $15cm^3$ of 2M sulphuric acid followed by $15cm^3$ of 10% potassium iodide solution shake the mixture for 1 minute.

Titrate the iodine liberated with **FA1** from the burette until the solution is pale-yellow. Add 4 – 5 drops of starch indictor and continue the titration until the end point. Repeat the titration until you obtain consistent results. Record your results in table I below.

Results

Volume of pipette used = ……(mark)

Final burette reading (cm^3)				
Initial burette reading (cm^3)				
Volume of FA1 used (cm^3)				

(a)(i)State the volumes of **FA1**used for calculating average. ($\frac{1}{2}$ mark)

(ii)Calculate the average volume of **FA1** ($2\frac{1}{2}$ marks)

Questions

(b)Calculate the number of moles of;

(i) Iodine that reacted with thiosulphate ions in FA1 (2½ marks)

(Na = 23, S = 32, O = 16)

(ii) Manganate (VII) ions in 65cm^3 of FA2 (2½ marks)

(b)Determine the concentration of manganate (VII) ions in FA2 in moldm^{-3} (2½ marks)

PART II

Procedure

Weigh accurately **1.5g** of **T** into a clean beaker. Add about 120cm^3 of 2M sulphuric acid and stir to dissolve. Transfer the contents to a 250cm^3 volumetric flask and add distilled water to make it up to the mark. Label the solution **FA4 Results**

Mass of weighing beaker +**T** = …….....g(½ mark)

Mass of weighing beaker alone = …….....g (½ mark)

Mass of **T** used = …….....g(½ mark)

PART III

Procedure

Pipette 25.0cm^3 (or 20.0cm^3) of **FA4** into a conical flask. Heat the mixture to about 60^{0}C and titrate the hot mixture with **FA2** from the burette until the end point. Repeat the titration until you obtain consistent results. Record your results in table II below.

Results

Volume of pipette used = …….....cm^3 ($\frac{1}{2}$ mark)

Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of **FA2** used (cm^3)			

(4½marks) (a)(i)State the volumes of **FA2** used for calculating average.

(½ marks)

(ii) Calculate the average volume of **FA2** (2½ marks)

(b) Calculate the number of moles of;

(i) Manganate (VII) ions that reacted with both iron (II) ions and ethanedioate ions in FA4

(ii) Iron(II) ions in FA4 that reacted manganate(VII).

(1mark)

(iii) Ethanedioate ions in FA4 that reacted with manganate (VII). (1mark)

(b)Determine the

(1mark)

i) Values x and y in solid T

ii) The formula mass of $Fe_x(C_2O_4)_y.nH_2O$ and hence the number of moles of water of crystallization, n (Fe = 56, C = 12, O = 16, H = 1)
(2marks)

Question two

You are provided with substance, **L**, which contains **two** cations and **two** anions. You are required to carry out the following tests on **L** to identify the cations and anions in it. Identify any gas (es) evolved.

Record your observations and deductions in the table below. (**30 marks**)

TESTS	**OBSERVATIONS**	**DEDUCTIONS**
(a)Heat **two** spatula end-ful of **L** in a dry test tube strongly until no further change.		
(b)To **two** spatula end-ful of **L** in a test tube add about $10cm^3$ of distilled water shake strongly. Filter, keep both the filtrate add the residue. Divide the filtrate into **four** portions.	.	
(i) . To the first portion of the filtrate, add 2-3 drops of Barium nitrate solution followed by dilute nitric acid.		
(b)(ii) . To the second portion of the filtrate, add 2-3 drops of lead (II) nitrate solution followed by dilute nitric acid.		
(b)(iii) To the third portion of the filtrate, add 1-2 drops of silver nitrate solution followed by dilute ammonia solution.		

(b)(iii)Use the fourth portion of the filtrate to carry out your own test to confirm the anion in the filtrate **Test**		
(c)Dissolve then residue in dilute nitric acid.(**warm to dissolve**) To the resultant solution add dilute sodium hydroxide solution drop- wise until in excess. Filter and keep both the filtrate and residue.		
(d). To the filtrate from part (c) add dilute nitric acid drop wise until the solution is just acidic. Divide the resultants into **three** parts.		
(d)(i)To the first portion of acidified filtrate, add dilute sodium hydroxide solution dropwise until in excess.		
(d)(ii)To the second part of acidified filtrate add dilute ammonia solution drop-wise until in excess.		
(d)(iii). Use the third part of acidified filtrate to carry out a test of your own choice to confirm one of the cation in the filtrate **Test**		
(e). Dissolve the residue from part (c) in minimum amount of nitric acid. Divide the resultant solution into three parts.		
(i) To the first part add 2-3 drops dilute sulphuric acid		

(ii). To the second part, add dilute ammonia solution drop wise until in excess.		
(iv) Use the third part of to carry out a test of your own choice to confirm the second cations in L **Test**		

(f) identify the (i) Cations in L …….. (ii) anions in L ……..

QUESTION THREE

You are provided with an organic substance, **R**. You are required to determine the nature of **R**. Carry out the following tests on **R** and record your observation and deductions in table below. (**20marks**)

TESTS	**OBSERVATIONS**	**DEDUCTIONS**
(a)Burn a small amount of **R** on a spatula end		
(b)To about 1 spatula end-ful of **R** in a test – tube, add about 10 cm^3 of distilled water. Shake strongly and test the mixture with litmus paper. Heat the mixture and Divide the resultant solution into **7** parts.		
(i)To the **first** part of the solution, add 2 – 3 drops of acidified potassium dichromate (VI) and **warm**		

(ii)To the **second** part of the solution add 2-3 drops of 2,4-dinitrophenylhydrazine solution		
iii)To the **third** part of the solution add 2 – 3 drops of iron (III) chloride solution		
(iv)To the **fourth** part of the solution add 1cm^3 of ethanoic acid followed by 3drops of concentrated sulphuric acid and heat to boiling		
(v)To the **fifth** part of the solution add little solid magnesium powder		
(vi)To the **six** part add 2-3 drops acidified potassium manganate(VII)		
(vii)To the **seventh** part add 2-3 drops of bromine water and shake strongly		
(c)Dissolve one spatula end-ful of R in about 3cm^3 of ethanol, add 3 drops of concentrated sulphuric acid and heat, pour the resultant solution on a petridish containing some water		

(e)Comment on the nature of **R**. ……

END

GRAND A'LEVEL CHEMISTRY SEMINAR AT ST. JOSEPH'S S.S.S NAGGALAMA

28TH SEPTEMBER 2024

Contacts: 0782-679542 / 0700-800305 / 0775-805462

SOLUTIONS

ST. JOSEPH'S SENIOR SECONDARY SCHOOL, NAGGALAMA

SOLUTIONS TO THE A'LEVEL CHEMISTRY SEMINAR HELD ON 28TH SEPTEMBER, 2024.

1. (a) There is an increase in atomic radii and decrease in electronegativity from chlorine to iodine. The bonding pair of electrons in the hydrogen – halogen bond becomes less strongly attracted from hydrogen chloride to hydrogen iodide. This leads to increase in bond length and hence decrease in bond strength from hydrogen chloride to hydrogen iodide, thus increasing the ease of the hydrogen halides to dissociate and release hydrogen ions in the solution from hydrogen chloride to hydrogen iodide.

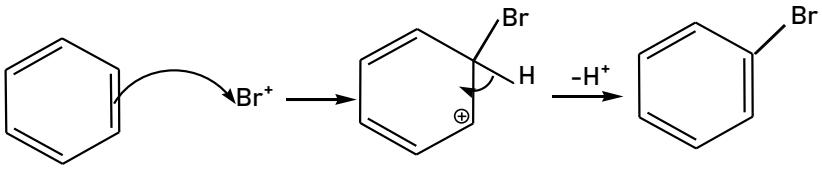
(b) The ethyl group in ethylamine has positive inductive effect and increases on the electron density on nitrogen atom. This makes the lone pair of electrons on nitrogen atom to be more easily available to accept proton from water molecules and produce more hydroxide ions in the solution.

In 1–amino–2–bromo ethane, [$H_2CBrCH_2NH_2$], the bromine atom has a negative inductive effect and reduces the electron density on nitrogen atom. This makes the lone pair of electrons less available to accept proton from water molecules and therefore produces less number of hydroxide ions in the solution.

(c) There is increase in ionic radius and decrease in charge density from magnesium ion to strontium ion. The bromide ions become less polarized by the group(II) cations from magnesium ions to strontium ions. This makes the bonds to become ionic from magnesium bromide to barium bromide. As such the strength of the ionic bonds increases from magnesium bromide to strontium bromide.

(d) Aluminium ion in Aluminium bromide has a small ionic radius and high charge, therefore high charge density and high polarizing power, it greatly polarizes the bromide ion resulting into formation of predominantly covalent character whereby there is sharing of electrons between Aluminium and bromine, by doing so Aluminium will lack two electrons to achieve its octet structure and thus reaction with halogens forms a stable complex and electrophile which attacks the benzene ring.

$$AlBr_3 + Br_2 \rightleftharpoons AlBr_4^- + Br^+$$



$$AlBr_4^- + H^+ \longrightarrow AlBr_3 + HBr$$

e) Peroxosulphate(VI) ion is a strong oxidizing agent which oxidizes iodide ions to iodine and itself reduced to sulphate ions.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

f) Hydrogen peroxide oxidizes chromate(III) ions to chromate(VI) ions

$$2Cr^{3+}(aq) + 10OH^-(aq) + 3H_2O_2(aq) \longrightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$$

Or $2Cr(OH)_4^-(aq) + 2OH^-(aq) + 3H_2O_2(aq) \longrightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$

g) Down the group, cationic radius increases.

For hydroxides, both lattice energy and hydration energy decrease, however, lattice energy decreases more than hydration energy and thus enthalpy of solution is negative and this makes the hydroxides increase in solubility down the group.

For sulphates, hydration energy decreases more than lattice energy and thus the enthalpy of solution is positive. Solubility of sulphates thus decrease down the group.

2.a)i) Distribution coeffecient is the ratio of concentrations of a solute in two immiscible solvents in contact at a given temperature.

ii) A known volume of an aqueous ammonia of known concentration is added to a known volume of trichloromethane in a separating funnel/flask. The mixture is shaken and allowed to stand at a constant temperature

A known volume of the aqueous layer is pipetted and titrated with a standard solution of hydrochloric acid and the concentration of ammonia determined. Ammonia reacts with hydrochloric acid according to the equation.

NH_3 (aq) + HCl (aq) $\longrightarrow$ NH_4Cl (aq)

The concentration of ammonia in the organic layer is obtained by subtraction. The distribution coefficient of ammonia between water and trichloromethane is calculated using the expression;

$$K_D = \frac{[NH_3]aq}{[NH_3]organic}$$

b) Organic layer.

Moles of HCl $= \frac{0.05 \text{ X } 23.10}{1000}$

$[NH_3] = \frac{0.05 \text{ X } 23.10}{1000} \text{ X } \frac{1000}{20} = 0.0578M$

$$K_D = \frac{[NH_3]aq}{[NH_3]organic}$$

$K_D = \frac{1.442}{0.0578} = 25$

Alternatively

Organic layer

Moles of HCl $= \frac{0.05 \text{ X } 23.10}{1000}$

Moles of Ammonia in 20 cm3 $= \frac{0.05 \text{ X } 23.10}{1000}$

Moles of NH_3in 50 cm^3 $= \frac{0.05 \text{ X } 23.10}{1000} \text{ X } \frac{50}{20}$

$= 2.9X10^{-3}$

Aqueous Layer

$[NH_3]$ aq = 1.5- 0.0578

=1.442M

Aqueous layer

Initial Moles of $NH_3 = \frac{1.5 \text{ X } 50}{1000} = 0.075$

Moles remaining in aqueous layer.

$= 0.075 - 2.9X10^{-3}$

$= 0.072$

$[NH_3]aq = \frac{0.072}{50} \times 1000.$

$[NH_3]\ CHCl_3 = \frac{2.9x10^{-3}}{50} \times 1000.$

$K_D = \frac{0.072\ x1000/_{50}}{2.9\ x10^{-3}\ x\ 1000/_{50}}$

= 25

c) Organic layer.

Moles of HCl in 12.5 $cm^3 = \frac{12.5\ x\ 0.1}{1000}$

$[NH_3] = \frac{12.5\ x\ 0.1\ x\ 1000}{1000\ x\ 50}$ = 0.025 moles

$\frac{[NH_3]CHCl_3}{[NH_3]free}$ = 0.04

$[NH_3]Free = \frac{0.025}{0.04}$ = 0.625M

Aqueous layer

Moles of HCl in 20 $cm^3 = \frac{20\ x\ 1}{1000}$

$[NH_3]aq = \frac{20\ x\ 1\ x\ 1000}{1000\ x\ 25}$ = 0.8M

$[NH_3]$ complex = 0.8 -0.625

0.175M

$Cu^{2+}(aq) + 4NH_3(aq) \longrightarrow Cu(NH_3)_4^{2+}(aq)$

$[Cu^{2+}] = \frac{0.175}{4}$ =0.0438M

d) Mass of silver in crude sample; = $\frac{2\ x\ 150}{100}$ = 3g

Let the mass extracted be Xg

$\frac{x/_{10}}{3-x/_{150}}$ = 300

X = 2.857 g

Mass remaining; = [3-2.857] = 0.143g

% of silver remaining; $= \frac{0.143}{3} \times 100$

=4.77%

3.(a)Dilute nitric acid followed by ammonium oxalate solution and ethanoic acid.

$BaCO_3$ – white precipitate soluble in ethanoic acid

$CaCO_3$ – white precipitate insoluble in ethanoic acid

$BaCO_3(s) + 2HNO_3 \longrightarrow Ba(NO)_3(aq) + H_2O(l) \quad CO_2(g)$

$CaCO_3(s) + 2HNO_3 \longrightarrow Ca(NO)_3(aq) + H_2O(l) \quad CO_2(g)$

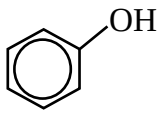
$Ba^{2+}(aq) + C_2O_4^{2-} \longrightarrow BaC_2O_4\ (s)$

Then,

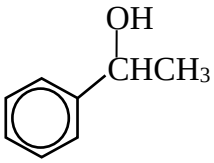
$BaC_2O_4\ (s) + CH_3COOH(aq) \longrightarrow (CH_3COO)_2Ba(aq) + H_2C_2O_4\ (aq)$

$Ca^{2+}(aq) + C_2O_4^{2-} \longrightarrow CaC_2O_4\ (s)$

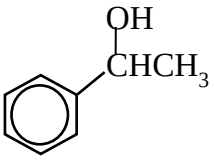
(b) Neutral iron (III) chloride



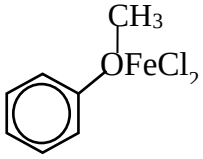
Purple colouration,



No observable change

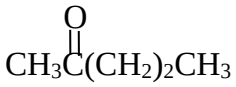


$+ FeCl_3 \longrightarrow$



(c) Ammoniacal silver nitrate solution and heat

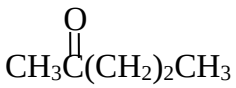
$CH_3(CH_2)_2CHO$ – silver mirror ,



– no observable change

(or Ammoniacal copper(I) chloride solution and heat or warm

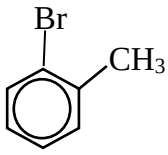
$CH_3(CH_2)_2CHO$ – red precipitate



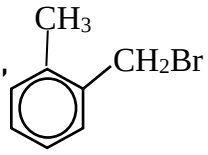
– no observable change

$CH_3(CH_2)_2CHO \xrightarrow[\text{heat}]{AgNO_3(aq)/NH_3(aq)} Ag(s) + CH_3(CH_2)_2COO^-\ (aq)$

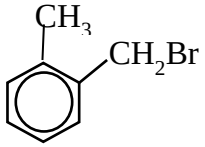
(d) Hot sodium hydroxide solution, dilute nitric acid and silver nitrate solution.



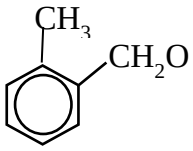
– no observable change,



– pale yellow precipitate



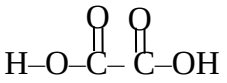
$\xrightarrow[\text{heat}]{NaOH(aq)}$



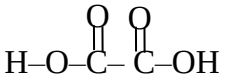
$+ Br^-$

$Br^-(aq) + Ag^+(aq) \longrightarrow AgBr(s)$

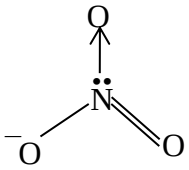
(e) Ammoniacal silver nitrate solution and heat.

$HCOOH$ – silver mirror,  – no observable change

Or, Fehlings solution and heat

$HCOOH$ – red precipitate  – no observable change

$$HCOOH \xrightarrow[heat]{AgNO_3(aq)/NH_3(aq)} CO_2\,(s) + Ag(s) + H_2O$$

4(a)(i) NO_3^-  Trigonal planar shape

(ii) NO_2^-  Bent (or V) shape

(b) The bond angle in NO_3^- is bigger than that in NO_2^-

This is because in nitrate ion the nitrogen atom has three bond pairs and no lone pair. The bond pairs repel each other until minimum repulsion occurs amongst them. This occurs when the bonded species symmetrically arrange themselves around the nitrogen atom.

In nitrite ion, the nitrogen atom has one lone pair and two bond pairs. The lone pair exerts greater repulsion on the two bond pairs. This makes the bond pairs get closer to each other hence making the bond angle in nitrite ion being smaller than that in nitrate ion.

(c)(i) Nitrite ion (NO_2^-)

ii) The nitrite ion reduces iodine to iodide ions and the nitrite ion is oxidized to nitrate ion

$$NO_2^-(aq) + H_2O\,(l) + I_2(aq) \longrightarrow NO_3^- + 2I^-\,(aq) + 2H^+(g)$$

5.(a)(i) Acidified solution of manganate(VII) ions

(ii) Aqueous solution of vanadium (II) ions

(b) (i) $Pt(s)/V^{2+}(aq),\ V^{3+}(aq)\ //\ MnO_4^-(aq), H^+(aq)\ Mn^{2+}(aq)/Pt(s)$

(ii) At positive terminal

$$MnO_4^-(aq) + 8H^+(aq) + 5e \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$$

At the negative terminal

$$V^{2+}(aq) \longrightarrow V^{3+}(aq) + e$$

iii) $E^\theta_{cell} = E^\theta_{right} - E^\theta_{left}$

$= +1.52 - (-0.27)\ V$

$= +1.79V$

$\Delta G = -nEF$

= (−5×1.79×96500)J

= 863675 J/mol or 863.675 KJ/mol

(c)i) Pt(s), $2Cl^-(aq)$ / $Cl_2(g)$ // PbO(s) / $H^+(aq)$, $Pb^{2+}(aq)$ / Pt

ii) $E^\theta_{cell} = E^\theta_{right} - E^\theta_{left}$

= (1.46 – 1.36)

= +0.10V

The E.m.f for the overall cell rotation is positive indicating that the cell produce electric current.

The e.m.f for the overall cell reaction between acidified potassium dichromate and chloride ions is

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l) \quad +1.33V$$
$$2Cl^- \longrightarrow Cl_2(g) + 2e \quad -1.36V$$

Overall equation

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Cl^-(aq) \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 3Cl_2(g) \quad -0.3V$$

The E.m.f for the overall cell reaction is –0.03V

This means that the acidified potassium dichromate cannot oxidize the chlorine ions to chlorine since the E.m.f value has a negative sign. Therefore potassium dichromate can be acidified using dilute hydrochloric acid.

Overall cell reaction for the reaction between acidified potassium permanganate and dilute hydrochloric acid is obtained as

$$MnO_4^-(aq) + 8H^+(aq) + 5e \longrightarrow Mn^{2+}(aq) + 4H_2O(l) \quad +1.52V$$
$$2Cl^- \longrightarrow Cl_2(g) + 2e \quad -1.36V$$

Overall equation

$$2MnO_4^-(aq) + 16H^+(aq) + 10Cl^-(aq) \longrightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5Cl_2(g) \quad +0.16V$$

Since the E.m.f value for the overall cell reaction has a positive sign, this means that the manganate (VII) ions can oxidize chloride ions to chlorine.
Therefore the manganate(VII) ions cannot be acidified using dilute hydrochloric acid.

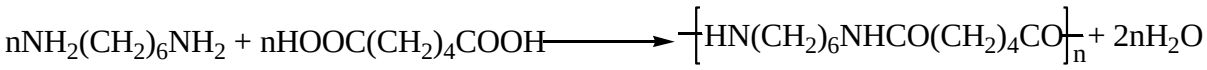
6.a). Addition polymerisation is the process by which small unsaturated molecules or molecules that contain carbon-carbon double bond combine to form a large molecule without loss of other small molecules.

Condensation polymerisation is the process by which many bifunctional molecules combine to form a large molecule accompanied by loss of other small molecules.

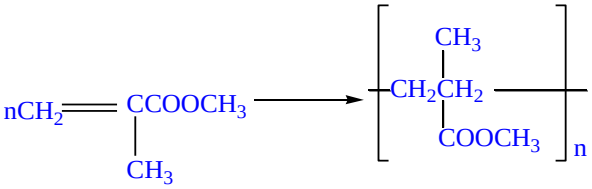
b)i) Hexane-1,6-dioic acid and Hexane-1,6-diamine

ii) Methyl-2-methylpropenoate

c) Nylon-6,6



Perspex



d)i) Nylon-6,6

Monomers are bifunctional

Perspex

Monomers contain carbon-carbon double bond

ii) In formation of nylon-6,6, there is loss of some molecules

In formation of persex, there is no loss of some molecules and the polymer is a multiplier of the monomer

e) Nylon-6,6; For making clothes, threads and fishing nets

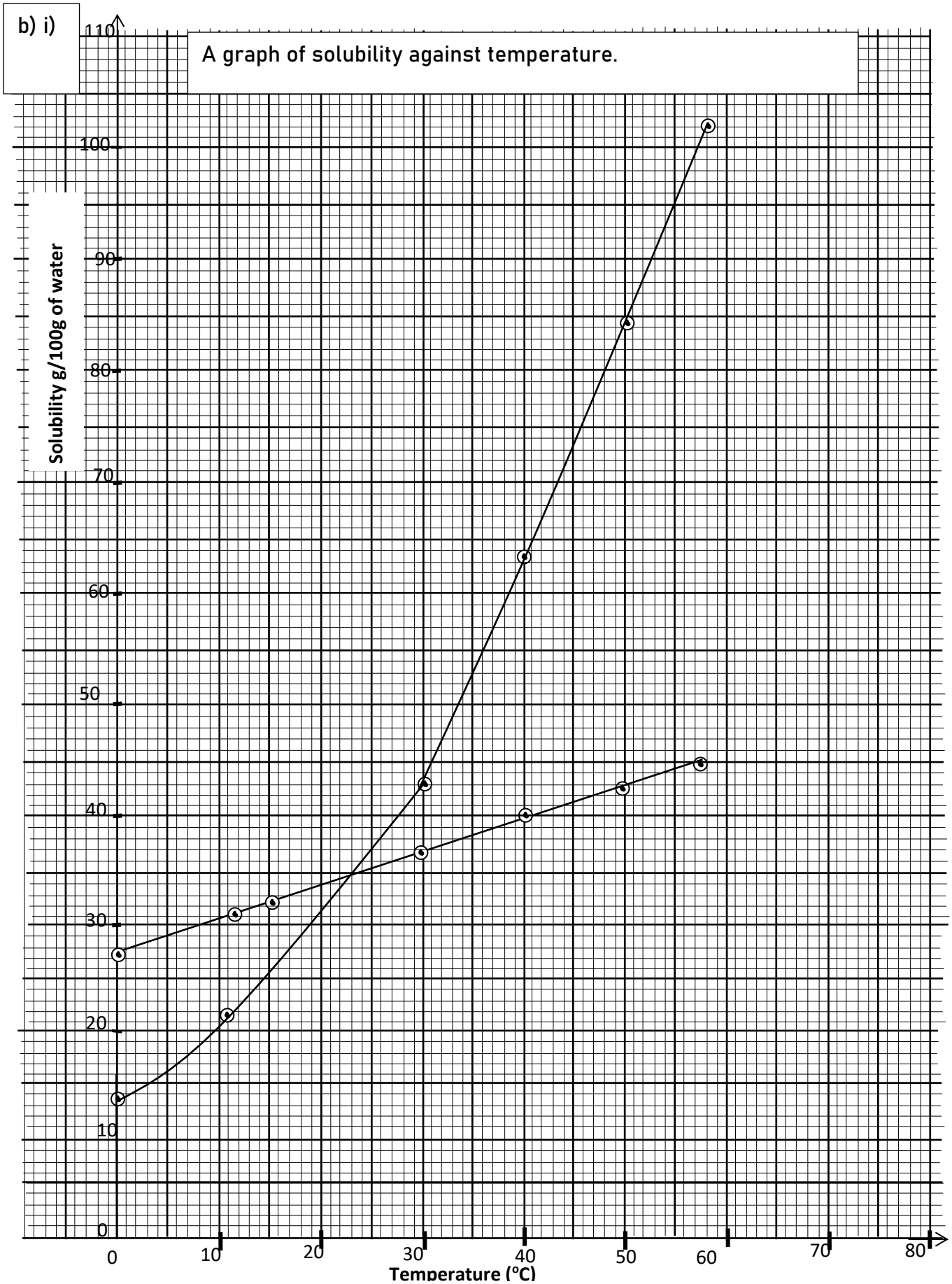
Perspex; For making aircraft, windows and rulers.

7. a)i) Solute is a substance that dissolves in a solvent to form a uniform solution.

ii) Saturated solution is one that cannot dissolve any more solute in the presence of undissolved solute at a given temperature.

b) i)

A graph of solubility against temperature.



ii) Potassium chloride

iii) At 23.5℃, the solubilities are equal.

iv) Solubility of potassium nitrate at 30℃ in 43.0g/ 100g of water.

Solubility of potassium nitrate at 5℃ is 17g / 100g of water.

Mass of potassium nitrate that crystallized = 43 – 17

= 26g

RFM of potassium nitrate (KNO_3) = 39+ 14 + 16x3 = 101

Number of moles of KNO_3 that crystallized = $\frac{26}{101}$

= 0.25743 moles

c) $2Cu^{2+}(aq) + 4I^{-}(aq) \longrightarrow 2CuI\,(s) + I_2(aq)$

$I_2\,(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^{-}\,(aq) + S_4O_6^{2-}\,(aq)$

Number of moles $S_2O_3^{2-}$ = $\frac{33.5 \times 0.118}{1000}$

= $3.953x10^{-3}$ moles

Mole ratio $S_2O_3^{2-}$: I_2 = 2: 1

Number of moles of I_2 liberated = $\frac{1}{2} \times 3.953 \times 10^{-3}$

= $1.9765x10^{-3}$ moles

Mole ratio I_2 : Cu^{2+} = 1:2

Number of moles of Cu^{2+} = $1.9765x10^{-3}x2$

= $3.953x10^{-3}$ moles

RFM of $CuSO_4$ = 64+ 32+ 16x4 = 160

25cm^3 of diluted solution contain $3.953x10^{-3}$ moles of copper(II) sulphate

200cm^3 of diluted solution contain $\left(\frac{3.953x10^{-3}\ x200}{25}\right)$ moles

= 0.031624 moles

Mass of $CuSO_4$ in the saturated solution = 0.031624x160

= 5.05984g

Mass of water in the saturated solution = 25.2-5.06

= 23.14g

23.14g of water dissolve 5.06g of $CuSO_4$

100g of water dissolve $\left(\frac{5.06x100}{23.14}\right)$g

Solubility of $CuSO_4$ = 21.87g/ 100g of water.

d) i) By boiling off most of the water such that the same solute is dissolved in less amount of water.

ii) By increasing the temperature of the solution.

e) i) Fractional crystallization is the process of separating two or more crystalline solids from their aqueous solution due to difference in their solubilities.

ii) 175g of saturated solution at 100℃ contain 75g of $CuSO_4$

∴ 50g of saturated solution contain $\left(\frac{75x50}{175}\right)$g

= 21.43g

125g of saturated solution of $CuSO_4$ at 30℃ contain 25g of $CuSO_4$

50g of saturated solution of $CuSO_4$ at 30℃ contain $\left(\frac{\mathbf{25x50}}{\mathbf{125}}\right)$g

= 10g

∴ Mass of $CuSO_4$ that crystallized = 21.43-10

= 11.43g

iii) Stir copper(II) sulphate into hot water until no more will dissolve. Pour the solution into a jar and wait for a few days for the crystals to grow. If one of the crystals is tied on the thread and is suspended in a hot saturated solution of copper(II) sulphate for several days. The crystal grows larger as the solution slowly evaporates.

8) a)i) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -ve$

ii) Temperature of 450°C.

Use of Vanadium pentoxide as a catalyst

Pressure of 2 atmosphere

b)i) When temperature is increased to 800 °C, the position of the equilibrium will shift from the right to the left since the forward reaction is an exothermic reaction and the temperature adjusted is beyond the optimum temperature.

ii) Acidified potassium permanganate reacts with sulphur dioxide, and reduces its concentration and as such the equilibrium position shifts from the right to the left.

c) Let the moles of oxygen which reacted be X

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Initial moles;	1.8	2.0	0
Reacted moles;	2X	X	2X
Equilibrium moles;	1.8-2X	2-X	2X

Moles of oxygen that reacted; $= \frac{26}{100} \, x \, 2 = 0.52$

Hence X= 0.52

Equilibrium concentration;

$[SO_2] = \frac{1.8-(2x0.52)}{2} = 0.38M$; $[O_2] = \frac{2-0.52}{2} = 0.74M$ $[SO_3] = \frac{2 \text{ x } 0.52}{2} = 0.52M$

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

$= \frac{0.52^2}{0.338^2 \text{ x } 0.74}$

= 2.53

d) $2P(s) + 5H_2SO_4(l) \longrightarrow 2H_3PO_4(aq) + 2H_2O(l) + 5SO_2(g)$

or $P_4(s) + 10H_2SO_4(l) \longrightarrow 4H_3PO_4(aq) + 4H_2O(l) + 10SO_2(g)$

$H_2S(g) + 3H_2SO_4(l) \longrightarrow 4H_2O(l) + 3SO_2(g) + S(s)$

$Sn(s) + 4H_2SO_4(l) \longrightarrow Sn(SO_4)_2(aq) + 4H_2O(l) + 2SO_2(g)$

9. a)i) A metal which is capable of forming at least one of its stable ions with a partially filled 3d subshell.

ii) Complex ion is either a positively charged or negatively charged ion in which the central ion is bonded to several other ligands.

b) They form cations with high charge density which are able to attract themselves. Their ions or atoms possess partially filled or vacant orbitals in which the ligands are able to donate their lone pair of electrons and form dative bonds.

c)i) $Co(H_2O)_6^{2+}$; Hexaaquacobalt(II)ions

ii) $Co(H_2O)_6^{2+}(aq) + SCN^-(aq) \longrightarrow [Co(H_2O)_5SCN]^+(aq) + H_2O(l)$

d)i) Pink solution turns blue;

$Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq) + 6H_2O(l)$

ii) A blue precipitate insoluble in excess and turns brown on standing

$Co^{2+}(aq) + 2OH^-(aq) \longrightarrow Co(OH)_2(s)$

$2Co(OH)_2(s) + {}^1/_2 O_2(g) \longrightarrow Co_2O_3.2H_2O(s)$

Or; $4Co(OH)_2(s) + O_2(g) \longrightarrow 2Co_2O_3.2H_2O(s)$

10.i) Standard electrode potential is the electrode potential of an electrode which is the measure with respect to a standard hydrogen electrode under standard conditions.(298K, 1Atm, 1M concentration of ions)

ii) it is impossible to measure an absolute standard electrode potential because it is necessary to have a second electrode as a reference electrode which also has a potential difference with respect to a solution

We can only measure relative values of standard electrode potentials using a second electrode. E.g. standard hydrogen electrode whose potential difference is arbitrarily taken to be zero (0.00v)

iii) When a metal is dipped in a solution containing its ions, the metal M dissolves so as to establish an equilibrium,

$$M(s) \rightleftharpoons M^{n+}(aq) + ne \quad \Delta H^{o}$$

The value of standard electrode potential will depend on the overall enthalpy change. For the reaction above, it will depend on;

Atomization/ sublimation energy. $M(s) \rightleftharpoons M(g)\ \Delta Hatm$

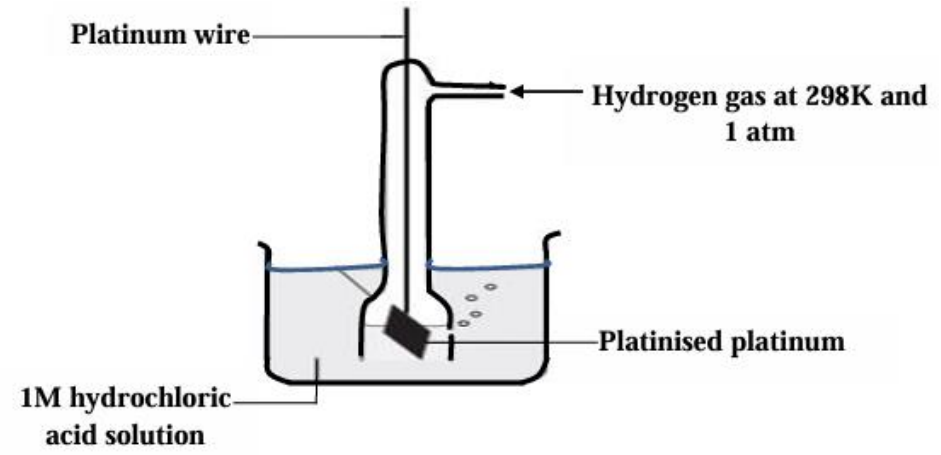
Ionization energy. $M(g) \rightleftharpoons M^{+}(g) + e \quad \Delta H_{I.E}$

Hydration energy $M^{+}(g) \rightleftharpoons M^{+}(aq) \quad \Delta H_{Hyd}$

The overall heat change, $\Delta H^{o} = \Delta H_{Hyd} + \Delta H_{I.E} + \Delta Hatm$

Both atomization and ionization energy are endothermic processes, hydration energy is an exothermic process. For large negative values of the electrode potentials, enthalpies of atomization and ionization should be small and the hydration energy should be large

b) A standard hydrogen electrode consists of hydrogen gas at 298K, and 1 Atm bubbling over a platinized platinum electrode suspended in 1M solution of hydrogen ions.



c) A silver plate is dipped in 1M solution of silver nitrate solution and connected to a standard hydrogen electrode via a voltmeter.

The two half cells are internally connected via a salt bridge

The E.m.f read off from the voltmeter is taken as the standard electrode potential of silver since the electrode potential of standard hydrogen electrode is arbitrarily taken to be zero volts.

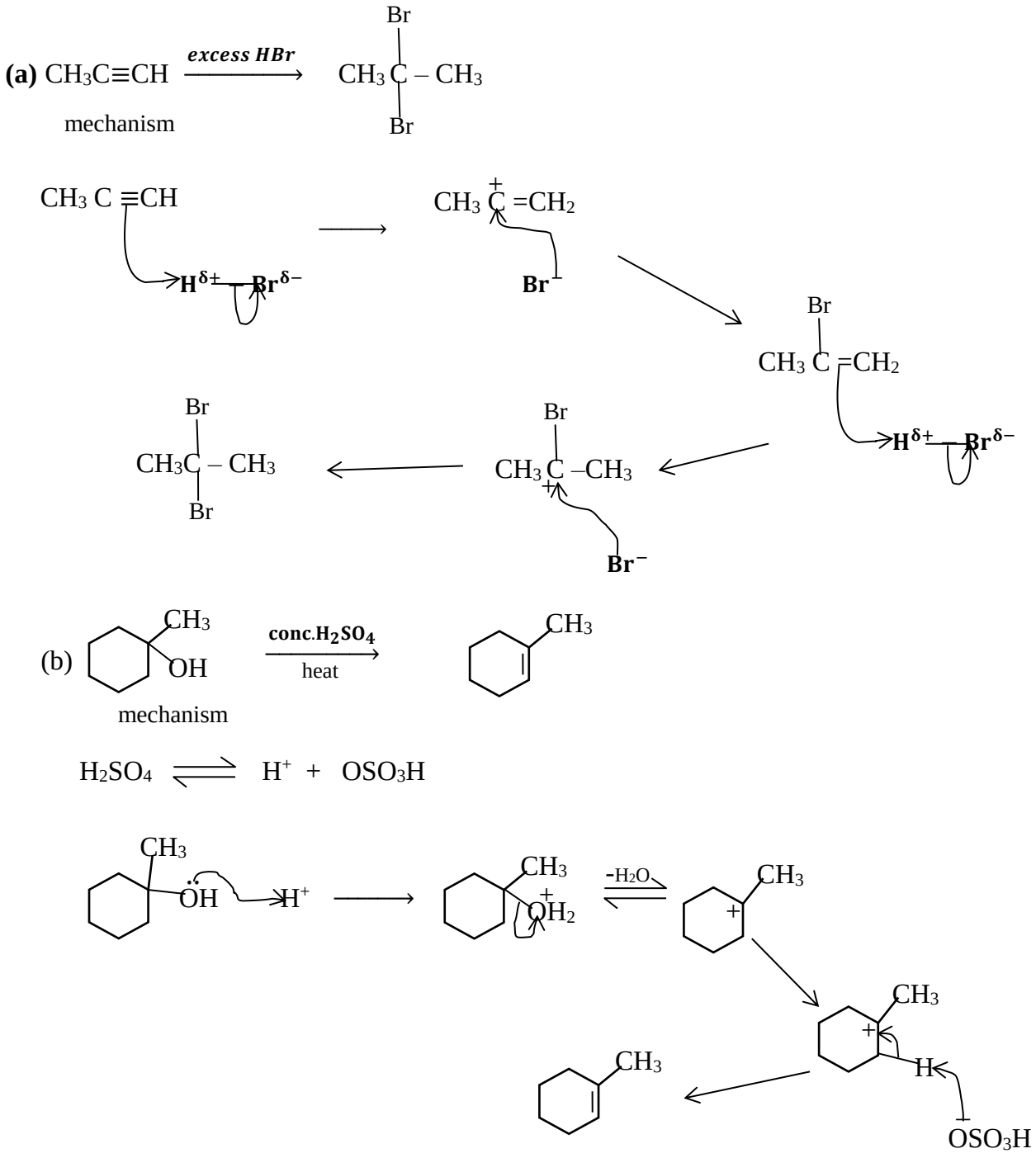
d)i) Eo Cell = $E_R - E_L$

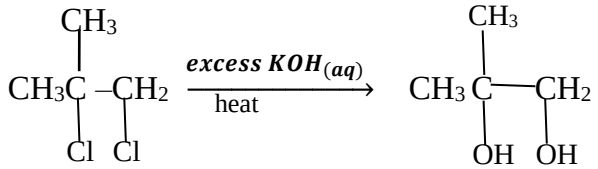
= -2.87-(-2.37)

= -0.5V

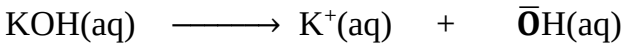
ii) The cell reaction is not feasible since the E.m.f of the cell is negative.

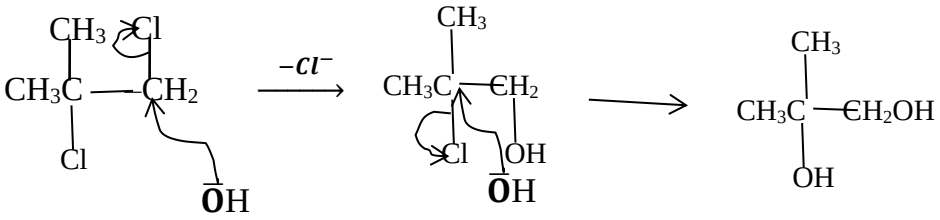
11.

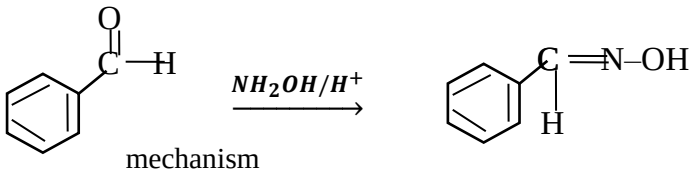


(c) 

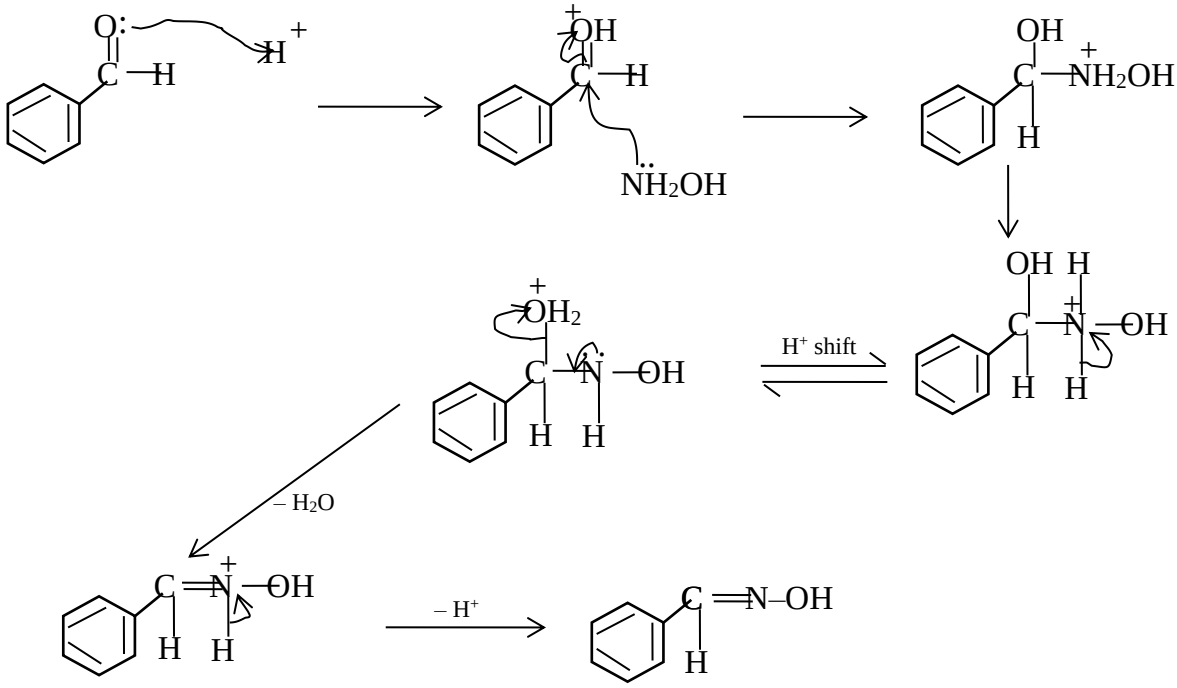
mechanism

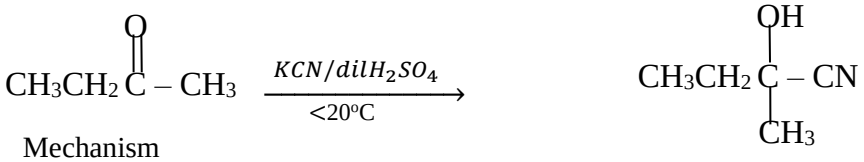




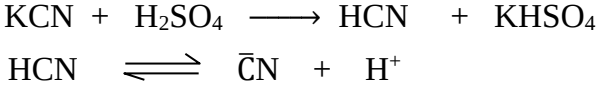
(d) 

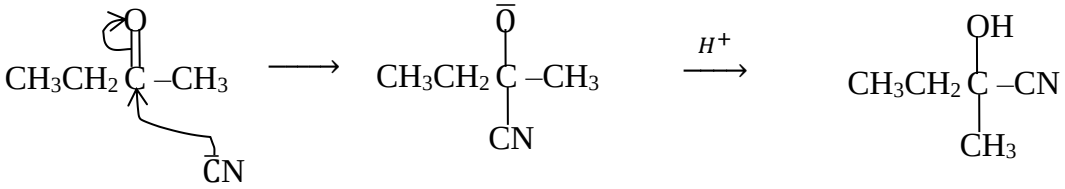
mechanism



(e) 

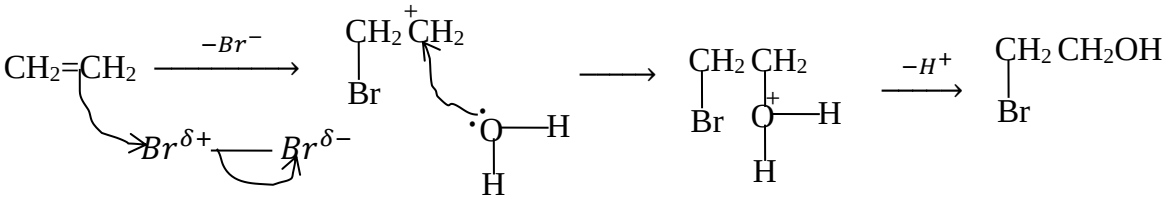
Mechanism



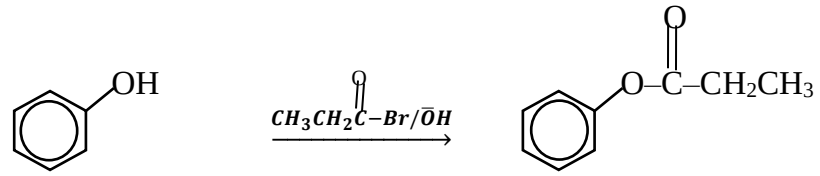


(f) $H_2C{=}CH_2 \xrightarrow{Br_2/H_2O}$ CH_2CH_2OH (Br)

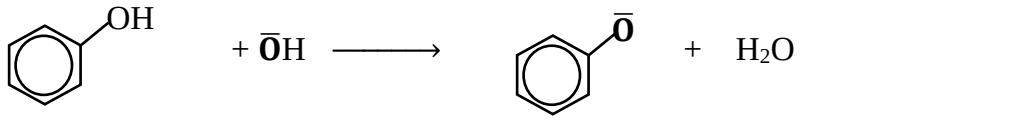
Mechanism

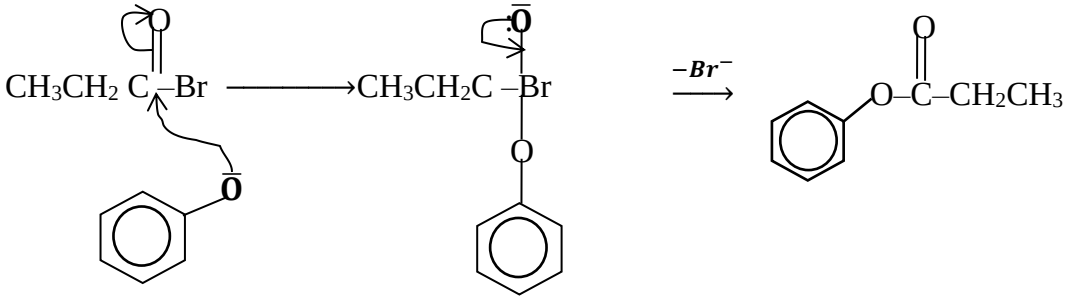


(g)



Mechanism





12. a) Relative atomic mass of an element is the ratio of the mass of its atom to a twelfth of the mass of carbon atom of carbon-12 isotope.

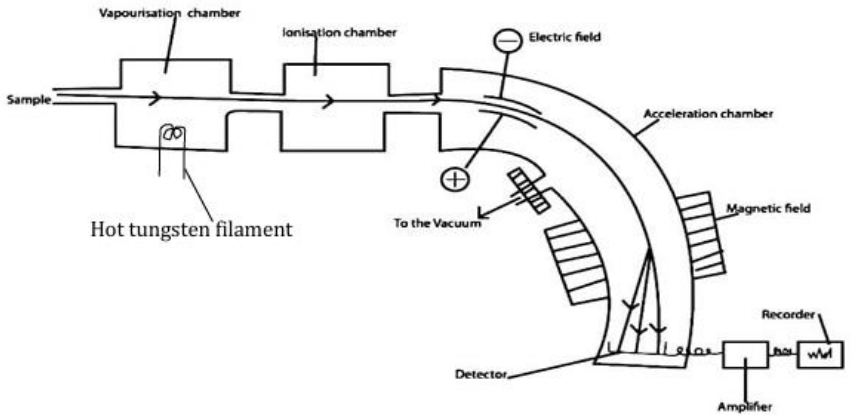
b) A vaporized sample of an element allowed to enter the ionization chamber where it is subjected to a beam of electrons from an electron gun

Positively charged ions are formed, they are accelerated to the same velocity by an electric field towards the magnetic field. In the magnetic field, the ions are deflected according to their charge/mass ratio

By varying both electric and magnetic field strengths, a particular set of ions is focused onto the detector

In the detector, the ions create electric impulse in form of detector current, the magnitude of each detector current proportional to the intensity of the ion producing it

The detector currents are recorded on a photographic plate as a series of lines or peaks called mass spectrum



c)i) Relative intensity is the proportion or ratio or fraction of each isotope in a given sample

ii) R.A.M = $\frac{(24x8)+(25x1)+(26x1)}{9+1+1}$

= 24.3

iii) W has three isotopes, ^{24}W, ^{25}W, ^{26}W

d) It produces accurate relative atomic mass

It uses very small amount of the sample

e) $$2.303 \log\left(\frac{No}{N}\right) = Kt$$

$$2.303 \log\left(\frac{680}{125}\right) = K350$$

$$K = 4.84\, x10^{-3} S^{-1}$$

iii) $$t_{1/2} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{0.693}{4.84\, x\, 10^{-3}}$$

143.2 seconds

13. a) $CH_3CH_2CH_2CH_2Br$ – 1-bromobutane

$(CH_3)_2CHCH_2Br$ – 1-bromo-2-methylpropane

$CH_3CH_2CHBrCH_3$ – 2-bromobutane

$(CH_3)_3CBr$- 2-bromo-2-methylpropane

b)i) 1-bromobutane has the highest boiling point

ii) 2-bromo-2-methylpropane has the lowest boiling point

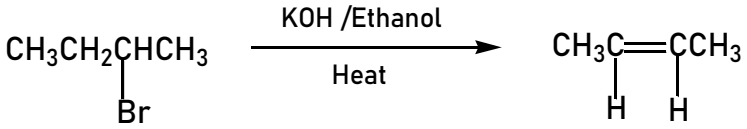
c) 1-bromobutane is a straight chain isomer and the molecules are closer to each other and this increases the intermolecular forces of attraction and thus more heat is required to break them

2-bromo-2-methylpropane is a branched isomer and increased branching gives the molecule a more spherical shape, this reduces the extent of contact between the neighboring molecules, consequently the attractive forces are reduced and therefore less energy is required to break the forces.

d) S- 2-bromobutane

T- Butan-2-ol

e)i)



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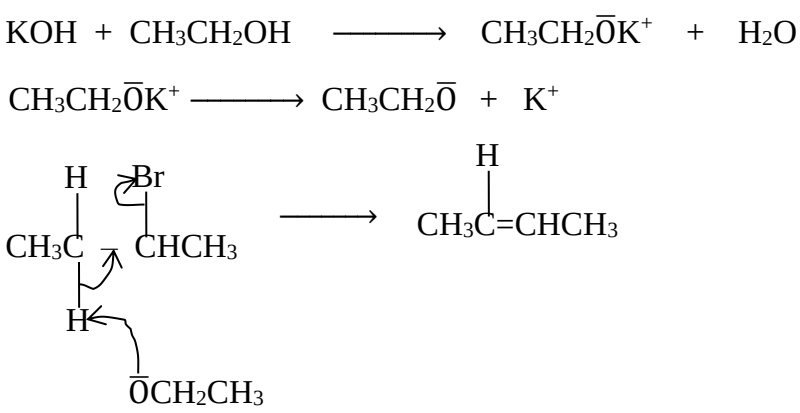
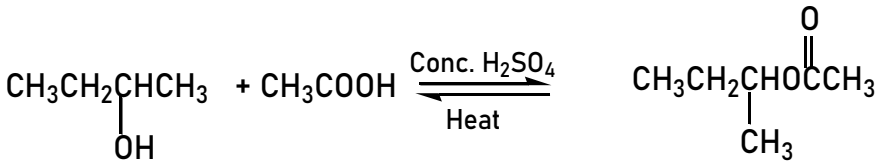


ii)



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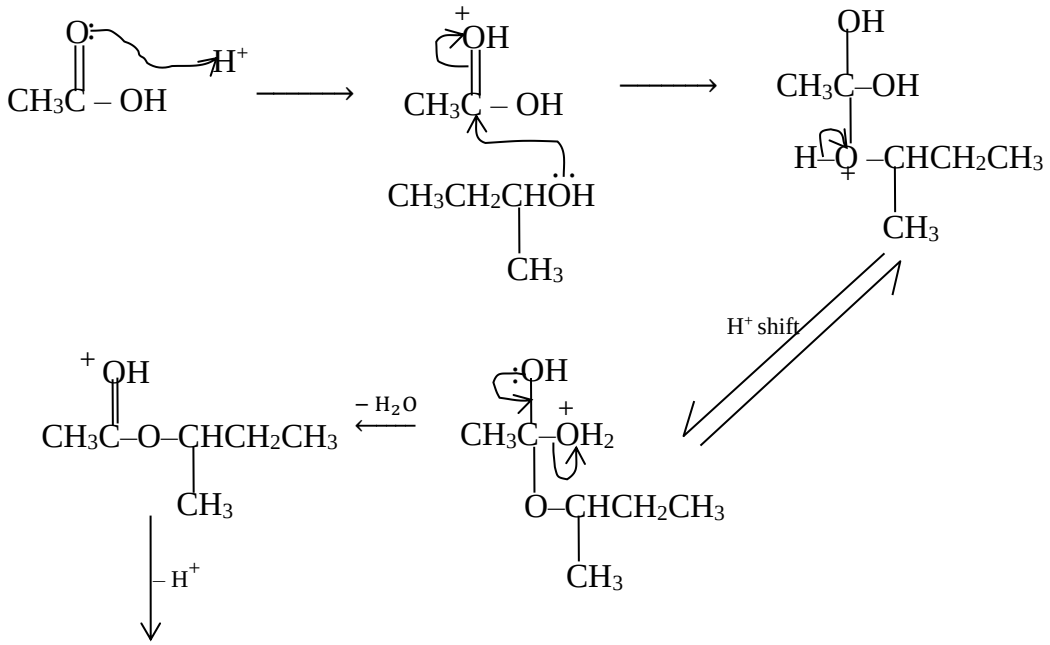
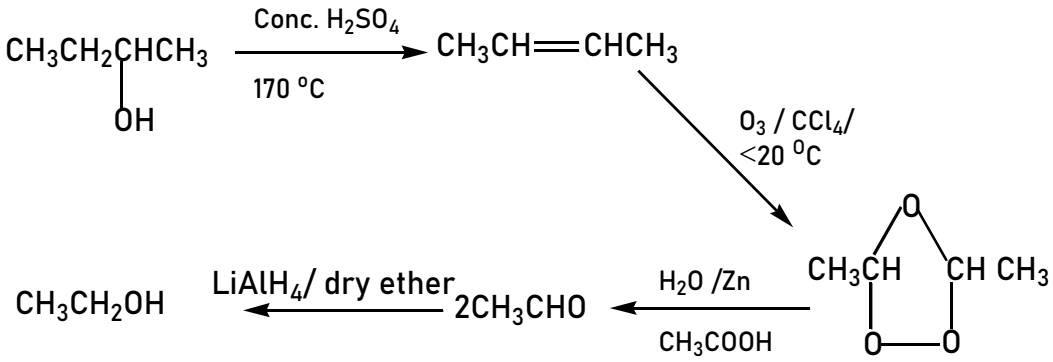


f)



14. a) $nS^2\ nP^5$

b)i) Fluorine reacts with water vigorously to form hydrofluoric acid and oxygen gas while bromine reacts with water slightly or slowly to form hypobromous acid and hydrobromic acid

$2F_2(aq) + 2H_2O(l) \longrightarrow 4HF(aq) + O_2(g)$

$Br_2(aq) + H_2O(l) \rightleftharpoons HOBr(aq) + HBr(g)$

ii) Fluorine reacts with cold dilute potassium hydroxide to form potassium fluoride, oxygen difluoride and water

$2F_2(aq) + 2OH^-(aq) \longrightarrow 2F^-(aq) + OF_2(g) + H_2O(l)$

Bromine reacts with cold dilute potassium hydroxide to form potassium hydroxide to form potassium bromide, potassium hypobromite (bromate(I))and water.

$Br_2(aq) + 2OH^-(aq) \longrightarrow Br^-(aq) + OBr^-(g) + H_2O(l)$

Fluorine reacts with hot concentrated potassium hydroxide solution to form potassium fluoride, oxygen gas and water

$2\mathrm{F}_2(\mathrm{aq}) + 4OH^-(\mathrm{aq}) \longrightarrow 4F^-(\mathrm{aq}) + O_2(\mathrm{g}) + 2H_2O(l)$

Bromine reacts with hot concentrated potassium hydroxide, potassium bromate, potassium bromide and water.

$3\mathrm{Br}_2(\mathrm{aq}) + 6OH^-(\mathrm{aq}) \longrightarrow 5Br^-(\mathrm{aq}) + \mathrm{BrO}_3^-(\mathrm{aq}) + 3H_2O(l)$

c)i) Pale green solution turned to brown solution

$\mathrm{Cl}_2(\mathrm{aq}) + 2\mathrm{FeCl}_2(\mathrm{aq}) \longrightarrow 2\mathrm{FeCl}_3$

ii) Brown solution turned to colorless

$I_2(aq) + SO_3^{2-}(aq) + H_2O(l) \longrightarrow 2I^-(aq) + SO_4^{2-}(aq) + 2H^+(aq)$

iii) Yellow precipitate

$\mathrm{Br}_2(\mathrm{aq}) + H_2S(\mathrm{aq}) \longrightarrow S(s) + 2HBr(aq)$

iv) Grey solid dissolves to form pale yellow solution which turns colorless on standing

$\mathrm{I}_2(\mathrm{s}) + 2OH^-(\mathrm{aq}) \longrightarrow I^-(\mathrm{aq}) + \mathrm{IO}^-(\mathrm{aq}) + H_2O(l)$

$3IO^-(aq) \longrightarrow IO_3^-(aq) + 2I^-(aq)$

15. a)i) Ionic product is the product of the molar concentrations of the ions that form a sparingly soluble salt raised to appropriate powers

Solubility product is the product of the molar concentrations of the ions of a sparingly soluble salt raised to appropriate powers when a solution is saturated at a given temperature.

ii) Ionic product is not affected by temperature because the ions are already in solution. However, solubility product is affected by temperature since solubility of a sparingly soluble salt is an endothermic process, increase in temperature increases the kinetic energy of the particles of the solute and thus ions can easily break off from their lattice and this increases the concentration of the ions in solution and thus solubility product increases.

b) Excess of solid Lead(II) iodide is mixed with a known volume of distilled water. The mixture is shaken vigorously for some time until equilibrium is established at a particular temperature. The mixture is filtered to obtain a filtrate which is saturated at a given temperature. The electrolytic conductivity of the filtrate is measured using conductivity meter.

The electrolytic conductivity of pure water is also determined which can be used to determine the electrolytic conductivity of Lead(II) iodide from the formula,

Ksolute = Ksolution-Kwater

The molar conductivity of the ions of lead(II) iodide at infinite dilution are obtained from the tables in the data books and can be used to determine the molar conductivity of Lead(II) iodide at infinite dilution from the formula,

$\Lambda\infty PbI_2 = \Lambda\infty Pb^{2+} + 2\Lambda\infty I^-$

The solubility of Lead(II) iodide can be obtained from formula,

$\Lambda\infty PbI_2 = \frac{\mathrm{K}\,PbI_2}{C}$

If C is the solubiblity of Lead(II) iodide, then solubility product is obtained as;

$PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$

C C 2C

Ksp = $[Pb^{2+}][I^-]^2$

= $C(2C)^2$

= $4C^3$ Mol^3dm^{-9}

c) Mass of PbI_2 = 207 + 127x2 = 461.

Mass of PbI_2 that dissolved = $\frac{11.62}{100}$ x $2.5 = 0.2905$ g

$[PbI_2] = \frac{0.2905}{461} = 6.3015\text{x}10^{-4}\ \text{moldm}^{-3}$

$PbI_2(s) + (aq) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$

Ksp = $[Pb^{2+}][I^-]^2$

= $6.3015\text{x}10^{-4}$ $\text{x}(2\text{x}6.3015\text{x}10^{-4})^2 = 1.0003\text{x}10^{-9}\text{mol}^3\text{dm}^{-9}$

d)i) The percentage of Lead(II) iodide that dissolved would be less than 11.62% because ammonium iodide is a strong electrolyte and its addition increases the concentration of the iodide ions. The excess iodide ions will react with the few Lead(II) ions to form insoluble lead(II) iodide and the equilibrium position shifts to the left

$Pb^{2+}(aq) + 2I^-(aq) \longrightarrow PbI_2(s)$

This is done to keep the solubility product of Lead(II) iodide constant at a particular temperature, hence its solubility reduces.

ii) The solubiblity will be more 11.62%, because magnesium ribbon reduces the lead(II) ions to lead metal.

$Pb^{2+}(aq) + Mg(s) \longrightarrow Pb(s) + Mg^{2+}(aq)$

The concentration of the lead(II) ions in solution reduces, thus more lead(II) iodide dissolves to restore the concentration of lead(II) ions to keep the Ksp for lead(II) iodide constant.

e)i) Total volume of solution = 500+500 = 1000 cm^3

$[Pb^{2+}] = \frac{0.025}{1000}$ x $1000 = 0.025\text{M}$

$[I^-] = \frac{0.01325}{1000}$ x $1000 = 0.01325\text{M}$

$Pb^{2+}(aq) + 2I^-(aq) \longrightarrow PbI_2(s)$

Ionic product = $[Pb^{2+}][I^-]^2$

= 0.025 x $[0.01325]^2$ = 4.3891 x 10^{-6} mol^3dm^{-9}

ii) Precipitation will occur because the ionic product has exceeded the solubility product.

f) Ksp for Ag_2CrO_4 = $[Ag^+]^2[CrO_4^{2-}]$

1.3×10^{-12} = $[Ag^+]^2 \times 0.005$

$[Ag^+]$ = $\sqrt{\frac{1.3 \times 10^{-12}}{0.005}} = 1.61245 \times 10^{-5} \text{moldm}^{-3}$

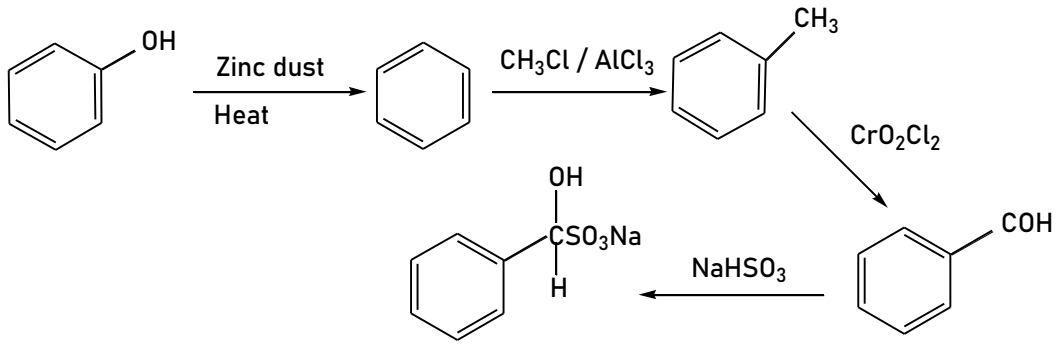
Ksp for AgCl = $[Ag^+][Cl^-]$

1.8×10^{-10} = $[Ag^+] \times 0.005$

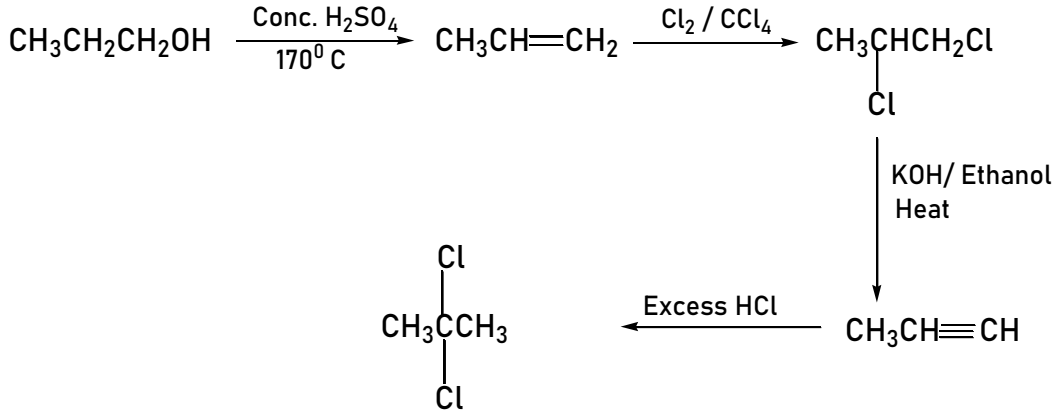
$[Ag^+]$ = $\frac{1.8 \times 10^{-10}}{0.005} = 3.6 \times 10^{-8} \text{ moldm}^{-3}$

Silver chloride precipitates first because it requires a much smaller amount of silver ions to precipitate.

16.



b)



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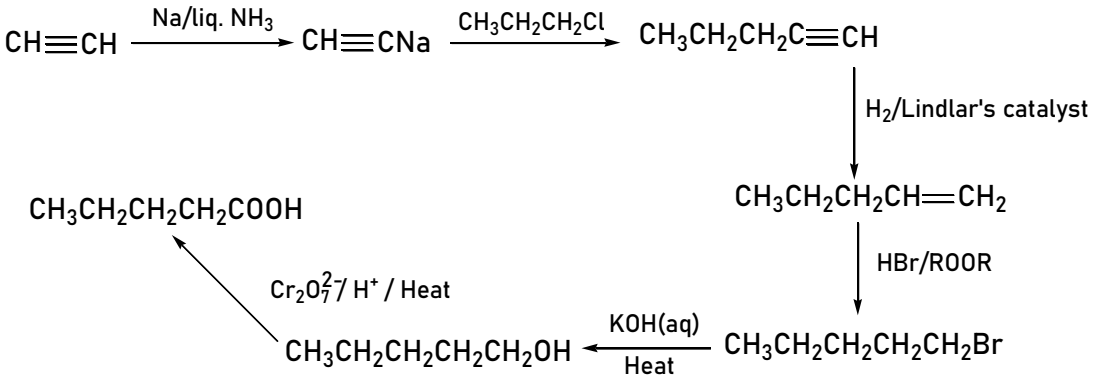
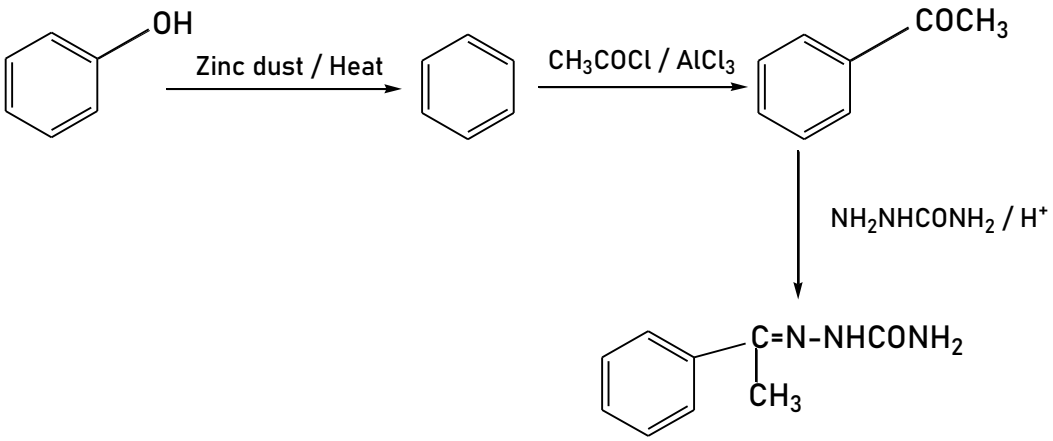
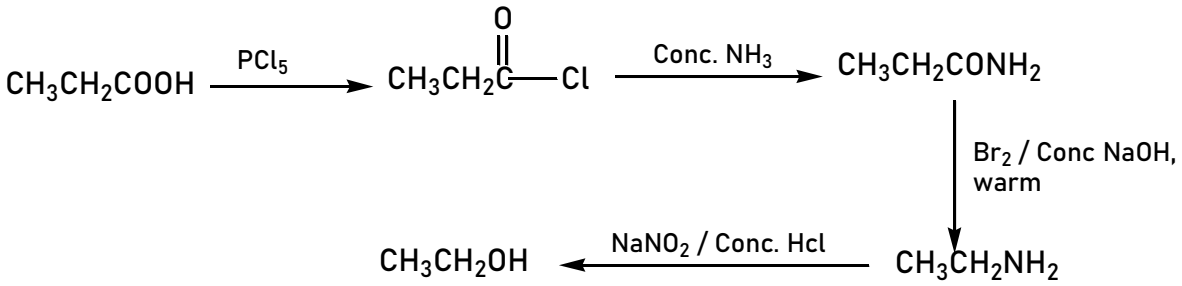

CH≡CH
Na/liq. NH3
CH≡CNa
CH3CH2CH2Cl
CH3CH2CH2C≡CH
H2/Lindlar's catalyst
CH3CH2CH2CH=CH2
HBr/ROOR
CH3CH2CH2CH2CH2Br
KOH(aq)
Heat
CH3CH2CH2CH2CH2OH
Cr2O7 2- / H+ / Heat
CH3CH2CH2CH2COOH

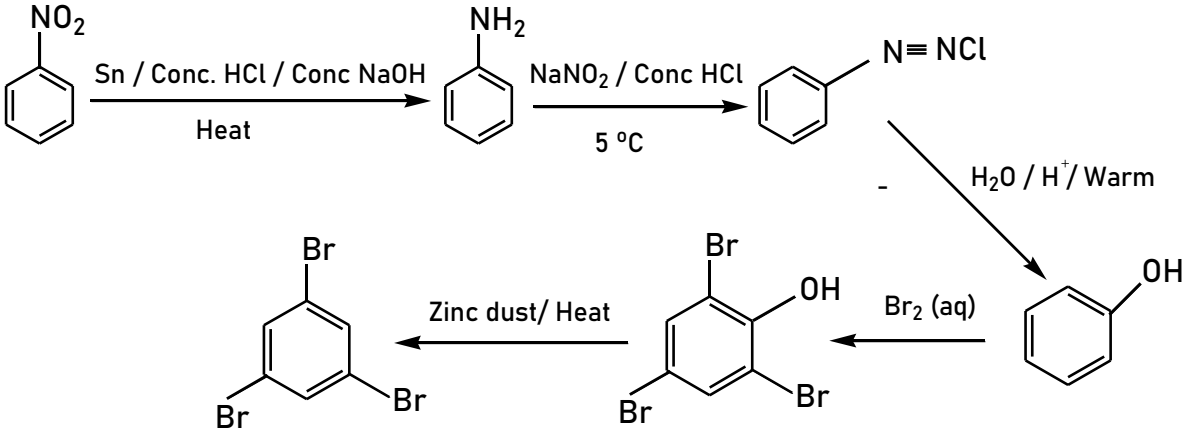
d)


OH
Zinc dust / Heat
CH3COCl / AlCl3
COCH3
NH2NHCONH2 / H+
C=N-NHCONH2
CH3

e)


CH3CH2COOH
PCl5
O
CH3CH2C—Cl
Conc. NH3
CH3CH2CONH2
Br2 / Conc NaOH, warm
CH3CH2NH2
NaNO2 / Conc. Hcl
CH3CH2OH

f)


NO2
Sn / Conc. HCl / Conc NaOH
Heat
NH2
NaNO2 / Conc HCl
5 °C
N≡NCl
H2O / H+ / Warm
OH
Br2 (aq)
Br
OH
Br
Br
Zinc dust/ Heat
Br
Br

17a)i) +2 and +4

ii) +2 oxidation state increases down the group while stability of +4 oxidation decreases down the group due to inert pair effect which increases with increases in atomic radius.

b)i) Carbon, germanium and tin react with hot concentrated nitric acid to form dioxides, nitrogen dioxide and water.

$C(s) + 4HNO_3(aq) \longrightarrow CO_2(g) + 4NO_2\ (l) + 2H_2O\ (l)$

$Ge(s) + 4HNO_3(aq) \longrightarrow GeO_2(g) + 4NO_2\ (l) + 2H_2O\ (l)$

$Sn(s) + 4HNO_3(aq) \longrightarrow Sn(g) + 4NO_2\ (l) + 2H_2O\ (l)$

Silicon does not react with nitric acid under any conditions

Lead reacts with hot concentrated nitric acid to form Lead(II) nitrate, nitrogen dioxide and water

$Pb(s) + 4HNO_3(aq) \longrightarrow Pb(N0_3)_2(g) + 2NO_2\ (l) + 2H_2O\ (l)$

ii) Carbon does not react sodium hydroxide under any condition

Silicon, germanium, and tin react with hot concentrated sodium hydroxide to form silicate(IV), germinate(VI) and stannate(VI) together with hydrogen gas

$Si(s) + 2OH^-(aq) + H_2O\ (l) \longrightarrow SiO_3^{2-} + 2H_2\ (g)$ $Ge(s) + 2OH^-(aq) + H_2O\ (l) \longrightarrow GeO_3^{2-} + 2H_2\ (g)$ $Sn(s) + 2OH^-(aq) + H_2O\ (l) \longrightarrow SnO_3^{2-} + 2H_2\ (g)$

Lead reacts with hot concentrated sodium hydroxide solution to form plumbate(II) and hydrogen gas

$Pb(s) + 2OH^-(aq) \longrightarrow PbO_2^{2-} + H_2\ (g)$

c)i) Hydrogen peroxide oxidizes sulphide ions to sulphate ions which react with lead(II) ions to form lead(II) sulphate.

$PbS(s) + (aq) \longrightarrow Pb^{2+}(aq) + S^{2-}(aq)$

$S^{2-}(s) + 4H_2O_2(aq) \longrightarrow SO_4^{2-}(aq) + 4H_2O\ (l)$

$Pb^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow PbSO_4(s)$

Overall equation; $PbS(s) + 4H_2O_2(aq) \longrightarrow PbSO_4(s) + 4H_2O\ (l)$

ii) Iodide ions have a bigger ionic radius than chloride ions, iodide ions act as strong reducing agent which reduces lead(IV) ions to lead(II) ions and iodide ions oxidized to iodine

$Pb^{4+}(aq) + 4I^-(aq) \longrightarrow PbI_2(s) + I_2\ (aq)$

Lead(IV) oxide does not form, instead lead(II) iodide forms. The chloride ions are weaker reducing agents and thus cannot reduce lead(IV) ions to Lead(II) ions. Therefore Lead(IV) chloride can be formed from Lead(IV) ions and chloride ions.

$Pb^{4+}(aq) + 4Cl^-(aq) \longrightarrow PbCl_4(s)$

iii) Carbon atom in tetrachloromethane has a smaller atomic radius than silicon in silicon tetrachloride, carbon does not have accessible empty d-orbitals to accommodate lone pairs of electrons from water molecules while silicon has accessible empty d-orbitals to accommodate

lone pairs of electrons from water molecules thus silicon(IV) chloride reacts with water to form silicon(IV) oxide and hydrochloric acid.

$SiCl_4(l) + 2H_2O(l) \longrightarrow SiO_2\ (s) + 4HCl(aq)$

iv) Lead(IV) oxide is a strong oxidizing agent which oxidizes hydrochloric acid to chlorine and itself reduced to Lead(II) chloride which is insoluble in cold solution

$PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_2(s) + Cl_2(g) + 2H_2O(l)$

v) Trileadtetraoxide is a mixed oxide containing lead(Ii) oxide and lead(IV) oxide, lead(IV) oxide being acid in nature does not react with nitric acid instead it is released in the solution to form insoluble solid while lead(II) oxide being basic reacts with nitric acid to form lead(II) nitrate which is a soluble compound.

$Pb_3O_4(s) + 4HNO_3(aq) \longrightarrow PbO_2(s) + 2H_2O(l) + 2Pb(NO_3)_2(aq)$

18.a) i) Order of reaction is the sum of the powers to which the molar concentration terms of the reactants are raised in an experimentally determined rate equation.

ii) Molecularity is the number of chemical species taking part in the rate determining step of the reaction mechanism.

iii) Activation energy is the minimum amount of energy possessed by the reactants for the reaction to take place.

b) i) Rate = K$[H_2O_2]$

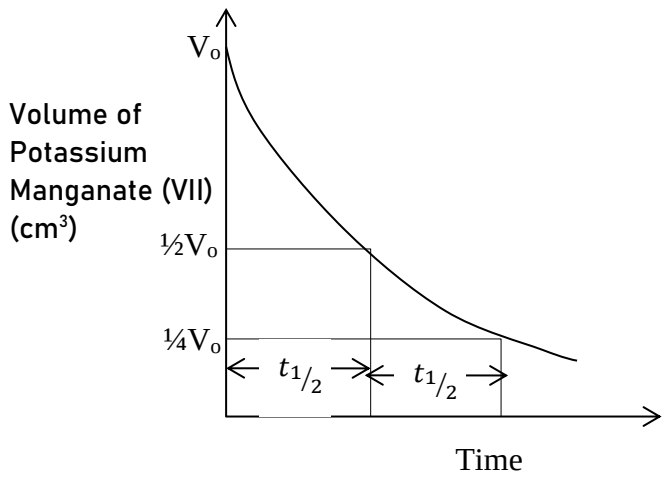
ii) A known volume of hydrogen peroxide of known concentration is placed in a flask.

A small amount of Iron(III) chloride solution is added followed by a small amount of sodium hydroxide solution and a stop clock is simultaneously started.

The mixture is shaken and allowed to stand at a constant temperature. After specific intervals of time, known volumes of the reaction mixture are pipetted into other conical flasks containing dilute sulphuric acid. The base in the reaction mixture is neutralized and the reaction stops.

The mixtures are titrated against standard potassium permanganate solution. The volumes of potassium permanganate solution are directly proportional to the concentration of hydrogen peroxide remaining in the reaction mixture.

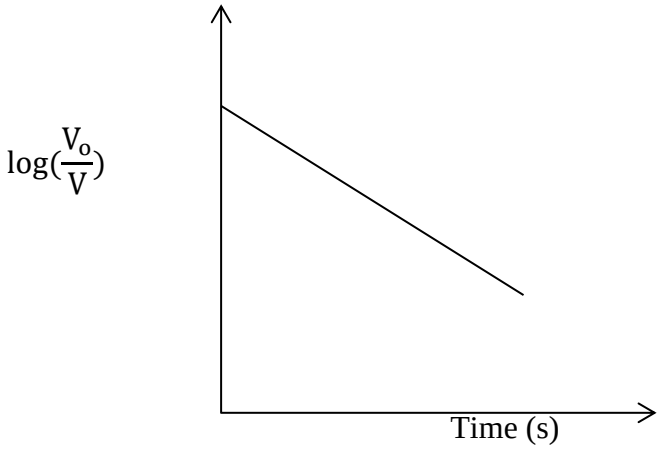
A graph of volume of potassium permanganate solution against time is plotted.



From the graph, half-lives ate equal, implying that the reaction is first order kinetics.

Or

A graph of $\log\left(\frac{Vo}{V}\right)$ against time is plotted.



A straight line graph with negative gradient implies that the reaction is first order.

iii) Increase in temperature increases the rate of decomposition of hydrogen peroxide. Increase in temperature increases the kinetic energy of the molecules and this increases the frequency of collision of molecules. The number of molecules acquiring activation energy increases.

c)

$[H_2O_2]$ (moldm^{-3})	0.0013	0.00076	0.00036	0.00014	0.0001
Time (min)	5	12	20	33	40
Log[H_2O_2]	-2.89	-3.12	-3.44	-3.85	-4.0

On graph paper.

d)i) Initial concentration of H_2O_2 = $10^{-2.7}$ = 0.001995 moldm^{-3}

ii) Slope = $\frac{-4.2-(-2.55)}{42.5-1.5}$

= - 0.04024 min^{-1}

Slope = $\frac{-k}{2.303}$

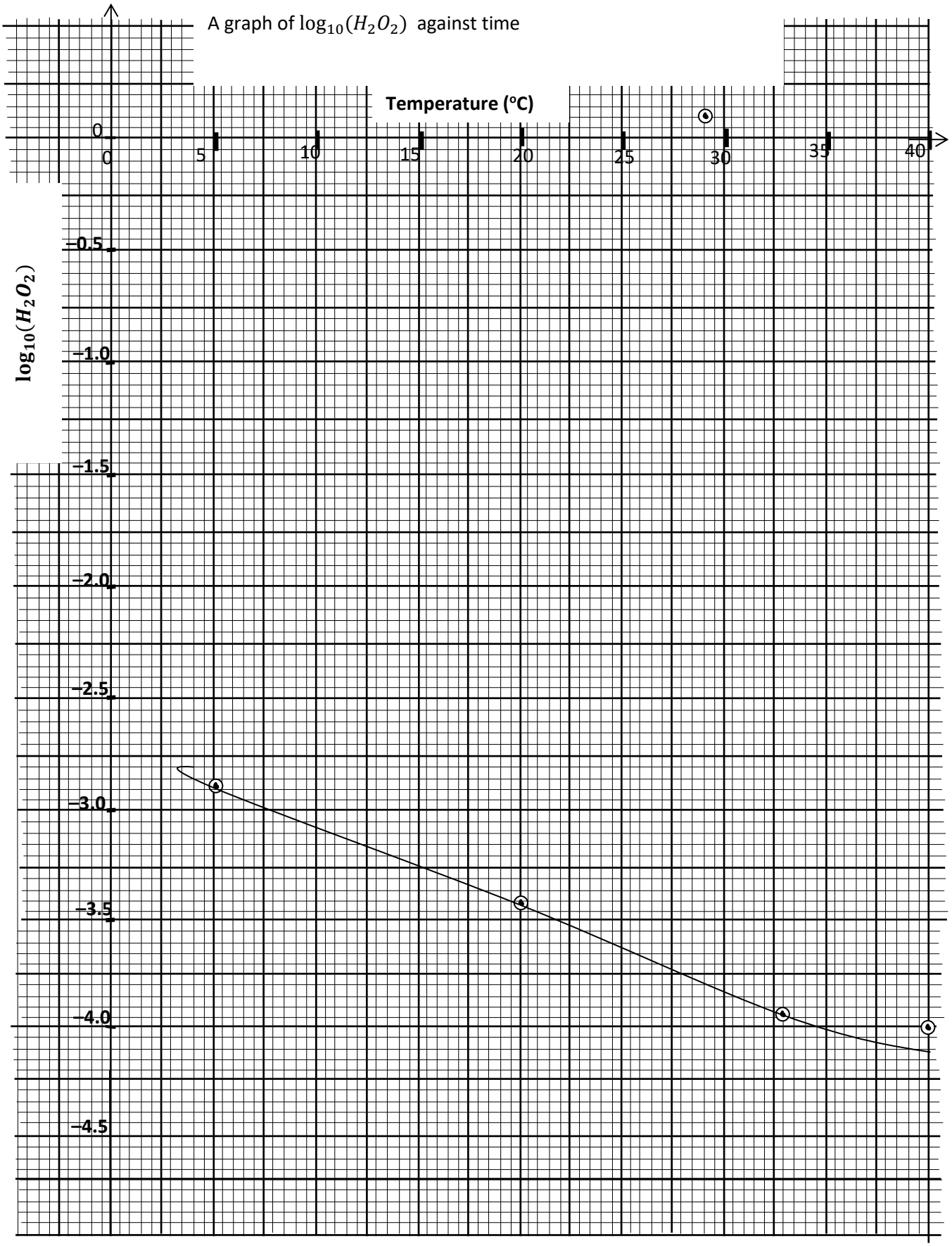
K = 0.092682 min^{-1}

Half-life, $t_{\frac{1}{2}}$ = $\frac{0.693}{k}$

= $\frac{0.693}{0.092682}$

= 7.48 minutes.

A graph of $\log_{10}(H_2O_2)$ against time



19. a)i) A buffer solution is a solution which resists change in pH when a small amount of an acid or a base are added to it.

ii) Salt hydrolysis is the reaction of a salt with water to produce products that affect the pH of the water.

b) i) $[H^+] = \alpha C$

= 0.025 x 0.02 = 5.25 x 10^{-4} moldm^{-3}

$\text{pH} = -\log[H^+]$

= -log (5.25 x 10^{-4}) = 3.28

ii) $Ka = \frac{C\alpha^2}{1-\alpha}$

$= \frac{0.021\ x 0.025^2}{1 - 0.025}$

= 1.346x 10^{-5} moldm^{-3}

c)i) New pH = 3.28+ 2.34

= 5.62

pH = pKa + $\log\left[\frac{[salt]}{[acid]}\right]$

5.62 = -log 1.346x 10^{-5} + $\log\left[\frac{[salt]}{0.021}\right]$

[Salt] = 0.11782 moldm^{-3}

RFM of CH_3CH_2COOK = (12x3) + (1x5) + (16x2) + (39 x1) = 112

Mass of CH_3CH_2COOK = 112 x 0.11782 =13.1958g

ii) Addition of potassium propanoate increases the concentration of propanoate ions since potassium propanoate is a strong electrolyte. The excess propanoate ions react with hydrogen ions from the partial ionization of propanoic acid. This is done to keep the Ka the same.

$CH_3CH_2COO^-$ (aq) + H^+(aq) $\longrightarrow$ CH_3CH_2COOH

The concentration of the hydrogen ions in solution reduces resulting into increase in pH

d)i) Ammonium ions undergo hydrolysis in aqueous solution to produce hydroxonium ions that react with magnesium ribbon to produce hydrogen gas.

NH_4^+ (aq) + H_2O(l) $\rightleftharpoons$ NH_3(g) + H_2O^{3+} (aq)

Mg(s) + H_2O^{3+} (aq) $\longrightarrow$ Mg^{2+}(aq) + H_2(g) + $2H_2O$(l)

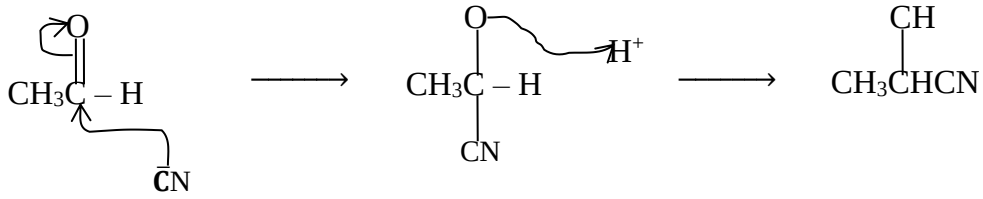
ii) In benzoic acid, the carbonyl functional group is attached directly to the benzene ring. The delocalized pi electrons of the benzene ring exerts a negative inductive effect which weakens the oxygen-hydrogen bond. In aqueous solution, benzoic acid can easily donate protons and a solution has a relatively high concentration of hydrogen ions.

In propanoic acid, the ethyl group attached to the carboxyl group exerts a positive inductive effect which strengthens the oxygen-hydrogen bond and the aqueous solution of propanoic acid has a relatively low concentration of hydrogen ions.

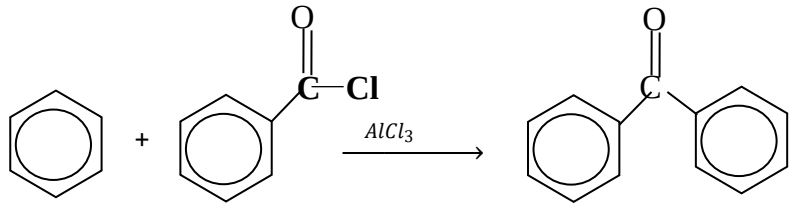
20. (a) $CH_3CHO \xrightarrow[< 20^0C]{KCN/dil.H_2SO_4}$ $CH_3CH(CN)$

mechanism

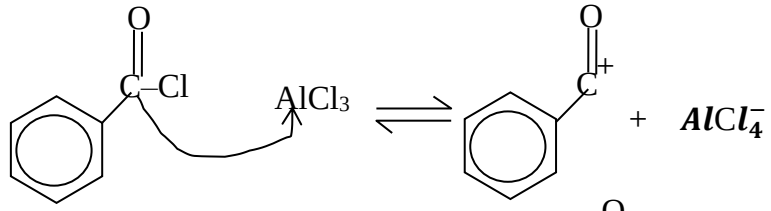
$$KCN + H_2SO_4 \longrightarrow KHSO_4 + HCN$$

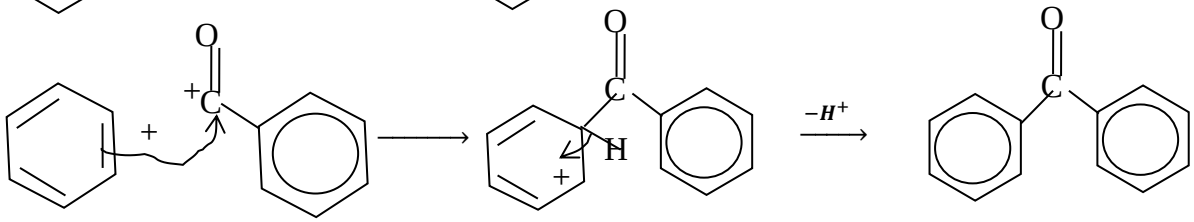


(b)



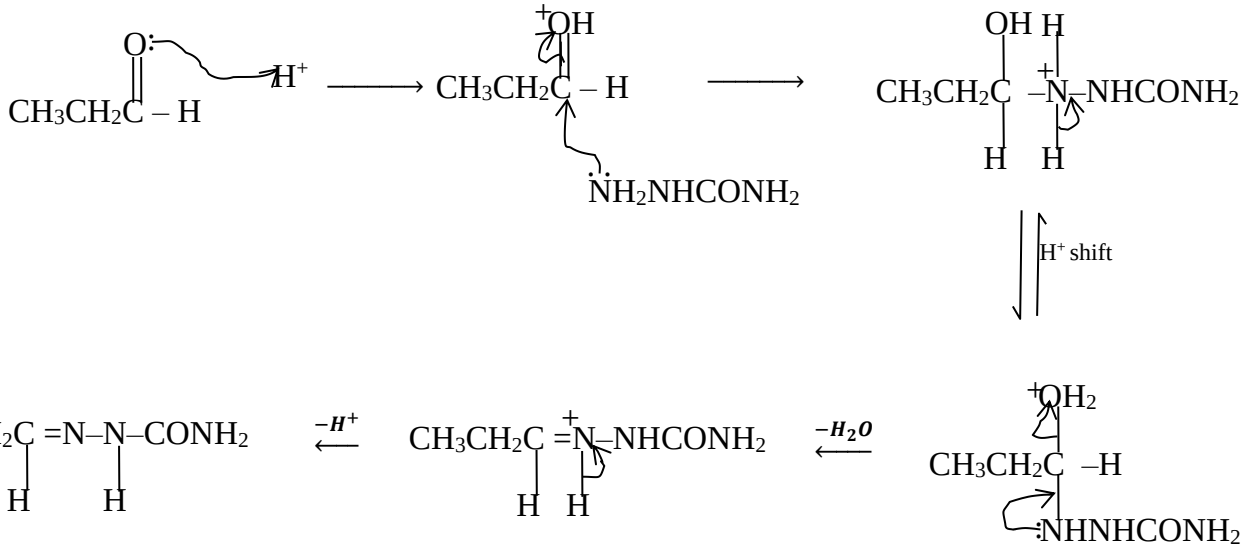
Mechanism



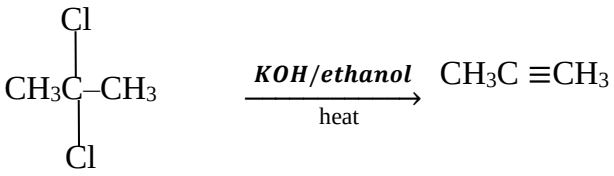


(c) $CH_3CH_2C(=O)-H + NH_2CONHNH_2 \xrightarrow{H^+} CH_3CH_2C(H)=N-NHCONH_2 + H_2O$

mechanism

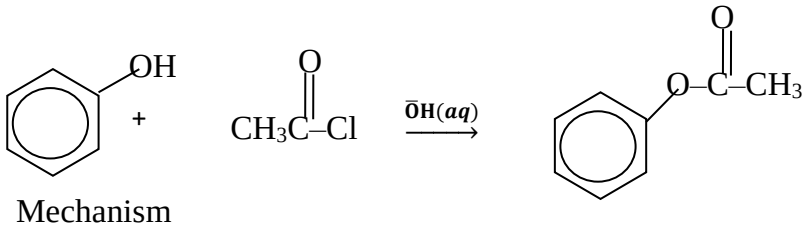


(d)

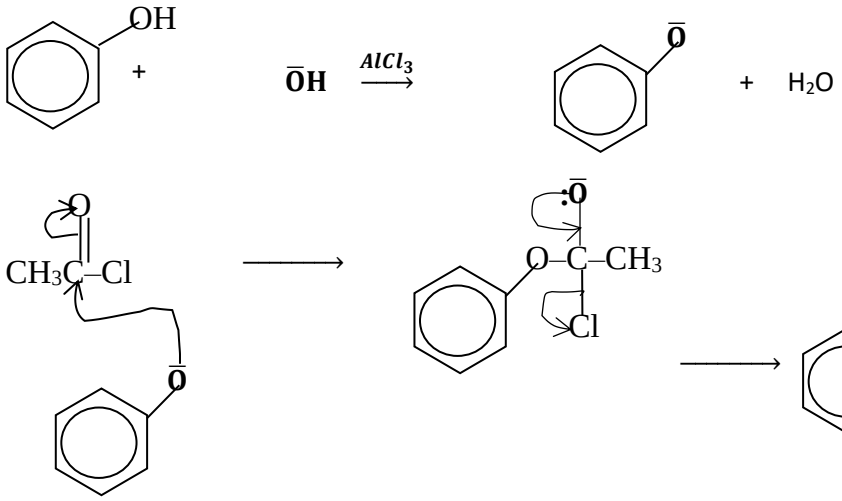


mechanism

(e)



Mechanism



21. a) Steam distillation is a technique of separation of a volatile component which is immiscible with water from a mixture containing a nonvolatile impurities by passing steam through the mixture at a temperature below the boiling point of water.

b) The principle is that when an immiscible mixture of two liquids is heated, each liquid will vaporize independent of each other and the vapour pressure above the mixture is the sum of the

individual vapour pressures. The total vapour pressure can easily reach external atmospheric pressure and the mixture boils at temperature below the boiling points of either liquids.

c)i) The component to be steam distilled must be immiscible with water

The components to be steam must be volatile.

The impurities must be nonvolatile.

The component should have high relative molecular mass such that much of it is isolated in the distillate.

The components should exert high vapour pressure near the boiling point of water.

ii) The component is isolated in much purer state.

Decomposition of the component near its boiling point is avoided.

d)

Temperature (°C)	40	50	60	70	80	90	100	110	120
Vapour pressure of phenylamine (mmHg)	10	20	25	32	40	50	55	65	80
Vapour pressure of water(mmHg)	629	632	645	655	670	690	710	730	760
Total vapour pressure of mixture(mmHg)	639	652	670	687	710	740	765	795	840

i) On graph paper.

ii) At 760 mmHg, P^oH_2O = 705 mmHg and P^oamine = 55 mmHg .

$$\frac{\text{Mass of phenylamine in distillate}}{\text{Mass of water in distillate}} = \frac{\text{V. P x RMM of amine}}{\text{V. P x RMM of water}}$$

RMM of Phenylamine = 93 RMM of water = 18.

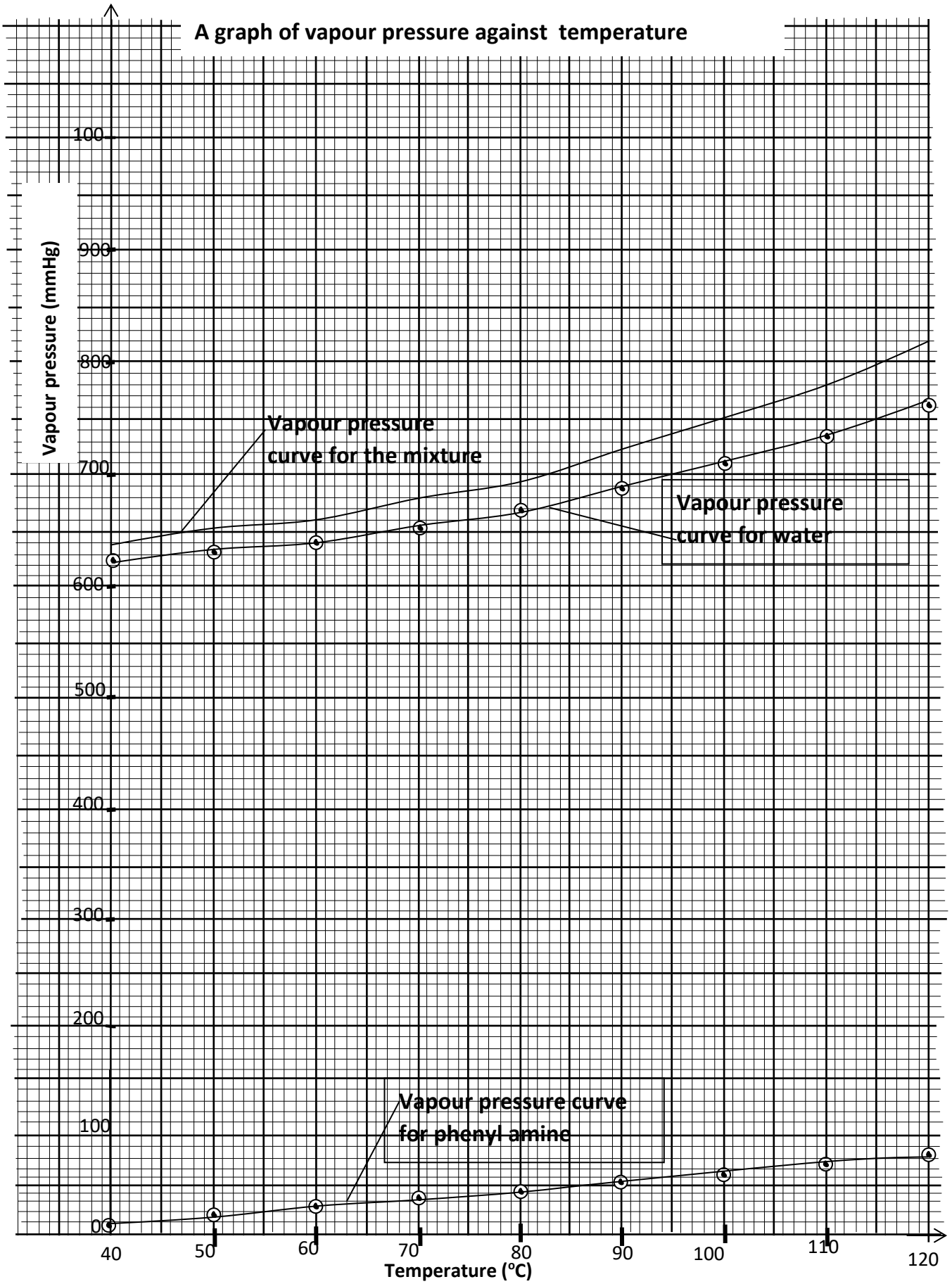
$$\frac{\text{Mass of phenylamine in distillate}}{\text{Mass of water in distillate}} = \frac{55 \text{ x } 93}{705 \text{ x } 18}$$

= 0.40307

The ratio of ammine to water is 0.40307:1

Percentage of phenylamine = $\frac{0.4037}{1.40307}\ x\ 100$

= 28.73%


A graph of vapour pressure against temperature
Vapour pressure (mmHg)
100
900
800
700
600
500
400
300
200
100
0
Vapour pressure curve for the mixture
Vapour pressure curve for water
Vapour pressure curve for phenyl amine
40
50
60
70
80
90
100
110
120
Temperature (°C)

e) Let the mass extracted by 100 cm^3 of ether be X g

K_D = $\frac{[Q]Ether}{[Q]Water}$

2.0 = $\frac{x}{100}\ x\ \frac{10-x}{50}$

X = 8 g

Mass that remained in the aqueous layer; 10 – 8 = 2 g

Percentage of Q extracted by the ether layer = $\frac{8}{10}\ x\ 100 = 80\%$

Percentage that remained in the aqueous layer = $\frac{2}{10}\ x\ 100 = 20\%$

22. a) Electropositivity of group(II) elements increases down the group. Down the group, both screening effect and nuclear charge increase due to addition of an extra shell of electrons and more protons to the nucleus respectively. However, increase in screening effect outweighs increase in nuclear charge. Thus, effective nuclear attraction decreases, and the outer electrons are not strongly attracted to the nucleus, therefore the outermost electrons can easily be lost.

b)(i) Beryllium does not react with water under any condition. Magnesium reacts slowly with cold water forming magnesium hydroxide and hydrogen gas.

$$Mg\ (s)\ +\ 2H_2O\ (l) \longrightarrow Mg(OH)_2\ (aq)\ +\ H_2\ (g)$$

However, heated magnesium reacts vigorously with steam to form magnesium oxide and hydrogen gas.

$$Mg\ (s)\ +\ H_2O\ (g) \longrightarrow MgO\ (s)\ +\ H_2\ (g)$$

The rest of the elements react with cold water vigorously to form hydroxides and hydrogen gas.

$Ca\ (s)\ +\ 2H_2O\ (l) \longrightarrow Ca(OH)_2\ (aq)\ +\ H_2\ (g)$

$Sr\ (s)\ +\ 2H_2O\ (l) \longrightarrow Sr(OH)_2\ (aq)\ +\ H_2\ (g)$

$Ba\ (s)\ +\ 2H_2O\ (l) \longrightarrow Ba(OH)_2\ (aq)\ +\ H_2\ (g)$

OR $X\ (s)\ +\ 2H_2O\ (l) \longrightarrow X(OH)_2\ (aq)\ + H_2\ (g)$ Where $(X =\ Ca, Sr, Ba)$

(ii) All group (II) metals react with dry air when heated to form monoxides (normal oxides) and nitrides.

$$2M\ (s)\ +\ O_2\ (g) \longrightarrow 2MO\ (s)$$
$$3M\ (s)\ +\ N_2\ (g) \longrightarrow M_3N_2\ (s)$$

Where $M =\ Be, Mg, Ca, Sr, Ba$

(iii) Beryllium does not react with nitric acid under any condition.

Magnesium reacts with very cold dilute nitric acid to form magnesium nitrate and hydrogen gas.

$$Mg\ (s)\ +\ 2HNO_3\ (aq) \longrightarrow Mg(NO_3)_2\ (aq)\ +\ H_2\ (g)$$

The rest of the metals including magnesium react with hot concentrated nitric acid to form metal nitrate, nitrogen dioxide gas and water.

$$M\ (s)\ +\ 4HNO_3\ (aq) \longrightarrow M(NO_3)_2\ (aq)\ +\ 2NO_2\ (g)\ +\ 2H_2O\ (l)$$

c)(i) Beryllium carbide is formed when beryllium is mixed with carbon and the mixture heated strongly at 950^{0}C. It may also be prepared by reduction of beryllium oxide with carbon at a temperature above 1500^{0}C.

$2Be\ (s) + C\ (s) \longrightarrow Be_2C\ (s)$

OR $2BeO\ (s) + 3C\ (s) \longrightarrow Be_2C\ (s) + 2CO\ (g)$

Calcium carbide is prepared by heating a mixture of calcium oxide (lime) and coke in an electric furnace at 2200 ^{0}C.

$$CaO\ (s) + 3C\ (s) \longrightarrow CaC_2\ (s) + CO\ (g)$$

(ii) Beryllium carbide reacts with dilute hydrochloric acid to form beryllium chloride and methane.

$$Be_2C\ (s) + 4HCl\ (aq) \longrightarrow 2BeCl_2\ (aq) + CH_4\ (g)$$

Calcium carbide reacts with dilute hydrochloric acid to form calcium chloride and ethyne.

$$CaC_2\ (s) + 2HCl\ (aq) \longrightarrow CaCl_2\ (aq) + C_2H_2\ (g)$$

d)(i) Cement is manufactured is manufactured from limestone, silica, alumina and iron ore. Silica, alumina and iron ore come from clay. These substances are mixed, and the mixture crushed into fine powder. The fine powder is heated in a kiln at 2000 ^{0}C. Other ingredients such as ash (powdered coal) and gypsum (magnesium sulphate) are added to the mixture to obtain good quality cement. Gypsum delays setting of cement.

$CaCO_3\ (s) \longrightarrow CaO\ (s) + CO_2\ (g)$
$CaO\ (s) + SiO_2\ (s) \longrightarrow CaSiO_3\ (s)$
$CaO\ (s) + Al_2O_3\ (s) \longrightarrow Ca(AlO_2)_2\ (s)$
$CaO\ (s) + Al_2O_3\ (s) + Fe_2O_3\ (s) \longrightarrow Ca(AlO_2)_2\ (s).Ca(FeO_2)_2\ (s)$

(ii) Concrete is a mixture of cement, sand, stones (gravel) and water. It becomes very hard on standing.

23. A concentrated solution of sodium chloride is electrolyzed using graphite anode and flowing mercury as the cathode.

At the anode; $2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$

At the cathode; $Na^+(aq) + e \longrightarrow Na(s)$

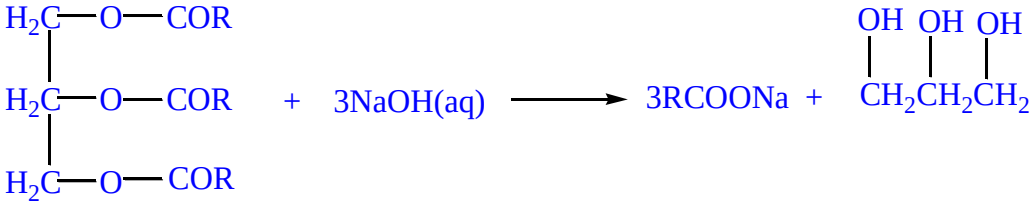
$$Na(s) + Hg(l) \longrightarrow Na(s)/Hg(l)$$

The sodium amalgam is dissolved in water to form sodium hydroxide solution.

$2Na(s)/Hg(l) + 2H_2O(l) \longrightarrow 2NaOH(aq) + 2Hg(l) + H_2(g)$

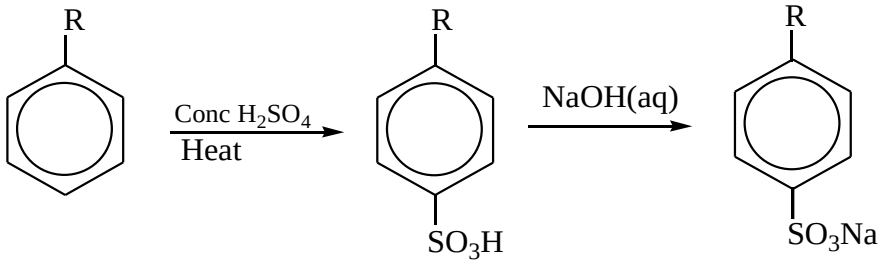
b)i) Animal fat or vegetable oil and sodium chloride

ii) The animal fat or vegetable oil is heated strongly with concentrated sodium hydroxide while stirring the mixture. The liquid mixture is removed from heat source and then concentrated sodium chloride solution is added while stirring the mixture in order to precipitate out the soap. The mixture is allowed to cool and the soap formed is removed then washed.



c) The soap lowers the surface tension between the dirt and the water. As soap is rubbed on a dirty fabric or as the dirty material is agitated with soap in the presence of water, the hydrophobic part attaches to the dirt and removes it. The hydrophilic part of soap dissolves in water. The hydrophobic part forms globules with dirt which is repelled and dispersed by water molecules hence the material being cleansed.

d)i)



d)ii) Sodium sulphate; increases the bulk of the powder making it economically profitable to the manufacturer

Sodium triphosphate; helps to form soluble calcium salts by reacting with calcium ions

Sodium peroborate; gives the detergent the bleaching action.

e) Advantages.

Do not form scum with hard water

Form almost neutral aqueous solutions since they are derived from fairly strong acids and strong bases.

24. a) Temperature above which a vapour of a substance cannot be liquefied by increasing pressure

b)i) F-Solid G- Solid H- Vapour

ii) B-Transition temperature C- Tripple point D- Critical point

c) The vapor phase changed to liquid phase and volume decreased.

PRACTICAL.

Number 1

Volume of pipette used = ……25.0 cm^3

Final burette reading (cm^3)	16.20	32.20	48.20
Initial burette reading (cm^3)	0.00	16.20	32.20
Volume of FA1 used (cm^3)	16.20	16.00	16.00

(a)(i) 16.00, 16.00

(ii) $\frac{16.00+16.00}{2}$ = 16.00

Questions

(b)(i) (Na = 23, S = 32, O = 16)

Molar mass of $Na_2S_2O_3$ =2x23+32x2+16x3 = 158g

158g of $Na_2S_2O_3$ contains 1 mole of $S_2O_3^{2-}$ ions

18.96g of $Na_2S_2O_3$ contains $\frac{18.96}{158}$ = 0.12mole of $S_2O_3^{2-}$ ions

1000cm^3 of FA1 contains 0.12 moles of $S_2O_3^{2-}$ ions

16.00cm^3 of FA1 contains $\frac{0.12\ x\ 16}{1000}$ = 1.92 x10^{-3} moles of $S_2O_3^{2-}$ ions

2 moles of $S_2O_3^{2-}$ ions react with 1 mole of iodine

1.92 x10^{-3} moles of $S_2O_3^{2-}$ ions react with$\frac{1}{2}x$ 1.92 x10^{-3} =9.6 x10^{-4} moles of iodine

Moles of iodine that reacted with thiosulphate ions =9.6 x10^{-4}

(ii) 5moles of iodine are liberated or produced by 2 moles of MnO_4^-

9.6 x10^{-4}moles of iodine are produced by $\frac{2}{5}x9.6\ \text{x}10^{-4}$ =3.84 x10^{-4}moles of MnO_4^-

25cm^3 of FA3 contains 3.84 x10^{-4}moles of MnO_4^-

100cm^3 of FA3 contains $\frac{3.84\ \text{x}10^{-4}x100}{25}$ = 1.536 x 10^{-3}moles of MnO_4^-.

(b) Moles of MnO_4^- in 100cm^3 of FA3= moles of MnO_4^-.in 65 cm^3 of FA2

65cm^3 of FA2 contains 1.536 x 10^{-3}moles of MnO_4^-.

1000cm^3 of FA2 contains $\frac{1.536\ \text{x}\ 10^{-3}x1000}{65}$ = 0.24moles of MnO_4^-.

Part II

Mass of weighing bottle +T = ……35.0g

Mass of weighing bottle alone = ……33.5g

Mass of T used = ……1.5g

Part III

Volume of pipette used = …… 25cm^3 ($\frac{1}{2}$ mark)

Final burette reading (cm^3)	21.00	41.80	20.80
Initial burette reading (cm^3)	0.00	21.00	0.00
Volume of FA2 used (cm^3)	21.00	20.80	20.80

(a)(i)20.80,20.80

(ii) $\frac{20.80+20.80}{2}$ = 20.80

(b)(i) 1000cm^3 of FA2 contain 0.024 moles of MnO_4^-

20.80cm^3 of FA2 contain $\frac{0.024 \text{ X} 20.80}{1000}$ = 4.99 x 10^{-4}moles of MnO_4^-.

(ii) Manganate (VII) reacts with both Fe^{2+} and $C_2O_4^{2-}$ in the ratio 1:2

Moles of MnO_4^- that reacted with Fe^{2+} = $\frac{1}{3}x$4.99 x 10^{-4}= 1.66 x 10^{-4}

1 Moles of MnO_4^- react with 5 moles of Fe^{2+}

1.66 x 10^{-4} Moles of MnO_4^- react with 5x1.66 x $10^{-4} = 8.3 \text{ x} 10^{-4}$moles of Fe^{2+}

(iii) Moles of MnO_4^- that reacted with $C_2O_4^{2-}$ = 4.99 x 10^{-4}- 1.66 x 10^{-4}= 3.33 x 10^{-4}

2 Moles of MnO_4^- react with 5 moles of $C_2O_4^{2-}$

3.33 x10^{-4}Moles of MnO_4^- react with $\frac{5\text{x}3.33 \text{ x } 10^{-4}}{2}$ = 8.3 x 10^{-4} moles of $C_2O_4^2$

(b)i)Values x and y in solid T

Moles Fe^{2+}	$C_2O_4^{2-}$
8.3 x 10^{-4}	8.3 x 10^{-4}
$\frac{8.3 \text{ x } 10^{-4}}{8.3 \text{ x } 10^{-4}}$	$\frac{8.3 \text{ x } 10^{-4}}{8.3 \text{ x } 10^{-4}}$
1:1	

X= 1, Y=1

ii) (Fe = 56, C = 12, O = 16, H = 1)

Moles of Moles Fe^{2+} = $C_2O_4^{2-}$ = $FeC_2O_4.nH_2O$=8.3 x 10^{-4}

25cm^3 of FA4 contains 8.3 x 10^{-4} moles $FeC_2O_4.nH_2O$

250cm^3 of FA4 contains $\frac{250}{25}x$8.3 x 10^{-4} = 8.3 x 10^{-3} moles $FeC_2O_4.nH_2O$

8.3 x 10^{-3} moles $FeC_2O_4.nH_2O$ weighs 1.5g

1 moles $FeC_2O_4.nH_2O$ weighs $\frac{1.5}{8.3 \text{ x } 10^{-3}}$ = 180.7g

Molar mass of $FeC_2O_4.nH_2O$ = 180.7g

56+2x12+4x16 +18n = 180.7

144+18n = 180.7

n=2

Number 2

TESTS	OBSERVATIONS	DEDUCTIONS
(a)Heat two spatula end-ful of L in a dry test tube strongly until no further change.	White powdery solid reddish brown residue hot yellow on cooling colourless gas, turns moist blue litmus red and forms a white precipitate with calcium hydroxide solution colourless condensate turn anhydrous copper(II) sulphate blue	non-transition metal ions present PbO formed CO_2 evolved CO_{32-},C_2O_{42-} suspected present hydrated salt

(b)To two spatula end-ful of L in a test tube add about 10cm^3 of distilled water shake strongly Filter, keep both the filtrate add the residue. Divide the filtrate into four portions.	. partly soluble white residue colourless filtrate	non-transition metal ions /Al^{3+},Ba^{2+},Zn^{2+} present non-transition metal ions /Al^{3+},Ba^{2+},Zn^{2+} present
(i) . To the first portion of the filtrate, add 2-3 drops of Barium nitrate solution followed by dilute nitric acid.	white precipitate soluble in nitric acid	PO_{43-} C_2O_{42-} , SO_{32-} Suspected present
(b)(ii) . To the second portion of the filtrate, add 2-3 drops of lead (II) nitrate solution followed by dilute nitric acid.	white precipitate soluble in nitric acid	PO_{43-} C_2O_{42-} , SO_{32-} Suspected present
(b)(iii) To the third portion of the filtrate, add 1-2 drops of silver nitrate solution followed by dilute ammonia solution.	white precipitate soluble in ammonia	C_2O_{42-} SO_{32-} Suspected present
(b)(iii)Use the fourth portion of the filtrate to carry out your own test to confirm the anion in the filtrate Test To the test solution I added acidified potassium manganate solution the warmed	purple solution turned colourless on warming	$C_2O_4^{2-}$ confirmed present
(c)Dissolve then residue in dilute nitric acid.(warm to dissolve) To the resultant solution add dilute sodium hydroxide solution drop- wise until in excess. Filter and keep both the filtrate and residue.	white residue dissolves on warming forming a colourless solution with effervescence of a colourless gas that forms a white precipitate with calcium hydroxide solution white precipitate insoluble in excess white residue colourless filtrate	non-transition metal ions /Pb^{2+},Ba^{2+},Zn^{2+} present CO_2 evolved CO_3^{2-} confirmed present Mg^{2+}, Ba^{2+} or Ca^{2+} Mg^{2+}, Ba^{2+} or Ca^{2+} Zn^{2+}, Pb^{2+} or Al^{3+}

(d). To the filtrate from part (c) add dilute nitric acid drop wise until the solution is just acidic. Divide the resultants into three parts.	white precipitate soluble in excess dilute nitric acid	Zn^{2+}, Pb^{2+} or Al^{3+} suspected
(d)(i)To the first portion of acidified filtrate, add dilute sodium hydroxide solution drop-wise until in excess.	white precipitate soluble in excess dilute nitric acid	Zn^{2+}, Pb^{2+} or Al^{3+} suspected
(d)(ii)To the second part of acidified filtrate add dilute ammonia solution drop-wise until in excess.	white precipitate insoluble in excess ammonia solution	Pb^{2+} or Al^{3+} suspected
(d)(iii). Use the third part of acidified filtrate to carry out a test of your own choice to confirm one of the cation in the filtrate Test To the test solution I added potassium iodide solution	yellow precipitate	Pb^{2+} confirmed present
(e). Dissolve the residue from part (c) in minimum amount of nitric acid. Divide the resultant solution into three parts.	white residue dissolves to form a colourless solution	Mg^{2+}, Ba^{2+} or Ca^{2+} suspected present
(i) To the first part add 2-3 drops dilute sulphuric acid	white precipitate	Ba^{2+} or Ca^{2+} suspected present
(ii). To the second part, add dilute ammonia solution drop wise until in excess.	no observable change	Ca^{2+} suspected present
(iv) Use the third part of to carry out a test of your own choice to confirm the second cations in L Test To the test solution I added ammonium oxalate solution followed by ethanoic acid	white precipitate insoluble in ethanoic acid	Ca^{2+} confirmed present

(f) Identify the

(i) Cations in L Pb^{2+} and Ca^{2+}

(ii) Anions in L $C_2O_4^{2-}$ and CO_3^{2-}

Number 3.

TESTS	OBSERVATIONS	DEDUCTIONS
(a)Burn a small amount of R on a spatula end	white powdery solid melts and burns with yellow sooty flame	aromatic compound with high carbon content
(b)To about 1 spatula end-ful of R in a test – tube, add about 10 cm^3 of distilled water. Shake strongly and test the mixture with litmus paper. Heat the mixture and Divide the resultant solution into 7 parts.	sparingly soluble in cold water turns blue litmus red dissolves on heating forming a colourless solution	polar aromatic compound acidic compound present
(i)To the first part of the solution, add 2 – 3 drops of acidified potassium dichromate (VI) and warm	No observable change	Primary alcohols secondary alcohol Aldehydes absent
(ii)To the second part of the solution add 2-3 drops of 2,4-dinitrophenylhydrazine solution	No observable change	Ketones absent
(iii)To the third part of the solution add 2 – 3 drops of iron (III) chloride solution	No observable change	Benzoic acid absent
(iv)To the fourth part of the solution add 1cm^3 of ethanoic acid followed by 3drops of concentrated sulphuric acid and heat to boiling	No sweet fruity smell	Tertiary alcohols absent
(v)To the fifth part of the solution add little solid magnesium powder	effervescence of a colourless gas	aromatic carboxylic acids present
(vi)To the six part add 2-3 drops acidified potassium manganate(VII)	purple solution turns colourless	un-saturated compound present
(vii)To the seventh part add 2-3 drops of bromine water and shake strongly	Reddish brown solution turns colourless	un-saturated compound present
(c)Dissolve one spatula end-ful of R in about 3cm^3 of ethanol, add 3 drops of concentrated sulphuric acid and heat pour the resultant solution on a Petri-dish containing some water	Sweet fruity smell	esters formed carboxylic acid confirmed present

(e)Comment on the nature of R. Aromatic unsaturated carboxylic acid

END

OLD KAMPALA SSS

A'LEVEL CHEMISTRY SEMINAR QUESTIONS 2022

(1ST OCTOBER 2022 AT 8:00AM)

1. (a) Explain what is meant by the terms;

(i) Lattice energy (2 marks)

(ii) Hydration energy (2 marks)

(iii) Enthalpy of solution (2 marks)

(b) The enthalpy of solution and lattice energy of Potassium Iodide are +21 and -642kJmol^{-1} respectively.

(i) Draw an energy diagram to show how the energy terms are related.(2 marks)

(ii) Calculate the hydration energy of Potassium Iodide. (2 marks)

(b) With the aid of a diagram, describe an experiment that can be carried out to determine the enthalpy of solution of ammonium chloride, write an expression to show how the enthalpy of solution of ammonium chloride can be calculated from the results of the experiment. (10 marks)

(KAJJANSI PROGRESSIVE SCHOOL)

2. (a) Write equation for the reaction between water and;

(i) Sodium hydride

(ii) Calcium hydride

(iii) Silicon hydride

(iv) Sulphur hydride

(b) (i) Silicon tetrachloride

(ii) Tin tetrachloride

(iii) Lead(IV) chloride

(iv) Tin(II) chloride

(v) Chromium(III) chloride

(ST.NOA GIRLS)

3. (a) Define the terms:

(i) eutectic point (1 mark)

(ii) eutectic mixture (1 mark)

(b) The table below shows the melting points of various mixtures for Lead and Tin

% of Tin	0	20	40	70	80	100
Melting point (^0C)	327	280	234	193	206	232

(i) Draw a fully labeled diagram of tin-lead system (5 marks)

(ii) Determine the eutectic temperature and composition of the eutectic mixture.

(iii) Describe the phase changes which would take place if a liquid mixture containing 30% tin is cooled from 400^0C to 100^0C. (5 marks)

(iv) 200g of the liquid mixture of composition 5% Tin was cooled to 200^0C. Determine the composition of the remaining liquid mixture at 200^0C and calculate the mass of lead in the remaining liquid mixture at this temperature . (5 marks)

(c) State three differences between a eutectic mixture and a pure compound. (3 marks)

(AGGREY MEMORIAL)

4. (a)Define the term buffer solution (1 mark)

(b) (i) Describe how an acidic buffer solution of pH 3.5 can be prepared using methanoic acid of pKa value 3.75 ($4^1/_2$marks)

(ii) Explain how an acidic buffer solution works. (6 marks)

(c) Ethanoic acid ionizes in water according to the following equation.

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

(i) Write an expression for the ionization constant, Ka for ethanoinc acid.

(ii) Using the expression in (c) (i) , calculate the ratio of the concentration of ethanoate ions to the concentration of ethanoic acid in a solution of pH 4 and also in a solution of pH 6. (Ka for ethanioic acid is $1.8x10^{-3}$ $moldm^{-3}$) (1 mark)

(iii) At which of the two pH values would better buffering occur? Give a reason for your answer. (2 marks)

(d) State one Biological and one industrial application of buffer solutions. (2 marks)

(OLD KAMPALA S.S.S)

5. (a) State the distribution law. (2 marks)

(b) Describe how the distribution coefficient of butane-1,4-dioic acid (succinic acid) between water and ethoxyethane can be determined. (5 marks)

(c) 100cm^3 of a solution contains 30g of substance Z. Calculate the mass of Z extracted by shaking the solution with:

(i) 100cm^3 of ethoxyethane (3 marks)

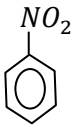
(ii) two 50cm^3 portions (5 marks)

(The distribution coefficient of Z between ethoxyethane and water is 5)

(d) Briefly describe how the distribution coefficient can be used to determine the formula of then complex formed between copper(II) ions and ammonia. (5 marks)

(BISHOPS S.S MUKONO)

6. Complete the following equations and in each case suggest a mechanism for the reaction

(a)  $\xrightarrow[AlCl_3]{CH_3COCl}$

(b)  $\xrightarrow[conc.\ H_2SO_4,\ 60^0C]{conc.\ HNO_3}$

(c) $CH_3CH_2CHO \xrightarrow{H^+/H_2NCONH_2}$

(d) $CH_3CHO \xrightarrow{dil.\ NaOH}$

(e) $CH_3COCl \xrightarrow{CH_3CH_2NH_2}$

(f) $CH_3COCH_3 \xrightarrow{KCN/H^+_{(aq)}}$

(STANDARD HIGH SCHOOL ZANA)

7. (a) Write the name and formula of one of the ores from which zinc is extracted and describe how zinc is extracted from the ore. (8 marks)

(b) Describe using equations the reactions of zinc with;

(i) air

(ii) water

(iii) sodium hydroxide (10 marks)

(c) (i). Explain why zinc is not considered a typical transition metal. (2marks)

(ii) State three ways in which the chemistry of zinc is similar to that of magnesium. (3 marks)

(d) (i). state what is observed when dilute aqueous ammonia is added dropwise to a solution containing zinc ions. (1 marks)

(ii) Write equation(s) for the reactions that take place in d(i). (2 marks)

(OLD KAMPALA S.S.S)

8. (a) Explain what is meant by an ideal solution (2 marks)

(b) The vapour pressures of benzene and methyl benzene are 75.2mmHg and 57.0mmHg respectively at 20^0C. Calculate;

(i) the vapour pressure of a mixture containing 15.6g of benzene and 73.6g of methyl benzene at 20^0C. (Assume that the two liquids form an ideal solution) (4 marks)

(ii) the composition of the vapour above the mixture. (2 marks)

(c) Compound A (boiling point 372^0C) and compound B (boiling point 399^0C) form an ideal solution.

(i) Sketch a labeled boiling point/composition diagram. (3 marks)

(ii) Using the diagram, describe and explain how pure B can be obtained from a mixture containing 50% B.

(STANDARD HIGH SCHOOL ZANA)

9. Write notes on the following. (your answer should include suitable examples and mechanisms for the reaction)

(a) Elimination reaction.

(b) Electrophilic substitution reaction

(c) Electrophilic addition reaction.

(OLD KAMPALA S.S.S, MBALALA SCH)

10. (a) Define the term standard electrode potential.

(b) With the aid of a diagram, briefly describe how the standard electrode potential of copper can be determined. (7 marks)

(c) The standard electrode potentials of copper and zinc are given below;

$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)} \qquad E^{\theta} = +0.34V$

$Zn^{2+}_{(aq)} + 2e \longrightarrow Zn_{(s)} \qquad E^{\theta} = -0.76V$

Write the cell notation for zinc/copper cell and calculate the e.m.f of the cell. (3 marks)

(d) State two ways in which an electrolytic cell differs from an e.m.f cell. (2 marks)

(e) A current of 2A was passed for 30 minutes through a cell containing dilute sulphuric acid and the hydrogen produced at the cathode collected. Calculate the volume of the hydrogen in cm^3 that was produced at 23^0C and 100kPa. (6 marks)

(f) State two applications of standard electrode potentials. (2 marks)

(ST NOA GIRLS S.S)

11. Electrode potentials for some half cells are given below.

Half cell	E^{θ}/V
$Fe^{2+}_{(aq)}, Fe^{3+}_{(aq)}/Pt_{(s)}$	-0.77
$Cr^{3+}_{(aq)}, Cr_2O^{2-}_{7(aq)}, H^{+}_{(aq)}/Pt_{(s)}$	-1.33

(a) Write the cell notation for the cell formed when the two half cells are connected. (1 mark)

(b) Write;

(i) Equations for the half cell and reactions at the anode and cathode. (2 marks)

(ii) Equations for the overall cell reaction. (1 mark)

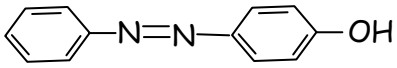
(c) (i) Calculate the e.m.f of the cell

(ii) State whether the reaction is feasible or not. Give a reason for your answer. (1mark)

(KASUBI S.S)

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

(a) 2-chloropropane to $CH_3CH_2CH_2NH_2$

(b) Nitrobenzene to 

(c) Propan-2-ol to $(CH_3)_3COH$

(d) Ethanol to CH_3COCH_3

(e) Ethene to CH_3CH_2COOH

(f) CH_3CH_2OH to CH_3OH

(g) Calcium dicarbide to $CH_3C \equiv CCH_2CH_3$

(SEROMA CHRISTIAN HIGH SCHOOL)

13. (a) Describe one general method for the preparing the halogens (excluding fluorine) in the laboratory. ($3^1/_2$marks)

(b) Discuss the reactivity of fluorine, chlorine, bromine and iodine with;

(i) Water (6 marks)

(ii) Aqueous sodium hydroxide solution ($10^1/_2$marks)

(KOLOLO HIGH SCHOOL)

14. The boiling points of hydrides of group(VII) elements are given in the table below.

Compound	HF	HCl	HBr	HI
Boiling point (^0C)	+19.9	-85.0	-66.7	-35.4

(a) Explain the trend in the boiling points of the hydrides (5 marks)

(b) Giving reasons, suggest the trend in the acid strength of the hydrides. (4 marks)

(c) Using equations where possible explain what happens when concentrated sulphuric acid is mixed with each of the hydrides. (6 marks)

(d) (i) Arrange the following compounds in their order of increasing acid strength $HClO_3, HClO_2, HClO$ (1 mark)

(ii) Explain your answer in d(i) (4 marks)

(SEROMA CHRISTIAN HIGH SCHOOL)

15. (a) When a mixture of water and nitric acid is distilled, a constant boiling point mixture containing 68% nitric acid is obtained at 120^0C. (The boiling points of pure water and nitric acid are 100^0C and 83^0C respectively)

(i) Define the term Constant boiling mixture (azeotropic mixture).

(ii) Draw a boiling point-composition diagram for the mixture of nitric acid and water. (5 marks)

(iii) Explain the shape of your diagram. (4 marks)

(iv) Describe what would happen if a mixture containing less than 60% nitric acid was fractionally distilled. (3 marks)

(b) A constant boiling mixture of nitric acid and water has density of 1.42gcm^{-3}. Calcualte the volume of the acid needed to prepare one litre of 2M nitric acid solution. (3 marks)

(STANDARD HIGH SCHOOL ZANA, KASUBI S.S)

16. (a)Describe the spectrum of hydrogen. (use a diagram to illustrate)(7 marks)

(b) Explain how the spectrum of hydrogen;

(i) is formed. (4 marks)

(ii) provides evidence for the existence of energy levels (7 marks)

(a) The frequency of hydrogen at the point of ionization is 3.28x10^{15} Hz. Calculate the ionization energy of hydrogen. (Plank's constant = 6.6x10^{-34} Js)

(OLD KAMPALA S.S.S, AGGREY MEMORIAL)

17. Discuss the reactivity of group(IV) elements (Carbon, silicon, Germanium, Tin and lead) of the periodic table with

(a) Water (4 marks)

(b) Concentrated acids (6 marks)

(c) Sodium hydroxide (6 marks)

(d) Dilute acids (4 marks)

(BISHOPS S.S MUKONO)

26. Berryllium, Magnesium, Calcium and Barium are some of the elements that belong to group (II) of the periodic table.

a) Describe giving conditions for the reactions of the elements with:

i) water

ii) sulphuric acid

[illustrate your answers with the equations]

(b) Giving reasons, state how the solubilities of;

(i) hydroxides

(ii) sulphates , vary down the group.

(KASUBI S.S)

27. (a) State four properties in which beryllium differs from other elements of group (II) of the periodic table.

(b) State four reasons why beryllium differs from the rest of the elements in group(II) of the periodic table.

(c) i) Name the reagent that can be used to distinguish between Ca^{2+} and Ba^{2+} ions.

(ii) State what would be observed and write equation(s) for the reactions that would take place if the reagent you have named in c(i) was separately treated with Ca^{2+} and Ba^{2+} ions.

(KASUBI S.S)

28. (a) Define the term relative atomic mass.

(b) Explain how the relative atomic mass can be determined can be determined by a mass spectrometer.

(c) The mass spectrum of an element A contained four lines at mass/charge of 204, 206, 207 and 208 with detector currents (mA) of 0.16, 2.72, 2.50 and 5.92 respectively. Calculate;

i) the relative abundance of the different isotopes in the sample of element A.
ii) the relative atomic mass of A.

(SEROMA CHRISTIAN HIGH SCHOOL)

29.(a) State what is meant by the following terms "order of reaction" and "half life of a reaction".

(b) A compound B shows the concentration of B at various times.

Time (minutes)	2.0	4.0	7.0	10.0	14.0	20.0
concentration of B ($moll^{-1}$) [B]	0.820	0.67	0.49	0.372	0.24	0.141

Draw a graph of $log_{10}[B]$ against time. (03 marks)

(c) Using the graph, determine the;

i) Order of the reaction
ii) Rate constant for the reaction
iii) Half-life for the reaction.

(KAJJANSI PROGRESSIVE S.S)

30.(a) What is meant by steam distillation.

(b) (i) State three properties of a substance that enable it to be purified by steam distillation.

(ii) Explain how the properties you have stated in b(i) enable the substance to be purified by steam distillation.

(i) State two advantages of isolating substances by steam distillation.

(c) The vapour pressure of water VP_{H2O} and that of substance A (VP_A) at different temperatures are given in the table below.

Temperature (^0C)	20	40	60	80	100
VP_{H2O} (atm)	0.22	0.26	0.30	0.35	0.39
VP_A(atm)	0.35	0.42	0.49	0.56	0.63

i) On the same axes, plot graphs of vapour pressure against temperature for water and substance A. (4marks)

ii) When substance A was distilled in steam at 1atm pressure the temperature of distillation was 97^0C and the distillate obtained contained 4.3g of substance A and 1.1g of water using your graph in c(i). Calculate the relative molecular mass of substance A. (4 marks)

(STANDARD HIGH SCHOOL ZANA)

31. (a) The molar conductivity of sodium hydroxide solutions of different concentrations are shown in the table below.

Concentration/ $moldm^{-3}$	0.01	0.04	0.09	0.16	0.25	0.36
Molar conductivity, Λ $\Omega^{-1}\,cm^2\,mol^{-1}$	238	230	224	217	210	202

i) Draw a graph of molar conductivity against square root of concentration. (4 marks)

ii) Explain the shape of the graph. (4 marks)

iii) Determine the value of molar conductivity at infinite dilution of sodium hydroxide and indicate its units.

Using the same conductivity cell, the resistance of a 0.1M Potassium Chloride solution and 0.1M bromoethanoic acid solution were found to be 24.96 and 66.50 Ohms respectively at 25^0C when determined using the same conductivity cell. [The Conductivity of Potassium Chloride at 25^0C is 0.01164 $\Omega^{-1}cm^2\,mol^{-1}$ and the molar conductivity of bromoethanoic acid at infinite dilution is 389 $\Omega^{-1}cm^2mol^{-1}$]

i) Calculate the cell constant. (2 marks)

ii) Calculate the molar conductivity of the 0.1M bromoethanoic acid. (3 marks)

iii) Determine the pH of 0.1M bromoethanoic acid. (4 marks)

(ST NOA GIRLS S.S)

32. (a) The table below shows the result of partitioning aminoethane between trichloromethane and 0.1M Copper(II) Sulphate solution.

$[CH_3NH_2$ (0.1M $CuSO_4)]$	0.87	1.10	1.33	1.57	1.80
$[CH_3NH_2$ $(CHCL_3)]$	0.02	0.03	0.04	0.05	0.06

i) Plot a graph of $[CH_3NH_2(0.1M\ CuSO_4)]$ versus $[CH_3NH_2(CHCL_3)]$

ii) Determine the number of moles of aminoethane that has formed a complex with copper(II) ion.

(b) Write the equation for the reaction between copper(II) ions and aminoethane.

(KOLOLO HIGH SCHOOL)

33.(a) Explain what is meant by the term electronegativity.

(b) State the factors that determine the value of electronegativity of an element.

(c) Explain how the factors you stated in (b) affect the value of electronegativity.

(d) The table below of some elements and their electron affinities.

Atomic number	11	12	13	14	15	16	17
Electron affinities$KJmol^{-1}$	2.0	-6.7	3.0	13.5	6.0	20.0	36.4

i) Draw a graph of electron affinities versus atomic number.

ii) Explain the shape of the graph.

(KAJJANSI PROGRESSIVE, MBALALA SCH MUKONO)

34.Describe how these conversions can be effected. Equations are not required;

a) Propanol to ethanol ($5^1/_2$marks)

b) Ethyne to benzoic acid (4 marks)

c) Butanoic acid to butan-2-ol ($5^1/_2$marks)

d) Ethanol to propan-2-ol (5 marks)

(KASUBI S.S)

35.a) Differentiate between soap and soapless detergents. (2 marks)

b) Write equations to show how alkyl benzene sulphonate can be prepared from octadecan-1-ol, $CH_3(CH_2)_{16}CH_2OH$ (6 marks)

c) Explain why the following compounds are added to soapless detergents;

(i) polyphosphates (2 marks)

(ii) sodium sulphate (2 marks)

(BISHOPS HIGH SCHOOL MUKONO)

36.a) Write equations to show how the following compounds can be prepared.

i) Phenylamine (4 marks)

ii) Ethalymine (aminoethane)

b) Which one of phenylamine and ethylamine is a stronger base? Explain your answer. (3 marks)

(ST NOA GIRLS S.S)

37.a) Write equations for each of the compounds Phenylamine and ethyl amine reacting with;

i) ethanoyl chloride

ii) acidified sodium nitrite at 5^0C

b) (i) Write a mechanism for the reaction of ethanoyl chloride with ethylamine. (3marks)

ii) How can the reaction in b(i) be used to distinguish between phenylamine and ethylamine. (1 mark)

c) Phenylamine can be converted to benzene diazonium chloride, write equations (reagents and conditions to be given) for the conversion of diazonium salt into

(i) iodobenzene

(ii) benzoic acid

(iii)an azo-dye

(KOLOLO HIGH SCHOOL)

38. (a) Aluminium can be extracted from bauxite, which is impure hydrated aluminium oxide. Describe how,

(i) Pure aluminium oxide is obtained from bauxite. (10 marks)

(ii) aluminium is obtained from pure aluminium oxide ($3^1/_2$marks)

(Your answer should include equations)

(b) Discusss the reactions of aluminium with hydrochloric acid, sulphuric acid and nitric acid ($3^1/_2$marks)

(c) Explain why aluminium utensils should not be washed using soap solutions.

(3 marks)

(SEROMA CHRISTIAN HIGH SCHOOL)

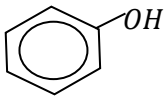
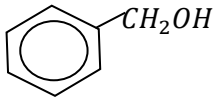
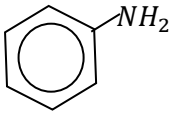
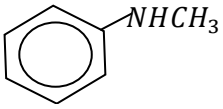
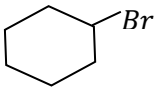
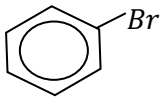
END

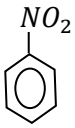
GOODLUCK

OLD KAMPALA SENIOR SECONDARY SCHOOL
A'LEVEL CHEMISTRY SEMINAR QUESTIONS, 2024

ORGANIC CHEMISTRY

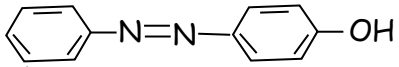
1. State what would be observed and write equations for the reaction(s) that would take place when the following pairs of substances are mixed.
   (a) $CH_3CH{=}CH_2$ and bromine water.
   (b) $HC{\equiv}CH$ and ammoniacal copper(I) chloride solution.
   (c) CH_3COCH_3 and sodium hydroxide in iodine solution.
   (d) CH_3CHO and ammoniacal silver nitrate solution.
   (e) $HCOOH$ and Fehlings solution on heating.

2. Name a reagent that can be used to distinguish between the following pairs of compounds and in each case state what would be observed if each member is separately heated with the reagent.
   (a)  and 
   (b)  and 
   (c) $HCOOH$ and 
   (d)  and 

3. Complete the following equations and in each case suggest a mechanism for the reaction
   (a)  $\xrightarrow[AlCl_3]{CH_3COCl}$
   (b)  $\xrightarrow[conc.\ H_2SO_4,\ 60^0C]{conc.\ HNO_3}$
   (c) $CH_3CH_2CHO \xrightarrow{H^+/H_2NCONH_2}$
   (d) $CH_3CHO \xrightarrow{dil.\ NaOH}$
   (e) $CH_3COCl \xrightarrow{CH_3CH_2NH_2}$
   (f) $CH_3COCH_3 \xrightarrow{KCN/H^+_{(aq)}}$

4. Write notes on the following. (your answer should include suitable examples and mechanisms for the reaction)
   (a) Elimination reaction.
   (b) Electrophilic substitution reaction
   (c) Electrophilic addition reaction.

5. Write equations to show how the following conversions can be carried out. In each case, indicate the reagents and conditions for the reactions.
   (a) 2-chloropropane to $CH_3CH_2CH_2NH_2$

   (b) Nitrobenzene to 
   (c) Propan-2-ol to $(CH_3)_3COH$
   (d) Ethanol to CH_3COCH_3
   (e) Ethene to CH_3CH_2COOH
   (f) CH_3CH_2OH to CH_3OH
   (g) Calcium dicarbide to $CH_3C \equiv CCH_2CH_3$
6. (a) A compound A, $C_7H_{14}O_2$ reacted with sulphuric acid on heating to form compound B, $C_4H_{10}O$ and C, $C_2H_4O_2$ B reacted with sodium with effervescence but had no effect on litmus paper.
   i) Write the names and structural formulae of all possible isomers of B.
   ii) Name a reagent that can be used to distinguish between the isomers in (i) and state what would be observed if the isomers are reacted with the reagent.
   (b). B reacted with acidified dichromate solution to give compound D which formed a yellow solid with alkaline Iodine.
   Identify B, D and the yellow solid.

c) Write equations and indicate a mechanism for the reaction between B and;
   i) Concentrated orthophosphoric acid. ii)Ethanyl chloride.

(b) Write the structural formula of A.

7. a) Differentiate between soap and soapless detergents.
   b) Write equations to show how alkyl benzene sulphonate can be prepared from octadecan-1-ol, $CH_3(CH_2)_{16}CH_2OH$
   c) Explain why the following compounds are added to soapless detergents;
   (i) polyphosphates (ii) sodium sulphate
8. a) Explain what is meant by ;
   i) Addition polymerization
   ii) Condensation polymerization
   b) Write the structural formula of;
   (i) Perspex
   (ii) terylene
   (iii)nylon 6,6
   c) Name the type of polymerization leading to the formation of polymers in (b).
   d) Explain the difference in properties of thermosetting and thermoplastics..
   e) State how;
   (i) vulcanisation of rubber is carried out.
   (ii) vulcanisation improves the properties of rubber.
9. a) Write equations to show how the following compounds can be prepared.
   i) Phenylamine
   ii) Ethalymine (aminoethane)

   b) Which one of phenylamine and ethylamine is a stronger base? Explain your answer.

10. a) Write equations for each of the compounds Phenylamine and ethyl amine reacting with;
    i) ethanoyl chloride
    ii) acidified sodium nitrite at 5^0C

    b) (i) Write a mechanism for the reaction of ethanoyl chloride with ethylamine.

    ii) How can the reaction in b(i) be used to distinguish between phenylamine and ethylamine.

    c) Phenylamine can be converted to benzene diazonium chloride, write equations (reagents and conditions to be given) for the conversion of diazonium salt into
    (i) iodobenzene
    (ii) benzoic acid
    (iii)an azo-dye
11. When 7.05g of an organic compound **T**, on complete combustion yielded $10.08dm^3$ of carbon dioxide and 4.05g of water at s.t.p. 0.225g of **T** on vaporisation at 273^oC and at $56.287kNm^{-2}$ occupied a volume of $193.04cm^3$.
    (a) (i) Calculate the empirical formula of **T**
    (ii) Determine the molecular formula of **T**
    (b) **T** burns with a sooty flame. Identify **T**
    (c) Write equation and suggest a mechanism for the reaction to show how the following compounds can be synthesized from **T**
    (i) methoxy benzene
    (ii) phenyl propanoate
    (iii) 4- hydroxyphenylethanone
    (d) State what was observed and write equation for the reaction when aqueous bromine solution was added to **T**.
12. Using equations only show how the following conversions can be effected. Indicate conditions and suitable reagents.
    (a) Phenylmethanol from bromobenzene and zinc turnings.
    (b) 2- hydroxypropanoic acid from 1,2- dichloroethane.
    (c) 3-methylbutan-1-ol from ethyne
    (d) *N*- methyl- *N*- nitrosylphenylamine from nitrobenzene.
    (e) Animoethane from propanoic acid

13. Describe how these conversions can be effected. Equations are not required;
    a) Propanol to ethanol
    b) Ethyne to benzoic acid
    c) Butanoic acid to butan-2-ol
    d) Ethanol to propan-2-ol

PHYSICAL CHEMISTRY

14. (a) State what is meant by the term partition coefficient.

(b) 4.5g of an impure sample of nickel(II) Sulpide was dissolved in excess concentrated solution of ammonia and the solution diluted to 500cm^3. The resultant solution was shaken with 25cm^3 of carbon tetrachloride layer and allowed to settle. 12.5cm^3 of the aqueous layer required 20cm^3 of 0.25M hydrochloric acid for complete reaction while 25.0cm^3 of the carbon tetrachloride layer required 12.5cm^3 of a 0.025M hydrochloric acid for complete reaction.

Calculate the number of;

(i) free ammonia in aqueous layer. (K_D for ammonia between carbon tetrachloride and water is 0.04)

(ii) complexed ammonia.

(c) Determine the percentage by mass of nickel in the impure nickel(II) sulphide.

15. (a) Define the following terms

(i) solute

(ii) saturated solution

(b) The solubilities of potassium chloride and potassium nitrate at certain temperature are shown in the table below.

Temperature / °C	0	11	15	30	40	50	57
Solubility of potassium chloride / g per 100g of water	27.9	31.0	32.0	36.5	40.0	43.0	45.0
Solubility of potassium nitrate /g per 100g of water	14.0	21.5	25.0	43.0	63.0	84.0	102.0

(i) Plot on the same axes, a graph of solubility against temperature for solubilities of potassium chloride and potassium nitrate.

(ii) State which one of the two salts has a solubility which increases less rapidly with increase in temperature.

(iii) Determine the temperature at which the solubilities of the **two** salts are equal.

(iv) A saturated solution of potassium nitrate at 30°C was cooled to 5°C . Determine the number of moles of potassium nitrate crystals formed.

(c) 25.2g of a solution saturated with copper(II) sulphate at 35°C was made up to 200cm^3 with de-ionised water. 25.0cm^3 of the diluted solution reacted with excess potassium iodide solution to liberate iodine which titrated against 33.5cm^3 of 0.118M sodium thiosulphate solution. Calculate the solubility of copper(II) sulphate in grams per 100g of water.

(d) Explain what would be observed when sodium chloride solution was added to lead(II) nitrate solution and the mixture boiled and then allowed to cool.

16. (a) State distribution law.

(b) Describe how the distribution coefficient of butanedioic acid can be determined between ethoxyethane and water.

(c) An aqueous solution containing 5.0g of Q in $100cm^3$ of solution. The partition coefficient of Q between water and ethoxyethane is 0.20. Calculate the mass of Q extracted by shaking $100cm^3$ of the aqueous solution with.

(i) $50cm^3$ of ether

(ii) two successive $25cm^3$ portions of ether.

(d) $25cm^3$ of 0.2M X^{2+} solution were mixed with $25cm^3$ of 1M ammonia solution. The total $50cm^3$ of the deep blue aqueous layer was shaken with $50cm^3$ of trichloromethane until equilibrium was attained. After the layers had settled, the whole of the organic layer required $4.0cm^3$ of 0.05M hydrochloric acid using phenolphthalein indicator. The K_D of ammonia between water and trichloromethane is 25.0 at room temperature. Determine the value of n in the complex, $[X(NH_3)_n]^{2+}$.

17. (a) What is meant by the term **standard enthalpy of displacement?**

(b) The table shows the results of an investigation of the reaction of copper(II) sulphate solution with two divalent metals **X** and **Y**.

Time (minutes)	0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Temperature of mixture of **X** and $50cm^3$ of 0.5M $CuSO_4$	26.5	38.0	42.5	43.5	44.0	43.0	42.0	41.0
Temperature of mixture of **Y** and $50cm^3$ of 0.5M$CuSO_4$	26.5	33.5	35.0	36.0	37.0	38.0	38.0	38.0

(i) On the same axes plot graphs of temperature against time for the two separate mixtures.

(ii) From the graphs determine the maximum temperature attained by each mixture.

(iii) Calculate the molar heat of displacement for each metal.

(iv) Write equation for the reaction in each mixture.

(v) What does 26.5°C in the table represent?

(vi) Which of the metals is more reactive? Give a reason for your answer

(d) Calculate the Gibbs free energy for the cell formed between each metal and copper(II) sulphate solution. Given that the standard reduction potentials for the half cells are; X is -0.76V, **Y** is -0.44V and copper is +0.34V.

18. (a) State what is meant by the term eutectic mixture.

(b) Table 1 below shows how the melting points of mixtures of copper and silver vary with composition.

Percentage of copper in the mixture	0	20	40	70	80	100
Melting point (°C)	961	830	830	955	1000	1085

(i) Draw a fully labelled diagram for the copper- silver system

(ii) Determine the eutectic temperature and the composition of the eutectic mixture.

(c) (i) Describe the changes that would take place when a liquid mixture of the above system containing 50% copper is cooled from 1000°C to 700°C.

(ii) Calculate the mass of silver that precipitated if 200g of the liquid mixture containing 10% copper was cooled from 1000°C to 800°C.

(d) Equations for some half – cell reactions are shown below

$Ag^{+}(aq) + e \longrightarrow Ag(s)$ $\quad E^{\ominus} = +0.80V$

$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$ $\quad E^{\ominus} = +0.34V$

(i) Write an equation for the overall cell reaction.

(ii) Calculate the $E^{\ominus}_{cell}$ in (d)(i).

(iii) Calculate the Gibb's free energy of the cell and state whether the reaction is feasible or not. Give a reason for your answer.

(e) Discuss the reactions of copper with sulphuric acid.

19. a) Silver ethanedioate is sparingly soluble in water. Write;

i) equation for the solubility of silver ethanedioate in water.

ii) the expression for the solubility product, *Ksp*, of silver ethanedioate.

b) The solubility product,*Ksp*, of Silver ethanedioate in 5.3×10^{-3} $mol^{-3}l^{-3}$at 25°C. Calculate the concentration of the following ions in a saturated solution of silvers ethanedioate

(i) silver ions.

(ii) ethanedioate ions.

c) Calculate the mass of silver nitrate that should be added to the saturated solution in (b) in order to reduce the concentration of ethanedioate ions to a third of its original values.

20. Propanone reacts with iodine in the presence of an acid catalyst according to the equation.

$$CH_3COCH_{3\,(aq)} + I_{2\,(aq)} \longrightarrow CH_3COCH_2I_{(aq)} + HI_{(aq)}$$

The reaction is first order with respect to propanone and independent of the concentration of iodine.

(i) Explain the term order of reaction

(ii) Write an expression for the rate law of the reaction.

(iii) Describe briefly how the order of the reaction with respect to iodine can be determined.

21. The equations for some redox reactions are shown below.

$2H^{+}_{(aq)} + 2Fe^{2+}_{(aq)} \rightleftharpoons H_{2(g)} + 2Fe^{3+}_{(aq)}$

$3Zn_{(s)} + 6OH^{-}_{(aq)} + BrO_3^{-}{}_{(aq)} + 3H_2O_{(l)} \rightleftharpoons 3Zn(OH)_4^{2-}{}_{(aq)} + Br^{-}_{(aq)}$

(a) For each reaction, write the half-cell reactions taking place at;

(i) the anode

(ii) the cathode

(b) (i) For each reaction, write the cell notation of the cell made by combining the electrodes in each half-cell.

(ii)state what each symbol used in b(i) stands for.

22.(a) Define the following terms.

(i) Solubility product

(ii) Common ion effect

(b) The solubility product of copper(II) iodate is given by the expression.

$$Ksp = [Cu^{2+}][IO_3^-]^2$$

Describe an experiment that can be carried out to determine the solubility product of copper(II) iodate.

(c) A saturated solution of copper(II) iodate has a concentration of 0.00833moles of copper(II) iodate per litre at 25^0C. Calculate the solubility product of copper(II) iodate at 25^0C and indicate its units.

(d) Determine the solubility of copper(II) iodate in a 0.02M copper(II) sulphate solution. State any assumptions you have made.

(e) Explain how the solubility of copper(II) iodate would be affected if few drops of;

(i) Concentrated ammonia solution is added

(ii) Potassium Iodate solution was added

23.(a) Define the term standard electrode potential.

(b) With the aid of a diagram, briefly describe how the standard electrode potential of copper can be determined. (7 marks)

(c) The standard electrode potentials of copper and zinc are given below;

$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)} \quad E^\theta = +0.34V$

$Zn^{2+}_{(aq)} + 2e \longrightarrow Zn_{(s)} \quad E^\theta = -0.76V$

Write the cell notation for zinc/copper cell and calculate the e.m.f of the cell.

(d) State two ways in which an electrolytic cell differs from an e.m.f cell.

(e) A current of 2A was passed for 30 minutes through a cell containing dilute sulphuric acid and the hydrogen produced at the cathode collected. Calculate the volume of the hydrogen in cm^3 that was produced at 23^0C and 100kPa.

(f) State two applications of standard electrode potentials.

24.Electrode potentials for some half cells are given below.

Half cell	E^θ/V
$Fe^{2+}_{(aq)}, Fe^{3+}_{(aq)}/Pt_{(s)}$	-0.77
$Cr^{3+}_{(aq)}, Cr_2O^{2-}_{7(aq)}, H^+_{(aq)}/Pt_{(s)}$	-1.33

(a) Write the cell notation for the cell formed when the two half cells are connected.

(b) Write;

(i) Equations for the half cell and reactions at the anode and cathode.

(ii) Equations for the overall cell reaction.

(c) (i) Calculate the e.m.f of the cell

(ii) State whether the reaction is feasible or not. Give a reason for your answer.

25.(a) When a mixture of water and nitric acid is distilled, a constant boiling point mixture containing 68% nitric acid is obtained at 120^0C. (The boiling points of pure water and nitric acid are 100^0C and 83^0C respectively)

(i) Define the term Constant boiling mixture (azeotropic mixture).

(ii) Draw a boiling point-composition diagram for the mixture of nitric acid and water.

(iii) Explain the shape of your diagram.

(iv) Describe what would happen if a mixture containing less than 60% nitric acid was fractionally distilled.

(b) A constant boiling mixture of nitric acid and water has density of 1.42gcm^{-3}. Calculate the volume of the acid needed to prepare one litre of 2M nitric acid solution.

26.(a)Describe the spectrum of hydrogen. (use a diagram to illustrate)

(b) Explain how the spectrum of hydrogen;

(i) is formed.

(ii) provides evidence for the existence of energy levels.

(c) The frequency of hydrogen at the point of ionization is 3.28x10^{15} Hz. Calculate the ionization energy of hydrogen. (Plank's constant = 6.6x10^{-34} Js)

27.(a) Sodium hydroxide solution was added to 25cm^3 of 0.1M ethanoic acid and the PH of the solution was measured at intervals. The results are given in the table below.

Volume of NaOH(cm^3)	0	4	8	12	16	20	22	22.5	23	24	28
pH of mixture	2.8	3.5	4	4.5	5.1	5.8	7	9	10.5	11.4	12.3

i) Plot a graph of PH against volume of Sodium hydroxide.

ii) Explain the shape of the graph.

iii) Determine the PH at the end point.

iv) Calculate the molar concentration of sodium hydroxide.

(b) i) Calculate the molarity of sodium ethanoate at the end point.

ii) Determine the hydrolysis constant for sodium ethanoate.

28.(a) Define the term relative atomic mass.

(b) Explain how the relative atomic mass can be determined can be determined by a mass spectrometer.

(c) The mass spectrum of an element A contained four lines at mass/charge of 204, 206, 207 and 208 with detector currents (mA) of 0.16, 2.72, 2.50 and 5.92 respectively. Calculate;

i) the relative abundance of the different isotopes in the sample of element A.

ii) the relative atomic mass of A.

29.(a) State what is meant by the following terms "order of reaction" and "half life of a reaction".

(b) A compound B shows the concentration of B at various times.

Time (minutes)	2.0	4.0	7.0	10.0	14.0	20.0
concentration of B (moll^{-1}) [B]	0.820	0.67	0.49	0.372	0.24	0.141

Draw a graph of $\log_{10}$[B] against time.

(c) Using the graph, determine the;

i) Order of the reaction

ii) Rate constant for the reaction

iii) Half-life for the reaction.

30.(a) What is meant by steam distillation.

(b) (i) State three properties of a substance that enable it to be purified by steam distillation.

(ii) Explain how the properties you have stated in b(i) enable the substance to be purified by steam distillation.

(iii) State two advantages of isolating substances by steam distillation.

(c) The vapour pressure of water VP_{H2O} and that of substance A (VP_A) at different temperatures are given in the table below.

Temperature (^0C)	20	40	60	80	100
VP_{H2O} (atm)	0.22	0.26	0.30	0.35	0.39
VP_A(atm)	0.35	0.42	0.49	0.56	0.63

i) On the same axes, plot graphs of vapour pressure against temperature for water and substance A.

ii) When substance A was distilled in steam at 1atm pressure the temperature of distillation was 97^0C and the distillate obtained contained 4.3g of substance A and 1.1g of water using your graph in c(i). Calculate the relative molecular mass of substance A.

31. (a) The molar conductivity of sodium hydroxide solutions of different concentrations are shown in the table below.

Concentration/ $moldm^{-3}$	0.01	0.04	0.09	0.16	0.25	0.36
Molar conductivity, Λ $\Omega^{-1}\,cm^2\,mol^{-1}$	238	230	224	217	210	202

i) Draw a graph of molar conductivity against square root of concentration.

ii) Explain the shape of the graph.

iii) Determine the value of molar conductivity at infinite dilution of sodium hydroxide and indicate its units.

Using the same conductivity cell, the resistance of a 0.1M Potassium Chloride solution and 0.1M bromoethanoic acid solution were found to be 24.96 and 66.50 Ohms respectively at 25^0C when determined using the same conductivity cell. [The Conductivity of Potassium Chloride at 25^0C is 0.01164 $\Omega^{-1}cm^2\ mol^{-1}$ and the molar conductivity of bromoethanoic acid at infinite dilution is 389 $\Omega^{-1}cm^2mol^{-1}$]

i) Calculate the cell constant.

ii) Calculate the molar conductivity of the 0.1M bromoethanoic acid.

iii) Determine the pH of 0.1M bromoethanoic acid.

32. (a) The table below shows the result of partitioning aminoethane between trichloromethane and 0.1M Copper(II) Sulphate solution.

$[CH_3NH_2$ (0.1M $CuSO_4)]$	0.87	1.10	1.33	1.57	1.80
$[CH_3NH_2$ $(CHCL_3)]$	0.02	0.03	0.04	0.05	0.06

i) Plot a graph of $[CH_3NH_2(0.1M\ CuSO_4)]$ versus $[CH_3NH_2(CHCL_3)]$

ii) Determine the number of moles of aminoethane that has formed a complex with copper(II) ion.

(b) Write the equation for the reaction between copper(II) ions and aminoethane.

33.a) Describe how the solubility product of Magnesium hydroxide in water can be determined.

b) (i) A saturated solution of magnesium hydroxide in water contains $1.44x10^{-4}$ mol of magnesium hydroxide per litre of sodium at 25^0C. Calculate the value of solubility product Ksp of Magnesium hydroxide at 25^0C.

(ii) Solid Magnesium hydroxide was shaken with a O.1M solution of Magnesium hydroxide until equilibrium was attained at 25^0C.

Calculate the amount of magnesium hydroxide in grams per litre that was precipitated.

INORGANIC CHEMISTRY

34. Beryllium , magnesium , calcium , strontium and barium are the elements of group(II) of the Periodic Table.

(a) Describe how the electropositivity of the elements varies down the group.

(b) Discuss the reaction of the elements with

(i) dry air (ii) nitric acid

(c) Describe how beryllium carbide and calcium carbide react with dilute hydrochloric acid

(d) Describe how cement is manufactured.

35. The atomic numbers and melting points of the oxides of elements of periodic (iii) of the periodic table are shown in the table below,

Element	*Na*	*Mg*	*Al*	*Si*	*P*	*S*	*Cl*
Atomic No.	11	12	13	14	15	16	17
Oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3	Cl_2O_7
Mpt	1275	2827	2007	1607	560	30	-91

(a) (i) Plot a graph of melting points of the oxides against the atomic numbers of the elements.

(ii) Explain the shape of the graph you have drawn in a(i) above.

(b) State the condition(s) and write equation to show the reactions between

(i) Water and

-Na_2O -MgO -Cl_2O_7

(ii) Sodium hydroxide and

$-Al_2O_3$ $-SiO_2$ $-P_4O_{10}$

36. The boiling points of some chlorides of period 3 elements of the periodic table are shown below.

Formula of chlorides	$NaCl$	$MgCl_2$	Al_2Cl_6	$SiCl_4$
Boiling point (°C)	1465	1418	423	57

(a) State the trend in the boiling points of chlorides.

(b) Explain your answer in (a) above.

37. State what would be observed and write equation(s) for the reaction(s) that will take place when to the solution of cobalt(II) chloride is added;

(a) Concentrated ammonia solution.

(b) Concentrated hydrochloric acid.

(c) Aqueous sodium hydroxide dropwise until in excess.

38. Chromium , manganese , copper and zinc are d – block elements in the Periodic Table.

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

(ii) Write the electronic configuration of the elements. (Atomic numbers of chromium , manganese, copper and zinc are 24, 25, 29 and 30 respectively).

(b) Zinc is a d- block element but it is **not** a typical transition element.

State **two** properties in which zinc shows

(i) similarity to the rest of d- block elements

(ii) differences from the rest of the d- block elements.

(c) Describe how zinc is extracted from zinc blende.

(d) Explain the following observations

(i) when zinc metal was added to concentrated sodium hydroxide solution , silver solid dissolves with effervescence of a colourless gas and a colourless solution is formed.

(ii) when few drops of concentrated sodium carbonate solution were added to aqueous chromium(III) sulphate solution, grey green precipitate was formed and bubbled of a colourless gas were produced.

(iii) When a hydrogen peroxide solution was added to a mixture of acidified solution potassium dichromate and pentan-1-ol, a deep blue solution was formed in the organic layer.

(d) State what would be observed and write equation for the reaction when

(i) barium chloride solution was added to potassium chromate solution.

(ii) dilute sulphuric acid was added to potassium manganate(VI) solution.

39. (a) Describe one general method for the preparing the halogens (excluding fluorine) in the laboratory.

(b) Discuss the reactivity of fluorine, chlorine, bromine and iodine with;

(i) Water

(ii) Aqueous sodium hydroxide solution

40.(a) State four properties in which fluorine differs from other elements of group(VII) of the periodic table.

(b) State three reasons why fluorine is more reactive than the other elements in the periodic table

(c) Write equation for the reaction between hydrofluoric acid and silicon dioxide.

41. The boiling points of hydrides of group(VII) elements are given in the table below.

Compound	HF	HCl	HBr	HI
Boiling point (^0C)	+19.9	-85.0	-66.7	-35.4

(a) Explain the trend in the boiling points of the hydrides

(b) Giving reasons, suggest the trend in the acid strength of the hydrides.

(c) Using equations where possible explain what happens when concentrated sulphuric acid is mixed with each of the hydrides.

(d) (i) Arrange the following compounds in their order of increasing acid strength $HClO_3, HClO_2, HClO$

(ii) Explain your answer in d(i)

42.Discuss the reactivity of group(IV) elements (Carbon, silicon, Germanium, Tin and lead) of the periodic table with

(a) Water

(b) Concentrated acids.

(c) Sodium hydroxide

(d) Dilute acids

43.Berryllium, Magnesium, Calcium and Barium are some of the elements that belong to group (II) of the periodic table.

a) Describe giving conditions for the reactions of the elements with:

i) water

ii) sulphuric acid [illustrate your answers with the equations]

(b) Giving reasons, state how the solubilities of;

(i) hydroxides (ii) sulphates , vary down the group.

MIXED QUESTIONS

44.Explain the following observations

(a) Propene undergoes electrophilic addition where propanone undergoes nucleophilic addition.

(b) Hydrogen bromide **can not** be prepared in the laboratory using potassium bromide and concentrated sulphuric acid however hydrogen chloride can efficiently be prepared using potassium chloride and concentrated sulphuric acid.

(c) Iodobenzene is more reactive than chlorobenzene towards nucleophiles but much less reactive than iodoethane.

(d) When potassium iodide solution was added to lead(II) nitrate solution drop-wise until in excess, a yellow precipitate is formed that dissolves to form a yellow solution. However

when the same reagent is trewated with copper(II) nitrate solution, a white precipitate in a brown solution was formed.

45. Explain the following observations

(a) Phenylamine is a weaker base than ethylamine

(b) Phenol is a stronger acid than Phenylmethanol

(c) Copper(I) oxide reacts with dilute sulphuric acid to give a pale blue solution and a brown solid is deposited.

(d) when hydrogen sulphide gas is bubbled through aqueous solution of lead(II) nitrate, a black precipitate is formed but no precipitate is formed when the same gas is bubbled through acidified lead(II) nitrate solution.

(e) Aluminium fluoride is more soluble in water than in ethanol whereas aluminium bromide is more soluble in ethanol than in water.

(f) Water boils at 100^0C and methyl benzene boils at 111^0C at 101.3kPa. The boiling point of a mixture of water and methyl benzene is 96^0C.

CHEMISTRY PRACTICAL

QUESTION ONE

You are provided with following;

FA1, which is a solution containing $13.44gdm^{-3}$ of thiosulphate ions.

FA2, which is a solution of manganate (VII) ions of unknown concentration.

SOLID T, which is a metal sulphite,

10% potassium iodide solution

2.0M sulphuric acid solution

You are required to determine the;

(i) Concentration of manganate(VII) ions in FA2 in $moldm^{-3}$

(ii) Percentage purity of metal sulphite

Theory

Acidic manganate (VII) ions oxidize iodide ions to liberate iodine according to the following equation.

$2MnO_4^-(aq) + 16H^+(aq) + 10I^-(aq) \longrightarrow 2Mn^{2+}(aq) + 5I_2(aq) + 8H_2O(l)$

The liberated iodine reacts with thiosulphate ions according to the following equation

$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

Manganate (VII) ions also react with sulphite ions in acid medium according to the following equations

$2MnO_4^-(aq) + 5SO_3^{2-}(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 3H_2O(l)$

PART I

Procedure

Using a measuring cylinder transfer $65cm^3$ of **FA2** into a clean $250cm^3$ **glass beaker**, followed by $35cm^3$ distilled water, label the resultant solution **FA3**

Pipette $25.0cm^3$ (or $20.0cm^3$) of **FA3** into a conical flask. Add $15cm^3$ of 2M sulphuric acid followed by $15cm^3$ of 10% potassium iodide solution.

Titrate the iodine liberated with **FA1** from the burette until the solution is pale-yellow.

Add 4 – 5 drops of starch indictor and continue the titration until the end point.

Repeat the titration until you obtain consistent results.

Record your results in table I below.

Results

Volume of pipette used = ……cm^3

Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of **FA1** used (cm^3)			

(a)(i)State the volumes of **FA1**used for calculating average.

(ii)Calculate the average volume of **FA1**

Questions

(b)Calculate the number of moles of;;

(i) Iodine that reacted with thiosulphate ions in FA1 **(S = 32, O = 16)**

(ii)Manganate (VII) ions in 100cm^3 of **FA2**

(b)Determine the concentration of manganate(VII)ions in **FA2** in $moldm^{-3}$

PART II

Procedure

Weigh accurately 1.20g of M into a beaker. Add a little water and shake to dissolve. Transfer the resultant solution into a 250cm^3 volumetric flask and top up with distilled water up to the mark. Label this solution FA4.

Results

Mass of weighing bottle + M = ……g

Mass of weighing bottle alone = ……g

Mass of M= ……g

PART III

Procedure

Pipette 20.0 or 25.0cm^3 of FA4 into a conical flask. Add an equal volume of 2M sulphuric acid and titrate the mixture with FA2 from the burette. Repeat the titration two more times and record your results in table 2 below

Volume of pipette used ……cm^3

Final burette readings (cm^3)			
Initial burette readings(cm^3)			
Volume of FA2 used (cm^3)			

(a)(i)Titre values used to calculate the average volume of FA2

(ii) Calculate the average volume of FA2

Questions

(a) Calculate the;

(i) molar concentration of sulphite ion in FA4

(b)Determine the;

(i)mass of pure metal sulphite (Molar mass of metal sulphite = 125g)

(ii) Percentage purity of the metal sulphite

Question two

You are provided with substance, **Y**, which contains **two** cations and **two** anions. You are required to carry out the following tests on **L** to identify the cations and anions in it. Identify any gas(es) evolved. Record your observations and deductions in the table below.

TESTS	OBSERVATIONS	DEDUCTIONS
(a)Heat **two** spatula end-ful of **Y** in a dry test tube strongly until no further change.		
(b)To two spatula end-ful of Y add 3-4 drops of concentrated sulphuric acid and warm		
(c)To **three** spatula end-ful of **Y** in a test tube add about $10cm^3$ of distilled water shake strongly to dissolve you may warm		
(d) . To $2cm^3$ of the solution in part(c) add $2cm^3$ of ethanol and 5drops of concentrated sulphuric acid and boil		
(e) Use $2cm^3$ of the solution in part(c) to carry out a test of your own to confirm one of the anion in solution of Y **test**		
(e) To the remaining solution add dilute sodium hydroxide solution drop-wise until no further change. Filter and keep both the filtrate and residue		
(f). To the filtrate from part (e) add dilute sulphuric acid drop wise until the solution is just acidic. Divide the resultants into **five** parts.		
(i)To the first part of acidified solution add 2-3 drops of barium nitrate solution		

(ii)To the second part of acidified solution add 2-3 drops of silver nitrate solution		
(iii)To the third part of acidified solution add little bleaching powder followed by $1cm^3$ of carbon tetrachloride and shake strongly allow to stand		
(iv)To the fourth part of acidified solution add dilute ammonia solution drop-wise until in excess		
(d)(iii). Use the fifth part of acidified filtrate to carry out a test of your own choice to confirm the cation in the filtrate **Test**		
(g). Dissolve the residue from part (e) in minimum amount of sulphuric acid. Divide the resultant solution into **three** parts.		
(i). To the first part, 2-3 drops add potassium hexacyanoferrate(II) solution followed by dilute ammonia solution.		
(ii). To the second part, add dilute ammonia solution drop-wise until in excess		
(iii) Use the third part of to carry out a test of your own choice to confirm the second cations in Y **Tes**		

(h) Identify the (i) Cations in Y (ii) Anions in Y .

QUESTION THREE

You are provided with an organic substance, ***O***. You are required to determine the nature of ***O***. Carry out the following tests on ***O*** and record your observation and deductions in table below. **(20marks)**

TESTS	OBSERVATIONS	DEDUCTIONS
(a)Burn a small amount of ***O*** on a spatula end		
(b)To about $1cm^3$ of *O* add $3cm^3$ of distilled water test the mixture with litmus paper		
(c)To about $1cm^3$ of *O* add $2cm^3$ of sodium hydrogen carbonate solution		
(d)To about $1cm^3$ of *O* add 2 – 3 drops of neutral iron (III) chloride solution		
(e)To about $1cm^3$ of *O* , add 2 – 3 drops of acidified potassium manganate (VII) and **warm**		
(f)To about $1cm^3$ of *O* , add 2-3 drops of 2,4-dinitrophenylhydrazine solution		
(g)To about $1cm^3$ of *O* , add 2-3 drops of saturated solution of sodium hydrogen sulphite and shake strongly		
(h)To about $2cm^3$ of silver nitrate solution in a clean test tube add 2drops of sodium hydroxide solution followed by ammonia solution until the		

precipitate just dissolves heat the mixture to the hot mixture add about $1cm^3$ of *O* and shake		
(i)To about $1cm^3$ of *O* , add 2-3 drops Fehling solution and heat		

(j)Comment on the nature of ***O***.