PROPOSED GUIDE

Name of School:..

Candidate's Name:..

Centre No./Index No: .... Signature:....................

P525/1
CHEMISTRY
Paper1
2 ¾ Hours
July/ August 2023

KAMSSA JOINT MOCK EXAMINATION
Uganda Advanced Certificate of Education
CHEMISTRY
Paper1
2 Hours 45 Minutes

INSTRUCTIONS TO CANDIDATES

- ✓ This paper consists of two sections **A** and **B**
- ✓ Section **A** is compulsory and attempt **only six** questions in section **B**
- ✓ Answers must be written in the spaces provided only
- ✓ The periodic table is provided at the end of the paper.
- ✓ mathematical calculators (3 figure tables or non programmable electronic calculators may be used)
- ✓ Illustrate your answers with equations where aplicable.
- ✓ Where necessary use:
- ✓ Gas constant R=8.314J/mol/k, sturndard pressure =101325N/m²=760mmHg, 1mole of a gas occupies a volume of 22.4dm³

For Examiner's Use Only																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
05	06	06	05 05	05	05	03	05	05	09	09	09	09	09	09	09	

SECTION A (46 MARKS)
(Attempt all questions)

1(a). What is meant by the term standard enthalpy of neutralization? (01marks)

It is the heat evolved when one mole of hydrogen ions reacts completely with one mole of hydroxyl ions to form one mole of water molecules at 1 atmosphere and 298 K.

(b). Explain why the value for heat of neutralization of a strong acid by a strong base is not the same as that of the formation of water. (01mark)

Heat of neutralisation is due to combination of many hydrogen ions and hydroxyl ions from the complete ionisation of a strong acid and a strong base respectively, while heat of formation of water is due to forming water from its constituent elements, hydrogen and oxygen.

(c). 250cm^3 of **0.40M** sodium hydroxide solutions were added to 250cm^3 of **0.40M** hydrochloric acid in a calorimeter of 500g and specific heat capacity of 400jkg^{-1}k^{-1}. All the three were initially at 17.05°c and the temperature rose to 19.55°c. (Assuming that the specific heat capacity of the two solutions is 4200jkg^{-1}k^{-1}). Calculate the standard enthalpy of neutralization. (03marks)

Heat evolved = Heat gained by solution + Heat gained by calorimeter

$= M_w C_w \Delta T + M_c C_c \Delta T$

$= (500 \times 1) \times 4.2 + (500 \times 1)(0.4)(19.55 - 17.05)$

$= 5750 J$

Moles of NaOH $= \dfrac{(0.4 \times 250)}{1000} = 0.1$ *moles*

0.1 moles of NaOH liberate 5750 J of heat

1 mole of NaOH liberated $\dfrac{(5750)}{0.1} J = 57500 Jmol^{-1} = \dfrac{-(57500)}{1000} KJmol^{-1}$

$= -57.5 KJmol^{-1}$

2. Propanone can be prepared from propan-1-ol according the scheme below.

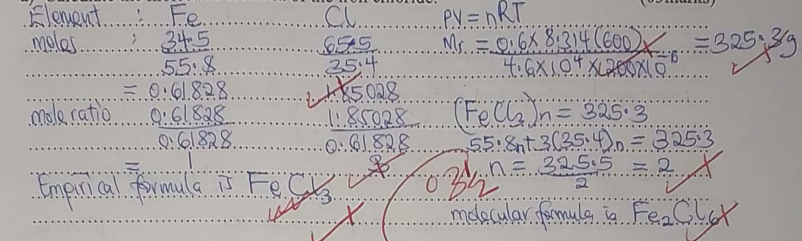$$CH_3CH_2CH_2OH \xrightarrow{A} CH_3CH=CH_2 \xrightarrow{B}$$

$$\underset{CH_3CHCH_3}{\overset{Cl}{|}}$$

$$\xrightarrow{C} \underset{CH_3CHCH_3}{\overset{OH}{|}} \xrightarrow{D} CH_3COCH_3$$
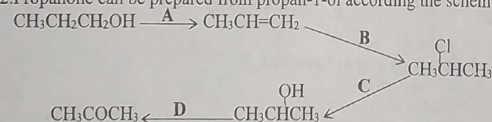
Identify the reagent A, B, C and D and state the condition(s) for the reaction in each case.
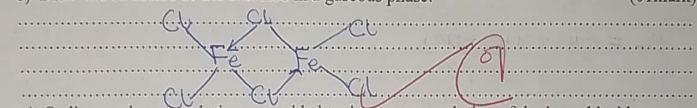
(06marks)

	Reagent	Condition(s)
A	Concentrated Sulphuric acid	Concentrated acid Temperature of 180°C
B	Hydrogenchloride gas	Room temperature
C	Aqueous sodium hydroxide	Heat
D	Potassium dichromate solution	Concentrated sulphuric acid Heat.

3. An iron chloride contains **34.5%** iron and **65.5%** chlorine. When **0.6** of the chloride of iron were strongly heated in a sealed tube of volume 200cm³ to a temperature of 600k, the pressure exerted was found to be 4.6x10⁴pa.

a) Calculate the molecular formula of the iron chloride. (03marks)

Element	:	Fe	Cl

$$PV = nRT$$

$$Mr = \frac{0.6 \times 8.314 (600)}{4.6 \times 10^4 \times 200 \times 10^{-6}} = 325.3 \, g$$

moles : $\frac{34.5}{55.8}$ $\frac{65.5}{35.4}$

$= 0.61828$ $= 1.85028$

mole ratio $\frac{0.61828}{0.61828}$ $\frac{1.85028}{0.61828}$ $(FeCl_2)_n = 325.3$

$= 1$ $= 3$ $55.8 + 3(35.4)n = 325.3$

Empirical formula is $FeCl_3$ $n = \frac{325.5}{2} = 2$

molecular formula is Fe_2Cl_6

b) Draw the structure of the chloride in a gaseous phase. (01mark)
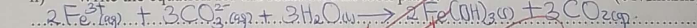

c) Sodium carbonate solution was added to the aqueous solution of the iron chloride
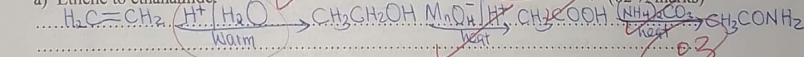i) State what was observed. (0½mark)

A brown precipitate, and bubbles effervescence of a colourless gas

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

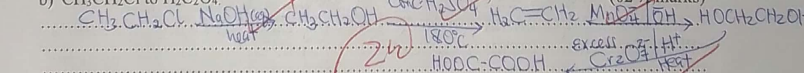$$2Fe^{3+}_{(aq)} + 3CO^{2-}_{3(aq)} + 3H_2O_{(l)} \rightarrow 2Fe(OH)_{3(s)} + 3CO_{2(g)}$$

4. Write equations to show how the following conversions can be affected
a) Ethene to ethanamide. (02 ½ marks)

$$H_2C=CH_2 \xrightarrow[Warm]{H^+ / H_2O} CH_3CH_2OH \xrightarrow[heat]{MnO_4^- / H^+} CH_3COOH \xrightarrow[heat]{(NH_4)_2CO_3} CH_3CONH_2$$

b) CH_3CH_2Cl to $H_2C_2O_4$ (02 ½marks)

$$CH_3CH_2Cl \xrightarrow[heat]{NaOH_{(aq)}} CH_3CH_2OH \xrightarrow[180°C]{Conc H_2SO_4} H_2C=CH_2 \xrightarrow[excess]{MnO_4^- / OH^-} HOCH_2CH_2OH$$

$$HOOC \cdot COOH \xleftarrow[heat]{Cr_2O_7^{2-} / H^+}$$

5a) State the oxidation state of the central atom in each of the following complex ions and in each case, give the name of the complex ion. (03marks)

Complex ion	Oxidation state of the central atom	Name of the complex ion
$[CuBr_4(H_2O)_2]^{2-}$	+2	Diaquatetrabromocuprate(II) ion
$[Al(OH)_4(H_2O)_2]^{1-}$	+3	Diaquatetrahydroxoaluminate(III) ion
$[Co(NH_3)_4Cl]^+$	+2	Tetraamminemonochlorocobalt(II) ion

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b) State 2 reasons why zinc is a d-block element but not a transition element. (01marks)

Zinc is not paramagnetic
Zinc doesnot form coloured compounds

6a) State any two colligative properties. (01marks)

Lowering of vapour pressure of the solvent
Elevation of boiling point of the solvent

b) A solution of 0.4% polyvinyl chloride, $+CH_2-CH+_n$ in dioxin has an osmotic pressure of 65pa at 20^0c
$$\overset{|}{Cl}$$
i) Calculate the relative formula mass of the polyvinyl chloride. (02marks)

$$\Pi V = nRT$$

$$M_r = \frac{0.4 \times 8.314 (20+273)}{65 \times 100 \times 10^{-6}}$$

$$= 149907.8$$

ii) Determine the number of monomer units in the polyvinyl chloride. (02marks)

$$M_r \quad n = \frac{149907.8}{(12\times2)+3+25.5}$$

$$= 2463 \text{ units} \qquad = 2399 \text{ units}$$

7. Beryllium exhibits different properties from the rest of the group II elements.
a) Explain what is meant by the term anomalous behavior. (01mark)

Is the tendancy of an element in period 2 of the periodic table to show properties different from those of other elements in the same group.

b) What 2 anomalies does beryllium show from group II elements? (01marks)

Beryllium atom has the smallest atomic radius.
Beryllium atom has the highest electronegativity

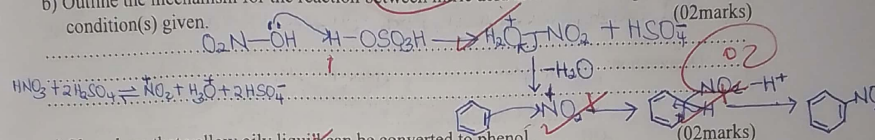c) Give any one property to show that beryllium is anomalous from the group II elements. (01marks)

Beryllium reacts with hot concentrated sodium hydroxide solution to form sodium beryllate and hydrogen gas while other elements donot react with sodium hydroxide solution.

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benzene

8a) Concentrated nitric acid reacts with, to form a yellow oily liquid. State the condition(s) under which the reaction occurs and give the IUPAC name of the yellow oily liquid. (01mark)
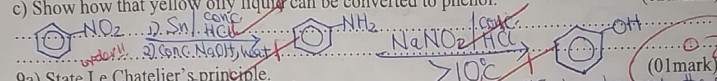
Condition(s): Concentrated sulphuric acid at $60°C$

IUPAC name: Nitrobenzene

b) Outline the mechanism for the reaction between nitric acid and benzene in presence of the condition(s) given. (02marks)

$O_2N-\overset{..}{O}H \quad H-OSO_3H \longrightarrow H_2\overset{+}{O}-NO_2 + HSO_4^-$

$HNO_3 + 2H_2SO_4 \rightleftharpoons NO_2^+ + H_3O^+ + 2HSO_4^-$

(diagram: $-H_2O$, benzene + NO_2^+ → intermediate → NO_2) (02marks)

c) Show how that yellow oily liquid can be converted to phenol. (01mark)

(benzene-NO_2) $\xrightarrow[\text{2) conc. NaOH, heat}]{\text{1) Sn / conc. HCl}}$ (benzene-NH_2) $\xrightarrow[>10°C]{NaNO_2/\text{conc.} HCl}$ (benzene-OH)

9a) State Le Chatelier's principle.

If one of the conditions under which a system is in equilibrium changes, the system adjusts in order to minimise that change.

b) Hydrogen and iodine react according to the following equation.

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
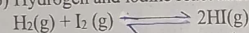
State what would happen to the position of equilibrium when;

i) temperature is lowered. (½marks)

The position of equilibrium would shift to the right.

ii) pressure is increased.

The position of equilibrium would shift to not change.

c) When molar quantities of hydrogen and iodine are reacted in a sealed vessel at 500°c and 10 atmospheres. The equilibrium mixture was found to contain 1.6 moles of hydrogen iodide. Calculate the equilibrium constant Kp for the reaction at 500°c. (03 marks)

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$
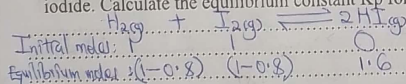
Initial moles: $\quad 1 \qquad 1 \qquad\qquad 0$

Equilibrium moles: $(1-0.8) \quad (1-0.8) \qquad 1.6$

Total equilibrium moles $= (1-0.8)+(1-0.8)+1.6$
$$= 2$$

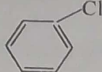$P_{HI} = \dfrac{1.6}{2} \times 10 = 8 \text{ atmospheres}$

$P_{H_2} = P_{I_2} = \dfrac{0.2}{2} \times 10 = 1 \text{ atmosphere}$

$K_p = \dfrac{(P_{HI})^2}{P_{H_2} \& P_{I_2}} = \dfrac{8^2}{1 \times 1} = 64$
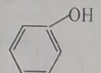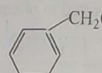
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SECTION B (54 MARKS)
(Attempt any 6 questions in this section)

10. Name **one reagent** that can be used to distinguish between each of the following pairs of compounds. In each case, state what is observer if each member of the pair is treated with the reagent?
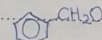
(a). [structure: benzene ring with Cl] and $CH_3CH_2CH_2Cl$ (03 marks)

Reagent: Hot sodium hydroxide solution, dilute nitric acid and silver nitrate solution.

Observation:
with [benzene-Cl] : No observable change
with $CH_3CH_2CH_2Cl$: White precipitate

(b). [benzene ring with OH] and [benzene ring with CH_2OH] (03 marks)

Reagent: with Neutral iron(III)chloride solution

Observation:
with [benzene-OH] : Purple/violet colouration
with [benzene-CH_2OH] : No observable change

(c). $CH_3COCH_2CH_2CH_3$ and $CH_3CH_2COCH_2CH_3$ (03 marks)

Reagent: Iodine solution and sodium hydroxide solution.

Observation:
with $CH_3COCH_2CH_2CH_3$: Yellow precipitate
with $CH_3CH_2COCH_2CH_3$: No observable change.

11a) Write an equation for the reaction between acidified potassium dichromate(vi) solution and potassium iodide solution.

(01½marks)

$$Cr_2O_7^{2-}{}_{(aq)} + 6I^-{}_{(aq)} + 14H^+{}_{(aq)} \rightarrow 2Cr^{3+}{}_{(aq)} + 3I_2{}_{(aq)} + 7H_2O_{(l)}$$
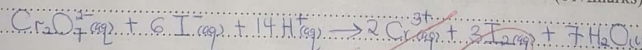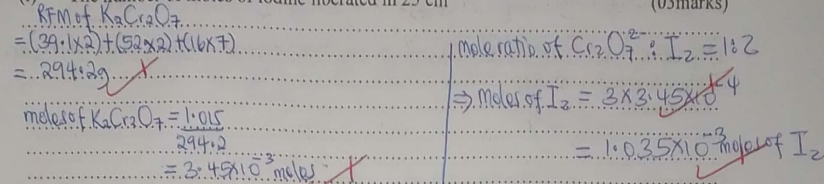
b) 1.015g of potassium dichromate (vi) were dissolved in 100cm³ and the solution made up to the mark in a 250cm³ volumetric flask with distilled water. A 25cm³ portion of the solution was added to excess 10% potassium iodide solution followed by 1.5M sulphuric acid and the iodine liberated required 19.2cm³ of sodium thiosulphate solution in presence starch indicator.
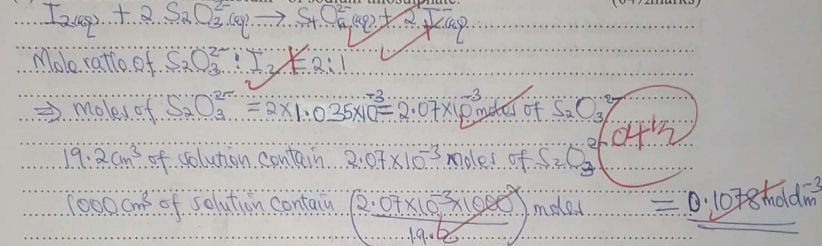
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Calculate;

(i) The number of moles of iodine liberated in 25 cm³. (03marks)

RFM of $K_2Cr_2O_7$

$= (39.1 \times 2) + (52 \times 2) + (16 \times 7)$

$= 294.2g$ ✗

moles of $K_2Cr_2O_7 = \dfrac{1.015}{294.2}$

$= 3.45 \times 10^{-3}$ moles ✗

250 cm³ of solution contain 3.45×10^{-3} moles of $Cr_2O_7^{2-}$

25 cm³ of solution contain $\left(\dfrac{3.45 \times 10^{-3} \times 25}{250}\right)$ moles

$= 3.45 \times 10^{-4}$ moles ✗

mole ratio of $Cr_2O_7^{2-} : I_2 = 1 : 2$

$\Rightarrow$ Moles of $I_2 = 3 \times 3.45 \times 10^{-4}$

$= 1.035 \times 10^{-3}$ mole of I_2

(circled) 03

(ii) The concentration in moldm⁻³ of sodium thiosulphate. (04½marks)

$I_{2(aq)} + 2S_2O_{3(aq)}^{2-} \rightarrow S_4O_{6(aq)}^{2-} + 2I_{(aq)}^{-}$

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

$\Rightarrow$ moles of $S_2O_3^{2-} = 2 \times 1.035 \times 10^{-3} = 2.07 \times 10^{-3}$ moles of $S_2O_3^{2-}$

(circled) 04½

19.2 cm³ of solution contain 2.07×10^{-3} moles of $S_2O_3^{2-}$

1000 cm³ of solution contain $\left(\dfrac{2.07 \times 10^{-3} \times 1000}{19.6}\right)$ moles $= 0.1078 \text{moldm}^{-3}$

12. Identify one compound that can be tested using the following reagents. In each case state what is observed and write equation for the reaction that takes place when the compound named is treated with the following reagents. (03marks each)
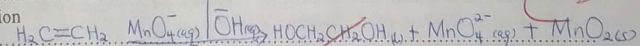
(margin note: Accept any alkene either by name or formula.)

a) Baeyer's reagent

Compound: $H_2C = CH_2$ ✓

Observation: A purple solution turns to a green solution and a brown solid is formed. ✓

(circled) 0.3

Equation $H_2C = CH_2 \xrightarrow{MnO_4^-/OH^-_{(aq)}} HOCH_2CH_2OH_{(\ell)} + MnO_4^{2-}{}_{(aq)} + MnO_{2(s)}$

b) Tollen's reagent

(margin note left: Accept; √Any terminal alkyne, √Any aldehyde except benzaldehyde)

Compound: $CH_3C \equiv CH$ (circled) 0.2

(note right: Accept CH_3CHO)

(note far right: Rej without warming/heating)

Observation: White precipitate.

(right: Silver mirror deposit formed on warming)

$7 \ CH_3CHO + 2Ag(NH_3)_2^+ + 3OH^- \rightarrow CH_3COO^- + 2Ag_{(s)} + 4NH_3 + 2H_2O$

$CH_3CHO \xrightarrow{Ag(NH_3)_2^+} CH_3COO^- + Ag_{(s)} + NH_3 + H_2O$

b) $CH_3C\equiv CH_{(g)} + [Ag(NH_3)_2]OH_{(aq)} \longrightarrow CH_3C\equiv CAg_{(s)} + H_2O_{(l)} + 2NH_{3(aq)}$

$CH_3C\equiv CH_{(g)} \xrightarrow{Ag(NH_3)_2^+} CH_3C\equiv CAg_{(s)} + \overset{+}{N}H_4$

Equation

$CH_3C\equiv CH_{(g)} + AgNO_{3(aq)} + NH_{3(aq)} \longrightarrow CH_3C\equiv CAg_{(s)} + NH_4NO_{3(aq)}$ ⊘ ①

$CH_3C\equiv CH_{(g)} + [Ag(NH_3)_2]NO_{3(aq)} \longrightarrow CH_3C\equiv CAg_{(s)} + NH_4NO_{3(aq)} + NH_{3(aq)}$
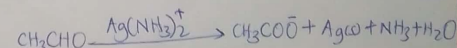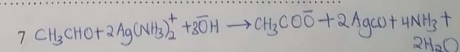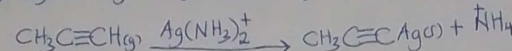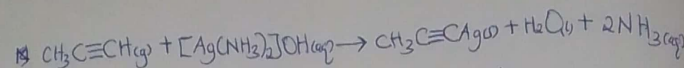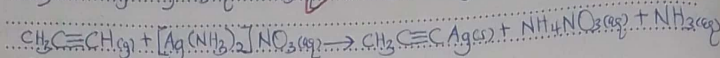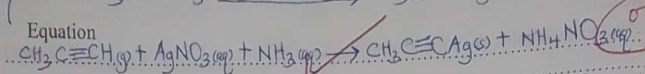
c) Phosphorous (v) chloride

Compound:

CH_3CH_2OH

Observation:

White fumes ✓   ③

Equation

$CH_3CH_2OH_{(l)} + PCl_{5(l)} \longrightarrow CH_3CH_2Cl + POCl_3 + HCl_{(g)}$
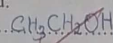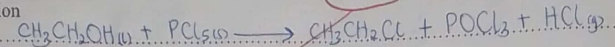
13. A compound R contains 40% carbon and 6.67% hydrogen, the rest being oxygen.

a) Calculate the empirical formula of R. (01½marks)

Element :	C	H	O
Composition :	40	6.67	$100 - (40+6.67) = 53.33$ ✓
moles :	$\frac{40}{12}$	$\frac{6.67}{1}$	$\frac{53.33}{16}$ ✓
$=$	3.333	6.67	3.333
mole ratio :	$\frac{3.333}{3.333}$	$\frac{6.67}{3.333}$	$\frac{3.333}{3.333}$	②
$=$	1	2	1 ✓

Empirical formula of R is CH_2O ✓

b) A solution containing 28.145g of R in 250g of water froze at -3.490°C.

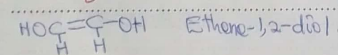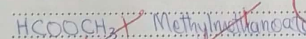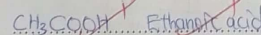*(The freezing point constant Kf of water 1.86°C/mol/1000g)*

i) Determine the molecular formula of R. (02marks)

250g of water dissolve 28.145g of R

1000g of water dissolve $\left(\frac{28.145\times1000}{250}\right) = 112.58g$ of R

$(0 - 3.490)°C$ is freezing point depression caused by 112.58g of R

$1.86°C$ is freezing point depression caused by $\left(\frac{112.58\times1.86}{3.490}\right)$ ②
$= 60$

$(CH_2O)_n = 60$
$(16+12+2)n = 60$
$n = \frac{60}{30}$
$= 2$ ✓

molecular formula is
$C_2H_4O_2$ ✓

ii) Write the structural formula and I.U.P.A.C names of all the possible isomers of R. (02marks)

CH_3COOH ✓   Ethanoic acid

$HCOOCH_3$ ✓   Methylmethanoate   ②

$HO\underset{\overset{|}{H}}{\overset{\overset{|}{H}}{C}}=C-OH$ Ethene-1,2-diol.

8

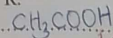c) R reacted with sodium carbonate with effervescence of a colourless gas.

i)   Identify R.   (01mark)
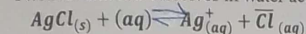
CH_3COOH

ii)   Write equations to show how R can be synthesized from ethene   (01½marks)

$$H_2C=CH_2 \xrightarrow[warm]{H^+/H_2O} CH_3CH_2OH \xrightarrow[heat]{MnO_4^-/H^+} CH_3COOH$$
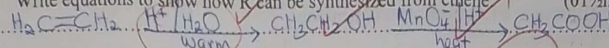
14. Silver chloride dissolves in water according to the following equations.

$$AgCl_{(s)} + (aq) \rightleftharpoons Ag^+_{(aq)} + \overline{Cl}_{(aq)}$$

a) Write the expression for the solubility product Ksp of silver chloride.   (01 marks)

$$K_{sp} = [Ag^+][Cl^-]$$

b) The electrolytic conductivity of a saturated solution of silver chloride in water at 25°C is 3.41 x $10^{-6}\Omega^{-1}cm^{-1}$ and that of pure water is 1.60 x 10-6 $\Omega^{-1}cm^2mol^{-1}$. The molar conductivities at infinite dilution of silver nitrate, potassium nitrate and potassium chloride is 133.4, 145.0 and 149.9$\Omega^{-1}cm^2mol^{-1}$ respectively ate 25°C. Calculate the solubility product of a saturated solution of silver chloride at 25°C.   (04$\frac{1}{2}$ marks)

$$\Lambda_o(AgCl) = \Lambda_o(AgNO_3) + \Lambda_o(KCl) - \Lambda_o(KNO_3)$$
$$= 133.4 + 149.9 - 145$$
$$= 138.3 \ \Omega^{-1} cm^2 mol^{-1}$$

$$K_{(AgCl)} = K_{solution} - K_{water}$$
$$= 3.41 \times 10^{-6} - 1.6 \times 10^{-6}$$
$$= 1.81 \times 10^{-6} \ \Omega^{-1} cm^{-1}$$

Solubility $= 1000 K = \dfrac{1000 \times 1.81 \times 10^{-6}}{138.3}$
$$= 1.3087 \times 10^{-5} \ mol \, dm^{-3}$$

$[Ag^+] = [Cl^-] = 1.3087 \times 10^{-5} \ mol \, dm^{-3}$

$K_{sp} = (1.3087 \times 10^{-5})^2$
$$= 1.71204 \times 10^{-10} \ mol^2 \, dm^{-6}$$

c) Ammonia solution was added to a solution containing silver chloride.

i) State how the solubility of silver chloride was affected.   (01mark)

Solubility would increase.

ii) Explain your answer in (c)(i) above.   (02½marks)

Ammonia solution reacts with silver ions forming diamminesilver(I) ion. This reduces the concentration of silver ions in the equilibrium mixture. To restore equilibrium more solid silver chloride ionises. $Ag^+_{(aq)} + 2NH_{3(aq)} \longrightarrow Ag(NH_3)_2^+_{(aq)}$

15a) State the essential conditions and give the IUPAC name for the product formed when chlorine;   (0 ½ marks each)

i)   Is added to benzene

Conditions; Presence of Ultra violet light
Excess Chlorine

Name of the product

.....1,2,3,4,5,6-hexachlorocyclohexane.....

ii) Substitutes a hydrogen atom of benzene

Conditions;

.....Presence of a halogen carrier like aluminium chloride;.....

Name of the product

.....Chlorobenzene.....

iii) Reacts with cyclohexene

Conditions;

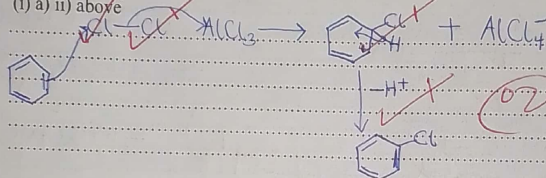.....Presence of carbon tetrachloride.....

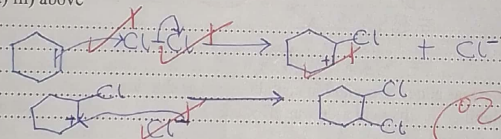Name of the product .....1,2-Dichlorocyclohexane.....

b) Outline the mechanism for the reaction in. (03marks)

(i) a) ii) above

(ii) a) iii) above

16. During the extraction of copper from copper pyrites, copper pyrites is crushed and agitated with water/oil mixture. Compressed air is bubbled through the mixture which is then filtered, roasted and finally impure molten copper is obtained.
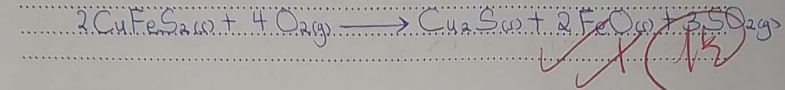
a) State the role of:

i) oil mixture ..... To wet the ore and make it float on the surface.

ii) compressed air. To agitate the mixture so as to form a froth and to (01 mark) raise it to the surface.

10

b) Write equation for the reaction that occurs when copper pyrites is roasted. (01$\frac{1}{2}$ marks)

$$2CuFeS_{2(s)} + 4O_{2(g)} \longrightarrow Cu_2S_{(s)} + 2FeO_{(s)} + 3SO_{2(g)}$$

c) Explain briefly how impure copper can be refined. (04 marks)

By electrolysis of Copper(II) sulphate solution using impure copper / blister copper anode and pure Copper cathode.

During electrolysis, the anode dissolves in the electrolyte into copper(II) ions

$$Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e$$

The copper(II) ions migrate to the cathode where they are reduced to pure copper leaving the impurities in the solution.

$$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)}$$

d) Explain why it is advantageous to have a sulphuric acid manufacturing plant near a copper extraction plant. (01½ marks)

The sulphur dioxide produced as a bi-product during roasting of copper pyrites in air is a raw-material in the manufacture of sulphuric acid.

THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
227 Ac 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

END