MARKING SCHEME

Candidate's Name: .....

Signature .....

P525/1

CHEMISTRY

Paper 1

2¾ hours

UGANDA ADVANCED CERTIFICATE OF EDUCATION

CHEMISTRY

Paper 1

2 hours 45 minutes

INSTRUCT NS TO CANDIDATES

- Answer **all** questions in Section A and **six** questions from Section B.
- All questions must be answered in the spaces provided.
- The periodic table, with relative atomic masses, is attached at the end of the paper.
- Where necessary, use the following;
  - *Molar gas constant,* R = 8.31JK^{-1} mol^{-1}.
  - *Molar volume of gas at s.t.p is* 22.4 litres.
  - *Standard temperature = 273* K.
  - *Standard pressure = 101325* NM^{-2}.

For Examiner's use only																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
04	05	4½	5½	06	3½	06	05	6½	09	09	09	09	09	09	09	09	

SECTION A (46 MARKS)

ANSWER ALL QUESTIONS IN THIS SECTION

1. (a) Bond energies for some bonds are given below;

Bond	Bond energy ($kjmol^{-1}$)
C=C	+813
C-C	+346
C-H	+413
H-H	+436

a) Calculate the enthalpy of hydrogenation of ethyne. (03amrks)

Required equation: $HC{\equiv}CH_{(g)} + 2H_{2(g)} \longrightarrow C_2H_{6(g)}$

$\Delta H_R = \sum B.E$ (for bonds broken) $+ \sum B.E$ (for bonds formed)

$= (2\times413 + 2\times436) + (-346 - 6(413))$ 0.2

$= -1126\ Kjmol^{-1}$

Accept: $\Delta H_R = \sum B.E$ (for bonds broken) $- \sum B.E$ for bonds formed

$= [2(413) + 2(436)] - [346 + 6(413)]$

$= -1126\ Kjmol^{-1}$

b) State whether hydrogenation of ethyne is feasible or not. (01 mark)

The reaction is feasible since the enthalpy of hydrogenation of ethyne is exothermic.

0

2. Complete the equation and write the accepted mechanism in each case.

$CH_3CH_2CH(OH)CH_3 \xrightarrow[180^0C]{Conc.\ H_2SO_4} CH_3C(H)=CHCH_3 + H_2O_{(l)}$ (2½ marks)

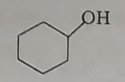
$H_2SO_4 \rightleftharpoons H^+ + HSO_3H$

$CH_3CH_2CH(OH)CH_3 \longrightarrow CH_3CH_2CH(OH_2)CH_3 \xrightarrow{-H_2O} CH_3C(H)\overset{+}{C}HCH_3$

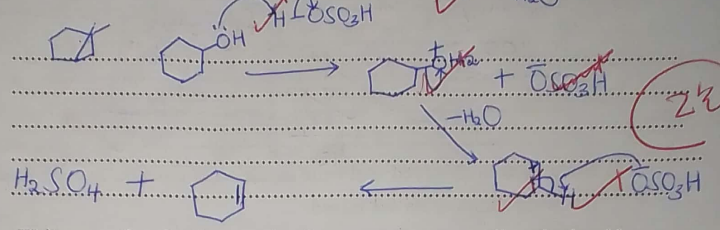
H^+ OSO_3H H

$CH_3C(H)=CHCH_3 + H_2SO_4$

2½

b) 

$\xrightarrow[heat]{Conc.\ H_2SO_4}$ + H_2O (2½ marks)



2½

3. Write equation for the reaction between aqueous sodium hydroxide solution and ;

a) Chromium(III) oxide

$Cr_2O_{3(s)} + 2\bar{O}H_{(aq)} + 3H_2O_{(l)} \rightarrow 2Cr(OH)_4^-{}_{(aq)}$

Accept: $Cr_2O_{3(s)} + 2\bar{O}H_{(aq)} \rightarrow 2CrO_{2(aq)}^- + H_2O_{(l)}$

b) Beryllium oxide

$BeO_{(s)} + 2\bar{O}H_{(aq)} \rightarrow BeO_{2(aq)}^{2-} + H_2O_{(l)}$

Accept: $BeO_{(s)} + 2\bar{O}H_{(aq)} + H_2O_{(l)} \rightarrow Be(OH)_{4(aq)}^{2-}$

1½

c) Sulphur (IV) oxide

$SO_{2(g)} + 2\bar{O}H_{(aq)} \rightarrow SO_{3(aq)}^{2-} + H_2O_{(l)}$

4. (a) Complete the following nuclear reactions and name the particle in each case. (03 marks)

i) $^{238}_{92}U + ^{1}_{0}n \longrightarrow ^{239}_{93}Pu + \underline{^{0}_{-1}e}$

Name of particle : Beta particle

ii) $^{241}_{95}AM + ^{4}_{2}He \longrightarrow ^{243}_{97}Bk + \underline{2\,^{1}_{0}n}$

Name of particle : Neutron particle

iii) $^{27}_{14}Si \longrightarrow ^{27}_{13}AL + \underline{^{0}_{+1}e}$

Name of the particle Positron particle

03

b) The mass of a radio isotope T, reduced by 32% in 40 days. Calculate the half life of T.

(2½ marks)

$\ln\left(\frac{N_0}{N_t}\right) = \lambda t$

$\ln\left(\frac{100}{100-32}\right) = 40\lambda$

$\lambda = \frac{\ln\left(\frac{100}{68}\right)}{40}$

$\lambda = 9.6416 \times 10^{-3}$ per day.

$t_{1/2} = \frac{\ln 2}{\lambda}$

$= \frac{\ln 2}{9.6416 \times 10^{-3}}$

$= 71.89$ days.

2½

5. State what is observed and write equation of reaction in each case when the following compounds are mixed.

(a) Methanoic acid and ammoniacal silver nitrate solution and heated.

(6½marks)

Observation

A silver mirror deposit is formed

02

Equation

$2Ag(NH_3)_2^+{}_{(aq)} + HCOOH_{(aq)} \rightarrow 2Ag_{(s)} + CO_{2(g)} + 4NH_{3(aq)} + 2H^+_{(aq)}$

Accept $HCOOH \xrightarrow{Ag(NH_3)_2^+} Ag_{(s)} + CO_{2(g)}$

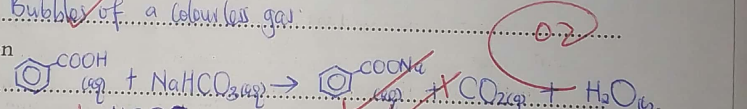
(b) Benzoic acid and sodium bicarbonate solution.

Observation

Bubbles of a colourless gas

02

Equation



Accept: $HCO_3^-{}_{(aq)} + 2H^+_{(aq)} \rightarrow CO_{2(g)} + H_2O$

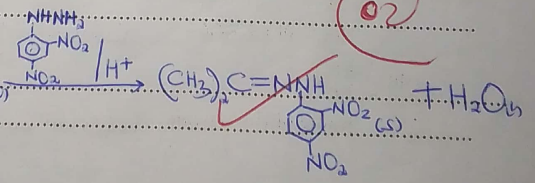
(c) propanone and Brady's solution

Observation

A yellow precipitate is formed

02

Equation



6. Calculate the PH of solution formed by mixing 80cm³ of 0.1M hydrochloric acid with 120cm³ of 0.1M potassium hydroxide.

1000cm³ of solution contain 0.1 moles of HCl

80cm³ of solution contain $\left(\frac{0.1 \times 80}{1000}\right) = 0.008$ moles

1000cm³ of solution contain 0.1 moles of KOH

120cm³ of solution contain $\left(\frac{0.1 \times 120}{1000}\right) = 0.012$ moles

$KOH_{(aq)} + HCl_{(aq)} \longrightarrow KCl_{(aq)} + H_2O_{(l)}$

mole ratio of HCl : KOH = 1:1

⇒ moles of KOH reacted = 0.008 mole

Excess moles of KOH = 0.012 − 0.008 = 0.004 moles

Total volume = 80 + 120 = 200cm³

200cm³ of solution contain 0.004 moles of KOH

1000cm³ of solution contain $\left(\frac{0.004 \times 1000}{200}\right)$

= 0.02M

$KOH_{(aq)} \longrightarrow K^+_{(aq)} + OH^-_{(aq)}$

$[OH^-] = 0.02M$

$pOH = -\log_{10}[OH^-]$

$= -\log_{10}(0.02) = 1.70$

⇒ pH = 14 − pOH

= 14 − 1.7 = 12.30

3½

7. (a) Write the

(i) equation for ionization of methanoic acid in water. (1½ marks)

$HCOOH_{(aq)} \rightleftharpoons H^+_{(aq)} + HCOO^-_{(aq)}$

1½

(ii) Expression for the constant Ka, for ~~methanoic~~ methanoic acid. (1½marks)

$K_a = \frac{[HCOO^-][H^+]}{[HCOOH]}$

1½

(b) The molar conductivity of 0.1M methanoic acid at 25°c is 16.25cm²mol⁻¹.

Calculate the;

(i) Degree of ionization of methanoic acid at 25°c. (molar conductivity of methanoic acid at infinite dilution at 25°c is 4055cm²mol⁻¹) (1½marks)

$\alpha = \frac{\Lambda_c(HCOOH)}{\Lambda_o(HCOOH)}$

$= \frac{16.25}{4055}$

$= 0.004007$

1½

(ii) Ionization constant, Ka, for methanoic acid at 25°c. (1½marks)

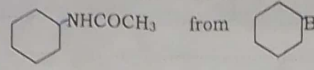
$K_a = C \cdot x^2$

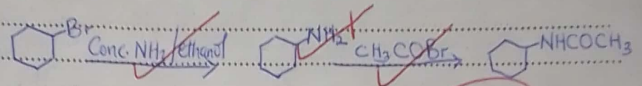
$= 0.1(0.00400)^2$

$= 1.6056 \times 10^{-6}$ mol/dm^3

1½

8. Write equation to show how the following conversions can be effected.

a)  from (2½ marks)



2½

b) CH_3COOH from $HC{\equiv}CH$ (2½marks)

$HC{\equiv}CH \xrightarrow[H_g SO_4, 60°C]{\text{Dilute } H_2SO_4} CH_3CHO \xrightarrow[heat]{MnO_4^-/H^+} CH_3COOH$

2½

9. Bauxite is the principal used in extraction of aluminum (a)

(i) Write the formula of Baluxite (01 mark)

$Al_2O_3 \cdot 2H_2O$

01

(ii) Name the impurities present in Bauxite (01 mark)

Iron(III) oxide

Silicon dioxide

01

(b) Bauxite was treated with concentrated sodium hydroxide solution. Write equation(s) for the reaction(s) that take place. (02 marks)

$Al_2O_{3(s)} + 2OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow 2Al(OH)^-_{4(aq)}$

$SiO_{2(s)} + 2OH^-_{(aq)} \longrightarrow SiO^{2-}_{4(aq)} + H_2O_{(l)}$

02

Accept: $Al_2O_{3(s)} + 2OH^-_{(aq)} \longrightarrow 2AlO^-_{2(aq)} + H_2O_{(l)}$

CamScanner

(c) The mixture in (b) was filtered and carbon dioxide was bubbled through the filtrate. State what is observed and write equation for the reaction.

(02 marks)

A white precipitate is formed

$2Al(OH)_4^-(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$

02

d) State one use of aluminium. (½ marks)

Used to make aluminium utensils

½

SECTION B (54 MARKS)

Answer six questions from this section

Any additional question(s) will not be marked

10. (a) 3.4g of an organic compound K, containing carbon, hydrogen and oxygen on complete combustion produced 5.04dm3 of carbon dioxide and 2.7g of water at s.t.p. calculate the empirical formula of K. (2½ marks)

Mass of $CO_2 = \frac{44}{22.4} \times 5.04$

$= 9.9g$

Mass of C $= \frac{12}{44} \times 9.9$

$= 2.7g$

Mass of $H_2 = \frac{2}{18} \times 2.7$

$= 0.3g$

Mass of $O_2 = 3.4 - (2.7 + 0.3)$

$= 0.4g$

Element :	C	H	O
Mass :	2.7	0.3	0.4
moles :	$\frac{2.7}{12}$	$\frac{0.3}{1}$	$\frac{0.4}{16}$
~~Mole ratio~~ =	0.225	0.3	0.025
mole ratio :	$\frac{0.225}{0.025}$	$\frac{0.3}{0.025}$	$\frac{0.025}{0.025}$
=	9	12	1

Empirical formula of K is $C_9H_{12}O$

2½

b) When K was steam distilled at 760mmHg and at 95°c the distillate contained 77.1% by mass of K. calculate the molecular formula of K. (The saturated vapour pressure of water at 95°c was 526mmHg). (03 marks)

Mass of K = $M_r K \cdot P_K$

Mass of H_2O $M_r H_2O \cdot P_{H_2O}$

$\frac{77.1}{(100-77.1)} = \frac{(760-526)M_r K}{(16+2)\times 526}$

$M_r K = \frac{77.1\times 526\times 18}{234\times 22.9} = 136$

$(C_9H_{12}O)_n = 136$

$(12\times 9+12+16)n = 136$

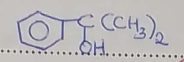
$n = \frac{136}{136}$

$n = 1$

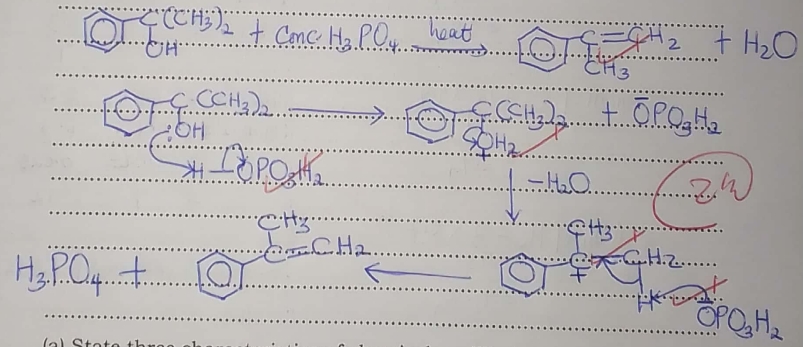
∴ Molecular formula of K is $C_9H_{12}O$

c) K burns with a sooty flame and reacts with sodium metal to produce a colorless gas that burns with a pop sound. When K was heated with acidified potassium chloromate solution, there was no observable change.

(i) Identify k (01 mark)



(ii) Write equation for the reaction and suggest a suitable mechanism when K was reacted with concentrated orthophosphoric acid. (2½ marks)



11. (a) State three characteristics of chemical equilibrium (1½ marks)

Occurs in a closed system

Occurs at constant temperature

It is dynamic.

(b) Phosphorous (v) chloride, when heated decomposed according to the following equation.

$PCl_5(g) \rightleftharpoons PCl_3 + Cl_2(g)$

i) Write the expression for the equilibrium constant, Kc at 350°c. (3½ marks)

$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]}$

02

ii) When 1 mole of phosphorus(v) chloride was heated in a closed vessel at 350°c, the equilibrium mixture was found to contain 38.4% of chlorine. Calculate the equilibrium constant, kc at 350°c. (3½marks)

	$PCl_5(g)$	$\rightleftharpoons$	$PCl_3(g)$	+	$Cl_2(g)$
Initial moles:	1 mole		0		0
If α dissociated:	−α		+α		+α
Equilibrium moles:	1−α		α		α
Equilibrium concentration: If V=1l	$\left(\frac{1-\alpha}{1}\right)$		$\alpha/1$		$\alpha/1$

But at equilibrium $\frac{100\alpha}{1-\alpha+\alpha+\alpha} = 38.4$

$\left(\frac{\alpha}{1+\alpha}\right) = \frac{38.4}{100}$

$= 0.384$

$\alpha = 0.62338$

$K_c = \frac{(0.62338)^2}{1+(0.62338)}$

$= 1.0318 \text{ mol}l^{-1}$

5½

iii) The equilibrium constant at 350°c is 1.54, state whether the reaction is exothermic or endothermic. Give a reason for your answer. (1½ marks)

Ignore! marks Transfered

c) State what would happen to the concentration of chlorine if the pressure in the vessel was decreased while the temperature is maintained at 350°c. give a reason for your answer. (1½ marks)

The concentration of chlorine would ~~to~~ increase. This is because the

0

forward reaction occurs with increase in volume. 01/2

12. Sodium, silicon and aluminium belong to period 3 of the periodic table. State the type of bonding and structure adopted by of the chloride of the elements.

(03 marks)

Formula of chloride	Bonding	Structure
NaCl	Ionic bonding	Giant ionic structure
$SiCl_4$	Covalent bonding	Simple molecular structure
$AlCl_3$	~~Iondi~~ Ionic bonding	Giant ionic structure

03

b) Write equation of reaction that takes place when the chlorides are reacted with water.

(03 marks)

(i) Sodium chloride

$NaCl_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

(ii) Aluminium chloride

$AlCl_{3(aq)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3HCl_{(aq)}$ 02

Accept: $Al(H_2O)^{3+}_{6(aq)} + 3H_2O_{(l)} \longrightarrow Al(H_2O)_3(OH)_{3(s)} + 3H_3O^+_{(aq)}$

(iii) Silcon (IV) chloride

SiO $SiCl_{4(l)} + 2H_2O_{(l)} \longrightarrow SiO_{2(s)} + 4HCl_{(aq)}$

c) State what would be observed when aqueous sodium carbonate is added to an aqueous solution of aluminum chloride and write equation of reaction that takes place.

(03 marks)

observation

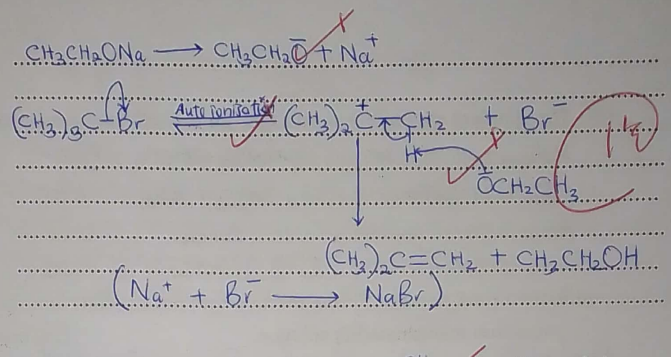
A white precipitate is formed with effervescence of a colourless gas. 1½

Equation

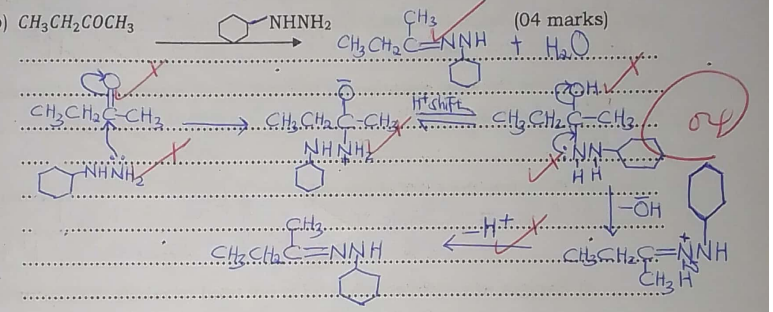
$2Al^{3+}_{(aq)} + 3CO^{2-}_{3(aq)} + 3H_2O_{(l)} \longrightarrow 2Al(OH)_{3(s)} + 3CO_{2(g)}$ 1½

13. Complete the following and write mechanism for the reaction in each case.

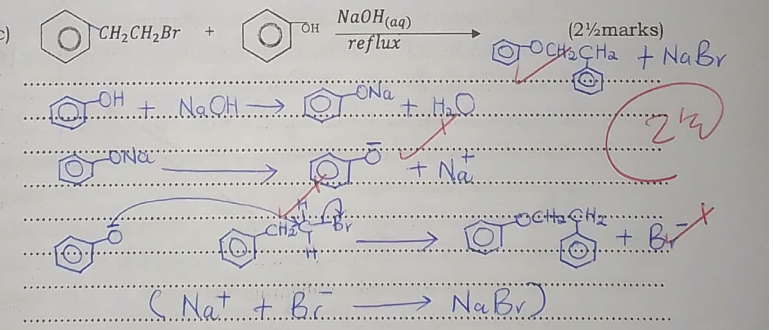
a) $(CH_3)_3CBr \xrightarrow[heat]{CH_3CH_2O^-Na^+ \text{ ethanol}} (CH_3)_2C{=}CH_2 + NaBr$ 01



b) $CH_3CH_2COCH_3$ (04 marks)



c) (2½marks)



14. The standard electrode potentials, Eθ for half-cell reactions are given below

$MnO_{4(aq)}^{-} + 8H^{+}(aq) + 5e^{-} \longrightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$ +1.52

$SO_{4(aq)}^{2-} + 2H^{+}(aq) + 2e^{-} \longrightarrow SO_{3(aq)}^{2-} + H_2O_{(l)}$ + 0.20

$Br_{2(aq)} + 2e \longrightarrow 2Br^{-}_{(aq)}$ +1.06

$Cl_{2(aq)} + 2e \longrightarrow 2Cl^{-}_{(aq)}$ +1.36

a) Write the cell notation for the reaction between sulphate ions and acidified potassium manganate(Vii) solution. (1½ marks)

$Pt_{(s)} / SO_{3(aq)}^{2-}, SO_{4(aq)}^{2-}, H^{+}_{(aq)} // MnO_{4(aq)}^{-}, H^{+}_{(aq)}, Mn^{2+}_{(aq)} / Pt_{(s)}$

01½

b) Write the ionic equation for the overall cell reaction (1½ marks)

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

01½

c) C ulate the e.m.t of the cell (1½ marks)

$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$

$= 1.52 - 0.2$

$E^{\theta}_{cell} = +1.32V$

1½

d) Explain why hydrochloric acid is not used to acidify titrants in volumetric analysis involving potassium manganate (VII). (2½ marks)

The manganate(VII) ions in potassium manganate(VII) oxidize chloride ions in hydrochloric acid to chlorine which is also an oxidizing agent and its colour interferes with the colour at the end point

$2MnO_{4(aq)}^{-} + 8H^{+}_{(aq)} + 5Cl^{-}_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 5Cl_{2(g)} + 8H_2O_{(l)}$

2½

e) State which of bromine and chlorine a stronger oxidizing agent is and give a reason for your answer. (01 mark)

Chlorine is a stronger oxidizing agent than bromine. This is because Chlorine has a more positive value of standard electrode potential than bromine.

01

15. (a) Write the electronic configuration of copper. (01 mark)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

01

(ii) State three properties which show copper as a d-block element. (1½marks)

Has Variable oxidation states

Forms Complexes ~~ions~~

Forms Coloured Compounds

1½

b) Excess ammonia was shaken with equal volume of trichromethane and a 0.05M aqueous solution of copper(ii) sulphate and allowed to stand. Some ammonia reacted with copper(II) ions to form a complex, $[CU[NH_3]n]^{2+}$

At equilibrium, the concentration of ammonia in the trihalomethane and in the aqueous layers were 0.021 moldm^{-3} and 0.725 moldm^{-3} respectively. (The partition coefficient KD1 of ammonia between water and trihalomethane is 25)

Calculate;

i) The concentration of ammonia in the aqueous layer (1½marks)

$K_D = \frac{[NH_3]_{free\ in\ aqueous\ layer}}{[NH_3]_{in\ organic\ layer}}$

$25 = \frac{[NH_3]_{free}}{0.021}$

$[NH_3]_{free} = 25 \times 0.021$

$= 0.525\ Moldm^{-3}$

1½

ii) The concentration of ammonia that formed the complex with copper. (1½marks)

$[NH_3]_{complexed} = [NH_3]_{total} - [NH_3]_{free}$

$= 0.725 - 0.525$

$= 0.2\ moldm^{-3}$

1½

iii) The value of n in the complex. (2½marks)

0.05 moles of Cu^{2+} complex with 0.2 moles of NH_3

1 mole of Cu^{2+} complex with $\left(\frac{0.2}{0.05}\right)$ moles

$= 4$

$\Rightarrow n = 4$

2½

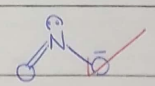
c) State any two uses of copper. (01 mark)

Used to make copper coins

Used to make electric wires

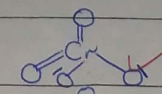
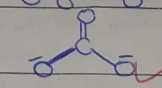
01

16. (a) Draw the structure and name the shapes of the following oxyanions. (4½ marks)

Oxyanion	Structure	Name of Shape
NO_2^-		Bent shape

V-shaped

1½

CrO_4^{2-}		Tetrahedral shape.
CO_3^{2-}		Trigonal planar

03

(c) Write equation for the reaction of ;

(i) NO_2^- with acidified potassium dichromate solution (1½ marks)

$3NO_{2(aq)}^- + Cr_2O_{7(aq)}^{2-} + 8H_{(aq)}^+ \longrightarrow 3NO_{3(aq)}^- + 2Cr_{(aq)}^{3+} + 4H_2O_{(l)}$

(ii) CrO_4^{2-} with dilute hydrochloric acid. (1½ marks)

$2CrO_{4(aq)}^{2-} + 2H_{(aq)}^+ \longrightarrow Cr_2O_{7(aq)}^{2-} + H_2O_{(l)}$

(iii) CO_3^{2-} with water. (1½ marks)

$CO_{3(aq)}^{2-} + 2H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + 2OH_{(aq)}^-$

4½

17. Bo hlorine and sodium hydroxide are manufactured by electrolysis of concentrated sodium chloride solution.

a) Name the substance used as the;

i) Cathode

Mercury

ii) Anode

Graphite

Accept : ~~Platinum~~ Titanium.

b) Write the equation(s) for the reaction(s) leading to the formation of.

i) Chlorine (01 mark)

$2Cl_{(aq)}^- \longrightarrow Cl_{2(g)} + 2e$

ii) Sodium hydroxide

$2NaHg_{(l)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + 2Hg_{(l)} + H_{2(g)}$

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c) State what would be observed and write the equation for the reaction that would take place if chlorine is bubbled through; (02 marks)

(i) sodium iodide solution

A colourless solution turns to a brown solution.

$Cl_{2(g)} + 2I^-_{(aq)} \longrightarrow 2Cl^-_{(aq)} + I_{2(aq)}$ 02

ii) Concentrated sodium hydroxide solution. (02 marks)

A greenish-yellow gas dissolves forming a colourless solution.

$3Cl_{2(g)} + 6OH^-_{(aq)} \longrightarrow 5Cl^-_{(aq)} + ClO_3^-{}_{(aq)} + 3H_2O_{(l)}$ 02

d) Give a reason for your answer in (c) (i) (01 mark)

Chlorine is more reactive than iodine. Therefore, chlorine oxidises iodide ions to iodine and itself reduced to chloride ions. 01

Reg: chlorine displaces iodine

END

f)

18.

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