Candidate's Name: MUNICEL .....

Signature: .....

Random No.					Personal No.		

(Do not write your School/Centre Name or Number anywhere on this booklet.)

P525/1
CHEMISTRY
(Theory)
Paper 1
Nov. /Dec. 2019.
2¾ hours.

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

CHEMISTRY

(THEORY)

Paper 1

2 hours 45 minutes

INSTRUCTIONS TO CANDIDATES:

Answer **all** *questions in Section* **A** *and* **six** *questions in Section* **B.**

All questions **must** *be answered in the spaces provided.*

The Periodic Table, with relative atomic masses, is supplied.

Mathematical tables (3-figure tables) are adequate or non-programmable scientific electronic calculators may be used.

Illustrate your answers with equations where applicable.

Where necessary use the following:

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

For Examiners' Use Only																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
4	6½	5	5	5	5½	4½	6	4½	9	9	9	9	9	9	9	9	100%

SECTION A (46 MARKS)

Answer **all** *questions from this section.*

1. (a) Complete the following nuclear reaction equations.

(i) $^{27}_{13}Al + {}^{4}_{2}He \longrightarrow {}^{30}_{15}P + {}^{1}_{0}n$. *(01 mark)*

(ii) $^{113}_{48}Cd + {}^{1}_{0}n \longrightarrow {}^{114}_{48}Cd + \gamma$. *(01 mark)*

(iii) $^{233}_{91}Pa \longrightarrow {}^{233}_{92}U + {}^{0}_{-1}e$. *(01 mark)*

(iv) $^{7}_{3}Li + {}^{1}_{1}H \longrightarrow {}^{4}_{2}He + {}^{4}_{2}He$. *(01 mark)*

2. State what would be observed and write equation(s) for the reaction(s) that would take place to a solution of iron(II) sulphate when;

(a) aqueous sodium hydroxide was added drop-wise until in excess and the mixture was allowed to stand. *(3½ marks)*

Green precipitate insoluble in excess sodium hydroxide turns brown on standing.

$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Fe(OH)_{2(s)}$

$4Fe(OH)_{2(s)} + O_{2(g)} + 2H_2O_{(l)} \longrightarrow 4Fe(OH)_{3(s)}$

$2Fe(OH)_{2(s)} + \frac{1}{2}O_{2(g)} \longrightarrow Fe_2O_3 \cdot 2H_2O_{(s)}$

(b) a few drops of concentrated sulphuric acid was added followed by concentrated nitric acid and the mixture was boiled. *(03 marks)*

Green solution turns brown/yellow and brown fumes given off or accept bubbles of a colourless gas

$3Fe^{2+}_{(aq)} + NO_3^-{}_{(aq)} + 4H^+_{(aq)} \longrightarrow 3Fe^{3+}_{(aq)} + 2H_2O_{(l)} + NO_{(g)}$

or $Fe^{2+}_{(aq)} + NO_2^-{}_{(aq)} + 2H^+_{(aq)} \longrightarrow Fe^{3+}_{(aq)} + NO_{2(g)} + H_2O_{(l)}$

or $6Fe^{2+}_{(aq)} + 8H^+_{(aq)} + 2NO_3^-{}_{(aq)} + O_{2(g)} \longrightarrow 6Fe^{3+}_{(aq)} + 4H_2O_{(l)} + 2NO_{(g)}$

or $Fe^{2+}_{(aq)} + H^+_{(aq)} + HNO_{3(aq)} \longrightarrow Fe^{2+}_{(aq)} + NO_{2(g)} + H_2O_{(l)}$.

3. A hydrocarbon Z, with molecular formular C_xH_y, reacts with oxygen according to the following equation:

$$C_xH_y + (x + \frac{y}{4})O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O.$$

When 20 cm^3 of Z was exploded in 200 cm^3 of an excess amount of oxygen, it burnt completely with a sooty flame. The volume of the residual

gas after cooling to room temperature was 160 cm^3.
When aqueous potassium hydroxide was added, the volume of the gas that finally remained was 20 cm^3.

(a) Calculate the molecular formula of *Z*. *(2½ marks)*

Volume of CO_2 formed = x X volume of C_xH_y used

$200 = 140$ ✓ $x = 140/2$; $x = 7$ ✓

Volume of oxygen used = $(200 - 120) = 180\ cm^3$.

$180 = 20(x + y/4)$ ✓

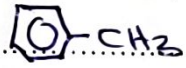
$200x + 5y = 180$

$y = 8$ ✓ (2½)

Molecular formular is C_7H_8 ✓

award if a(i) is correct.

(b) When Z was treated with bromine in the presence of iron(III) bromide, the bromine was decolorised. Identify *Z*. *(01 mark)*

 CH_3 or $C_6H_5CH_3$ or Methylbenzene ✓

ref: Toluene; Methyl benzene

(c) Write equation(s) to show how *Z* can be synthesized from ethyne. *(1½ marks)*

$3\,HC{\equiv}CH \xrightarrow[60-70^oC \text{ or Heat}]{\text{Organonickel}}$  $\xrightarrow{CH_3Br\,/\,FeBr_3}$  $-CH_3$.

3 ✓ Ignore Accept Cu or Fe, 400 - 600°C ✓ $FeCl_3$ or $AlCl_3$ or $AlBr_3$.

4. The data in the Table 1 was obtained for the reaction between an alkylhalide, *R* and sodium hydroxide solution.

Table 1

Experiment	[R] (mol dm^{-3})	[$\bar{O}H$] (mol dm^{-3})	Rate (mol dm^{-3} s^{-1})
1	0.100	0.50	2.0×10^{-3}
2	0.100	0.25	2.0×10^{-3}
3	0.050	0.25	1.0×10^{-3}
4	0.025	0.25	5.0×10^{-4}

(a) Determine the order of the reaction with respect to:

(i) Alkyl halide, *R*. *(01 mark)*

- Allow logical flow.
- keep the comparison between the two reactants.

Using experiments 2 and 3

$2.0 \times 10^{-3} = K(0.1)^x(0.25)^y$ ✓

$1.0 \times 10^{-3} = K(0.05)^x(0.25)^y$

$2^x = 2$; $x = 1$ ✓

or Keeping concentration of hydroxyl ions constant and halving the concentration of R, the rate is halved. Therefore the reaction is first order.

Turn Over

(ii) Sodium hydroxide. **(01 mark)**

$2.0\times10^{-3} = K(0.1)^x(0.5)^y$ ✓+

$2.0\times10^{-3} = K(0.1)^x(0.25)^y$

$2^y = 1 \therefore y = 0$ ✓+

(b) Write the rate equation for the reaction. **(01 mark)**

Rate $= K[RJ^1[OH]^0$ ✓ (1)

Accept Rate $= K[RJ^1$

(c) (i) State the class of the alkylhalide. **(01 mark)**

Tertiary alkylhalide ✓ (1) spelling

reject: 3^0

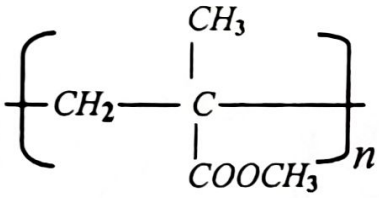
reject: y (a) is wrong

(ii) Give a reason for your answer in (c)(i). **(01 mark)**

The rate of reaction only depends on the concentration ✓+ of alkylhalide and independent ✓+ (01) of the concentration of hydroxide ion.

emphasise concentration.

5. (a) Perspex is a synthetic polymer with a structure; [05]



(i) Name the type of reaction that leads to the formation of perspex. **(½ marks)**

Accept: Addition reaction.

✓+ Addition polymerisation reject: Additional

(ii) Write the structure of the monomer of perspex. **(01 mark)**

$H_2C=C(CH_3)COOCH_3$ ✓ (1)

(b) When 1.25×10^{-3} moles of perspex were heated strongly with silicon(IV) oxide as a catalyst, 4.85 g of the monomer was produced. Calculate the;

(i) value of *n*. **(02 marks)**

1.25×10^{-3} moles of polymer produce 4.85g monomer

1 mole of polymer $= \left(\frac{4.85}{1.25\times10^{-3}}\right)$ ✓+ $= 3880$ g. ✓+ (02)

Rfm of monomer $= (12\times5)+(8\times1)+(2\times16) = 100$ ✓+

$n = \left(\frac{3880}{100}\right) = 39$ ✓+

reject: 38.8

— Accept alternative working logic

mass of Perspex $= \left(\frac{4.85}{1.25 \times 10^{-3}}\right) = 3880$.

(ii) molar mass of perspex. *(01 mark)*

Molar mass of Perspex $= (39 \times 100) = 3900_g$ ✓ (01)

Accept $(38.8 \times 100) = 3880$

(b) State one use of perspex. *(½ mark)* reg: glasses.

- aeroplane window ✓
- safety windscreen; optical lenses; corrugated roof lights (½)

[05

6. (a) When manganese(II) nitrate was heated, a black solid *R*, was formed.

Write equation for the reaction that took place. *(1½ marks)*

$Mn(NO_3)_{2(s)} \longrightarrow MnO_{2(s)} + 2NO_{2(g)}$ ✓ ✓ (1½)

(b) *R* was heated with excess potassium hydroxide:

emphasize green liquid.

(i) State what was observed. *(01 mark)*

Black solid dissolves to form green solution/liquid (1)

(ii) Write equation for the reaction that took place. *(1½ marks)*

$2MnO_{2(s)} + 4KOH_{(aq/l)} + O_{2(g)} \longrightarrow 2K_2MnO_{4(l)} + 2H_2O_{(g)}$ ✓ ✓

$2MnO_{2(s)} + 4OH^-_{(aq/s)} + O_{2(g)} \longrightarrow 2MnO_4^{2-}{}_{(l)} + 2H_2O_{(g)}$ reg: (l).

(c) To the mixture in (b), chlorine gas was bubbled. Write equation for the reaction that took place. *(1½ marks)*

$MnO_4^{2-}{}_{(l)} + \frac{1}{2}Cl_{2(g)} \longrightarrow MnO_4^-{}_{(l)} + Cl^-_{(l)}$ ✓ ✓

emphasize states on wires reg: (g)

[05½

7. The standard electrode potentials for some redox systems are shown below.

$Fe\,O_4^{2-}{}_{(aq)} + 8H^+_{(aq)} + 3e^- \rightarrow Fe^{3+}_{(aq)} + 4H_2O_{(l)} \quad E^0 = +2.20\ V$

$O_{2\,(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)} \quad E^0 = +1.23\ V$

(a) Write: accept !!

(i) The cell notation for the cell formed when the half cells are combined. *(01 mark)*

$Pt_{(s)} | H_2O_{2(l)}, H^+_{(aq)} | O_{2(g)} \| FeO_4^{2-}{}_{(aq)}, H^+_{(aq)}, Fe^{3+}_{(aq)} | Pt_{(s)}$ ✓

$Pt_{(s)} | H_2O_{2(l)}, H^+_{(aq)} | O_{2(g)} \| FeO_4^{2-}{}_{(aq)}, H^+_{(aq)}, Fe^{3+}_{(aq)}, H_2O_{(l)} | Pt_{(s)}$

(ii) The overall equation for the reaction. *(1½ marks)*

$4FeO_4^{2-}{}_{(aq)} + 20H^+_{(aq)} \longrightarrow 4Fe^{3+}_{(aq)} + 3O_{2(g)} + 10H_2O_{(l)}$ ✓ ✓

(b) (i) Calculate the e.m.f. of the cell in (a). *(01mark)*

$E_{cell} = E^{\ominus}_{right} - E^{\ominus}_{left}$ ✓ ①

$= +2.20 - +1.23$ ✓ $= +0.97V$ ✓ (reference +)

(ii) State whether the cell reaction in (a)(ii) is feasible or not. Give a reason for your answer. *(01 mark)*

Reaction is feasible ✓ because emf is positive ✓ (when +ve has been shown above).

8. Write equation(s) to show how the following conversions can be effected:

(a) CH_3CH_2CHO to $CH_3CH_2NH_2$ *(3½ marks)*

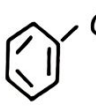
$CH_3CH_2CHO \xrightarrow[\text{Heat}]{H^+ | Cr_2O_7^{2-}} CH_3CH_2COOH$ ✓✓✓

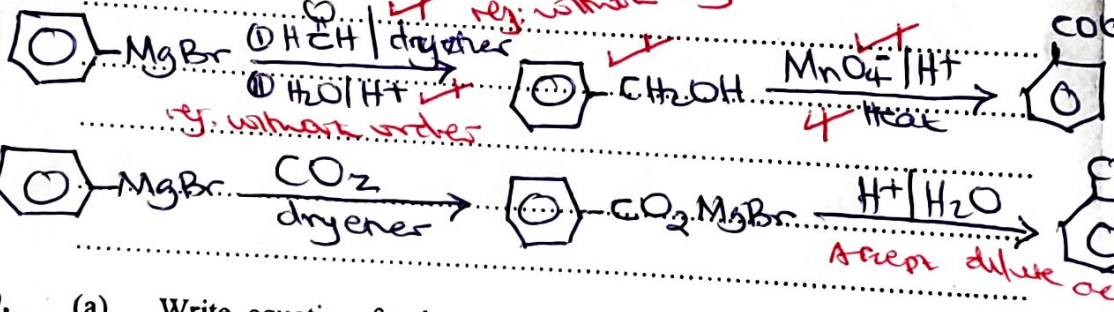
$CH_3CH_2COOH \xrightarrow[\text{Heat}]{(NH_4)_2CO_3(s)} CH_3CH_2CONH_2$ ✓✓ ③½

reject (s) if missing

$CH_3CH_2CONH_2 \xrightarrow[\text{warm}]{Br_2 | \text{Conc. } NaOH} CH_3CH_2NH_2$ ✓✓

reject: Heat or reflux.

(b)  to  *(2½ marks)*



9. (a) Write equation for the reaction between fluorine and;

(i) water. *(1½ marks)*

$2F_{2(g)} + 2H_2O_{(l)} \longrightarrow 4HF_{(aq)} + O_{2(g)}$ ✓✓

accept: molecular equations.

(ii) hot concentrated sodium hydroxide. *(1½ marks)*

$2F_{2(g)} + 4\bar{O}H_{(aq)} \longrightarrow O_{2(g)} + 4F^-_{(aq)} + 2H_2O_{(l)}$ ✓✓

05½

$CH_3CH_2COOH \xrightarrow{SOCl_2} CH_3CH_2COCl \xrightarrow{\text{Conc. } NH_3} CH_3CH_2CONH_2$ ✓✓✓

$CH_3CH_2COOH \xrightarrow[\text{Heat}]{\text{Soda lime}} CH_3CH_3 \xrightarrow[SO_2Cl_2;\ 40-80^oC]{\text{dibenzoyl peroxide}} CH_3CH_2Cl$

accept $CaO_{(s)} | NaOH_{(s)}$ or Ca reject: without states.

reject: excess excess without

excess alcoholic NH_3

$CH_3CH_2CONH_2$

(b) Although fluorine is an element in group(VII) of the Periodic Table, it behaves differently from the other members of the group.

State **three** reasons why fluorine behaves differently from the other members. *(1½ marks)*

- Fluorine atom has the largest electronegativity
- Fluorine molecule has the lowest bond dissociation energy
- Fluorine atom has the smallest atomic radius.
- Fluorine atom lacks vacant d-orbitals

SECTION B (54 MARKS)

Answer **six** *questions from this section. Any additional question(s) answered will* **not** *be marked.*

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

(a) $(CH_3)_3C-Br \xrightarrow[CH_3CH_2\,OH/\,heat]{CH_3CH_2\bar{O}\,Na^+}$ ..... *(03 marks)*

Mechanism: $(CH_3)_3C-Br \rightleftharpoons (CH_3)_3\overset{+}{C} + Br^-$

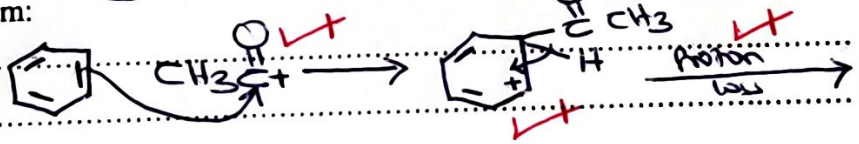
$H_2C-\overset{CH_3}{\overset{|}{C}}+ \longrightarrow H_2C=\overset{CH_3}{C}$

$CH_3CH_2\bar{O}: + H \rightarrow CH_3CH_2OH$

(b)  + $CH_3COCl \xrightarrow{AlCl_3}$ ..... *(03 marks)*

$CH_3COCl + AlCl_3 \longrightarrow CH_3\overset{O}{\overset{\|}{C}}{}^+ + AlCl_4^-$

Mechanism:



(c) $HC\equiv CH \xrightarrow[(2)\ CH_3CH_2\,Br]{(1)\ Na/NH_3(l)}$ ..... *(03 marks)*

Mechanism:

$HC\equiv CH + Na \longrightarrow HC\equiv CNa + \frac{1}{2}H_2$

$CH_3CH_2-Br \longrightarrow CH_3CH_2C\equiv CH$

$:\bar{C}\equiv CH$

11. Table 2 shows acid dissociation constants, *Ka*, for some acids at 25°C.

Table 2

Acid	Ka (mol dm^{-3})
$H-COOH$	1.70×10^{-4}
CH_3COOH	1.70×10^{-5}
CH_3CH_2COOH	1.35×10^{-5}

(i) State the trend in acid strength of the acids in Table 2. (*01 mark*)

decreases down the table or group

Acidic strength increases from propanoic acid to ethanoic acid to methanoic acid. (½)

Accept $HCOOH > CH_3COOH > CH_3CH_2COOH$

(ii) Explain your answer in (a)(i). (*03 marks*)

The strength of an acid depends on the ease of release of proton. The strength of the oxygen-hydrogen bond increases with increasing number of carbon atoms in the alkyl group attached on the carbonyl group. This is because alkyl groups have a positive inductive effect which decreases the polarity of the oxygen-hydrogen bond. Methanoic acid has a hydrogen atom instead of an alkyl group attached to the carbonyl group and it has no inductive effect, hence the oxygen-hydrogen bond is weakest. (2½)

- Award ½ each correct

(b) Calculate the pH of a 0.5 M CH_3CH_2COOH solution. (*1½ marks*)

$Ka = \frac{[H^+]^2}{c}$; $H^+ = \sqrt{(1.35\times10^{-5}\times0.5)} = 2.598\times10^{-3}M$

$pH = -\log[H^+]$; $pH = -\log(2.598\times10^{-3}) = 2.58$ (1½)

(c) (i) 45.0 cm^3 of a solution in (b) was mixed with 35.0 cm^3 of a 0.5 M potassium hydroxide solution. Calculate the change in pH of the solution. (*2½marks*)

Moles $KOH = \left(\frac{0.5\times35}{1000}\right) = 0.0175$ moles

$[SALT] = \left(\frac{0.0175\times1000}{80}\right) = 0.21875M$

Moles Propanoic acid $= \left(\frac{0.5\times45}{1000}\right)$

$= 0.0225$ moles.

Moles of excess acid $= (0.0225 - 0.0175)$

$= 0.005$ moles

$[ACID] = \left(\frac{0.005\times1000}{80}\right) = 0.0625M$

$[H^+] = Ka\frac{[ACID]}{[SALT]}$ (04)

$= \left(\frac{1.35\times10^{-5}\times0.0625}{0.21875}\right)$

$= 3.857\times10^{-6}M$

$pH = -\log[H^+]$

$pH = -\log(3.857\times10^{-6})$

$= 5.41$

pH change $= (5.41 - 2.58) = 2.83$.

(ii) Predict the effect of adding **two** drops of dilute hydrochloric acid to the solution in (c)(i). *(01 mark)*

No change in pH. ✓ (½) [09.

12. (a) The atomic number of aluminium is 13.

Write the;

(i) electronic configuration of aluminium. *(01 mark)*

$1s^2 2s^2 2p^6 3s^2 3p^1$ ✓ (1)

(ii) formula of the chloride of aluminium. *(01 mark)*

$AlCl_3$ ✓ (1)

(b) Write equation for the reaction between aluminium chloride and;

(i) water. *(1½ marks)*

$AlCl_{3(s/aq)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3HCl_{(aq)}$ ✓ ✓ (1½)

$Al^{3+}_{(s/aq)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3H^+_{(aq)}$.

(ii) excess ammonia solution. *(1½ marks)*

$Al^{3+}_{(aq/s)} + 3\bar{O}H_{(aq)} \longrightarrow Al(OH)_{3(s)}$ ✓ ✓ (1½)

$AlCl_{3(s)} + 3NH_{3(aq)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3NH_4Cl$.

(iii) excess sodium hydroxide solution. *(03 marks)*

$Al^{3+}_{(aq)} + 3\bar{O}H_{(aq)} \longrightarrow Al(OH)_{3(s)}$ ✓

$Al(OH)_{3(s)} + \bar{O}H_{(aq)} \longrightarrow Al(OH)_4^-{}_{(aq)}$ ✓ (03)

(c) Name **one** reagent that can be used to distinguish between aluminium and lead(II) ions in solution. *(01 mark)*

Potassium iodide solution. ✓ (1)

Acc; without solution.

Accept: ~~Ammonia solution followed by excess solution~~

- Ammonia solution followed by excess.
- dilute HCl or H_2SO_4
- Any soluble chloride / sulphate.

13. Name **one** reagent that can be used to distinguish between the following pairs of compounds. In each case, state what would be observed if each member of the pair is separately treated with the reagent you have named.

(a) $CH_3COOCH_2CH_3$ *and* CH_3CH_2COOH. **(03 marks)**

Sodium carbonate solution or sodium hydrogen carbonate solution. ✓ (accept solid.)

$CH_3COOCH_2CH_3$ - No observable change. ✓

CH_3CH_2COOH - Bubbles of a colourless gas. ✓ (03)

- Accept sodium / calcium / potassium / magnesium metal.

(b) $HO-\overset{\overset{O}{\|}}{C}-H$ and $HO-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-OH$ **(03 marks)**

Ammoniacal silver nitrate solution ✓

$HO-\overset{\overset{O}{\|}}{C}-H$ - silver mirror ✓

$HO-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-OH$ No observable change. ✓ (03)

accept Fehling solution $HCOOH$ - Reddish brown ppt.
$HOOCCOOH$ - No observable change.

(c) $C_6H_5CH_2I$ and $H_3CC_6H_4I$. **(03 marks)**

Hot sodium hydroxide solution followed by nitric acid and silver nitrate solution. ✓

$C_6H_5CH_2I$ - Yellow precipitate ✓

$H_3CC_6H_4I$ - No observable change. ✓ (03)

Accept: Hot sodium hydroxide and silver nitrate solution.

14. (a) Define the term **molar conductivity**. **(01 mark)**

:- Electrolytic conductivity divided by concentration. ✓ (1)

or $\Lambda_c = \frac{K}{C}$ where Λ_c - Molar conductivity
K - electrolytic conductivity
C - concentration.

reg without defining terms

- Accept alternative definitions which are correct.

(b) (i) **Sketch a graph to show the variation of molar conductivity of sodium chloride with dilution.** ***(02 marks)***

- should not start from the origin.

02

(ii) **Explain the shape of the graph in (b)(i).** ***(2½ marks)***

- Molar conductivity increases with increase in dilution and reaches a constant value at infinite dilution because molarity of ions increases since ions get far apart and ionic interference gets reduced. At infinite dilution, ionic interference has been eliminated and further dilution results in no change in molar conductivity.

03

(c) The electrolytic conductivity of a saturated solution of silver chloride at 25°C is $1.5\times10^{-4}\ \Omega^{-1}m^{-1}$. The molar conductivities at infinite dilution of silver and chloride ions are 6.2×10^{-3} and $7.7 \times 10^{-3}\ \Omega^{-1}m^2\ mol^{-1}$ respectively.

Determine the solubility of silver chloride at 25 °C. ***(3½ marks)***

$\Lambda_{o AgCl} = \Lambda_{o Ag^+} + \Lambda_{o Cl^-}$ reg: without infinite symbols.

$= 6.2\times10^{-3} + 7.7\times10^{-3} = 1.39\times10^{-2}\ \Omega^{-1}m^2mol^{-1}$

$C = \frac{K}{\Lambda_o} = \frac{1.50\times10^{-4}}{1.39\times10^{-2}} = 1.079\times10^{-2}\ mol\,dm^{-3}$

03

$C = \left(\frac{1.079\times10^{-2}}{1000}\right) = 1.079\times10^{-5}\ mol\,dm^{-3}$.

or $C = \frac{10^{-3}K}{\Lambda_o} = \frac{1.54\times10^{-4}\times10^3}{1.39\times10^{-2}} = 1.079\times10^{-5}\ mol\,dm^{-3}$.

or: $K_{solution} = K_{solute} + K_{solvent}$.

$K_{AgCl} = (1.50\times10^{-4} - K_{water})$

$\Lambda_o = \frac{10^{-3}K_{AgCl}}{C}$; $C = \frac{10^{-3}(1.50\times10^{-4} - K_{water})}{1.39\times10^{-2}}$.

15. **Cobalt(II) nitrate dissolves in water to form a pink solution and decomposes on heating to form a green solid.**

(a) **Write equation to show the effect of heat on cobalt(II) nitrate.** **(1½ marks)**

$2Co(NO_3)_{2(s)} \longrightarrow 2CoO_{(s)} + 4NO_{2(g)} + O_{2(g)}$ ✓✓

(b) **State what would be observed and write equation for the reaction that would take place when the following substances are added to the solution of cobalt(II) nitrate in water.**

(i) **Concentrated hydrochloric acid.** **(02 marks)**

The solution turns from pink to blue ✓✓

$Co^{2+}_{(aq)} + 4Cl^-_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)}$ ✓✓

or $Co(H_2O)_6^{2+}{}_{(aq)} + 4Cl^-_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)} + 6H_2O_{(l)}$

(ii) **Aqueous ammonium thiocyanate solution.** **(02 marks)**

Pink solution turns blue ✓✓

$Co^{2+}_{(aq)} + SCN^-_{(aq)} \longrightarrow Co(SCN)^+_{(aq)}$ ✓✓

$Co^{2+}_{(aq)} + 2SCN^-_{(aq)} \longrightarrow Co(SCN)_{2(aq)}$

(iii) **Aqueous sodium hydroxide.** **(3½ marks)**

Blue precipitate turns brown/pink on standing ✓✓

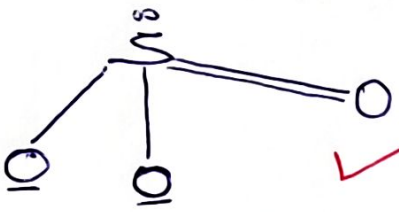
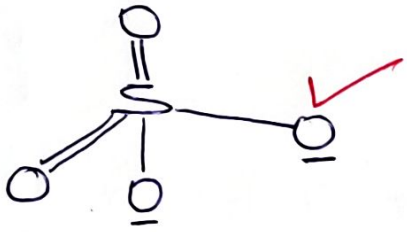
$Co(H_2O)_6^{2+}{}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Co(OH)_{2(s)} + 6H_2O_{(l)}$ ✓✓

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

$4Co(OH)_{2(s)} + O_{2(g)} \longrightarrow 2Co_2O_3 \cdot 2H_2O_{(s)}$ ✓✓

09

16. (a) (i) Draw the structure and name the shape of the following oxyanions. *(04 marks)*

Oxyanion	Structure	Shape
SO_3^{2-}		Trigonal Pyramidal ✓ ✓
SO_4^{2-}		Tetrahedral. ✓ ✓

allow delocalised structures.

(ii) Explain the structure of the SO_3^{2-} ion. *(1½ marks)* ✓

The Sulphite ion poss a lone pair of electron on the sulphur atom and three bonding pairs of electrons ✓ The bonding pair of electrons repel each ✓ other but the lone pair bond pair repulsion is greater ✓ reducing the bond angle ✓ forming a trigonal pyramidal shape. (2½)

(b) (i) Name the reagent(s) that can be used to distinguish between the oxyanions in (a)(i). *(01mark)*

Dilute nitric acid followed by barium nitrate. ✓ (1)
Dilute hydrochloric acid followed by barium chloride.

(i) State what would be observed; if a solution of each of the oxyanion is treated separately with the reagent(s) you have named in (b)(i). *(01 mark)*

SO_3^{2-} – No observable change ✓ (1)
SO_4^{2-} – White precipitate ✓

Allow: Acidified potassium manganate (VII) solution.
Acidified potassium dichromate solution.
dilute HCl, HNO_3; H_2SO_4
Iodine solution.

eg SO_3^{2-} – Purple solution turns colorless
– orange solution turns green.
SO_4^{2-} No observable change.

(ii) Write the equation(s) for any reaction(s) that would take place when a solution of each of the oxyanions is treated separately with the reagent(s) you have named in (b)(i). ..... *(1½ marks)*

Award accordingly.

$Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \longrightarrow BaSO_{4(s)}$

$3SO_3^{2-}_{(aq)} + Cr_2O_7^{2-}_{(aq)} + 8H^+_{(aq)} \longrightarrow 2Cr^{3+}_{(aq)} + 4H_2O_{(l)} + 3SO_4^{2-}_{(aq)}$

$2MnO_4^-_{(aq)} + 5SO_3^{2-}_{(aq)} + 6H^+_{(aq)} \longrightarrow 2Mn^{2+}_{(aq)} + 3H_2O_{(l)} + 5SO_4^{2-}_{(aq)}$

[05

17. (a) State **three** conditions that enable isolation of a solute from a mixture by solvent extraction. *(1½ marks)*

eg: Temperature must be constant

- Two solvents should not react with each other
- solvents must be immiscible with each other (1½)
- solute should be more soluble in the extracting solvent.
- solute should not dissociate or associate in any solvent.

(b) When one litre of an aqueous solution containing 25.0 g of solute X was shaken with 500 cm^3 of ethoxyethane, 9.7g of X was extracted in the ethoxyethane layer.

Calculate the partition coefficient of X between ethoxyethane and water. *(02 marks)*

$K_D = \frac{[X]_{organic}}{[X]_{H_2O}}$; mass remaining in water $= (25.0 - 9.7) = 15.3\,g$

$= \frac{9.5/500}{15.3/1000} = 1.27$ (02)

(c) The solution in (b) was shaken with two successive 250 cm^3 portions of ethoxyethane. Calculate the total mass extracted. *(04 marks)*

Let mass extracted by 1st 250 cm^3 portion $= y\,g$

mass remaining in water $= (25.0 - y)$

$1.27 = K_D = \frac{y/250}{(25.0-y)/1000} = \frac{y/1000}{250(25.0-y)}$; $y = 6.0\,g$ (04)

mass remaining in water $= (25.0 - 6.0) = 19.0\,g$

Let mass extracted by second portion $= z$

$1.27 = \frac{z/250}{(19.0-z)/1000}$; $\frac{z \times 1000}{250(19.0-z)}$; $z = 4.58\,g$

Total mass extracted $= (6.0 + 4.58) = 10.58\,g$

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(d) Comment on the result in (c). *(01 mark)*

Mass extracted by 250 cm³ portion is greater than the mass extracted by using 500 cm³ portion once. ✓1

emphasis successive

(e) State **one** application of solvent extraction. *(½ mark)*

- Purification of Zinc ores ✓½
- separation of azeotropic mixture
- Extraction of Oil from sim sim
- separation of inorganic salts eg Iron(III) chloride from manganese(II) chloride; Iron(II) chloride; Cobalt(II) chloride and Nickel(II) chloride.

I09