**SECTION A**

A1. a. A 0.2368 g sample of impure sodium thiosulfate was added to 25.00 cm$^3$ of 0.0400 mol dm$^{-3}$ iodine solution. The excess iodine that remained after the reaction was titrated with 27.80 cm$^3$ of a standard sodium thiosulfate (Na$_2$S$_2$O$_3$) solution. Calculate the percentage purity of the impure sample of sodium thiosulfate.

\[ \text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-} \]

[8 marks]

b. A solution of hydrated iron(II) sulfate, FeSO$_4$.nH$_2$O, contained 28.515 g dm$^{-3}$. A 25.00 cm$^3$ aliquot of this iron(II) solution required 26.00 cm$^3$ of a 0.01644 mol dm$^{-3}$ potassium dichromate solution to give an end point.

\[ \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} \]

\[ \text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+} \]

i. Write a balanced net equation for the reaction. [2 marks]

ii. Calculate the molarity of the iron(II) sulfate solution. [5 marks]

iii. Determine the value of n in FeSO$_4$.nH$_2$O. [5 marks]

*Formula weights (g mol$^{-1}$): Na$_2$S$_2$O$_3$ = 158.1, FeSO$_4$ = 151.9, H$_2$O = 18.02*
A2. a. Explain the following observations:
   i. Although nitrogen and phosphorus are both elements of group 15, PCl$_5$ exists but not NCl$_5$.  
      [4 marks]
   ii. An aqueous solution of aluminium ions is acidic.  
       [5 marks]

b. Discuss the variation of the boiling points of the halogens down the group and relate it to the physical state of each halogen at room temperature and pressure.  
   [5 marks]

c. Chlorofluorocarbons (CFCs) were widely used as refrigerants and aerosol propellants. Discuss the reasons why their usage has been abandoned. Be sure to include balanced chemical equations in your answer.  
   [6 marks]

A3. a. Account for the fact that iron exists in a variety of oxidation states whereas magnesium has only one oxidation state.  
   [4 marks]

b. Give the IUPAC names for the following complexes:
   i. [Cu(NH$_3$)$_6$](NO$_3$)$_2$  
      [3 × 1 mark]
   ii. Na$_4$[NiBr$_7$]  
   iii. [Mn(OH)$_4$(H$_2$O)$_2$]SO$_4$  

   c. Write the chemical formulae for the following complexes:
   i. Dibromobis(ethylenediamine)chromium(III) bromide  
   ii. Sodium diamminetetrachloroplatinate(II)  
   iii. Potassium hexachloroplatinate(III)  
      [3 × 1 mark]

d. [PtCl$_2$(NH$_3$)$_2$] and [Fe(ox)$_3$]$^{2-}$ both exist in two (2) isomeric forms. Sketch their structures and identify the type of isomerism involved in each complex. (ox = oxalate, C$_2$O$_4^{2-}$)  
   [6 marks]

e. Some transition metals are required by humans as trace elements. Give two (2) examples and state the importance of each metal.  
   [4 marks]
A4. a. Diamond and graphite are two (2) allotropes of carbon. Compare these two allotropes based on their structure and bonding. With examples, relate their structure to their uses. [10 marks]

b. Carbon and silicon are both in group 14. Explain why silicon does not have a graphite like allotrope. [2 marks]

c. The common ore of lead is galena, PbS. Describe how lead is extracted from galena, giving balanced equations for the chemical reactions. [8 marks]

END OF SECTION A

SECTION B

B1. a. Three compounds A, B and C all have the same molecular formula, \( \text{C}_3\text{H}_6\text{O} \). A is an alcohol, B is a ketone and C is an aldehyde.

i. Draw possible structures for compounds A, B and C. [3 marks]

ii. Describe simple test-tube reactions (including reagents and observations) that would allow you to show that:
   1. B and C are carbonyl compounds but not A.
   2. C is an aldehyde whereas compounds A and B are not. [2 x 3 marks]

b. Give detailed mechanisms for the following reactions, showing all important intermediates and resonance structures, as well as positive and negative charges.

i. \[
\begin{align*}
\text{CH}_3 & \quad + \quad \text{Br}_2 \quad \xrightarrow{\text{FeBr}_3} \quad \text{CH}_3 \\
\text{C} & \quad + \quad \text{Br} & \quad + \quad \text{HBr}
\end{align*}
\]

[7 marks]

ii. \[
\begin{align*}
\text{CH}_3 & \quad + \quad \text{HCN} \quad \xrightarrow{\quad} \quad \text{OH} \\
\text{C} & \quad + \quad \text{CN} & \quad [4 \text{ marks}]
\end{align*}
\]
B2. a. Define the following terms and give one (1) example of each:
   i. Nucleophilic substitution
   ii. Markovnikov's addition
   iii. Saturated and unsaturated hydrocarbons

   [3 x 4 marks]

b. Predict the product(s) of the following reactions:
   i. \( \text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \xrightarrow{\text{Cl}_2, \text{UV light}} \)

   [2 marks]

   ii. \( \text{CH}_3\text{C}≡\text{CCH}_3 \xrightarrow{\text{Br}_2} \)

   [3 marks]

   iii. \( \text{COOH} \xrightarrow{\text{SOCl}_2} \)

   [3 marks]

B3. a. List the reagents and conditions (solvents, temperature, etc.) necessary to carry out the following reactions:

   i. \( \text{ } \xrightarrow{\text{ } \text{NO}_2} \)

   [3 marks]

   ii. \( \text{ } \xrightarrow{\text{ } \text{COOH}} \)

   [4 marks]

   iii. \( \text{HC}≡\text{CCH}_2\text{CH}_3 \xrightarrow{\text{H}_2\text{C}≡\text{CHCH}_2\text{CH}_3} \text{CH}_3\text{CHCH}_2\text{CH}_3 \text{OH} \)

   [4 marks]

   iv. \( \text{ } \xrightarrow{\text{ } \text{O}} \)

   [4 marks]
B3. Continued

b. Outline a detailed mechanism for the addition of hydrogen chloride (HCl) to 1-methylcyclohexene. Include the product and all important intermediates, as well as positive and negative charges in your answer.

[5 marks]

B4. a. Give the IUPAC names for the following compounds:

i. 

ii. 

iii. 

iv. 

[4 × 1 mark]

b. Draw the structures for the following compounds:

i. \( m \)-ethylbenzoic acid

ii. 5-bromohexan-3-one

iii. 4,4-dimethylcyclohexanol

iv. 2-bromo-2,4-dimethylheptane

[4 × 1 mark]

c. Give one (1) example of each of the following:

i. A pair of cis/trans isomers (label each)

ii. A pair of optical isomers

iii. A secondary alcohol, an ester and a tertiary carbocation (each with four carbons).

[3 x 3 marks]

d. Use a full equation, showing the reagents and conditions, describe one (1) method by which propan-1-ol may be prepared from 1-chloropropane.

[3 marks]
These elements

The International Union for Pure and Applied Chemistry has not adopted official names or symbols for

All atomic masses have been rounded off to four significant figures.

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