Constitutional isomers and stereoisomers

1) The amino acid alanine below can exist as two enantiomers (optical isomers).

\[
\begin{align*}
\text{O} & \\
\text{H}_2\text{N} - \text{CH} - \text{C} - \text{OH} & \\
\text{CH}_3 & \\
\end{align*}
\]

i) Draw three-dimensional structures for the two enantiomers that clearly show the relationship between them.

ii) Alanine has two straight chain isomers that do not show acidic properties. One of these isomers, \( P \), can exist as an enantiomer, the other isomer, \( Q \), cannot. Draw \( P \) and \( Q \).

iii) Explain why \( P \) exists as an enantiomer.

2) An alcohol \( \text{A} \) with the molecular formula \( \text{C}_4\text{H}_{10}\text{O} \) can exist as enantiomers (optical isomers).

i) State the structural requirement for a molecule to be able to exist as enantiomers.

ii) Describe a property of enantiomers that would enable them to be distinguished from each other.

iii) Draw the structural formulae of the enantiomers of alcohol \( \text{A} \).

3) Compound \( \text{A} \) is a carboxylic acid with the molecular formula \( \text{C}_4\text{H}_8\text{O}_2 \). Identify an isomer of Compound \( \text{A} \) that can exist as a pair of enantiomers (optical isomers) and justify your choice.

4) i) Draw a circle around the product of the reaction below that will show optical isomerism (exist as enantiomers). Give a reason for your answer.

\[
\begin{align*}
\text{CH}_2 - \text{CH} - \text{CH}_2 & \xrightarrow{\text{oxidation}} \text{CH} - \text{CH} - \text{CH}_2 + \text{CH}_2 - \text{C} - \text{CH}_2 \\
glycerol & \quad \text{glyceraldehyde} \quad \text{Compound A}
\end{align*}
\]

ii) Explain how the two enantiomers of the compound circled above could be distinguished from each other.
5) \( \text{C}_5\text{H}_{11}\text{OH} \) is an example of an alcohol that can exist as a number of different isomers.

a) Draw structures of the isomers of \( \text{C}_5\text{H}_{11}\text{OH} \) that satisfy the requirements of

i) a branched-chain secondary alcohol (A) and ii) a branched-chain tertiary alcohol (B)

b) Explain why \( \text{A} \) is the only primary alcohol isomer of \( \text{C}_5\text{H}_{11}\text{OH} \) that is able to exist as a pair of enantiomers (optical isomers).

6) i) Draw structural formulae for all the possible constitutional (structural) isomers of \( \text{C}_4\text{H}_{10}\text{O} \) that are alcohols.

ii) Circle any isomer above that can exist as a pair of enantiomers (optical isomers).

iii) Explain what physical property would allow the two enantiomers to be distinguished.

7) Lactic acid is the common name for 2-hydroxypropanoic acid. Lactic acid can exist as enantiomers (optical isomers)

\[
\text{H}_3\text{C} \quad \text{CH} \quad \text{COOH} \\
\quad \text{OH}
\]

a) Draw three-dimensional structures for the two enantiomers of lactic acid that clearly show the relationship between them.

b) Compound \( \text{X} \) is a structural isomer of lactic acid. Compound \( \text{X} \) will turn blue litmus red but cannot exist as enantiomers.

i) Draw the structural formula for Compound \( \text{X} \).

ii) Explain why this structure cannot exist as enantiomers.

8) An alcohol (\( \text{C}_4\text{H}_{10}\text{O} \)) can exist as optical isomers (enantiomers).

i) Draw three-dimensional structures that show the relationship between the two enantiomers.
ii) Draw and name a structural (constitutional) isomer of

\[ \text{CH}_3-\text{CH}_2-\text{C}=\text{O} \]

\[ \text{OH} \]

iii) Discuss the differences in chemical and physical properties between samples of these two structural isomers.

9) a) **Compound A** is an isomer of \( \text{C}_4\text{H}_8\text{O} \) and can exist as two enantiomers (optical isomers). It contains two different functional groups – an alcohol(OH) group and an alkene group. Draw 3-dimensional structures for both enantiomers that clearly show the relationship between them.

b) Two compounds (B and C) have the same molecular formula, \( \text{C}_4\text{H}_8\text{O} \). They are **cis-trans isomers** that contain a primary alcohol group. Both compounds rapidly decolourise bromine solution. Draw the structural formulae of compounds B and C.

10) i) **Compound** can exist as two optical isomers (enantiomers). Draw 3-dimensional structures that clearly show the relationship between the two enantiomers.

ii) Describe similarities and differences in the chemical and physical properties of the enantiomers.