

# Organic 1 – Alkanes and Alkenes

## Mark Scheme

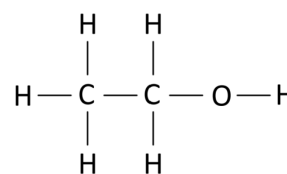
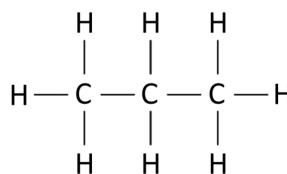
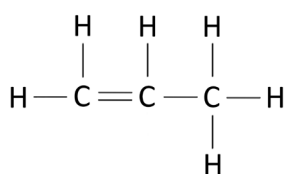
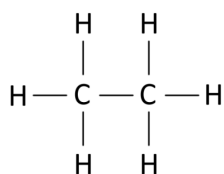


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1. Alkanes and alkenes are the two simplest families of hydrocarbons, whose properties and reactions are determined by the presence of single or double carbon-carbon bonds.

Circle the letter of the correct answer for each of the following questions.

- a. The structures of **four** different organic compounds are shown in the figure below.



Which statement is about these compounds is **not** correct?

|                                        |               |
|----------------------------------------|---------------|
| <b>D – is the only correct answer.</b> | 1 mark        |
|                                        | Total: 1 mark |

- b. Which of the following gives the formula of an **alkene**?

|                                        |               |
|----------------------------------------|---------------|
| <b>D – is the only correct answer.</b> | 1 mark        |
|                                        | Total: 1 mark |

- c. Alkanes are a homologous series of hydrocarbons.

What is the general formula for the alkanes?

|                                        |               |
|----------------------------------------|---------------|
| <b>C – is the only correct answer.</b> | 1 mark        |
|                                        | Total: 1 mark |

- d. Which of the following molecular structures shows pentene?

|                                        |               |
|----------------------------------------|---------------|
| <b>B – is the only correct answer.</b> | 1 mark        |
|                                        | Total: 1 mark |

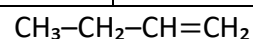
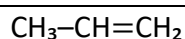
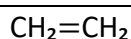
- e. Alkenes are a homologous series of unsaturated hydrocarbons.

Which of the following represents the general formula for the alkenes?

|                                        |                      |
|----------------------------------------|----------------------|
| <b>A – is the only correct answer.</b> | <b>1 mark</b>        |
|                                        | <b>Total: 1 mark</b> |

- f. The structures of three hydrocarbons, P, Q, and R, are shown below.

|                                        |                      |
|----------------------------------------|----------------------|
| <b>A – is the only correct answer.</b> | <b>1 mark</b>        |
|                                        | <b>Total: 1 mark</b> |



**P**

**Q**

**R**

Which of the following statements about these three compounds is correct?

1. They all contain a carbon-carbon double bond (C=C).
2. They are all members of the same homologous series.
3. They all have the same boiling point.

|                                        |                      |
|----------------------------------------|----------------------|
| <b>A – is the only correct answer.</b> | <b>1 mark</b>        |
|                                        | <b>Total: 1 mark</b> |

- g. The oil industry uses **cracking** to break down long-chain alkanes.

Which equation correctly represents this industrial process?

|                                        |                      |
|----------------------------------------|----------------------|
| <b>D – is the only correct answer.</b> | <b>1 mark</b>        |
|                                        | <b>Total: 1 mark</b> |

- h. A molecule of propane ( $\text{C}_3\text{H}_8$ ) and a molecule of ethene ( $\text{C}_2\text{H}_4$ ) are two different hydrocarbons.

Which type of covalent bond is present in both molecules?

|                                        |                      |
|----------------------------------------|----------------------|
| <b>B – is the only correct answer.</b> | <b>1 mark</b>        |
|                                        | <b>Total: 1 mark</b> |

- i. The structural formulae for two hydrocarbons are shown below.



Which statement correctly describes the relationship between these two hydrocarbons?

|                                        |                      |
|----------------------------------------|----------------------|
| <b>B – is the only correct answer.</b> | <b>1 mark</b>        |
|                                        | <b>Total: 1 mark</b> |

(Total for Question 1 is 9 marks)

2. Propane, C<sub>3</sub>H<sub>8</sub>, is an alkane. Propane is the main component of bottled gas and is used in camping stoves.

- a. Propane undergoes complete combustion.

Write the balanced symbol equation for the complete combustion of propane.

|                                                                                     |                |
|-------------------------------------------------------------------------------------|----------------|
| $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$ | 2 marks        |
| Accept multiples.                                                                   |                |
| Award 1 mark for the correct chemical formulae.                                     | 1 mark         |
| Award 1 mark for the correct balancing.                                             | 1 mark         |
|                                                                                     | Total: 2 marks |

The table below gives the viscosity of some different alkanes.

Viscosity is a measure of how easily a liquid flows.

| Alkane  | Relative Viscosity |
|---------|--------------------|
| Propane | 0.22               |
| Hexane  | 0.51               |
| Methane | 0.11               |
| Octane  | 0.72               |

- b. State the relationship between the number of carbon atoms in the alkane and its viscosity.

|                                                                                     |               |
|-------------------------------------------------------------------------------------|---------------|
| As the number of carbon atoms (in the molecule) increases, the viscosity increases. | 1 mark        |
| Allow: the larger the molecule, the more viscous it is.                             |               |
| Allow: viscosity increases as chain length increases'                               |               |
|                                                                                     | Total: 1 mark |

- c. Propane is found in the refinery gas fraction when crude oil is separated by fractional distillation.

The table below shows some information about four molecules that are found in four different fractions.

| Molecule    | Formula                         | Boiling point (°C) |
|-------------|---------------------------------|--------------------|
| Pentadecane | C <sub>15</sub> H <sub>32</sub> | 271                |
| Nonadecane  | C <sub>19</sub> H <sub>40</sub> | 330                |
| Docosane    | C <sub>22</sub> H <sub>46</sub> |                    |
| Tetracosane | C <sub>24</sub> H <sub>50</sub> | 391                |

- i. Predict the boiling point of docosane.

|                                                         |        |
|---------------------------------------------------------|--------|
| (Value in the range of) 350 – 380 (°C)                  | 1 mark |
| Allow any specific value within this range (e.g., 366). |        |

|                                                         |               |
|---------------------------------------------------------|---------------|
| Do not accept a range that extends outside these limits |               |
|                                                         | Total: 1 mark |

- ii. Tetracosane is separated lower down the fractionating column than pentadecane.  
Explain why, using ideas about intermolecular forces.

|                                                                                                                                                                                                              |                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| An explanation to include the following:                                                                                                                                                                     |                |
| Tetracosane is a larger molecule / has a longer carbon chain (than pentadecane).                                                                                                                             | 1 mark         |
| Allow tetracosane has a larger relative formula mass / Mr.                                                                                                                                                   |                |
| So the intermolecular forces are stronger.                                                                                                                                                                   | 1 mark         |
| Allow: intermolecular bonds or forces of attraction between molecules.<br>Do not accept covalent bonds.<br>Do not accept reference to breaking bonds (as this implies chemical change rather than physical). |                |
| (Therefore) more energy is needed to overcome / break these forces.                                                                                                                                          | 1 mark         |
| Allow more heat is needed to separate them.                                                                                                                                                                  |                |
|                                                                                                                                                                                                              | Total: 3 marks |

- d. Cracking is used to break down large, less useful alkane molecules into smaller, more useful ones.  
The equation shows the cracking of tetracosane to make decane and one other product.  
Complete and balance the equation.

|                  |                |
|------------------|----------------|
| $C_{14}H_{28}$   | 2 marks        |
| Allow multiples. |                |
|                  | Total: 2 marks |

- e. The table below shows the percentage supply and demand for some of the different fractions obtained from crude oil.

More petrol can be obtained by cracking another fraction.  
Suggest and explain which fraction is cracked to obtain petrol.

|                                                                                                                              |                |
|------------------------------------------------------------------------------------------------------------------------------|----------------|
| Fraction: Lubricating oil.                                                                                                   | 1 mark         |
| Reason: The supply exceeds the demand.                                                                                       |                |
| Allow: there is a surplus or percentage supply is greater than percentage demand.<br>Reason must follow the chosen fraction. |                |
|                                                                                                                              | Total: 2 marks |

(Total for Question 2 is 11 marks)

3. Alkenes are a homologous series of unsaturated hydrocarbons which are made by cracking larger alkane molecules.

a. Explain what is meant by the term “unsaturated hydrocarbon”.

|                                                  |                       |
|--------------------------------------------------|-----------------------|
| An explanation to include:                       |                       |
| Contains carbon and hydrogen atoms <u>only</u> . | 1 mark                |
| Contains a double bond.                          | 1 mark                |
| <b>Allow:</b> contains C=C bond.                 |                       |
|                                                  | <b>Total: 2 marks</b> |

b. Alkenes are very useful substances.

i. Write the general formula for alkenes.

|             |                      |
|-------------|----------------------|
| $C_nH_{2n}$ | 1 mark               |
|             | <b>Total: 1 mark</b> |

ii. Explain why the products of cracking are economically more important than the large alkane molecules they are made from.

|                                                           |                      |
|-----------------------------------------------------------|----------------------|
| There is a higher demand for alkenes / smaller molecules. | 1 mark               |
|                                                           | <b>Total: 1 mark</b> |

iii. Describe **two** industrial conditions needed for cracking to occur.

|                                                                                   |                       |
|-----------------------------------------------------------------------------------|-----------------------|
| <u>High temperature.</u>                                                          | 1 mark                |
| <b>Allow:</b> heat or specific temperature in range 450 to 800°C.                 |                       |
| <u>Catalyst.</u> Allow aluminium oxide / porous pot / ceramic / zeolite or steam. | 1 mark                |
|                                                                                   | <b>Total: 2 marks</b> |

c. The table below gives the boiling points of some alkenes.

i. Predict the boiling point of pentene.

|                                  |                      |
|----------------------------------|----------------------|
| Value in the range 25 – 35 (°C). | 1 mark               |
|                                  | <b>Total: 1 mark</b> |

ii. The melting point of propene is –185 °C.

Deduce the physical state of propene at room temperature (20 °C).

|                                                                                         |                       |
|-----------------------------------------------------------------------------------------|-----------------------|
| <b>Physical state:</b> gas                                                              | 1 mark                |
| <b>Reason:</b> (room temperature / 20 °C) is higher than the boiling point (of –48 °C). |                       |
|                                                                                         | <b>Total: 2 marks</b> |

d. Propene reacts with hydrogen to produce propane in an addition reaction.  
Complete the symbol equation for this reaction.

|                                                                                 |                       |
|---------------------------------------------------------------------------------|-----------------------|
| $C_3H_8$                                                                        | 2 marks               |
| 1 mark for the correct formula of propane and 1 mark for the correct balancing. |                       |
|                                                                                 | <b>Total: 2 marks</b> |

(Total for Question 3 is 11 marks)

4. A chemist is provided with three unlabelled bottles, each containing a different clear, colourless liquid. The chemist knows that the three liquids are:

- Octane,  $C_8H_{18}$ , a liquid alkane
- Octene,  $C_8H_{16}$ , a liquid alkene
- Ethanoic acid,  $C_2H_4O_2$ , a carboxylic acid, in aqueous solution.

Describe, in detail, a logical sequence of tests the chemist could perform to identify each of the three liquids.

Your description should include the expected observations for each liquid and the balanced chemical equations for any reactions described.

| Marking guidance |       |                                                                                                                                                                                                                                                     |
|------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level            | Marks | Descriptor                                                                                                                                                                                                                                          |
| Level 1          | 1 - 2 | Simple statements are made regarding tests for alkenes or acids. The response may not be in a logical sequence. One valid test or observation is given. No relevant equation is provided.                                                           |
| Level 2          | 3 - 4 | The method is mostly relevant and logical. Tests and observations are described that would identify at least two of the liquids (or groups of liquids). There is an attempt at a symbol equation, but it may be unbalanced or contain minor errors. |
| Level 3          | 5 - 6 | The method is coherent, relevant, and logically structured to identify all three liquids. The correct tests and observations are given for the alkene and the carboxylic acid. At least one correct balanced symbol equation is included.           |

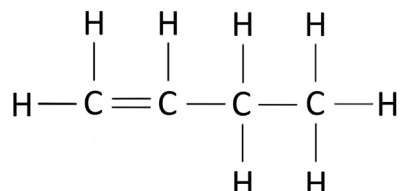
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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Indicative content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       |
| <p><b>Sequence 1: test for alkenes (bromine water):</b></p> <ul style="list-style-type: none"> <li>• Add bromine water to all three liquids.</li> <li>• Observation (octene): the orange / brown colour turns colourless (decolourises). This identifies the alkene (octene).</li> <li>• Observation (octane &amp; ethanoic acid): The solution remains orange / brown (no change). This separates the alkene from the other two.</li> </ul> <p><b>Equation for the reaction with octene:</b></p> $C_8H_{16} + Br_2 \rightarrow C_8H_{16}Br_2$ <p><b>Sequence 2: Test for carboxylic acids:</b></p> <ul style="list-style-type: none"> <li>• To the remaining liquids, add a metal carbonate (e.g., sodium carbonate / calcium carbonate).</li> <li>• Alternative: add a reactive metal (e.g., magnesium).</li> <li>• Alternative: add an indicator (e.g., universal indicator / litmus).</li> <li>• Observation (ethanoic acid): effervescence / bubbling / fizzing (gas produced). If indicator used: turns red / orange.</li> <li>• This identifies the carboxylic acid.</li> <li>• Observation (octane): No reaction / no colour change. This identifies the alkane (octane) by elimination.</li> </ul> <p><b>Equation for the reaction with ethanoic acid:</b></p> <p><b>With carbonate:</b> <math>2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2</math></p> <p><b>With metal:</b> <math>2CH_3COOH + Mg \rightarrow (CH_3COO)_2Mg + H_2</math></p> |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Total: 6 marks</b> |

(Total for Question 4 is 6 marks)

5. The alkenes are a series of unsaturated hydrocarbons.
- a. Deduce, using the general formula for alkenes, the molecular formula of an alkene which has a relative molecular mass of 140. You must show your working.

|                                          |                |
|------------------------------------------|----------------|
| $(C_nH_{2n} \text{ has mass}) 14n = 140$ |                |
| $14n = 140 \quad n = 10$                 | 1 mark         |
| Molecular formula = $C_{10}H_{20}$       | 1 mark         |
|                                          | Total: 2 marks |

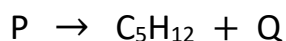
The figure below shows the structural formula of butene.



- b. Draw an electron shell diagram showing the arrangement of the electrons in one molecule of butene. Use dots (•) to represent the electrons for the carbon atoms. Use crosses (x) represent the electrons for the hydrogen atoms.

|                                                      |                |
|------------------------------------------------------|----------------|
|                                                      |                |
| Accept any correct version of the above diagram.     |                |
| One C=C bond showing 4 electrons (2 pairs) shared    | 1 mark         |
| All other C-C and C-H bonds showing 2 electrons.     | 1 mark         |
| Correct allocation of hydrogen atoms to carbon atoms | 1 mark         |
|                                                      | Total: 3 marks |

- c. A large alkane P was cracked to form one molecule of pentane,  $C_5H_{12}$ , and one molecule of an alkene Q. The relative formula mass of Q is 42. The empirical formula of Q is  $CH_2$ .



Deduce the molecular formula of the large alkane P. You must show your working.

|                                                           |                |
|-----------------------------------------------------------|----------------|
| Step 1: deduce Q (Mr of $CH_2 = 14$ ) so $42 \div 14 = 3$ |                |
| Formula of Q is $C_3H_6$                                  | 1 mark         |
| Step 2: conservation of atoms.<br>$C_5H_{12} + C_3H_6$    | 1 mark         |
| Step 3: final formula<br>$C_8H_{18}$                      | 1 mark         |
|                                                           | Total: 3 marks |

(Total for Question 5 is 8 marks)

6. Propane, C<sub>3</sub>H<sub>8</sub>, is a saturated hydrocarbon used as a fuel in patio heaters.
- a. In a faulty patio heater with a poor oxygen supply, propane undergoes incomplete combustion to form a toxic gas and water.

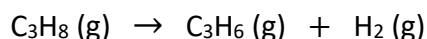
- i. Name the toxic gas produced during this reaction.

|                  |               |
|------------------|---------------|
| Carbon monoxide. | 1 mark        |
|                  | Total: 1 mark |

- ii. Write the **balanced** chemical equation for this incomplete combustion reaction.

|                                                                                    |                |
|------------------------------------------------------------------------------------|----------------|
| $2\text{C}_3\text{H}_8 + 7\text{O}_2 \rightarrow 6\text{CO} + 8\text{H}_2\text{O}$ | 2 marks        |
| Accept multiples.                                                                  |                |
| Award 1 mark for the correct chemical formulae.                                    | 1 mark         |
| Award 1 mark for the correct balancing.                                            | 1 mark         |
|                                                                                    | Total: 2 marks |

- b. Propane can also be used as a chemical feedstock. It can be converted into propene, C<sub>3</sub>H<sub>6</sub>, and hydrogen gas in a process called dehydrogenation. The equation for the reaction is:



A chemist reacts 8.8 g of propane.

Calculate the volume of hydrogen gas, in dm<sup>3</sup>, that would be produced at room temperature and pressure (RTP).

(Relative atomic masses: H = 1.0, C = 12.0. The molar volume of any gas at RTP is 24.0 dm<sup>3</sup>/mol.)

|                                                                                                   |                |
|---------------------------------------------------------------------------------------------------|----------------|
| <b>Step 1: calculate</b><br>Mr of propane: $(3 \times 12) + (8 \times 1) = 44$                    | 1 mark         |
| <b>Step 2: calculate moles of propane:</b><br>$8.8 \div 44 = 0.2 (\text{mol})$                    | 1 mark         |
| <b>Step 3: Determine moles of hydrogen.</b><br>Ratio is 1 : 1 so moles H <sub>2</sub> = 0.2 (mol) | 1 mark         |
| <b>Step 4: Calculate volume.</b><br>$0.2 \times 24.0 = 4.8(\text{dm}^3)$                          | 1 mark         |
| Allow correct answer with or without working.                                                     |                |
|                                                                                                   | Total: 4 marks |

- c. Alkanes can also react with halogens in the presence of ultraviolet (UV) light.

- i. Name the type of reaction that occurs when ethane (C<sub>2</sub>H<sub>6</sub>) reacts with bromine (Br<sub>2</sub>).

|               |               |
|---------------|---------------|
| Substitution. | 1 mark        |
|               | Total: 1 mark |

- ii. State the essential condition required for this reaction to occur.

|                         |               |
|-------------------------|---------------|
| Ultraviolet / UV light. | 1 mark        |
|                         | Total: 1 mark |

(Total for Question 6 is 9 marks)

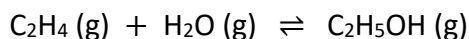
7. Ethene, C<sub>2</sub>H<sub>4</sub>, is the first member of the alkene homologous series.  
It is a key industrial chemical produced by cracking long-chain alkanes.
- a. A student is given two unlabelled samples, one of ethane (C<sub>2</sub>H<sub>6</sub>) and one of ethene (C<sub>2</sub>H<sub>4</sub>).  
Describe a chemical test the student could carry out to distinguish between the two hydrocarbons.  
Include the expected result for both samples.

|                                                                                                                                                    |                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <b>Test:</b> Add bromine water.                                                                                                                    | 1 mark                |
| <b>Result with ethane:</b> (Remains) orange / brown / yellow.                                                                                      | 1 mark                |
| <b>Result with ethene:</b> (Turns) colourless.<br><br>Do not accept clear (clear means transparent, not colourless).<br><b>Allow</b> decolourised. | 1 mark                |
|                                                                                                                                                    | <b>Total: 3 marks</b> |

- b. The reaction of ethene with the chemical in part (a) is an example of an addition reaction.  
Explain why alkenes undergo addition reactions but alkanes do not.  
Refer to the bonding in your answer.

|                                                                                                                                                      |                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Alkenes contain a double bond / C=C bond.<br><br>Allow atoms are added across the double bond.                                                       | 1 mark                |
| Which opens up / breaks allowing atoms to bond (to the carbons).<br><br>Allow alkanes only contain single bonds / are saturated so cannot add atoms. | 1 mark                |
|                                                                                                                                                      | <b>Total: 2 marks</b> |

- c. Ethene is used to produce ethanol by reacting it with steam. This is a reversible reaction.



- i. State the industrial conditions of temperature and pressure used for this reaction.

|                                |                       |
|--------------------------------|-----------------------|
| Temperature: 300 °C            | 1 mark                |
| Pressure: 60 – 70 atmospheres. | 1 mark                |
|                                | <b>Total: 2 marks</b> |

- ii. Name the catalyst used in this process.

|                                                                      |                      |
|----------------------------------------------------------------------|----------------------|
| Phosphoric acid.<br><br><b>Allow:</b> H <sub>3</sub> PO <sub>4</sub> | 1 mark               |
|                                                                      | <b>Total: 1 mark</b> |

- iii. The forward reaction to produce ethanol is exothermic.  
Explain why a compromise temperature of 300 °C is used rather than a lower temperature which would give a higher yield.

|                                                                              |                       |
|------------------------------------------------------------------------------|-----------------------|
| Lower temperatures give a higher yield (because the reaction is exothermic). | 1 mark                |
| But the rate of reaction would be too slow.                                  | 1 mark                |
|                                                                              | <b>Total: 2 marks</b> |

- iv. The atom economy of this reaction is 100%.

Explain why the atom economy for this reaction is 100%.

|                                                                                                                               |                       |
|-------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Because only one product is formed.                                                                                           | 1 mark                |
| <b>Allow:</b> all the reactant atoms end up in the desired product.<br>So no atoms are wasted / no waste products are formed. | 1 mark                |
|                                                                                                                               | <b>Total: 2 marks</b> |

- d. In a laboratory experiment, a student reacted 7.0 g of ethene with excess steam and produced 9.2 g of ethanol.

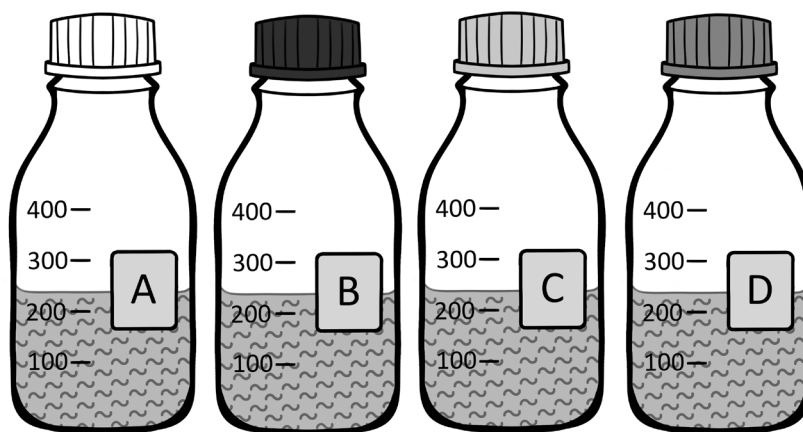
Calculate the percentage yield of ethanol for this experiment.

(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0)

|                                                                                  |                       |
|----------------------------------------------------------------------------------|-----------------------|
| <b>Step 1: Moles of ethene.</b><br>$7.0 \div 28 = 0.25 \text{ (mol)}$            | 1 mark                |
| <b>Step 2: Theoretical mass of ethanol.</b><br>$0.25 \times 46 = 11.5 \text{ g}$ | 1 mark                |
| <b>Step 3: Percentage yield.</b><br>$(9.2 \div 11.5) \times 100$                 | 1 mark                |
| $= 80 \text{ (\%)}$                                                              | 1 mark                |
|                                                                                  | <b>Total: 4 marks</b> |

(Total for Question 7 is 14 marks)

8. A student is provided with four unlabelled bottles (A, B, C, and D), each containing a different clear, colourless liquid.



The liquids are known to be:

- Hexane,  $C_6H_{14}$ , a saturated hydrocarbon
- Hex-1-ene,  $C_6H_{12}$ , an unsaturated hydrocarbon
- Cyclohexane,  $C_6H_{12}$ , a saturated hydrocarbon
- Ethanol,  $C_2H_5OH$ , an alcohol which is soluble in water

The student is told that hexane and cyclohexane are immiscible (do not mix) with water.

- a. Describe a logical sequence of tests the student could carry out to identify each of the four liquids. Your plan should explain how you would use the results to distinguish the liquids from each other. You should include the expected observations for all four liquids at each stage of your procedure.

| Marking guidance |       |                                                                                                                                                                                                                                                                                         |
|------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level            | Marks | Descriptor                                                                                                                                                                                                                                                                              |
| Level 1          | 1 - 2 | At least one valid test and relevant observation is given (e.g., testing for the alkene). The logic may be disjointed or the sequence incomplete.                                                                                                                                       |
| Level 2          | 3 - 4 | Two distinct tests are described (e.g., bromine water and solubility). The observations listed would allow the student to identify at least two of the liquids (usually the alkene and the alcohol). The distinction between the final two liquids is missing or incorrect.             |
| Level 3          | 5 - 6 | A coherent, logically structured sequence of tests is described. The specific tests and observations allow for the successful identification of the alkene and the alcohol. A valid method (chemical or physical) is suggested to distinguish the remaining two saturated hydrocarbons. |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Indicative content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <b>Step 1: Identify the alkene (hex-1-ene)</b> <ul style="list-style-type: none"> <li>• <b>Test:</b> Add bromine water to a sample of each liquid and shake.</li> <li>• <b>Observation:</b> hex-1-ene will turn the orange bromine water colourless (decolourise it).</li> <li>• <b>Conclusion:</b> The other three liquids remain orange (no reaction).</li> </ul> <b>Step 2: Identify the alcohol (ethanol).</b> <ul style="list-style-type: none"> <li>• <b>Test:</b> Add water to the remaining three liquids.</li> </ul> |  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <ul style="list-style-type: none"> <li><b>Observation:</b> ethanol will dissolve / mix completely (it is soluble).</li> <li><b>Conclusion:</b> Hexane and cyclohexane will not mix; they will form two distinct layers (immiscible).</li> <li><b>Alternative test:</b> Add a small piece of sodium metal → ethanol will fizz/produce hydrogen gas).</li> </ul> <p><b>Step 3: Distinguish hexane from cyclohexane.</b></p> <ul style="list-style-type: none"> <li><b>Test:</b> Burn a small sample of the remaining two liquids (combustion test).</li> <li><b>Observation:</b> cyclohexane has a lower hydrogen-to-carbon ratio, so it burns with a sootier / smokier flame than hexane.</li> <li><b>Conclusion:</b> The liquid with the cleaner flame is hexane.</li> <li><b>Alternative:</b> Measure the boiling points of the liquids and compare to known data).</li> </ul> |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Total: 6 marks</b> |

- b. The student performs a test that confirms one of the liquids is hex-1-ene.

Write the balanced chemical equation for the reaction that takes place in this test.

|                                                     |                       |
|-----------------------------------------------------|-----------------------|
| $C_6H_{12} + Br_2 \rightarrow C_6H_{12}Br_2$        | <b>2 marks</b>        |
| Award 1 mark for the correct reactants and product. | <b>1 mark</b>         |
| Award 1 mark for the correct balancing.             | <b>1 mark</b>         |
|                                                     | <b>Total: 2 marks</b> |

- c. To confirm the identity of another liquid as hexane, the student carries out a combustion analysis. When 1.29 g of the liquid is burned completely in excess oxygen, 3.96 g of carbon dioxide is produced.

Show by calculation that this result is consistent with the liquid being hexane ( $C_6H_{14}$ ).

(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0)

|                                                                                                                                                                                                      |                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <p><b>Step 1: Calculate moles of <math>CO_2</math>.</b></p> <p><math>3.96 \div 44 = 0.09 \text{ (mol)}</math></p>                                                                                    | <b>1 mark</b>         |
| <p><b>Step 2: Calculate mass of carbon and hydrogen in sample.</b></p> <p>Mass of C = <math>0.09 \times 12 = 1.08 \text{ g}</math></p> <p>Mass of H = <math>1.29 - 1.08 = 0.21 \text{ g}</math></p>  | <b>1 mark</b>         |
| <p><b>Step 3: Determine ratio.</b></p> <p>Mole Ratio C : H = <math>0.09 : 0.21</math></p> <p><math>1 : 2.33</math></p>                                                                               | <b>1 mark</b>         |
| <p><b>Step 4: conclusion ratio.</b></p> <p><math>1 : 2.33</math> is equivalent to <math>3 : 7</math> or <math>6 : 14</math></p> <p>This matches the formula for hexane (<math>C_6H_{14}</math>).</p> | <b>1 mark</b>         |
|                                                                                                                                                                                                      | <b>Total: 4 marks</b> |

(Total for Question 8 is 12 marks)