

Exercise walk-through

1.4.1

Fuel processing, hazards and life-cycle carbon

Pearson Edexcel · International A-Level · Chemistry

Count pairs before naming shape

- 1** NH_4^+ and CH_4 : four bonding regions, tetrahedral, 109.5° .
- 2** NH_3 : three bonds and one lone pair, pyramidal, about 107° . H_2O : two bonds and two lone pairs, bent, about 104.5° .
- 3** Lone pairs repel more strongly; the angle reduction is not a fixed amount per pair.

Compare fuels using their whole pathway

- 1** Cracking makes smaller hydrocarbons including alkenes; balance atoms in proposed products.
- 2** CO reduces oxygen transport; nitrogen/sulfur oxides can contribute to acid pollution.
- 3** Bioethanol growth can absorb CO₂, but processing and transport still emit. Hydrogen production also matters.

Choose reagents and conditions

- 1 **1** H_2/Ni adds hydrogen; steam/acid catalyst adds water; Br_2 adds bromine across $\text{C}=\text{C}$.
- 2 **2** Cold dilute acidified manganate(VII) gives a diol. Bromine decolourisation supports unsaturation, not a unique identity.
- 3 **3** Addition polymerisation opens $\text{C}=\text{C}$, retains side groups and loses no small molecule.

Exercises 2.1·2.3

2.1 Distinguish hazard from risk for a flammable organic solvent. Suggest two different controls and explain what risk each reduces. [4]

2.2 Complete and balance: $\text{C}_{12}\text{H}_{26} \rightarrow \text{C}_8\text{H}_{18} + \dots$. State which product is an alkene and why this is a chemical change. [3]

2.3 Classify the conversion of ethene to poly(ethene), methane to chloromethane, ethanol to ethanal, and ethene to ethane as polymerisation, substitution, oxidation or reduction. [4]

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2.1 Hazard is potential to cause harm; risk concerns likelihood and severity during actual use. Smaller quantities reduce the possible scale of a fire; an appropriate electric heater instead of a naked flame reduces ignition risk. Accept a suitable less flammable solvent or other justified controls. Ventilation addresses vapour exposure but does not alone remove ignition risk.

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2.2 $\text{C}_{12}\text{H}_{26} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_4\text{H}_8$. In the stated cracking model, C_4H_8 is the alkene product; bonds change and new substances form, unlike physical separation. Its formula alone would not distinguish an unknown alkene from a cycloalkane.

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2.3 Polymerisation; substitution; oxidation; reduction respectively. Adding hydrogen to ethene reduces the organic molecule.

Exercises 3.1·3.2

3.1 Compare the problems caused by CO, sulfur dioxide, nitrogen oxides and carbon particulates from fuel use. Explain why removing sulfur from a fuel does not prevent nitrogen oxide formation in a hot engine. [5]

3.2 One litre of a biofuel absorbs 1.60 kg CO₂ during crop growth. Its cultivation and processing emit 0.45 kg, distribution emits 0.10 kg and combustion emits 1.60 kg. Calculate net emissions within this boundary. Evaluate the claim that the fuel is carbon neutral, including one excluded factor. [4]

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3.1 CO is toxic because it binds strongly to haemoglobin and reduces oxygen transport. SO₂ and nitrogen oxides contribute acidity/acid deposition. Carbon particulates damage air quality and can harm respiratory health. Nitrogen oxides can form from atmospheric nitrogen and oxygen at high engine temperatures even if the fuel contains no sulfur.

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3.2 Net CO₂ = 0.45 + 0.10 + 1.60 – 1.60 = 0.55 kg per litre. It is not carbon neutral within this boundary because net emissions are positive. Land-use change, soil carbon changes or machinery manufacture could change the full-life-cycle result. Crop uptake cancels the stated combustion emission only.

Exercise 3.3

3.3 A refinery can reform hexane to benzene and hydrogen. Balance $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_6 + \text{H}_2$. Explain why this process is not fractional distillation, and give one sustainability advantage and one limitation of using its hydrogen as a fuel. [4]

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3.3 $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_6 + 4\text{H}_2$. Reforming changes chemical bonds; fractional distillation separates existing substances by boiling range. Hydrogen forms water rather than CO_2 at its point of use, but this hydrogen originated from a fossil feedstock and processing consumes energy, so use-stage emissions alone do not show life-cycle carbon neutrality.