4.1 Crude oil alkanes and alkenes

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

Objective

Build the skills to answer exam questions on **crude oil, alkanes and alkenes** 、 : homologous series and formulae, fractional distillation, combustion and pollution, cracking, and the reactions of alkanes and alkenes.

You must be able to:

- write formulae and names of alkanes and alkenes
- explain fractional distillation and cracking
- write equations for complete and incomplete combustion
- explain how burning fuels causes pollution

1 Key knowledge and worked examples

Hydrocarbons

idea	rule
alkanes	C_nH_{2n+2}; only single C−C bonds (saturated): methane, ethane, propane, butane
alkenes	C_nH_{2n}; one C=C double bond (unsaturated): ethene, propene, butene
fractions	the larger the molecules, the higher the boiling point and the lower they come off the column
complete combustion	hydrocarbon + oxygen → carbon dioxide + water
incomplete combustion	too little oxygen: carbon monoxide and carbon (soot) form as well
cracking	a long alkane → a shorter alkane + an alkene (hot catalyst, about 600 °C)

Worked example 1: a formula. Find the formula of the alkane with 8 carbon atoms.

1. Known: $n = 8$.

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2. Rule: C_nH_{2n+2}.
3. Numbers: $2 \times 8 + 2 = 18$.
4. Result: $\mathbf{C_8H_{18}}$ (octane).

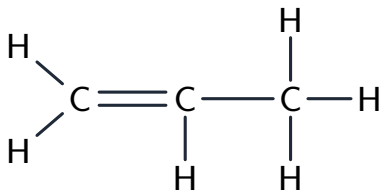
Worked example 2: combustion. Balance the complete combustion of propane, C_3H_8.

1. Known: products CO_2 and H_2O.
2. Rule: balance C, then H, then O.
3. Numbers: $3\,CO_2$; $4\,H_2O$; oxygen atoms $6 + 4 = 10$, so $5\,O_2$.
4. Result: $\mathbf{C_3H_8} + 5\mathbf{O_2} \rightarrow 3\mathbf{CO_2} + 4\mathbf{H_2O}$.

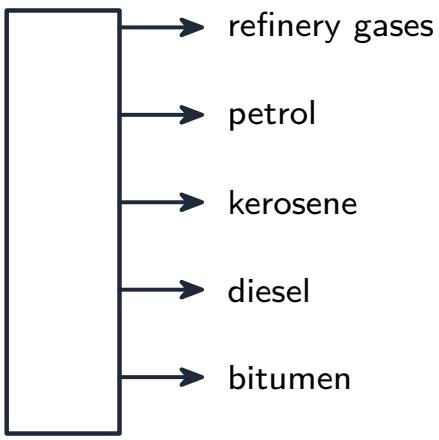
Answer shapes: in equations, check the number of each atom on both sides before you finish.

2 Practice

2.1 Give the general formula of the alkenes, and name the alkene C_3H_6. [2]



2.2 Give a use of the refinery gases fraction and a use of the bitumen fraction. [2]

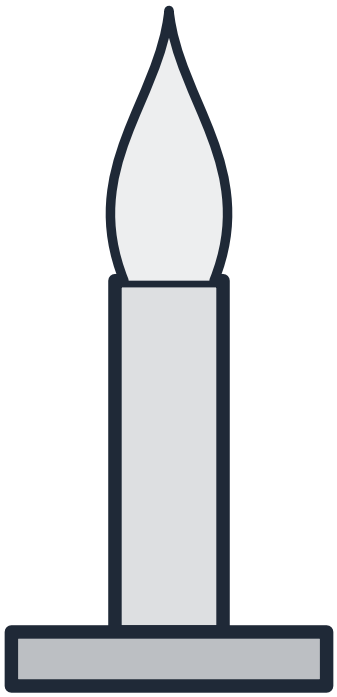


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2.3 Describe a test to tell hexane from hexene, giving the result for each. [2]



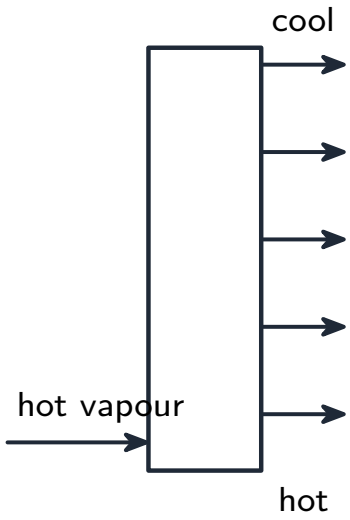
2.4 Balance the equation for the complete combustion of methane: $CH_4 + O_2 \rightarrow CO_2 + H_2O$. [2]



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3 Exam-style questions

3.1 Describe how crude oil is separated into fractions in a fractionating column. [3]



3.2 Decane, $C_{10}H_{22}$, is cracked to make octane and ethene. Write the equation, and give **two** reasons why oil companies crack long alkanes. [3]



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3.3 A town gets its electricity from a power station. Fuels, and the pollutants they release when burned, are shown in the table.

fuel	pollutants when burned
natural gas	carbon dioxide; carbon monoxide if air is short
coal	carbon dioxide, soot, sulfur dioxide
any fuel, hot flame	nitrogen oxides

(a) Write a balanced equation for methane burning in too little air to give carbon monoxide and water, and explain why carbon monoxide is poisonous. [3]

(b) Explain how sulfur dioxide and nitrogen oxides are formed when fuels burn, and how they cause acid rain. [4]

(c) Petrol contains octane: $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$. Calculate the mass of carbon dioxide made when 57 g of octane burns (M_r: octane 114, CO_2 44). [3]

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(d) Compare natural gas (methane) and coal as fuels for the power station in terms of pollution. [6]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- C_nH_{2n}
- propene

2.2

- refinery gases: bottled gas for heating and cooking
- bitumen: surfacing roads and roofs

2.3

- add bromine water and shake
- hexene turns it from orange to colourless; with hexane it stays orange

2.4

- $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

3.1

- crude oil is heated until most of it turns to vapour
- the column is hot at the bottom and cooler at the top
- each fraction condenses at a different height, depending on its boiling point

3.2

- $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$
- there is more demand for short-chain fractions such as petrol than there is supply
- the alkenes made are used to make polymers

3.3

(a) $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$; carbon monoxide joins to haemoglobin, so the blood carries less oxygen

(b) sulfur impurities in the fuel react with oxygen to form sulfur dioxide; at the high temperature of burning, nitrogen and oxygen from the air react to form nitrogen oxides; these gases dissolve in rain water to form acids (sulfuric and nitric acid) that fall as acid rain

(c) moles octane $= 57 \div 114 = 0.50$; moles $CO_2 = 0.50 \times 8 = 4.0$; $4.0 \times 44 =$ **176** g

(d) points to include:

- both release carbon dioxide, a greenhouse gas linked to climate change (K)
- coal contains more carbon per unit of energy, so it releases more carbon dioxide (An)
- coal contains sulfur, so it releases sulfur dioxide and causes acid rain; natural gas has almost none (An)

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- coal releases soot (particulates), which harm lungs; methane burns cleanly with enough air (An)
- both make nitrogen oxides at high temperature (K)
- conclusion: natural gas pollutes less, but both are non-renewable (An)

Levels: **5–6** a full, logical answer with correct chemistry and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.

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