

Splitting crude oil into alkanes and alkenes

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Every answer shows the method: the formula or rule, the substitution, and the final result in bold with its unit. Compare each step with your own working before checking the final number, because marks in an exam usually go to the method as well as to the answer.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C7

Problem 1 Hydrocarbon vocabulary

1. Carbon and hydrogen.
2. **Saturated**, single bonds.
3. **C_nH_{2n+2}**.
4. Fractional.

Problem 2 Alkane formulae

Use C_nH_{2n+2}.

1. n = 6: H = 14. **C₆H₁₄**.
2. n = 11: H = 24. **C₁₁H₂₄**.
3. 2n + 2 = 42, so 2n = 40 and **n = 20**.

Problem 3 Spot the alkenes

1. An alkene has H = 2 × C: **C₄H₈, C₃H₆ and C₆H₁₂**.
2. The formula fits C_nH_{2n}. The others fit C_nH_{2n+2} and are alkanes.
3. **C₈H₁₆**.

Problem 4 Test for unsaturation

1. The mixture stays **orange**: alkanes do not react with bromine water.
2. The orange colour disappears and the liquid becomes **colourless**: bromine adds across C=C.
3. The bottle that decolourised the water contains **hex-1-ene**.

Problem 5 Reading the column

1. **A**: refinery gases, the smallest molecules.
2. **F**, the hottest part at the bottom.
3. **E**, fuel oil.
4. Petrol has shorter chains, so it is **more flammable** than diesel.

Problem 6 Complete combustion equations

1. Oxygen atoms needed: $8 \times 2 + 10 = 26$, so 13 O₂. **$2\text{C}_4\text{H}_{10} + 13\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O}$** .
2. Oxygen atoms: $10 + 6 = 16$, so 8 O₂. **$\text{C}_5\text{H}_{12} + 8\text{O}_2 \rightarrow 5\text{CO}_2 + 6\text{H}_2\text{O}$** .
3. One butane molecule needs 6.5 O₂, and half a molecule cannot be written in an equation, so every coefficient is doubled to whole numbers.

Problem 7 Trends along the series

1. Diesel has a **higher** boiling point, a **higher** viscosity and is **harder** to ignite.
2. Longer molecules have stronger forces between them, so more energy is needed to separate them: **the boiling point rises with chain length**.

Problem 8 Balance the cracking

1. Carbon left $14 - 10 = 4$, hydrogen left $30 - 22 = 8$. The product is **C_4H_8** .
2. It is an **alkene** (it fits C_nH_{2n}).
3. Carbon left 8, hydrogen left 16: **$\text{C}_{16}\text{H}_{34} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_8\text{H}_{16}$** .

Problem 9 Mass of carbon dioxide

1. **$\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$** .
2. $M = 3 \times 12 + 8 = 44 \text{ g/mol}$. $n = 44 \div 44 = \textbf{1.0 mol}$.
3. $\text{CO}_2 = 3 \times 1.0 = 3.0 \text{ mol}$. $M(\text{CO}_2) = 44 \text{ g/mol}$. Mass = $3.0 \times 44 = \textbf{132 g}$.

Problem 10 Reading a molecule

1. Three carbons and six hydrogens: **C_3H_6** .
2. **Unsaturated**: it contains a C=C double bond between carbons 2 and 3.
3. The bromine water changes from orange to **colourless**.

Problem 11 Carbon percentage and soot

1. $M(\text{CH}_4) = 16$. $12 \div 16 \times 100 = \textbf{75.0 \%}$.
2. $M(\text{C}_2\text{H}_6) = 30$: $24 \div 30 \times 100 = \textbf{80.0 \%}$. $M(\text{C}_2\text{H}_4) = 28$: $24 \div 28 \times 100 = \textbf{85.7 \%}$.
3. **Ethene** has the highest percentage of carbon, so in limited oxygen more carbon is left over as soot.

Problem 12 Boiling points of alkanes

1. About **-42°C** .
2. Pentane boils at 36°C , which is above 25°C , so at 25°C it is a **liquid**.
3. The boiling point **rises** as the chain gets longer, in smaller steps each time. Hexane: $36 + 33 = \textbf{69}^\circ\text{C}$ (accept 65 to 70°C).

Problem 13 Fuel tank conversion

1. $1 \text{ dm}^3 = 1000 \text{ cm}^3$, so $45 \text{ dm}^3 = \mathbf{45\,000 \text{ cm}^3}$.
2. Mass = density $\times$ volume = $0.74 \times 45\,000 = \mathbf{33\,300 \text{ g}}$.
3. $33\,300 \div 1000 = \mathbf{33.3 \text{ kg}}$.

Problem 14 Why fractions separate

1. Petrol vapour travels up until the temperature falls below its boiling point, then it **condenses** and is drawn off.
2. Bitumen has a very high boiling point and very long molecules, so it condenses almost at once **at the bottom**.
3. The temperature gradient (hot at the bottom, cool at the top) makes each fraction condense at its own height.

Problem 15 Supply and demand

1. 18 % of 5000 = **900 t**.
2. Fuel oil = $0.24 \times 5000 = 1200 \text{ t}$. Cracked = 600 t. Extra petrol = $0.40 \times 600 = \mathbf{240 \text{ t}}$.
3. Increase = $240 \div 900 \times 100 = \mathbf{26.7 \%}$.

Problem 16 Ethene from a big alkane

1. Carbon: $16 = 8 + 8$. Hydrogen: $34 = 18 + 16$. **Balanced**.
2. $M = 16 \times 12 + 34 = \mathbf{226}$.
3. $1000 \text{ g} \div 226 = 4.425 \text{ mol}$. Ethene = $4 \times 4.425 = 17.70 \text{ mol}$. Mass = $17.70 \times 28 = 495.6 \text{ g}$, about **496 g**.

Problem 17 Bromine addition by mass

1. $M(\text{C}_2\text{H}_4) = 28$; $n = 2.8 \div 28 = \mathbf{0.10 \text{ mol}}$.
2. 1 : 1 ratio, so 0.10 mol Br_2 ; $M = 160$; mass = **16.0 g**.
3. $M(\text{C}_2\text{H}_4\text{Br}_2) = 24 + 4 + 160 = 188$; mass = $0.10 \times 188 = \mathbf{18.8 \text{ g}}$. Reactants $2.8 + 16.0 = 18.8 \text{ g}$, equal to the product.

Problem 18 Design an identification test

1. Add a few drops of bromine water to a sample of each and shake. The sample that makes the orange colour disappear is **hex-1-ene**.
2. Hexane does not mix with water: it stays as a separate **layer on top** of the orange water, while water mixes completely with the bromine water.
3. Hex-1-ene has a **C=C double bond** where bromine can add; hexane has only single bonds and is saturated.

Problem 19 Air needed for burning

1. $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$.
2. Gas volumes are in the mole ratio 1 : 5, so $\text{O}_2 = 5 \times 2.0 = \mathbf{10.0 \text{ dm}^3}$.
3. Air = $10.0 \div 0.21 = \mathbf{47.6 \text{ dm}^3}$. $\text{CO}_2 = 3 \times 2.0 = \mathbf{6.0 \text{ dm}^3}$.

Problem 20 Find the faulty statements

1. Statements **(a), (c) and (d)** are wrong; (b) is correct.
2. (a) Alkenes are **unsaturated** because they contain a C=C double bond and fewer hydrogen atoms than the alkane. (c) Fractional distillation is a physical separation that breaks no bonds; **cracking** breaks them. (d) The fraction at the top has the **lowest** viscosity; bitumen at the bottom has the highest.