Exercise walk-through

7.1
Crude oil, fuels and feedstock (4.7.1.1–4.7.1.3)

AQA · GCSE · Chemistry

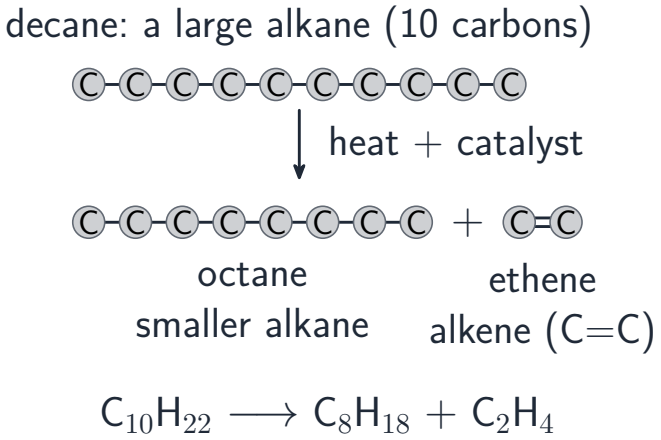
Crude oil and the alkanes

- **Crude oil** is a finite resource found in rocks.
- It formed over millions of years from the remains of plankton buried in mud, so it is not being replaced as fast as we use it.
- **Crude oil** is a mixture of a very large number of compounds.
- Most of them are each a **hydrocarbon** : a compound of hydrogen and carbon only.

Cracking and alkenes

- **Crude oil** contains more large hydrocarbons than we need, and fewer small ones such as petrol. **Cracking** breaks long **hydrocarbon** molecules into shorter, more useful ones.
- In catalytic **cracking**, the vapour is passed over a hot catalyst; in steam cracking, it is mixed with steam at a very high temperature.
- Cracking makes smaller alkanes, which are useful fuels, and alkenes, which are used to make polymers and other chemicals.
- **Worked example 4.** Balance $\mathrm{C_{10}H_{22}} \rightarrow \mathrm{C_8H_{18}} + \mathrm{X}$.

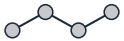
Figure: Cracking and alkenes



- Heat and a catalyst break the chain.
- One product is always an **alkene**.

Exercises 2.1·2.3

2.1 Give the formula of the alkane with four carbon atoms. [1]



2.2 State two trends in properties as hydrocarbon molecules get bigger. [2]

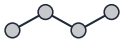


2.3 What type of hydrocarbon decolourises bromine water? [1]



Exercises 2.1–2.3

2.1 Give the formula of the alkane with four carbon atoms. [1]



2.1 C_4H_{10}.

2.2 State two trends in properties as hydrocarbon molecules get bigger. [2]



2.2 Any two of: boiling point rises; viscosity increases; flammability decreases.

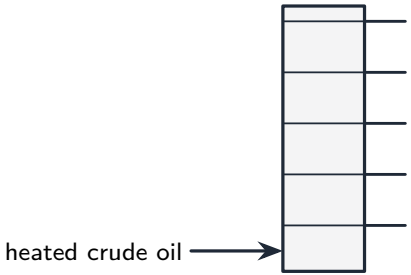
2.3 What type of hydrocarbon decolourises bromine water? [1]



2.3 An alkene – unsaturated.

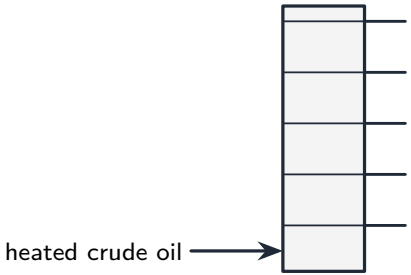
Exercise 3.1

3.1 Explain how fractional distillation separates crude oil into fractions. [4]



Exercise 3.1

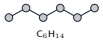
3.1 Explain how fractional distillation separates crude oil into fractions. [4]



3.1 The oil is heated and vapourised; the column is cooler towards the top; vapours condense at the level where the temperature equals their boiling point; molecules with similar boiling points – similar sizes – collect as the same fraction.

Setup for exercise 3.2

3.2 Balance and complete: $C_6H_{14} \rightarrow C_4H_{10} + _____$. Name the missing product. [3]



3.3 Describe the two industrial methods of cracking and why cracking is commercially necessary. [5]



3.4 A fictional oil sample contains C_3H_8, C_2H_5OH and C_4H_{10}. Identify its hydrocarbons and explain why the whole sample cannot be given one molecular formula. [3]

C_3H_8 C_2H_5OH C_4H_{10}

3.5 Write a balanced equation for complete combustion of butane, C_4H_{10}. Explain why the molecular formula of butane must not be changed while balancing. [4]



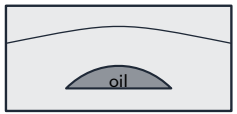
3.6 A fictional burner needs fuel that flows in less than 15 s in a specified test and ignites readily. At the same temperature, fraction P flows in 12 s and ignites readily; Q flows in 30 s and needs strong heating to ignite. Choose a fraction and justify it against both requirements. Explain why the test does not show that Q's viscosity is exactly 2.5 times P's. [4]



Exercise 3.2

3.7 Crude oil is a finite resource found in rocks.

(a) Describe how crude oil was formed. [2]



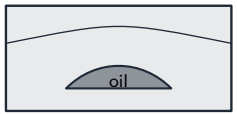
(b) Crude oil is a mixture of hydrocarbons, most of which are alkanes. Give the names and molecular formulae of the first four alkanes. [2]

(c) Give the general formula of the alkanes. [1]

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3.2 C_2H_4; $C_6H_{14} \rightarrow C_4H_{10} + C_2H_4$ is balanced – 6 C and 14 H each side; ethene.

3.3 Catalytic cracking – vaporised hydrocarbon passed over a hot catalyst; steam crack-

Full solution on next slide

Full solution 3.2 (1/2)

3.2 C_2H_4; $C_6H_{14} \rightarrow C_4H_{10} + C_2H_4$ is balanced – 6 C and 14 H each side; ethene.

3.3 Catalytic cracking – vaporised hydrocarbon passed over a hot catalyst; steam cracking – vaporised hydrocarbon mixed with steam at very high temperature. Cracking provides smaller alkanes for fuels, in higher demand than the large fractions supplied by distillation; and alkenes for polymers and other chemicals.

3.4 C_3H_8 and C_4H_{10} are hydrocarbons: only C and H. The whole sample is a mixture of different compounds, including oxygen-containing ethanol, and has no single fixed molecular formula.

3.5

Full solution 3.2 (2/2)

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

Correct products, balanced C/H, oxygen coefficient with matching fuel coefficient. Changing a subscript changes the identity of the molecule; balance with coefficients instead. The equivalent equation with one butane and 6.5 oxygen is acceptable.

3.6 P: 12 s is below 15 s and it meets the ignition requirement. The ratio $r = 30/12 = 2.5$ is a flow-time ratio, not a calibrated viscosity ratio. Both requirements, not molecule size alone, decide this supplied comparison.

3.7 (a) Crude oil formed from the remains of ancient biomass, mainly plankton, buried in mud and changed by heat and pressure over millions of years. (b) Methane CH_4, ethane C_2H_6; propane C_3H_8, butane C_4H_{10}. (c) C_nH_{2n+2}.