Knowledge check

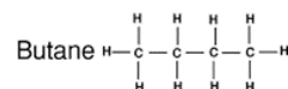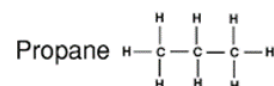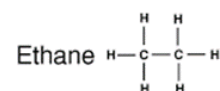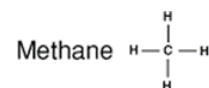| Subject area: Organic chemistry	Level: 14–16 years (Higher)
Topic: Burning hydrocarbons	Source: rsc.li/2SGIgfO

1. **Here are the first four members of the alkane homologous series.**

   John and Josie make some statements about these alkanes.

   State which statements are true, and which are false.

   Write 'T' or 'F' into the box.

   a) **The alkanes are hydrocarbons.**

   T

   b) **In this homologous series, it is always true that the molecular formula of one alkane differs from the next alkane by a CH$_3$ unit.**

   F

   c) **The alkanes in this series are called straight chain hydrocarbons.**

   T

   d) **The formula of the alkane having 24 hydrogen atoms is C$_{12}$H$_{24}$.**

   F

   e) **When an alkane burns, water is always formed.**

   T

   f) **It is always true that when an alkane burns, more heat energy is given out on forming new product chemical bonds than is required to break reactant bonds.**

   T

   g) **When methane burns, 882 kJ of heat energy is produced per mole. If 1.00 g of methane burns, 14.1 kJ of heat energy is released. [RAM data: C = 12, H = 1]**

   F

2. **This shows what happens when rubber tyres are set on fire.**

    Source: Adobe Stock

a) **What type of combustion is taking place?**

    Give a reason.

    Answer: Incomplete combustion.
    Carbon is formed.

b) **State two environmental problems with this type of combustion.**

    Answer: Breathing problems due to particulate carbon, blackening of buildings, global dimming.

3. **Some car and lorry engines produce a pollutant called nitrogen dioxide.**

a) **Name the two gases that react together to make nitrogen dioxide.**

    Answer: Nitrogen and oxygen.

b) **State the name of the substance that contains these two gases before the engine is used.**

    Answer: Air.

c) **Describe how nitrogen dioxide is formed inside an engine.**

    Answer: Nitrogen reacts with oxygen inside the engine to make nitrogen dioxide.
    It can do this because the engine gets very hot when the fuel burns.

d) **Sulfur is an impurity in fossil fuels. When this substance burns, it can produce a gas that can be very harmful to the environment.**

    Explain why this gas is harmful.
    Write a chemical equation to help you explain your answer.

    Answer: Sulfur burns in air (oxygen) to form sulfur dioxide.
    Sulfur dioxide dissolves and reacts with water to form sulfurous acid (sulfuric(IV) acid):
    $H_2O + SO_2 \rightarrow H_2SO_3$
    Sulfurous acid is a weak acid but when dissolved in water, for example in rain, it forms solutions of a low pH e.g. 3–6 (sometimes lower).

This acid rain can destroy wildlife based in water as well as have a disastrous effect on some life on land, for example, trees.

4. **Petrol may produce a lot of pollution when it burns.**

   Hydrogen is seen as a better fuel to use as it does not make any pollution.

a) **Give the names of two pollutants produced from burning petrol.**

   Answer: Carbon dioxide, soot, nitrogen dioxide (and other NO_x gases).

b) **Complete the symbol equation to show what happens when hydrogen burns in air:**

   $2H_2 + O_2 \rightarrow 2H_2O$

c) **Use your answer to part b) to explain why hydrogen does not make any pollution when it burns.**

   Answer: Water is the product of combustion of burning hydrogen, and this is non-polluting and harmless.

d) **When a hydrocarbon burns in a limited or short-supply of oxygen, a toxic gas may form.**

   Draw straight lines from the statements on the left to the correct answer on the right.

Statement	Answer
The name of the gas?	Carbon monoxide
	Carbon dioxide
The chemical formula of the gas?	CO
	CO_2
The type of combustion taking place?	Complete
	Incomplete

The name of the gas? → Carbon monoxide
The chemical formula of the gas? → CO
The type of combustion taking place? → Incomplete

e) **Explain why the gas in part d) is toxic.**

> *Answer: Carbon monoxide bonds to haemoglobin.*
> *It occupies the sites in the haemoglobin molecule used by oxygen.*
> *The levels of oxygen in the bloodstream decrease, resulting in tissue damage and other serious health consequences.*

5. **State which of these equations show complete and incomplete combustions.**

Draw a straight line from the chemical equation to the correct type of combustion.

Chemical equation

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

$C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$

$2C_{10}H_{22} + 11O_2 \rightarrow 20C + 22H_2O$

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

Type of combustion
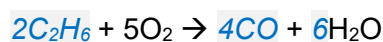
Complete combustion

Incomplete combustion

6. **This question is about writing chemical equations for combustion reactions.**

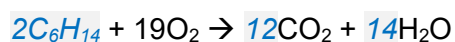Complete the equations.
Make sure that each equation is balanced.

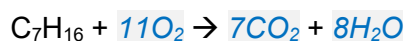a) **The complete combustion of methane.**

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
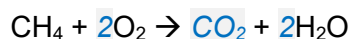
b) **The incomplete combustion of ethane.**

$2C_2H_6 + 5O_2 \rightarrow 4CO + 6H_2O$

c) **The complete combustion of hexane.**

$2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$

d) **The incomplete combustion of heptane.**

C_7H_{16} + $11O_2$ → $7CO_2$ + $8H_2O$

e) **The complete combustion of the molecule shown.**

C_5H_{12} + $8O_2$ → $5CO_2$ + $6H_2O$
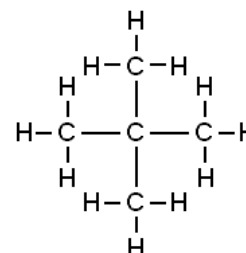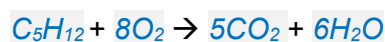
7. **Steph and Nikita set us a puzzle.**

They write down the combustion equation below.

$2C_8H_{16}$ + $24O_2$ → $16CO_2$ + $16H_2O$
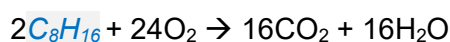
a) **What is the formula of the missing straight chain hydrocarbon?**

Answer: C_8H_{16}

b) **State if the missing hydrocarbon is an alkane. Give a reason.**

Answer: Not an alkane, as it is a straight chain hydrocarbon, and must therefore have the alkane general formula: $C_nH_{(2n+2)}$, not C_nH_{2n}.