In context

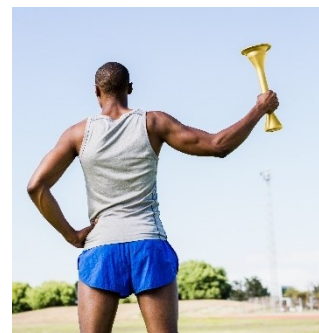| Subject area: Organic chemistry	Level: 14–16 years (Foundation)
Topic: Hydrocarbons	Source: rsc.li/34Fv93j

1. **The torch used to start the modern Olympic Games uses a mixture of propane and butane.**

   When propane and butane burn in air, they produce heat energy, and a flame.

   Source: Envato Elements

a) **Propane and butane are chemical compounds.**

   Name the two elements that make these compounds.

   Answer: Hydrogen and carbon.

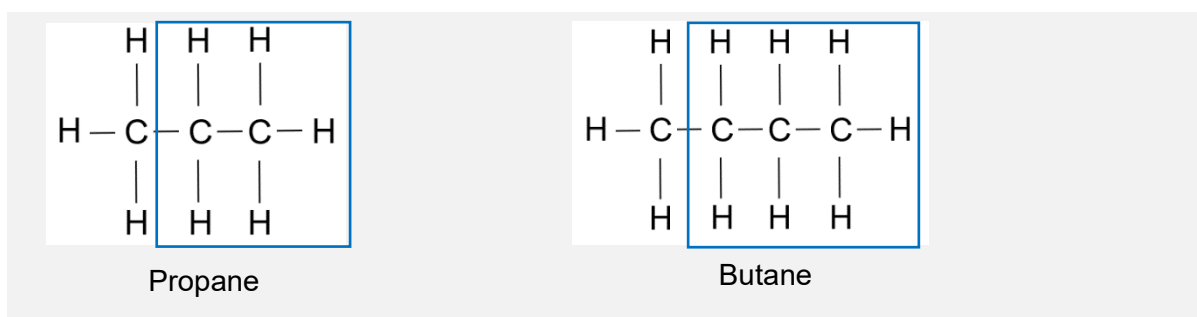b) **State the name of the compounds that contain the elements in part a).**

   Answer: Hydrocarbons.

c) **To which homologous series do propane and butane belong?**

   Answer: The alkanes.

d) **Below are the incomplete molecular structures for propane and butane.**

   Complete these structures.

Propane   Butane

e) **Using your answers to part d), explain what is meant by the word 'saturated'.**

   Answer: Hydrocarbons containing carbon single bonds only.

f) **When propane and butane burn in air, the same two products are made in each case.**

State the names of the products formed.
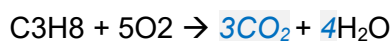
> *Answer: Carbon dioxide and water.*

g) **Complete the word equation to show what happens when these gases burn in air:**

Propane + oxygen → *carbon dioxide* + *water*

Butane + *oxygen* → *carbon dioxide* + *water*

h) **The chemical formula for propane is C_3H_8.**

Complete the symbol equation below to show propane burning in air.

C3H8 + 5O2 → *$3CO_2$* + *4*H_2O

The ratio in which propane and butane are mixed together as a fuel in the torch (by volume) is 2 : 1.

i) **What fraction of the fuel is butane?**

> *Answer:* $\frac{1}{3}$

j) **An Olympic torch contains 37.8 cm³ of fuel.**

Calculate the volume of butane in the fuel.
Show your working.

> *Answer:* $\frac{1}{3}$ *x 37.8 = 12.6 cm³*

2. **The image to the right shows a car called the 'Bio-Bug'.**

    You can find out more at
    www.geneco.uk.com/Case_study_Bio_bug/.
    Solid human waste decomposes to make a gas
    that powers the car.
    This gas is a hydrocarbon containing only one
    carbon atom.
    The gas is the first member of the alkane
    homologous series.

    Source: Wessex Water

    a) **What is the name of the gas?**

    Answer: Methane.

    b) **State the chemical formula for the gas.**

    Answer: CH_4

    c) **Explain how the gas powers the car.**

    *Answer: Methane burns in oxygen (from the air) to form heat energy. The car's engine
    converts most of that heat energy to kinetic energy, powering the car.*

    d) **Complete the symbol equation to show the gas burning in air.**

    Methane + oxygen → *carbon dioxide* + water

    e) **Suggest why this car is considered to be more environmentally friendly, or 'greener', than a car that runs on petrol or diesel.**

    *Answer: Petrol and diesel come from crude oil and this is a finite resource. However,
    methane (in this case) comes from human waste and is therefore renewable.
    The energy costs will be lower in the latter case.*

f) **When 16.0 g of methane burns, 890 kJ of heat energy is produced.**

Calculate how much heat energy is produced when 1.00 kg of methane burns.
Give your answer in MJ and to 3 significant figures.
Show your working.

> *Answer:* *Unit conversion: 1.00 kg = 1000 g.*
>
> *1.00 g of methane produces $\frac{890}{16}$ kJ = 55.625 kJ.*
>
> *1000 g of methane produces 55.625 kJ × 1000 = 55,625 kJ or 55.6 MJ (to 3 significant figures).*