Enthalpy of Combustion: Experimental Data

1. When 3·6 g of butanal (relative formula mass = 72) was burned, 134 kJ of energy was released.

From this result, what is the enthalpy of combustion, in kJ mol^{-1}?

A −6·7

B +6·7

C −2680

D +2680

2. The enthalpy of combustion of methanol is −727 kJ mol^{-1}.

What mass of methanol has to be burned to produce 72·7 kJ?

A 3·2 g

B 32 g

C 72·7 g

D 727 g

3. Aluminium reacts with oxygen to form aluminium oxide.

$2Al(s) + 1½O_2(g) \rightarrow Al_2O_3(s) \quad \Delta H = -1670\ kJ\ mol^{-1}$

What is the enthalpy of combustion of aluminium in kJ mol^{-1}?

A −835

B −1113

C −1670

D +1670

4. The enthalpy of combustion of a hydrocarbon is the enthalpy change when

A one mole of a hydrocarbon burns to give one mole of water

B one mole of a hydrocarbon burns to give one mole of carbon dioxide

C one mole of a hydrocarbon burns completely in oxygen

D one mole of a hydrocarbon burns in one mole of oxygen.

5. Which of the following equations represents the enthalpy of combustion of propane?

A $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$

B $C_3H_8(g) + \frac{7}{2}O_2(g) \rightarrow 3CO(g) + 4H_2O(\ell)$

C $C_3H_8(g) + 3O_2(g) \rightarrow 3CO_2(g) + 4H_2(g)$

D $C_3H_8(g) + \frac{3}{2}O_2(g) \rightarrow 3CO(g) + 4H_2(g)$

6 Which of the following equations represents an enthalpy of combustion?

A $2CH_4(g) + 3O_2(g) \rightarrow 2CO(g) + 4H_2O(\ell)$

B $CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(\ell)$

C $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(\ell)$

D $C_2H_6(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

7 $5N_2O_4(\ell) + 4CH_3NHNH_2(\ell) \rightarrow 4CO_2(g) + 12H_2O(\ell) + 9N_2(g) \quad \Delta H = -5116\ kJ$

The energy released when 2 moles of each reactant are mixed and ignited is

A 2046 kJ

B 2558 kJ

C 4093 kJ

D 5116 kJ.

Enthalpy of Combustion: Experimental Data

8. The enthalpy of combustion of an alcohol is always the enthalpy change for

A the alcohol burning in 1 mole of oxygen

B the alcohol burning to produce 1 mole of water

C 1 mole of the alcohol burning completely in oxygen

D 1 mole of the alcohol burning to produce 1 mole of carbon dioxide.

9 $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(\ell)$

A student recorded the following temperatures when reacting 20 cm^3 dilute hydrochloric acid with 20 cm^3 dilute sodium hydroxide solution.

Solution	Temperature/°C
HCl(aq)	18
NaOH(aq)	20
NaCl(aq)	27

ΔT for this reaction will be

A 2 °C

B 7 °C

C 8 °C

D 9 °C.

10 Excess iron was added to 100 cm^3 of 1·0 mol l^{-1} copper(II) sulfate solution releasing 3·1 kJ of energy.

$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_4(aq)$

What is the enthalpy change, in kJ mol^{-1} for the above reaction?

A −0·31

B −3·1

C −31

D −310

11 Which of the following equations represents an enthalpy of combustion?

A $C_2H_6(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

B $C_2H_5OH(\ell) + O_2(g) \rightarrow CH_3COOH(\ell) + H_2O(\ell)$

C $CH_3CHO(\ell) + \frac{1}{2}O_2(g) \rightarrow CH_3COOH(\ell)$

D $CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(\ell)$

12 A group of students added 6 g of ammonium chloride crystals to 200 cm^3 of water at a temperature of 25 °C.

The enthalpy of solution of ammonium chloride is +13·6 kJ mol^{-1}.

After dissolving the crystals, the temperature of the solution would most likely be

A 23 °C

B 25 °C

C 27 °C

D 30 °C.

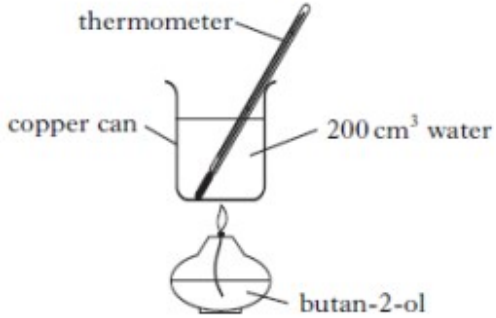
Enthalpy of Combustion: Experimental Data

1. The enthalpies of combustion of some alcohols are shown in the table.

Name of alcohol	Enthalpy of combustion/kJ mol^{-1}
methanol	–727
ethanol	–1367
propan-1-ol	–2020

(*a*) Using this data, predict the enthalpy of combustion of butan-1-ol, in kJ mol^{-1}.

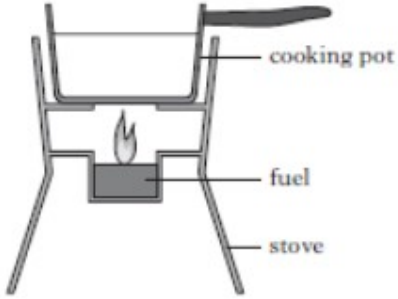
(*b*) A value for the enthalpy of combustion of butan-2-ol, C_4H_9OH, can be determined experimentally using the apparatus shown.



Mass of butan-2-ol burned = 1·0 g
Temperature rise of water = 40 °C

Use these results to calculate the enthalpy of combustion of butan-2-ol, in kJ mol^{-1}.

2. Ethanol, C_2H_5OH, can be used as a fuel in some camping stoves.



(*a*) The enthalpy of combustion of ethanol is –1367 kJ mol^{-1}.

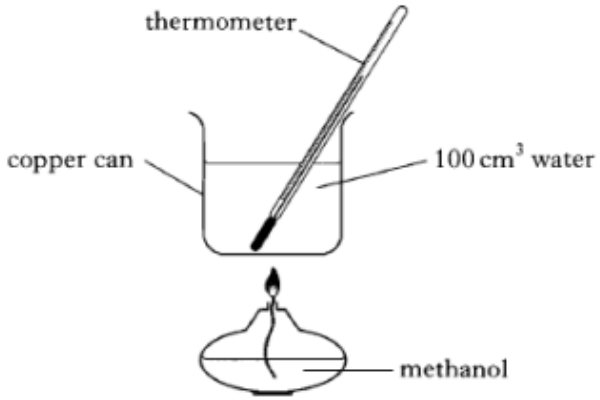
Using this value, calculate the number of moles of ethanol required to raise the temperature of 500 g of water from 18 °C to 100 °C.

Show your working clearly.

(*b*) Suggest **two** reasons why less energy is obtained from burning ethanol in the camping stove than is predicted from its enthalpy of combustion.

Enthalpy of Combustion: Experimental Data

3 The enthalpy of combustion of methanol (CH_3OH) can be determined from measurements using the apparatus shown.



In an experiment, the following results were obtained.

mass of methanol burned = 0·45 g

temperature rise of water = 10·0 °C

Use these results to calculate the enthalpy of combustion, in kJ mol^{-1}, of methanol.

Show your working clearly.

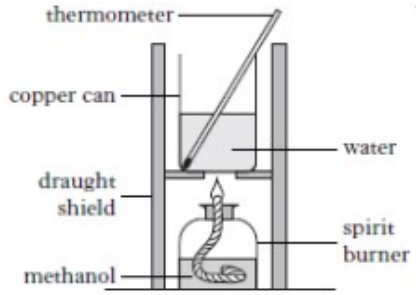
4. The energy changes taking place during chemical reactions have many everyday uses.

Flameless heaters are used by mountain climbers to heat food and drinks. The chemical reaction in a flameless heater releases 45 kJ of energy.

If 200 g of water is heated using this heater, calculate the rise in temperature of the water, in °C.

Enthalpy of Combustion: Experimental Data

5. A student used the simple laboratory apparatus shown to determine the enthalpy of combustion of methanol.

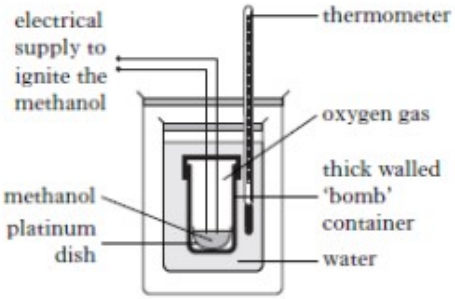


(*a*) (i) What measurements are needed to calculate the energy released by the burning methanol?

(ii) The student found that burning 0·370 g of methanol produces 3·86 kJ of energy.

Use this result to calculate the enthalpy of combustion of methanol.

(*b*) A more accurate value can be obtained using a bomb calorimeter.



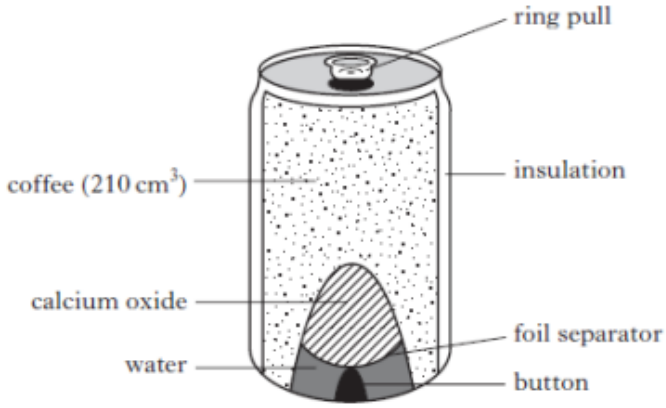
One reason for the more accurate value is that less heat is lost to the surroundings than in the simple laboratory method.

Give **one** other reason for the value being more accurate in the bomb calorimeter method.

6. Self-heating cans may be used to warm drinks such as coffee.

When the button on the can is pushed, a seal is broken allowing water and calcium oxide to mix and react.

The reaction produces solid calcium hydroxide and releases heat.



The equation for this reaction is:

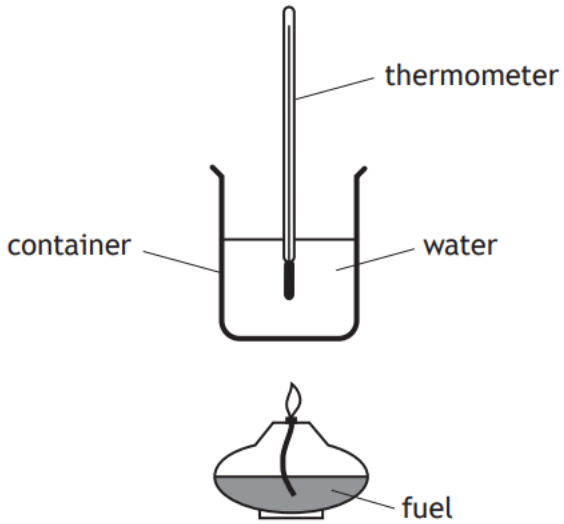
$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -65\ kJ\ mol^{-1}$$

Calculate the mass, in grams, of calcium oxide required to raise the temperature of 210 cm^3 of coffee from 20 °C to 70 °C.

Show your working clearly.

Enthalpy of Combustion: Experimental Data 2024

7. The energy released per gram of fuel can be measured using the following apparatus.



A student wanted to compare the energy released by different types of biodiesel.

(i) Suggest one variable the student would need to keep the same in both experiments to make a fair comparison. **1**

(ii) Heat is lost to the surroundings during the experiment.

Suggest an improvement to the apparatus that would prevent heat loss to the surroundings. **1**

(iii) The student's results for one type of biodiesel are shown in the table.

Mass of biodiesel burned (g)	0.420
Volume of water (cm^3)	200
Initial temperature of water (°C)	17
Final temperature of water (°C)	38

Calculate the energy released, in $kJ\,g^{-1}$, when 1.0 g of the biodiesel was burned. **3**

Enthalpy of Combustion: Experimental Data Answers

1. C
2. A
3. A
4. C
5. A
6. D
7. A
8. C
9. C
10 C
11 A
12. A

1. a) 2650-2750
   b) -2475

2. a) (171.38/1367) = 0.125 moles
   b) Incomplete combustion and heat loss to the surroundings.

3. -297

4. 53.8°C

5. a) i) Temperature of water before
   Highest temperature of water after heating
   Volume/mass of water heated
   ii) -334 kJ mol^{-1}
   b) Complete combustion will occur since it is in an atmosphere of oxygen.

6. 0.675 mol = 37.9g

7.

(i)	**1 from:** Distance between burner/wick/flame and container Material/type of container Stirring water in both Size of wick Use same draught shield Indication of same insulation in both experiments	**1**
(ii)	**1 from:** Use a draught shield Move flame closer to container Fit a lid on the container Insulate container	**1**
(iii)	(-)41.8 (kJ g^{-1}) (3 marks)	**3**