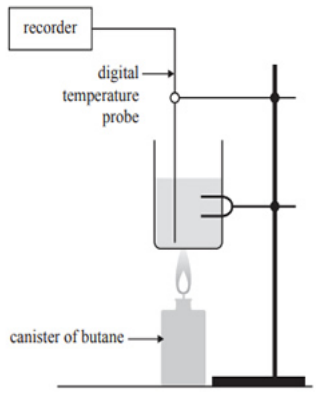
Thermochemistry (2016 VCE)

1)A senior Chemistry student bought a packet of Krispy Krackers from the local farmers' market. The label on the packet had no information on the energy content of the biscuits. The student decided that he would measure the energy content of a Krispy Krackers biscuit by burning it under a can of water and measuring the temperature rise of the water. Having performed a similar experiment in class, he knew that when the biscuit was burnt, heat energy would be lost to the environment. To increase the accuracy of the result, some butane gas from a butane canister was first burnt and the temperature rise of the water from that was measured. The heat energy released by burning butane was known, and the percentage energy loss using the equipment could be determined and adjusted to get the result for the biscuit. The experimental set-up and the results for Part 1 of the experiment are shown below.



Part 1 – The heat content of butane

1. Measure the initial mass of a butane canister.
2. Measure the mass of a metal can, add 250 mL of water and re-weigh.
3. Set up the apparatus as in the diagram and measure the initial temperature of the water.
4. Burn the butane gas for five minutes.
5. Immediately measure the final temperature of the water.
6. Measure the final mass of the butane canister when cool.

Solution will appear here

Results table for Part 1

Quantity	Measurement
mass of empty can	52.14 g
mass of can + water before combustion	303.37 g
mass of butane canister before heating	260.15 g
mass of butane canister after heating	259.79 g
initial temperature of water	22.1 °C
final temperature of water	32.7 °C

a) Write the balanced thermochemical equation for the complete combustion of butane

Solution

b) Calculate the amount of heat energy absorbed by the water when it was heated by burning the butane. Give your answer in kilojoules.

Solution will appear here

Solution

c) Calculate the experimental value of the molar heat of combustion of butane. Give your answer in kJ mol^{-1}.

Solution will appear here

Solution

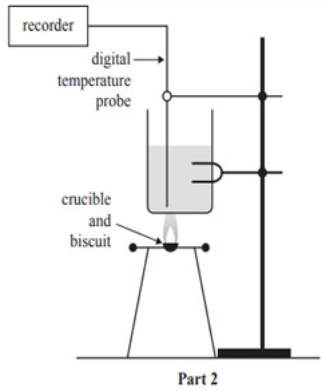
d) Use the known enthalpy change for butane to calculate the percentage energy loss to the environment using the following relationship.

$$\text{percentage energy loss} = \frac{(\text{theoretical value of } \Delta H - \text{experimental value of } \Delta H)}{\text{theoretical value of } \Delta H} \times \frac{100}{1}$$

Solution will appear here

Solution

e) The experimental set-up and the results for Part 2 of the experiment are shown below.



Part 2

Part 2 – The heat content of a Krispy Kracker

1. Measure the mass of a crucible, add a biscuit and re-weigh.
2. Set up the apparatus as in the diagram, using the same can of water as used in Part 1, and measure the initial temperature of the water.
3. Burn the biscuit until the flame runs out.
4. Immediately measure the final temperature of the water.
5. Measure the final mass of the crucible when cool.

Results table for Part 2

Quantity	Measurement
mass of crucible	44.33 g
mass of biscuit + crucible before combustion	46.75 g
mass of crucible after combustion	44.34 g
mass of water (from Part 1)	251.23 g
initial temperature of water	28.5 °C
final temperature of water	34.9 °C

Solution will appear here

Calculate the energy content of Krispy Krackers using the data in the results table for Part 2. Give your answer in kJ/100 g.

Solution

f) Explain why the energy content of a biscuit cannot be given in kJ mol^{-1}.

Solution

g) Assume that the same percentage heat energy loss occurred when burning the Krispy Kracker as when the butane was burnt in Part 1. Calculate a more accurate value of the energy content of Krispy Krackers in kJ/100 g

Solution will appear here

Solution

2) Methanol is a liquid fuel that is often used in racing cars. The thermochemical equation for its complete combustion is

$$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$$

Octane is a principal constituent of petrol, which is used in many motor vehicles. The thermochemical equation for the complete combustion of octane is

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$$

The molar mass of methanol is 32 g mol–1 and the molar mass of octane is 114 g mol–1. Which one of the following statements is the most correct?
A. Burning just 1.0 g of octane releases almost 96 kJ of heat energy.
B. Burning just 1.0 g of methanol releases almost 23 kJ of heat energy.
C. Octane releases almost eight times more energy per kilogram than methanol.
D. The heat energy released by methanol will not be affected if the oxygen supply is limited.

Solution will appear here

Solution

3) The combustion of hexane takes place according to the equation

$$C_6H_{14}(g) + \frac{19}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(g) \qquad \Delta H = -4158 \text{ kJ mol}^{-1}$$

Consider the following reaction.

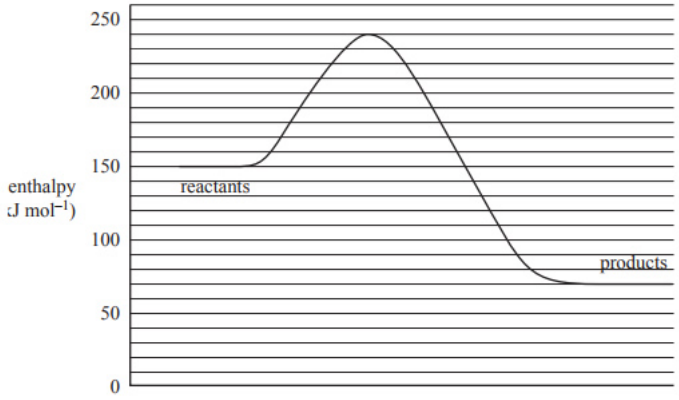
$$12CO_2(g) + 14H_2O(g) \rightarrow 2C_6H_{14}(g) + 19O_2(g)$$

The value of ΔH, in kJ mol^{-1}, for this reaction is
A. +8316
B. +4158
C. –2079
D. –3568

Solution will appear here

Solution

4) A chemical reaction has the following energy profile.



The enthalpy change of the forward reaction, in kJ mol^{-1}, is
A. –170
B. –80
C. +70
D. +240

Solution will appear here

Solution

5) A student calibrated a calorimeter using an electric heating coil. A current of 1.50 A with a potential difference of 4.50 V was applied for two-and-a-half minutes. A digital probe recorded a temperature rise of 5.35 °C.

The value of the calibration factor, in J °Cl^{-1}, is

A. 189
B. 42.1
C. 3.15
D. 0.317

Solution

Solution will appear here