Investigation 9.B: Molar Enthalpy of Combustion Answer Key

Answers to Analysis Questions Part 1

Typical data:

Initial mass of candle and lid = 35.40 g
Final mass of candle and lid = 34.81 g
Initial temperature of water = 13.8 °C
Final temperature of water = 39.9 °C
Initial mass of can = 49.56 g
Final mass of can and water = 189.56 g

1. **(a)** The mass of water is 189.56 g – 49.56 g = 140.00 g
(b) The mass of the candle burned is 35.40 g – 34.81 g = 0.59 g

2. Assuming that the can is made of aluminium, *heat lost by system = –heat gained by surroundings*

$$n\Delta H = -\left(Q_{water} + Q_{can}\right)$$

$$\Delta H = \frac{-\left(mc\Delta t + mc\Delta t\right)}{n}$$

$$= \frac{-\left[\left(140.00\,\text{g}\right)\left(4.19\frac{\text{J}}{\text{g}\bullet{}^{\circ}\text{C}}\right)\left(39.9\,{}^{\circ}\text{C} - 13.8\,{}^{\circ}\text{C}\right) + \left(49.56\,\text{g}\right)\left(0.897\frac{\text{J}}{\text{g}\bullet{}^{\circ}\text{C}}\right)\left(39.9\,{}^{\circ}\text{C} - 13.8\,{}^{\circ}\text{C}\right)\right]}{\left(0.59\,\text{g C}_{25}\text{H}_{52}\right)\left(\frac{1\,\text{mol C}_{25}\text{H}_{52}}{352.77\,\text{g C}_{25}\text{H}_{52}}\right)}$$

$$= -9.9\times10^{6}\ \text{J/mol C}_{25}\text{H}_{52}\text{(s)}$$

$$= -9.9\times10^{3}\ \text{kJ/mol C}_{25}\text{H}_{52}\text{(s)}$$

Answers to Conclusion Questions Part 1

3. **(a)** The two largest sources of experimental error are heat losses and incomplete combustion of the paraffin wax. Measurement errors in reading the thermometer and massing the candle wax and water should also be mentioned. The loss of some water during the experiment due to evaporation is trivial compared with the major sources of error mentioned.

(b) Focus on the large sources of error in the experiment, and how these can be reduced. While you could use a thermometer with more precision, this is no real improvement if the sources of heat loss are not addressed. The calorimeter used is open, and good suggestions would include ways to close and insulate the calorimeter. The calorimeter has a specific heat capacity that is not precise, as the chemical composition of the can may be in question. The experiment is probably limited to two significant digits because of the amount of candle wax burned. Suggestions to increase the measurement to allow for three significant digits (a more precise balance, or burning more candle wax) may be made. Focus on suggestions to make the burning of the paraffin wax a complete combustion.

4. The appearance of soot confirms that the combustion is incomplete, and therefore the molar enthalpy of combustion is lower than the expected value since not all of the carbon is burned. For every mole of carbon burned, 393 kJ of energy are released (the molar enthalpy of formation of carbon dioxide).

Investigation 9.B: Molar Enthalpy of Combustion Answer Key (cont'd)

Answers to Analysis Questions Part 2

1. Calculations will vary depending on the fuel that is used. However, the skeleton calculation will resemble that of the calculations performed in Part 1.

Answers to Conclusion Questions Part 2

2. (a) Combustion of paraffin:

$C_{25}H_{52}(s) + 38O_2(g) \rightarrow 25CO_2(g) + 26H_2O(g)$ $\Delta_c H = -9.9 \times 10^3$ kJ/mol

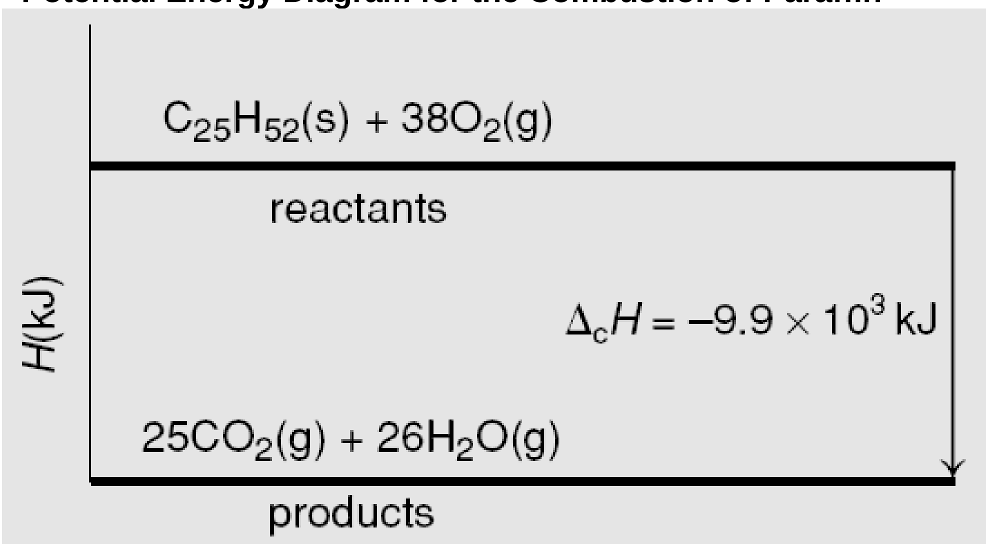
Some other common fuels:

Methane (natural gas): $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ $\Delta_c H = -802.5$ kJ/mol

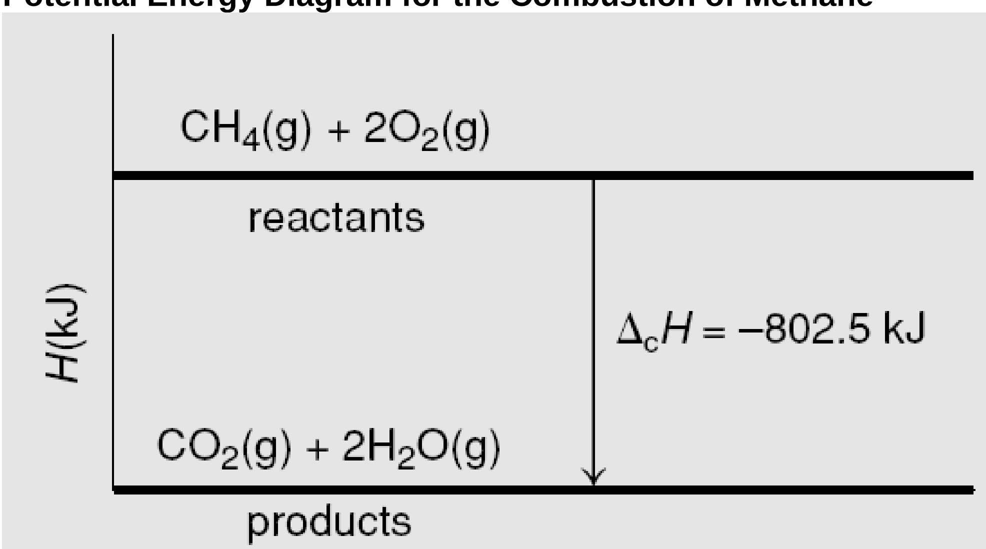
Ethanol (alcohol burners): $C_2H_5OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta_c H = -1234.8$ kJ/mol

Propane (barbeque): $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\Delta_c H = -2043.9$ kJ/mol

2. (b) Potential Energy Diagram for the Combustion of Paraffin



Potential Energy Diagram for the Combustion of Methane



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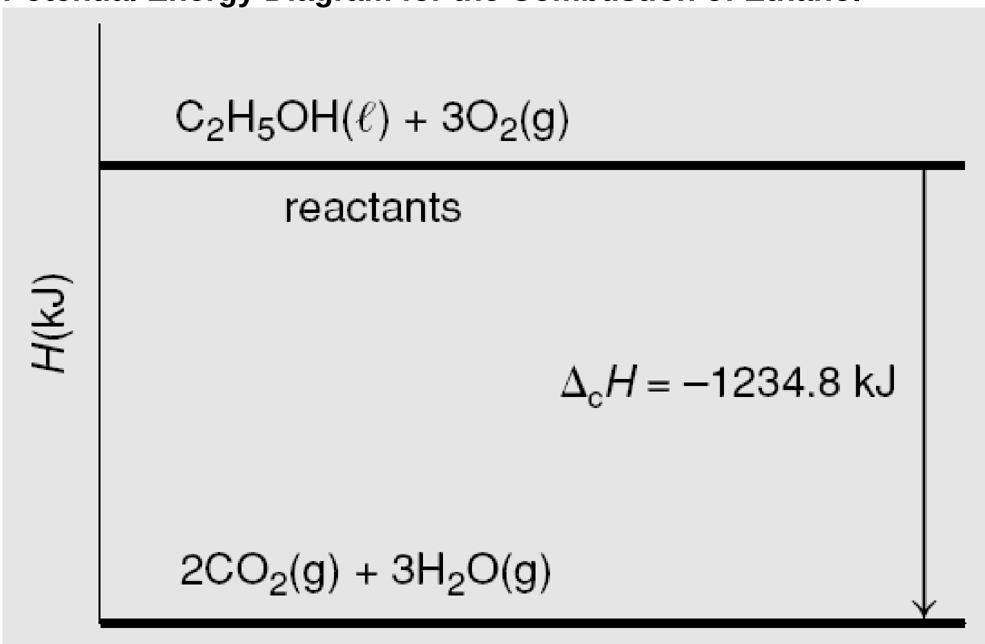
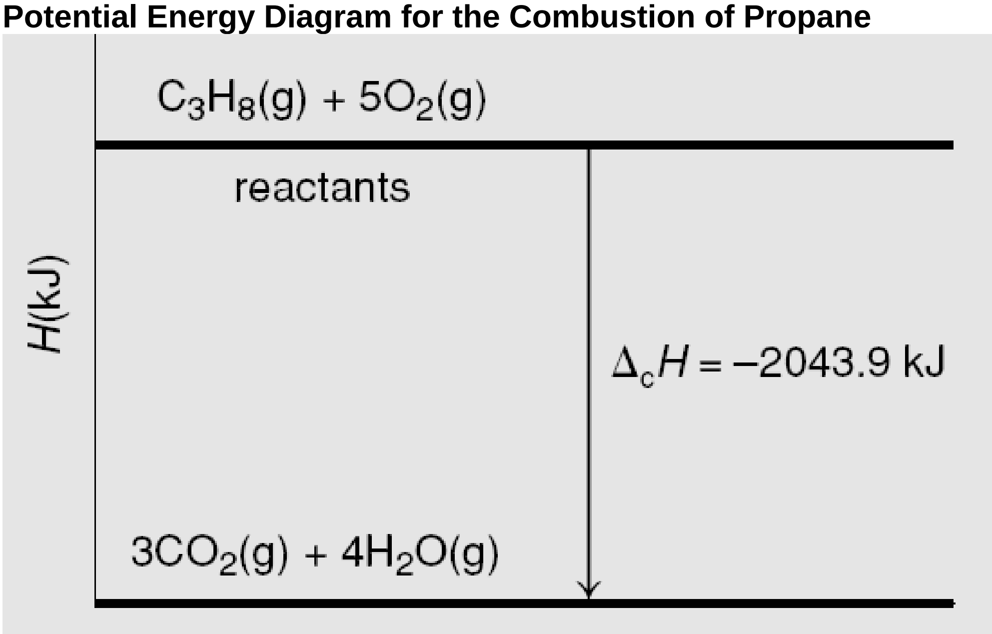
Potential Energy Diagram for the Combustion of Ethanol



Potential Energy Diagram for the Combustion of Propane



Investigation 9.B: Molar Enthalpy of Combustion Answer Key (cont'd)

3.

Fuel	Molar enthalpy	Environmental Impact	Appropriate Use
Paraffin	Highest of the four fuels (most carbons)	Since it does not burn completely, there is a residue of carbon, and some carbon monoxide released. This is not a fuel used for heat as much as light.	Since it burns incompletely and cooler, it produces light, which is paraffin's principal use.
Methane	Lowest (fewest carbons)	Considered to be a "clean" fuel, it burns completely, therefore producing little carbon monoxide. It is obtained principally from fossil fuels, so it is limited and requires drilling. When harnessed from waste, methane is considered a renewable resource.	Methane, the chief component in natural gas, heats most homes in Alberta and is used for cooking and heating water in many.
Ethanol	Two carbons, so higher than methane	It can be obtained from crops, and can therefore be considered renewable. It burns cleanly.	At present, ethanol is primarily used as an additive for gas, increasing the octane level of fuel.
Propane	Three carbons, so higher than methane and ethanol	Propane is produced from fossil fuels. It burns more cleanly than heavier fuels (ones with more carbons).	Propane is used mostly as a barbeque fuel. It is portable and burns hotter than methane, making it a more attractive choice for barbeques, especially for portable barbeques.

Answer to Extension Question

4. To be suitable as a survival food, it must not only have a high energy content, but be portable, not need refrigeration, be easily packaged and have a balanced nutrient content. A good survival food should be able to be kept in a knapsack, or car, for long periods of time and keep a hiker alive in adverse conditions.