

Thermochemical equations – combustion reactions stoichiometry – determining ΔH

Lesson 4

- 1) a) Write a balanced chemical equation for the complete combustion of liquid butane (C_4H_{10}) in oxygen gas, where the products are a gas and a liquid.



- b) An investigation was conducted to find the ΔH for the reaction represented by the equation above. Calculate the experimental value of the ΔH of the equation a) above if 0.580 grams of pure butane generated 28.9 kJ of heat energy

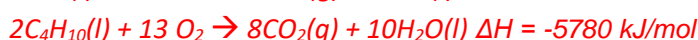
Step 1 find the mol of butane

$$\Rightarrow 0.580 / 58.12 = 0.0100$$

Step 2 Calculate the energy per mol of butane

$$\Rightarrow 28.9 / 0.0100 = 2890 \text{ kJ}$$

$$\Delta H = -2890 \text{ kJ/mol}$$



- b) Calculate the mass of carbon dioxide produced if an unknown mass of butane delivered 3.10×10^3 kJ of energy.

Step 1 find the mol of CO_2 produced if 3100 kJ of energy is released

$$\Rightarrow 4/2890 = x / 3100$$

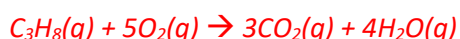
$$\Rightarrow (4/2890) \times 3100 = 4.29$$

Step 2 calculate the mass of CO_2

$$\Rightarrow 4.29 \times 44.0 = 189 \text{ grams}$$

- 2) Propane gas undergoes complete combustion in excess oxygen gas to produce gaseous products.

- a) Write a balanced chemical equation for the combustion reaction.



- b) If 120.0 g of pure propane generated 6.05×10^3 kJ of heat energy, find the ΔH for the equation for the combustion reaction above.

Step 1 Find the mol of propane

$$\Rightarrow 120.0 / 44.1 = 2.72$$

Step 2 Find the energy released per mol of propane

$$\Rightarrow 6050 \text{ kJ} / 2.72 = 2224 \text{ kJ/mol}$$

$$\Rightarrow \Delta H = -2224 \text{ kJ/mol}$$

- c) What mass of water is produced from the reaction represented by the equation above if

6.60 kJ of energy is produced?

$$\Rightarrow 4\text{mol}/2224\text{kJ} = n_{\text{water}}/6.60\text{kJ}$$

$$\Rightarrow 0.0119 \text{ mol of water}$$

$$\Rightarrow 0.0119 \times 18.0 \text{ grams} = 0.214$$

3) A student conducted an experiment to determine the molar heat of combustion for the complete combustion of ethanol .

a) If 9.20 grams of pure ethanol generated 273.4 kJ of heat energy, write the balanced thermochemical equation, including states for this reaction where a gas and a liquid are formed as products.

Step 1 Find the mol of ethanol

$$\Rightarrow 9.20 / 46.1 = 0.200$$

Step 2 Find the energy released per mol of ethanol

$$\Rightarrow 273.4 \text{ kJ} / 0.200 = 1367 \text{ kJ/mol}$$

$$\Rightarrow \Delta H = -1367 \text{ kJ/mol}$$

Step 2 Write the balanced thermochemical equation



b) What mass of carbon dioxide is produced from the reaction represented by the equation in a) above if 1.37kJ of energy is produced?

Step 1 apply the ratios as per the balanced thermochemical equation.

The amount of energy given out per mol of CO₂ produced will always be the same.

$$\Rightarrow \text{energy/mol of CO}_2 = \text{energy/ mol of CO}_2$$

$$\Rightarrow 1367 / 2 = 1.37 / \text{ mol of CO}_2$$

$$\Rightarrow 0.00200 \text{ mol of CO}_2$$

Step 2 find the mass of CO₂

$$\Rightarrow 0.00200 \times 44.0 = 0.0880\text{g}$$

c) Given that the density of ethanol is 0.7854 g/mL, calculate the volume of ethanol required to produce 54.8 kJ of energy when it burns in oxygen according to the equation in a) above. *Step 1 Calculate the mol of ethanol.*

The amount of energy given out per mol of ethanol used will always be the same.

$$\Rightarrow \text{energy/mol of ethanol} = \text{energy/ mol of ethanol}$$

$$\Rightarrow 1367 / 1 = 54.8 / \text{ mol of ethanol}$$

$$\Rightarrow 0.0401 \text{ mol of ethanol}$$

Step 2 calculate the mass of ethanol used

$$\Rightarrow \text{mass} = 46.1 \times 0.0401 = 1.85\text{g}$$

Step 3 Calculate the volume of ethanol

$$\Rightarrow \text{volume (mL)} = \text{mass} / \text{density}$$

$$\Rightarrow \text{vol} = 1.85 / 0.7854 = 2.36 \text{ mL}$$