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.

$C_4H_{10}(l) + 6\frac{1}{2}\ O_2 \rightarrow 4CO_2(g) + 5H_2O(l)$ or

$2C_4H_{10}(l) + 13\ O_2 \rightarrow 8CO_2(g) + 10H_2O(l)$

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

=> 0.580 / 58.12 = 0.0100

Step 2 Calculate the energy per mol of butane

=> 28.9 / 0.0100 = 2890 kJ

ΔH = -2890 kJ/mol

$C_4H_{10}(l) + 6\frac{1}{2}\ O_2 \rightarrow 4CO_2(g) + 5H_2O(l)$ ΔH = -2890 kJ/mol or

$2C_4H_{10}(l) + 13\ O_2 \rightarrow 8CO_2(g) + 10H_2O(l)$ ΔH = -5780 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

=> 4/2890 = x / 3100

=> (4/2890) X 3100 = 4.29

Step 2 calculate the mass of CO_2

=> 4.29 X 44.0 = 189 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.

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

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

=> 120.0 / 44.1 = 2.72

Step 2 Find the energy released per mol of propane

=> 6050 kJ / 2.72 = 2224 kJ/mol

=> ΔH = -2224 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?

=> 4mol/2224kJ = n_{water}/6.60kJ
=> 0.0119 mol of water
=> 0.0119 X 18.0 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
=> 9.20 / 46.1 = 0.200
Step 2 Find the energy released per mol of ethanol
=> 273.4 kJ / 0.200 = 1367 kJ/mol
=> ΔH = -1367 kJ/mol
Step 2 Write the balanced thermochemical equation
=> $C_2H_6O(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ ΔH = -1367 kJ/mol

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 CO_2 produced will always be the same.
=> energy/mol of CO_2 = energy/ mol of CO_2
=> 1367 / 2 = 1.37 / mol of CO_2
=> 0.00200 mol of CO_2
Step 2 find the mass of CO_2
=> 0.00200 X 44.0 = 0.0880g

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.
=> energy/mol of ethanol = energy/ mol of ethanol
=> 1367 / 1 = 54.8 / mol of ethanol
=> 0.0401 mol of ethanol

Step 2 calculate the mass of ethanol used
=> mass = 46.1 X 0.0401 = 1.85g
Step 3 Calculate the volume of ethanol
=> volume (mL) = mass / density
=> vol = 1.85 /0.7854 = 2.36 mL