Thermochemical equations

Lesson 1

$2C_8H_{18}(g) + 25O_2(g) \Rightarrow 16CO_2(g) + 18H_2O(g)$ $\Delta H = -10900$ kJ mol^{-}

What does a thermochemical equation reveal about a reaction?

i) What is enthalpy? *Total heat energy in a chemical system.*

ii) What is enthalpy change (ΔH)? *The difference in heat content between the products and reactants. A negative sign for the ΔH indicates that the products of a chemical reaction have less energy than the reactants and hence energy is given out to the environment. A positive sign for the ΔH indicates that the products of a chemical reaction have more energy than the reactants and hence energy is absorbed from the environment*

iii) Stoichiometric ratio of a balanced chemical equation

$2C_8H_{18}(g) + 25O_2(g) \Rightarrow 16CO_2(g) + 18H_2O(g)$ $\Delta H = -10900$ kJ mol^{-}

For example. The equation above shows that for :

- 2 mol of C_8H_{18} gas that is consumed 10900 kJ of energy is released.

- 25 mol of O_2 gas that is consumed 10900 kJ of energy is released.

- 16 mol of CO_2 gas that is produced10900 kJ of energy is released.

- 18 mol of H_2O gas that is produced 10900 kJ of energy is released.

The ratio is always the same. Eg if 9 mol of water is produced (half the amount shown in the equation) then we would expect that 5450 kJ of energy is released, that is, half the amount shown in the equation.

States

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iv) Energy output or input (depending on sign)

negative sign indicates - *energy released to the environment*

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positive sign indicates- *energy absorbed from the environment*

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v) Amount of energy is dependent on the mol of the equation

For example *See stoichiometric ratio above.*

1) Consider the thermochemical equation for the combustion of octane shown below.

$2C_8H_{18}(g) + 25O_2(g) \Rightarrow 16CO_2(g) + 18H_2O(g)$ $\Delta H = -10900$ kJ mol^{-}

i. It shows that for 2 mol of octane that reacts *completely* 10900 kJ of energy is *released*

ii. Calculate the ΔH for the following equations

a) $C_8H_{18}(g) + 12½O_2(g) \Rightarrow 8CO_2(g) + 9H_2O(g)$ $\Delta H = ?$ kJ mol^{-}

If we divide the equation by 2 then we must do the same for the ΔH

=> hence, 10900/2 kJ/mol = 5450 kj/mol

=> $C_8H_{18}(g) + 12½O_2(g) \Rightarrow 8CO_2(g) + 9H_2O(g)$ $\Delta H = -5450$ kJ mol^{-}

notice how the sign of the ΔH remains the same (negative) indicating that energy is released.

b) $8CO_2(g) + 9H_2O(g) \Rightarrow C_8H_{18}(g) + 12½O_2(g)$ $\Delta H = ?$ kJ mol^{-}

Reversing the equation we must now change the sign of the ΔH.

$8CO_2(g) + 9H_2O(g) \Rightarrow C_8H_{18}(g) + 12½O_2(g)$ $\Delta H = +5450$ kJ mol^{-}

c) Consider the equation below

$C_6H_{12}O_6(aq) + 6O_2(g) \Rightarrow 6CO_2(g) + 6H_2O(l)$ $\Delta H = -2803$ kJ mol^{-}

What is the ΔH for the following equations?

i. $2C_6H_{12}O_6(aq) + 12O_2(g) \Rightarrow 12CO_2(g) + 12H_2O(l)$ $\Delta H =$

Multiplying the equation by 2 we must also multiply the ΔH by 2.

$2C_6H_{12}O_6(aq) + 12O_2(g) \Rightarrow 12CO_2(g) + 12H_2O(l)$ $\Delta H = -5606$ kJ mol^{-}

ii. $3CO_2(g) + 3H_2O(l) \Rightarrow ½\, C_6H_{12}O_6(aq) + 3O_2(g)$ $\Delta H =$

The equation below is halved and flipped.

$C_6H_{12}O_6(aq) + 6O_2(g) \Rightarrow 6CO_2(g) + 6H_2O(l)$ $\Delta H =$ *-2803 kJ mol^{-}*

=> Hence we halve the ΔH and change its sign.

=> $3CO_2(g) + 3H_2O(l) \Rightarrow ½\, C_6H_{12}O_6(aq) + 3O_2(g)$ $\Delta H = +1402$ kJ mol^{-}

d) What is the amount of energy given off when 18.0 grams of glucose (Molar mass 180.2 amu) burns completely in oxygen gas according to the equation below?

$C_6H_{12}O_6(aq) + 6O_2(g) \Rightarrow 6CO_2(g) + 6H_2O(l)$ $\Delta H = -2803$ kJ mol^{-}

Step 1 find the mol of glucose.

=> 18.0 / 180.2 = 0.100 mol

Step 2 apply the ratios as per the balanced thermochemical equation.

The amount of energy given out per mol of glucose consumed will always be the same.

=> energy/mol of glucose = energy/ mol of glucose

=> 2803 / 1 = energy / 0.100

=> 2.80×10^2 kJ = energy released (3 significant figures)

e) What amount of energy, in kJ, is released if 8.80 grams of carbon dioxide is produced when glucose burns in excess oxygen?

Step 1 find the mol of CO_2.

=> 8.80 / 44.0 = 0.200 mol

Step 2 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

=> 2803 / 6 = energy / 0.200

=> 93.4 kJ = energy released

f) What amount of energy, in kJ, is released if 3.60 grams of water is produced when glucose burns in excess oxygen?

Step 1 find the mol of H_2O.

=> 3.60 / 18.0 = 0.200 mol

Step 2 apply the ratios as per the balanced thermochemical equation.

The amount of energy given out per mol of H_2O produced will always be the same.

=> energy/mol of H_2O = energy/ mol of H_2O

=> 2803 / 6 = energy / 0.200

=> 93.4 kJ = energy released

g) What amount of energy, in kJ, is released if 3.60 grams of glucose reacts completely?

Step 1 find the mol of glucose.

=> 3.60 / 180.2 = 0.0200 mol

Step 2 apply the ratios as per the balanced thermochemical equation.

The amount of energy given out per mol of glucose consumed will always be the same.

=> energy/mol of glucose = energy/ mol of glucose

=> 2803 / 1 = energy / 0.0200

=> 56.1 kJ = energy released

h) Consider the equation below.

$6CO_2(g) + 6H_2O(l) \Rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

i. What is the ΔH of the thermochemical equation above ?

The equation is reversed hence the ΔH = +2803 kJ mol^{-}

ii. Is energy absorbed or released?

Absorbed

iii. What amount of energy, is involved if 36.0 grams of glucose (molar mass = 180.2 amu) is formed?

$6CO_2(g) + 6H_2O(l) \Rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$ ΔH = +2803 kJ mol^{-}

Step 1 find the mol of glucose.

=> 36.0 / 180.2 = 0.200 mol

Step 2 apply the ratios as per the balanced thermochemical equation.

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

=> energy/mol of glucose = energy/ mol of glucose

=> 2803 / 1 = energy / 0.200

=> 5.60×10^2 kJ = energy absorbed