Multi-Step Energy Calculations

Step 1: *Find H_r general*
-use Hess' law
-from equation
-$\Delta H = nH$

Step 2: *Find n (specific)*
-use mass (molar mass)
-use calorimetry
-use $n = \Delta H/H^o$

Step 3: *Find ΔH (specific), mass,* ΔT
-use $\Delta H = nH^o$
-use calorimetry

Sample Problem

Ex. $2NaHCO_{3(s)}$ + 129.2kJ ⟶ $Na_2CO_{3(s)}$ + $CO_{2(g)}$ + $H_2O_{(g)}$

What quantity of energy, ΔH_r, is required to decompose 100. kg of $NaHCO_{3(s)}$?

$\Delta H_r = \Sigma n H_{fp} - \Sigma n H_{fr}$

Step 1: Hr (general)

$\Delta H_r = nH_r$

$H_r = \frac{\Delta H_r}{n}$

$H_r = \frac{129.2\ kJ}{2\ mol}$

$H_r = 64.6\ kJ/mol$

Step 2: n (specific)

$100\,000 g\ NaHCO_3 \times \frac{1\ mol\ NaHCO_3}{84.01 g\ NaHCO_3} = 1190.33\ mol$

Step 3: ΔH_r (specific)

$\Delta H_r = nH_r$

$\Delta H_r = (1190.33\ mol)(64.6\ \frac{kJ}{mol})$

$\Delta H_r = 76900\ kJ$

Calculate the mass of methane combusted when 3700. kJ of energy is released according to the following reaction.

$CH_{4(g)} + 2O_{2(g)} \Rightarrow CO_{2(g)} + 2H_2O_{(g)} + 802.7kJ$

Step1: H_r (general)

$\Delta H_r = nH_r$

$H_r = \frac{\Delta H_r}{n}$

$\Delta H_r = \Sigma nH_{fp} - \Sigma nH_{fr}$

$H_r = \frac{-802.7 kJ}{1 mol}$

$H_r = -802.7 kJ/mol$

Step2: n (specific)

$\Delta H_r = nH_r$

$n = \frac{\Delta H_r}{H_r}$

$n = \frac{-3700 kJ}{-802.7 kJ/mol}$

$n = 4.6094 mol$

Step3: m (specific)

$4.6094 mol\ CH_4 \times \frac{16.05 g\ CH_4}{1 mol\ CH_4} = 73.98 g\ CH_4$

Multi-Step Energy Calculations can be used when energy produced in one chemical reaction is used to heat another substance. These calculations are very similar to calorimetry calculations.

total enthalpy change = quantity of heat

$$\Delta H_r = q$$

Sample Problem

What mass of octane is completely burned during the heating of 20.L of aqueous ethylene glycol automobile coolant from -10°C to 70°C? The volumetric heat capacity of aqueous ethylene glycol is 3.7 kJ/L°C.

Ex. $2C_8H_{18(l)} + 25O_{2(g)} \longrightarrow 18H_2O_{(s)} + 16CO_{2(g)}$

Worksheet #1-5