Determining Chemical Potential Energy From Experiment

→ see bomb calorimeter on pg. 299

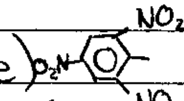
→ all potential energy determinations have been done using a bomb calorimeter (or equivalent) either directly or indirectly

Terminology:

Heat of Reaction → ΔH for any reaction
eg. $C_6H_{14}(l) + \frac{19}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l)$

Heat of Combustion → ΔH for a combustion reaction
→ O_2 reaction, common oxide products
→ see above for an example

Heat of Formation → ΔH for a formation reaction
→ formation → one product only
→ one mole of one product
→ reactants are started in their natural state at SATP (↑ 1 atm, ↖ 25°C)
→ $H_2(g)$, $N_2(g)$, $O_2(g)$, $F_2(g)$, $Cl_2(g)$, $Br_2(l)$, $I_2(s)$, C(graphite), P_4, S_8 or just the element (Fe, Sn, Pb... etc)

eg. heat of formation for TNT (trinitro toluene) 
$C_7H_5N_3O_6(l)$

$7C_{(s)} + \frac{5}{2}H_2(g) + \frac{3}{2}N_2(g) + 3O_2(g) \rightarrow C_7H_5N_3O_6(l)$

$\frac{3}{2}H_2(g) + \frac{1}{4}P_4 + 2\,O_2(g) \rightarrow H_3PO_4(l)$

Ex. 1 5g of methanol is placed in a bomb calorimeter containing 3500 mL of H_2O. The methanol undergoes complete combustion causing the H_2O to warm from 20.00°C to 27.734°C. Use this info. to determine the heat of combustion for methanol.

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + H_2O(l)$ $\Delta H = ?$

① $Q = ?$

mass of substance being warmed → $m = 3500\,mL \rightarrow 3500\,g$

$C = 4.184\,J/g°C$

$\Delta T = (27.734 - 20.000)°C$
$= 7.734°C$

$Q = mC\Delta T$

$Q = 3500g \times 4.184\,J/g°C \times 7.734°C$

$Q = 113\,257\,J$

$Q = 113.257\,kJ$

② Conversion / Scaling Step

$\frac{113.257\,kJ}{5g\,CH_3OH} \times \frac{32.05\,g\,CH_3OH}{1\,mol\,CH_3OH} = 725.977\,kJ/mol\,CH_3OH$

mass of substance producing heat (→ 5g CH_3OH)

③ $\Delta H = -Q$

$\Delta H = -725.977\,kJ/mol\,CH_3OH$

note drop of units

④ ∴ $CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ $\Delta H = -725.977\,kJ$

Ex 2 Determine the change in temp one would expect in 3.5L of H_2O when 5g of methanol is combusted. The heat of combustion for methanol is $-725.977\,kJ/mol\,CH_3OH$

① $CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ $\Delta H = -725.977\,kJ$

② $Q = -\Delta H$

$Q = 725.977\,kJ/mol\,CH_3OH$

③ $5g\,CH_3OH(l) \times \frac{1m\,CH_3OH}{32.05g\,CH_3OH} \times \frac{725.977\,kJ}{1\,mol\,CH_3OH} \times \frac{1000J}{1kJ} = 113\,257\,J$

(4) $Q = 113.257\,J$

$m = 3.5\,L \rightarrow 3500\,mL \rightarrow 3500\,g\,H_2O$

$C = 4.184\,J/g°C$

$\Delta T = ?$

$$\Delta T = \frac{Q}{mc}$$

$$\Delta T = \frac{113.257\,J}{3500\,g \times 4.184\,J/g°C}$$

$$\Delta T = 7.734°C$$