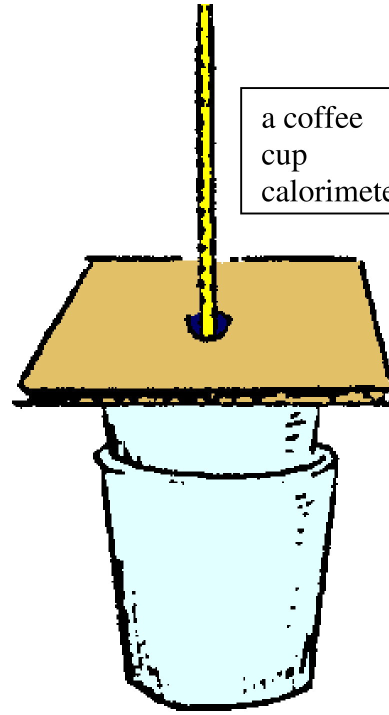
Unit 3, Lesson 04: Calorimetry: Using Q to Calculate ΔH



The heat (Q) lost or gained by a system during a chemical reaction at constant pressure is equal to the enthalpy change (ΔH) for the reaction.

- to calculate Q for the system, we use the equation:

$$\boxed{Q = m \cdot c \cdot \Delta T}$$

where m = the mass of the system (the reactants and products)
c = the specific heat capacity of the system
= 4.184 J/g°C for an aqueous system
ΔT = the change in temperature of the system

if the reaction is carried out in aqueous solution in a coffee cup calorimeter, the heat lost to the surroundings will be negligible, so we can calculate Q

<u>Sample Calculation</u>: The Molar Heat of Solution of NaOH in Water

1.046 g of sodium hydroxide is dissolved in 100.0 mL of water in a styrofoam cup. The initial temperature of the water before adding the sodium hydroxide is 23.2 ºC. After all of the sodium hydroxide has dissolved, the temperature of the water is 27.5 ºC. Calculate the ΔH per mole for NaOH dissolving in water (the molar enthalpy (heat) of solution of sodium hydroxide).

$$NaOH\ (s) \xrightarrow{H_2O} NaOH\ (aq) \qquad \Delta H = ?$$

1. To calculate the amount of heat (Q) released when the NaOH dissolves:

   The density of pure water is 1.00 g/mL, so the mass of water is 100.0 g

   Given: $m = 100.0$ g
   $c = 4.184$ J/g°C
   $\Delta T = T_2 - T_1$
   $= 27.5$ ºC $- 23.2$ ºC
   $= 4.3$ ºC

   $Q = m \cdot c \cdot \Delta T$
   $= 100.0$ g x 4.184 J/g°C x 4.3 ºC
   $= 1799.12$ J
   $= 1.799$ kJ (carry at least 4 sig digs)

2. At constant pressure (when the reaction produces no gases), then $\Delta H = -\ Q$

   $\Delta H = -\ 1.799$ kJ

3. To find ΔH/mol of NaOH, we must convert this value to kJ per mole of NaOH:

   $$1.046 \text{ g NaOH} \times \frac{1 \text{ mol}}{40.00 \text{ g}} = 0.02615 \text{ mol of NaOH}$$

   Then:
   $$\frac{\Delta H}{\text{mol}} = \frac{-1.799 \text{ kJ}}{0.02615 \text{ mol}}$$

   $= -\ 68.8$ kJ/mol NaOH (you can report either 2 or 3 sig digs)

   Therefore, the ΔH for dissolving **one mole** of NaOH is – 68.8 kJ/mol.