Investigation 1: Calorimetry

**Question:** How much heat is absorbed or lost when solids are dissolved in water? Using this information, how would you design and test a heat pack?

Pre-lab required reading

Atkins & Jones (6th ed.): Sections 8.4 – 8.5, 8.8

Safety and Waste Disposal

- Eye protection should be worn at all times.
- Waste solutions produced in this investigation can be washed down the drain.

Background

Calorimetry is used to determine the amount of heat released or taken up during a chemical reaction or physical process. In this lab we will use simple solution calorimeters to determine the heat of reaction for three different solids dissolving, sodium chloride, potassium chloride and calcium chloride. Note that when these ionic solids dissolve they dissociate into ions. For example:

\[ \text{NaCl} \ (s) \rightarrow \text{Na}^+ \ (aq) + \text{Cl}^- \ (aq) \]  

We will use simple polystyrene coffee cups for a calorimeter. These cups have (to a very close approximation) a zero heat capacity. Thus no heat is transferred to the cups. However, the heat released or absorbed by the process of the solid dissolving is released to the surrounding aqueous solution. We will assume that the aqueous solutions have the same heat capacity and density of pure water (i.e. \( c_{\text{sol}} = 4.184 \ \text{J/g.C} \) and a density of 1.00g/mL). We can measure the increase in temperature of the solution (\( \Delta T \)) and calculate the amount of heat gained by the solution (\( q_{\text{sol}} \)) using our model for heat transfer:

\[ q_{\text{sol}} = m_{\text{sol}} \cdot c_{\text{sol}} \cdot \Delta T \]  

Since the heat gained by the solution equals the heat lost by the reaction we find that the heat of the solution is related to the enthalpy change for the reaction (i.e. the process of the solid dissolving):

\[ q_{\text{rxn}} = -q_{\text{sol}} \]  

And

\[ \Delta H_{\text{rxn}} = \frac{q_{\text{rxn}}}{n} \]

Procedure

Obtain a beaker with about 500 mL of distilled water, a thermometer and a “coffee-cup” calorimeter (consisting of two nested polystyrene cups, a lid, and stirrer).

Begin each trial by placing 50.0mL of water into the calorimeter. Record the temperature of the water. Precisely weigh 4-6 g of one of the salts (sodium chloride, potassium chloride or calcium chloride). Add the salt to the water in the calorimeter and place the lid on the calorimeter. Gently stir the reaction mixture, recording the temperature at 5-second intervals until the temperature reaches a plateau. Record the maximum or minimum temperature reached by the solution.

Dispose of the reaction mixture, rinse and dry the calorimeter, and repeat the procedure for the remaining two salts. Do two or three trials for each salt.
References