Name:____Date:____________Block:____

Urea Calorimetry Lab

Introduction

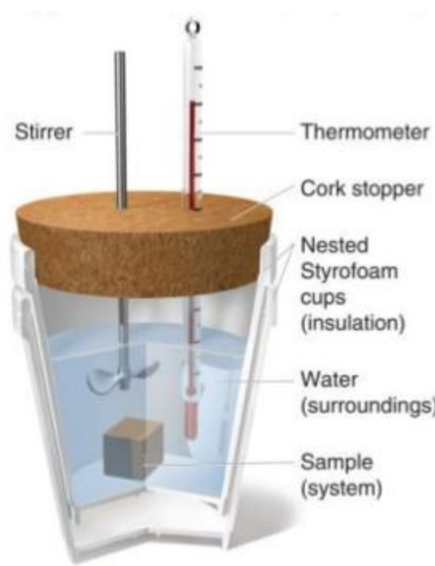
When a substance is heated, the motion of its individual particles increases, resulting in an increase in temperature. The more heat that is added per gram of substance, the greater the temperature change. The relationship between the heat added, the mass of a substance, and the temperature change it undergoes is known as *specific heat*.

$$Specific\ Heat = \frac{Energy\ in\ joules}{Mass\ in\ grams\ \ x\ \ Temperature\ change\ in\ Celsius\ or\ Kelvin}$$

Specific heat is defined as the amount of energy necessary to produce a temperature change of 1°C per gram of substance. The specific heats of different substances vary, and therefore this quantity may be useful in identifying an unknown.

The measurement of heat changes is called *calorimetry*. A calorimeter is a piece of equipment designed to measure the energy released or absorbed during a chemical reaction or phase change. In this lab, a coffee cup calorimeter will be constructed to measure the heat exchanged between the system (reactants and products) and the surroundings (the water). The temperature change of water will then be used to determine the amount of energy transferred either into or out of the water.

The diagram below shows the basic setup of a coffee cup calorimeter.



According to the Law of Conservation of Energy, energy is neither created nor destroyed. It can be assumed that no heat is lost to the calorimeter or the environment outside the calorimeter.

Energy lost/gained by the system = Energy gained gained/lost by water

The formula below is used to calculate the amount of energy absorbed/released during calorimetry.

$$q = mc\Delta T$$

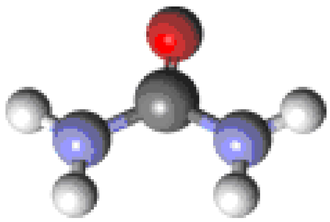
where **q** = heat (in joules); **m** = mass (in grams); **c** = specific heat (in joules/grams • °C); **ΔT** = change in temperature (i.e. final temp – initial temp) (in °C or K)

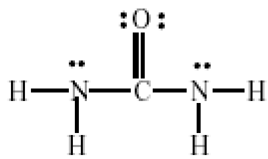
Safety

Goggles and closed toed shoes must be worn at all times.

Pre-lab

Consider the structure of urea.





1. Is urea a polar or nonpolar molecule? Explain your reasoning.
2. Would you expect urea to dissolve in water? Explain your reasoning.

Procedure

1. Assemble the calorimeter.
    a. Place one Styrofoam cup inside the other.
    b. Place the Styrofoam cups into the beaker.
2. Measure 50.0 mL of distilled water into the top Styrofoam cup.
3. Measure and record the initial temperature of the water.
4. Measure approximately 2 grams of urea. Record the exact mass of urea used.
5. Quickly add the urea to the water and stir with a glass stirring rod to dissolve the urea.
6. Record the final temperature of the water.
7. Discard the aqueous urea solution down the sink.
8. Rinse the Styrofoam cup with tap water.
9. Repeat Steps 1-8 twice.

Data

Construct your own data table.

Data Analysis and Calculations

*Note: the density of water is 1.00 g/mL and specific heat of water is 4.184 joules/grams • °C. Assume the urea solution has the same density and specific heat of water.

1. Calculate the amount of heat transferred, in joules, for each trial.
   a. Trial #1
   b. Trial #2
   c. Trial #3

2. Calculate the amount of heat transferred, in kilojoules per gram of urea, for each trial.
   a. Trial #1
   b. Trial #2
   c. Trial #3

3. Calculate the amount of heat transferred, in kilojoules per mole of urea, for each trial.
   a. Trial #1
   b. Trial #2
   c. Trail #3

4. Calculate the average heat transferred, in kilojoules per mole of urea.

5. The accepted value of heat transfer (ΔH) is 13.8 kJ/mol. Using the average obtained in Question #4 as the experimental ΔH, calculate the experimental error.

Discussion Questions

1. During any chemical reaction or physical process, heat is exchanged between the system and the surroundings. In a coffee cup calorimeter, the water is considered the surroundings. Is the dissolving of urea in water an exothermic or endothermic process? Justify your answer using the data collected in this lab.

2. The enthalpy change, ΔH, the dissolving of urea is 13.8 kJ/mol. Calculate the amount of heat that would be transferred if a student dissolved 8.8 grams of urea in water.

3. Entropy (S) is the measure of randomness of particle arrangements. For example, gases have much more entropy than solids because gas particles are more dispersed and in constant motion. Which would you expect to have a larger entropy value: solid urea or an aqueous urea solution?