Determining ΔS for the Dissolution of Urea

In this lab, you will determine the change in entropy when urea dissolves. Although this cannot be measured directly, it can be calculated from direct measurements using a thermometer, balance, and graduated cylinder.

The ΔH for the reaction will be determined by measuring the change in temperature when a known amount of urea is dissolved in a known amount of water. The equation you will use is:

$$q = \mathrm{mCp}\Delta\mathrm{T}$$

In part two, you will determine the K value for the dissolution of urea, knowing that a saturated solution is at equilibrium and K = $\frac{[products]}{[reactants]}$ You will create and record the concentration of a saturated urea solution, thus being able to determine the value of K.

$$NH_2CONH_2\ (s) \leftrightarrow NH_2CONH_2\ (aq)$$

Using the K determined from part 2, you will determine ΔG. Finally you will determine ΔS.

$$\Delta\mathrm{G} = -\mathrm{RT}\ln\mathrm{K}$$

$$\Delta\mathrm{G} = \Delta\mathrm{H} - \mathrm{T}\Delta\mathrm{S}$$

Materials

2 Styrofoam cups
Temperature probe
100 mL graduated cylinder
10 mL graduated cylinder
400 mL beaker
Urea

Procedure

Part I: Determining q and ΔH

1. Place one Styrofoam cup inside the other.
2. Measure approximately 50.0 mL of distilled water and record exact volume. Pour into Styrofoam cup.
3. Record the initial temperature of the water.
4. Mass out approximately 2 grams of urea. Record the exact mass.
5. Quickly add the urea to the water and stir with the temperature probe. Record the minimum temperature reached.

Part 2: Determining [urea] and K

1. Obtain a small amount of urea in an evaporating dish.
2. Measure out 2.00 mL of water in a 10 mL graduated cylinder. Measure the mass of the water and the graduated cylinder.
3. Begin adding crystals of urea to the water in the graduated cylinder. Add only a few crystals at a time. After adding the crystals, use a stirring rod to stir the solution and to dissolve the crystals. Keep adding crystals just until the urea no longer dissolves.
4. Record the volume and temperature of the solution.
5. Measure and record the total mass of the solution and the graduated cylinder. Also record the volume of the solution.

Data Table 1

Volume water used	
Mass urea used	
Initial Temperature	
Final Temperature	

Data Table 2

Mass of water and graduated cylinder	
Mass of urea solution and graduated cylinder	
Mass of urea used	
Volume of solution	
Final Temperature	

Data Analysis

1. Determine q_{rxn} (in joules) for part 1. Assume the solution has the same density and specific heat of water.
2. Determine the enthalpy change (ΔH) for the dissolution of urea **PER MOLE OF UREA** (kJ/mol).
3. Using the mass of urea and volume of solution from part 2, determine the concentration of urea.
4. Determine K for the dissolution of urea.
5. Use the K value from question 4 to determine ΔG.
6. Use the ΔH from question 2, ΔG from question 5, and the final temperature of the solution in part 2 to determine the ΔS for the dissolution of urea.
7. Calculate the percent error for the value of ΔS. (theoretical value = 69.5 J/K)

Discussion Questions

1. Is the dissolution of urea an endothermic or exothermic? How do you know?
2. Is the dissolution of urea spontaneous or non-spontaneous? Explain.
3. Is the dissolution of urea enthalpy or entropy driven? Explain.