Dougherty Valley HS Chemistry - AP
Thermodynamics – Entropy of a Reaction

Worksheet #8

Name: **Period:** **Seat#:**

Introduction

When studying thermodynamics, the equation for free energy of a reaction, $\Delta G° = \Delta H° - T\Delta S°$, is often encountered. In this experiment, you will use this equation to estimate the minimum entropy change required to bring about a reaction. The enthalpy change, ΔH, and the initial temperature will be determined for a reaction. From these values and the equation for free energy, the minimum entropy change to bring about a *spontaneous reaction* will be estimated.

Purpose

The purpose of this experiment is to estimate the minimum entropy change required for a reaction.

Materials

Chemicals

- Solid $NaNO_3$
- Solid NH_4Cl
- Solid NH_4NO_3

Equipment

- Thermometer
- Calorimeter
- Distilled water

SAFETY PRECAUTIONS

Make sure to wear goggles the entire time during the lab. Each group may be given a different chemical to use for their trials, so make note of which chemical your group is working with. Your instructor may change the chemicals for this lab so make note of any changes to the lab procedure.

Prelab Questions (Part of your Prelab Assignment)

Instead of a traditional set of prelab questions, your prelab "question" will consist of you finding and writing a procedure determining the "Calorimeter Constant" for this experiment using known amounts of Hot and Cold water. Do not put this procedure in the Prelab Section, put it in the procedure section where indicated below. You will still have a Prelab section with the rest of your typical Prelab.

Procedure

1) Obtain a microcalorimeter (Styrofoam Cup) and thermometer. The calorimeter is made up of two styrofoam cups separated by a rubber band. A lid punched with a hole for the thermometer should also be used. Weigh and record the mass of the calorimeter.

2) We will be determining the Calorimeter Constant for this experiment. Using known amount of Hot and Cold Water. **Look up a procedure for this process and include it in your procedure as part of the Pre-lab. Step 2 will be this Calorimeter Constant determination procedure. Label the steps as follows – 2a, 2b, 2c etc.**

3) Place about 50 mL of distilled water in the calorimeter. Reweigh and subtract to determine the mass of the water. Measure the temperature of the water.

4) Calculate the mass of solid needed to prepare 50.0 mL of a 1.00 M solution of the solid you will be using. Weigh the sample, and record the mass in the data table.

5) Add the stir bar to the calorimeter. Turn stir knob to #1. Make sure it's stirring gently before the next step.

6) Add the solid to the water, and place the lid on the calorimeter. Stir gently, and record the temperature when the entire solid has dissolved.

7) Calculate the heat of the reaction. *The heat capacity of the calorimeter will be included in the calculation*.

8) Calculate the ΔH for the reaction using the heat of reaction and the number of moles of the solid used.

9) Repeat the procedure two more times.

10) Average the data for your trials.

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Disposal and Cleanup

Your teacher will provide disposal and cleanup instructions.

Data Table

Calorimetry of a Reaction Data	Trials [2 per cmpd]	
	1	2
Mass of calorimeter (g)		
Mass of water (g)		
Solid used:		
Mass of solid (g)		
Moles of solid (mol)		
Initial temperature (°C)		
Final temperature (°C)		
Temp. change (Δ°C)		
Heat of reaction, J		
ΔH, kJ/mole		
ΔS, J/mole•K		
Average Value for ΔS		

Calorimeter Constant	
Mass of cold water (g)	
Initial Temp of cold water (°C)	
Final Temp of mixed water (°C)	
Temp. change cold water (Δ°C)	
$q_{cold\ water}$ (J)	
Mass of hot water (g)	
Initial Temp of hot water (°C)	
Final Temp of mixed water (°C)	
Temp. change hot water (Δ°C)	
$q_{hot\ water}$ (J)	
$q_{hot} - q_{cold}$ (J)	
C_{cal} (J/°C)	

Calculations

Record all values into your Data Table

1. Show all calculations for at least one trial. You may show all calculations for all trials if you would like. You do not need to gather data for the other compounds used by other groups. We will report out to the class and discuss the results for each compound.

Post Lab Discussion Questions

Answer as part of your post lab. Do not recopy the questions, just paraphrase them into your answer so the reader can infer what the question was.

1. Write a balanced equation for the reaction your group studied (include heat as a reactant or product).
2. Was the reaction spontaneous? How do you know this?
3. From the temperature change of your trials, what mus the sign for ΔH? How do you know?
4. From question 3, what must be true about the sign for ΔS? Explain why with support.
5. What are the units for entropy, ΔS?
6. Many students believe that a reaction must be exothermic to be spontaneous. Comment on this in terms of this experiment. Looking for detailed thoughts about why someone would think a reaction must be exothermic to be spontaneous, if they are correct or not, and why.