AR CHEMISTRY LAB: THE SPECIFIC HEAT OF LEAD NAME________________________

INTRODUCTION: The amount of heat energy that is required to raise the temperature of one gram of a substance by one degree Celsius is called the specific heat capacity, or simply the specific heat, of that substance. The specific heats of some common substances are given in Table 1 below. Water, for instance, has a specific heat of 1.0 calorie per gram degree Celsius (1.0 cal/(g x ^{o}C)). You will note that this value is high in comparison with the specific heats given for other materials in the table.

The amount of heat energy involved in changing the temperature of a sample of a particular substance depends on three parameters--the specific heat of the substance, the mass of the sample, and the magnitude of the temperature change. The amount of heat energy that is transferred in the process of producing a temperature change can be calculated from this information, according to the following equation:

change in heat energy of sample = specific heat of sample x mass of sample x Δ T of sample

$$\mathbf{Q} = \mathbf{c} \times \mathbf{m} \times \Delta T$$

In this activity, you will determine the specific heat of lead and / or aluminum. A heated sample of this metal will be poured into a crude calorimeter, consisting of cool water contained in a plastic styrofoam cup. Shortly after mixing, the water and the lead will have come to the same temperature.

Substance	Specific Heat (cal / (g x ^{o}C))	Substance	Specific Heat (cal / (g x ^{o}C))
Water	1	Glass	0.12
Grain Alcohol	0.58	Iron	0.11
Ice	0.5	Silver	0.06
Wood	0.42	Mercury	0.03
Steam	0.4	Copper	0.01
Aluminum	0.21	Zinc	0.01

Because styrofoam is a good insulator, heat cannot easily escape from the calorimeter to the surroundings. Therefore, the heat lost by the lead can be said, for the purposes of this experiment, to be equal to the heat gained by the water. The amount of heat energy gained by the water will be calculated in the following manner.

(1) heat gained$_{water}$ = specific heat$_{water}$ x mass$_{water}$ x Δt_{water}

$$\mathbf{Q} = \mathbf{c} \times \mathbf{m} \times \Delta T$$

The heat lost by the lead is given by a similar equation.

(2) heat lost$_{lead}$ = specific heat$_{lead}$ x mass$_{lead}$ x Δt_{lead}

$$\mathbf{Q} = \mathbf{c} \times \mathbf{m} \times \Delta T$$

Because the heat gained must equal the heat lost, a third equation can be written.

(3) specific heat$_{water}$ x mass$_{water}$ x ΔT_{water} = specific heat$_{lead}$ x mass$_{lead}$ x ΔT_{lead}

$$\mathbf{c} \times \mathbf{m} \times \Delta T = \mathbf{c} \times \mathbf{m} \times \Delta T$$

The specific heat of water is known (1.00 cal/g ^{o}C). The temperature changes of the water, and of the lead, can be measured, as can the mass of the water and the mass of the lead. Using this data, the specific heat of lead can be calculated by using Equation (3). The specific heat of an unknown metal can also be determined by application of this method.

PROCEDURE:

A. Heat Transfer: Calorimetry

i. Same volumes of water

1. Measure 100 mL (g) of tap water in your graduated cylinder. Pour your water into your Styrofoam Calorimeter. Record, in the table below, the temperature of the water when it is in the Styrofoam cup
2. Heat a beaker of tap water. When the water is about 50 to 60 degrees Celsius, measure 100 mL of the warm water in a 100 mL graduated cylinder..
3. Place the warm water into a second Styrofoam cup. Record the temperature of the water when it is in the Styrofoam cup.
4. Pour the warm water into the cup holding the "cold" water. Place the calorimeter lid on the cup and Record the highest temperature the new water system achieves.
5. Determine your percentage difference.. Because you used the same amount of water, the final temperature should be the average of the two starting temperatures.

$$\% \text{ difference} = \frac{|\text{lab} - \text{predicted}|}{\text{predicted}} \times 100$$

ii. Different volumes of water

1. Measure 100 mL (g) of tap water in your graduated cylinder. Pour your water into your Styrofoam Calorimeter. Record, in the table below, the temperature of the water
2. Heat a beaker of tap water. When the water is about 50 to 60 degrees Celsius, place your choice of volume into your graduated cylinder. Record the volume you measured
3. Place the warm water into a second Styrofoam cup. Record the temperature of the water when it is in the Styrofoam cup.
4. Pour the warm water into the cup holding the "cold" water. Place the calorimeter lid on the cup and Record the highest temperature the new water system achieves.
5. Determine your relative error. Give your values to the instructor and S/he will calculate your predicted Temperature (this is an introductory lab – you will soon learn how to do this yourself

Trial		Equal Volumes	Different Volumes
Mass/Volume of Cold Water (g)	**m-cold**	100 g	100 g
Mass/Volume of Warm Water (g)	**m-hot**	100 g	
Initial temperature of Cold water (°C)	**T-cold**		
Initial temperature of Warm Water (°C)	**T-hot**		
Final temperature (°C)	**T-final**		
Average Temperature **(T-cold + T-hot) / 2**			See instructor

Percentage Difference		

B. Specific Heat of Aluminum

1. Measure 50 mL (grams) of tap water in your graduated cylinder. Pour your water into your Styrofoam calorimeter. While the water is in the cup, record the temperature of your water in the table below.

2. Heat a beaker of water until it boils. Place your metal sample(s) gently into the water using tongs. Allow the sample to reach the temperature of the water (1 minute should be fine).

3. Gently, but quickly, place your metal sample into the cup of water. Place the lid of the calorimeter on top of the cup.

4. Allow the water and aluminum sample to reach equilibrium temperature. Record the maximum temperature of the aluminum / water system the table below.

5. Dry your metal sample and measure its mass to the nearest 0.1 gram. If time permits, repeat the experiment.

Sample Type____________		Trial 1	Trial 2	
Mass of Sample (g)	##			
Mass/Volume of Water (g)	**			
Initial temp of water (^{o}C)				
Initial temp of metal		100 C	100 C	
Final temp metal + water				
Temperature Change H_2O	dTW			
Temperature Change Al	dTAl			
				Average
Specific Heat of Metal				
Percentage Difference				

DATA ANALYSIS: Show setups / units, etc. for each trial.

1.. Remembering that the heat gained by the water is equal to the heat lost by the lead, calculate the specific heat of metal for each trial.

$$\text{specific heat}_{water} \times \text{mass}_{water} \times \Delta T_{water} = \text{specific heat}_{metal} \times \text{mass}_{metal} \times \Delta T_{metal}$$

$$\mathbf{c} \times \mathbf{m} \times \Delta T = \mathbf{c} \times \mathbf{m} \times \Delta T$$

(1 cal /g C) x **______ x dtW_______ = ???**c** x ##_______ x dtAl______

Trial 1

Trial 2

2. Determine your relative error using the accepted value of 0.215 cal/g^{o}C for aluminum, and <u>your</u> average value for the specific heat of lead.

Average = ________

% Difference = ____________