Advanced Chemistry Name ______________________________ Period ______

Calorimetry Lab

Introduction: Chemical reactions involves the release or consumption of energy, usually in the form of heat. Heat is often measured in energy units called Joules (J) or kilojoules (kJ). Depending on the direction of heat transfer, reactions can be classified as endothermic or exothermic.

In this lab, you will be measuring the heat transfer between a piece of metal and its surroundings using calorimetry. You will then find the specific heat of a metal by equating the heat lost or gained by the metal to the heat lost or gained by the water

Remember $-q_{metal} = q_{water.}$ Therefore, $-[C_{metal} \times mass_{metal} \times \Delta T_{metal}] = C_{water} \times mass_{water} \times \Delta T_{water}$

Rearranging this equation to solve for the specific heat of the metal results in an experimentally determined specific heat of metal.

$$C\ metal = \frac{(Cwater)(mass\ water)(\Delta T\ water)}{-(mass\ metal)(\Delta T\ metal)}$$

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Materials: Balance, Styrofoam cups, masking tape, sample of metal, graduated cylinder, water, beaker to heat water, tongs, thermometer, cardboard, exacto knife, stirring rod.

Pre-Lab Questions

1. Define energy.
2. In what two units can energy be measured?
3. Explain the direction of heat flow between two objects of different temperatures.
4. Is heat and temperature the same? If not, briefly describe the difference.
5. What is calorimetry?
6. What is the specific heat of water?
7. Choose one: Objects that have a high specific heat requires (less, more) energy to heat up.
8. Choose one: Objects that have a high specific heat tends to heat up (slower, faster).
9. What equation should you use to calculate specific heat of an object?
10. What does it mean if the reaction is exothermic? Endothermic?
11. What does it mean if you calculate a positive "q" value? Be sure to mention heat and temperature in your answer.
12. What does it mean if you calculate a negative "q" value? Be sure to mention heat and temperature in your answer.
13. What is the 1^{st} law of thermodynamics?
14. What is the relationship between the heat gained or lost by the metal and the heat gained or lost by the water?
15. What happens when a hot object is placed in a cool bath of water? Where does the heat go?

Procedure Part 1: Building Calorimeter

1. Fill a beaker with approximately 2/3 full of water. Place the beaker on a hot plate turned up on high.
2. To build the calorimeter, take one Styrofoam cup and place it inside the other. Next, use your Exacto knife or scissors to cut the cardboard into a circle that fits snuggle on top of the cup.
    a. Be careful not to cut too small. It's important that the cup is sealed for the experiment.
3. Cut two small holes in the cardboard which will fit the stirring rod and the thermometer and place them in the holes. Seal any gaps with masking tape.
4. Weigh your calorimeter and record your results.
    a. You should weigh the calorimeter without the stirring rod or thermometer in it.
5. Now use the graduated cylinder to measure approximately 150 mL of water.
6. Unseal your calorimeter and add the water to your calorimeter.
7. Weigh your calorimeter with the water and record your results.
    a. You should weigh the calorimeter without the stirring rod or thermometer in it.
8. Determine the weight of the water you added by subtracting the weight of your calorimeter from the weight of calorimeter + water.
9. Add the stirring rod and thermometer to your calorimeter.
10. Measure the temperature of the water as precisely as possible. Record this value as initial temperature of water.

Procedure Part 2: Metal

1. Determine the mass of your metal by weighing it on the scale. Record this value.
2. Add your metal to the boiling beaker of water. Wait approximately 5 minutes for the metal to heat up. Since water boils at 100 degrees C, record the initial temperature of the metal as 100 degrees C as well.
3. Using tongs, QUICKLY transfer the metal to the calorimeter and quickly close the cardboard. Wrap the layer of tape around the edge to secure the lid. Twist the stirrer to mix the water.
4. When the temperature stops changing, the system is at equilibrium. Record this final temperature for both water and metal in your data table.
5. Your metal was a specific element. Look at the bottom of your metal to find which element you used for your lab, record the element.

Data 1:

1. Weight of Calorimeter	
2. Weight of Calorimeter + Water	
3. Weight of Water	
4. Weight of Metal	
5. Initial temperature of water	
6. Final temperature of water	
7. Change in temperature of water	
8. Initial temperature of metal	
9. Final temperature of metal	
10. Change in temperature of metal	
11. Element Used in Lab	

Post Lab Questions:

1. During this calorimetry lab, what would be considered the system? What would be considered the surroundings?

2. Calculate the heat energy gained by the water (q_{water}) using the equation q = Cs x m x ΔT

3. Knowing the heat gained by water is equal and opposite the heat lost by the metal ($-q_{metal} = q_{water}$). What is the heat gained by the metal?

4. Using your answer from #3, calculate the specific heat of your metal using the equation -q = Cs x m x ΔT.

5. You can also calculate the specific heat of your metal using the formula

$$C\ metal = \frac{(Cwater)(mass\ water)(\Delta T\ water)}{-(mass\ metal)(\Delta T\ metal)}$$

   Using information from your table and the equation, calculate the specific heat of your metal. SHOW YOUR WORK.

6. Is the heat exchange for the system endothermic or exothermic? Explain your answer.

7. Look up and record the specific heat capacity of your element on the following website: https://material-properties.org/specific-heat-capacity-of-chemical-elements/

8. Calculate your percent error for the specific heat of your element. Experimental value is what you calculated in lab. Accepted value was determined in question #7.

$$\%\ error = \frac{|experimental\ value - accepted\ value|}{accepted\ value} \cdot 100$$