**Specific Heat with Calorimeters Lab**

**Introduction**:

So far this chapter we have learned how to measure how much heat is being either absorbed (if the reaction is endothermic) or released (if the reaction is exothermic) within a phase (sold, liquid or gas). This is called Calorimetry. Remember, according to the Law of Conservation of Energy, energy cannot be created or destroyed; instead, it is transferred between the system (qsys) and its surroundings (qsurr). Insulated devices that are designed to measure this heat transfer are called Calorimeters, and can be something as simple as a Styrofoam cup, like what we will be using in today’s lab.

|  |  |
| --- | --- |
| **Substance** | **Specific Heat (c)**  **in J/g•oC** |
| Water | 4.184 |
| Aluminum | 0.902 |
| Iron | 0.451 |
| Copper | 0.385 |
| Zinc | 0.385 |
| Lead | 0.160 |

In this lab we will be using an unknown metal substance in order to determine the change in temperature within a system. The specific heats (c) of notable substances that could be used in this lab are shown below:

Remember, specific heat is the measurement of how much energy is required to increase the temperature of 1 gram of a substance by 1oC. With respect to specific heat, the q = m • c • ΔT formula will be used.

In this lab you will be measuring the heat in two different forms: the water inside your Styrofoam cup calorimeter, and the unknown metal substance you will eventually be placing into it. Because the water will be heating up as the metal is placed inside the calorimeter, it is considered an endothermic reaction: qwater = (mwater)(Cwater)(∆Twater). The metal, on the other hand, will be cooling down upon being placed in the calorimeter, making it an exothermic reaction: qmetal = (mmetal) (Cmetal) (∆Tmetal).

The important concept of this lab is, due to the Law of Conservation of Energy, the heat absorbed by the water inside the calorimeter should be the same as the heat released by the metal. Therefore we can assume qwater = - qmetal, or:

**(mwater)(Cwater)(∆Twater) = -(mmetal)(Cmetal)(∆Tmetal).**

**Purpose**:

To measure the amount of heat transferred between an unknown metal and water, and to identify this unknown metal using its measured specific heat.

**Materials**:

* Unknown Metal
* Test Tube
* Balance
* Beaker
* Graduated Cylinder
* Hot Plate
* Calorimeter
* Tongs
* Thermometer

**Pre**-**Laboratory** **Questions**:

1. What is a Calorimeter? In this experiment, what is serving as our Calorimeter?
2. In this experiment, what will serve as the endothermic system? How do you know?
3. In this experiment, what will serve as the exothermic system? How do you know?
4. How we will be able to identify the unknown metal being used in this experiment?
5. If a 58 g sample of metal at 100 oC is placed into a calorimeter containing 60 g of water at 18 oC, the temperature of the water increases to 22 oC. Assume the metal is also at this temperature.
   1. Calculate the amount of heat absorbed by the water in Joules.
   2. Determine the identity of the metal by calculating its specific heat.

**Procedure**:

**Metal Set Up**

1. Fill a medium sized beaker with water and boil it using the hot plate.
2. While the water is boiling, go up to the front lab desk and obtain your unknown metal (about 50 grams). Record its mass using the balance on the front lab desk. Place metal in test tube.
3. Once the water inside the beaker is boiling, place the test tube with metal inside the beaker for approximately 5-10 minutes, ensuring that the metal will be at the boiling point of water. Record this information in your data section.

**Water/Calorimeter Set Up**

1. Obtain two Styrofoam cups and place one inside the other. This will be your calorimeter.
2. Using a graduated cylinder, measure 200 mL of water, and place this water inside the Calorimeter.
3. With the thermometer record the temperature of the water inside the Styrofoam cup, and record this information in the data table provided below.

**Combining Metal and Water**

1. Using tongs, remove the test tube from the boiling water and quickly pour metal into the Calorimeter. Place a lid over the top of the calorimeter to as soon as possible to ensure minimal heat escapes.
2. Place the thermometer inside the calorimeter once again, and record the temperature change. The number you put in your data table will be the highest temperature the water reaches while the metal is inside.

***[make sure to hold the thermometer at all times, making sure it does not tip over the Styrofoam cup, nor touch the sides/bottom of the cup]***

1. To ensure the water temperature is even throughout, periodically stir the water using the thermometer.

**Data and Calculations:**

*Metal (qsurr)*

**Mass of metal \_\_\_\_\_\_g**

Temp. of Metal in Boiling Water Bath: \_\_\_\_\_oC Temp. of Metal in Calorimeter: \_\_\_\_\_oC **ΔT = \_\_\_\_\_\_oC**

***qsurr = \_\_\_\_\_\_\_\_\_\_\_\_\_\_(show set up)***

*Water (qsys)* **Specific Heat of Water \_\_\_\_\_\_J/g•oC**

Volume of Water in Calorimeter: \_\_\_\_\_mL Density of Water at \_\_\_oC = \_\_\_\_g/mL **mass of water: \_\_\_\_g**

Temp. of Water before Metal: \_\_\_\_oC Temp. of Water after Metal: \_\_\_\_\_oC **ΔT = \_\_\_\_\_\_oC**

***qsys = \_\_\_\_\_\_\_\_\_\_\_\_\_\_J (show work)***

**Specific Heat of Metal \_\_\_\_\_\_J/g•oC** ***(show work)*** **Identify of Metal**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Post-Laboratory Questions:**

1. Was the qmetal a negative or a positive number? This means that the reaction was (endothermic/exothermic). Why does this make sense?
2. How can could you tell that the water inside the calorimeter was endothermic (what observations could be made to suggest the reaction was endothermic?)
3. Why were we able to set qwater = -qmetal in this experiment?
4. What metal did the unknown metal end up being? How did you figure this out?
5. What possible errors could have arisen from conducting this experiment? In your answer, provide a suggestion of what could be done to rectify these possible set-backs (saying “none or nothing” is not an acceptable answer).