**Calorimetry**

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**ABSTRACT**

Calorimetry is the process of measuring heat exchange between a system and its surroundings. A calorimeter is the equipment used to measure heat exchange. The calorimeter constant (Ccal) measures the heat capacity of the calorimeter and is determined by adding a known mass of hot water into a known mass of cold water and noting the final temperature of the mixture. The calorimeter constant is also a value that can be used to determine the specific heat of an unknown metal and identify what the unknown metal is.

1. **INTRODUCTION**

The purpose of this experiment was to use calorimetry to identify an unknown metal through its specific heat value. The first part of the experiment was to find the calorimeter constant. The calorimeter constant would be used in the second part of the experiment to identify a sample of an unknown metal. The formulas used for the first part were:

**Δqhw = Δqcw + Δqcal**

**sw x mhw x (Th – Tf) = sw x mcw x (Tf – Tc) + Ccal (Tf – Tc)**

**Ccal = (Δqhw – Δqcw) / (Tf – Tc)**

For the second part of the experiment, the Ccal value obtained from the first part was used to find the specific heat of an unknown metal. The same formulas from the first part of the lab were used for this second part except the specific heat value for a metal (sm) was used instead of the specific heat value for H2O (sw) and we have the missing Ccal value.

1. **EXPERIMENTAL**

For the first part of the lab, the calorimeter constant was determined. A simple calorimeter was assembled by stacking one Styrofoam cup within another cup and capping the cups with a plastic cover. A metal beaker filled with distilled water was obtained and heated to 60-70 ºC on a hotplate. 30 mL of cold distilled water was placed into the calorimeter and the temperature was measured. 30 mL of the hot water was added onto the 30 mL of cold water and the final temperature was noted when the temperature stabilized. This process was repeated another 2 times for a total of 3 trials. For each trial, the Ccal was calculated.

After the Ccal value was calculated from the first part of the lab, the specific heat of a metal could be determined for the second part. Unknown samples of the same metal were obtained. The samples were of different sizes and masses but were all cylindrical in shape. Each of the metal samples was weighed and the masses were recorded. The metal cylinders were placed into hot water. Using a 100 mL graduated cylinder, 35 mL of distilled water was added into the calorimeter and the temperature was recorded. The temperature of the hot water bath was also taken and the metal cylinder was moved from the hot water bath to the calorimeter. The temperature of the water in the calorimeter with the metal cylinder was measured when the temperature stabilized. This process was repeated another 2 times for a total of 3 metal cylinders and 3 trials. The data collected was used to calculate the specific heat of the metal (sm).

The equipment used in this experiment were: calorimeter, beakers, thermometer, distilled H2O, hotplate, graduated cylinder and unknown cylindrical metal samples.

1. **RESULTS AND DISCUSSION**

For the first part of the experiment, the data obtained was accurate for the most part because formulas were used to compute further data. Some measurement values might be inaccurate one or two significant figures but it does not affect the data. Moreover, the change in heat may vary between trials because the calorimeter used was not perfect and was subject to small discrepancies in heat change. Moreover, the temperature change when transporting the hot water after heating it can be inaccurate because the temperature will decrease if left at room temperature. It is also impossible to transport the hot water because the metal beaker was too hot to lift up without a specific tool. Therefore, the temperature of the hot water is actually higher than it should be due to the time that passes when transporting the hot water into the calorimeter.

For the second part of the experiment, the same formulas were used so there would not be any inaccuracies in that part. Metal cylinders were used so we could measure the specific heat of the metal to identify it. However, during the time the metal cylinders are taken out of the hot water bath and placed into the calorimeter, some heat is lost and the specific heat is not as accurate as it should be. This error could be minimized by reducing the distance the hot water bath is from the calorimeter. Each trial was different because the sample metal cylinders were of different sizes. Overall, there will be variations for the data and human error must be accounted for.

1. **CONCLUSION**

Calorimetry and the process of measuring heat exchange are important concepts in chemistry. They allow us to create and maintain accurate results from experiments and force us to recognize that excellent results can only be obtained through trial and error. By learning how to use a calorimeter and the techniques involved, we also learn about other science concepts such as the specific heat of a metal, laws of thermodynamics and heat capacity. Chemistry is a field of study that uses knowledge from all fields of study in order to create better experiments and have more fascinating data.

Table I. The volume and temperature of cold water, volume and temperature of hot water, final temperature of the calorimeter and the calculated calorimeter constant value.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Trial #1 | Trial #2 | Trial #3 |
| Volume of cold water Vcw | 30 mL | 30 mL | 30 mL |
| Temp. of cold water Tcw | 22.5 ºC | 22.0 ºC | 22.5 ºC |
| Volume of hot water Vhw | 30 mL | 30 mL | 30 mL |
| Temp. of hot water Thw | 61.5 ºC | 64.0 ºC | 68.5 ºC |
| Final temperature Tf | 39.5 ºC | 41.5 ºC | 43.5 ºC |
| Ccal | 33.2 J/ºC | 19.3 J/ºC | 23.9 J/ºC |

Table II. The code of the metal sample, mass of the metal sample, volume and temperature of cold water, calorimeter constant value from Table I, temperature of the hot metal, final temperature of the calorimeter, specific heat of the metal and description and volume and density values of the metal samples.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Trial #1 | Trial #2 | Trial #3 |
| Code | A01D | A01D | A01D |
| Mass of metal | 12.787 g | 12.931 g | 13.738 g |
| Volume of cold water | 35 mL | 35 mL | 35 mL |
| Ccal from Table I | 33.2 J/ºC | 19.3 J/ºC | 23.9 J/ºC |
| Temp. of cold water Tc | 22.5 ºC | 22.0 ºC | 22.5 ºC |
| Temp. of hot metal Th | 73.5 ºC | 75.5 ºC | 78.0 ºC |
| Final temperature Tf | 47.0 ºC | 47.5 ºC | 49.0 ºC |
| sm | 0.1299 | 0.1167 | 0.1133 |
| Physical description of metal | Silver, gray color; not solid and uniform gray, cloudy with particles; metallic; cylindrical | Silver, gray color; not solid and uniform gray, cloudy with particles; metallic; cylindrical | Silver, gray color; not solid and uniform gray, cloudy with particles; metallic; cylindrical |
| Volume of metal cylinder | 5 mL | 5.5 mL | 6 mL |
| Density of metal cylinder | 2.56 g/cm3 | 2.35 g/cm3 | 2.29 g/cm3 |