**NOTE:** Temperatures are measured at minutes 1, 2 and 3, solutions are mixed minute 4, and the temperature of the mixture is taken at minutes 5, 6 & 7. The temperature at the time of mixing is interpreted and/or extrapolated from the graph.

1. **Water Equivalent of the Calorimeter:**

Obtain two calorimeters and two thermometers. Designate one setup as primary and one as secondary and label them accordingly. (You can identify the primary thermometer by putting a piece of masking tape on it.)

Compare the two thermometers by immersing them together in water at room temperature for one minute and reading them. Make note of a correction factor for the secondary thermometer. (If it reads 2.7°C higher than the primary thermometer, you will subtract 2.7°C from all temperatures measured with the secondary thermometer throughout the remainder of the experiment.

In this part of the experiment, we will be establishing the Water Equivalent (Weq) of the primary calorimeter. In parts 2-5 of this experiment, we will use the Weq established here in an effort to account for heat absorbed by the calorimeter and its surroundings. Place 50.0 mL of room temperature tap water in your primary calorimeter and 50.0 mL of tap water which has been heated to about 20°C above room temperature in the secondary calorimeter. Read the temperatures of both calorimeters at 1, 2, and 3 minutes, quickly pour the warm water into the room temperature water at the 4 minute mark, then measure the temperature of the mixture at minutes 5, 6 & 7. Graph the data as in the example above and use it to extrapolate/interpret the temperatures just before and just after mixing (at the 4 minute mark).

Calculate the heat lost by the warm water and the heat gained by the room temperature water. The difference between these two values will be assumed to be equal to the heat absorbed by the calorimeter and/or lost to the surroundings. (Assume the density of the water = 1.00 g/mL and the specific heat capacity = 4.184 J/gC°.) The heat lost divided by the change in temperature of the primary calorimeter gives the value for Weq.

The examples below illustrate (a) how to determine Weq and (b) how to use Weq with calculations in subsequent parts of the lab.

**Water Equivalent of the Calorimeter Data:**

|  |  |
| --- | --- |
| Temperature of 50.0 mL of Cooler Water | 37.9°C |
| Temperature of 50.0 mL of Warmer Water | 20.9°C |
| Temperature after Mixing | 29.1°C |
| Heat Lost by Warm Water:  = 50.0 g x 4.184 J/gC° x 8.8 C° | 1840 J |
| Heat Absorbed by Room Temperature Water  = 50.0 g x 4.184 J/gC° x 8.2 C° | 1710 J |
| Heat Lost to Calorimeter  = 1840 J – 1710 J | 130 J |
| Water Equivalent of the primary calorimeter  = 130 J ÷ 8.2 C° | 15.9 J/C° |

**Using Weq to calculate the heat of a reaction:**

In this example, 100.0 g of solution with a heat capacity of 4.00 J/g C° experiences a 7.2 C° temperature increase;

Heat absorbed by the solution:

=100.0 g x 4.00 J/g C° x 7.2 C° = 2880 J

Heat absorbed by the calorimeter:

=15.9 J/ C° x 7.2 C° = 110 J

Heat of the reaction = 2880 J + 110 J = 2990 J

(This is the total heat. Typically, this will be divided by the number of moles of product produced to give an enthalpy of reaction in J/mol or KJ/mol.)

1. **Heat of Neutralization of HC2H3O2(aq) and NaOH (aq):**

Place 50.0 mL of 1.0 M Acetic Acid in the primary calorimeter and 50.0 mL of 1.0 M NaOH in the secondary calorimeter. As in Part 1, measure the temperatures at minutes 1, 2 & 3, pour the NaOH into the HC2H3O2 at minute 4, and read the temperature of the mixture at minutes 5, 6 & 7. Calculate the heat of neutralization per mole of water formed. (What solution is produced here? What is it’s concentration? Assume the density of this solution to be 1.02 g/mL and its specific heat capacity to be 4.01 J/gC° in order to perform your calculations.)

**(QUESTIONS ON REVERSE SIDE)**

**Questions:**

1. What is the water equivalent of a calorimeter? How is it determined? What units is it expressed in? Why would we want to use it in calorimetry experiments?
2. What source(s) of error are corrected for by using Weq? List at least 3 sources of error which Weq would not account for.
3. A reaction between 75.0 mL of 2.1 M solution A and 75.0 mL of 2.1 M solution B produces a solution with a specific heat capacity of 3.72 J/gC° and a density of 1.14 g/mL. Reference values indicate that the enthalpy change for this reaction is -69.2 kJ/mol. A previous experiment yielded a water equivalent for this calorimeter of 4.9 J/C°.
   1. Is this reaction exothermic or endothermic? (Explain.)
   2. Would this reaction cause the temperature of the system to increase, decrease or stay the same? (Explain.)
   3. If the solutions were both at 22.6**°**C prior to the reaction, what would be the final temperature of the system? (Show work.)