Calorimetry – Measurement of Heat Energy

Why?

The amount of energy released or absorbed by a chemical reaction can be measured using a calorimeter. This information is essential to understanding the stability of chemical compounds, predicting equilibrium concentrations in chemical reactions, and identifying conditions for a reaction to occur efficiently and safely. In this activity you will learn how the energy change in a chemical reaction can be measured using a calorimeter.

Success Criteria

- Quantify the relationship between heat absorbed or lost and an observed temperature change.
- Calculate the heat required to raise the temperature of a given mass of water.
- Determine the specific heat capacity of a substance other than water.
- Compare the expected temperature changes for a sample of lead with the expected temperature change for a sample of water of equal mass.

Prerequisites

- Exothermic Change
- Endothermic Change
- Law of Conservation of Energy

Information

- **Heat** is the energy associated with the random motion of particles.
- The unit for **Heat Energy** is the **Joule (J).**
- **Kinetic Energy** is the energy associated with the motion of atoms and molecules.
- **Temperature** is a measure of the **energy** in a sample of material.
- The symbol **ΔT** refers to **"the change in temperature."**
  Example: $\Delta T = 5.00\ ^0C$ means a temperature ***change*** of $5\ ^0C$.
- **Heat Capacity** is the energy required to raise the temperature of a 1 g sample of a substance $1\ ^0C$ (or 1 Kelvin degree).
- The specific heat capacity for water is 4.18 Joule/gram Kelvin degree

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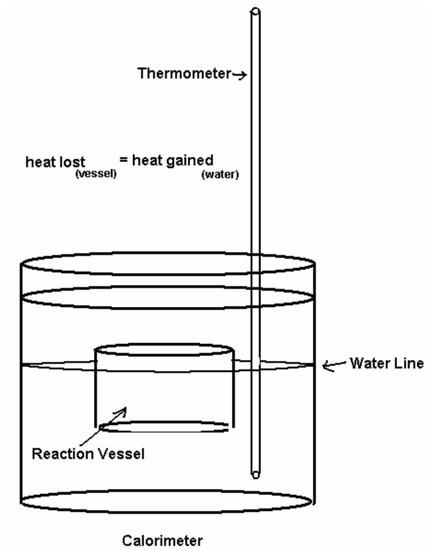
Model

Assume that a calorimeter is a closed system where all the energy released by an exothermic change is absorbed by the water in the calorimeter. If the mass of the water is known, the temperature change of the water can be used to determine the amount of heat energy released.



Equation for the calculation of heat is: **$q = mC\Delta T$**

q = heat released in Joules
m = mass of water in the calorimeter
C = specific heat capacity (**not ^{0}C which is a temperature**)
ΔT = [final temperature – initial temperature] (absolute value)

Key Questions:

1. What is the numerical value and units of the specific heat capacity of water?

2. What information does the specific heat capacity of water provide?

3. How can the heat released into some mass of water be calculated from the specific heat capacity of water and the change in temperature of the water? Answer in words not with an equation.

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Exercises

Answer Exercises 1-5 based upon the passage that follows.

A calorimeter was used to measure the heat released by a chemical change. The calorimeter contained 100.00 g of water at an initial temperature of 10.0 ^{0}C. When the reaction was finished the temperature of the water increased to 75.0 ^{0}C.

1. Write the mass of water (m) indicated in the passage.

2. Write the change in temperature (ΔT) indicated in the passage.

3. Write the correct mathematical set-up for the calculation of heat (q)? (Substitute the appropriate values for m, C and ΔT in the equation.)

4. What is the heat quantity released by the chemical change? (Include correct unit)

5. If a substance with a larger specific heat than water were used in the experiment, identify whether ΔT would be larger or smaller. Explain.

Show the set-up used to solve each of the following exercises. Report your final answer with the correct unit.

6. Determine the heat required to raise the temperature of a 50. g sample of water from 10. ^{0}C to 45 ^{0}C.

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7. Determine the mass of a water sample that is heated from an initial temperature of 25 ^{0}C to a final temperature of 100. ^{0}C following the addition of 1200 J of heat energy.

8. A 100. g sample of pure lead is heated from 10.0^{o}C to 197.5^{o}C by the addition of 3000. J of heat energy. Calculate the specific heat capacity of lead.

Problem

1. The specific heat (C) of water is quite high compared to the specific heat of lead, so the energy released by a sample of heated lead to its surroundings will be only around 4% of the amount of heat released by an equal mass of water under identical conditions.

   (a) Calculate the change in temperature that results from the addition of 2500 J of heat energy to a 25g sample of water.

   (b) Calculate the change in temperature that results from the addition of 2500 J of heat energy to a 25g sample of lead.

   (c) Explain the difference in the temperature changes, found in parts (a) and (b), in terms of the specific heat capacities of lead and water.

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