

Experiment 14

Heat Effects and Calorimetry

Heat is a form of energy, sometimes called thermal energy, that can pass spontaneously from an object at a high temperature to an object at a lower temperature. If the two objects are in contact, they will, given sufficient time, both reach the same temperature.

Heat flow is ordinarily measured in a device called a calorimeter. A calorimeter is simply a container with insulating walls, made so that essentially no heat is exchanged between the contents of the calorimeter and the surroundings. Within the calorimeter chemical reactions may occur or heat may pass from one part of the contents to another, but no heat flows into or out of the calorimeter from or to the surroundings.

A. Specific Heat

When heat flows into a substance, the temperature of that substance will increase. The quantity of heat q required to cause a temperature change Δt of any substance is proportional to the mass m of the substance and the temperature change, as shown in Equation 1. The proportionality constant is called the specific heat, $S.H.$, of that substance.

$$q = (\text{specific heat}) \times m \times \Delta t = S.H. \times m \times \Delta t \quad (1)$$

The specific heat can be considered to be the amount of heat required to raise the temperature of one gram of the substance by 1°C (if you make m and Δt in Equation 1 both equal to 1, then q will equal $S.H.$). Amounts of heat are measured in either joules or calories. To raise the temperature of 1 g of water by 1°C , 4.18 joules of heat must be added to the water. The specific heat of water is therefore 4.18 joules/g $^\circ\text{C}$. Since 4.18 joules equals 1 calorie, we can also say that the specific heat of water is 1 calorie/g $^\circ\text{C}$. Ordinarily heat flow into or out of a substance is determined by the effect that that flow has on a known amount of water. Because water plays such an important role in these measurements, the calorie, which was the unit of heat most commonly used until recently, was actually defined to be equal to the specific heat of water.

The specific heat of a metal can readily be measured in a calorimeter. A weighed amount of metal is heated to some known temperature and is then quickly poured into a calorimeter that contains a measured amount of water at a known temperature. Heat flows from the metal to the water, and the two equilibrate at some temperature between the initial temperatures of the metal and the water.

Assuming that no heat is lost from the calorimeter to the surroundings, and that a negligible amount of heat is absorbed by the calorimeter walls, the amount of heat that flows from the metal as it cools is equal to the amount of heat absorbed by the water.

In thermodynamic terms, the heat flow for the metal is equal in magnitude but opposite in direction, and hence in sign, to that for the water. For the heat flow q ,

$$q_{\text{H}_2\text{O}} = -q_{\text{metal}} \quad (2)$$

If we now express heat flow in terms of Equation 1 for both the water and the metal M , we get

$$q_{\text{H}_2\text{O}} = S.H._{\text{H}_2\text{O}} m_{\text{H}_2\text{O}} \Delta t_{\text{H}_2\text{O}} = -S.H._M m_M \Delta t_M \quad (3)$$

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Robert Bruce Thompson



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Laboratory Manual for Chemistry Karen Timberlake, 1979

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