

Lab Session 9, Experiment 8: Calorimetry, Heat of Reaction

Specific heat is an intensive property of a single phase (solid, liquid or gas) sample that describes how the temperature of the sample changes as it either absorbs or loses heat energy. Specific heat is generally a function of temperature, but, to a good approximation, it can be treated as being constant for a single phase over a moderate temperature range. The table below lists the specific heats at 25°C of liquid water and selected metal solids.

The Zeroth Law of Thermodynamics states: "If two samples of matter, initially at different temperatures (T_H and T_C , respectively), are placed in thermal contact, heat will be lost by the hotter sample (T_H) and gained by the cooler one (T_C). This exchange of heat will take place until both samples achieve the same final temperature, T_F , so that $T_H > T_F > T_C$." The First Law of Thermodynamics states: "During heat exchange (or, as we shall see, during a chemical reaction), heat is neither created nor destroyed." Thus, heat lost equals heat gained, if the heat exchange can be sufficiently insulated from the surroundings so that not very much heat escapes to the surroundings. A vessel that provides adequate heat insulation from its surroundings, and in which temperature changes are measured in order to determine specific heats (or heats of chemical reactions) is called a **calorimeter**. A perfect calorimeter absorbs no heat from the solution that it

Substance	Specific Heat, J/(g°C)
water (liquid)	4.184
aluminum (solid)	0.901
chromium (solid)	0.448
copper (solid)	0.386
iron (solid)	0.450
lead (solid)	0.129
nickel (solid)	0.443
tin (solid)	0.217
zinc (solid)	0.386

contains, nor loses any heat to the surroundings. No calorimeter is perfect, however. A typical calorimeter used in freshman chemistry labs is made of two nested Styrofoam cups, and looks like the one shown in Figure 9.1.

If we place m_{metal} grams of a hot metal, at a Celsius temperature T_H , into a nearly perfect calorimeter, along with m_{water} grams of water, at a lower Celsius temperature T_C , then the metal and the water will thermally equilibrate at a final intermediate Celsius temperature, T_F .

Since the heat lost by the metal is equal to the heat gained by the water within the calorimeter, the following equation holds (m is in the units g, T is in the units °C and sp ht is in the units J/g °C):

$$[(m_{\text{metal}}) \times (T_H - T_F) \times (\text{sp ht}_{\text{metal}})] = [(m_{\text{water}}) \times (T_F - T_C) \times (\text{sp ht}_{\text{water}})] .$$

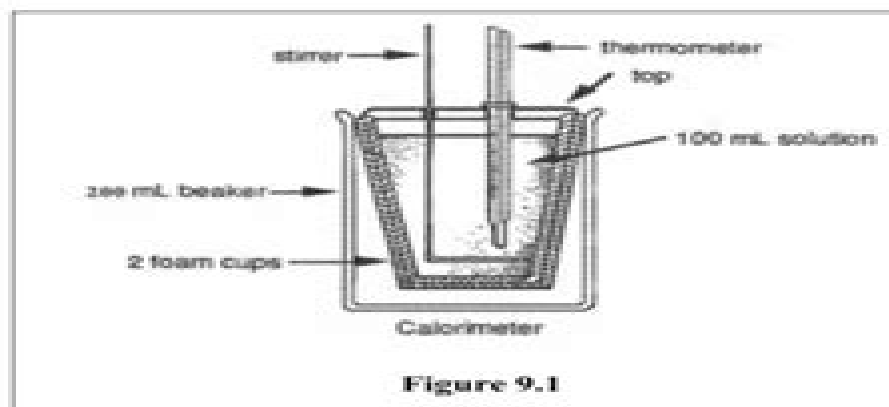


Figure 9.1

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