PRACTICE PROBLEMS

11. How much heat is required to raise the temperature of 854 g H_2O from 23.5°C to 85.0°C?
12. Phosphorus trichloride, PCl_3, is a compound used in the manufacture of pesticides and gasoline additives. How much heat is required to raise the temperature of 96.7 g PCl_3 from 31.7°C to 69.2°C? The specific heat of PCl_3 is 0.874 J/g·C°.
13. Carbon tetrachloride, CCl_4, was a very popular organic solvent until it was found to be toxic. How much heat is required to raise the temperature of 10.35 g CCl_4 from 32.1°C to 56.4°C? (See Appendix Table A-5.)
14. If a piece of aluminum with mass 3.90 g and a temperature of 99.3°C is dropped into 10.0 cm^3 of water at 22.6°C, what will be the final temperature of the system? (Recall the density of water is 1.00 g/cm^3.)
15. The color of many ceramic glazes comes from cadmium compounds. If a piece of cadmium with mass 65.6 g and a temperature of 100.0°C is dropped into 25.0 cm^3 of water at 23.0°C, what will be the final temperature of the system?
16. A piece of an unknown metal with mass 23.8 g is heated to 100.0°C and dropped into 50.0 cm^3 of water at 24.0°C. The final temperature of the system is 32.5°C. What is the specific heat of the metal?

Specific Heat of a Metal — 3

One physical property of a pure substance is the amount of heat energy it will absorb per unit of mass. This property can be measured quite accurately and is called **specific heat** (C_p). Often applied to metallic elements, specific heat is the amount of heat energy, measured in joules, needed to raise the temperature of one gram of the substance one degree Celsius.

To measure specific heat in the laboratory, a calorimeter of some kind must be employed. A calorimeter is simply a well insulated container used to reduce the loss or gain of heat energy from the surrounding room conditions. Heat energy always flows from a body at a higher temperature to a body at a lower temperature. The heat gained by the cooler substance equals the heat lost by the warmer substance if we assume no loss of heat to the surrounding environment.

A metal sample will be heated to a high temperature then placed into a calorimeter containing a known quantity of water at a lower temperature. Having measured the mass of the water in the calorimeter, the temperature change of the water (ΔT), and knowing the specific heat of water (4.184 J/g·C°), the heat gained by the water (lost by the metal) can be calculated as follows:

$$\text{Heat gained by the water} = \text{Mass of Water (g)} \times \Delta T\ (C°) \times \text{Specific heat of water (4.184 J/g·C°)}$$

From the measured heat lost by the metal, the specific heat of the metal can be calculated as follows:

$$\text{Specific heat of metal } (C_p) = \frac{\text{Heat gained by the water}}{\text{Mass of metal (g)} \times \Delta T \text{ of metal } (C°)}$$

Objective

In this experiment, you will determine the specific heat of a metal sample.

Equipment

250 mL beaker
styrofoam cup
thermometer
18 × 150 mm test tube

Procedure

1. Fill a 250 mL beaker about half full with tap water.
2. Place the beaker of water on a ringstand with wire gauze. Begin heating to boiling.
3. Measure the mass of an empty, dry 18 × 150 mm test tube and record.
4. Add the sample metal pieces until the test tube is half-full. Record the mass of the test tube and metal.
5. Place the test tube containing the metal into the beaker of water as shown in Figure 3-1 and continue heating the water to the boiling point.

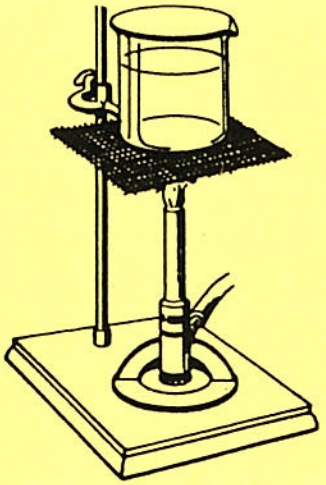

FIGURE 3-1. Apparatus set-up for boiling a liquid such as water.

6. Obtain a styrofoam cup to be used as a calorimeter and measure the mass carefully. Record.
7. Fill the styrofoam cup about half-full with distilled water at room temperature and record the mass.
8. After the water in the beaker containing the test tube with the metal has boiled for several minutes, measure the temperature of the water with a thermometer and record. (It will be assumed the temperature of the metal is the same as the boiling water.)
9. Measure the temperature of the water in the styrofoam cup and record.
10. Remove the test tube containing the metal from the boiling water and immediately dump the metal into the styrofoam cup.
11. Stir the water in the styrofoam cup *slowly* (thermometers can be broken easily), then record the highest temperature reached.
12. Recover the metal by carefully pouring the water off (decanting), then spread the solid metal on a paper towel to dry. *Do not let any metal particles get into your laboratory sink.*
13. Repeat entire procedure with a different metal if time permits.

Data

The following table will help to organize your data. In future experiments, you will need to design your own table:

1. Mass of test tube empty _____ g
2. Mass of test tube + metal _____ g
3. Mass of styrofoam cup _____ g
4. Mass of styrofoam cup + water _____ g
5. Temperature of boiling water _____ °C
6. Temperature of water in cup _____ °C
7. Temperature of water in cup after metal was added _____ °C

Calculations

1. Calculate the heat gained by the water (lost by the metal) in the calorimeter using the equation in the Introduction.
2. Calculate the specific heat of the metal using the answer from Calculation 1 and the equation in the Introduction.

Questions and Problems

1. Why is water an excellent material to use in a calorimeter?
2. Calculate the specific heat of a metallic element if 50.0 g of the metal need 314 joules of heat energy to raise the temperature from 25°C to 50°C.