

USE OF LABORATORY EQUIPEMENT

C. Laboratory Thermometers

Most thermometers are based upon the principle that liquids expand when heated. Most common thermometers use mercury or colored alcohol as the liquid. These thermometers are constructed as that a uniform-diameter capillary tube surmounts a liquid reservoir. To calibrate a thermometer, one defines two reference points, normally the freezing point of water (0°C, 32°F) and the boiling point of water (100°C, 212°F) at 1 tam of pressure (1 tam = 760 mm Hg). Once these points are marked on the capillary, its length is then subdivided into uniform divisions called *degrees*. There are 100° between these two points on the Celsius (°C, or centigrade) scale and 180° between those two points on the Fahrenheit (°F) scale.

$$^{\circ}\text{F} = 1.8\ ^{\circ}\text{C} + 32$$

The Thermometer and Its Calibration

This section describes the proper technique for checking the accuracy of your thermometer. These measurements will show how measured temperatures (read from thermometer) compare with true temperatures (the boiling and freezing points of water). The freezing point of water is 0°C; the boiling point depends upon atmospheric pressure but at sea level it is 100°C. Option 1: Place approximately 50 mL of ice in a 250-mL beaker and cover the ice with distilled water. Allow about 15 min for the mixture to come to equilibrium and then measure and record the temperature of the mixture. *Theoretically, this temperature is 0°C.* Option 2: Set up a 250-mL beaker on a wire gauze and iron ring. Fill the beaker about half full with distilled water. Periodically determine the temperature of the water with the thermometer, but be careful not to touch the walls of the beaker with the thermometer bulb. Record the boiling point (b.p.) of the water.

Significant figures in relationship to Temperature

The simple act of measuring a temperature with a thermometer can easily involve errors. Not only does the calibration of the scale on the thermometer limit the precision of the measurement, but the improper placement of the thermometer bulb in the material being measured introduces a common source of human error. When measuring the temperature of a liquid, one can minimize this type of error by observing the following procedures:

1. Hold the thermometer away from the walls of the container
2. Allow sufficient time for the thermometer to reach equilibrium with the liquid.
3. Be sure the liquid is adequately mixed.

When converting from degrees Celsius to Fahrenheit or vice versa, we make us of the following formulas:

$$^{\circ}\text{C} = \left(\frac{^{\circ}\text{F}-32}{1.8}\right) \text{ or } ^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$$

Example Problem: Convert 70.0°F to degrees Celsius:

$$^{\circ}\text{C} = \left(\frac{70.0^{\circ}\text{F}-32}{1.8}\right) = \frac{38.0}{1.8} = 21.11^{\circ}\text{C} \text{ rounded to } 21.1^{\circ}\text{C}$$

This example shows not only how the formula is used by also a typical setup of the way chemistry problems should be written. It shows how the numbers are used, but does not show the multiplication and division, which should be worked out by calculator. The answer was changed from 21.11 °C to 21.1 °C because the initial temperature, 70.0 °F, has only three significant figures. The 1.8 and 32 in the formulas are exact numbers and have no effect on the number of significant figures.