
Experiment 1 – Measurements

Discussion

Experimental sciences, such as Chemistry, depend on making and using measurements properly. The SI system of units (sometimes called the metric system) is used almost exclusively. This system is very similar to our monetary system: \$1 = 10 dimes = 100 cents = 1000 mills. In chemistry, the basic units of length, mass, and volume are the meter, gram, and liter, respectively. They all are divided the same way. For example, 1 meter = 10 decimeters = 100 centimeters = 1000 millimeters. The kilo is also commonly used; it equals 1000 of the basic unit. For example, 1 kilogram = 1000 grams.

Often you will be asked to compare your experimental or calculated value to an “accepted” or theoretical value. The closer you are to the accepted value, the greater the accuracy of your experiment. The accepted value could be located in a reference such as the *CRC Handbook of Chemistry and Physics*. Percent error is a common method for reporting accuracy, where a smaller percent error represents a more accurate experimental value. Percent error is calculated as:

$$\text{Percent error} = \left| \frac{\text{Experimental} - \text{Accepted}}{\text{Accepted}} \right| \times 100 \% \quad (1)$$

In science, an experimenter is allowed to estimate one more digit past what can be measured exactly on an instrument. For example, if the smallest lines on a ruler are centimeters, and an object’s length falls between 2 lines, more precision is gained by estimating between the lines. Therefore, the length of an object might be reported as 25.5 cm. The reported numbers are called “significant figures”, and the more precise the instrument, the more significant figures it can produce.

A calculation cannot be any more precise than the least precise measurement. For example, density is calculated by dividing the mass of an object by its volume. Therefore, the density of an object might be $23.57 \text{ g} / 4.2 \text{ mL} = 5.61190476 \text{ g/mL}$. But, the least precise measurement (the volume) only has a precision of 2 significant figures. Therefore, the density must be reported as 5.6 g/mL.

Procedure

Record your data on the report form as you complete the measurements.

A. Temperature

5 beakers with thermometers have been set up for you: (1) room temperature water, (2) boiling water, (3) a mixture of ice and water, (4) a stirred mixture of ice and water, and (5) a stirred mixture of ice, water and salt. Observe and record all temperatures to the nearest 0.1 °C.

B. Mass

When using any measuring device, never round off your raw data. If the balance fluctuates on the last digit, estimate that value. Weigh a (1) 100-mL beaker, (2) a 250-mL Erlenmeyer flask, (3) a plastic empty weighing boat, and (4) and then add approximately 2 grams of sodium chloride to the weighing boat. Calculate the mass of the sodium chloride added.

C. Length

Using a metric ruler, measure the following in centimeters, remembering to estimate one extra digit: (1) the length of the double arrow on the report sheet, (2) the length of the external height of a 250-mL beaker, and (3) the length of a medium sized test tube.

D. Volume

The graduated cylinder is the most accurate equipment in your locker for measuring volume and can give a precision of 0.1 mL. Water is attracted to the glass sides of the cylinder, causing a curved effect called the meniscus. The cylinder should be read at eye level using the bottom of the meniscus. In theory, a 250-mL Erlenmeyer flask with a marking for 200 mL should have a volume of 200 mL at that mark! However the problem is that volumes marked on beakers and flasks are only approximate values. Therefore, fill a 250-mL Erlenmeyer flask to the 200 mL mark with water, transfer this volume of water to a 250-mL graduated cylinder, and determine the exact volume.

It is often convenient to estimate volumes of 5 and 10 mL simply by observing the height of a liquid in a test tube. Use your graduated cylinder to place 5 and 10 mL of water in a medium-sized test tube and measure the heights in cm.

Name: _____

Section: _____

Data and Calculations for Experiment 1

Be sure to record all numerical values with the correct number of significant figures and note the units are already recorded for each in this first experiment!

A. Temperature

1. Water at room temperature _____ °C
2. Boiling point _____ °C
3. Ice water
Unstirred _____ °C
Stirred _____ °C
4. Ice water with salt added _____ °C

B. Mass

1. 100 mL beaker _____ g
2. 250 mL Erlenmeyer flask _____ g
3. Weighing boat _____ g
4. Mass of weighing boat + sodium chloride _____ g
Mass of sodium chloride (show calculation setup) _____ g

C. Length

1. Length of  _____ cm
2. Height of 250 mL beaker _____ cm
3. Length of test tube _____ cm

D. Volume

1. 200 mL mark (from Erlenmeyer flask) water
transferred to graduated cylinder _____ mL
2. Height of 5.0 mL of water in test tube _____ cm
3. Height of 10.0 mL of water in test tube _____ cm