## 1.8: Volume

Volume is the amount of 3D space a substance or object occupies. In the photo above, the same volume of water (50 mL) is shown in each of the beakers. As you noticed, the 50 mL looks radically different from beaker to beaker. What causes this variation? Volume is a derived unit, depending on 3 quantities: length, width, and height. Therefore, though the beakers each contain the same volume, their differing lengths, widths, and heights makes that volume look deceptively different.
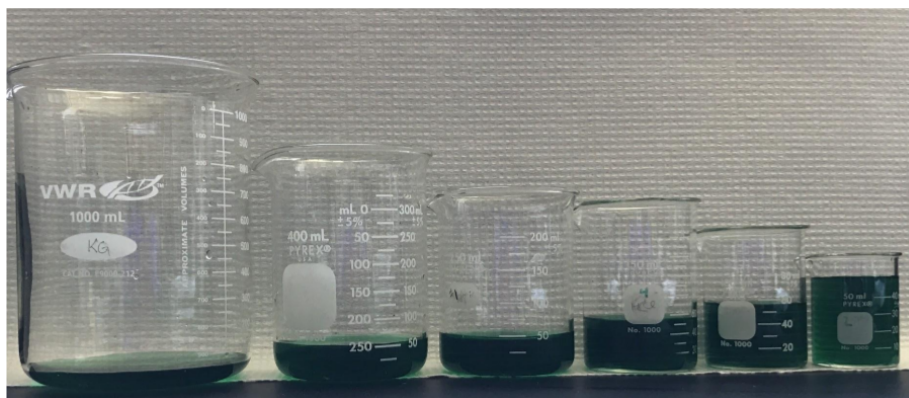
Six beakers are arranged starting from the largest on the left to the smallest on the right. All of the beakers are filled with the same amount of liquid. The liquid occupies more and more space in the beaker as we progress along to the right.

The most commonly used derived units are those of volume. As we have already seen, calculation of the volume of an object requires that all 3 dimensions are multiplied together (length, width, and height). Thus the SI unit of volume is the cubic meter (m^3). This is rather large for use in the chemical laboratory, and so the cubic decimeter (dm^3) or cubic centimeter $(cm^3$, formerly cc) are more commonly used. The relationship between these units and the cubic meter is easily shown:

$$1 \text{ dm} = 0.1 \text{ m}$$

$$1 \text{ cm} = 0.01 \text{ m}$$

Cubing both sides of each equation, we have

$$1 \text{ dm}^3 = 0.1^3 \text{m}^3 = 0.001 \text{ m}^3 = 10^{-3} \text{m}^3$$

$$1 \text{ cm}^3 = 0.01^3 \text{m}^3 = 0.000\,001 \text{ m}^3 = 10^{-6} \text{m}^3$$

> Note that in the expression dm^3 the *exponent includes the prefix(opens in new window)* as well as the base unit. A cubic decimeter is one-thousandth of a cubic meter, not one-tenth of a cubic meter.

Two other units of volume are commonly encountered in the chemical laboratory — the liter (l) and the milliliter (ml — one-thousandth of a liter). The liter was originally defined as the volume of one kilogram of pure water at the temperature of its maximum density (3.98°C) but in 1964 the definition was changed. The liter is now exactly one-thousandth of a cubic meter, that is, 1 dm^3. A milliliter is therefore exactly 1 cm^3. Because the new definition of liter altered its volume slightly, it is recommended that the results of highly accurate measurements be reported in the SI units cubic decimeters or cubic centimeters, rather than in liters or milliliters. For most situations discussed in this online textbook, however, the units cubic decimeter and liter, and cubic centimeter and milliliter may be used interchangeably. Thus when recording a volume obtained from laboratory glassware calibrated in milliliters, you can just as well write 24.7 cm^3 as 24.7 ml.