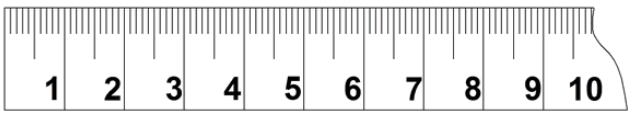
Units of Measure

How were sailors able to measure the depths of seas?
Back in the days before all the electronic gadgets for measuring depth and locating undersea objects existed, the "fathom" was the unit of measurement for depth. A rope was knotted every six feet and the end was dropped over the side of the ship. You could tell how deep the water was by how many knots went under the water before the rope hit bottom. Today, we just turn on an instrument and read the depth to a high level of accuracy.

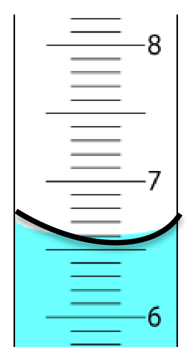
Length and Volume



Length is the measurement of the extent of something along its greatest dimension. The SI basic unit of length, or linear measure, is the **meter** (m). All measurements of length may be made in meters, though the prefixes listed in various tables will often be more convenient. The width of a room may be expressed as about 5 meters (m), whereas a large distance, such as the distance between New York City and Chicago, is better expressed as 1150 kilometers (km). Very small distances can be expressed in units such as the millimeter or the micrometer. The width of a typical human hair is about 20 micrometers (µm).

Volume is the amount of space occupied by a sample of matter. The volume of a regular object can be calculated by multiplying its length by its width by its height. Since each of those is a linear measurement, we say that units of volume are derived from units of length. The SI unit of volume is the **cubic meter** (m^3), which is the volume occupied by a cube that measures 1 m on each side. This very large volume is not very convenient for typical use in a chemistry laboratory. A **liter** (L) is the volume of a cube that measures 10 cm (1 dm) on each side. A liter is thus equal to both 1000 cm^3 (10 cm × 10 cm × 10 cm) and to 1 dm^3. A smaller unit of volume that is commonly used is the **milliliter** (mL – note the capital L which is a standard practice). A milliliter is the volume of a cube that measures 1 cm on each side. Therefore, a milliliter is equal to a cubic centimeter (cm^3). There are 1000 mL in 1 L, which is the same as saying that there are 1000 cm^3 in 1 dm^3.

To determine the volume of a liquid, usually in a graduated cylinder, you look at the bottom curve which is called the **meniscus**, the curve seen at the top of a liquid in response to its container. When you read a scale on the side of a container with a meniscus, such as a graduated cylinder or volumetric flask, it's important that the measurement accounts for the meniscus. Measure so that the line you are reading is even with the center of the meniscus. For water and most liquids, this is the bottom of the meniscus.



Units of Measure

Mass and Weight

How is he floating?

One of the many interesting things about travel in outer space is the idea of weightlessness. If something is not fastened down, it will float in mid-air. Early astronauts learned that weightlessness had bad effects on bone structure. If there was no pressure on the legs, those bones would begin to lose mass. Weight provided by gravity is needed to maintain healthy bones. Specially designed equipment is now a part of every space mission, so the astronauts can maintain good body fitness.

Mass is a measure of the amount of matter that an object contains. The mass of an object is made in comparison to the standard mass of 1 kilogram. The kilogram was originally defined as the mass of 1 L of liquid water at 4°C (volume of a liquid changes slightly with temperature). In the laboratory, mass is measured with an electric balance which must be calibrated with a standard mass so that its measurements are accurate.

Other common units of mass are the gram and the milligram. A gram is 1/1000th of a kilogram, meaning that there are 1000 g in 1 kg. A milligram is 1/1000th of a gram, so there are 1000 mg in 1 g.

Mass is often confused with the term weight. **Weight** is a measure of force that is equal to the gravitational pull on an object. The weight of an object is dependent on its location. On the moon, the force due to **gravity** is about one sixth that of the gravitational force on Earth. Therefore, a given object will weigh six times more on Earth than it does on the moon. Since mass is dependent only on the amount of matter present in an object, mass does not change with location. Weight measurements are often made with a spring scale by reading the distance that a certain object pulls down and stretches a spring.

Temperature and Temperature Scales

Touch the top of the stove after it has been on, and it feels hot. Hold an ice cube in your hand and it feels cold. Why? The particles of matter in a hot object are moving much faster than the particles of matter in a cold object. An object's **kinetic energy** is the energy due to motion. The particles of matter that make up the hot stove have a greater amount of kinetic energy than those in the ice cube.

Temperature is a measure of the average kinetic energy of the particles in matter. In everyday usage, temperature indicates a measure of how hot or cold an object is. Temperature is an important parameter in chemistry. When a substance changes from solid to liquid, it is because there was an increase in the temperature of the material. Chemical reactions usually proceed faster if the temperature is increased. Many unstable materials (such as enzymes) will be viable longer at lower temperatures.

Units of Measure

Temperature Scales

The first thermometers were glass and contained alcohol, which expanded and contracted as the temperature changed. The German scientist, Daniel Gabriel Fahrenheit, used mercury in the tube. The Fahrenheit scale was first developed in 1724 and tinkered with for some time after that. The main problem with this scale is the arbitrary definitions of temperature. The freezing point of water was defined as 32°F and the boiling point as 212°F. The Fahrenheit scale is typically not used for scientific purposes.

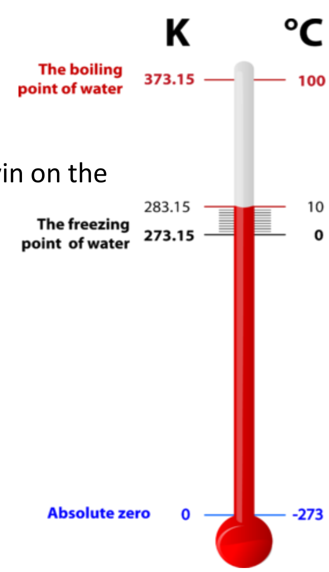
Daniel Gabriel Fahrenheit

The Celsius scale of the metric system is named after Swedish astronomer Anders Celsius (1701-1744). The Celsius scale sets the freezing point and boiling point of water at 0°C and 100°C respectively. The distance between those two points is divided into 100 equal intervals, each of which is one degree. Another term sometimes used for the Celsius scale is "centigrade" because there are 100 degrees between the freezing and boiling points of water on this scale. However, the preferred term is "Celsius."

Anders Celsius

The Kelvin temperature scale is named after Scottish physicist and mathematician Lord Kelvin (1824-1907). It is based on molecular motion, with the temperature of 0 K, also known as absolute zero, being the point where all molecular motion ceases. The freezing point of water on the Kelvin scale is 273.15 K, while the boiling point is 373.15 K. Notice that here is no "degree" used in the temperature designation. Unlike the Fahrenheit and Celsius scales where temperatures are referred to as "degrees F" or "degrees C," we simply designated temperatures in the Kelvin scale as kelvins.

Lord Kelvin



As can be seen by the 100 kelvin difference between the two, (boiling points and freezing point), a change of one degree on the Celsius scale is equivalent to the change of one kelvin on the Kelvin scale. Converting from one scale to another is easy, as you simply add 273 to go from Celsius to Kelvin or subtract 273 to go from Kelvin to Celsius.

Resources

Video Clip: Absolute Zero
https://www.youtube.com/watch?v=TNUDBdv3jWI

PBS Show: The Race to Absolute Zero by PBS
https://www.youtube.com/watch?v=m1wBWtUG2uY