1.4: The International System of Units (SI)

The results of a scientific experiment must be communicated to be of value. This affords an opportunity for other scientists to check them. It also allows the scientific community, and sometimes the general public, to share new knowledge. Communication, however, is not always as straightforward as it might seem. Ambiguous terminology can often turn a seemingly clear statement into a morass of misunderstanding.

As an example, consider someone tells you that the forecast is a high of 25°. Do you put on a winter jacket, or summer wear? If you are thinking winter, then you interpreted the temperature as 25°F. However if 25°C was meant, which is equal to 77°F, a winter jacket would be far too warm. Or consider filling up a car with gasoline. If you are in the US, you will be dealing in dollars per gallon, whereas, if you were in continental Europe, you will be dealing in Euros per liter. Given that the exchange rate from USD to Euros fluctuates and that there are roughly 3.79 liters in 1 gallon, it is difficult to simply compare numbers between gas prices in the USA, and say, France, if you don't know what units you are using. As a final example, consider the speed 24 meters/sec. Do you interpret this as close to highway speed limits in the US? It is the same speed as 53.7 miles per hour, likely a more familiar set of units for speed for people in the US.

While some of these examples may seem tired and overdone, they still showcase that even if you know unit conversions well, the many systems for measuring quantities can make things complex and confusing. Even rocket scientists get it wrong sometimes, as was seen in 1999 when a orbiter sent to Mars was unable propel itself correctly into orbit because one team had used metric system measurements, whereas another had used English system measurements.[1] If in the midst of this hodgepodge, you asked, “Would it not be easier to have a single unit for mass, a single unit for volume, and express all masses or volumes in these units,” you would not be the first person to have such an idea. The main difficulty is that it is hard to get everyone to agree on a single consistent set of units. Some units are especially convenient for some tasks. For example, a yard was originally defined as the distance from a man’s nose to the end of his thumb when his arm was held horizontally to one side. This made it easy to measure cloth or ribbon by holding one end to the nose and stretching an arm’s length with the other hand. Now that yardsticks, meter sticks, and other devices are readily available, the original utility of the yard is gone, but we still measure ribbon and cloth in that same unit. Many people would probably be distressed if a change were made.

Scientists are not all that different from other people—they too have favorite units which are especially suited to certain areas of research. Nevertheless, scientists have constantly pressed for improvement and uniformity in systems of measurement. The first such action occurred nearly 200 years ago when, in the aftermath of the French Revolution, the *metric system* spread over most of continental Europe and was adopted by scientists everywhere. The United States nearly followed suit, but in 1799 Thomas Jefferson was unsuccessful in persuading Congress that a system based on powers of 10 was far more convenient and would eventually become the standard of the world.

The metric system has undergone continuous evolution and improvement since its original adoption by France. Beginning in 1899, a series of international conferences have been held for the purpose of redefining and regularizing the system of units. In 1960 the Eleventh Conference on Weights and Measures proposed major changes in the metric system and suggested a new name — the **International System of Units** — for the revised metric system. (The abbreviation **SI**, from the French *Système International*, is commonly used.) Scientific bodies such as the U.S. National Bureau of Standards and the International Union of Pure and Applied Chemistry have endorsed the SI.

At the heart of the SI are the seven units, listed here. All other units are derived from these seven so-called **base units**. For example, units for area and volume may be derived by squaring or cubing the unit for length. Some of the base units are probably familiar to you, while others, such as the mole, candela, and kelvin, may be less so. Rather than defining each of them now, we shall wait until later chapters when the less familiar units, as well as the quantities they are used to measure, can be described in detail. The candela, which measures the intensity of light, is not used often by chemists, and so we shall pay no further attention to it.

Table 1.4.1: The Seven Base Units of the SI.

Quantity (parameter) Measured	abbreviation	Name of Unit	Symbol for Unit
Length	L	meter	m
Mass	m	kilogram	kg

Quantity (parameter) Measured	abbreviation	Name of Unit	Symbol for Unit
Time	t	second	s
Electric current	I	ampere	A
Temperature	T	kelvin	K
Amount of substance	n	mole	mol
Luminous intensity	I_v	candela	cd

Web Sites

- NIST: National Institutes of Standards and Technology. Physics NIST [physics.nist.gov]
- Dictionary of Units of Measurement: www.unc.edu/~rowlett/units/index.html
- Robin Lloyd. Metric mishap caused loss of NASA orbiter. CNN. September 30, 1999. CNN [www.cnn.com]