Measurement

The Metric System

The metric system was adopted in France in 1795 as a standardized system of measurement. Today, the worldwide scientific community and most countries use a version of the metric system, known as the **SI system**.

In the SI system, there are seven **base units**. All other quantities can be measured using combinations of these.

SI Base Units		
Base Quantity	**Base Unit**	**Symbol**
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	Kelvin	K
Amount of Substance	mole	mol
Electric Current	ampere	A
Luminous Intensity	candela	cd

A wide variety of other units, called **derived units**, are combinations of the base units.

SI Derived Units				
Quantity	**Unit**	**Symbol**	**In Base Units**	**Alternate Units**
Acceleration		m/s^2	m/s^2	
Activity	Bequerel	Bq		
Electric Charge	Coulomb	C	$A \cdot s$	
Electric Field		N/C	$kg \cdot m/C \cdot s^2$	
Electric Resistance	Ohm	Ω	$kg \cdot m^2 / A^2 \cdot s^3$	V/A
Energy, Work	Joule	J	$kg \cdot m^2/s^2$	$N \cdot m$
EMF	Volt	V	$kg \cdot m^2 / A \cdot s^3$	
Force	Newton	N	$kg \cdot m/s^2$	
Frequency	Hertz	Hz	s^{-1}	
Magnetic Field	Tesla	T	$kg / A \cdot s^2$	
Magnetic Flux	Weber	Wb	$\left(kg \cdot m^2\right)/\left(s^2 \cdot A\right)$	$T \cdot m^2$
Momentum, Impulse		$kg \cdot m/s$	$kg \cdot m/s$	$N \cdot s$
Potential Difference	Volt	V	$kg \cdot m^2 / A \cdot s^3$	W/A or J/C
Power	Watt	W	$kg \cdot m^2/s^3$	J/s
Velocity		m/s	m/s	

SI Prefixes
Unusually large or small measurements can be tedious to write out. For example, the mass of an electron is about 0.000 000 000 000 000 000 000 000 000 000 911 kg. In the metric system, we use two different methods to simplify the writing of such numbers.

First, we make use of scientific notation. The mass of an electron, for example, is more commonly written as $9.11 \times 10^{-31}\ kg$.

Second, we make use of metric prefixes. A prefix, when added to a unit, represents a power of 10 by which the measurement is multiplied.

Example 1
1 kilometer (note the prefix kilo-) is equivalent to:

$$1\ km = 1 \times 1000\ m$$
$$1\ km = 10^3\ m$$

The prefix kilo- represents 1000 or 10^3.

SI Prefixes			
Prefix	**Symbol**	**Power of 10**	**Example**
nano	*n*	10^{-9}	nanometer (*nm*)
micro	μ	10^{-6}	microgram (μg)
milli	*m*	10^{-3}	milligram (*mg*)
centi	*c*	10^{-2}	centimeter (*cm*)
deci	*d*	10^{-1}	deciliter (*dL*)
Base Unit	varies	10^0	meter (*m*)
kilo	*k*	10^3	kilometer (*km*)
mega	*M*	10^6	megagram (*Mg*)
giga	*G*	10^9	gigameter (*Gm*)

Example 2
250 micrograms is equivalent to:

Unit Conversions

It is often necessary to change from one set of units to another. For example, you may have to convert a given number of seconds into minutes, or a given number of centimeters into meters.

The procedure for converting units involves two steps.

1. Write a conversion factor.
2. Multiply the given set of units by the conversion factor to get the desired set of units.

Several examples of unit conversion will help illustrate this procedure.

Example 3
Convert 1.1 *cm* to meters.

Example 4
Convert 2.278×10^{11} *m* to kilometers.

Example 5
Convert 1 m/s to km/h.

Example 6
Convert 108 km/h to m/s.

Homework
Measurement Worksheet

Measurement Worksheet

1. Convert each of the following length measurements as directed.

   a. 1.1 *cm* to meters.
   b. 76.2 *nm* to millimeters.
   c. 2.1 *km* to meters.
   d. 2.278×10^{11} *m* to centimeters.

2. Convert each of the following measurements to meters.

   a. 42.3 *cm*
   b. 21 *km*
   c. 0.023 *mm*
   d. 214 μm
   e. 570 *nm*

3. Convert each of the following mass measurements to its equivalent in kilograms.

   a. 147 *g*
   b. 11 *Mg*
   c. 7.23 μg
   d. 478 *mg*

4. Rank the following mass measurements from smallest to largest: 11.6 *mg*, 1021 μg, 0.000006 *kg*, 0.31 *mg*.

5. Express each of the following measurements in terms of the basic SI unit. (e.g. 1.6 km = 1600 m)

   a. 0.56 *km*
   b. 75 *cm*
   c. 3224 *mm*
   d. 655 *mm*
   e. 961 μm
   f. 7564 *g*
   g. 252 *g*
   h. 52 μs
   i. 15 *years*

6. Convert each of the following velocities as directed.

   a. 25 *m/s* to *km/h*.
   b. 90 *km/h* to *m/s*.
   c. 75 *km/h* to *m/s*.
   d. 15 *m/s* to *km/h*.
   e. 225 *km/h* to *m/s*.

Measurement Worksheet Key

1. (a) 0.011 m (b) 76.2×10^{-6} mm (c) 2 100 m (d) 2.278×10^{13} cm

2. (a) 0.423 m (b) 21 000 m (c) 2.3×10^{-5} m (d) 2.14×10^{-4} m
   (e) 5.7×10^{-7} m

3. (a) 0.147 kg (b) 11 000 kg (c) 7.23×10^{-9} kg (d) 4.78×10^{-4} kg

4. 0.31 mg, 1021 μg , 0.000006 kg, 11.6 mg

5. (a) 560 m (b) 0.75 m (c) 3.224 m (d) 0.655 m
   (e) 9.61×10^{-4} m (f) 7.564 kg (g) 0.252 kg (h) 5.2×10^{-5} s
   (i) 4.7304×10^{8} s

6. (a) 90 km/h (b) 25 m/s (c) $20.8\overline{3}$ m/s (d) 54 km/h
   (e) 62.5 m/s