Measurement

International System of Units (SI)

- revised metric system proposed in 1960
- widely used in science
- 7 base units

SI Base Units

Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electrical current	Ampere	A
Temperature	Kelvin	K
Amount of Substance	Mole	mol
Luminous intensity	Candela	cd

SI Prefixes

Tera-	T	10^{12}	Deci-	d	10^{-1}
Giga-	G	10^{9}	Centi-	c	10^{-2}
Mega-	M	10^{6}	Milli-	m	10^{-3}
Kilo-	k	10^{3}	Micro-	μ	10^{-6}
			Nano-	n	10^{-9}
			Pico-	p	10^{-12}

Derived units in SI

measured in terms of one or more base units

volume

m x m x m = (m^3) = 1000 (dm^3)

$1 dm^3$ = 1 liter (L)

density

mass/volume = (kg/dm^3) = (g/cm^3) = (g/ml)

Density

The mass of a substance that occupies one unit of volume

$$\textbf{Density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{kg}}{\text{dm}^3} = \frac{\text{g}}{\text{cm}^3} = \frac{\text{g}}{\text{ml}}$$

Example

What is the density of a piece of concrete that has a mass of 8.76 g and a volume of 3.07 cm^3

$$\textbf{Density} = \frac{\textbf{mass}}{\textbf{volume}} = \frac{8.76\text{g}}{3.07\ \text{cm}^3} = 2.85\text{g/cm}^3$$

practice problem 1

A piece of metal with a mass of 147 g is placed ina graduated cylinder. The water level rises from 20 ml to 41 ml. what is the density of the metal.

41 ml - 20 ml = 21 ml

$$\textbf{Density} = \frac{\textbf{mass}}{\textbf{volume}} = \frac{\textbf{146 g}}{\textbf{21 ml}} = 6.95 \text{ g/ml}$$

practice problem 2

What is the volume of a sample that has a mass of 20 g and a density of 4 g/ml

$$\frac{20\ \cancel{g}}{} \times \frac{ml}{4\ \cancel{g}} = 5\ ml$$

Practice problem 3

A metal cube has a mass of 20 g and a volume of 5 cm^3. Is the cube made of pure aluminum?

$$\textbf{Density} = \frac{\text{mass}}{\text{volume}} = \frac{20\text{ g}}{5\text{ cm}^3} = 4\text{ g/ml}$$

density of Aluminum is 2.7 g/ml

Temperature

There are three systems for measuring temperature that are widely used:

Kelvin scale $K = C^\circ + 273.15$

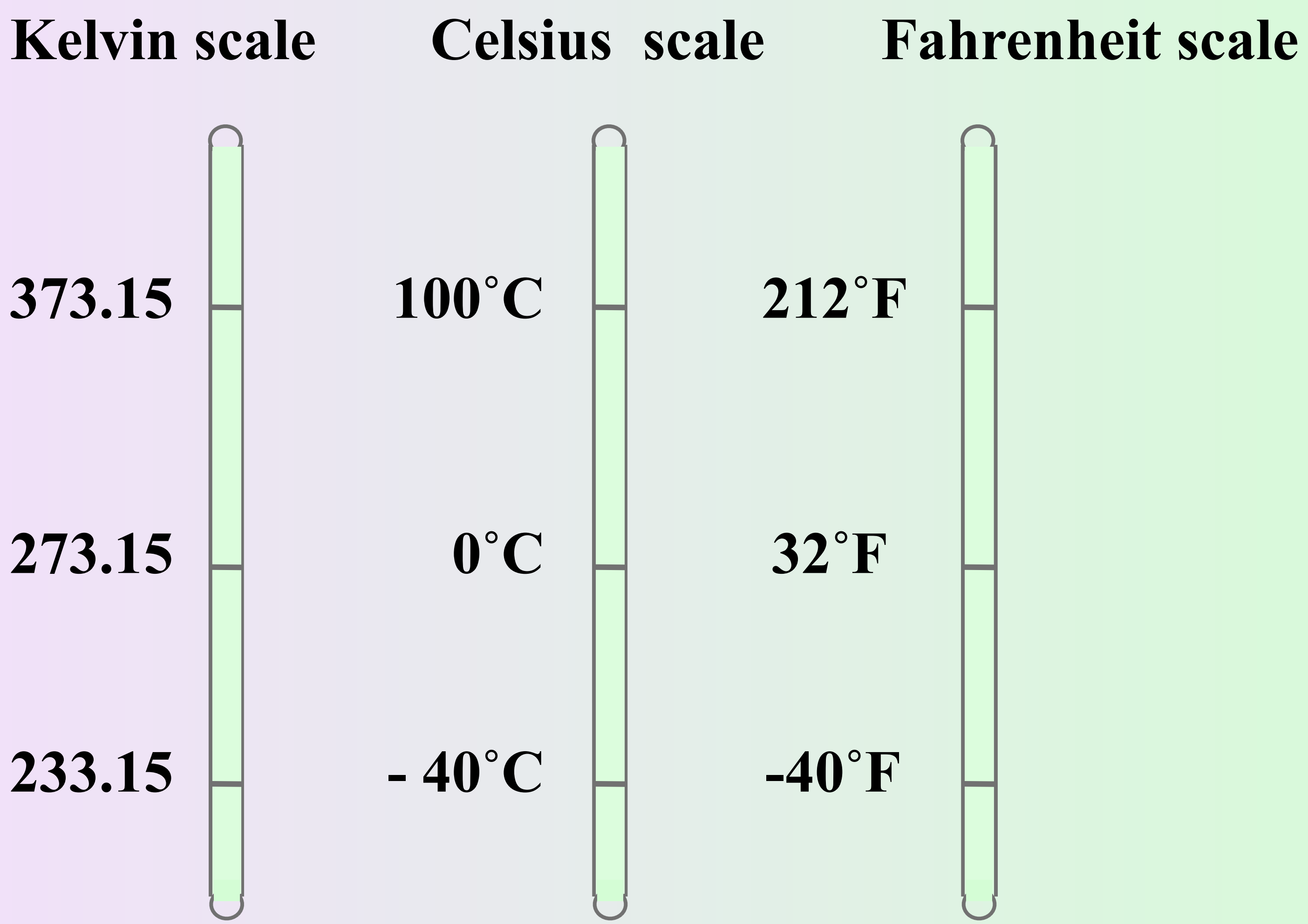
Celsius scale $C^\circ = K - 273.15$

Fahrenheit scale $F^\circ = C^\circ\,(9/5) + 32$

$C^\circ = (F^\circ - 32)\,5/9$

Used mainly in engineering

Temperature



Handling Numbers

In chemistry we deal with very large and very small numbers

Scientific Notation

is a way of dealing with numbers that are either extremely large or extremely small

$N \times 10^n$

where **N** is a number between 1 and 10 and **n** is an exponent that can be a positive or negative integer

Exponents

$$100 = 10 \times 10 = 10^2$$

$$0.1 = \frac{1}{10} = 10^{-1}$$

$$0.001 = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 10^{-3}$$

Example

Express 568.762 in scientific notation.

$568.762 = 5.68762 \times 10^2$

note that the decimal point moved to the left by two places and $n = 2$.

Example

Express 0.00000772 in scientific notation.

$0.00000772 = 7.72 \times 10^{-6}$

note that the decimal point moved to the right by six places and $n = -6$.

practice problem 12

Express the following quantities in scientific notation.

c. 4500000. m $= 4.5 \times 10^{6}$

d. 685000000000. m $= 6.85 \times 10^{11}$

practice problem 12

Express the following quantities in scientific notation.

e. 0.0054 kg = 5.4×10^{-3}

f. 0.00000687 kg = 6.87×10^{-6}

Scientific Notation

To add or subtract using scientific notation, first write each quantity with the same exponent n. Then add or subtract the N parts of the numbers; the exponent parts remain the same.

practice problem 14e

$$(1.26 \times 10^{4}\ \text{kg}) + (2.5 \times 10^{3}\ \text{kg})$$

$$= (1.26 \times 10^{4}\ \text{kg}) + (0.25 \times 10^{4}\ \text{kg})$$

$$= 1.51 \times 10^{4}\ \text{kg}$$

practice problem 14f

$$(7.06 \times 10^{-3}\ \text{kg}) + (1.2 \times 10^{-4}\ \text{kg})$$

$$= (7.06 \times 10^{-3}\ \text{kg}) + (0.12 \times 10^{-3}\ \text{kg})$$

$$= 7.18 \times 10^{-3}\ \text{kg}$$

Scientific Notation

To multiply numbers expressed in scientific notation, multiply the N parts of the numbers in the usual way, but add the exponent n's together.

practice problem 15a - 15b

$(4 \times 10^{2}\ \text{cm})\ (1 \times 10^{8}\ \text{cm})$

$= 4 \times 10^{10}\ \text{cm}^{2}$

$(2 \times 10^{-4}\ \text{cm})\ (3 \times 10^{-2}\ \text{cm})$

$= 6 \times 10^{-6}\ \text{cm}^{2}$

Scientific Notation

To divide numbers expressed in scientific notation, divide the N parts of the numbers in the usual way, but subtract the exponent n's together.

practice problem 16a - 16c

6×10^{2} g / 1×10^{8} cm^{3}

= 3×10^{1} g/cm^{3}

9×10^{5} g / 3×10^{-1} cm^{3}

= 3×10^{6} g/cm^{3}

The Unit-Factor Method of Solving Problems

also called "dimensional analysis"

it is a good idea to carry units in a calculation to ensure that the answer to the problem has the correct units

The Unit-Factor Method

$$\frac{2.54\text{cm}}{2.54\text{cm}} = \frac{1\text{ in}}{2.54\text{cm}}$$

dividing both sides of the equation by 2.54cm

$$1 = \frac{1\text{ in}}{2.54\text{cm}}$$

we create an expression called a unit-factor

$$1 = \frac{2.54\text{cm}}{1\text{ in}}$$

also called a conversion factor

Example

What is the length of a 2.85cm pin in inches?

$$2.85\ \cancel{cm} \times \frac{1\,in}{2.54\,\cancel{cm}} = 1.12\ in$$

practice problem 17a

convert 360 s to ms

$$360\ \cancel{s} \times \frac{1000\ \text{ms}}{1\ \cancel{s}} = 3.6 \times 10^5\ \text{ms}$$

practice problem 17b

convert 4800 g to kg

$$4800\cancel{g} \times \frac{1\ kg}{1000\cancel{g}} = 4.8\ kg$$

Example 2 - 4

what is a speed of 550 meters per second in kilometers per minute

$$\frac{550\ \text{m}}{1\ \text{s}} \times \frac{1\ \text{km}}{1000\ \text{m}} \times \frac{60\ \text{s}}{1\ \text{min}}$$

$$= \frac{33\ \text{km}}{1\ \text{min}}$$

practice problem 19

How many seconds are there in 24 hours ?

$$24\ \cancel{hr} \times \frac{60\ \cancel{min}}{1\ \cancel{hr}} \times \frac{60\ s}{1\ \cancel{min}} = \mathbf{8.64 \times 10^4\ s}$$

practice problem 20

the density of gold is 19.3 g/mL.What is the gold's density in decigrams per liter ?

$$\frac{19.3\ \text{g}}{1\ \text{mL}} \times \frac{0.1\ \text{dg}}{1\ \text{g}} \times \frac{1000\ \text{mL}}{1\ \text{L}}$$

$$= \frac{1930\ \text{dg}}{1\ \text{L}}$$

Example

Where were you a billion seconds ago ?

$$1\times10^9\ \text{sec} \times \frac{1\ \text{min}}{60\ \text{sec}} \times \frac{1\ \text{hour}}{60\ \text{min}} \times \frac{1\ \text{day}}{24\ \text{hours}}$$

$$\times \frac{1\ \text{year}}{365\ \text{days}} = \mathbf{31.7\ years}$$