Chapter 2: Measurement and Problem Solving

Scientific Notation

- Large and small numbers can be difficult to use. For example:

The mass of one iron atom is:

0.0000000000000000000000911 g

The number of water molecules in one cup is:

7,910,000,000,000,000 000,000,000 molecules

Scientific notation is a system in which an ordinary decimal number is expressed as a product of a number between 1 and 9 multiplied by 10 raised to a power.

In scientific notation:

Mass of an iron atom = 9.11×10^{-23} g

# of water molecules in one cup = 7.91×10^{24} molecules

Writing numbers in scientific notation

$7070 = 7.07 \times 10^3$

Must be between 1 and 9

$0.0004601 = 4.601 \times 10^{-4}$

Express the following numbers in scientific notation:

a) 16,020,000 mg b) 0.00001206 m c) 24 km

Express the following numbers in decimal notation:

a) 4.38×10^4 b) 8.770×10^{-15} c) 6.23×10^8

Significant figures

- A method for handling uncertainty in measurement

Exact and Measured Numbers

- Two kinds of numbers are associated with physical quantities:

Exact numbers
and
Measured numbers

Exact numbers - we know the exact value
- no approximation involved

Measured numbers - we can never know the exact value

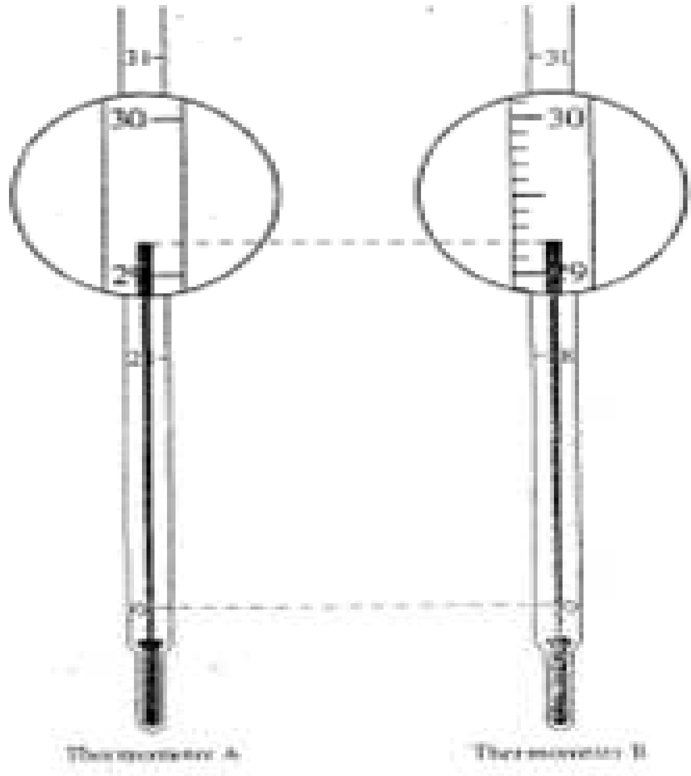
Exact number examples:

1 dozen eggs = 12 eggs exactly

A square has 4 sides (not 3.7 or 4.1)

- **All** measured numbers carry with them a degree of uncertainty. The degree of uncertainty depends on the measuring device used.

Precision



→ Thermometer A marked off in 1 degree increments - can estimate temp as

29.2°C or 29.3°C

→ Thermometer B divided into 0.1 degree increments - the temp can be estimated as

29.18°C or 29.19°C

(Thermometer B is more precise)

Significant Figures are the digits in any measurement that are known with certainty plus <u>one</u> digit that is uncertain.

Guidelines for Determining the Number of Significant Figures

1. All nonzero digits are significant

   45.1

   49

   1.279

2. Confined zeros (or zeros between nonzero digits) **ALWAYS** count as significant

   2.075

   70.7

   940005.008

3. Trailing zeros are significant **<u>if</u>** there is a decimal point in the number

   62.00

   78.00012000

   0.02000

4. Leading zeros (zeros to the left of the first nonzero number) are NOT significant. These zeros merely "place" the decimal point.

   0.0145

   0.00034

   0.000002279

5. In cases where there is no decimal point, assume trailing zeros are NOT significant. (These types of numbers should be avoidedby using scientific notation).

93,000,000
60
4000
6310

How many significant figures are in the following numbers?

426	0.0126
406.00	0.0100
4600	1.01001
515.0	0.01001
20	4.008
200	40.008
200.00	100.2900
907,000,000	0.0000003007
6.022×10^{23}	4.680×10^{-5}

Calculations with Significant Figures

Rounding off is the process of deleting insignificant digits from a calculated number.

→ If the digit to be dropped is less than 5, that digit and all digits that follow it are simply dropped

62.314 rounded to 3 sf becomes 62.3

504.902 rounded to 4 sf becomes _______

9,017.000427 rounded to 8 sf = __________

→ If the digit to be dropped is 5 or greater, the last retained digit is increased by **one**

62.782 rounded to 2 sf becomes 63

726.679 rounded to 5 sf becomes _______

4.056639 x 10^{17} rounded to 4 sf = __________

Calculated quantities cannot be any more precise than the least precise piece of information that goes into the calculations

- Multiplying and Dividing: There can be no more total sig. figs. in the answer than there are in the quantity having the fewest sig. figs.

- Adding and Subtracting: There can be ***no more decimal places*** in the **answer** than in the quantity with the least number of decimal places.

65.6 x 0.0024 =

$\dfrac{983.24\ g}{1270\ cm^3} =$

46.014 g
- 27.8 g

1.578 cm
+ 1.4762 cm
1.52 cm

Calculations involving multiplication/division and addition/subtraction:

(1.023 x 0.895)+ 0.16 =

(4.1792 - 4.024) x 57.884 =

Metric and SI Units

- The metric system is much easier to use than English system. There are fewer units to learn and it is much easier to interconvert in the metric system

- System used for scientific measurements (based on metric system) is called the SI System (System International). The SI System is used throughout the world.

TABLE 2.1 Important SI Standard Units

Quantity	Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
temperature*	kelvin	K

TABLE 2.2 SI Prefix Multipliers

Prefix	Symbol	Multiplier	
tera-	T	1,000,000,000,000	(10^{12})
giga-	G	1,000,000,000	(10^{9})
mega-	M	1,000,000	(10^{6})
kilo-	k	1,000	(10^{3})
deci-	d	0.1	(10^{-1})
centi-	c	0.01	(10^{-2})
milli-	m	0.001	(10^{-3})
micro-	μ	0.000001	(10^{-6})
nano-	n	0.000000001	(10^{-9})
pico-	p	0.000000000001	(10^{-12})
femto-	f	0.000000000000001	(10^{-15})

Ex: kilo means a thousand so:

1 kilometer = 1000 meters
1 kilogram = 1000 grams
1 kiloliter = 1000 liters

5.62 Gm (gigameters) = 5.62×10^9 meters
(5620000000 meters)

12.5 ml (milliliters) = 12.5×10^{-3} liters
(1.25×10^{-2} liters in scientific notation)

5 μs (microseconds) = 5×10^{-6} seconds
(0.000005 seconds)

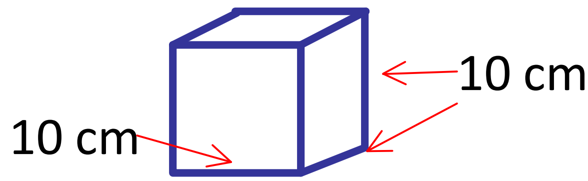
3.9 ng (nanograms) = ________________g

Units of Volume

Volume is a measure of the amount of space occupied by on object. Volume is 3-dimensional so the units are ft^3, cm^3, in^3... etc.

Liter is also a volume unit

A liter is the basic unit of measurement in the metric system. A liter is a volume equal to a perfect cube that is 10 cm on each side.



1 L = 10 cm x 10 cm x 10 cm

= 1000 cm^3

(symbol for Liter is capital "L")

Converting from One Unit to Another

We often need to convert from one unit to another: inches → feet

lbs → kg

miles → km

To do this, use Conversion Factors!

- Conversion factors are derived from equal quantities of two different units

Ex. 1 foot = 12 inches conversion factors:

$$\frac{1 \text{ foot}}{12 \text{ inches}} \quad \text{or} \quad \frac{12 \text{ inches}}{1 \text{ foot}}$$

How many inches are in 2.30 feet?

$$?? \text{ inches} = 2.30\ \cancel{\text{ft}} \times \frac{12 \text{ in}}{1\ \cancel{\text{ft}}}$$

(choose conversion factor that allows cancellation of unwanted unit)

= 27.6 inches

Metric-to-Metric Conversion Factors

You will need to know the metric conversions in Table 2.2 that are enclosed in the box.

Ex. 0.01 meters = 1 cm or 100 cm = 1 meter

Conversion factors:

$$\frac{0.01 \text{ m}}{1 \text{ cm}} \text{ or } \frac{1 \text{ cm}}{0.01 \text{ m}} \qquad \frac{100 \text{ cm}}{1 \text{ m}} \text{ or } \frac{1 \text{ m}}{100 \text{ cm}}$$

English-to-English and Metric-to -English conversion factors will be provided on the Constants and Conversion Sheet.

- How many meters are in 9.87×10^{-3} km?

- How many inches are in 0.13 miles?

- A trip takes 2.5 days. How many seconds did the trip take?

- A certain species of snail can travel 14.0 feet in 1.00 day. How many kilometers can the snail travel in 1.00 year?

- The tallest person in the NBA is7 ft 7 in. what is his height in cm and m?

- How many cans of Diet Coke would you have to drink to consume 1.00 gallon?
  (1 can Diet Coke = 12.0 fluid ounces)

- To get a daily dose of the antibiotic tetracycline a patient needs 25.0 mg per kg of body weight. How many mg of tetracycline should a 154 lb patient take daily?

- A car travels at 50.0 miles per hour. How fast is this in meters per second?

- A bedroom has a volume of 135 m^3. What is this volume in km^3?

Density

- Density is the ratio of the mass of an object to the volume occupied by that object

$$Density = \frac{mass}{volume}$$

Most frequently encountered units are:

Solids	g/cm^3
Liquids	g/mL
Gases	g/L

Rounded to 2 sig. figs
the density of water
at room temp = 1.0 g/mL

(You need to know this)

- A solid 75.0 cm^3 block of table salt has a mass of 163 g. What is its density?

- The density of solid gold is 19.3 g/cm^3

  (19.3 g = 1 cm^3 of gold)

  Density can be used as a conversion factor:

  $$\frac{19.3\ g}{1\ cm^3} \quad \text{or} \quad \frac{1\ cm^3}{19.3\ g}$$

- What is the mass of 25.6 cm^3 of gold?

- What is the volume(in cm^3) of 342 g of gold?

- The density of ethyl alcohol is 0.790 g/mL. What is the mass of 875 mL of ethyl alcohol?