MEASUREMENTS / SI (METRIC) UNITS

- **Measurements** are made by scientists to determine size, length and other **properties** of matter.

- For measurements to be useful, a measurement **standard** must be used.

- A **standard** is an exact quantity that people agree to use for **comparison**.

- **SI (Metric)** system is the **standard** system of measurement used **worldwide** by scientists.

SI BASE UNITS:
- There are 7 base SI units. Five of these are of importance in the study of chemistry.

Quantity Measured	Metric Units	Symbol	English Units
Length	Meter	m	yd
Mass	Kilogram	kg	lb
Time	Seconds	s	s
Temperature	Kelvin	K	°F
Amount of substance	Mole	mol	mol

DERIVED UNITS:
- In addition to the **fundamental** units above, several useful **derived** units are commonly used in SI system.
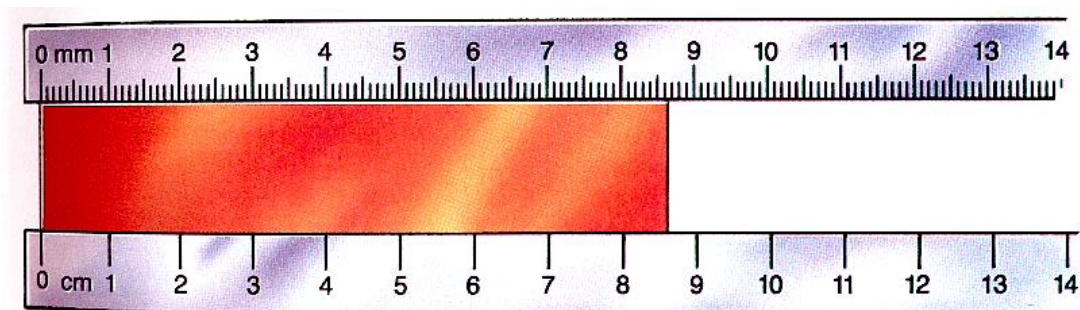
Quantity Measured	Units	Symbol
Volume	Liter	L
Density	grams/cc	g/cm^3

ERROR IN MEASUREMENTS

Two kinds of numbers are used in science:

- **Counted or Defined**: exact numbers; **no uncertainty**

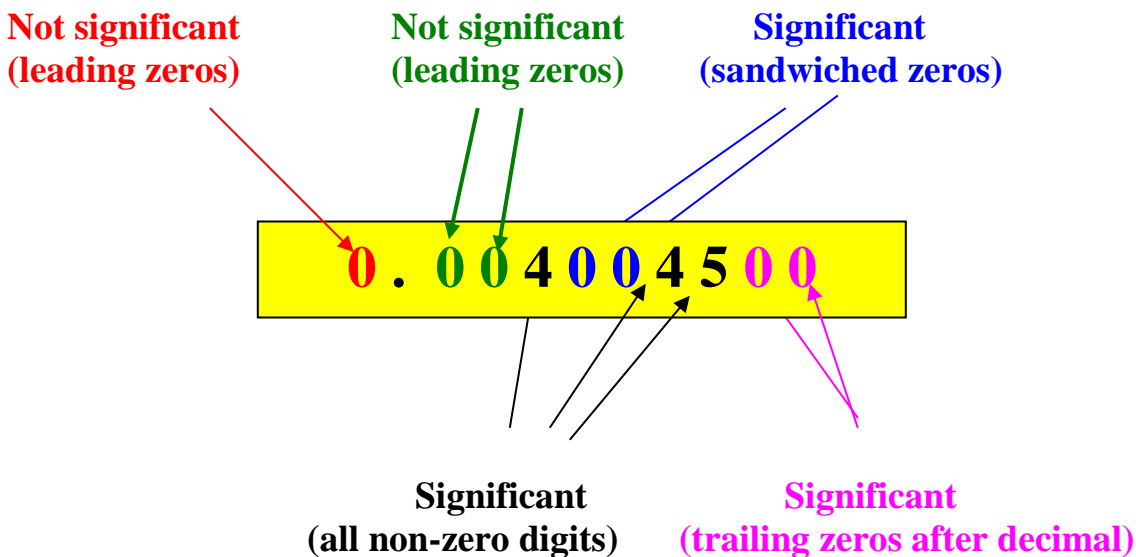- **Measured**: are subject to error; have **uncertainty**

8.6<u>5</u> cm

8.<u>6</u> cm

- Every measurement has **uncertainty** because of instrument limitations and human error.

- The **last** digit is the **estimated** one.

- **Significant numbers** are the **certain** and **uncertain** digits.

SIGNIFICANT FIGURE RULES

Not significant
(leading zeros)

Not significant
(leading zeros)

Significant
(sandwiched zeros)

$$0 . 0 0 4 0 0 4 5 0 0$$

Significant
(all non-zero digits)

Significant
(trailing zeros after decimal)

Examples:
Determine the number of significant figures in each of the following measurements:

461 cm   93.500 g

1025 g   0.006 m

0.705 mL   5500 km

Rounding Off Rules

- If the rounded digit is **<5**, the digit is simply dropped.
- If the rounded digit is **≥5**, the digit is increased.

Examples:

	3 sig. figs	2 sig. figs.
8.4234 rounds off to	8.42	8.4
14.780 rounds off to	14.8	15
3256 rounds off to	3260 (3.26×10^3)	3300 (3.3×10^3)

3

SIGNIFICANT FIGURES AND CALCULATIONS

- The results of a calculation cannot be more precies than the least precise measurement.

- For **multiplication and division,** the **answer** must contain the **same number of significant figures** as there are in the measurement with the **fewest significant figures**.

$$\mathbf{9.2} \ \text{x} \ 6.80 \ \text{x} \ 0.3744 \ = \mathbf{23}.4225 \ (\text{calculator answer})$$

$$= \mathbf{23} \qquad (\text{rounded answer})$$

- For **addition and subtraction**, the **answer** must have the **same number of decimal places** as there are in the measurement with the **fewest decimal places**.

$$
\begin{array}{r}
83.\mathbf{5} \\
+ \ \underline{23.28} \\
106.\mathbf{7}8 \ \ (\text{calculator answer})
\end{array}
$$

106.**8**   (rounded answer)

Examples:

1) $5.008 + 16.2 + 13.48 =$

2) $\dfrac{3.15 \ \text{x} \ 1.53}{0.78} =$

3) $104.45 \ \text{mL} - 0.838 \ \text{mL} \ + \ 46 \ \text{mL} \ =$
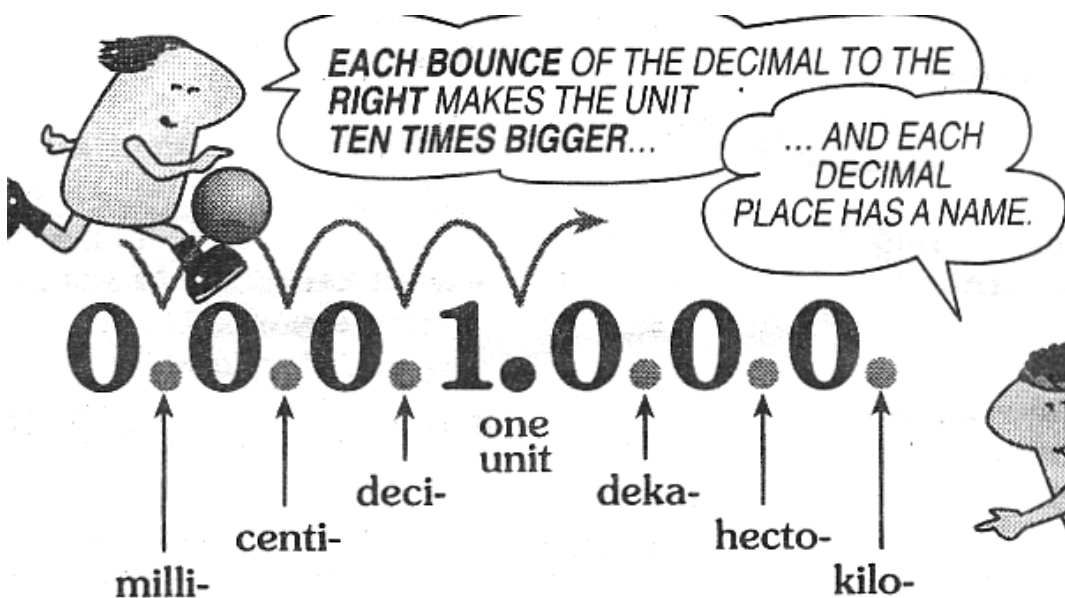
4) $\dfrac{4.0 \ \text{x} \ 8.00}{16} =$

SI PREFIXES

- The **SI** system of units is easy to use because it is based on **multiples of ten**.

- Common **prefixes** are used with the base units to indicate the multiple of ten that the unit represents.

SI PREFIXES

Prefixes	Symbol	Multiplying factor	
mega-	M	1,000,000	10^6
kilo-	k	1000	10^3
centi-	c	0.01	10^{-2}
milli-	m	0.001	10^{-3}
micro-	μ	0.000,001	10^{-6}

CONVERSION FACTORS

- Many problems in chemistry and related fields require a change of units.

- Any unit can be converted into another by use of the appropriate **conversion factor**.

- Any equality in units can be written in the form of a fraction called a **conversion factor**. For example:

Equality: 1 m = 100 cm

Conversion factors: $\dfrac{1\ m}{100\ cm}$ or $\dfrac{100\ cm}{1\ m}$ **Metric-Metric**
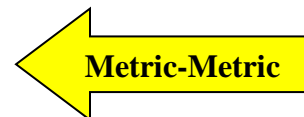
Equality: 1 kg = 2.20 lb

Conversion factors: $\dfrac{1\ kg}{2.20\ lb}$ or $\dfrac{2.20\ lb}{1\ kg}$ **Metric-English**

- Sometimes a conversion factor is given as a percentage. For example:

Percent quantity: 18% body fat by mass

Conversion factors: $\dfrac{18\ kg\ body\ fat}{100\ kg\ body\ mass}$ or $\dfrac{100\ kg\ body\ mass}{18\ kg\ body\ fat}$ **Percentage**
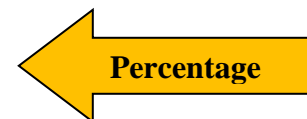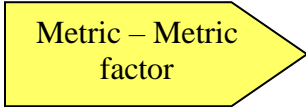
CONVERSION OF UNITS

- Problems involving conversion of units and other chemistry problems can be solved using the following step-wise method:

    1. Determine the intial unit given and the final unit needed.
    2. Plan a sequence of steps to convert the initial unit to the final unit.
    3. Write the conversion factor for each units change in your plan.
    4. Set up the problem by arranging cancelling units in the numerator and denominator of the steps involved.

$$\text{beginning unit} \times \frac{\textbf{final unit}}{\text{beginning unit}} = \textbf{final unit}$$

$\uparrow$

conversion factor

Examples:
1. How many mg are equivalent to 2.5 µg?

    Step 1:   Given   2.5 µg   Need   mg

    Step 2:   µg | Metric – Metric factor | mg

    Step 3: $\dfrac{10^3 \ \mu g}{1 \ mg}$ or $\dfrac{1 \ mg}{10^3 \ \mu g}$

    Step 4:
    $$2.5 \ \mu g \times \frac{1 \ mg}{10^3 \ \mu g} = 2.5 \times 10^{-3} mg$$

2. A doctor orders 0.50 g of Chloromyedin to be given to a patient. Chloromedin comes in 250 mg tablets. How many tablets should be given to this patient?

    Step 1:   Given   Need

    Step 2 & 3:

    Step 4:

3. The order is to give a patient 250 mg Keflin. The bottle's direction is to add 9.5 mL of sterile water to the vial to yield 0.50 g/mL. How many mL should be given to the patient to fill this order?

    Step 1:   Given 250 mg   Need mL

4. An order is given to infuse 250 mL of IV solution in 100 minutes. If the IV tubing delivers at a rate of 15 drops/mL, what should be the flow rate of the IV in drops/min?

5. The dosage for Mannitol is 2g/kg, and it is available in 30% (m/v) solution. How many mL of this solution should be given to a patient weighing 137 lb? (1 kg = 2.2 lb)

VOLUME & DENSITY

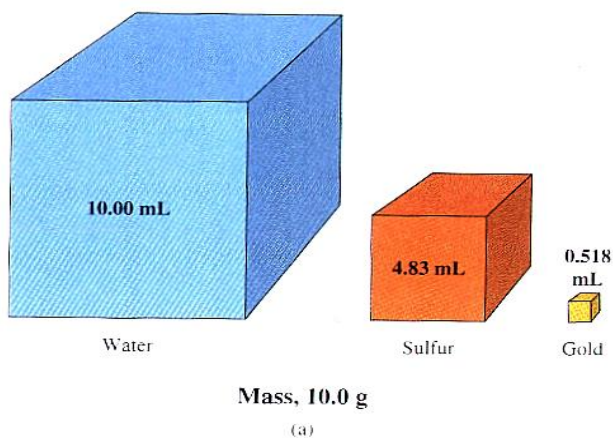- **Volume** is the amount of **space** an object occupies. Common units are **cm³** or **liter** (L) and **milliliter** (mL).

$$1 \text{ L} = 1000 \text{ mL} \qquad\qquad 1 \text{ mL} = 1 \text{ cm}^3$$
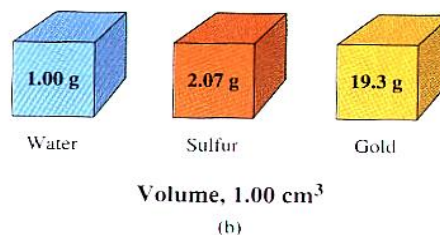
- **Density** is **mass per unit volume** of a material. Common units are **g/cm³** or **g/mL**.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \qquad d = \frac{m}{v}$$

- Density **is** <u>directly</u> related to mass **of an object, and** <u>indirectly</u> related to the volume **of an object.**

Comparison of the *volume* of equal masses of 3 materials with different *densities*

Comparison of the *masses* of equal volumes of 3 materials with different *densities*

VOLUME & DENSITY

Examples:

1. A copper sample has a mass of 44.65 g and a volume of 5.0 cm^3. What is the density of copper?

    m = 44.65 g $d = \dfrac{m}{v} =$

    v = 5.0 mL

    d = ???

2. A silver bar with a volume of 28.0 cm^3 has a mass of 294 g. What is the density of this bar?

    m =
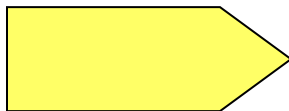
    v =

    d =

3. If the density of gold is 19.3 g/cm^3, how many grams does a 5.00 cm^3 nugget weigh?

    Step 1:   Given   Need

4. If the density of milk is 1.04 g/mL, what is the mass of 0.50 qt of milk? (1L = 1.06 qt)

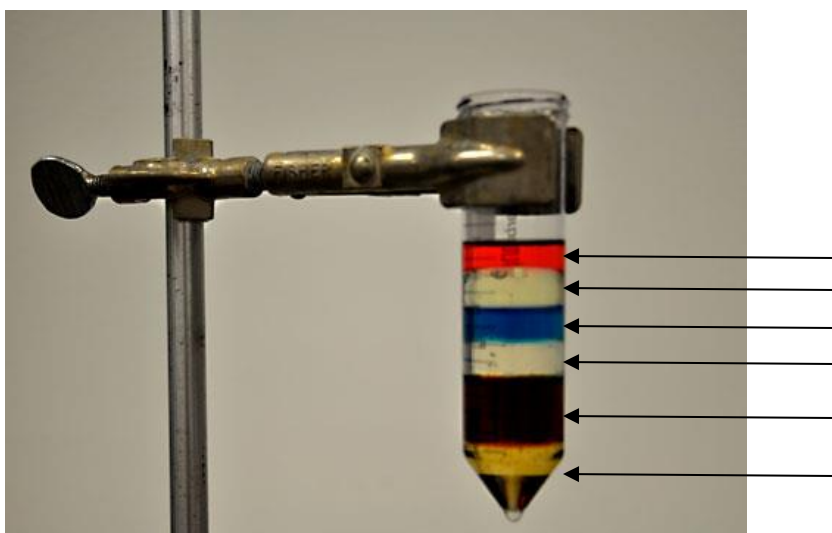   Step 1:   Given   Need

   Step 2:

   Step 3:

   Step 4:
                          x ─────────── =

5. What volume of mercury has a mass of 60.0 g if its density is 13.6 g/ml?

DENSITY & FLOATING

- Objects float in liquids when their density is lower relative to the density of the liquid.

- The density column shown below was prepared by layering liquids of various densitites.

- The greater the density of the liquid, the lower it layers itself.