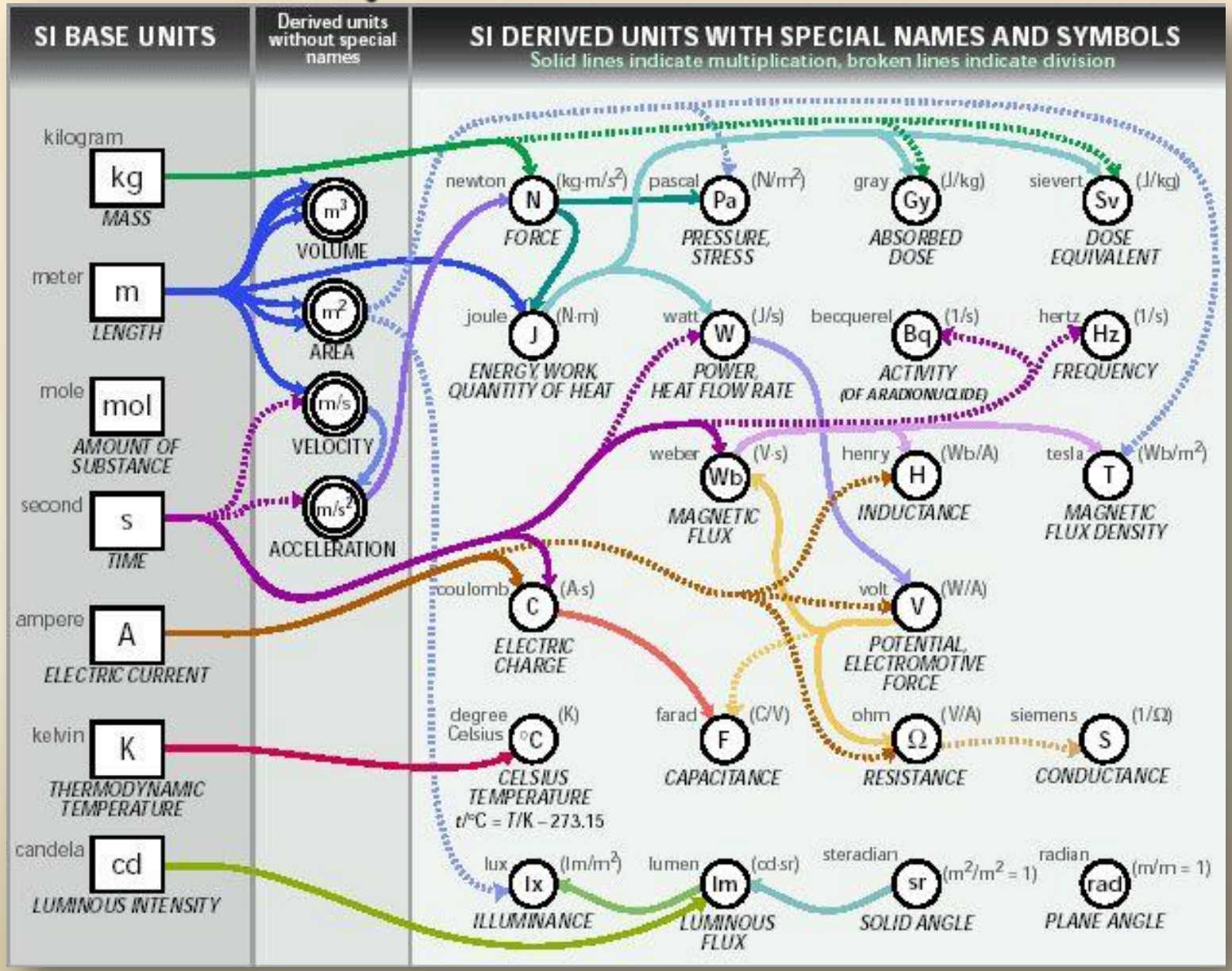
The SI System of Measurement



Objectives

- ✓ Use appropriate Metric/SI units of measurement
- ✓ Use common SI prefixes
- ✓ Convert within a unit
- ✓ Understand and use common derived SI units
- ✓ Convert between English and Metric Units.

The Nature of Measurement

A Measurement is a quantitative observation consisting of TWO parts

Part 1 - number
Part 2 - scale (unit)

Examples:

20 grams
6.63×10^{-34} Joule·seconds

The Fundamental SI Units
(le Système International, SI)

Physical Quantity	Name	Abbreviation
Mass	kilogram	kg
Length	meter	m
Time	second	s
Temperature	Kelvin	K
Electric Current	Ampere	A
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

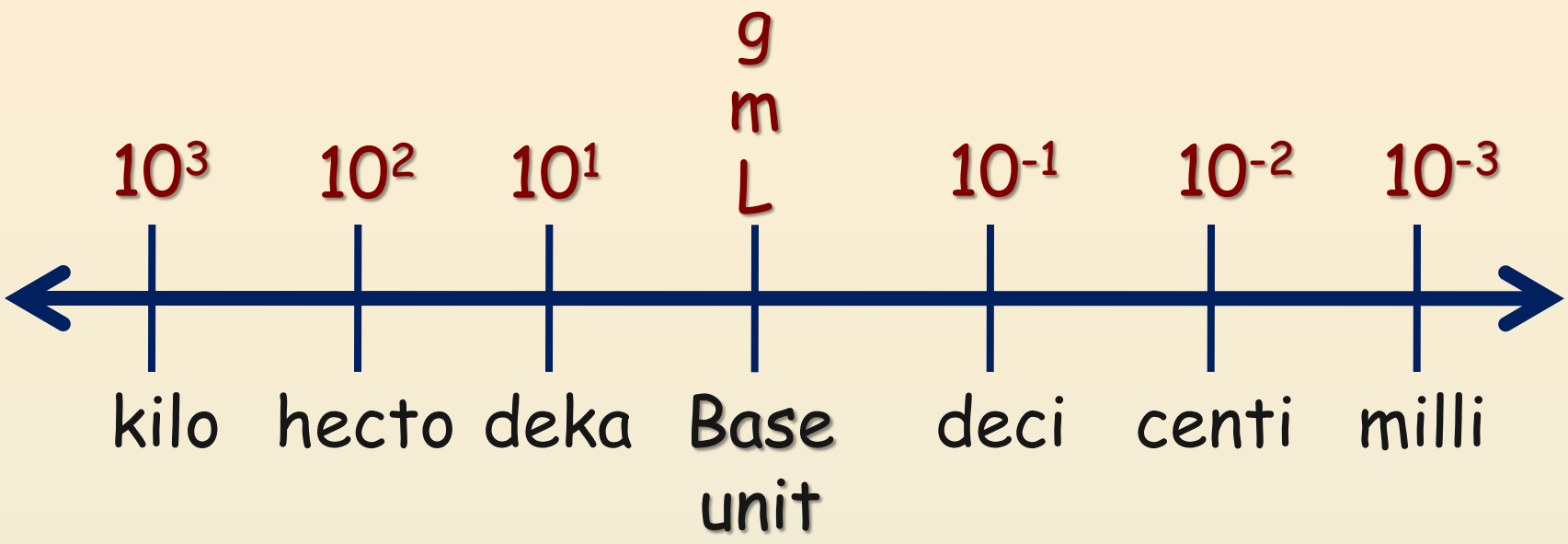
SI Prefixes Common to Chemistry

Prefix	Unit Abbr.	Exponent
Kilo	k	10^{3}
Deci	d	10^{-1}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	μ	10^{-6}

Common Metric Prefixes

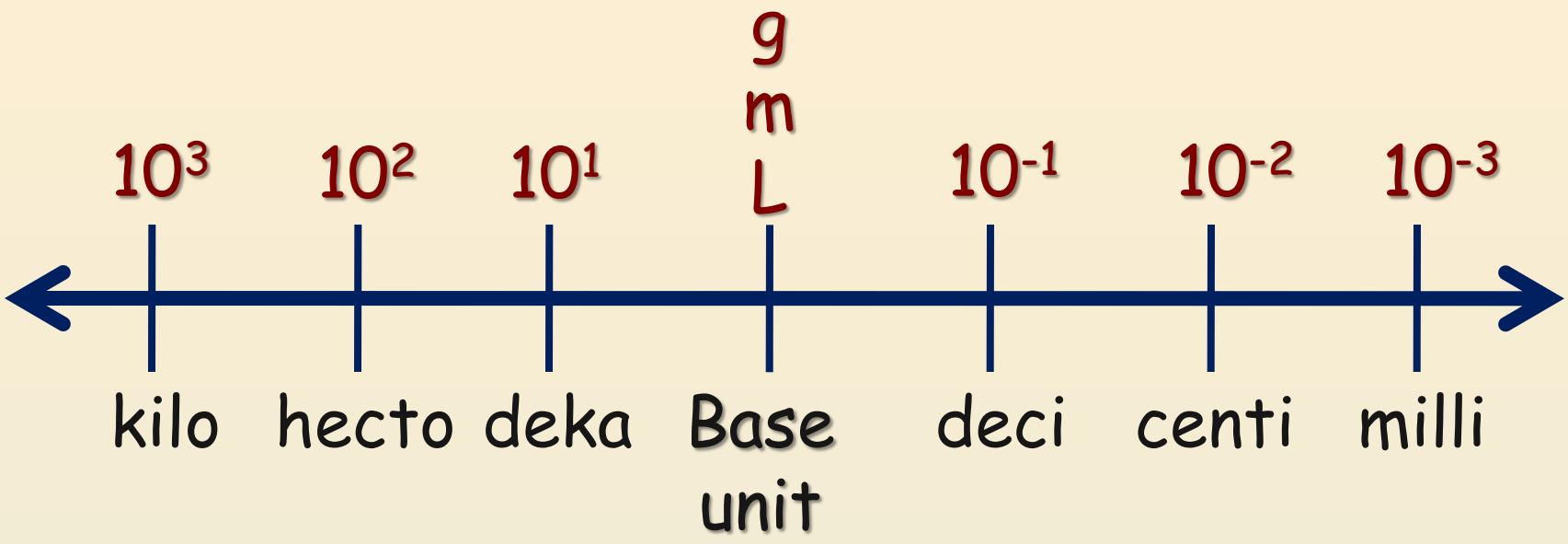
Kilo	Hecto	Deca	Liter Meter Gram	deci	centi	milli
1,000	100	10	1	0.1	0.01	0.001
10^3	10^2	10^1		10^{-1}	10^{-2}	10^{-3}
King	Hersey's	Daughter	Likes, Makes, Gulps	Delicious	Chocolate	Milk

Metric Conversions



Conversions in the metric system are merely a matter of moving a decimal point. The "base unit" means the you have a quantity (grams, meters, Liters, etc without a prefix.

Metric Conversions



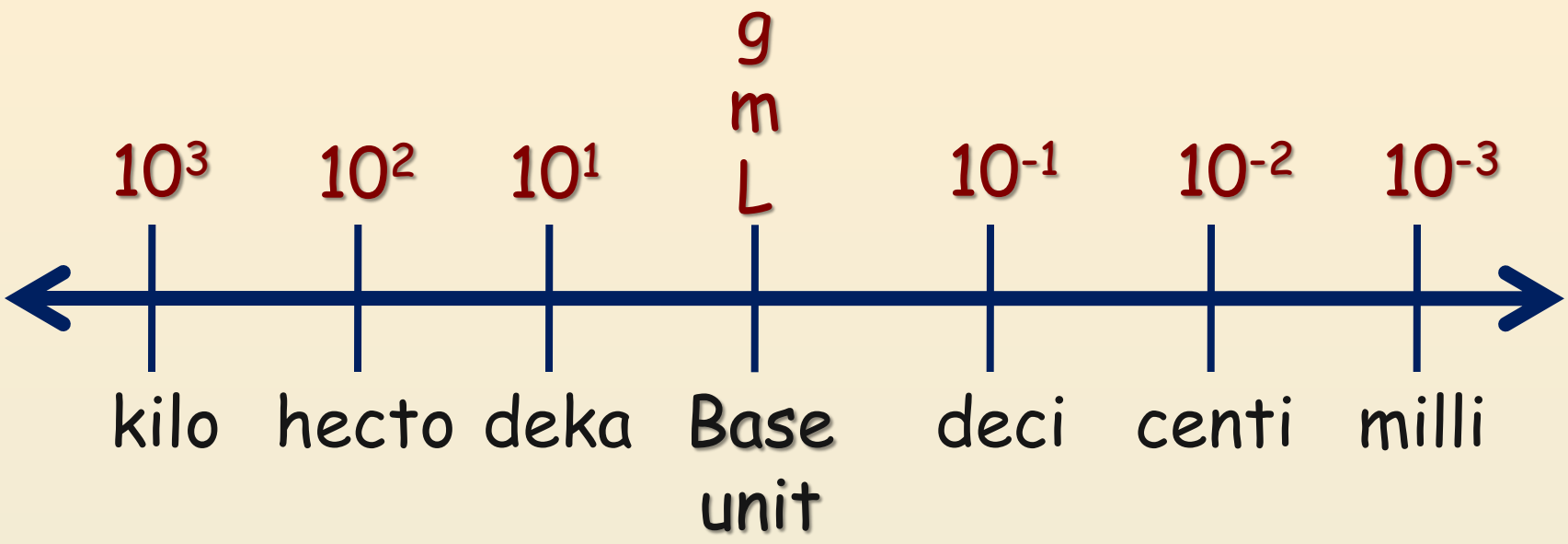
1 2 3

18 L → → →

18 liters = 18 000 milliliters

Example #1: Convert 18 liters to milliliters

Metric Conversions

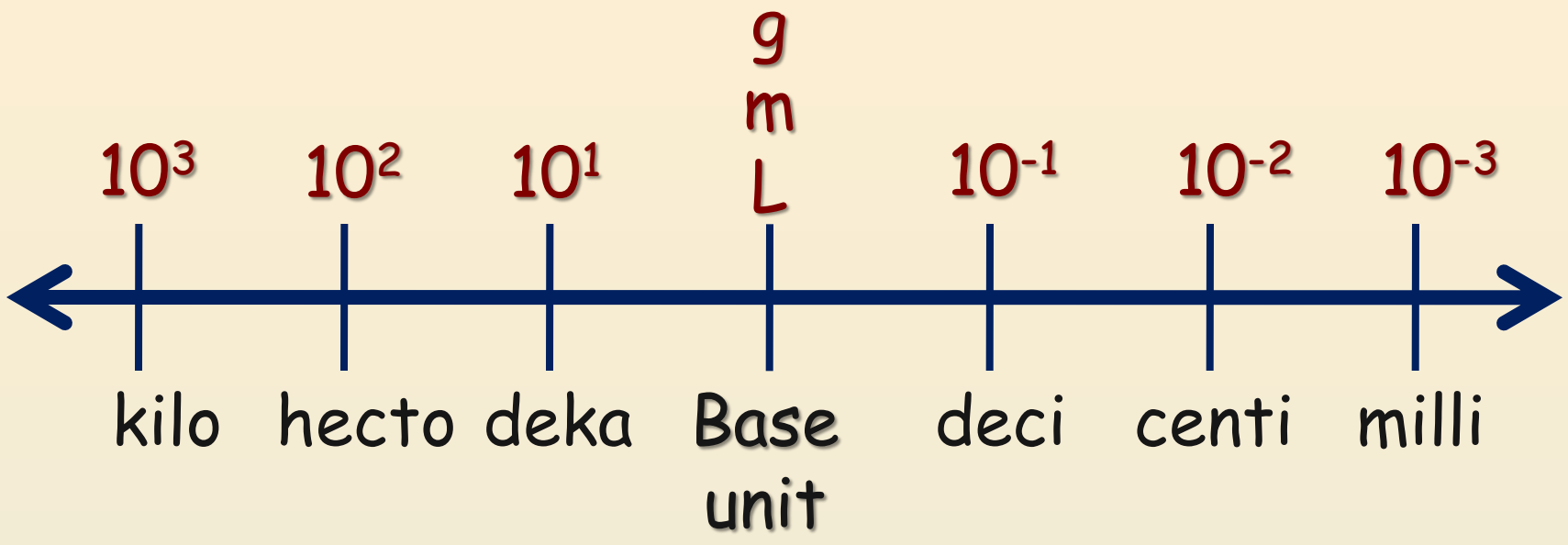


3 2 1

450 mg = 0.450 g ← ← ← 450 mg

Example #2: Convert 450 milligrams to grams

Metric Conversions



20 kg = 20 000 000 mg

Example #3: Convert 20 kilograms to milligrams

Metric Conversion Practice

In practice a conversion factor is used to convert between units.
Example We know that 1dollar = 4 quarters

How many quarters in 20 dollars?

$$20\ \cancel{\text{dollars}} \times \frac{4\ \text{quarters}}{1\ \cancel{\text{dollar}}} = 80\ \text{quarters}$$

$$\text{Number} \cdot (\text{old } \cancel{\text{unit}}) \times \left[\frac{\text{new unit}}{\text{old } \cancel{\text{unit}}}\right] = \text{New number} \cdot (\text{new unit})$$

Conversion factor

Problem #1

Convert 400 mL to Liters

$$\frac{400\ \text{mL}}{1\ \text{L}} \Big| \frac{1\ \text{L}}{1\ 000\ \text{mL}} = .400\ \text{L}$$

$$= 0.4\ \text{L}$$

$$= 4 \times 10^{-1}\ \text{L}$$

Problem #2

Convert 10 meters to mm

$$\frac{10\ \text{m}}{1}\left|\frac{1\ 000\ \text{mm}}{1\ \text{m}}\right. = 10\ 000\ \text{mm}$$

$$= 1\times10^{4}\ \text{mm}$$

Problem #3

Convert 73 grams to kg

$$\frac{73\ g}{1\ 000\ g} \times \frac{1\ kg}{} = 0.073\ kg$$

$$= 7.3 \times 10^{-2}\ kg$$

Problem #4

Convert 0.02 kilometers to m

$$\frac{0.02\ \text{km} \mid 1\ 000\ \text{m}}{\qquad\quad \mid 1\ \text{km}} = 20\ \text{m}$$

$$= 2 \times 10^{1}\ \text{m}$$

Problem #5

Convert 20 centimeters to m

$$\frac{20\ \text{cm}}{}\left|\frac{1\ \text{m}}{100\ \text{cm}}\right. = 0.20\ \text{m}$$

$$= 2\times10^{-1}\ \text{m}$$

Problem #6

Convert 10 kilograms to grams

$$\frac{10\ \text{kg} \mid 1\ 000\ \text{g}}{\qquad\quad 1\ \text{kg}} = 10\ 000\ \text{g}$$

$$= 1 \times 10^{4}\ \text{g}$$

Derived SI Units

Quantity	Quantity Symbol	Unit abbreviation	Derivation
Area	A	m^2	length x width
Volume	V	m^3	length x width x height
Density	D	kg/m^3	$\frac{\text{mass}}{\text{volume}}$
Molar Mass	M	kg/mol	$\frac{\text{mass}}{\text{amount of substance}}$
Concentration	c	M	$\frac{\text{amount of substance}}{\text{volume}}$
Energy	E	J	force x length

Derived Units

- Volume: is the space occupied by an object. The derived unit is the m^3 cubic meter, which is equal to the volume of a cube whose edges are 1meter long. This is too large so they use the cm^3 in most calculations.

- 1 cm^3 is equal to 1mL which how most chemists refer to volumes of gases and liquids.

Derived Units

- Density: is the ratio of mass to volume.
- *So is a measure of how much mass something has compared to it's size and is an important physical property that can often be used to identify a substance.*

Solids	Density (g/cm^3)	Liquids	Density (g/mL)
Cork	0.24	Gasoline	0.67
Ice	0.92	Kerosene	0.82
Copper	8.92	Water	0.998
Lead	11.35	Mercury	13.6

What can you conclude about the density of rubber, glycerol, oil, paraffin and cork?

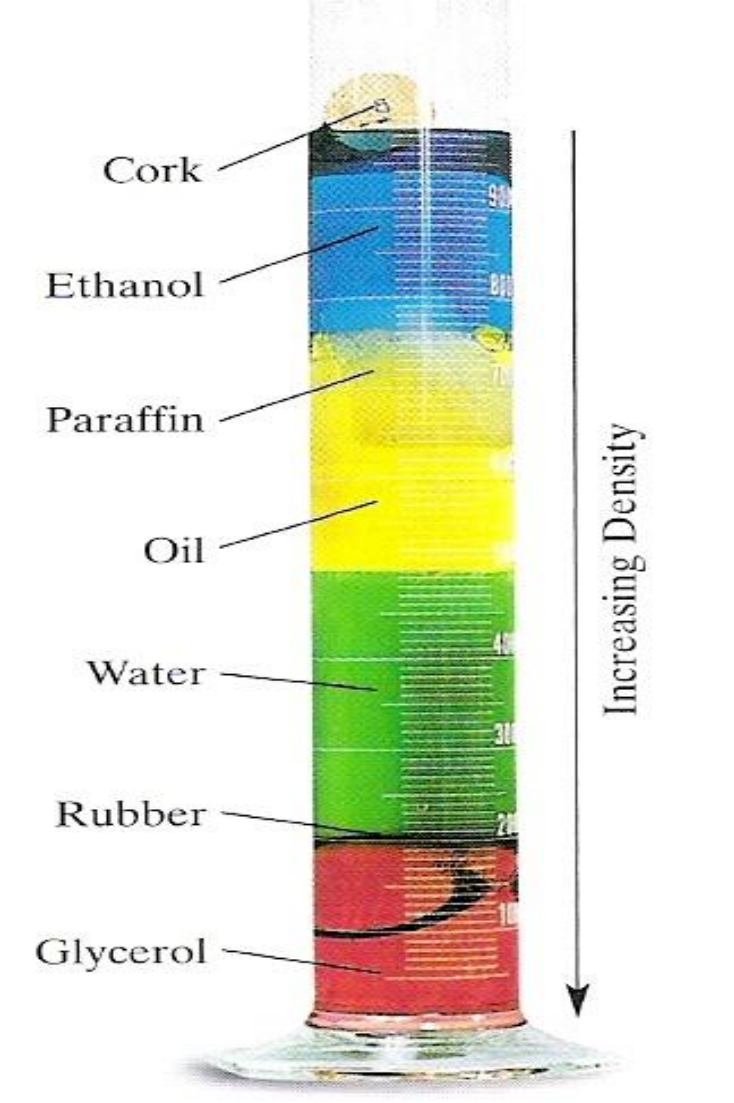


Table 4 Densities of Various Substances

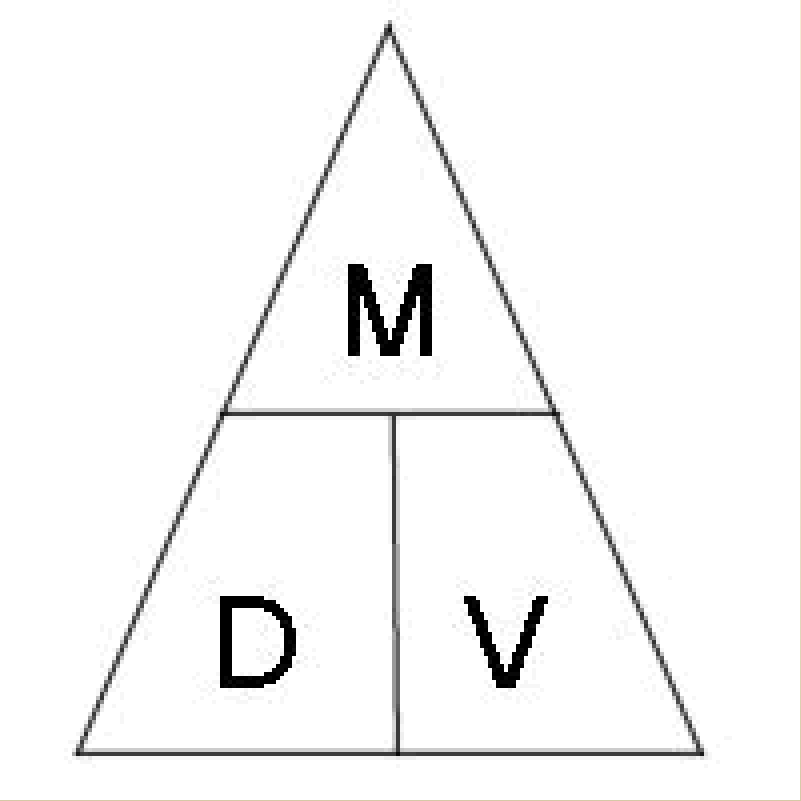
Substance	Density (g/cm^3) at 25°C
Hydrogen gas, H_2*	0.000 082 4
Carbon dioxide gas, CO_2*	0.001 80
Ethanol (ethyl alcohol), C_2H_5OH	0.789
Water, H_2O	0.997
Sucrose (table sugar), $C_{12}H_{22}O_{11}$	1.587
Sodium chloride, NaCl	2.164
Aluminum, Al	2.699
Iron, Fe	7.86
Copper, Cu	8.94
Silver, Ag	10.5
Gold, Au	19.3
Osmium, Os	22.6

*at 1 atm

Density- the amount of matter in a unit of volume-

can be used for identification purposes!

- Using the density triangle – any variable equation can be found by covering the unknown-



USEFUL INFORMATION!

$1\ cm^3 = 1\ mL$

Density of water = 1 g/mL therefore

50 g of water= 50 mL !

Finding Density

1. What is the density of a cube of material that has a mass of 25.00 grams and a side dimension of 2.0 cm?

2. A material has a mass of 45.8 grams and a volume of 7.15 mL. What is the density?

Volume can be determined two ways:

- Example One direct volume measurement.
- **3. Silver has a density of 10.5 g/cm^3. A cube with a side dimension of 2.0 cm is found. It has a mass of 84.0 grams. Could the cube be silver?**

- Example two indirect volume measurement:
- **4. A necklace is found with a mass of 21.5 grams. When it is placed in 50.0 mL of water the water rises to 51.7 mL. Is the necklace silver?**

Finding Volume

- 7. Gold has a density of 19.34 g/cm^3. A nugget is found with a mass of 5.60 grams. What should 50.0 mL of water rise to if the nugget is gold?

Finding Mass

8. Copper has a density of 8.89 g/mL. A cube of copper with a side dimension of 3.0 cm is found. What will the mass be?

English & Metric conversions

English units are what we use in the US.

- For example 1 yard = 3 feet

To convert between these two system of units, we need to again use conversion factors.

To use conversion factors we will use dimensional analysis, which is a method of using factor-label cancellation.

$$\text{Number} \cdot (\text{old unit}) \times \left[\frac{\text{new unit}}{\text{old unit}}\right] = \text{New number} \cdot (\text{new unit})$$

Conversion factor

Examples of Conversion Factors

1 in. = 2.54 cm

1 meter = 3.2808 ft

1ft = 12inches

1 kg = 2.205 lbs.

1 fathom = 6 ft

1 km = 0.6214 miles

1 lb. = 16 ounces

0.943 L = 1 quart

1 gallon = 4 Quarts

Type 1: Conversion of Distance

(always convert to metric)

- Example 1: Sammy the sail slithers 5.05 in how far is that in cm?

•5.05 inches = ? Cm $5.050\text{in} \left| \frac{2.54\ \text{cm}}{1\ \text{inch}} \right| = 12.8\ \text{cm}$

Example 2 : Bob the bunny hops 6.63 yards. How far is that in meters?

$6.63\ \text{yds} \left| \frac{3.00\text{ft}}{1\ \text{yd}} \right| \left| \frac{12.00\text{in}}{1\ \text{ft}} \right| \left| \frac{2.54\ \text{cm}}{1\ \text{in}} \right| = 606\ \text{cm} = 6.06\ \text{meters}$

Type 2: Volume Conversions

- 3. Mrs. Gleavy drank 1.55 gallons of water in a day. How many liters did she drink that day?

- $1.54\ \text{gal} \left| \frac{4\ \text{qts}}{1\ \text{gal}} \right| \left| \frac{0.943\ \text{L}}{1\ \text{qt}} \right| = 5.81\ \text{L}$

Type 3: Conversion of Mass

- 4. A child's chair can hold 150 kilograms. A person that weighs 195.0 pounds sits on the chair will it break?

- $195.0\text{lbs} \left| \frac{1\text{kg}}{2.205\text{ lb}} \right| = 88.435 \text{ kilograms}$

NO! 88.44kg < 150 kg

Type Four: Two Units !!!!

- 5. A speed limit sign reads 40 km/hour. You are traveling 73.3 ft/min. Should you get a ticket?

$$\frac{73.3\ \text{ft}}{\text{Min}} \left| \frac{60.0\text{min}}{1\text{hr}} \right| \frac{12\ \text{in}}{1\ \text{ft}} \left| \frac{2.54\ \text{cm}}{1\ \text{in}} \right. = 134051.9\ \text{cm/hr}$$

= 1.34km/hr NO < 40 km/Hr

Example #1

How many centimeters is a 100.yd football field?

Remember 1 yard = 3ft and 1 meter = 3.2808 ft

$$100\cancel{yd} \times \left[\frac{3ft}{\cancel{yd}}\right] = 300\cancel{ft} \times \left[\frac{1\,m}{3.2808\cancel{ft}}\right] =$$

$$91.44m = 9140cm$$

Example #2

How many grams are in a 7.0 ounce package of m & m's?

1lbs =16 ounce and 1 kg = 2.205 lbs

$$7.0\text{oz} \times \left[\frac{1\text{lbs}}{16\text{oz}}\right] = .438\text{lb} \times \left[\frac{1\text{ kg}}{2.205\text{lbs}}\right]$$

0.199kg = 200g

You Try:

- 1. A polar bear with a weight of 275 pounds sit on a chair that can hold 98.0 kilograms. Will the chair break?

#2.

- A runner needs to complete a 5k road race. He is running 2.20 miles to see his predicted time. IS he running the correct distance?

#3

- A speed limit sign reads 30km/hr. Your are traveling 25.0 ft/sec. Will you get a ticket?