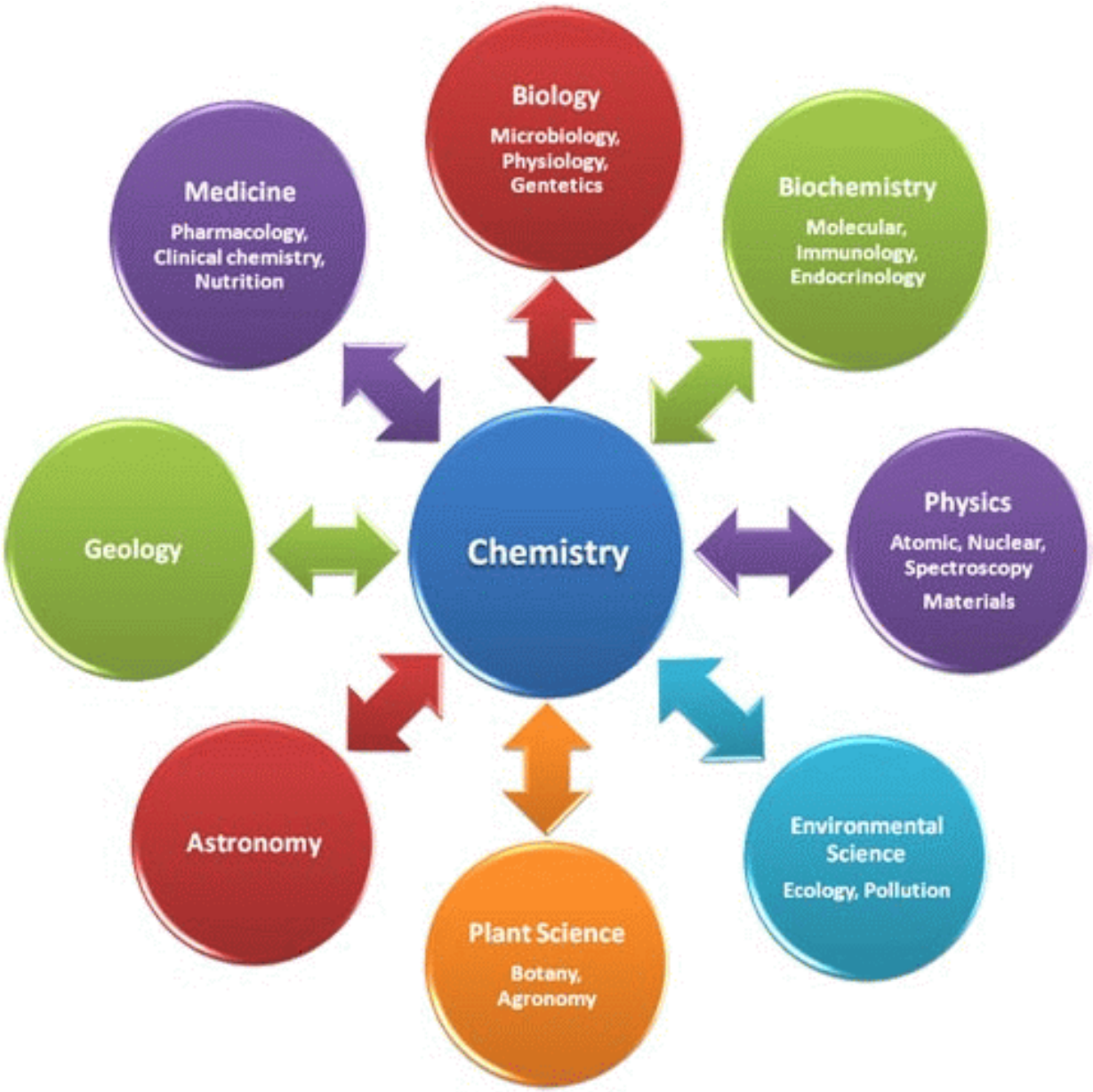
GENERAL CHEMISTRY

CHEM 1100 & CHEM 1101

Why Study Chemistry?

- learn fundamental physical laws
- develop problem solving skills
- gain technical perspective on current events

The Central Science



Major Divisions

- **biochemistry**

  study of biological compounds

- **organic chemistry**

  carbon based compounds

- **inorganic chemistry**

  all other elements

- **analytical chemistry**

  methods of analysis

- **physical chemistry**

  theory and concepts

Chemistry .....

- the study of matter &
- the changes it undergoes

Chemistry .....

- These changes are called chemical reactions

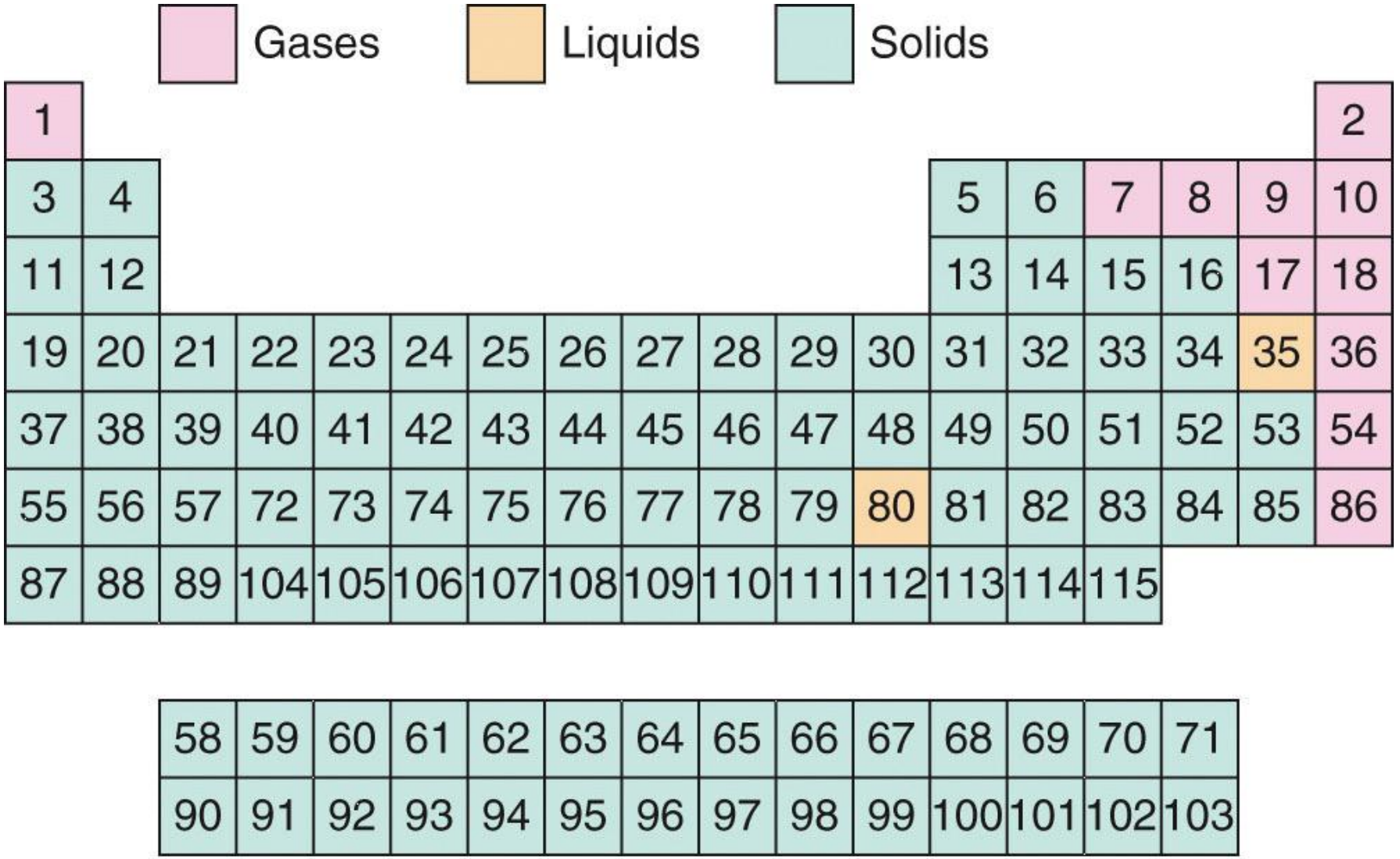
- Elements: atoms & molecules
- Compounds: molecules

Periodic table of elements

Period	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** 1.00794																	2 **He** 4.00260
2	3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.811	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.1797
3	11 **Na** 22.9898	12 **Mg** 24.3050											13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.066	17 **Cl** 35.4527	18 **Ar** 39.948
4	19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.9381	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
5	37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.906	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.904	54 **Xe** 131.29
6	55 **Cs** 132.905	56 **Ba** 137.327	57 ***La** 138.906	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.967	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.980	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.025	89 **†Ac** 227.028	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (281)	111 ** (272)	112 ** (285)		114 ** (289)		116 ** (292)		

*Lanthanide series	58 **Ce** 140.115	59 **Pr** 140.908	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.965	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 164.930	68 **Er** 167.26	69 **Tm** 168.934	70 **Yb** 173.04	71 **Lu** 174.967
†Actinide series	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Most elements are solids at normal temperatures

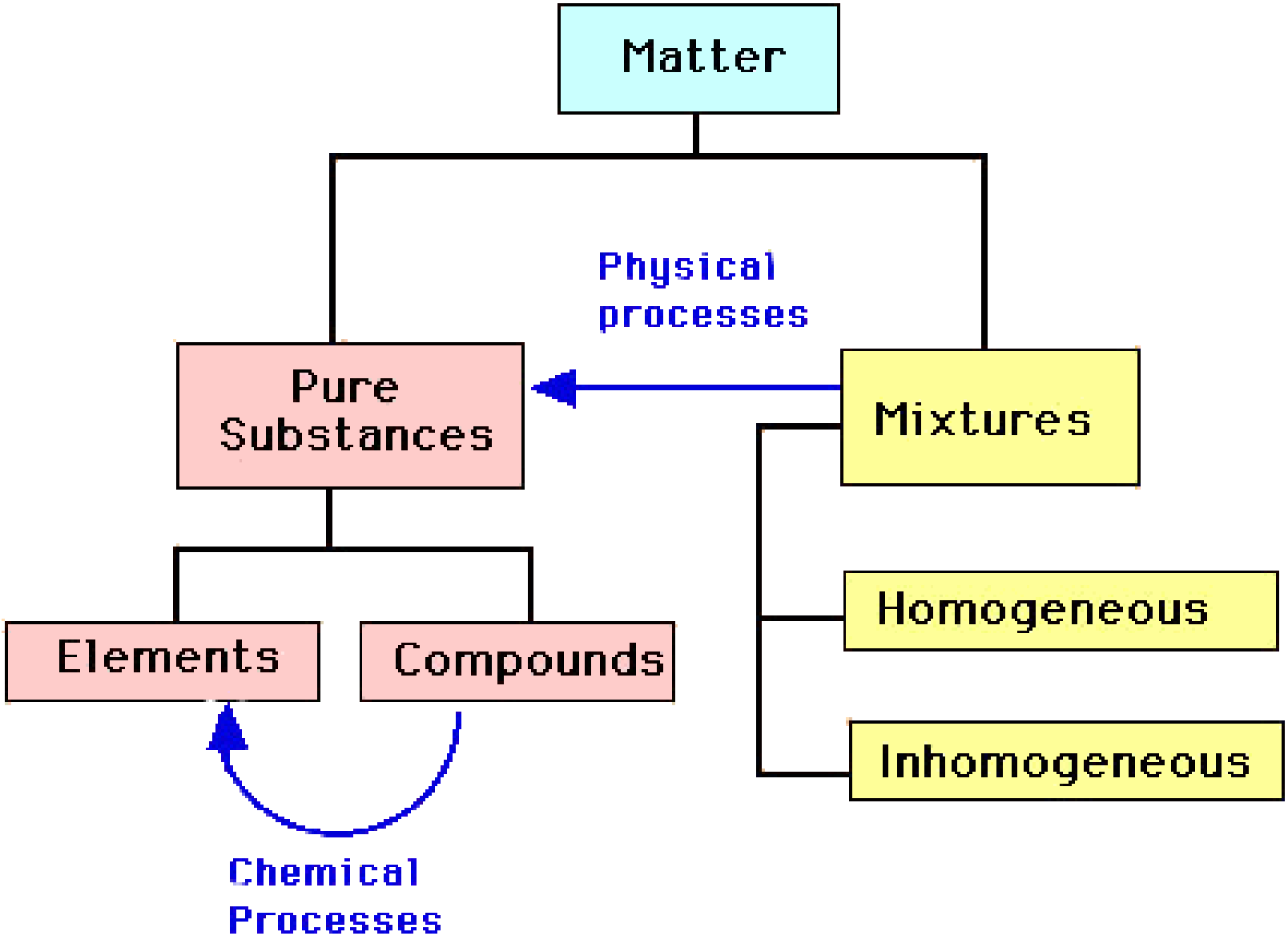


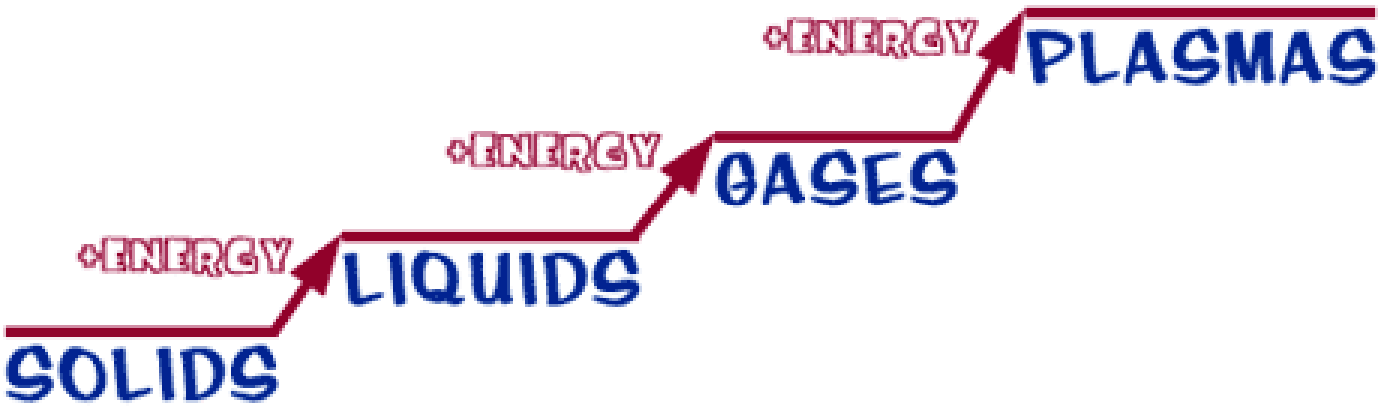
- **1 oz silver coin contains 160,000,000,000,000,000,000,000 atoms of silver**

Matter & Energy

Matter ◆ **Anything that occupies space and has mass**

Mass ◆ **Measures the amount of matter an object contains**


Matter
Physical processes
Pure Substances
Mixtures
Elements
Compounds
Homogeneous
Inhomogeneous
Chemical Processes



States of matter

Math Review

1. Exponents/Scientific noatation
2. Ratios and Proportions
3. Percentage (%)

1. Exponents (+) or (-)

10^2 2 is exponent; 10 is base number

10^2 means take 10 twice = 10 x 10 = 100

10^{-2} means $\frac{1}{10 \times 10} = \frac{1}{100} = 0.01$

$10^2 \times 10^3 =$

$10^5 \div 10^2 =$

2. Ratios and Proportions

CAR: 4 wheels per car

or 4 wheels : 1 car

or 4 wheels/1 car

These are all ratios.

Show numerical relationships

How many wheels on 2 cars?

$$4 : 1 = x : 2 \quad \text{or} \quad \frac{4}{1} = \frac{x}{2} \quad \text{or} \quad x = 4 \times 2$$

3. Percentage (%)

= parts per 100 parts

Class of 100 students has 35 F ? %

Ans. 35%

Class of 75 students has 25 F ? %

$$= \frac{25}{75} \times 100 = 33\%$$

% by mass

Origins of Chemistry

Two facets

technological (or factual)

philosophical (or theoretical)

Technological

first humans, antiquity

Fire ⇨ **chemical changes such as Cook food, baked pottery, smelted ores**

Others ⇨ **fermentation, dyes, drugs from plants**

All possible without knowing scientific principles

Philosophical

Ancient Greeks

First to formulate theories explaining behavior of matter principles

In medieval times, chemistry did not exist as we know it today.

Instead, alchemy was popular.

Objectives of alchemy

- **To find the panacea**
  - medicine to cure illness & diseases
- **To find the elixir of life**
  - immortality
- **Transmutation**
  - convert "base metals" to gold

Alchemy

⇓

New discoveries

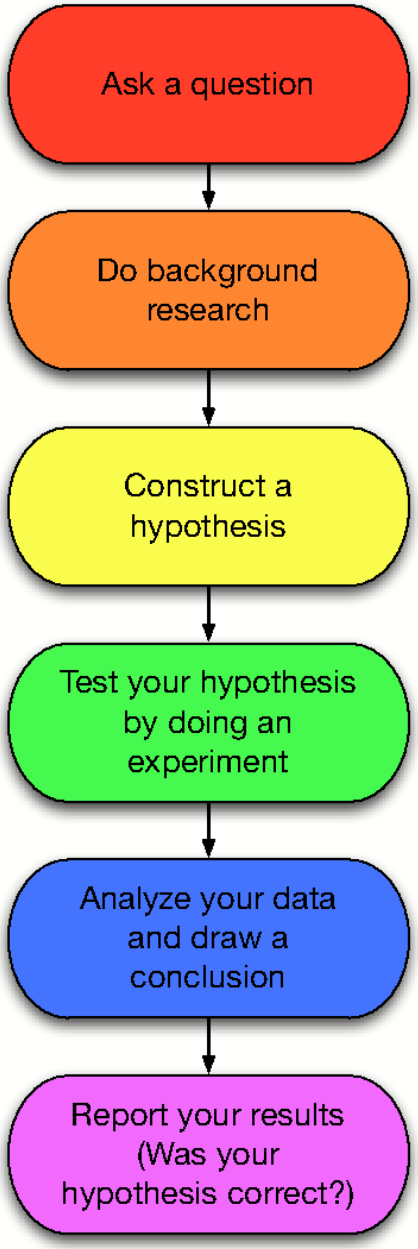
⇓

Modern science

The Scientific Method

Process used to develop laws and theories

The Scientific Method



The Scientific Method

Can a theory be proved?

New experiments *could* prove it wrong

Research is planned but ....

1. **Trial and error**
2. **Accidental discoveries**

Risks: Accidents, pollution

Elements

Pure substances that can't be broken down in simpler substances

Metal

Copper

Metalloid

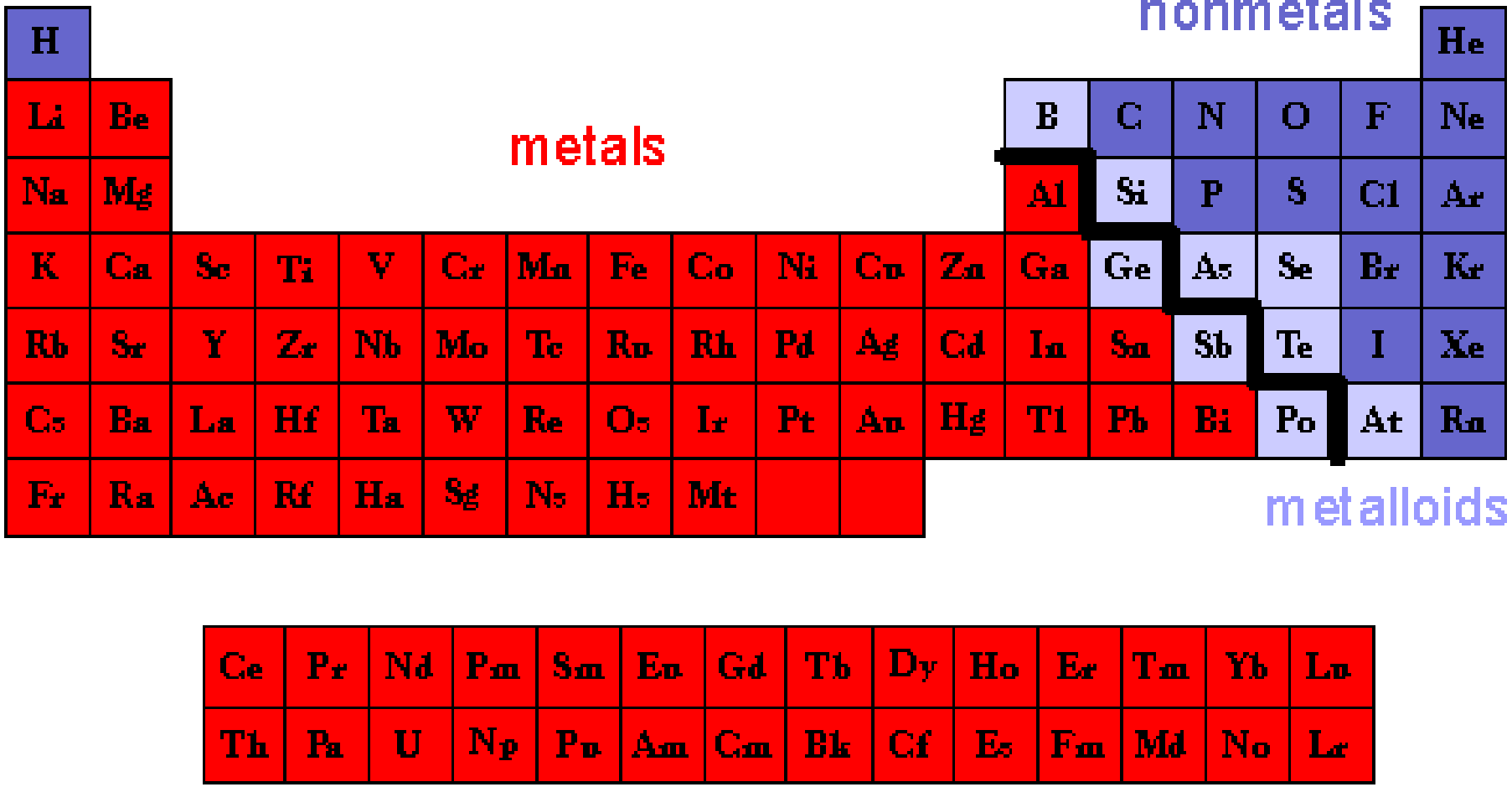
Antimony

Nonmetal

Sulfur

Elements arranged in Periodic Table

- May be metals, nonmetals, metalloids



Element Symbols

- **Each element assigned a unique symbol**
- **Each is 1-2 letter; first letter capitalized**
- **Symbol may not match name;**
  May be based on different name

Measurements, Units, Significant Figures

Measurements

English System
Metric System

1. English (Imperial) System

Ancient commerce/merchants needed agreement for weights and measures, but standards varied from town to town

1. English (Imperial) System

Body parts often used

Yard: nose to outstretched hand
Inch: thumb width
Cubit: forearm length

hands ***cubit***

Metric system

- Photo film:35 mm
- Soft drinks: liters
- Medical volumes:cc
- Sports:100 m sprint

2. Metric (Decimal) System

French Revolution (1800)

meter ⇨
“one-ten-millionth the distance from the equator to North Pole”

2. Metric (Decimal) System

Volume ⇨ liter

Mass ⇨ kilogram

Time ⇨ second

2. Metric (Decimal) System

In science:
use SI units
(mostly metric)

2. Metric (Decimal) System

Metric units:

One base unit for each type of measurement

Use prefixes to change size of units

Metric/SI units

Type	Name	Symbol
Mass	gram	g
Length	meter	m
Volume	liter	L
Energy	joule	J
Temp	Celsius	°C
Amount	Mole	mol

see table 1.2, p9

Metric/SI system

Prefix	Symbol	Factor
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Also tera-, giga-, pico-

see table 1.3, p10

Converting between units

English ⇔ English
English ⇔ Metric
Metric ⇔ Metric

Converting between units

How many miles in 50 kilometers?

Need conversion factor

1 kilometer = 0.62 miles

Converting between units

There are 0.62 miles per 1 km

or.....

$$\frac{0.62 \text{ miles}}{1 \text{ km}}$$

Converting between units

To convert: multiply given quantity by conversion factor

Make sure end up with right units

Converting between units

$$\text{Miles} = 50\ \cancel{\text{km}} \times \frac{0.62\ \text{miles}}{1\ \cancel{\text{km}}}$$

$$= 31\ \text{miles}$$

Holtermann nugget

How much is it worth?

Mass = 290 kg

$1,200 per oz

Dimensional analysis

$$290\ \text{kg} \times \frac{1\ \text{lb}}{0.45\ \text{kg}} \times \frac{16\ \text{oz}}{1\ \text{lb}} \times \frac{1{,}200\ \text{dollars}}{1\ \text{oz}}$$

= 12,373,330 dollars

≈$12 million

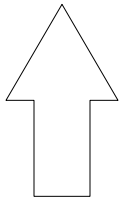
Significant figures

- Used in measurements or counting objects
- Measured - measurement tool gives level of significance or accuracy
- Counted - all digits are significant

Significant figures

- **Significant figures indicate accuracy and precision of measurements.**

9.36 has 3 significant figures



Uncertain digit, but significant

Significant figures

- Example Area of rectangle 10.5 inch long & 6.401 inch wide
- Answer 67.2105 $inch^2$
- Can't get answer more accurate than the numbers used in measurement
- Correct Answer 67.2 $inch^2$
- This is Rounding off

Significant figures

➢ **Rules for zeros**

4,012 **has 4 significant figures**

0.421 **has 3 significant figures**

114.20 **has 5 significant figures**

Leading, captive, trailing zeros

Significant figures

- Number of significant figures independent of the decimal point

- 255 25.5 2.55 0.255 0.0255

Keep track of significant figures during problem solving

Scientific Notation

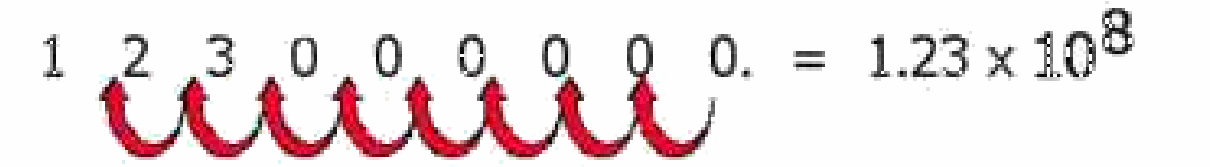
- **$123{,}000{,}000 = 1.23 \times 10^{8}$**

mantissa x base^{power}

mantissa: >1 and <10

Scientific notation

123,000,000



0.000000123

Problem solving

Keep track of significant figures during problem solving

Problem solving

Creatine is a substance found in blood. If an analysis of a blood sample detected 0.58 mg of creatinine, how many micrograms are present?

Converting between Units

Need to convert mg ⇒ µg

There are 1000 µg per 1 mg

Converting between Units

$$0.58 \text{ mg} \times \frac{1000 \text{ µg}}{1 \text{ mg}}$$

$$= 580 \text{ µg}$$

Calculators

- Most calculators use scientific notation when the numbers get large or small

- Display varies with model
  May be x 10^n or with an E

Calculators

- **Usually have a button to enter exponent**

EE Exp

Temperature

- **Measure of heat energy**

Three common scales used:

- $°F = (1.8 \times °C) + 32$

$$°C = \frac{(°F - 32)}{1.8}$$

Temperature

$$K = {}^{o}C + 273$$

$${}^{o}C = K - 273$$

Density

- $\text{Density} = \frac{\text{Mass}}{\text{Volume}}$

- Lead is a “heavy” metal
  Aluminum is a “light” metal

Density

Density is a characteristic property of a substance.

Common units are g / cm^3 or g / ml. $cm^3 = ml$

	g / cm^3		g / cm^3
Air	0.0013	Bone	1.7 - 2.0
Water	1.0	Urine	1.01 - 1.03
Gold	19.3	Gasoline	0.66 - 0.69

Density

$$D = \frac{M}{V}$$

Therefore.....

$$M = D \times V$$

And.....

$$V = \frac{M}{D}$$

Density

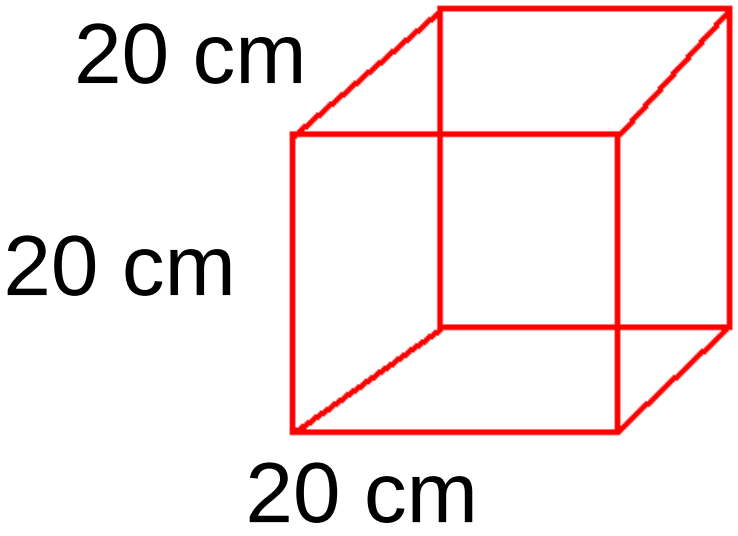
What is the density of 5.00 mL of salt water if it has a mass of 5.23 grams?

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{density} = \frac{5.23\ \text{g}}{5.00\ \text{mL}}$$

$$\text{density} = 1.05\ \text{g/mL}$$

Density

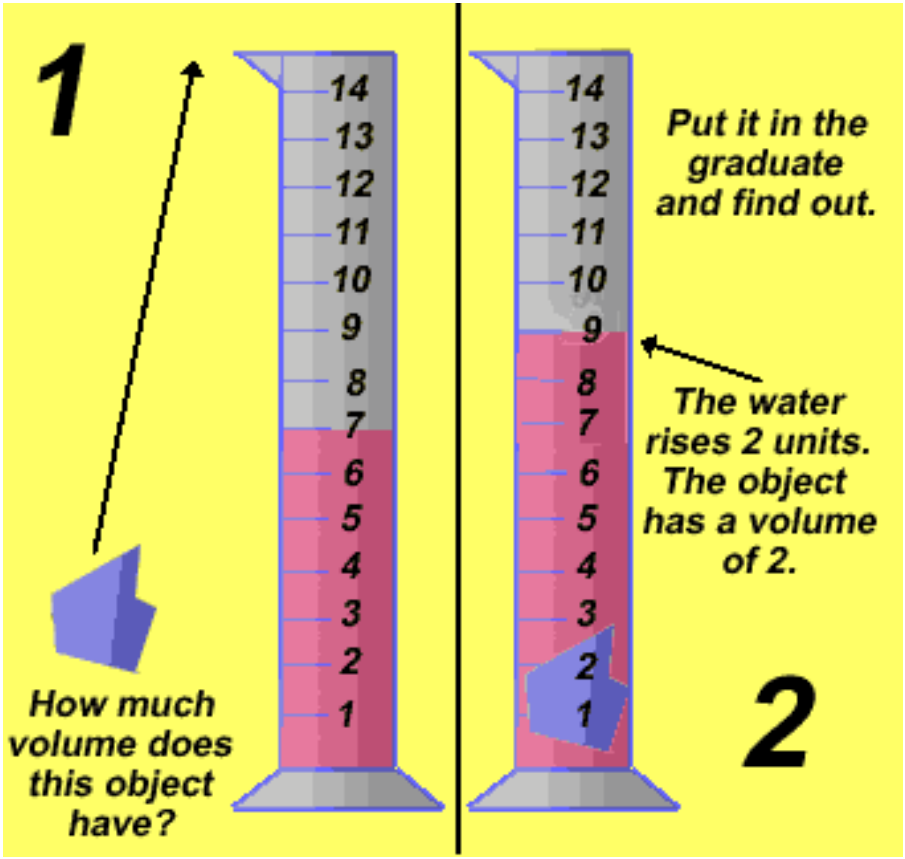


volume
= 20 cm x 20 cm x 20 cm
= 8000 cm^3

How do you determine the volume of a regular object..... a cube?

Density

What about irregular objects - a rock?



Water displacement

Properties of Matter

Two categories:

Extensive properties: Mass

Depends on how much matter present

Intensive properties: Bp

Does not depends on how much matter present

Physical Properties

Characteristics that can be evaluated without changing the composition of a material

Examples

Physical Properties

Color **Taste** **Odor** **Feel**

Density

Melting/boiling point

Compressibility

Chemical Properties

Characteristics that result in a change in the composition of a material

This is called a chemical reaction

And produces a chemical change

Chemical Properties

A chemical property of wood is its ability to burn in air/oxygen

This type of reaction is called combustion

Chemical Properties

Chemical reactions are described with chemical equations

$$H_2 + O_2 \Rightarrow H_2O + \text{heat}$$

Chemical Properties

No change in composition
Chemical nature of components unchanged
Examples melting, boiling, cutting, bending

Ask: Has the composition of the substance changed?

Are these chemical or physical changes?

milk turning sour

making wine

ice melting

Coke going flat

sugar dissolved in water

water boils

End of chapter 1