Mid-Term Topics

Honors

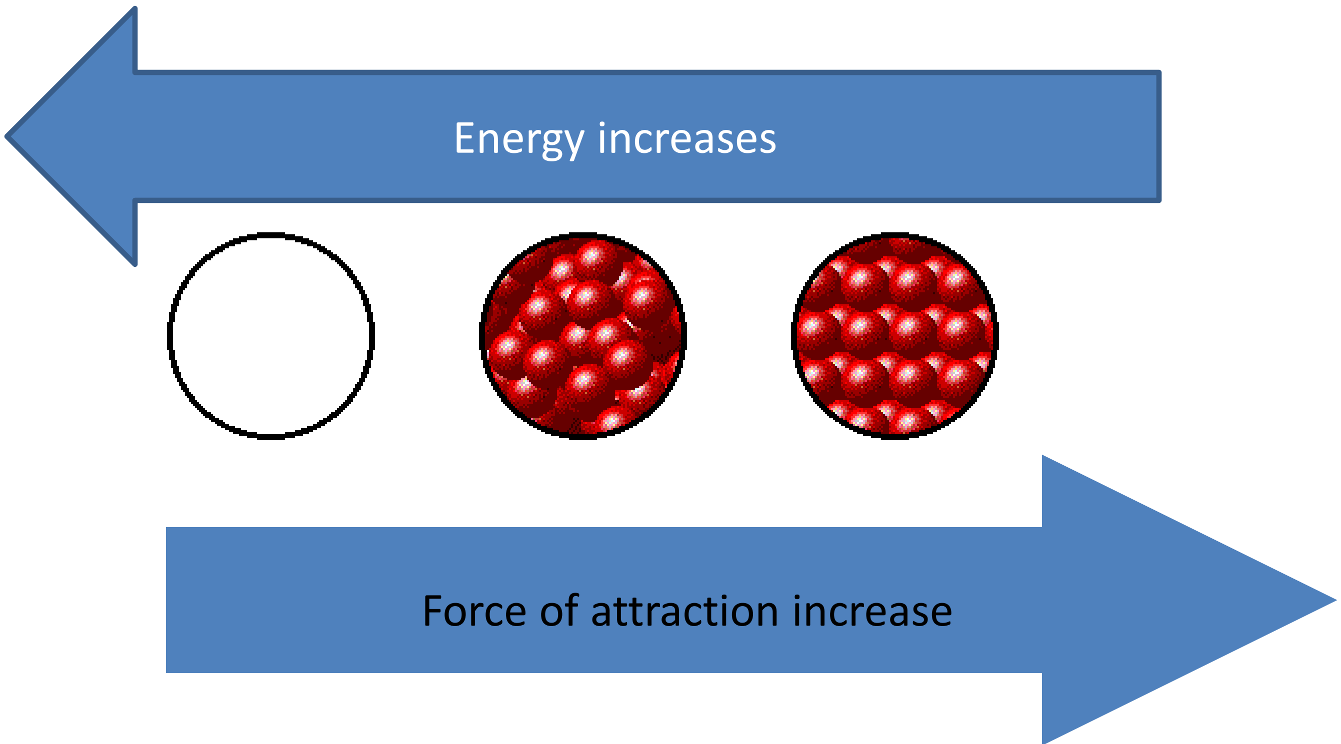
Observations

- Qualitative: descriptive observation that is *not numerical*.
  - Example: This apple is red.

- Quantitative: Numerical observation.
  - Example: The temperature of this room is 23°C.

States of Matter

- Difference between solids, liquids, & gases are the attractive forces amongst the particles and their energy.

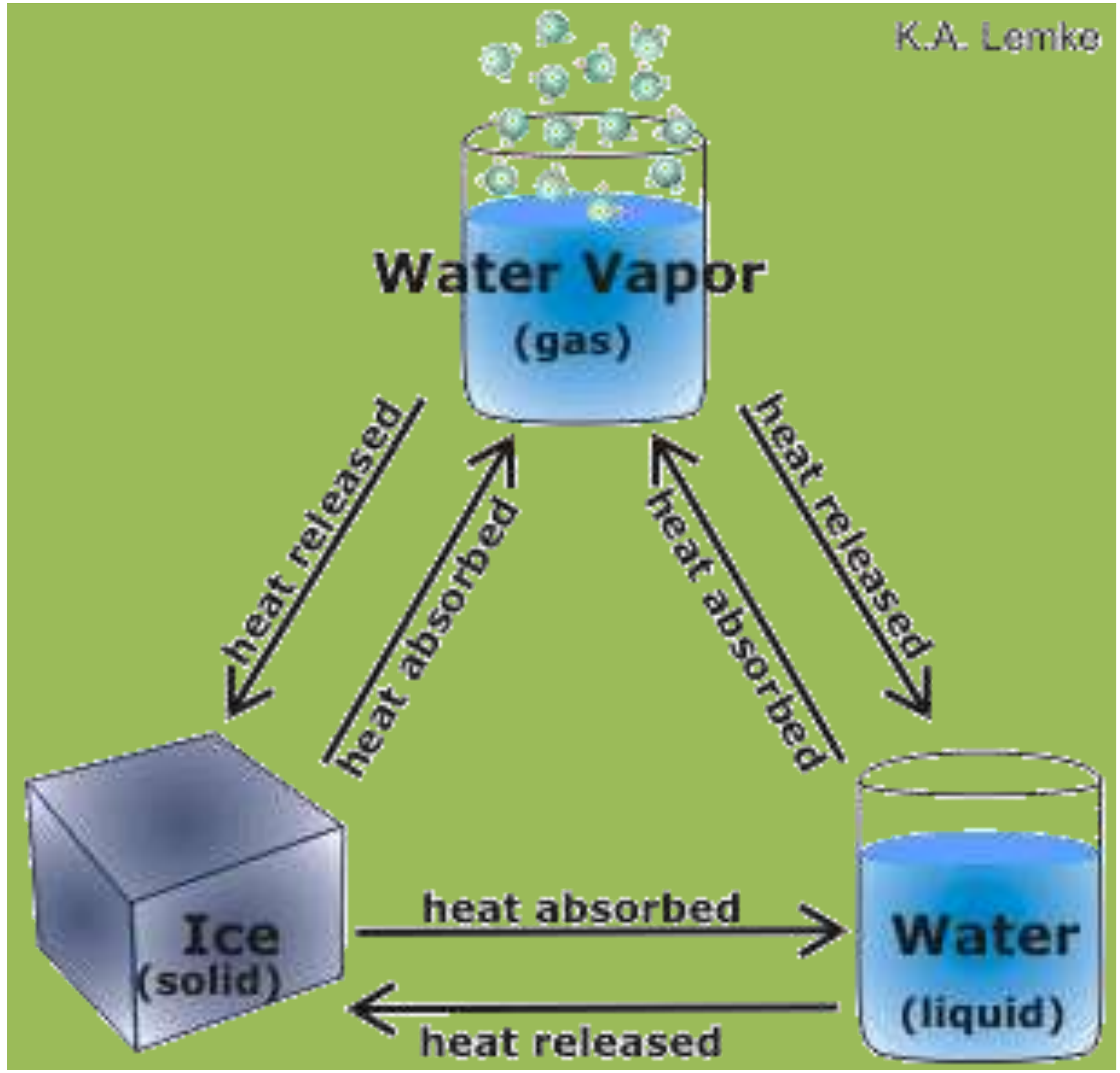


Properties of Solids, Liquids, & Gases

State	Shape	Volume	Compressibility	Microscopic Properties
Solid	Definite	Definite	Negligible	Particles touching & tightly packed in rigid arrays.
Liquid	Indefinite	Definite	Very Little	Particles touching but mobile.
Gas	Indefinite	Indefinite	High	Particles far apart and independent of one another.

Energy and Phase Changes

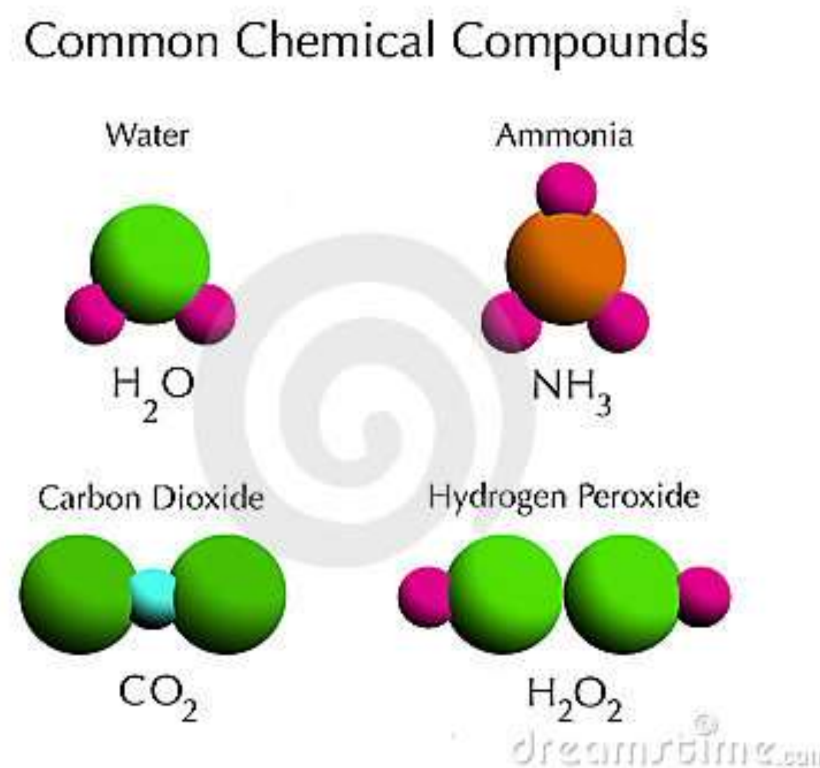
- <u>Endothermic</u> : energy/heat is absorbed
- <u>Exothermic</u> : energy/heat is released



Pure Substances

- Elements and compounds are pure substances.
- Pure substances have a uniform and defined composition.
  - Atoms of Helium always have 2 protons, 2 neutrons and 2 electrons.
  - Sugar, glucose, always has 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.
- Pure Substances also have distinct properties.

- <u>Compounds</u> are made up of two or more different kinds of elements that are linked together via chemical bonds.



Mixtures

- Two or more substances that are physically combined together.
- Two types of mixtures
  - Homogeneous mixtures have a uniform composition throughout and have the same properties throughout.
  - Heterogeneous mixtures do not have a uniform composition throughout and the properties are not the same throughout.

Adding Liquids Together

- Miscible- will mix- water and alcohol

- Immiscible- wont mix
  water and oil

Increase solubility of a gas in a liquid

- Henrys Law- solubility of the gas is directly proportional to the pressure above the liquid-
- Effervescence- rapid escape of gas from liquid
- Decrease temperature- slows down diffusion

Physical & Chemical Changes

- Physical changes *do not* change to the composition of the substance.
  - Typically involve phase changes.
- In any chemical change, one or more substances are used up while one or more new substances are formed. This means that the composition of the original substance has changed.
  - Chemical reactions are chemical changes.

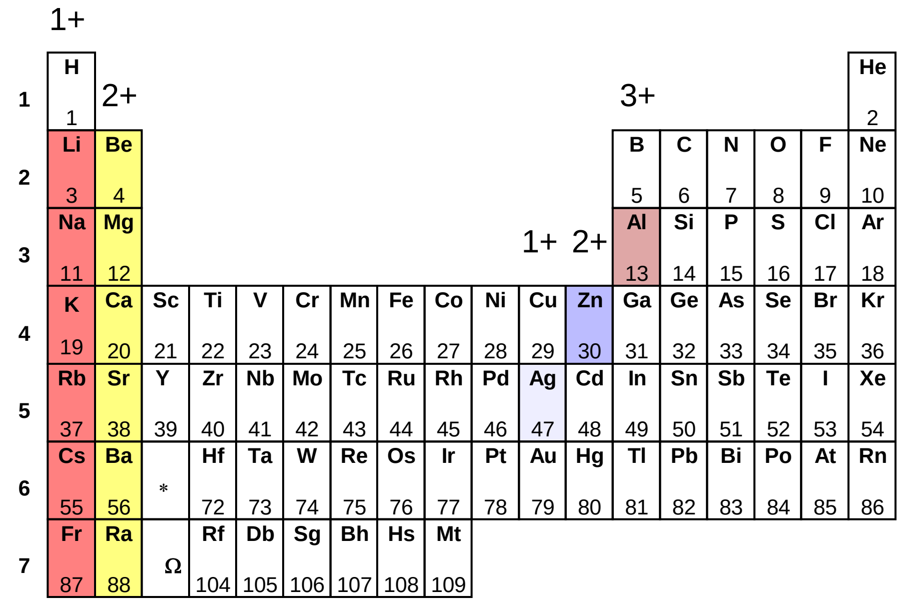
Indications of A Chemical Reaction

1) Bubbles- gas given off
2) Change in energy-
   a. Becomes warm- exothermic
   b. Becomes cool- endothermic
   c. Light is given off
3) A precipitate (solid) forms
4) A change in color

More on Properties

- Intensive Properties *are not* dependent on the amount of matter present.
- Depend on what is **In**side
  - Density, boiling point, color
- Extensive Properties *are* dependent on the amount of matter present.
- Depend on how far they **EX**tend
  - Mass, volume, length

Binary Compounds



Binary compounds that contain a metal of fixed oxidation number (group 1, group 2, Al, Zn, Ag, etc.), and a non-metal.

To name these compounds, give the name of metal followed by the name of the non-metal, with the ending replaced by the suffix –**ide.**

Examples:

NaCl	sodium chloride	(Na^{1+} Cl^{1-})
CaS	calcium sulfide	(Ca^{2+} S^{2-})
AlI_3	aluminum iodide	(Al^{3+} 3 I^{1-})

Criss-Cross Rule

Example: Aluminum Chloride

Step 1:
write out name with space

Aluminum Chloride

Step 2:
write symbols & charge of elements

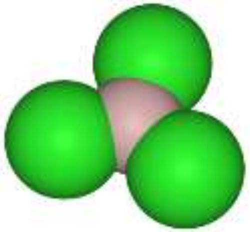
Al^{3+} Cl^{1-}

Step 3:
criss-cross charges as subsrcipts

Al_1 Cl_3

Step 4:
combine as formula unit
("1" is never shown)

$AlCl_3$



Type Two **Polyvalent Metals with Elemental Anions**

Pb^{2+}/Pb^{4+},
Sn^{2+}/Sn^{4+},
transition elements (not Ag or Zn)

A. To name, given the formula:

1. Figure out charge on cation.
2. Write name of cation.
3. Write Roman numerals in ( ) to show cation's charge.

Stock System of nomenclature

4. Write name of anion.

FeO	Fe^{2+}	O^{2-}	iron (II) oxide
Fe_2O_3	$2\ Fe^{3+}$	$3\ O^{2-}$	iron (III) oxide
$CuBr$	Cu^{1+}	Br^{1-}	copper (I) bromide
$CuBr_2$	Cu^{2+}	$2\ Br^{1-}$	copper (II) bromide

Name this compound!

$$Cu_3P_2$$

1. Find oxidation number of the metal :

$$(3)\ (x) + 2\ (-3) = 0$$

$$X = +2$$

2. state the metal
3. state the value of the Roman Numeral
4. state non-metal change ending to ide

Copper II Phosphide

Chromium (III) Chloride

RECALL: Chromium forms oxides in which metal exhibits oxidation states of +3 and +2. STOCK system indicates oxidation state of compound. Assume Cr^{3+} (chromium (III) chloride).

Step 1: Chromium (III) Chloride

Step 2: Cr^{3+} Cl^{1-}

Step 3: Cr_1 Cl_3

Step 4: $CrCl_3$

Return to Centrum Bottle

Type Two Cont
Monovalent metals ^{w}/Polyatomic Ions

Parentheses are required *only* when you need more than one "bunch" of a particular polyatomic ion.

Ba^{2+}	and	SO_4^{2-}	$BaSO_4$	barium sulfate
Mg^{2+}	and	NO_3^{1-}	$Mg(NO_3)_2$	magnesium nitrate
NH_4^{1+}	and	ClO_3^{1-}	NH_4ClO_3	ammonium chlorate

Compounds Containing Polyatomic Ions

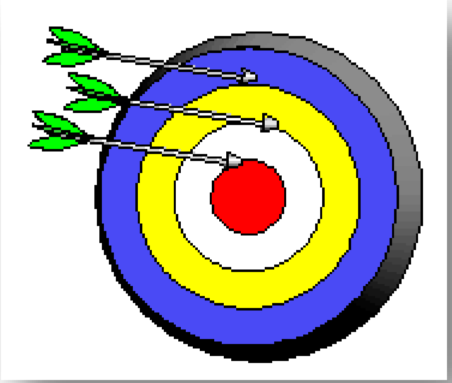
Insert name of ion where it should go in the compound's name.
Cross and Drop Reduce if you can!

Write formulas:

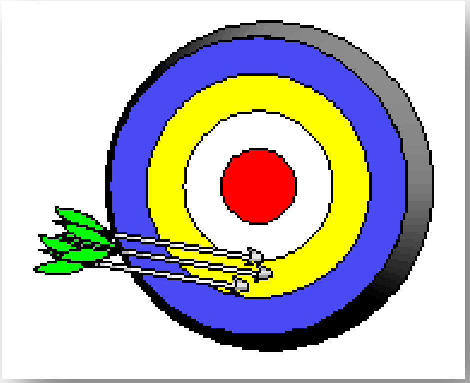
iron (III) nitrate	Fe^{3+}	3 NO_3^{1-}	$Fe(NO_3)_3$
Copper I phosphate	3 Cu^{1+}	$PO_4 3^{-}$	Cu_3PO_4
Silver chlorate	Ag^{1+}	ClO_3^{1-}	$AgClO_3$
Nickel II phosphate	3 Ni^{2+}	2 PO_4^{3-}	$Ni_3(PO_4)_2$
lead (II) permanganate	Pb^{2+}	2 MnO_4^{1-}	$Pb(MnO_4)_2$

Precision and Accuracy

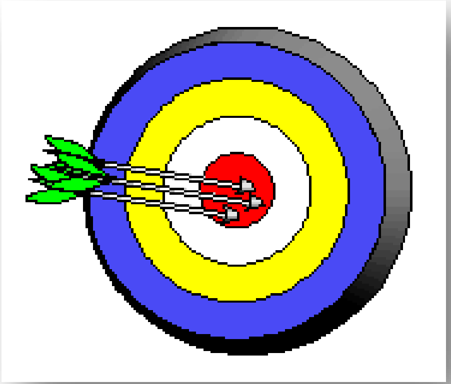
- Accuracy refers to the agreement of a particular value with the true value.
- Precision refers to the degree of agreement among several measurements made in the same manner.



Neither accurate nor precise



Precise but not accurate



Precise AND accurate

Why Is there Uncertainty?

- Measurements are performed with instruments
- No instrument can read to an infinite number of decimal places

Which of these balances has the greatest uncertainty in measurement?

- <u>Identifying & Counting Significant Figures:</u>
- Use the *Atlantic-Pacific Rule*! If the decimal point is *absent* approach the number from the *Atlantic* side, go to your first non-zero number, and count all the way through. If the decimal point is *present* approach the number from the *Pacific* side go to your first non-zero number, and count all the way through.

Sig Fig Practice #1

How many significant figures in each of the following?

1.0070 m → 5 sig figs

17.10 kg → 4 sig figs

100,890 L → 5 sig figs

3.29×10^3 s → 3 sig figs

0.0054 cm → 2 sig figs

3,200,000 → 2 sig figs

Rules for Significant Figures in Mathematical Operations

Multiplication and Division: # sig figs in the result equals the number in the least precise measurement used in the calculation.

6.38 × 2.0 =

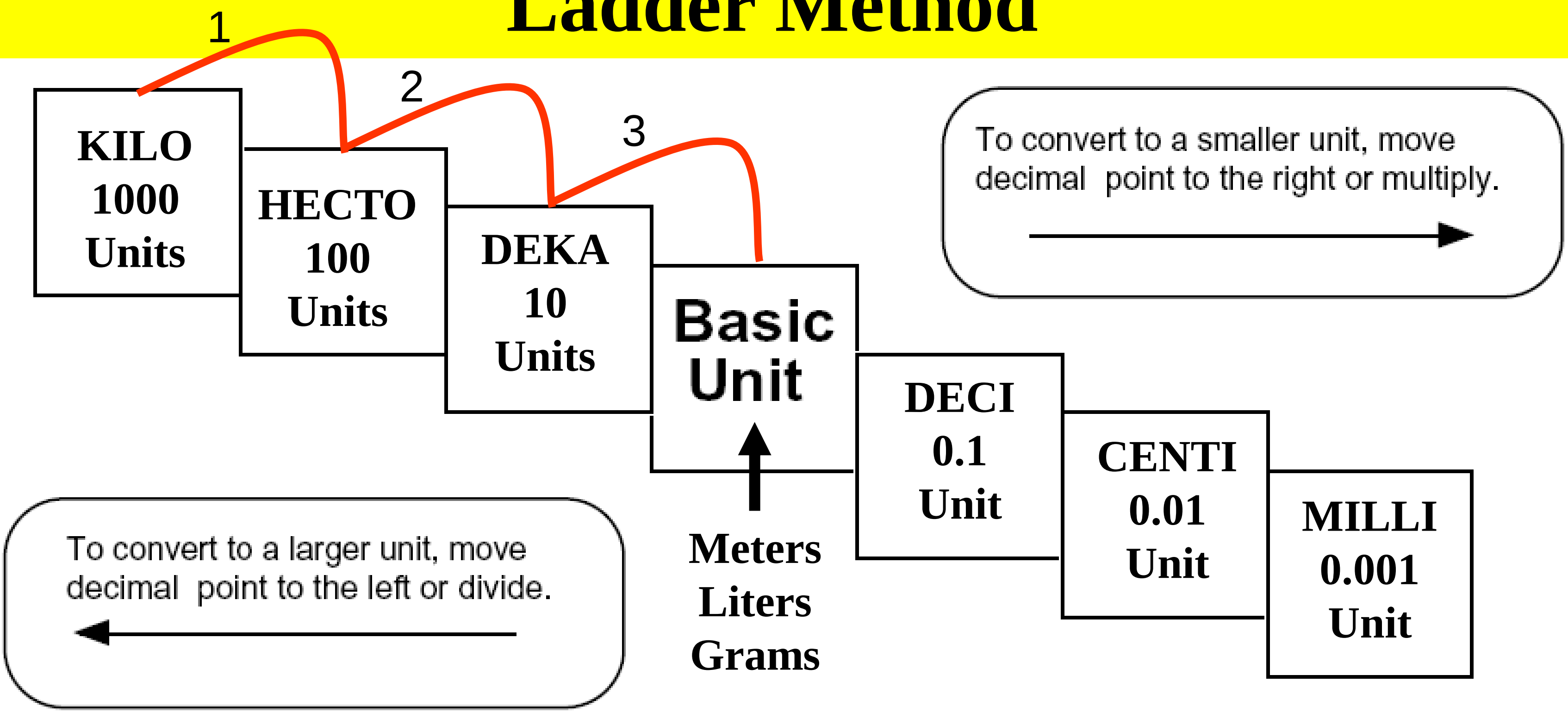
12.76 → 13 (2 sig figs)

Addition and Subtraction: The number of decimal places in the result equals the number of decimal places in the least precise measurement.

6.8 + 11.934 =

18.734 → 18.7 (3 sig figs)

Ladder Method



How do you use the "ladder" method?

1st – Determine your starting point.

2nd – Count the "jumps" to your ending point.

3rd – Move the decimal the same number of jumps in the same direction.

4 km = __________ m

Starting Point   Ending Point

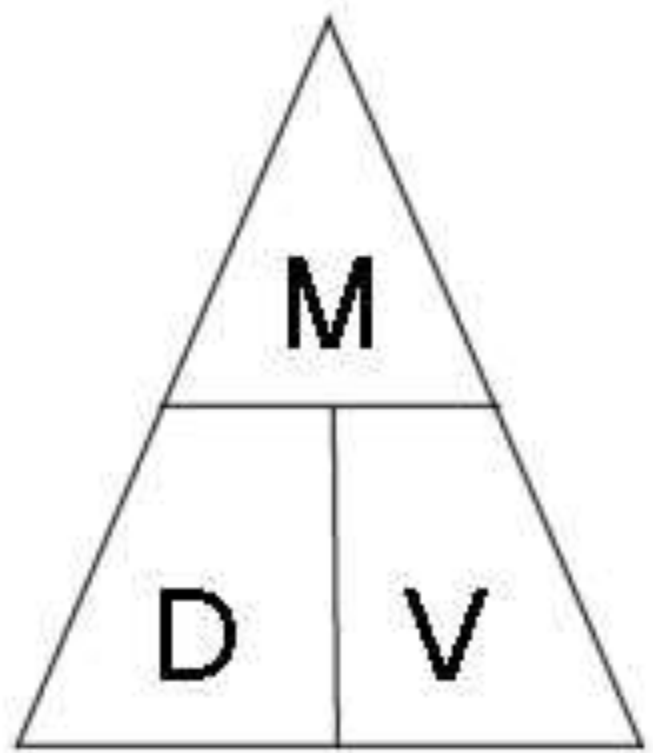
How many jumps does it take?

4. __. __. __. = 4000 m

1 2 3

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-



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

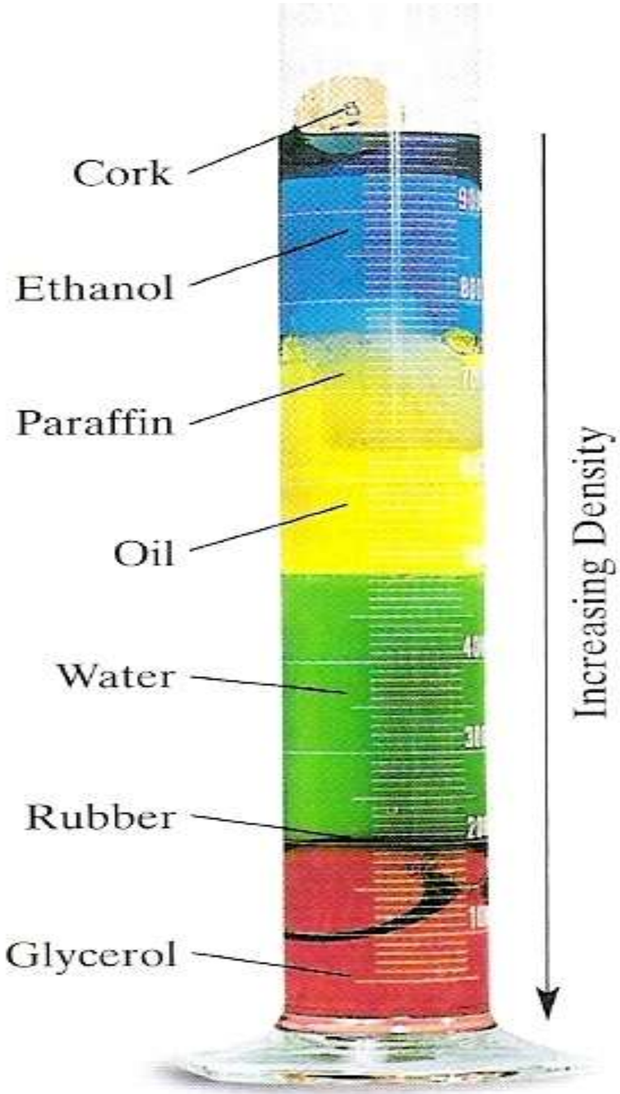


Table 4 **Densities of Various Substances**

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 Calculations

- A sample of metal has a mass of 8.4g. The volume of the sample is 3.1cm^3. What is the density?

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{8.4\text{g}}{3.1\text{cm}^3} = 2.7\text{g/cm}^3$$

What is the volume of a sample of liquid Mercury that has a mass of 76.2g. Given that the density of mercury is 13.6g/mL?

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{76.2\text{g}}{13.6\text{g/mL}} = 5.60\text{mL}$$

Heat Capacity

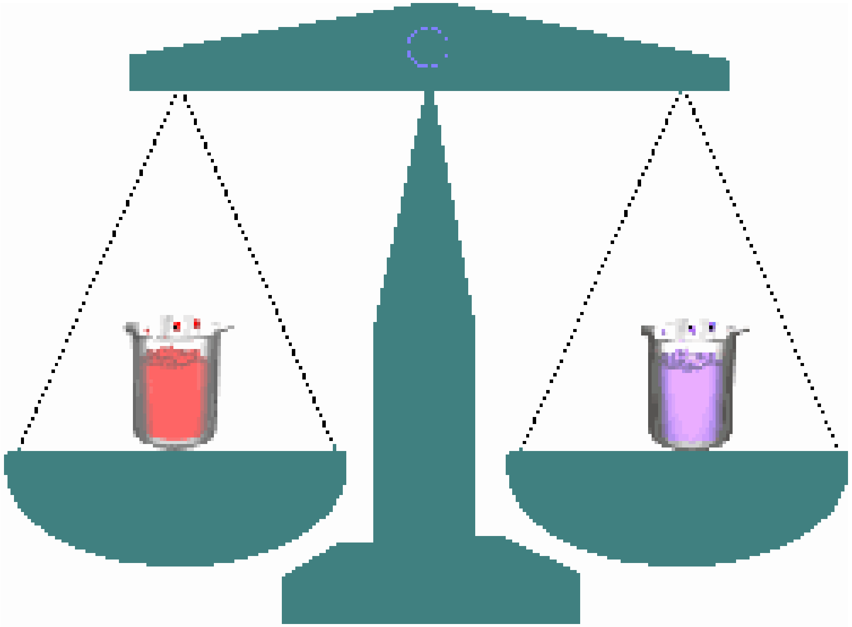
- Amount of energy required to change a given sample by a given amount
  - $Q = m\, C\, \Delta T$
- Q= Heat= Joules
- C= specific heat (table value) J/g^0c

  (unique to material)
- $\Delta T = T_{Final} - T_{Initial}$

Problems

- 1. a. How much energy is required to warm 5.00 grams of copper from 22.00c to 40.00c?
- b. How much energy is lost when 2.00 grams of lead is cooled from 25.00c to 15.00c?
- Find Mass
- 2. a. How many grams of water are in a sample if it required 166 joules of energy to be warmed from 20.00c to 40.00c?

LAW OF CONSERVATION OF MATTER



Mass is not created (gained) nor destroyed (lost) during ordinary physical and chemical reactions.

Proven by Antoine Lavoisier 200 years ago

LAW OF DEFINITE PROPORTIONS

Chemical compound contains the same elements in exactly the same proportions by mass regardless of sample size or source of substance

1700's Joseph Proust

We all know the chemical formula for water is H_2O . It is essential for the body. The water from a Poland Spring bottle and from a your tap at home is always 2 hydrogen atoms to 1 oxygen atom

LAW OF MULTIPLE PROPORTIONS

Two elements may combine in different ratios to form different compounds.

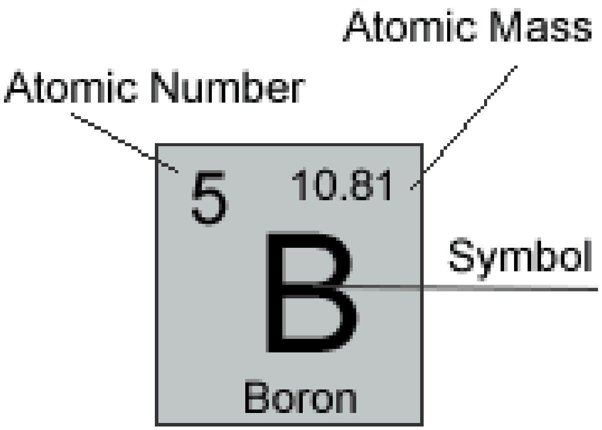
Change the ratio …Change the compound

John Dalton

Water is composed of hydrogen and oxygen in a 2 to 1 ratio needed for body

Hydrogen Peroxide is H_2O_2 in a ratio of 2 to 2. Used as an antiseptic poisonous to body

DETERMINING ATOMIC STRUCTURE



Atomic Number is equal to the number of protons in the nucleus.

Abbreviated as Z

- It is like a social security number because it identifies the element.
- No two elements have the same atomic number.

Element	# of protons	Atomic # (Z)
Carbon	6	6
Phosphorus	15	15
Gold	79	79

MASS NUMBER

Mass number is the number of protons and neutrons in the nucleus of an isotope.

$$\text{Mass \#} = p^+ + n^0$$

Nuclide	p^+	n^0	e^-	Mass #
Oxygen - 18	8	10	8	18
Arsenic - 75	33	42	33	75
Phosphorus - 31	15	16	15	31

Mass # is abbreviated as *A*

NUCLEAR SYMBOLS

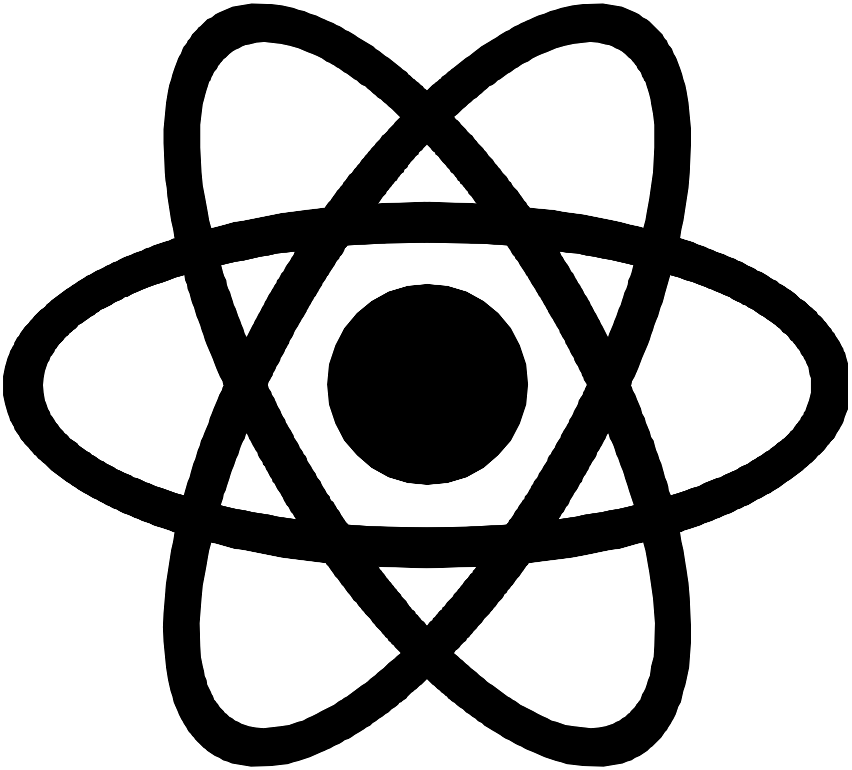
Mass number
(p^+ + n^o)

Element symbol

$$^{235}_{92}U$$

Atomic number
(number of p^+)

VALENCE ELECTRONS

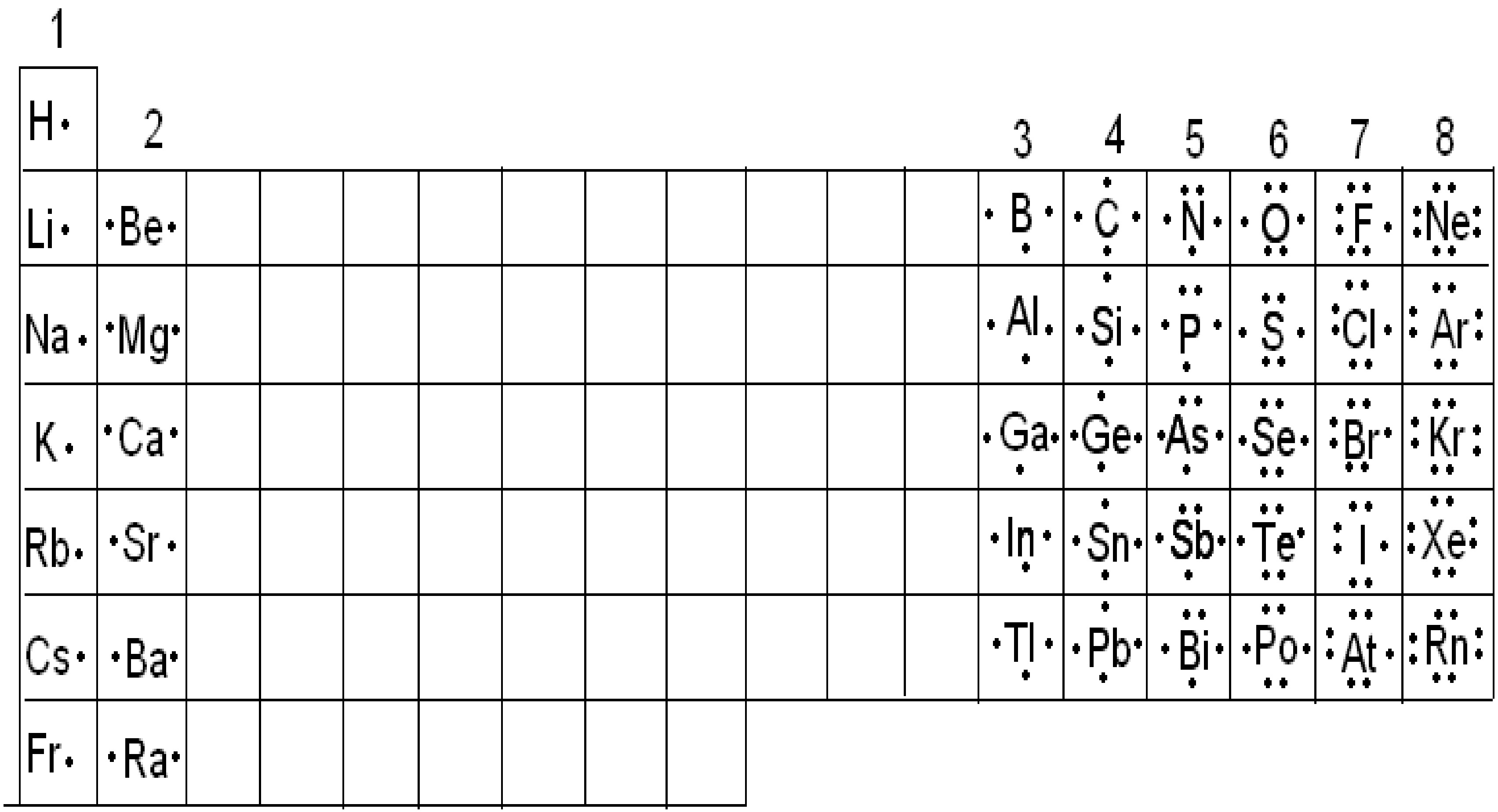


Valence electrons: an electron that is able to be lost gained or shared during bonding, due to it's location in the outer shell of the electron cloud.

Number of Valence electrons = group number

LEWIS DOT DIAGRAMS

Shows the kernel of the atom (all inner shells and nucleus) as the symbol and dots represent the outer electrons- Valence Electrons



TYPES OF RADIOACTIVE DECAY

$2+$

- **alpha production (α): helium nucleus**

$$^{238}_{92}U \rightarrow {}^{4}_{2}He + {}^{234}_{90}Th$$

- **beta production (β):**

$$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e$$

NUCLEAR FISSION AND FUSION

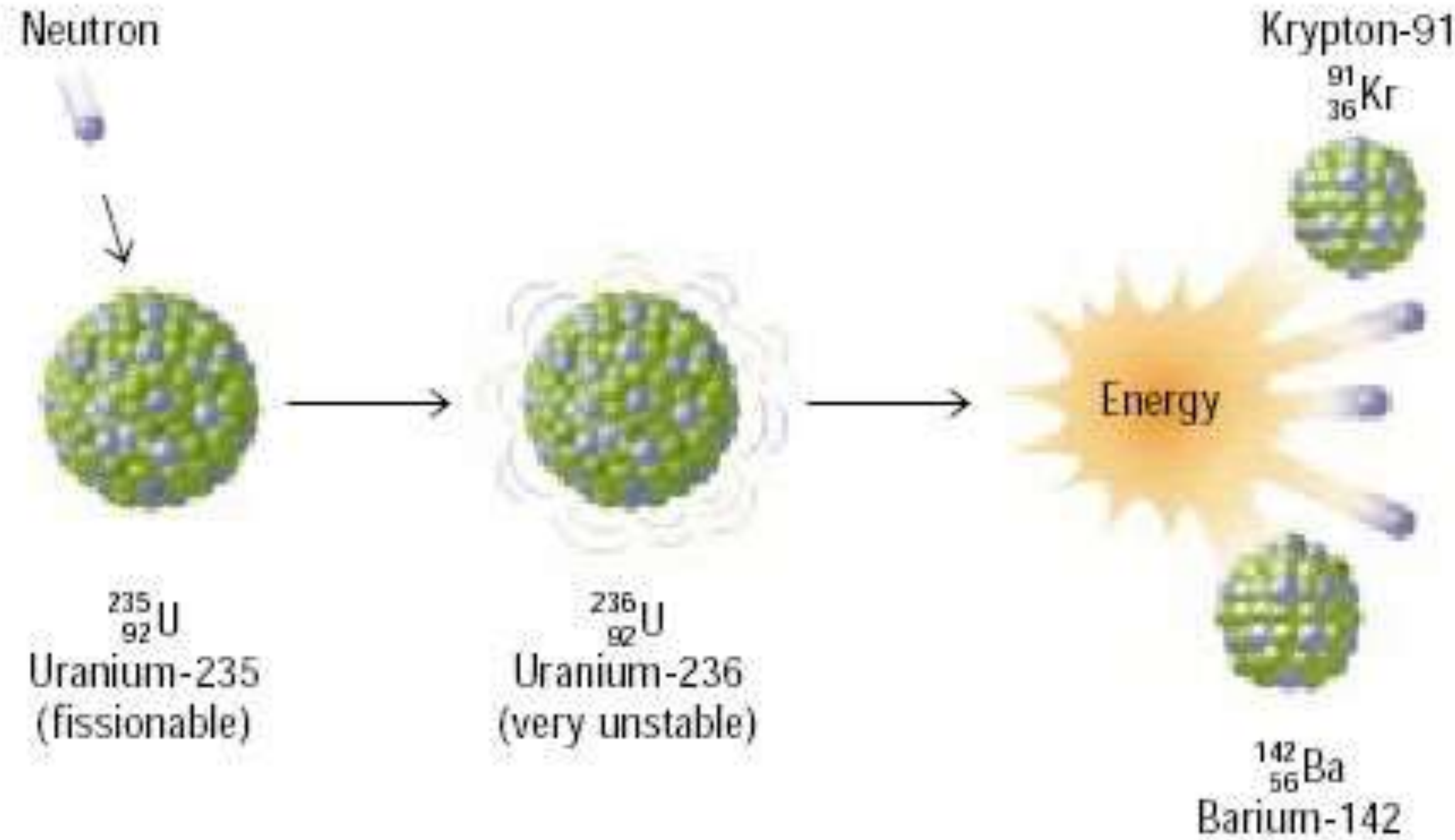
Fusion: **Combining two light nuclei to form a heavier, more stable nucleus.**

$$^{3}_{2}\text{He} + ^{1}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + ^{0}_{1}\text{e}$$

Fission: **Splitting a heavy nucleus into two nuclei with smaller mass numbers.**

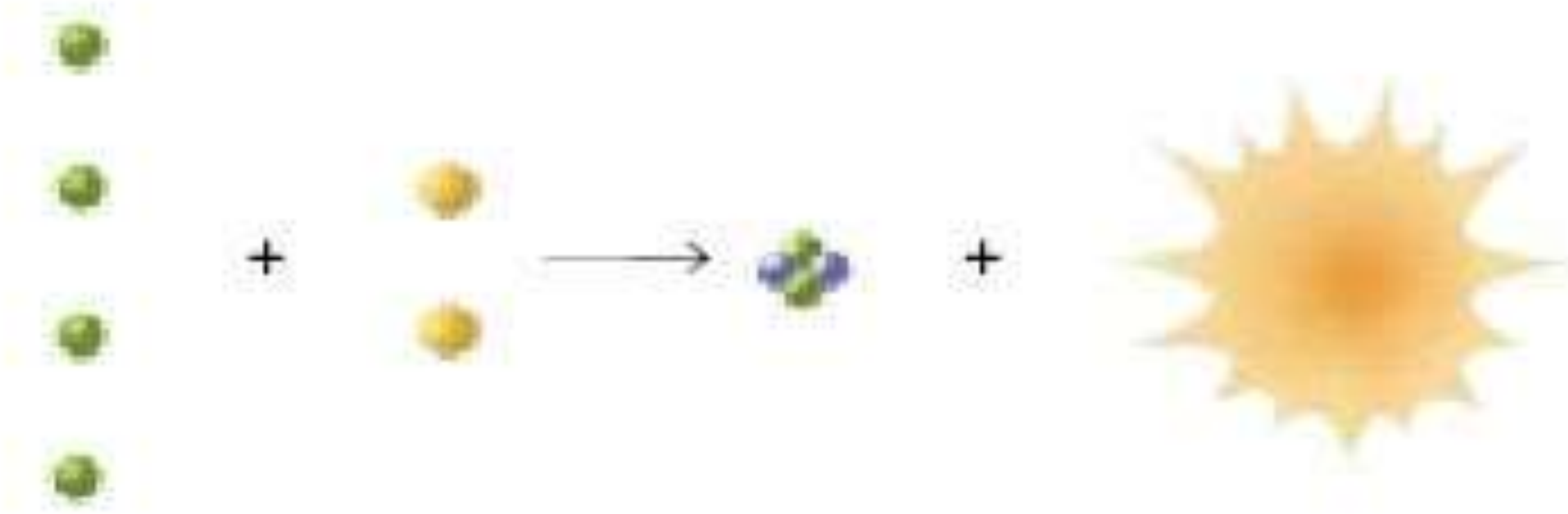
$$^{1}_{0}\text{n} + ^{235}_{92}\text{U} \rightarrow ^{142}_{56}\text{Ba} + ^{91}_{36}\text{Kr} + 3^{1}_{0}\text{n}$$

FISSION



Neutron
Krypton-91
$^{91}_{36}Kr$
Energy
$^{235}_{92}U$
Uranium-235
(fissionable)
$^{236}_{92}U$
Uranium-236
(very unstable)
$^{142}_{56}Ba$
Barium-142

FUSION



$$4\,^{1}_{1}H + 2\,^{0}_{-1}e \longrightarrow \,^{4}_{2}He + \text{Energy}$$

Four hydrogen nuclei (protons) + Two beta particles (electrons) → One helium nucleus + Energy

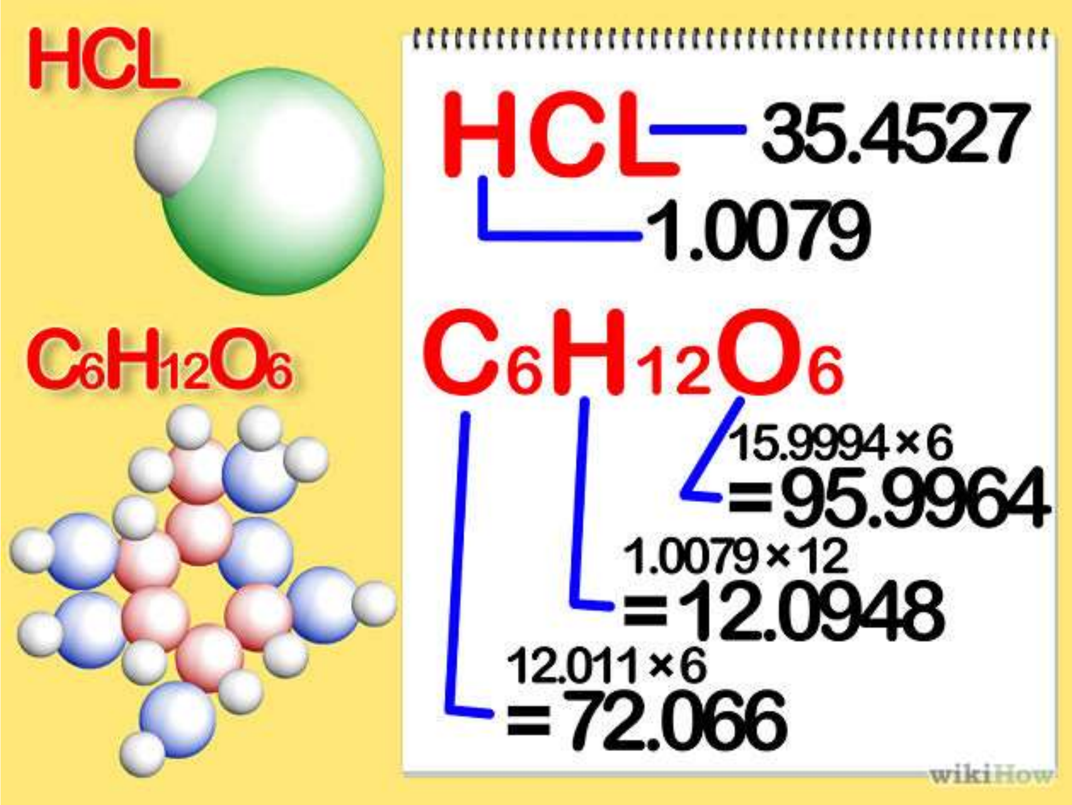
HALF-LIFE

Amount of time it takes for one half of a sample of radioactive atoms to decay

HALF-LIFE CALCULATION #1

You have 400 mg of a radioisotope with a half-life of 5 minutes. How much will be left after 30 minutes?

Find the molar mass of each element in the compound. Multiply the element's atomic mass by the molar mass constant by the number of atoms of that element in the compound. Here's how you do it:

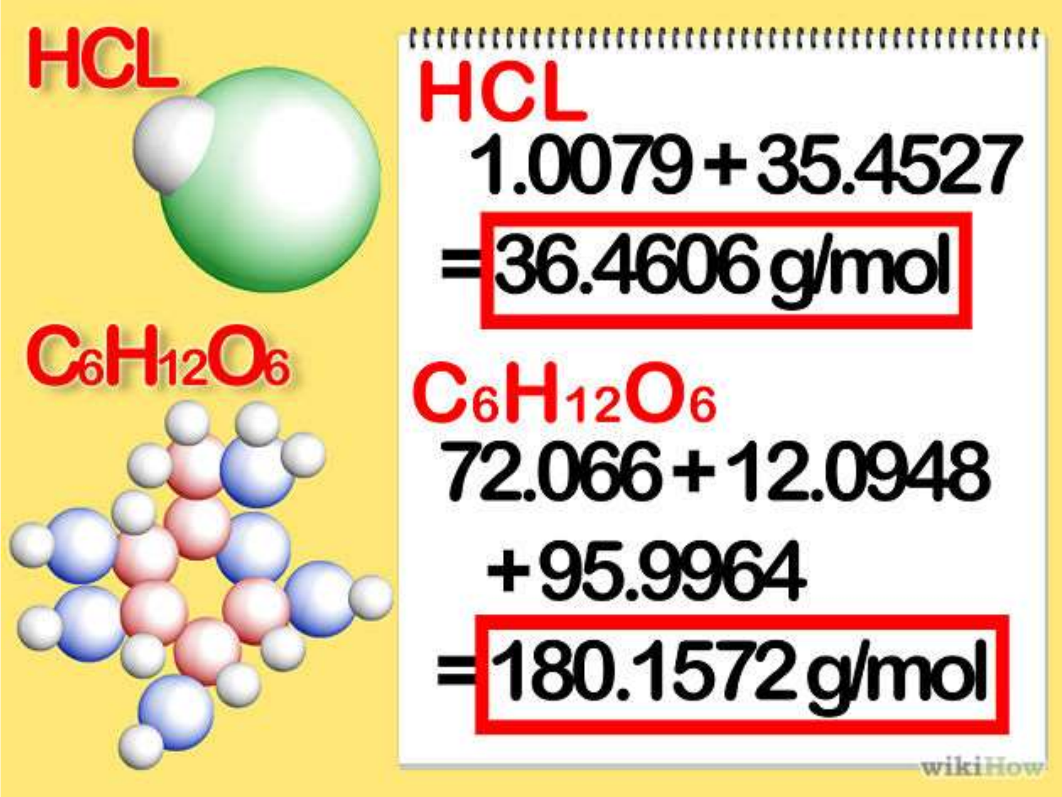


For hydrogen chloride, HCl, the molar mass of each element is 1.007 grams per mole for hydrogen and 35.453 grams per mole for chlorine.

For glucose, $C_6H_{12}O_6$, the molar mass of each element is 12.0107 times 6, or 72.0642 grams per mole for carbon; 1.007 times 12, or 12.084 grams per mole for hydrogen; and 15.9994 times 6, or 95.9964 grams per mole for oxygen.

MOLAR MASS

Add the molar masses of each element in the compound. This determines the molar mass for the compound. Here's how you do it:



For hydrogen chloride, the molar mass is 1.007 + 35.453, or 36.460 grams per mole.

For glucose, the molar mass is 72.0642 + 12.084 + 95.9964, or 180.1446 grams per mole.

CALCULATING PERCENT BY MASS

What is the percent by mass of metal in the compound copper II phosphate? ($Cu_3(PO_4)_2$)

Find total mass

Find mass due to the part

Divide mass of part by total

Multiply by 100

($Cu_3(PO_4)_2$)

subscript → from P.T.

Cu 3 x 63.55 +

P 2 X 30.97 +

O 8 x 16.00 =

Total mass= 380.59 amu

Mass of metal = 190.7 amu

$$\frac{190.7}{380.59} \times 100 = 50.1\%$$

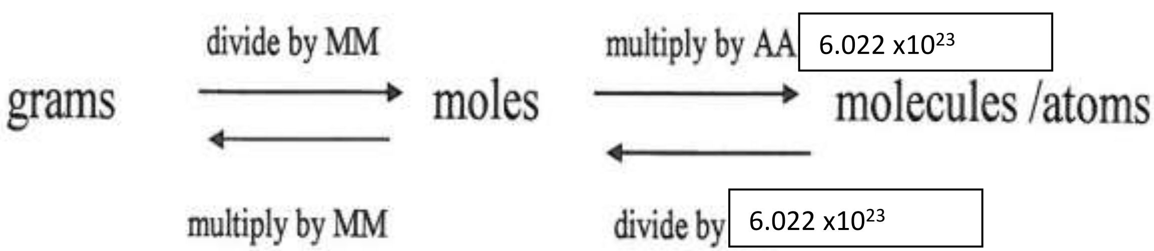
WHAT ARE MOLES??

Chemistry counting unit

Used to count atoms or particles

One mole of any substances contains 6.022×10^{23} atoms or particles

- Particles is somewhat of a generic term that represents a minute piece of matter; like an atom, ion or molecule.



EXAMPLES

How many atoms of Carbon are in 2.25 moles of C?

$$2.25\ \text{mol C}\left(\frac{6.022\text{x}10^{23}\ \text{atoms C}}{1\ \text{mol C}}\right) = 1.35\text{x}10^{24}\ \text{atoms C}$$

How many grams are in 3.456 moles of Calcium?

$$3.456\ \text{mol Ca}\left(\frac{40.08\ \text{g Ca}}{1\ \text{mol Ca}}\right) = 138.1648 = 138.2\text{g Ca}$$

How many atoms are in 340g of Magnesium?

$$340\ \text{g Mg}\left(\frac{1\ \text{mol Mg}}{24.30\text{g Mg}}\right)\left(\frac{6.022\text{x}10^{23}\ \text{atoms Mg}}{1\ \text{mol Mg}}\right) = 8.4\text{x}10^{24}\ \text{atoms Mg}$$

Determining the Formula of a Hydrate

Name ____________________

Chem Worksheet 11-6

A **hydrate** is an ionic compound that contains water molecules in its structure. To determine the formula of a hydrate experimentally, we must calculate the mole: mole ratio of the water portion compared to the anhydrate portion. An **anhydrate** is the substance that remains after the water is removed from a hydrate. When a hydrate is heated the water molecules are driven off as steam, leaving behind the water-free anhydrate.

The first step to finding the formula for a hydrate is to record the mass of the hydrate. After heating the hydrate, the mass is determined for the anhydrate that remains. The mass of the water that was present is calculated by finding the difference between the mass of the hydrate and the mass of the anhydrate. The mass of the water and the mass of the anhydrate are each converted to moles using their respective molar masses. From this a whole number ratio can be determined (see example).

Data Table

Mass of hydrate ($CaCl_2 \cdot xH_2O$)	4.72 g
Mass of anhydrate ($CaCl_2$)	3.56 g
Mass of water	1.18 g

Example

A calcium chloride hydrate has a mass of 4.72 g. After heating for several minutes the mass of the anhydrate is found to be 3.56 g. Use this information to determine the formula for the hydrate.

- find the mass of the water driven off:

mass of hydrate – mass of anhydrate = mass of water

4.72 g – 3.56 g = 1.18 g

- convert the mass of anhydrate to moles:

$$\frac{3.56\ \text{g}\ CaCl_2}{1} \times \frac{1\ \text{mol}\ CaCl_2}{110.98\ \text{g}\ CaCl_2} = 0.0321\ \text{mol}\ CaCl_2$$

- convert the mass of water to moles:

$$\frac{1.18\ \text{g}\ H_2O}{1} \times \frac{1\ \text{mol}\ H_2O}{18.02\ \text{g}\ H_2O} = 0.0655\ \text{mol}\ H_2O$$

- find the mole H_2O to mole $CaCl_2$ ratio:

$$\frac{0.0655\ \text{mol}\ H_2O}{0.0321\ \text{mol}\ CaCl_2} = \frac{2\ \text{mol}\ H_2O}{1\ \text{mol}\ CaCl_2}$$

Finding an Empirical Formula from Experimental Data

1. Find # of g of each element.
2. Convert each g to mol.
3. Divide each "# of mol" by the smallest "# of mol."
4. Use whole number ratio to find formula.

A compound is 45.5% yttrium and 54.5% chlorine. Find its empirical formula.

$$45.5\ \text{g Y}\left(\frac{1\ \text{mol Y}}{88.9\ \text{g Y}}\right) = 0.512\ \text{mol Y} \div 0.512 \rightarrow 1$$

$$54.5\ \text{g Cl}\left(\frac{1\ \text{mol Cl}}{35.5\ \text{g Cl}}\right) = 1.535\ \text{mol Cl} \div 0.512 \rightarrow 3$$

YCl_3

A ruthenium/sulfur compound is 67.7% Ru. Find its empirical formula.

$$67.7\ \text{g Ru}\left(\frac{1\ \text{mol Ru}}{101.1\ \text{g Ru}}\right) = 0.670\ \text{mol Ru} \quad \div\ 0.670 \rightarrow 1$$

$$32.3\ \text{g S}\left(\frac{1\ \text{mol S}}{32.1\ \text{g S}}\right) = 1.006\ \text{mol S} \quad \div\ 0.670 \rightarrow 1.5$$

Multiply each by 2 to get to next whole number → Ru_2S_3

To find molecular formula…

A. Find empirical formula.

B. Find molar mass of empirical formula.

C. Find $n = \frac{\text{mm molecular}}{\text{mm empirical}}$

D. Multiply all parts of empirical formula by n.

(How many empiricals “fit into” the molecular?)

A carbon/hydrogen compound is 7.7% H and has a molar mass of 78 g. Find its molecular formula.

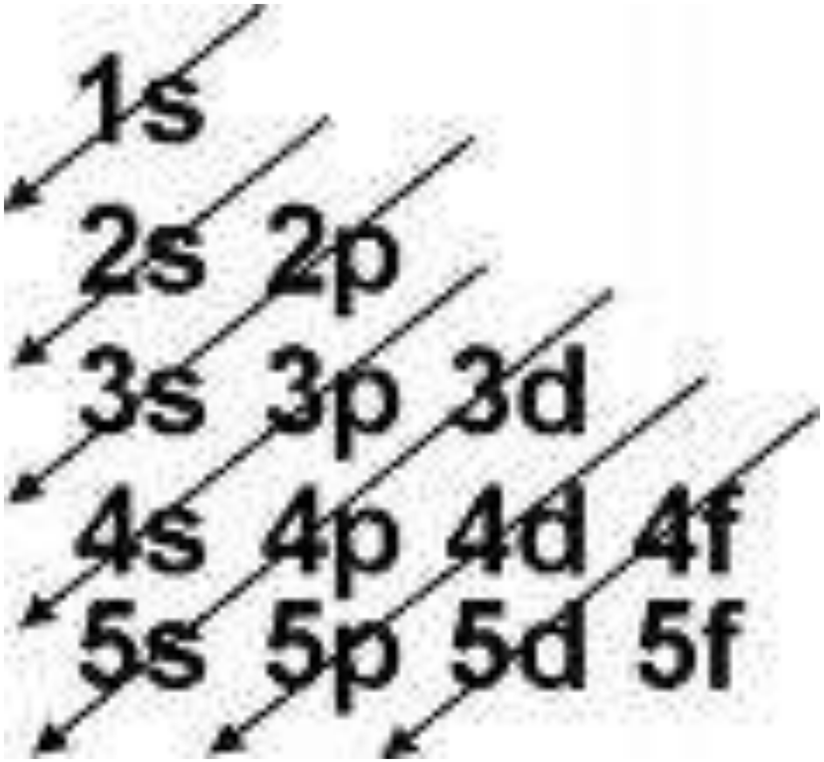
$$7.7\ \text{g H} \left(\frac{1\ \text{mol H}}{1.0\ \text{g H}}\right) = 7.7\ \text{mol H} \div 7.69 \rightarrow 1$$

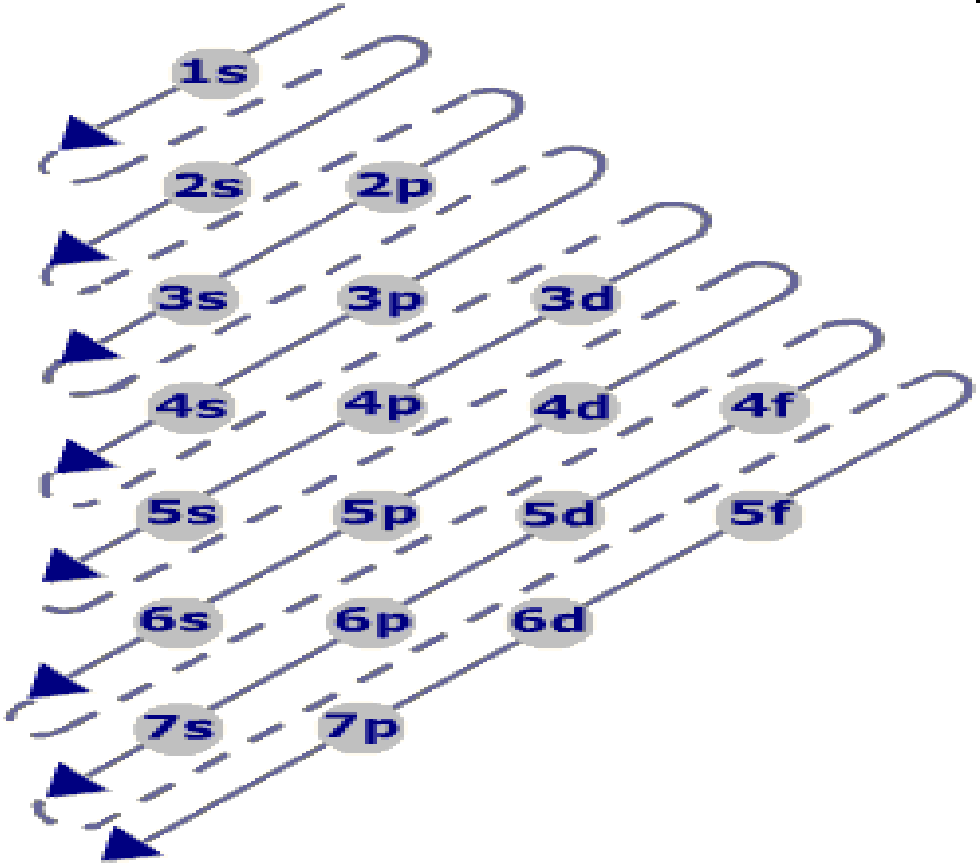
$$92.3\ \text{g C} \left(\frac{1\ \text{mol C}}{12.0\ \text{g C}}\right) = 7.69\ \text{mol C} \div 7.69 \rightarrow 1$$

emp. form. → <u>CH</u>

$$mm_{emp} = 13\ \text{g} \longrightarrow \frac{78\ \text{g}}{13\ \text{g}} = 6 \longrightarrow \boxed{C_6H_6}$$

HOW DO ELECTRONS FILL IN AN ATOM? THE DIAGONAL RULE





HOW TO FILL

1 Find total # of electrons

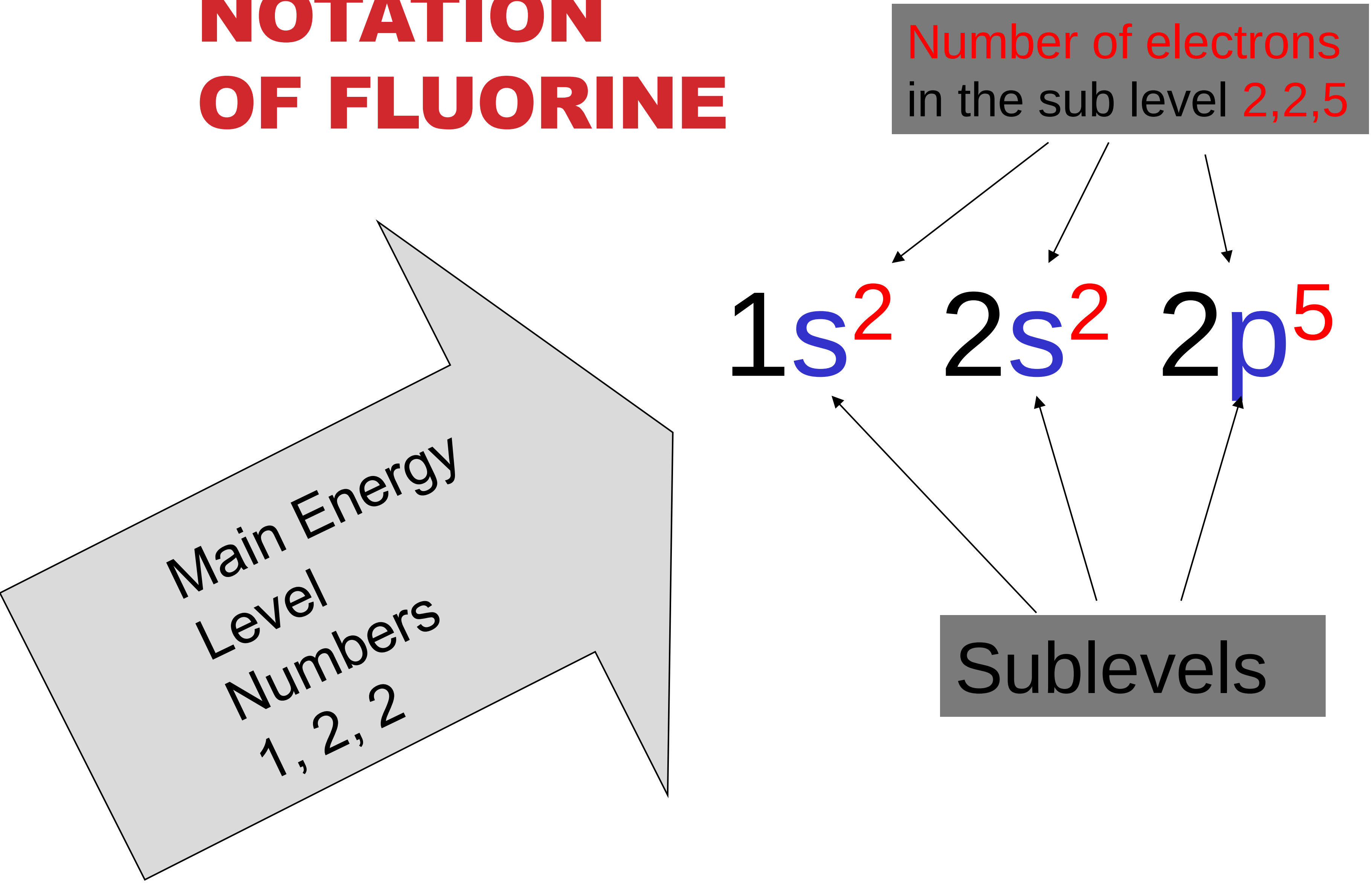
2 Write subshells in order of diagonal rule

3. Fill in subshells till all electrons are used

4. Last subshell may be partially filled.

Sublevel	# of electrons can hold
S	2
P	6
D	10
F	14

STANDARD NOTATION OF FLUORINE



STEPS FOR NOBLE GAS CONFIGURATION

1 Find element on periodic table.
2 Find number of electrons
3 Find Group 8 element from period above target element
4 Write group 8 element symbol in [brackets]
5 Subtract noble gases electrons from initial elements
6 Start filling from S subshell of initial elements period # til all electrons are placed

Orbital Notation or Diagrams

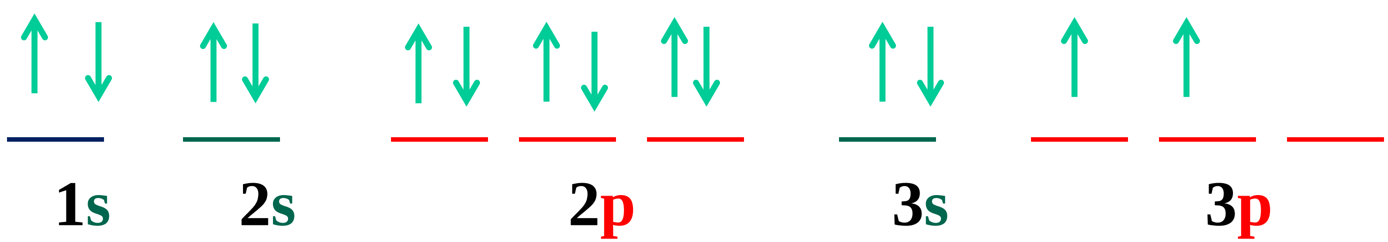
Simply use horizontal lines and arrows instead of exponents to represent the electrons

1 arrow = 1electron   Each line holds 2 electrons

# of lines for S P D F must be able to hold same number of electrons as in longhand electron configuration

S = 2e$^-$ so 1 line   P= 6e$^-$ so 3 lines   d=10e$^-$ so 5 lines

f= 14e$^-$ so 7 lines

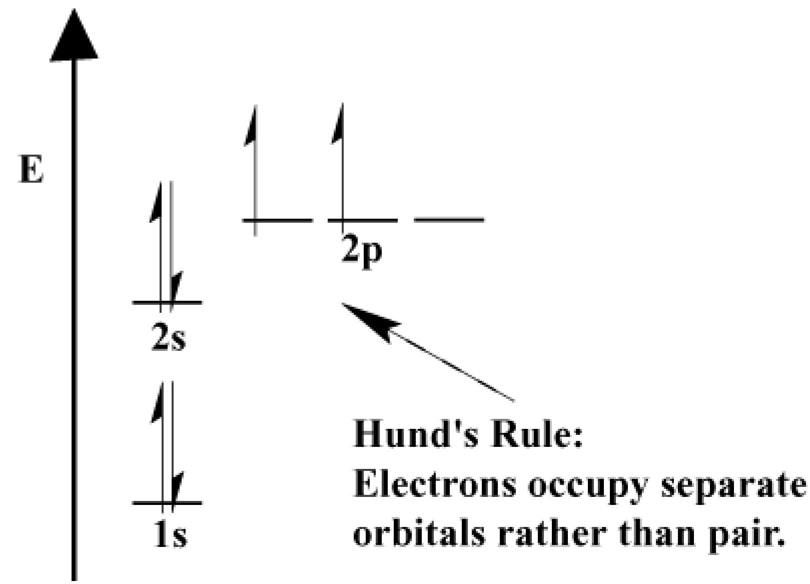


Rules for electron filling:

- Aufbaus Rule- must fill the lowest energy level available first!
- Hunds Rule -1 electron in each orbital of a sublevel before pairing begins

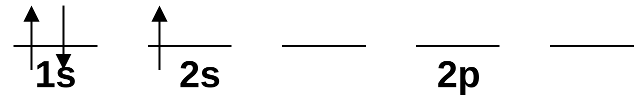
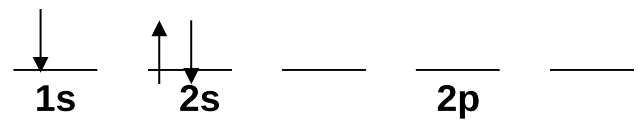
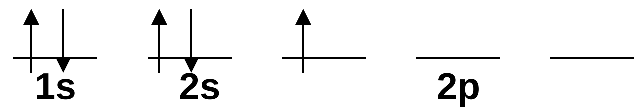
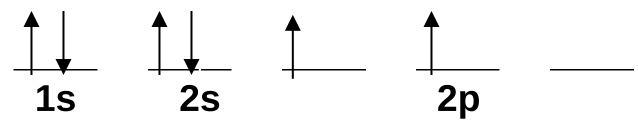
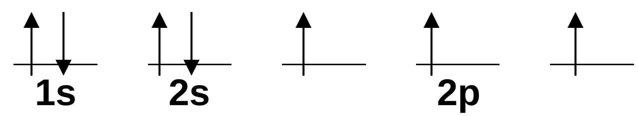
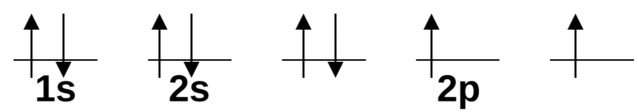
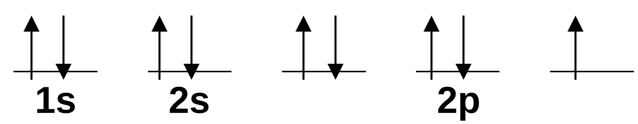
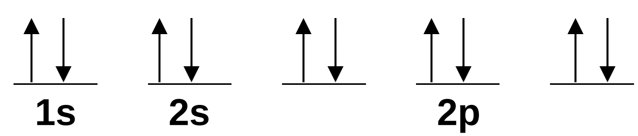
Must fill all seats on the bus before doubling up!

- Pauli Exclusion Principle-2 electrons occupying the same orbital must have opposite spins- 1 up 1 down



Things you must accept to do orbital Diagrams (energy diagrams)

- Energy builds further away from the nucleus
- Each line represents an orbital
- Each orbital can hold only two electrons
- We as a group will decide to place positive spin arrows in first this is arbitrary NOT A RULE Just so all our QNS are the same
- Each electron is represented by an arrow
- In an orbital the two electrons must point in different directions
- Remember from the diagonal rule 4s fills before 3d breaking Aufbau's Rule

Element	Configuration notation	Orbital notation	Noble gas notation
Lithium	$1s^2 2s^1$		$[He]2s^1$
Beryllium	$1s^2 2s^2$		$[He]2s^2$
Boron	$1s^2 2s^2 p^1$		$[He]2s^2 p^1$
Carbon	$1s^2 2s^2 p^2$		$[He]2s^2 p^2$
Nitrogen	$1s^2 2s^2 p^3$		$[He]2s^2 p^3$
Oxygen	$1s^2 2s^2 p^4$		$[He]2s^2 p^4$
Fluorine	$1s^2 2s^2 p^5$		$[He]2s^2 p^5$
Neon	$1s^2 2s^2 p^6$		$[He]2s^2 p^6$