Objective 3

Write chemical formulas of ionic and molecular compounds.
Determine mole ratio of elements in compounds.
Name ionic and molecular compounds.

(John Dalton: Atoms combine in whole number ratios to form compounds)

*Chemical Formula Tells Us the **Ratio** of Elements in a Compound*

The ***subscripts*** represent the number of each element in one molecule/particle or ***moles*** of each element in one mole of the compound.

12 eggs = 1 dozen eggs
24 sodas = 1 case
144 = 1 gross (a dozen dozen)
42 gallons of oil = 1 barrel

6.02 x 10^{23} = 1 mole (Avogadro's number, "chemist's dozen")

(John Dalton: Atoms combine in whole number ratios to form compounds)

*Chemical Formula Tells Us the **Ratio** of Elements in a Compound*

Is H_2O the same as H_2O_2? Yes No

(John Dalton: Atoms combine in whole number ratios to form compounds)

*Chemical Formula Tells Us the **Ratio** of Elements in a Compound*

Is H_2O the same as H_2O_2? Yes No

See Subscripts: 1 H_2O has 2 H and 1 O

1 H_2O_2 has 2 H and 2 O

Objective: relate moles to chemical formula

How many atoms of H are in 20 water molecules?

How many atoms of O are in 20 water molecules?

Think: Conversions
What is the Conversion Factor?

Why Use Moles? We can't see one atom or molecule of a substance (size of 1 H_2O molecule = 0.2 nm) but we can see one mole of a substance (1 mole of H_2O = 18 g).

Example:

H_2O = 2 atoms of H and 1 atom of O in 1 molecule

Or

2 moles of H and 1 mole of O in 1 mole of H_2O

Think: Conversions
What is the Conversion Factor?

In 20 water molecules, 40 H atoms and 20 O atoms.

Objective: relate moles to chemical formula

How many moles of H are in 4.5 moles of water?

How many moles of O are in 4.5 moles of water?

Think: Conversions
What is the Conversion Factor?

In 4.5 moles of water, 9 moles of H and 4.5 moles of O.

Objective: relate moles to chemical formula

How many moles of C are in 4.5 moles of glycine (the simplest amino acid), H_2NCH_2COOH?

How many moles of H are in 4.5 moles of glycine (the simplest amino acid), H_2NCH_2COOH?

How many moles of O are in 4.5 moles of glycine (the simplest amino acid), H_2NCH_2COOH?

Think: Conversions

In 4.5 moles of glycine (the simplest amino acid), H_2NCH_2COOH, 9 moles C, 22.5 moles H, 9 moles O, 4.5 moles N.

Objective: relate moles to chemical formula

How many moles of C are in 4.5 moles of ethanol, C_2H_5OH?

How many moles of H are in 4.5 moles of ethanol, C_2H_5OH?

How many moles of O are in 4.5 moles of ethanol, C_2H_5OH?

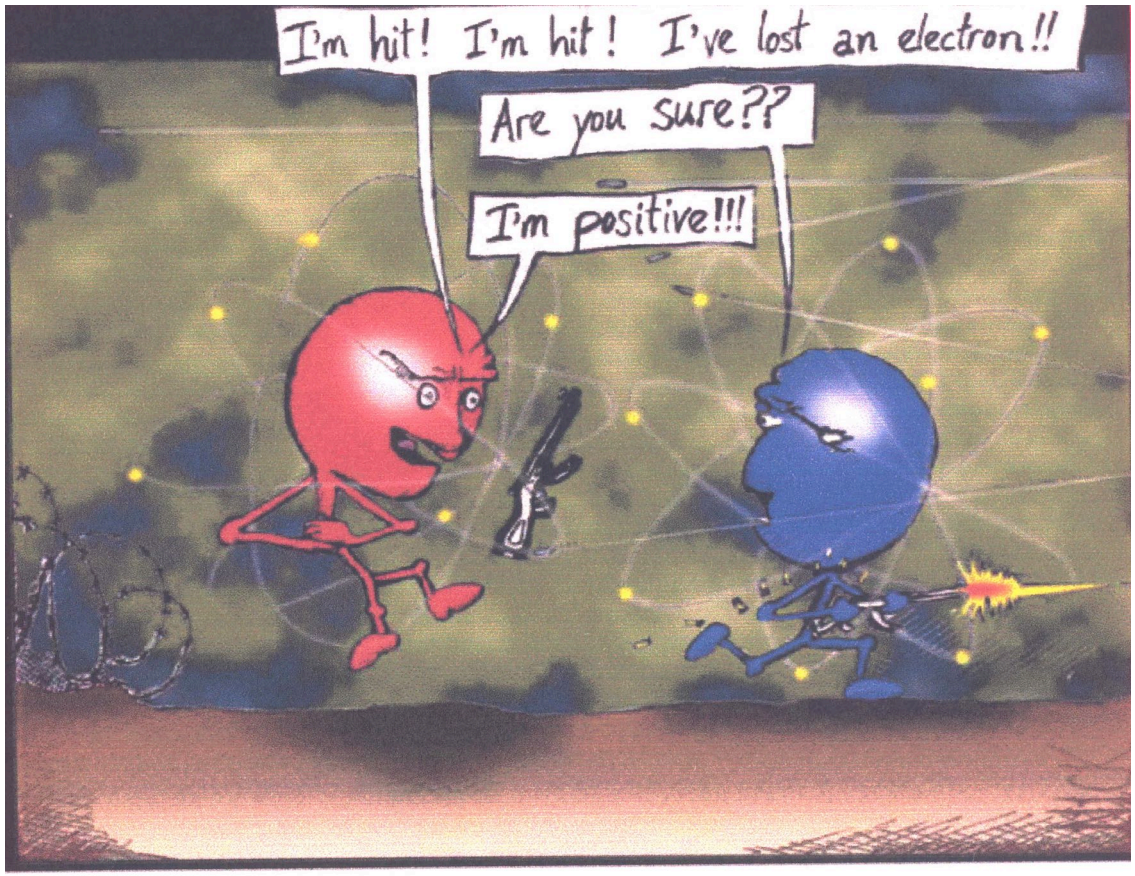
Think: Conversions

Objective: Identify and distinguish between atoms, molecules, and ions

How Do Ion(s) Form?

http://www.starlight-tower.com/the_thinker.html

Element: *same* number of protons and electrons.
Element exists all by itself.



Another casualty in the War of the Atoms.

Ions exist in compounds.

Ion: an element that has
gained electron(s) to form (-) ion (or ***anion***)
or lost electron(s) to form (+) ion (or ***cation***)

Ionic Charge Is Determined From the Periodic Table

Group Number (see Roman numeral) and Ionic Charge

a. Metals lose electrons to form cations.

Metal ion charge = Metal group number. See Fig. 2.10, p. 39.

b. Non-metals gain electrons to form anions.

Non-metal ion charge = Non-metal group number - 8

- Group Letter (next to Roman numeral)

A = Main Group element

B = Transition element

- Period Number

Atomic orbitals occupied by valence electrons. See Chapter 7.

Each Element has several ***Isotopes***.
An Isotope has the same number of _____ but a different number of _____.

Isotope	Mass Number	# of protons	# of electrons	# of neutrons
Hydrogen	1			
Deuterium	2			
Tritium	3			

What does atomic weight tell you about the most abundant isotope?

CHM 1A - we will look at most abundant isotope of elements

Application: "Isotopes Mark The Spot" (C&EN, 6/27/11, p. 32)

Isotope ratios vary around the world and are used to determine origin, migration routes, and authenticate items like bottled water and fancy foods.

"Dinosaur Thermometry" (C&EN, 6/27/11, p. 15)

Researchers: dinosaur's body temperature was the same as that of large modern-day mammals: 36–38°C by analyzing carbon and oxygen isotopes in the tooth enamel of ancient dinosaur fossils.

^{13}C and ^{18}O preferentially bind to one another. The precise amount of ^{13}C–^{18}O-rich carbonate in a tooth mineral is related to the temperature at which the tooth formed. E.g., animals with high body temperatures incorporate less ^{13}C–^{18}O-rich carbonate in their enamel than do animals with low body temperatures.

http://cen.acs.org/articles/88/i51/New-Format-Atomic-Weights.html

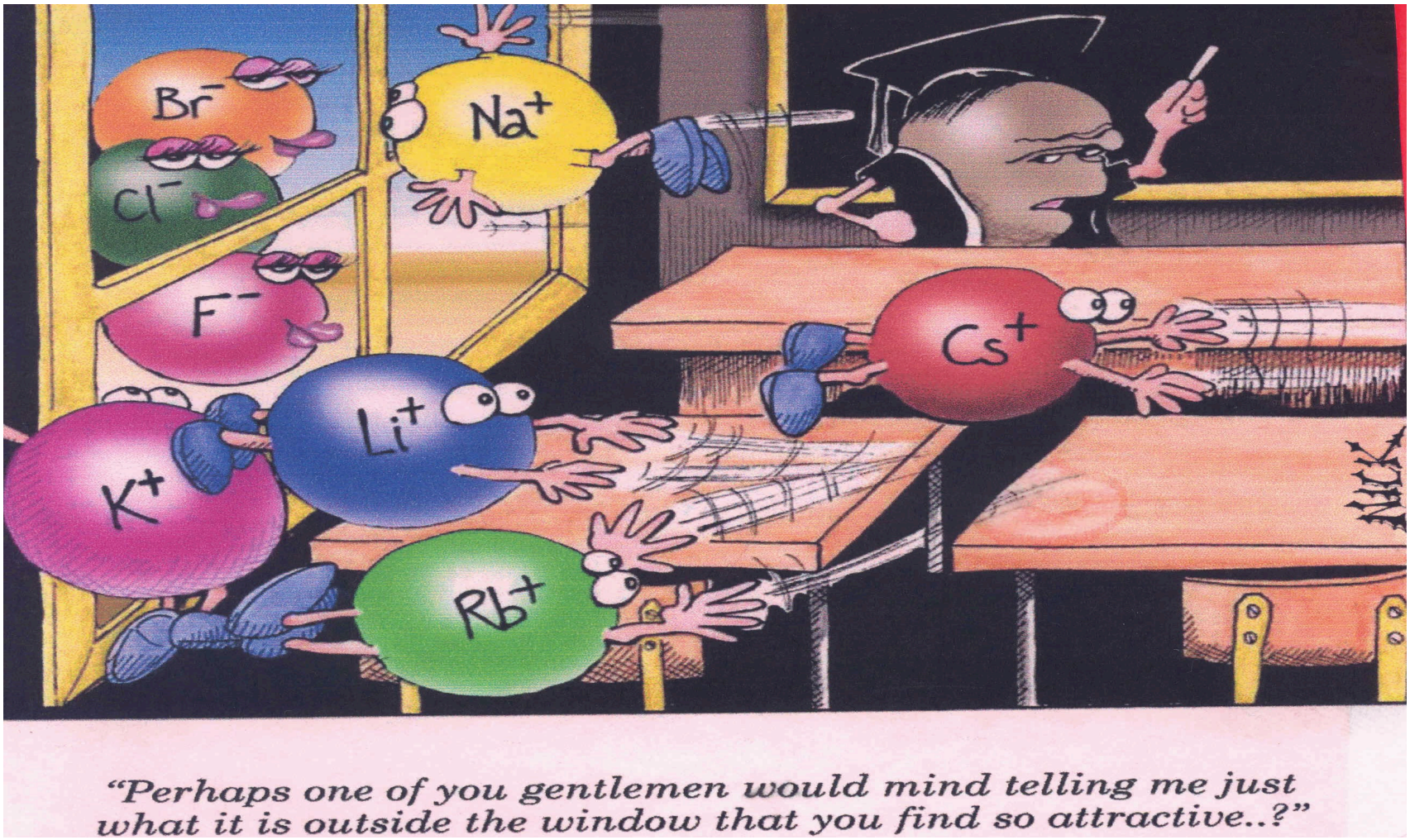
12/10/10, New Format For Atomic Weights

IUPAC is publishing a new table of standard atomic weights in which the values for 10 elements (H, Li, B, C, N, O, Si, S, Cl, Tl) will be given as mass ranges rather than single values to address the natural variation in a material's isotope abundances, which depend on the sample's physical, chemical, and nuclear history.

For example, boron's atomic mass until now has been given as 10.811 amu. The new tables will list the value as [10.806; 10.821] to reflect the element's true atomic weight, which can vary over that range depending on the material's source.

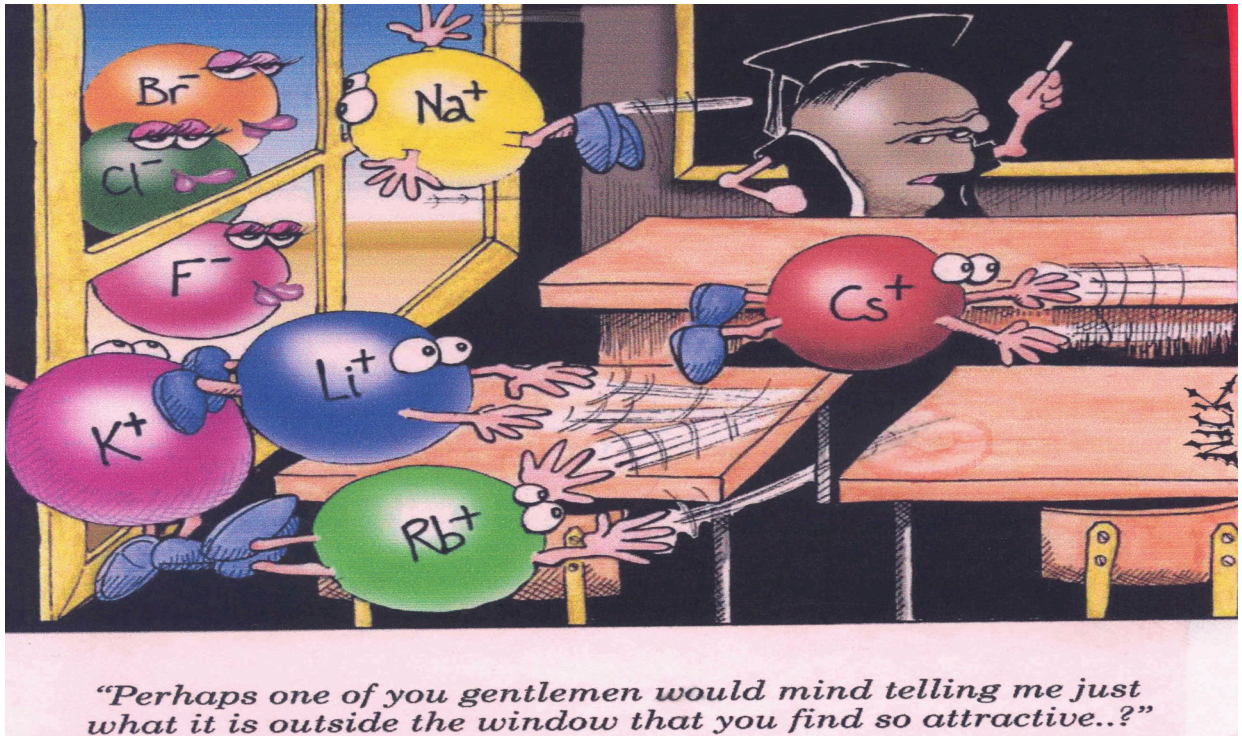
"We've grown up thinking that standard atomic weights given in the periodic table are constants of nature," says Tyler B. Coplen, an isotope specialist at the U.S. Geological Survey, in Reston, Va. Coplen, adds that that fact holds true only for elements with just one stable isotope.

What Scientific Principle Is Involved Here?



"Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive..?"

Charge Can Be Used to Write a Chemical Formula



Coulomb's law

Metal ion charge = Metal group number
Non-metal ion charge = Non-metal group number - 8
H has a charge = +1, O has a charge = -2, so H_2O
Na has a charge = +1, Cl has a charge = -1, so NaCl
Ca has a charge = +2, Cl has a charge = -1, so $CaCl_2$

Molecules gain/lose electrons to form Polyatomic Ions

One oxygen combines with one hydrogen to form the hydroxide ion. What is the charge on this polyatomic ion?

See *Table of Common Monoatomic and Polyatomic Ions*.

Name	Polyatomic Ion
Hydroxide	$OH^{(?)}$
Carbonate	CO_3^{2-}
Bicarbonate	HCO_3^-
Sulfate	SO_4^{2-}
Phosphate	PO_4^{3-}
Nitrate	NO_3^-
Ammonium	NH_4^+

Communication is Important!

Ionic Compounds: Name Metal 1st, followed by Non-Metal using the "-ide" suffix.

If you see a compound with a metal and 2 or more different non-metals, think polyatomic ion.

a. CaO = calcium oxide

b. Na_3PO_4 =sodium phosphate

c. Calcium carbonate = $CaCO_3$

d. $NaHCO_3$ = sodium bicarbonate or sodium hydrogen carbonate

Molecular Compounds Name in order of Chemical Formula using "mono-", "di-", etc. prefix and "-ide" suffix on last element.

CO = carbon monoxide

N_2O = dinitrogen monoxide

Write the chemical formula of a compound that contains the following ions:

sodium and iodide	(used to treat iodine def.)
calcium and oxygen	(lime)
calcium and sulfate	(used in Plaster of Paris)
magnesium and hydroxide	(used in Milk of Magnesia)
ammonium and nitrate	(used in fertilizer)

Give the name or chemical formula of the following compounds:

a. CaO

b. Na_3PO_4

c. Calcium carbonate

d. $NaHCO_3$

e. CO

f. N_2O

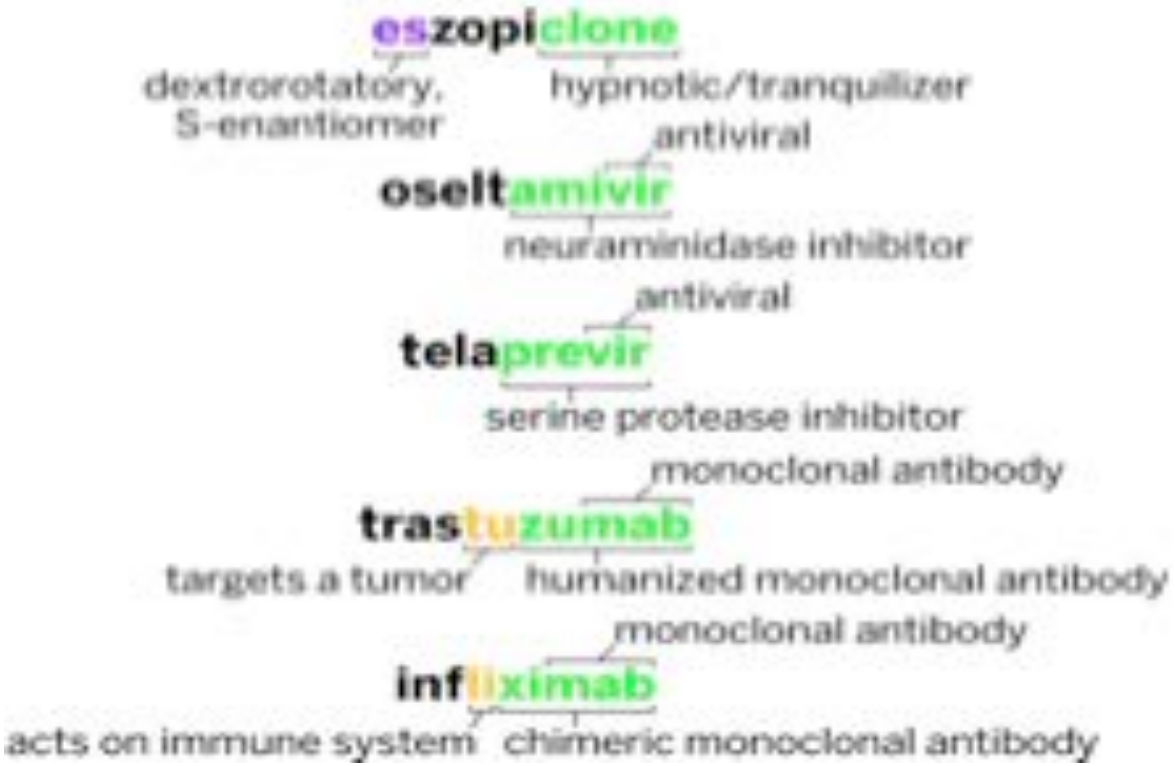
Communication is Important: Naming Acids

NOTE: an **Acid** has to have H in its chemical formula (usually written first in chemical formula)

Binary Acids Contain H and a 2nd element
Naming: use "hydro-" prefix, "-ic" suffix, followed by acid
E.g., HCl = hydrochloric acid

Ternary Acids Contain H, O, and a 3rd element
Naming: remove H to determine polyatomic ion.
If polyatomic ion suffix is "-ate" ===> use "-ic" suffix, followed by acid.
If polyatomic ion suffix is "-ite" ===> use "-ous" suffix, followed by acid.
E.g., H_2SO_4 remove H ==> SO_4^{2-} = sulfate
so H_2SO_4 = sulfuric acid

How are drugs named? Where do drug names come from?



http://www.ama-assn.org/resources/doc/usan/stem-list-cumulative.pdf

Name the following compounds.
Which compound(s) is/are acids?
Which compound(s) is/are bases?

Formula	Compound Type	Name
CO	Molecular	Carbon monoxide
CO_2		
K_2CO_3		
P_2O_5		
NaOH		
HCl (g)		
HCl (aq)		
H_3PO_4		
Na_3PO_4		

'Super' Mineral (http://pubs.acs.org/cen/newscripts/85/8532newscripts.html CEN, 8/6/07, p. 48)

Supervillain Lex Luthor no longer needs to steal KRYPTONITE from museums to fight Superman. Thanks to geologists at Rio Tinto, a London-based mining company, Luthor can get it free in Serbia. All he'll need is a shovel.

The museum heist scene in last year's "Superman Returns" revealed **kryptonite's composition** to movie fans: **sodium lithium boron silicate hydroxide with fluorine**. Around the same time, far from theaters and beneath the surface of Serbia's Jadar Basin, Rio Tinto geologists stumbled upon an unknown mineral. They sent a sample to London's Natural History Museum (NHM) for identification. Museum mineralogists knew they had a new mineral on their hands, but they had to prove it.

This mineral "was somewhat unusual, in that there was lots of material available, but the crystals were less than 5 μm in size-too small for conventional single-crystal analysis," says Pamela Whitfield, a researcher with Canada's National Research Council. By combining specialty X-ray powder diffraction techniques and computational methods, Whitfield's team determined the crystal's structure as well as its composition, $LiNaSiB_3O_7(OH)$ (Acta Cryst. 2007, B63, 396)—like the cinematic kryptonite sans fluorine. It was a near match that Whitfield failed to notice but that was not lost on Chris Stanley, a mineralogist at NHM.

The International Mineralogical Association has since recognized the Jadar Basin mineral as new, but to the disappointment of Superman fans, named it "jadarite."

Is it green? Does it glow? Is it radioactive? "No, no, no," says Whitfield. Most likely, jadarite does not have the power to hurt a fly, let alone a flying superhero. August 6, 2007, p. 48

(John Dalton: Atoms combine in whole number ratios to form compounds)

*Chemical Formula Tells Us the **Ratio** of Elements in a Compound*

The ***subscripts*** represent the **number of each element** in one molecule/particle or ***moles*** of each element in one mole of the compound.

12 eggs = 1 dozen eggs
24 sodas = 1 case
144 = 1 gross (a dozen dozen)
42 gallons of oil = 1 barrel

6.02 x 10^{23} = 1 mole (Avogadro's number, "chemist's dozen")

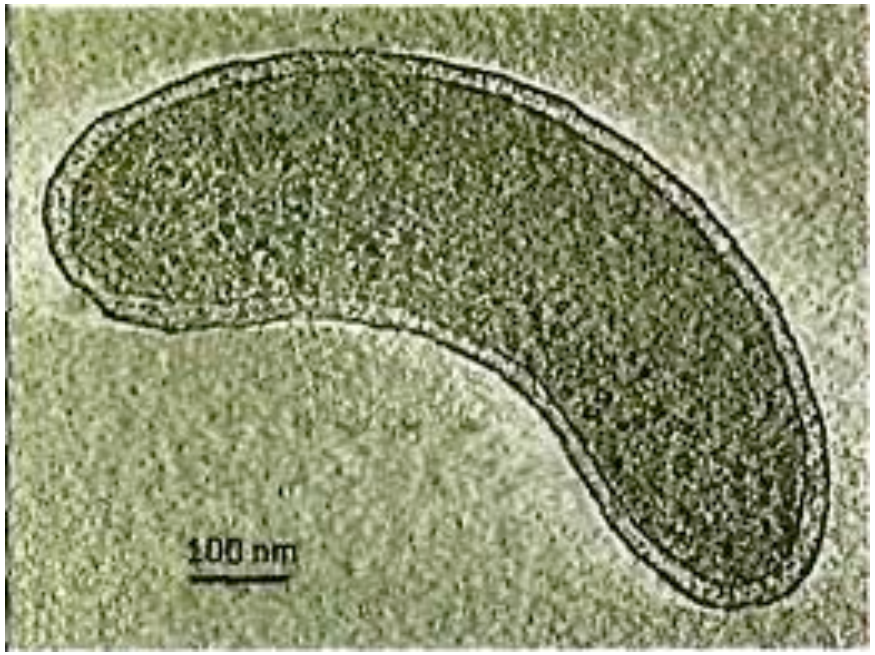
Mole Day = October 23 from 6:02 am to 6:02 pm

1 mole of pennies distributed evenly to each person in the world (7 billion people) = each person could spend $1 million per second for one year.

1 mole of paper clips (3 cm) linked together would wrap around the Earth's equator 1.3 billion times.
(From C&EN, 10/24/11, Newscripts, p. 56)

Ocean based Pelagibacter ubique has an estimated population of $10^{28} \approx 30\%$ of all living things.

It is one of the smallest self-replicating cells known, with a length of 0.37-0.89 μm and a diameter of only 0.12-0.20 μm. 30% of the cell's volume is taken up by its genome. It is gram negative. It recycles dissolved organic carbon. It undergoes regular seasonal cycles in abundance - in summer reaching ~50% of the cells in the temperate ocean surface waters and plays a major role in the Earth's carbon cycle. (http://en.wikipedia.org/wiki/Pelagibacter_ubique)



How many moles of this bacteria exist?

Hint: do a conversion.

http://problemas-microbiologia.blogspot.com/2010/01/cuanto-pesa-la-biomasa-de-un-microbio.html