CHEM 106

The Mole / Molar Mass
and
Molecular Formulas

Moles & Mass

How big is a mole?
(Not the animal, the other one.) - Daniel Dulek

https://www.youtube.com/watch?v=TEl4jeETVmg

The Mole

- *Definition: The* number *of carbon atoms in exactly 12 grams of pure ^{12}C. The* number *equals* **6.02×10^{23}** *atoms.*
- ✓ *1 mole =* **6.02×10^{23} units of anything**
- **6.02×10^{23}** *"units" of atoms, people, ants, stars, $$$s, etc., etc. =* **1 mole**

There are about 7.4 billion people in the world.
How many moles of people are there?

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- ✓ *1 mole =* **6.02×10^{23} units of anything**
- **6.02×10^{23}** *people =* **1 mole**

7.4 x 10^{9} people / 6.02 x 10^{23} people / 1 mol =

1.2×10^{-14} mol

Avogadro's Number

Avogadro's number equals 1 mole
….which equals
6.022×10^{23} "units"

How many molecules are there in one half mole of oxygen?

3.011×10^{23} molecules of oxygen

Calculate the number of atoms of silicon in 0.367 moles of silicon.

What do you need ?

Avogadro's Number
1 mole = 6.02 x 10^{23} atoms

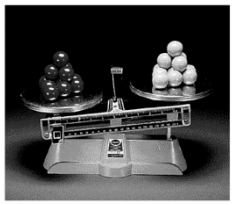
0.367 ~~mol~~ x 6.02 x 10^{23} atoms / 1 ~~mol~~ =

2.21×10^{23} atoms Si

What do you get if you divide an avocado into 6.02 x 10^{23} pieces?

guaca-mole!

Counting by Weighing



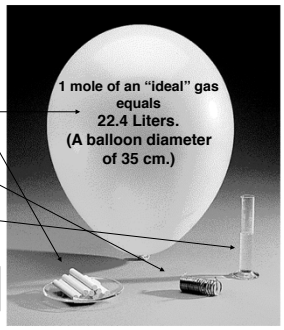
A
12 red marbles @ 7g each = 84g
12 yellow marbles @ 4g each=48g

B
55.85g Fe = 6.022 x 10^{23} atoms Fe
32.07g S = 6.022 x 10^{23} atoms S

Consult the Periodic Table

Relative Masses of 1 Mole

$CaCO_3$ *Name?*
100.09 g
Oxygen
32.00 g
Copper
63.55 g
Water
18.02 g



What is the volume of 1 mole of water?

Atomic and Molecular Weights
Mass Measurements

- ***^{1}H weighs 1.6735 x 10^{-24} g and ^{16}O 2.6560 x 10^{-23} g.***
- ***DEFINITION: mass of ^{12}C = exactly 12 amu.***
- ***Using atomic mass units:***
- ***1 amu = 1.66054 x 10^{-24} g***
- ***1 g = 6.02214 x 10^{23} amu***

Atomic and Molecular Weights

- ***Formula Weight a.k.a. Molecular Weight***
- ***Formula weights (FW): sum of Atomic Weights (AW) for atoms in formula.***
- ***FW (H_2SO_4) = 2AW(H) + AW(S) + 4AW(O)***
- ***= 2(1.0 amu) + (32.0 amu) + 4(16.0)***
- ***= 98.0 amu***

Atomic and Molecular Weights

- ***Molecular weight (MW) is the weight of the molecular formula in amu.***
- ***MW of sugar ($C_6H_{12}O_6$) = ?***
- ***MW = 6(12.0 amu) + 12(1.0 amu) + 6(16.0 amu)***
- ***= 180 amu***

Molar Mass

- *A substance's* **molar mass** *is the mass in grams of one mole of the element or compound. (Equals the formula weight: atomic or molecular weight in grams)*

Molar Mass CO_2 = ?

C = 12.01 grams per mole (g/mol)
O = 16.00 grams per mole (g/mol)
CO_2 = 44.01 grams per mole (g/mol)
12.01 + 2(16.00) = 44.01

Calculate the molar mass of potassium phosphate.

What do you need ?

1) Formula of potassium phosphate: K_3PO_4

2) Atomic Weights (molar mass) K = 39.10, P = 30.97, O = 16.00

3(39.10) + 30.97 + 4(16.00) = 212.27 g/mol

Calculate the mass in grams of 4.00 moles of sulfur.

What do you need ?

Atomic Weight sulfur (S) = 32.07

(molar mass) = 32.07 g/mol

4 mol $_{sulfur}$ x 32.07 g/mol $_{sulfur}$ = 128.3 g

Percent Composition

- *Mass percent of an element:*

$$\text{mass \%} = \frac{\text{mass of element in compound}}{\text{mass of compound}} \times 100\%$$

- *For iron in (Fe_2O_3), iron (III) oxide = ?*

$$\text{mass \% Fe} = \frac{111.69}{159.69} \times 100\% = 69.94\%$$

Which iron ore would you buy: one high in Fe_2O_3 or one high in FeO, Iron (II) oxide? 55.84 / 71.84 x 100 = 77.7%

Calculate the percentage composition for all the elements in an alkaloid with the molecular formula $C_{10}H_{14}N_2$.

What do you need ?

Molar mass $C_{10}H_{14}N_2$

C = 12.01, H = 1.01, N = 14.01

10(12.01) + 14(1.01) + 2(14.01) = 162.26 g/mol

120.1g/mol 14.14 g/mol 28.02 g/mol

120.1/ 162.26 x 100 = 74.02% | 14.14 / 162.26 x 100 = 8.71% | 28.02 / 162.26 x 100 = 17.27%

Formulas: Dalton's Law

- *Dalton's law of multiple proportions:*

When two elements form different compounds, the mass ratio of the elements in one compound is related to the mass ratio in the other by a small whole number.

Formulas: Multiple Proportions

http://chemconnections.org/general/movies/multiple-proportions.MOV

Formulas & Multiple Proportions

Components of acid rain, $SO_2(g)$ and $SO_3(g)$

- *Compound A contains:*
  1.000 g Sulfur & 1.500 g Oxygen
- *Compound B contains:*
  1.000 g Sulfur & 1.000 g Oxygen
- *Mass ratio A: 1 to 1.5; Mass ratio B: 1 to 1*
- *MUST adjust for atomic mass differences: AW sulfur is 2x the AW oxygen; therefore the oxygen ratios are 2x sulfur.*
- *S_1O_3 and S_1O_2 respectively*

Compounds with the Same Formula

[eg. $C_9H_8O_4$]

Aspirin
4-Hydroxyphenylpyruvic acid
Dihydroxycinnamic acids:
Caffeic acid (3,4-dihydroxycinnamic acid)
Umbellic acid (2,4-dihydroxycinnamic acid)
2,3-Dihydroxycinnamic acid
2,5-Dihydroxycinnamic acid
3,5-Dihydroxycinnamic acid

Molar Comparisons of Analgesics

Moles : Doses (mmol/dose)

Which analgesic has the most biologically active ingredient based on millimoles per dose (*mmol/dose*)?

5.0 g of each would produce the following number of doses:

	Formula	*Doses*	*mmol/dose*
Aspirin	$C_9H_8O_4$	15.4	
Ibuprofen	$C_{13}H_{18}O_2$	25	
Naproxen Sodium	$C_{14}H_{13}O_3Na$	22.7	
Acetaminophen	$C_8H_9NO_2$	5	

Molar Mass Aspirin = 180.1 g/mol
5.0 g */ 180.1 g/mol = 0.028 mol = 28 mmol*