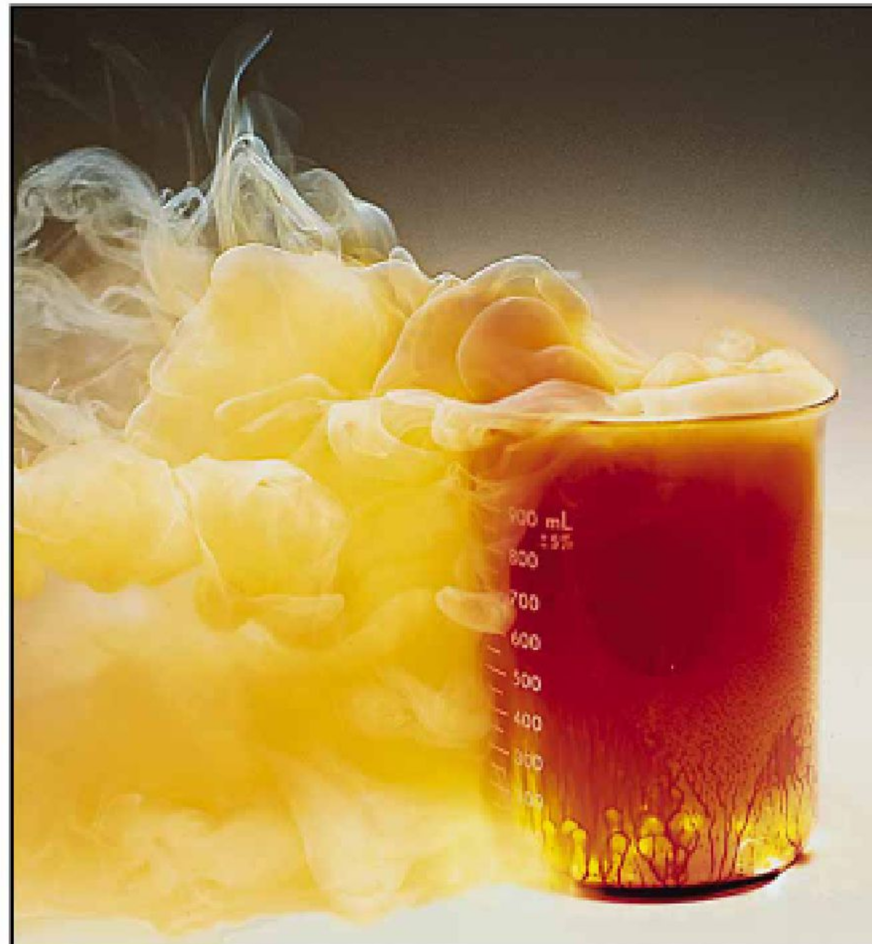
STOICHIOMETRY

- the study of the quantitative aspects of chemical reactions.



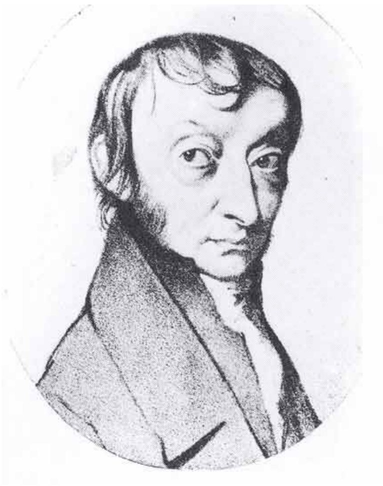
Atomic mass unit

- The atomic mass unit was used – symbol, u (or amu).
  - 1 u= 1.661 X 10^{-24} g
- Based on 12.0 g of carbon-12 which has an atomic mass of 12.0 u
- Because the mass of one atomic mass unit is so small, chemists deal with a much larger number of atoms while working with chemicals

Moles!

- The unit is called moles. Its symbol is mol. The quantity it measures is number of "things" or entities

The Mole



- The mole is the amount of **entities** in 12.0 g of carbon
  - All other elements are compared to carbon

- The mole is a counting unit
  - Similar to a dozen = 12
  - Similar to quartet = 4
  - Similar to trio = 3
  - Baker's dozen = 13

- One mole is defined as **6.02×10^{23}**. (3 sig digits)

- This refers to one mole of anything, eggs, paperclips, atoms.
- One mole of anything is 6.02×10^{23} items. Much like one dozen of something is 12.

- This number is named in honor of Amedeo Avogadro (1776 – 1856), who studied quantities of gases and discovered that no matter what the gas was, there were the same number of molecules present

- https://www.youtube.com/watch?v=qmCAnw7D17g
- Show video clip from 1:22min – 2:31min
- The entire video is posted on D2L for your review

The Mole

- 1 dozen cookies = 12 cookies
- 1 mole of cookies = 6.02×10^{23} cookies

- 1 quintet of cars = 5 cars
- 1 mole of cars = 6.02×10^{23} cars

- 1 couple of Al atoms = 2 Al atoms
- 1 mole of Al atoms = 6.02×10^{23} atoms

Note that the NUMBER is always the same, but the MASS is very different!

Just How Big is a Mole?

- Enough soft drink cans to cover the surface of the earth to a depth of over 200 miles.
- If you had Avogadro's number of unpopped popcorn kernels, and spread them across the United States of America, the country would be covered in popcorn to a depth of over 9 miles.
- If we were able to count atoms at the rate of 10 million per second, it would take about 2 billion years to count the atoms in one mole.

A Mole of Particles

Contains 6.02×10^{23} particles

1 mol C	= 6.02×10^{23} C atoms
1 mol H_2O	= 6.02×10^{23} H_2O molecules
1 mol NaCl	= 6.02×10^{23} NaCl "molecules"

(technically, ionics are compounds not molecules so they are called formula units)

6.02×10^{23} Na^+ ions and

6.02×10^{23} Cl^- ions

The mole concept

- The mole and the atomic mass units are related. For atoms, the atomic mass of an element corresponds to the average mass of a single atom in u

And

- The mass of a mole of atoms in grams.

Example

- The atomic mass of iron (Fe) is 55.85 u.

And

- One mole of iron atoms (6.02×10^{23} iron atoms) has a mass of 55.85 grams/mole

Molar Mass

- Units are g/mol (grams per mole)
- Equal to the numerical value of the average atomic mass (get from periodic table)
- Round to 1 decimal place

Na = 23.0 g/mol

Mg = 24.3 g/mol

O_2 (there are TWO moles of O) = 32.0 g/mol

Your Turn!

Find the molar mass

(usually we round to the tenths place)

1 mole of Br atoms = 79.9 g/mol

1 mole of Sn atoms = 118.7 g/mol

Molar Mass of Molecules and Compounds

Mass in grams of 1 mole equals numerically to the sum of the atomic masses of all elements in chemical formula

e.g 1 mol of $CaCl_2$ = 111.1 g/mol

1 mol Ca x 40.1 g/mol

+ 2 mol Cl x 35.5 g/mol = 111.1 g/mol $CaCl_2$

e.g. 1 mole of N_2O_4 = 92.0 g/mol

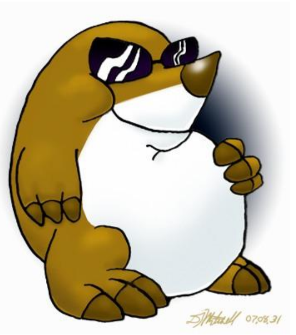
Your Turn!

A. Molar Mass of K_2O = <u>94.2</u> g/mol

B. Molar Mass $Al(OH)_3$ = <u>78.0</u> g/mol

C. Prozac, $C_{17}H_{18}F_3NO$, is a widely used antidepressant that inhibits the uptake of serotonin by the brain. Find its molar mass.

Mole Formula #1



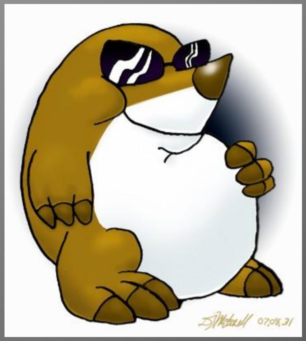
$$n = \frac{m}{M}$$

Mass (g)

# of moles (mol)

Molar mass (g/mol)

Sample Problems



- Sample problem#1

Find the # of moles in 5.0g of Mg.

G: m = 5.0 g

M_{Mg} = 24.3 g/mol

U: n = ? mol

E: n = m/M

S: n = 5.0g / 24.3 g/mol

S: n = 0.20576

= 0.21 mol (2 sig figs)

∴ There are 0.21 moles in 5.0 g of Mg.

- Sample problem#2

A balloon is filled with 0.50 mol of helium gas. What is the mass of helium in the balloon?

G: n = 0.50 mol

M_{He} = 4.0 g/mol

U: m = ? g

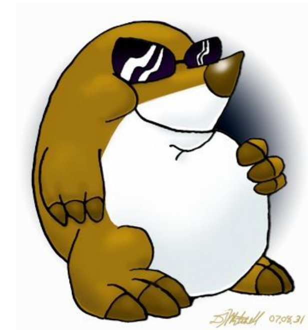
E: m = n x M

S: m = 0.50 mol x 4.0 g/mol

S: m = 2.0 g

∴ The mass of helium in the balloon is 2.0 g.

Mole Formula #2



$$n = \frac{\text{\# of Entities } (N)}{N_A}$$

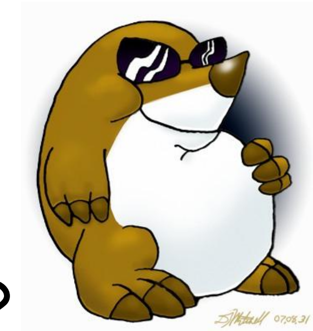
# of moles (mol)

Avogadro's constant

(6.02×10^{23} entities/mol)

Entities can be atoms, molecules, formula units

Sample problem#3



How many atoms are there in 0.50 mol of helium?

G: $n = 0.50\ \text{mol}$

$N_A = 6.02 \times 10^{23}$ atoms/mol

U: N(# of atoms) = ?

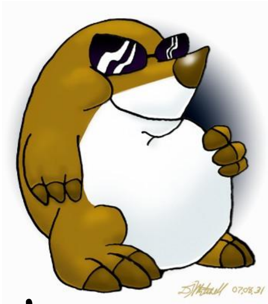
E: $N = n \times N_A$

S: $N = 0.50\ \cancel{\text{mol}} \times 6.02 \times 10^{23}\ \text{atoms}/\cancel{\text{mol}}$

S: $N = 3.0 \times 10^{23}$ atoms

∴ There are 3.0×10^{23} atoms in 0.50 moles of helium.

Sample problem#4



A beaker of contains 8.96×10^{25} molecules of water. How many moles of water are in the beaker?

G: N(# of molecules) = 8.96×10^{25}

$N_A = 6.02 \times 10^{23}$ molecules/mol

U: n = ? mol

E: $n = N / N_A$

S: $n = 8.96 \times 10^{25}$ ~~molecules~~ / 6.02×10^{23} ~~molecules~~/mol

S: n= 149 moles

∴ There are 149 moles of water in the beaker.