The Mole

The student will be able to:

1. List the 4 molar equalities.
2. Complete molar conversions
3. Determine molar mass
4. Determine % composition
5. Determine empirical formulas
6. Determine molecular formulas

Molar Equalities:

$$\boxed{1\text{ Mole}} = \boxed{6.022\times10^{23}\ \frac{\text{atoms}}{\text{-or- molecules}}} = \boxed{\text{molar mass}\ \left(\frac{\text{g}}{\text{mol}}\right)} = \boxed{22.4\text{ L of a gas}}$$

Molar mass is equal to the atomic mass of an element expressed as grams per mole ($\frac{g}{mol}$) and comes from the periodic table.

For example:

1 mole of sodium = 23.00 g/mol

1 mole of water (H_2O) = 18.02 g/mol

$$1.01 + 1.01 + 16.00 = 18.02\ \text{g/mol}$$

Practice: Determine the molar mass of the following molecules/compounds.

① $KClO_3$

$$39.10 + 35.45 + (3\times16.00) = 122.55\ \text{g/mol}$$

② Al_2S_3

$$(2\times26.98) + (3\times32.07) = 150.17\ \text{g/mol}$$

③ $MgBr_2$

$$24.31 + (2\times79.90) = 184.11\ \text{g/mol}$$

Molar Conversions:

Because the 4 molar equalities can be set equal to each other they can also be used as conversion factors.

Example: ? atoms (need) in 2.2 mol (given amt.) of Ca (2 SF)

$$2.2\text{ mol Ca} \times \frac{6.022\times10^{23}\text{ atoms}}{1\text{ mole Ca}}$$

$$\hookrightarrow 2.2\text{ mol Ca} \times \frac{6.022\times10^{23}\text{ atoms}}{1\text{ mole}} = \boxed{1.3\times10^{24}\text{ atoms}}$$

$\times10 = \overset{EE}{\boxed{\ }}$

Steps:

Ex. ? atoms are in 2.2 mol of Ca?

① to start the problem choose the 2 equalities involved by looking at the labels in the problem.

1 mole = 6.022×10^{23} atoms ← 2 equalities

The equalities can be written as a ratio $\frac{1\text{ mol}}{6.022\times10^{23}\text{ atoms}}$ or $\frac{6.022\times10^{23}\text{ atoms}}{1\text{ mol}}$

② the ratio you pick depends on what label is being changed and what label you need

? atoms are in 2.2 mol of Ca?

↑ label needed ↑ label being changed

③ Set up the conversion problem.

Amt given w/ label × $\frac{\text{conversion unit needed}}{\text{conversion unit changing}}$ =

for the example →

$2.2\text{ mol Ca} \times \frac{6.022\times10^{23}\text{ atoms}}{1\text{ mol Ca}} = \boxed{1.3\times10^{24}\text{ atoms Ca}}$

*Remember to finish with Sig. figs!

Practice:

① How many (grams) (need) are in (3.4×10^{25} atoms of Sulfur) (given)?

$3.4\times10^{25}\text{ atoms S} \times \frac{32.07\text{ g}}{6.022\times10^{23}\text{ atoms}} = \boxed{1800\text{ g S}}$

② How many (moles) (need) are in (4.5 L of oxygen gas) (given)?

$4.5\text{ L} \times \frac{1\text{ mol}}{22.4\text{ L}} = \boxed{0.20\text{ mol } O_2}$

mass before: _____

mass after: _____

mass of chalk ($CaCO_3$): 0.02 g

? mol of chalk are in your name:

$0.02\text{ g} \times \frac{1\text{ mol}}{100.09\text{ g}} = 0.0002\text{ mol}$ 2×10^{-4} mol

Homework: 1-15 & 26-30

? How many molecules of $CaCO_3$ did you put on the paper?

$0.02\text{ g} \times \frac{6.022\times10^{23}\text{ molecules}}{100.09\text{ g}} = \boxed{1.\times10^{20}\text{ molecules}}$

(3) How many liters of helium gas would be 1.4×10^{20} atoms ?

(4) What mass would 3.8 moles of Sodium Chloride contain?

Percent Composition

Calculating % composition determines the % of each element present in a compound based on mass.

Steps: (1) calculate the total mass of the compound. (molecular mass)
(2) take the total mass of one of the elements & divide by the molecular mass $\times 100$
(3) Repeat for all other elements

Example:

$Al(NO_3)_3$ $\quad Al - 26.98$ g/mol
$3 \times N = 42.03$ g/mol
$9 \times O = 144.00$ g/mol
molecular mass = 213.01 g/mol total

$\%\,Al = (26.98 \text{ g/mol} / 213.01 \text{ g/mol}) \times 100 = 12.67\%\,Al$
$\%\,N = (42.03 \text{ g/mol} / 213.01 \text{ g/mol}) \times 100 = 19.73\%\,N$
$\%\,O = (144.00 \text{ g/mol} / 213.01 \text{ g/mol}) \times 100 = 67.60\%\,O$

% Composition
Practice
BaO

$Zn(ClO_2)_2$

Mn_2O_3

Determining Empirical Formulas

The empirical formula is the simplest ratio of a group of elements in a compound.

Steps:

1. Divide each % by the elements molar mass (creates ratio)
2. Divide each ratio # by the smallest of the # - this should create a whole # ratio that is the subscripts for the formula.
3. (if needed) if step 2 yields a decimal: use the chart on the next page

Decimal	What to do
0.8 or higher	round # up to next whole #
0.75	multiply all ratios by 4
0.6	" " 3
0.5	" " 2
0.3	" " 3
0.25	" " 4
0.2 or less	round off to whole #

Example Ratio : Step 2 = 3 1.3 2

you can't have 0.3 of an atom, multiply all # by 3

3(3) 1.3(3) 2(3)

9 4 6

your subscripts ☺

Example:

$\frac{88.8\%\ Cu}{63.55}$ $\frac{11.2\%\ O}{16.00}$ } Step #1

$\frac{1.4}{0.7}$ $\frac{0.7}{0.7}$ } Step #2

2 1 → Cu_2O

subscripts