

Chapter 6: Chemical Composition

We buy beans by the pound and eggs by the dozen.

WHY? Because these are convenient ways of purchasing these items.

Two ways of specifying quantity: 1) **Mass** 2) **Number**

1 dozen eggs = _____ eggs 1 dozen donuts = _____ donuts
1 dozen carbon atoms = _____ carbon atoms

Your coworker brought in 42 donuts. How many dozen donuts did she bring to share?

The **counting unit** used in chemistry is the **MOLE (mol)**

1 Mole = 6.022×10^{23} of Anything

$6.022 \times 10^{23} = 6022000000000000000000000$
(Also called **AVOGADRO'S Number**)

1 mole of dollar bills = 6.022×10^{23} dollar bills
1 mole of sand grains = _____ sand grains
1 mole of copper atoms = _____ copper atoms

Two conversion factors can be derived:

$\frac{1 \text{ mole}}{6.022 \times 10^{23} \text{ objects}}$ or $\frac{6.022 \times 10^{23} \text{ objects}}{1 \text{ mole}}$

How many copper atoms are in 2.45 moles of copper?

How many moles of water are equivalent to 2.97×10^{24} molecules of water?

Molar Mass

Molar Mass of an element or compound:

- the **mass in grams** of **1 mole** of that element or compound

The mass standard is carbon-12.

- 1 carbon-12 **atom** has a mass of exactly 12 **amu**
- 1 **MOLE** of carbon-12 atoms (6.022×10^{23} carbon atoms) has a mass of exactly 12 **grams**

For an element, Molar Mass is **numerically** equivalent to the atomic mass

11
Na
22.99

Atomic number =

Atomic mass =

Molar mass =

What is the molar mass of Aluminum? Of bromine?

For a compound, Molar mass is **numerically** equivalent to the **formula mass**

(Recall: **Formula Mass** = the mass of an **individual** molecule or formula unit)

Mass to Mole/Mole to Mass Conversions

What is the formula mass and molar mass of water?

	Formula Mass of 1 H ₂ O molecule	Molar Mass of 1 mole of H ₂ O molecules
H	2 x 1.008 amu = 2.016 amu	2 x 1.008 g = 2.016 g
O	1 x 16.00 amu = <u>16.00</u> amu	1 x 16.00 g = <u>16.00</u> g
	18.016 amu	18.016 g
	18.02 amu per <u>molecule</u> of H ₂ O	18.02 g per <u>mole</u> of H ₂ O

Formula Mass of H₂O = 18.02 amu

Molar Mass of H₂O = 18.02 g/mole

Molar mass can be used as a *conversion factor*:

mass → *moles* *moles* → *mass*

How many grams of aluminum are in 1.68 moles of Al?

What is the mass (in grams) of 2.45 moles of CO₂?

How many moles of water are equivalent to 8.50 grams of water?

How many moles of NaCl are in 152.0 g NaCl?

Conversions between Mass, Moles and Number of Particles

We have used Avogadro's number as a conversion factor to convert:

of particles \longrightarrow # of moles

of moles \longrightarrow # of particles

where the particles are usually **atoms, molecules or formula units**

$$1 \text{ mole} = 6.022 \times 10^{23} \text{ particles}$$

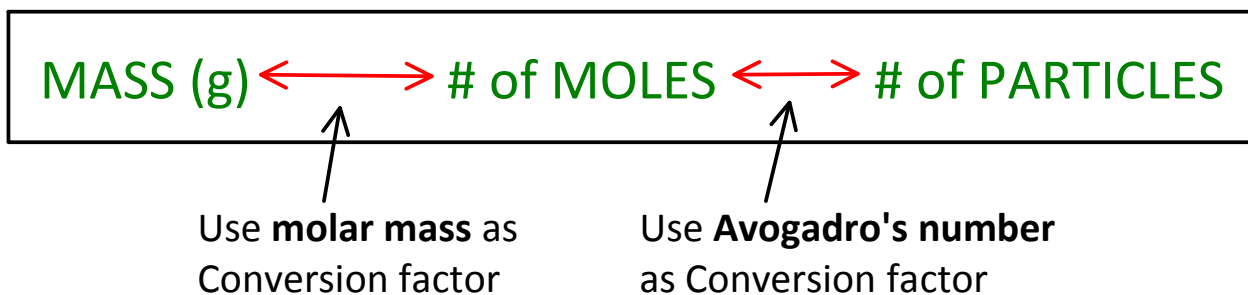
(Avogadro's number)

We have used molar mass as a conversion factor to convert:

mass (g) \longrightarrow # of moles

of moles \longrightarrow mass (g)

We can use both Avogadro's number and molar mass to do **TWO STEP** conversions:



How many atoms of chromium (Cr) are in 8.65 g of Cr?

Conversions between Mass, Moles and Number of Particles

MASS (g) \longleftrightarrow # of MOLES \longleftrightarrow # of PARTICLES

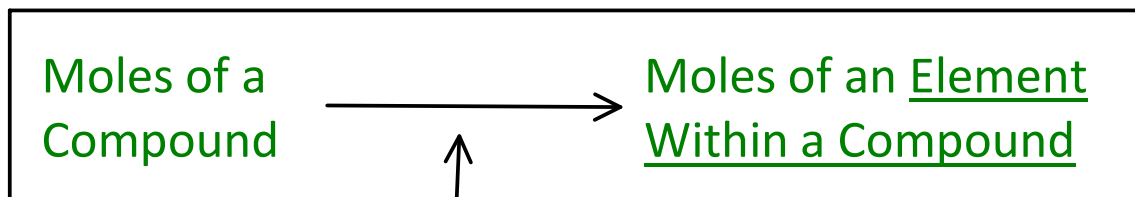
If there are 7.58×10^{21} molecules of hexane present in a sample of hexane (molecular formula = C_6H_{14}), how many grams of hexane are there?

How many molecules of nitrogen gas (N_2) are in 42.8 g of nitrogen gas?

1.45×10^{24} atoms of Fe is equivalent to how many grams of iron?

Using Chemical Formulas in Conversions

There is ANOTHER conversion we can do:



Use mole ratio
determined from the
formula as conversion
factor

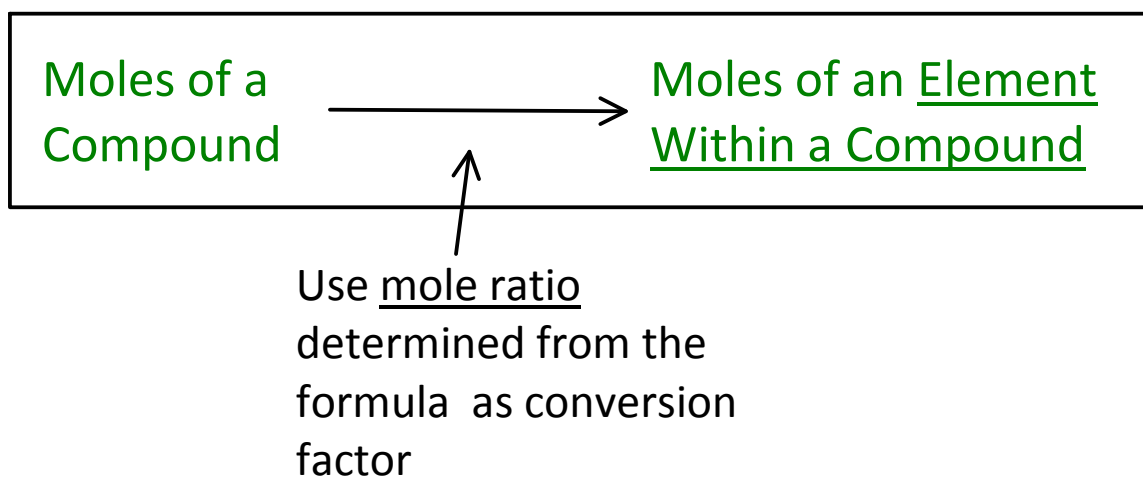
To determine the **MOLE RATIOS** from a formula, look at the subscripts of the elements that make up that compound.....

Using Chemical Formulas in Conversions

Example:

1 mole Li_3PO_4 contains... ___ moles Li
___ moles P
___ moles O

So the mole ratios are:

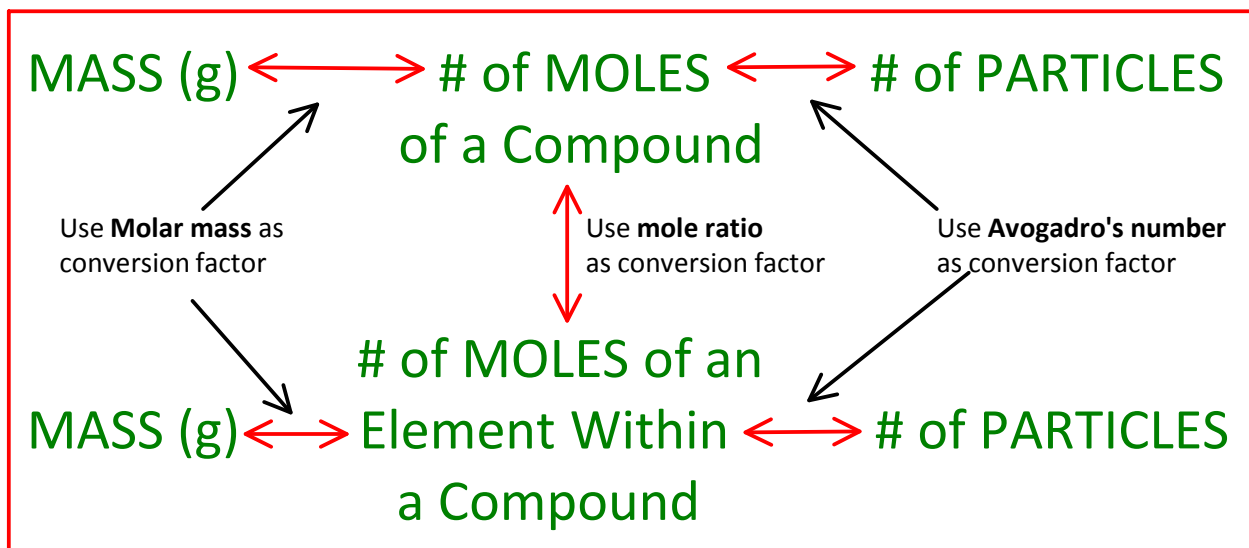


How many moles of oxygen are in 2.65 moles of Li_3PO_4 ? How many moles of Li are in this compound? Of Phosphorus?

How many moles of C are in 0.955 moles of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)?

More Complex Conversions

Putting it ALL together to solve more complex problems:



How many **sodium cations** are in 1.50 moles of Na_2SO_4 ?

How many **moles of hydrogen** are in 1.68 g of H_2O ? How many **hydrogen atoms** are in this mass of water?

3.70 g $\text{Fe}_2(\text{CO}_3)_3$ contains how many **grams of Fe**?

How many **molecules of sulfur dioxide** (SO_2) are present in 5.88 g of SO_2 ? How many **atoms of oxygen** are in this mass of SO_2 ?

Mass Percent Composition

Mass Percent Composition = Percentage (by mass) of each element in a compound

What is the mass percent of **calcium** in CaBr_2 ?

1st step: Determine the molar mass of the compound:

2nd step: Determine the molar mass of Ca in the compound.

3rd step: Determine the mass percent of Ca in the compound.

$$\text{Mass \%} = \frac{\text{Mass of element in 1 mol cmpd}}{\text{Mass of 1 mol compound}} \times 100\%$$

What is the mass percent of **bromine** in CaBr_2 ?

Determine the percent composition of **each element** in H_2SO_4 .

Using Mass Percent as a Conversion Factor

Silver chloride (AgCl) contains 75.27% by mass of silver (Ag). What is the % by mass of Cl?

If a sample contains 4.95 grams of silver chloride, how many grams of Ag are present in the sample?

- Use mass percent to determine a conversion factor

$$\begin{array}{l} \% \text{ Ag} = 75.27\% \\ \% \text{ Cl} = 24.73\% \end{array} \quad \text{in AgCl}$$

In **100 g** of AgCl there are:

_____ g of Ag
_____ g of Cl

So, the conversion factors are:

How many grams of Ag are present in 4.95 grams of silver chloride? How many grams of chlorine are present in this sample?