The problem: atoms are *so tiny* that we couldn't possibly measure them directly!

Examples:

1 drop of water ≈ 5,000,000,000,000,000,000,000 atoms
1 copper penny ≈ 28,000,000,000,000,000,000,000 atoms
1 balloon ≈ 300,000,000,000,000,000,000,000 atoms
1 Earth ≈ 133,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000 atoms

In order to get *anything* done, we have to use some conversion factor to turn these huge numbers into ones we can use and understand.

Amadeo Avogadro

- experimented with gasses, developed this Principle:

"equal volumes of all gases at the same temperature and pressure contain the same number of molecules"

- 50 years later, Stanislao Cannizarro argued this could be used for atomic masses as well
- decades of experiments led to Avogadro's number and the mole:

$$1 \text{ mole} = 6.0221367 \times 10^{23} \text{ particles}$$

or

602,000,000,000,000,000,000,000!

Some crazy mole math:

If you could count a million atoms per second, it would take you 16 billion years to count the number of atoms in one mole!

If you covered the United States with a mole of marshmallows, it would be 6500 miles deep!

If you lined up one mole of (animal) moles end to end, they would stretch 11-million light-years and weigh almost the same as the moon!

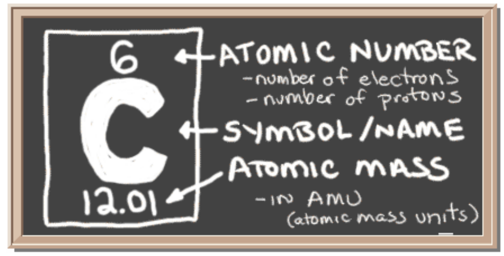
If we took a mole of pennies and split them evenly amongst the 6.7 billion people on Earth, we would all be able to spend $1 million each hour, 24-7, for our entire lives and still have over half left when we died!

The Pacific Ocean is estimated to have one mole (6.02×10^{23}) of milliliters of water!

1 pair = 2
1 dozen = 12
1 gross = 144
1 mole = 6.02×10^{23}

The atomic mass of an element is equal to 1 mole of that element.

for example, carbon-12:



6 protons
+ 6 neutrons
12 atomic mass units (amu)

Instead of amu, we typically use:
grams per mole (g/mol).

The reason carbon has a mass of 12.011 g/mol on the periodic table is due to the average of its different isotopes (C-12, C-13 and C-14).

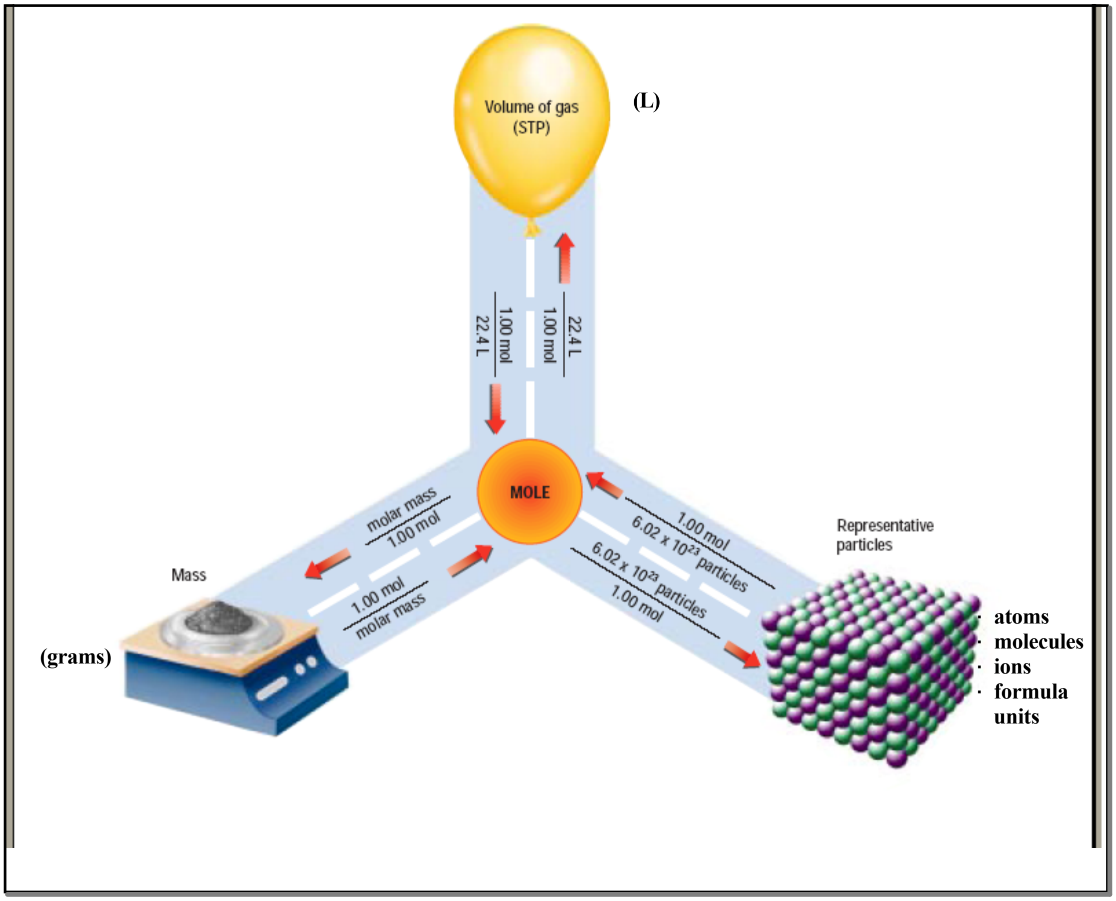
To calculate molar mass, just add all of the atoms' masses together!

For example:

- carbon dioxide (CO_2) has 1 carbon atom and 2 oxygen atoms per molecule

1 C: 1 x 12.011 g/mol = 12.011 g/mol
2 O: 2 x 15.999 g/mol = + 31.998 g/mol
44.009 g/mol

The molar mass of CO_2 is 44.009 g/mol. This means that every mole of CO_2 has a mass of 44.009 grams.



KNO_3

1 K 39.098 g/mol

1 N 14.007 g/mol

2 O +(2×15.999) g/mol

39.098 + 14.007 + (2×15.999) =

85.103 g/mol

$Ca_3(PO_4)_2$

3	Ca	3 × 40.078
2	P	2 × 30.974
8	O	+ 8 × 15.999
		310.174 g/mol