

Molar mass (Chapter 2.7 and 2.8)

1 dozen = 12 “things” or items
(1 dozen eggs = 12 eggs)

1 mole = $6.02214199 \times 10^{23}$ “things” or items
(1 mole eggs = $6.02214199 \times 10^{23}$ eggs)

Avogadro’s number, $N_A = 6.022 \times 10^{23}$ items/mol

The mole unit connects the nanoscale (atoms, molecules, etc.) to the macroscale (human scale).

1 mole of copper atoms = 1 mol Cu
= 6.022×10^{23} atoms Cu
 \approx 24 pennies

Molar mass: the mass in grams of one mole of any substance (elements or compounds).

Also known as atomic mass, atomic weight, molecular weight (MW), and formula weight (FW), but these terms can be misleading.

What is the molar mass (MM) of an element?

For carbon-12 (^{12}C), the molar mass is

1 mole $^{12}\text{C} = 6.022 \times 10^{23}$ atoms $^{12}\text{C} = 12 \text{ g } ^{12}\text{C}$.
 ^{12}C is defined to be exactly 12 g.

MM of $^{12}\text{C} = \text{exactly } 12 \text{ g/mol}$.

What is the MM of carbon from the periodic table?

Isotope	Atomic mass (g)	Molar mass (g/mol)	Abundance
^{12}C	1.992646×10^{-23}	12 (exactly)	98.93%
^{13}C	2.15928×10^{-23}	13.003354826	1.070%

Elemental molar mass of C from periodic table
 = (98.93% from ^{12}C) + (1.070% from ^{13}C)

= $(0.9893 \times 12^* \text{ g/mol}) +$
 $(0.01070 \times 13.003354826 \text{ g/mol})$

= 12.0107 g/mol.

Molar mass as a ratio and a conversion factor

$$\text{MM} = \frac{\text{g}}{\text{mol}} \qquad \text{MM of C} = 12.0107 \frac{\text{g}}{\text{mol}}$$

Example:

Convert units of grams into moles

10.0 g of C

Convert units of moles into grams

2.50 mol of C

Practice: 168 grams of Ag (silver). How many moles of Ag? How many atoms of Ag?

N_A is another conversion factor

(Avogadro's number, definition of mole unit)

1 mol = 6.022×10^{23} items, particles, things, etc.

Example:

Conversion of moles into number of particles

1.73 mol of pencils

2.41 mol of C

Conversion of particles into moles

803×10^{12} atoms of C ($10^{12} = 1$ trillion in U.S.)

Practice:

1. 50.4 moles of Cu equals how many ...

- a. Atoms?
- b. Grams?
- c. Pennies?

2. 0.983 g of Xe equals how many atoms?

Try to use **molar mass** when talking about the mass of one mole of a substance. The following terms can be confusing ...

Atomic mass: the mass in grams of one atom (1.992646×10^{-23} g for ^{12}C). Atomic mass is different than the mass number A (#protons).

Atomic weight: often means the mass in grams of **one mole**, *not one atom*, of a naturally occurring element, i.e., the molar mass average of the natural isotopes, like 12.0107 g/mol. Sometimes can mean the mass in grams of one “average” atom of the isotopes of an element (an “average” atom that is 98.93% ^{12}C and 1.07% ^{13}C). Sometimes can mean the same as atomic mass.

Molar masses of molecules and compounds

Add the molar masses of the elements in the compound.



Account for multiple atoms of the same element in one molecule.



Molar mass = mass of one mole of a substance.
More terms that can be confusing ...

Molecular weight (MW): often means the mass in grams of **one mole**, *not one molecule*, of a compound, e.g., 18 g/mol for H₂O, 32 g/mol for O₂.

Formula weight (FW): often means the mass in grams of **one mole**, *not one molecule*, *not one formula unit*, of a compound. Similar to molecular weight, but meant for use with ionic compounds, e.g., 58.5 g/mol for NaCl.