Atoms, Molecules, Moles and Their Masses:

Molar Mass and Avogadro's number

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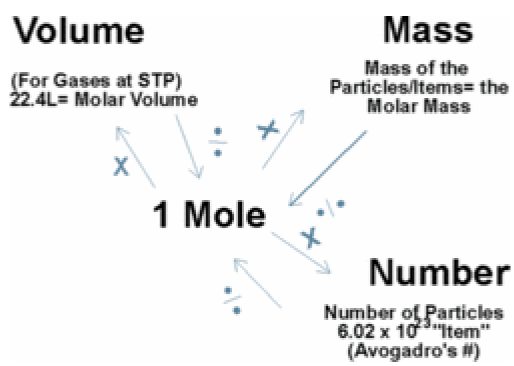

One Mole (or abbreviated 1 mol) of any substance is a fixed number, i.e. Avogadro's number ($N_A = 6.022 \cdot 10^{23}$) of elementary particles (atoms for elements or molecules for compounds or atomic group, etc.), equal to the number of atoms in 12 grams of ^{12}C carbon. Therefore, 1 mol (or mole) of any substance has the same number, i.e. Avogadro's number, or 6.022E23 elementary particles. Since different elementary particles have different masses, one mole of different substances has different masses. Atomic and thus molecular mass of any substance represent the mass in grams of Avogadro's number of atoms or molecules (whatever the substance is made of).

Therefore, since carbon atomic mass is 12 *AMU* (Atomic Mass Units) and water molecular weight is about 18, then 1 mol of carbon, or Avogadro's number, or 6.022E23 atoms of carbon has 12 *g (*gram) of mass; and 1 mol of water, or Avogadro's number, or 6.022E23 molecules of water has about 18 gram of mass, and similar for others (see also a note at www.polyacs.org/nomcl/mnn22.pdf).

The following correlations exist:

	Where,
$N_A = \dfrac{N}{n}$	$N_A = 6.022141 \cdot 10^{23}\,[particles/mol]$, number of elementary particles (atoms, molecules, etc.) in one mole.
$N = n \cdot N_A$	M [$g/mol=AMU/particle$], molar mass M and (relative to ^{12}C carbon) atomic or relative molecular mass M_r (note: $AMU=1/N_A g$)
$m = n \cdot M = N \cdot \underbrace{\left(\dfrac{M}{N_A}\right)}_{m_1} = N \cdot m_1$	$n\,[mol]$, number of moles.
	N [$particles$], total number of particles.
$m_1 = \dfrac{M}{N_A} = \dfrac{m}{N}$	m [g], total mass.
$M_r = M / M_{^{12}C}$	m_1 [$g/particle$], mass of one elementary particle (atom, molecule, etc.). M_r relative molecular or molar mass to ^{12}C carbon mass.

For ideal gas equation, after using above correlations, we have:

$$P \cdot V = N \cdot k \cdot T = \underbrace{n(N_A}_{N} k)T = n \cdot \underbrace{\hat{R}}_{N_A k} \cdot T = \underbrace{\left(\frac{m}{M}\right)}_{n} \cdot \underbrace{R_u}_{\hat{R}} \cdot T = m \underbrace{\left(\frac{R_u}{M}\right)}_{R_g} T = m \cdot R_g \cdot T$$

Or in general, any mass-specific property, p, and molar-specific property, $\hat{p}$, are related as:

$$p\left[\frac{(any)}{g}\right] = \frac{\hat{p}\left[\dfrac{(any)}{mol}\right]}{M\left[\dfrac{g}{mol}\right]} \quad or \quad \hat{p}\left[\frac{(any)}{mol}\right] = p\left[\frac{(any)}{g}\right] \cdot M\left[\frac{g}{mol}\right]$$