THE MOLE
THE MOLE, MOLAR MASS AND MASS — MOLE RELATIONSHIPS

The Mole

The mole was introduced in Unit C as a convenient *number* of atoms, ions or molecules to work with in the laboratory. This convenient number (Avogadro's number, 6.02×10^{23}) also has significance in terms of the atomic mass of elements. The mole is defined as the number of atoms in exactly 12 g of a particular isotope of carbon. The particular carbon isotope is the most common isotope of carbon — the carbon-12 isotope with 6 protons and 6 neutrons.

The Green Pea Analogy

If you selected a hundred (10^2) average-sized peas, you would find that they occupy roughly a volume of 20 cm^3. A million (10^6) peas are just enough to fill an ordinary household refrigerator and a billion (10^9) peas will fill a three bedroom house from cellar to attic. A trillion (10^{12}) peas will fill a thousand houses, the number you might find in a medium-sized town. A quadrillion (10^{15}) peas will fill all the buildings in one of our larger cities such as Calgary or Edmonton.

Obviously you will run out of buildings very soon. Let us try a larger measure, for instance the province of Alberta. Suppose that there is a blizzard over Alberta, but instead of snowing snow, it snows peas. Alberta is covered with a blanket of peas about one metre deep all the way from Saskatchewan out to British Columbia and all the way from the United States to the Northwest Territories. This blanket of peas drifts over the roads and banks up against the sides of the houses, and covers all the fields and forests. Think of flying across the province with the blanket of peas extending out as far as you can see. This gives you an idea of our next number. There will be in this blanket about a quintillion (10^{18}) peas.

Imagine that this blizzard of peas falls over the entire land of the globe — North America, Africa, South America, Europe, Australia, and Asia. All of the continents are covered with peas one metre deep. This global blanket will contain sextillion (10^{21}) peas. Then imagine that the oceans are frozen over and the blanket of peas covers the entire land and sea area of Earth. Go out among the neighboring stars and collect 250 planets the size of Earth and cover each of these with a blanket of peas one metre deep. *Then you have a mole of peas.*

Furthermore, go out into the farthest reaches of the Milky Way, and collect 250 000 planets, each the size of Earth. Cover each one with a blanket of peas one metre deep. You now have cotillion (10^{27}) - a number corresponding to the number of atoms in your body.

Note:

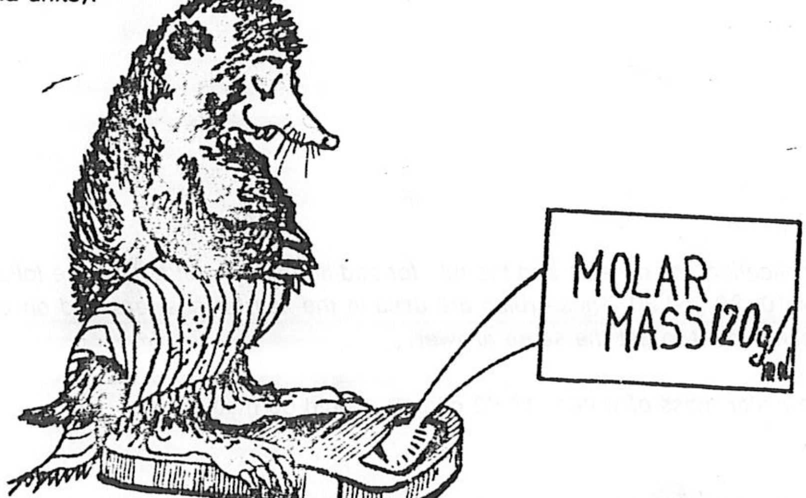
If anyone knows the author of the original Green Pea Analogy please contact ALCHEM so proper credit can be given.

Molar Mass

One mole is defined as the number of atoms of carbon—12 in exactly twelve grams. The mass of one mole of all other atoms is determined relative to the mass of one mole of carbon—12. The *average* mass of one mole of atoms of an element is given to the nearest hundredth of a gram on the ALCHEM periodic table. For example the mass of one mole (molar mass) of chlorine atoms is 35.45 g/mol. This molar mass in an *average* value which takes into account that a sample of chlorine is composed of several isotopes of chlorine.

The molar mass (mass of one mole) of compounds may be determined from the molar masses of their component atomic elements. Examples of how to determine these molar masses (always in grams per mole, g/mol) are provided on the pages to follow.

Molar mass is a general term which may refer to the mass of one mole of atoms, molecules, formula units, etc. In order to avoid confusion the term *atomic* molar mass should be used to refer to the mass of one mole of *atoms* (versus molecules or formula units).



THE MOLE
MOLAR MASS

Determine the molar mass (mass of one mole) of each of the following substances. Show all work as in .

Example:

$Ca(HCO_3)_2$ (in hard water)

atomic molar masses from ALCHEM periodic table

1 Ca	=	1 x 40.08	=	40.08	
2 H	=	2 x 1.01	=	2.02	
2 C	=	2 x 12.01	=	24.02	
6 O	=	6 x 16.00	=	96.00	
				162.12	g/mol

Note:
A number with two decimal places multiplied by an exact number has two decimal places in the answer. See notes below.

1. $FeSO_4$ (iron pills)

2. magnesium sulfate (Epsom salts)

3. sodium carbonate decahydrate (washing soda) (List water of hydration as $10H_2O$ = 10 x 18.02 = 180.20)

4. $MgSiO_3$ (asbestos)

5. sodium hypochlorite (laundry bleach)

6. $Al(OH)_3$ (water clarifier)

7. sodium chloride (table salt)

8 calcium carbonate (limestone)

9. dinitrogen oxide (anesthetic)

10. $Na_2S_2O_3 \bullet 5H_2O$ (photographic hypo)

11. $NH_4H_2PO_4$ (fertilizer)

Notes:

1. *The rule for multiplication and division and the rule for addition and substraction are followed in this example and throughout ALCHEM 10, 20 and 30. These rules are used in the key for answers and on exams. If these rules are followed everyone can expect to get the same answer.*

2. *For hydrates the molar mass of water* (18.02 g/mol) should be memorized.