The Mole

6.02×10^{23}

Review

The Mole

- In everyday life we use units that represent specific quantities:
  - 1 dozen = 12
  - 1 gross = 144
  - 1 ton = 2000lbs
- Any given sample contains a very large number of atoms ions or molecules. For example, **a teaspoon of water contains 2 x 10^{23} atoms!!**
- In science we use the term ***mole*** to *represent the very large numbers of atoms, ions and molecules* in substances.

$$1\,mol = 6.022 \times 10^{23}(atoms, ions, molecules, etc)$$

The Mole

- **A counting unit**
- **Similar to a dozen, except instead of 12, it's 602 billion trillion 602,000,000,000,000,000,000,000**
- **6.02 X 10^{23} (in scientific notation)**

The Mole

This number is named in honor of Amedeo Avogadro (1776 – 1856), who studied quantities of gases and discovered that no matter what the gas was, there were the same number of molecules present in a given volume.

- **The volume of one mole of gas (any gas) at Standard Temperature (0°Celsius) and Standard Pressure (1 atmosphere) is 22.4 liters.**

Avogadro's Number Where Did it Come From?

- **It was NOT just picked! It was MEASURED!**
- First measured by **Lohschmidt** and some European chemistry texts use Lo for Avogadro's number and calls it Lohschmidt's number.
- **Jean Perrin**, in his paper "Brownian Movement and Molecular Reality", was the first scientist to call this number after Amadeo Avogadro.

Just How Big is a Mole?

- **Enough soft drink cans to cover the surface of the earth to a depth of over 200 miles.**
- **If you had Avogadro's number of unpopped popcorn kernels, and spread them across the United States of America, the country would be covered in popcorn to a depth of over 9 miles.**
- **If we were able to count atoms at the rate of 10 million per second, it would take about 2 billion years to count the atoms in one mole.**

A Mole of Particles Contains 6.02×10^{23} particles

1 mole C = 6.02×10^{23} C atoms

1 mole H_2O = 6.02×10^{23} H_2O molecules

1 mole NaCl = 6.02×10^{23} NaCl "molecules"

(technically, ionics are compounds not molecules so they are called formula units)

6.02×10^{23} Na^+ ions and

6.02×10^{23} Cl^- ions

Examples of Moles

Moles of elements

1 mol Mg = 6.02×10^{23} Mg atoms

1 mol Au = 6.02×10^{23} Au atoms

Moles of compounds

1 mol NH_3 = 6.02×10^{23} NH_3 molecules

1 mol $C_9H_8O_4$ = 6.02×10^{23} aspirin molecules

Avogadro's Number as Conversion Factor

$$\frac{6.02 \times 10^{23} \text{ particles}}{1 \text{ mole}}$$

or

$$\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ particles}}$$

Note that a particle could be an atom OR a molecule!

Learning Check

1. Number of atoms in 0.500 mole of Al

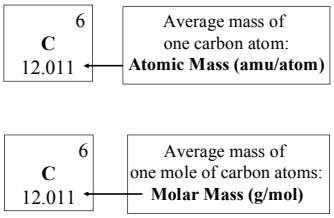
a) 500 Al atoms
b) 6.02 x 10^{23} Al atoms
c) 3.01 x 10^{23} Al atoms

2.Number of moles of S in 1.8 x 10^{24} S atoms

a) 1.0 mole S atoms
b) 3.0 mole S atoms
c) 1.1 x 10^{48} mole S atoms

Molar Mass KNOW THIS !!!

Information about atomic or molar mass can be found on the periodic table:



Average Atomic Mass

Naturally occurring chlorine is 75.53% ^{35}Cl which has an atomic mass of 34.969 amu, and 24.47% ^{37}Cl which has an atomic mass of 36.966 amu. Calculate the average atomic mass of chlorine.

$$(0.7553)(34.969amu) + (0.2447)(36.966amu) = 35.46\ amu$$

Molar Mass

- **The Mass of 1 mole (in grams)**
- **Equal to the numerical value of the average atomic mass (get from periodic table)**

1 mole of C atoms	**=**	**12.01 g**
1 mole of Mg atoms	**=**	**24.3 g**
1 mole of Cu atoms	**=**	**63.5 g**

- **Some people used to call this a "GFM" (gram formula mass) when used with ionic compounds**

Molar Mass

- From our previous calculation we found the mass of 1 mol of carbon atoms is 12.01 g
- The mass of 1 mol of atoms, ions or molecules is called **Molar Mass.** The *molar mass* of carbon is 12.01 g/mol
- We can state the following:

$$\frac{12.01 g\ \mathrm{C}}{mole\ \mathrm{C}} = \frac{12.01\ amu}{atom\ \mathrm{C}}$$

- We have related a specific number of atoms to a specific mass; We can "count atoms by weighing".

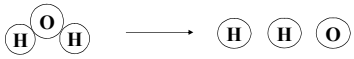
Learning Check!

Find the molar mass
(round to the tenths place)

A. 1 mole of Br atoms = 79.9 g/mole
B. 1 mole of Sn atoms = 118.7 g/mole

Formula and Molecular Weights

- The **formula weight** of a substance is *the sum of the atomic weights of each atom in its chemical formula*.
- For example, each molecule of H_2O contains 2 hydrogen atoms and 1 oxygen atom The formula weight of water is calculated as:

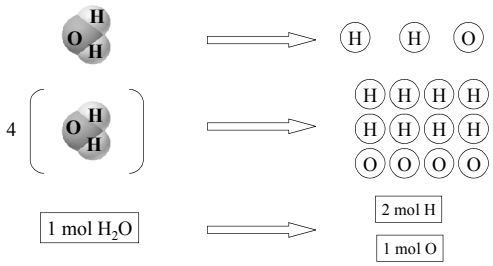


$$\text{FW} = (2)(1.00794\,amu) + (1)(15.9994\,amu) = 18.022\,amu$$

- If the chemical formula of a substance is also the molecular formula, then the formula weight is also called the **molecular weight**

Molar Mass of Compounds

- In the lab we work with billions of molecules at one time. So it is convenient to work with moles



Molar Mass of Compounds

- The molar mass of H_2O is calculated as follows:

The mass of 1 mol of H_2O molecules = 2(molar mass H) + 1(molar mass O)

$$2\,mole\,H\left(\frac{1.008\,g\,H}{1\,mole\,H}\right) = 2.016\,g\,H \qquad 1\,mole\,O\left(\frac{16\,g\,O}{1\,mole\,O}\right) = 16\,g\,O$$

$$molar\ mass\ of\ H_2O = 2.016g + 16.00g = 18.02\frac{g\,H_2O}{1\,mol\,H_2O}$$

Molar Mass of Compounds

Mass in grams of 1 mole equal numerically to the sum of the atomic masses

1 mole of $CaCl_2$ = 111.1 g/mol

1 mole of N_2O_4 = 92.0 g/mol

Learning Check!

A. Molar Mass of K_2O = ? Grams/mole

B. Molar Mass of antacid $Al(OH)_3$ = ?

Learning Check

Prozac, $C_{17}H_{18}F_3NO$, is a widely used antidepressant that inhibits the uptake of serotonin by the brain. Find its molar mass.