EXAMPLE: **How many moles of gas are contained in a balloon with a volume of 10.0 L at STP?**

$$\text{\# of moles} = 10.0\text{ L} \times \frac{1\text{ mol}}{22.4\text{ L}} = \mathbf{0.446\ mol}$$

EXERCISES:

11. Calculate the volume at STP occupied by the following.
    (a) 12.5 mol of $NH_3(g)$ (b) 0.350 mol of $O_2(g)$ (c) 4.25 mol of $HCl(g)$
12. Calculate the number of moles in the following gases at STP.
    (a) 85.9 L of $H_2(g)$ (b) 375 mL of $SO_3(g)$ (c) 5.00 mL of $OCl_2(g)$

CALCULATIONS RELATING THE NUMBER OF MOLES AND THE NUMBER OF PARTICLES

The **MOLE** is the fundamental unit in chemistry for measuring the **AMOUNT OF SUBSTANCE** in the sense of "number of particles of the substance". The preceding sections showed how to perform calculation based on the mass and the volume of a mole of a substance, but a question which you might have is "how many particles ARE THERE in one mole"?

Experimentally–measured value: **1 mol = 6.02 x 10^{23}**

This value, 6.02 x 10^{23}, is called **AVOGADRO'S NUMBER.** (No, Avogadro didn't discover it; it was named in his honour.)

Notice that there are NO UNITS attached to "6.02 x 10^{23}", simply because it is just a number. (This is similar to the same way that "dozen" stands for the number "12".)

EXERCISES: (These exercises are not important but may help you gain some idea of the enormity of Avogadro's Number.)

13. Assume that you distribute Avogadro's Number of dollars evenly among each of the 4.5 x 10^9 people on Earth. Further, assume that everyone spends ONE THOUSAND dollars each second, day and night. What percentage of each person's wealth will have been spent after one year?
14. The total land area of the earth is 1.49 x 10^8 km^2. The cross–sectional area of a penny is 3.61 cm^2 (1 km^2 = 10^{10} cm^2) and the thickness of a penny is 1.50 mm. If a mole of pennies is distributed evenly over the total land area of the earth, how thick a layer will be formed?

In general, chemists have little interest in the actual numbers of molecules involved in a reaction. However, on occasion, the number of particles is required, so let's examine the calculations involved.

Conversion factor: $\frac{1\text{ mol particles}}{6.02 \times 10^{23}\text{ particles}}$ or $\frac{6.02 \times 10^{23}\text{ particles}}{1\text{ mol particles}}$

EXAMPLE: **How many molecules are there in 0.125 mol of molecules?**

$$\text{\# of molecules} = 0.125\text{ mol} \times \frac{6.02 \times 10^{23}\text{ molecules}}{1\text{ mol}} = \mathbf{7.53 \times 10^{22}\ molecules}$$

EXAMPLE: **How many moles of N atoms are there in 5.00 x 10^{17} N atoms?**

$$\text{\# of moles} = 5.00 \times 10^{17} \text{ atoms} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}} = \mathbf{8.31 \times 10^{-7} \text{ mol}}$$

EXAMPLE: **A light source emits 8.50 x 10^{17} photons per second. (A photon is a "particle of light".) How many moles of photons are emitted by the light source in one minute?**

$$\text{\# of moles} = 1 \text{ min} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{8.50 \times 10^{17} \text{ photons}}{1 \text{ s}} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ photons}}$$

$$= \mathbf{8.47 \times 10^{-5} \text{ mol}}$$

Note: The above three examples don't depend on whether the particles are atoms, molecules, or whatever. The calculations just deal with the numbers of particles.

Avogadro's Number is also used to find the molar mass of particles if the mass of one particle is known.

EXAMPLE: **A particular variety of carbon atom has a mass of 2.16 x 10^{-23} g/atom. What is the mass of a mole of this variety of carbon atom?**

$$\text{mass} = 2.16 \times 10^{-23} \frac{\text{g}}{\text{atom}} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = \mathbf{13.0 \frac{g}{mol}}$$

IMPORTANT: If the actual mass of the particles involved is given in grams (or kilograms, etc.), then multiplying the mass by Avogadro's Number gives the mass of a mole of such particles, as found in the preceding example.

mass of 1 mol in grams = (6.02 x 10^{23}) x (individual mass of atom in grams)

When a particle's atomic symbol is found on the periodic table, just use the mass of the particle given in the periodic table and simply attach the unit "g" to get the molar mass (as you did when you first learned how to find the molar mass).

COMBINED EXERCISES:

15. Calculate the number of moles contained in the following.
    - (a) 10.6 L of SO_2(g) at STP
    - (b) 7.50 x 10^{21} molecules of HNO_3
    - (c) 425 mg of $Ca(OH)_2$
    - (d) 4.25 x 10^{12} molecules of Fe_2O_3
    - (e) 0.950 kg of NaOH
    - (f) 25.0 mL of N_2(g) at STP
    - (g) 5.50 x 10^{25} molecules of CCl_4
    - (h) 0.120 L of NO_2(g) at STP
16. Calculate the volume of the following gases at STP.
    - (a) 0.235 mol of B_2H_6(g)
    - (b) 9.36 mol of SiH_4(g)
    - (c) 2.55 x 10^3 mol of C_2H_6(g)
17. Calculate the mass of each of the following.
    - (a) 0.125 mol of CO_2(g) at STP
    - (b) 5.48 mol of $FeCl_3$(s)
    - (c) 6.54 x 10^{-4} mol of HCN(g) at STP
    - (d) 15.4 mol of $Ni(OH)_2$(s)
18. Calculate the mass of 1 mol of each of the following.
    - (a) $Na_2B_4O_7 \cdot 10H_2O$
    - (b) Grandma Smith, an average grandmother, having a mass of 52 kg. (Express your answer in kilograms.)
    - (c) a bismuth atom with a mass of 3.52 x 10^{-22} g
    - (d) an electron having a mass of 9.1 x 10^{-28} g.
    - (e) $Cu_3(OH)_2(CO_3)_2$
    - (f) a book having a mass of 1.34 kg