To calculate the molar mass of **$Cu(NO_3)_2 \cdot 6H_2O$**, recall that the "**$\cdot 6H_2O$**" indicates that six water molecules are attached to the $Cu(NO_3)_2$ molecule to make a hydrate.

$$Cu(NO_3)_2 \cdot 6H_2O = Cu + 2\ NO_3 + 6\ H_2O = Cu + 2 \times (N + 3 \times O) + 6 \times (2 \times H + O)$$
$$= 1\ Cu + 2\ N\text{'s} + 12\ O\text{'s} + 12\ H\text{'s}$$

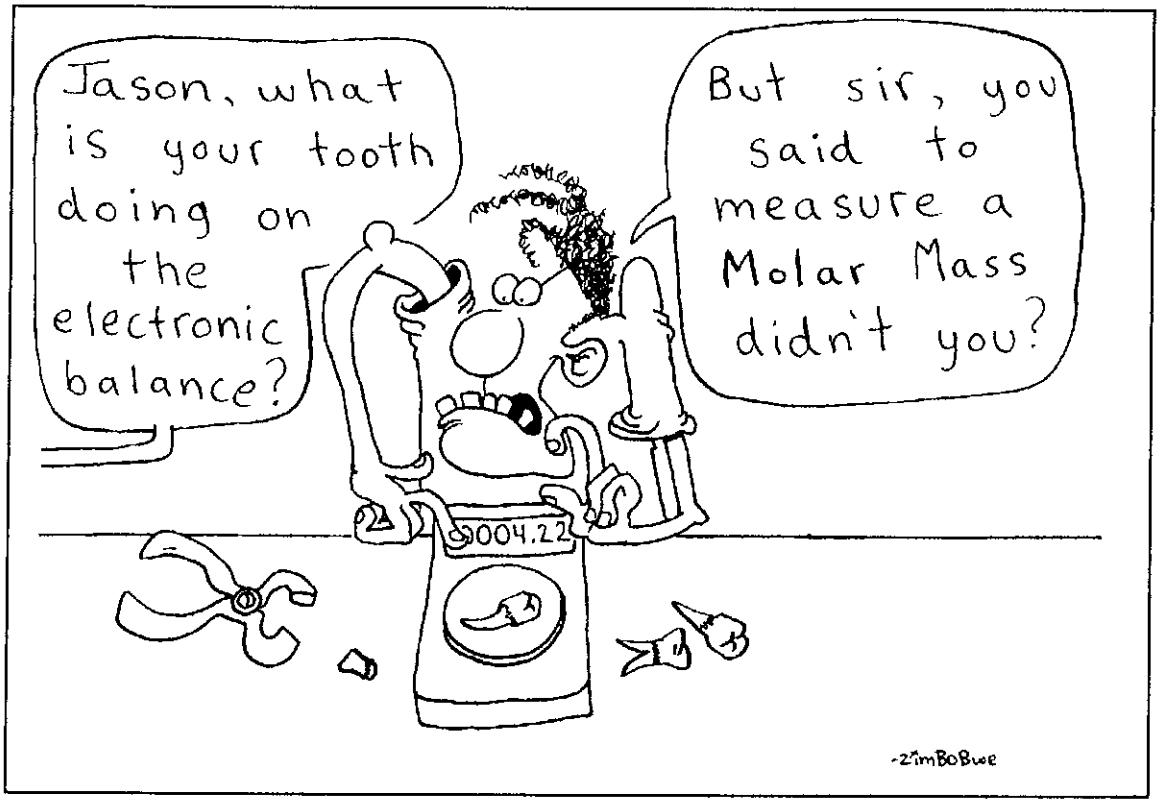
$$1\ Cu = 1 \times 63.5 = 63.5\ g$$
$$2\ N = 2 \times 14.0 = 28.0\ g$$
$$12\ O = 12 \times 16.0 = 192.0\ g$$
$$12\ H = 12 \times 1.0 = 12.0\ g$$

molar mass = **295.5 g**

EXERCISES:

6. Calculate the molar mass of each of the following.
   (a) NO (e) CH_4 (i) $FeCl_3$ (m) CH_3COOH
   (b) H_2O (f) $AgNO_3$ (j) SnC_2O_4 (n) $CH_3CH_2CH_2CH_3$
   (c) NH_3 (g) $Ca(OH)_2$ (k) $Sn(C_2O_4)_2$ (o) $Ni(H_2O)_2(NH_3)_4Cl_2$
   (d) CO_2 (h) $Al(NO_3)_3$ (l) $(NH_4)_3PO_4$ (p) $Al_2(SO_4)_3$

7. Calculate the molar mass of each of the following.
   (a) $Co_3(AsO_4)_2 \cdot 8H_2O$ (b) $Pb(C_2H_3O_2)_2 \cdot 3H_2O$ (c) $MgSO_4 \cdot 7H_2O$ (d) $KAl(SO_4)_2 \cdot 12H_2O$



CALCULATIONS RELATING THE NUMBER OF MOLES AND THE MASS OF A SUBSTANCE

The use of the MOLAR MASS allows the calculation of the mass of a given number of moles of a substance and the calculation of the number of moles in a given mass of a substance.

Note: Recall that the unit symbol for "mole" is "**mol**".
Example: three moles = 3 mol

Under **no** circumstances must you use any other unit symbol for the unit "mole", because all other possibly–suitable abbreviations (m, mo, M, Mo) already have special meanings in chemistry. Using any unit symbol besides "mol" will cause you great confusion later on in this course.

The following conversion factors are used to relate the number of moles to the mass of material present.

1 mol of X has a mass of **(molar mass of X) g**
produces the conversion factors

$$\frac{1 \text{ mol}}{(\textit{molar mass of X}) \text{ g}} \text{ or } \frac{(\textit{molar mass of X}) \text{ g}}{1 \text{ mol}}$$

EXAMPLE: **What is the mass of 3.25 mol of CO_2?**

molar mass of CO_2 = 44.0 g = mass of 1 mol of CO_2

$$\text{mass of } CO_2 = 3.25 \text{ mol} \times \frac{44.0 \text{ g}}{1 \text{ mol}} = \mathbf{143\ g}$$

EXAMPLE: **What is the mass of 1.36×10^{-3} mol of SO_3?**

molar mass of SO_3 = 80.1 g = mass of 1 mol of SO_3

$$\text{mass of } SO_3 = 1.36 \times 10^{-3} \text{ mol} \times \frac{80.1 \text{ g}}{1 \text{ mol}} = \mathbf{0.109\ g}$$

EXAMPLE: **How many moles of N_2 are there in 50.0 g of N_2?**

molar mass of N_2 = 28.0 g = mass of 1 mol of N_2

$$\text{\# of moles} = 50.0 \text{ g} \times \frac{1 \text{ mol}}{28.0 \text{ g}} = \mathbf{1.79\ mol}$$

EXAMPLE: **How many moles of CH_3OH are there in 0.250 g of CH_3OH?**

molar mass of CH_3OH = 32.0 g = mass of 1 mol of CH_3OH

$$\text{\# of moles} = 0.250 \text{ g} \times \frac{1 \text{ mol}}{32.0 \text{ g}} = \mathbf{7.81 \times 10^{-3}\ mol}$$

The units of molar mass are actually **g/mol.** This suggests that the molar mass can be calculated by dividing the mass of a substance by the number of moles contained in the substance.

EXAMPLE: **If 0.140 mol of acetylene gas has a mass of 3.64 g, what is the molar mass of acetylene?**

$$\text{molar mass} = \frac{3.64 \text{ g}}{0.140 \text{ mol}} = \mathbf{26.0\ g/mol}$$

EXERCISES:

8. Calculate the mass of the following.
   (a) 1.00 mol of NH_4Cl
   (b) 4.50 mol of NH_4Cl
   (c) 3.25 mol of PCl_3
   (d) 0.00355 mol of Na_2HPO_4
   (e) 0.0125 mol of XeF_4
   (f) 2.60 mol of CH_3CH_3
   (g) 3.25×10^2 mol of NH_3
   (h) 7.90×10^{-4} mol of H_2SO_3
   (i) 1.00×10^{-3} mol of NaOH
   (j) 1.75×10^{-4} mol of Fe

9. Calculate the number of moles in the following.
   (a) 17.0 g of H_2SO_4
   (b) 91.5 g of H_2O
   (c) 53.0 g of C
   (d) 0.125 mg of CuS
   (e) 4.50 kg of CH_4
   (f) 225 g of $(NH_4)_2SO_4$
   (g) 55.2 mg of Cl_2
   (h) 128.2 g of SO_2
   (i) 2955 kg of Ag
   (j) 0.0845 g of $KMnO_4$

10. Calculate the molar mass of each of the substances mentioned in the following.
    (a) A 0.250 mol sample of methane has a mass of 4.00 g.
    (b) A 0.00248 mol sample of cholesterol has a mass of 0.947 g.
    (c) The mass of 6.47×10^{-4} mol of diamond is 7.76 mg.
    (d) A 3.44×10^{-5} mol sample of a particular protein has a mass of 74.8 g.

CALCULATIONS RELATING THE NUMBER OF MOLES AND THE VOLUME OF A GAS

Calculations involving gas volumes are simplified by the previously–mentioned Avogadro's Hypothesis.

Avogadro's Hypothesis: Equal volumes of different gases, at the same temperature and pressure, contain the same number of particles.

Before proceeding, some additional definitions are needed.

Definition: The **MOLAR VOLUME** of a gas is the volume occupied by one mole of the gas.

STANDARD TEMPERATURE AND PRESSURE (STP) = **0°C** and **101.3 kPa.**

Avogadro's Hypothesis is interpreted to mean: **all gas samples with the same pressure, temperature and number of particles occupy identical volumes. This restatement implies that equal numbers of moles of every gas at STP occupy identical volumes.**

Experimentally–determined fact:

1 mol of **ANY GAS** at STP has a volume of **22.4 L.**

In other words **the MOLAR VOLUME of *any gas* at STP is 22.4 L.**

Conversion factor: $\frac{1\text{ mol}}{22.4\text{ L}}$ or $\frac{22.4\text{ L}}{1\text{ mol}}$

NOTE: These conversion factors **ONLY apply to gases and only at STP.**

EXAMPLE: **What is the volume occupied by 0.350 mol of $SO_2(g)$ at STP?**

$$\#\text{ of litres} = 0.350\text{ mol} \times \frac{22.4\text{ L}}{1\text{ mol}} = \mathbf{7.84\ L}$$