

**Key**

**Mole-1**

1. Describe/relate the size of the mole to an everyday object.

2. What is Avogadro's Number?  $6.02 \times 10^{23}$

3. How many marbles are in a mole of marbles?  $6.02 \times 10^{23}$  marbles

4. How many mosquitoes are in a mole of mosquitoes?

$6.02 \times 10^{23}$  mosquitoes

**Mole-2 Molar Mass**

Find the molar mass of the following compounds: Show work and include units

$$1. \text{ CO}_2 | 2.0 + (16.0 \times 2) = \boxed{\frac{44.0 \text{ g}}{1 \text{ mol}}}$$

$$2. \text{ Fe}_2\text{O}_3 | (55.8 \times 2) + (16.0 \times 3) = \boxed{\frac{159.6 \text{ g}}{1 \text{ mol}}}$$

$$3. \text{ AgCl} | (107.9 + 35.5) = \boxed{\frac{143.4 \text{ g}}{1 \text{ mol}}}$$

$$4. \text{ Ca}_3(\text{PO}_4)_2 | (40.1 \times 3) + (31.0 \times 2) + (8 \times 16.0) = \boxed{\frac{310.3 \text{ g}}{1 \text{ mol}}}$$

$$5. \text{ W}_3(\text{PO}_4)_5 | (183.8 \times 3) + (31.0 \times 5) + (15 \times 16.0) = \boxed{\frac{946.4 \text{ g}}{1 \text{ mol}}}$$

$$6. \text{ Fe(C}_2\text{H}_3\text{O}_2)_2 | 55.8 + (4 \times 12.0) + (6 \times 1.0) + (4 \times 16.0) = \boxed{\frac{173.8 \text{ g}}{1 \text{ mol}}}$$

$$7. \text{ Calcium Carbonate } \text{CaCO}_3$$

$$40.1 + 12.0 + (3 \times 16.0) = \boxed{\frac{100.1 \text{ g}}{1 \text{ mol}}}$$

$$8. \text{ Lead IV Sulfate } \overset{+4}{\text{Pb}}_2\overset{-2}{\text{S}\text{O}_4}_{2-} | 207.2 + (32.1 \times 2) + (8 \times 16.0) = \boxed{\frac{399.4 \text{ g}}{1 \text{ mol}}}$$

$$9. \text{ Lead IV Sulfite } \overset{+4}{\text{Pb}}\overset{-2}{\text{S}\text{O}_3}_2 | 207.2 + (32.1 \times 2) + (6 \times 16.0) = \boxed{\frac{367.4 \text{ g}}{1 \text{ mol}}}$$

$$10. \text{ Lead IV Sulfide } \overset{+4}{\text{Pb}}\overset{-2}{\text{S}}_2 | 207.2 + (32.1 \times 2) = \boxed{\frac{271.4 \text{ g}}{1 \text{ mol}}}$$

$$11. \text{ Lead II sulfate } \overset{+2}{\text{Pb}}\overset{-2}{\text{S}\text{O}_4} | 207.2 + 32.1 + (4 \times 16.0) = \boxed{\frac{303.3 \text{ g}}{1 \text{ mol}}}$$

$$12. \text{ Lead II Sulfite } \overset{+2}{\text{Pb}}\overset{-2}{\text{S}\text{O}_3} | 207.2 + 32.1 + (3 \times 16.0) = \boxed{\frac{287.3 \text{ g}}{1 \text{ mol}}}$$

$$13. \text{ Lead II Sulfide } \overset{+2}{\text{Pb}}\overset{-2}{\text{S}} | 207.2 + 32.1 = \boxed{239.3 \text{ g/mol}}$$

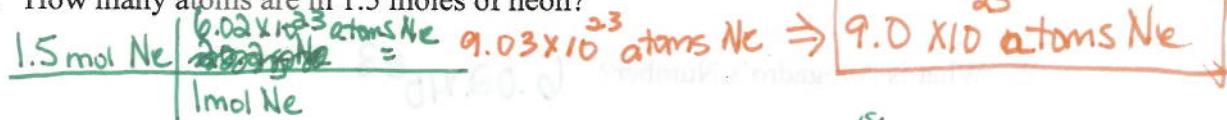
$$14. \text{ Copper I Sulfide } \overset{+1}{\text{Cu}}_2\overset{-2}{\text{S}} | (63.5 \times 2) + 32.1 = \boxed{\frac{159.1 \text{ g}}{1 \text{ mol}}}$$

$$15. \text{ Copper II Sulfite } \overset{+2}{\text{Cu}}\overset{-2}{\text{S}\text{O}_3} | 63.5 + 32.1 = \boxed{\frac{143.6 \text{ g}}{1 \text{ mol}}} + (48)$$

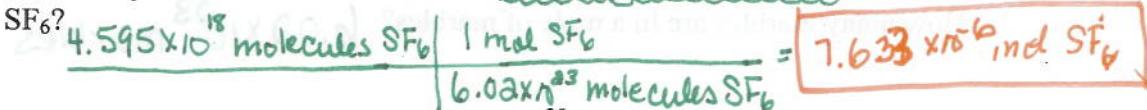
**Mole-3 Mole Conversions (one step)**

**Directions:** Answer the following questions. Set-up all problems using the factor-label method of dimensional analysis and show all your work and units.

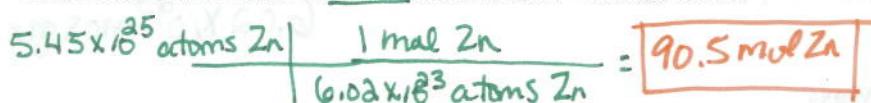
1. How many atoms are in 1.5 moles of neon?



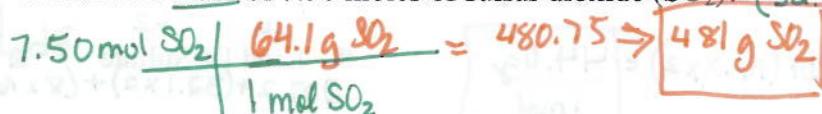
2. How many moles of SF<sub>6</sub> are there in  $4.595 \times 10^{18}$  molecules of SF<sub>6</sub>?



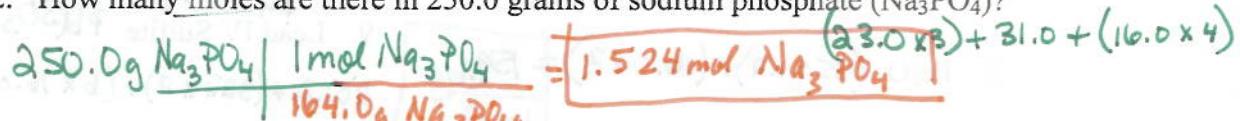
3. Calculate the number of moles in  $5.45 \times 10^{25}$  atoms of Zn



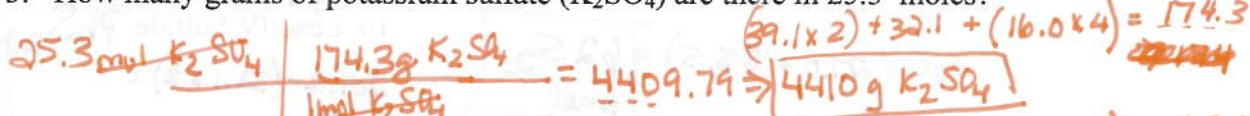
1. What is the mass of 7.50 moles of sulfur dioxide (SO<sub>2</sub>)?



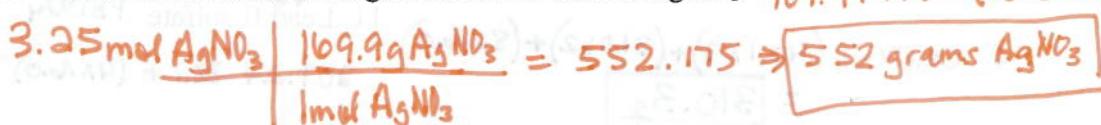
2. How many moles are there in 250.0 grams of sodium phosphate (Na<sub>3</sub>PO<sub>4</sub>)?



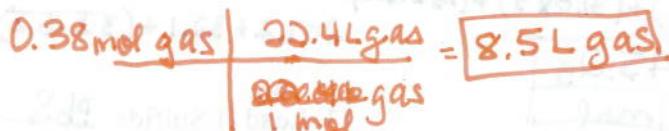
3. How many grams of potassium sulfate (K<sub>2</sub>SO<sub>4</sub>) are there in 25.3 moles?



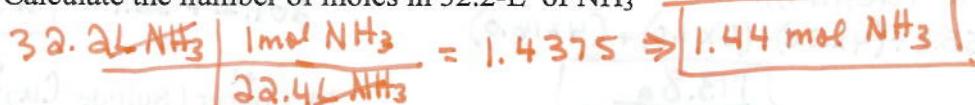
4. Calculate the number of grams in 3.25-mol of AgNO<sub>3</sub>



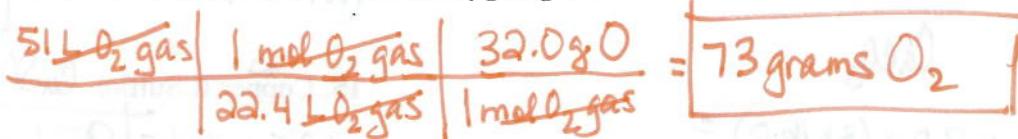
5. What is the volume of 0.38 moles of any gas at STP?



6. Calculate the number of moles in 32.2-L of NH<sub>3</sub>



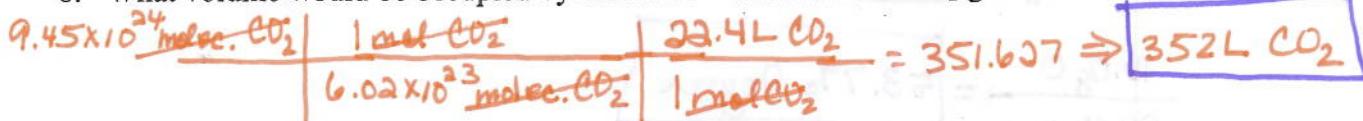
7. What is the mass of 51 liters of oxygen gas?



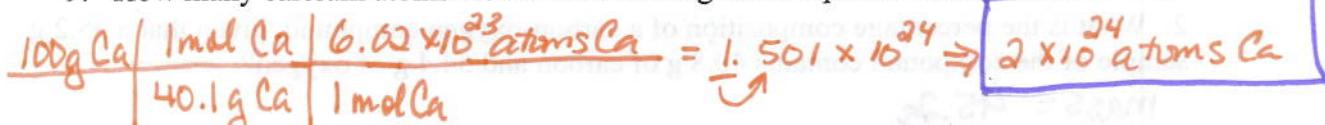
**Mole-4: Mole Conversions (two steps)**

**Directions:** Answer the following questions. Set-up all problems using the factor-label method of dimensional analysis and show all your work and units.

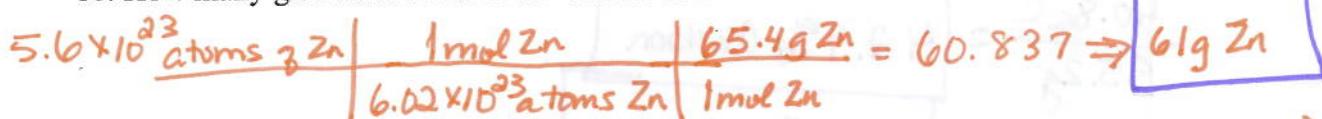
8. What volume would be occupied by  $9.45 \times 10^{24}$  molecules of CO<sub>2</sub> gas at STP?



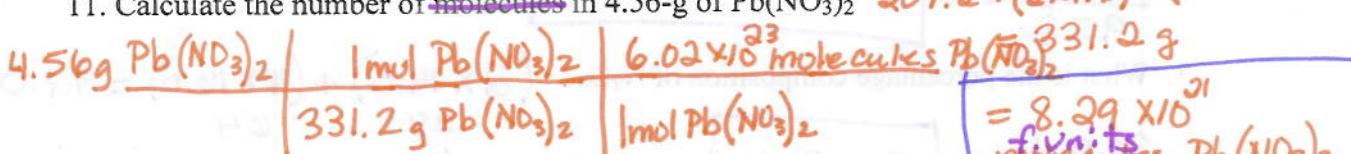
9. How many calcium atoms would be in a 100 gram sample of calcium metal?



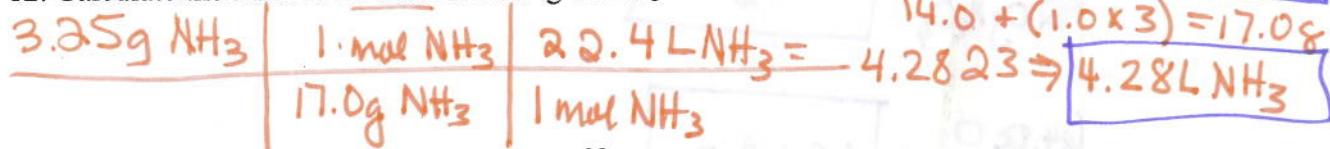
10. How many grams are in  $5.6 \times 10^{23}$  atoms of Zinc?



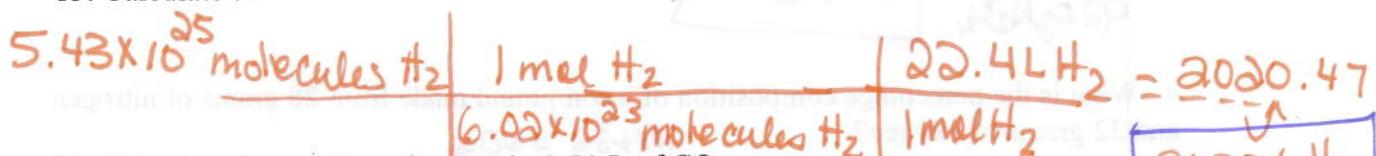
\* 11. Calculate the number of molecules in 4.56-g of Pb(NO<sub>3</sub>)<sub>2</sub>



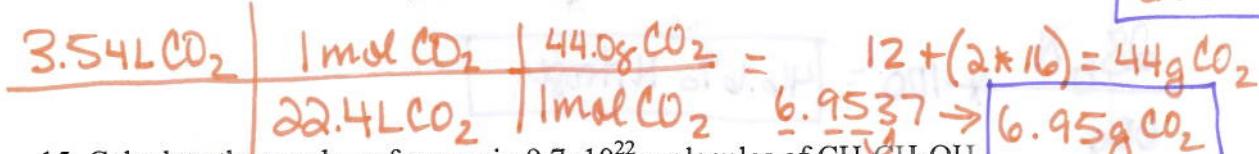
12. Calculate the number of liters in 3.25-g of NH<sub>3</sub>



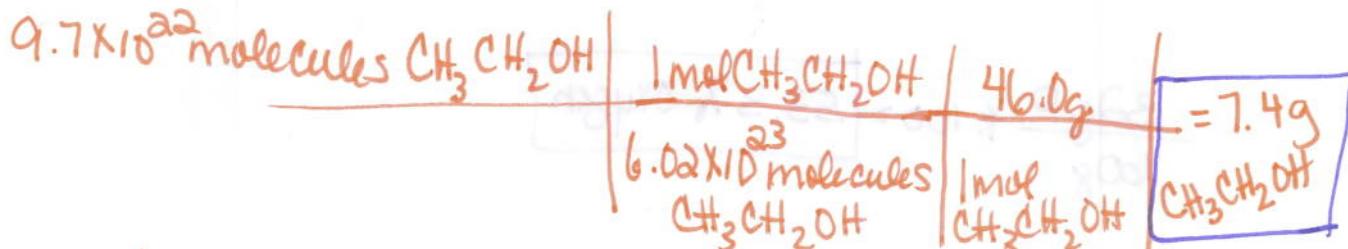
13. Calculate the number of liters in  $5.43 \times 10^{25}$  molecules of H<sub>2</sub>



14. Calculate the number of grams in 3.54-L of CO<sub>2</sub>



15. Calculate the number of grams in  $9.7 \times 10^{22}$  molecules of CH<sub>3</sub>CH<sub>2</sub>OH



$$\frac{C}{(2+12)+(5 \times 10)+16O} = 46.0$$

**Mole-5 Percent Composition**

1. Calculate the % composition of Li<sub>2</sub>O.  $(2 \times 6.9) + 16.0 = 29.8 \text{ g Li}_2\text{O}$

$$\frac{13.8 \text{ g Li}}{29.8 \text{ g Li}_2\text{O}} = 46.3\% \text{ Lithium}$$

$$\frac{16.0 \text{ g O}}{29.8 \text{ g Li}_2\text{O}} = 53.7\% \text{ Oxygen}$$

2. What is the percentage composition of a carbon-oxygen compound, given that a 95.2 g sample of the compound contains 40.8 g of carbon and 54.4 g of oxygen?

$$\text{mass} = 95.2 \text{ g}$$

$$\frac{40.8 \text{ g C}}{95.2 \text{ g}} = 42.9\% \text{ Carbon}$$

$$\frac{54.4 \text{ g O}}{95.2 \text{ g}} = 57.1\% \text{ Oxygen}$$

3. What is the percentage composition of N<sub>2</sub>O<sub>4</sub>?  $(2 \times 14.0) + (4 \times 16.0) = 92.0$

$$\frac{28.0 \text{ g N}}{92.0 \text{ g N}_2\text{O}_4} = 30.4\% \text{ N}$$

$$\frac{64.0 \text{ g O}}{92.0 \text{ g N}_2\text{O}_4} = 69.6\% \text{ O}$$

4. What is the percentage composition of a compound made from 28 grams of nitrogen and 32 grams of oxygen?  $28+32=60 \text{ g}$

$$\frac{28 \text{ g N}}{60 \text{ g}} * 100 = 46.6\% \text{ Nitrogen}$$

$$\frac{32 \text{ g O}}{60 \text{ g}} * 100 = 53.3\% \text{ Oxygen}$$

5. What is the percentage composition of a carbon-hydrogen-fluorine compound which contains 7.2 grams of carbon, 11.4 grams of fluorine, and 1.8 grams of hydrogen?

$$7.2 + 11.4 + 1.8 = 20.4 \text{ g}$$

$$\frac{7.2 \text{ g C}}{20.4} \times 100 = \boxed{35.39\% \text{ C}}$$

$$\frac{11.4 \text{ g F}}{20.4 \text{ g}} \times 100 = \boxed{55.99\% \text{ F}}$$

$$\frac{1.8 \text{ g H}}{20.4 \text{ g}} \times 100 = \boxed{8.87\% \text{ H}}$$

6. Find the percentage composition of  $\text{Na}_2\text{SO}_4$ ?

$$\frac{(23.0 \times 2)}{46} + 32.1 + (16.0 \times 4) = 142.1 \text{ g}$$

$$\frac{46.0 \text{ g Na}}{142.1 \text{ g } \text{Na}_2\text{SO}_4} \times 100 = \boxed{32.49\% \text{ Na}}$$

$$\frac{32.1 \text{ g S}}{142.1 \text{ g } \text{Na}_2\text{SO}_4} \times 100 = \boxed{22.6\% \text{ S}}$$

$$\frac{64.0 \text{ g O}}{142.1 \text{ g } \text{Na}_2\text{SO}_4} \times 100 = \boxed{45.0\% \text{ O}}$$

7. If a compound is formed from 60.0 liters of nitrogen gas,  $\text{N}_2$ , (at STP) and 180 liters of hydrogen gas,  $\text{H}_2$ , (at STP), what is its percentage composition?

$$\frac{60 \text{ L } \text{N}_2}{22.4 \text{ L } \text{N}_2} \left| \begin{array}{c} 1 \text{ mol } \text{N}_2 \\ 1 \text{ mol } \text{N}_2 \end{array} \right| \frac{28.0 \text{ g } \text{N}_2}{1 \text{ mol } \text{N}_2} = 75 \text{ g } \text{N}_2$$

$$\frac{75 + 16.1}{91.1} = \frac{91.1 \text{ g}}{\text{1 mol compound}}$$

$$\frac{180 \text{ L } \text{H}_2}{22.4 \text{ L } \text{H}_2} \left| \begin{array}{c} 1 \text{ mol } \text{H}_2 \\ 1 \text{ mol } \text{H}_2 \end{array} \right| \frac{2.0 \text{ g } \text{H}_2}{1 \text{ mol } \text{H}_2} = 16.1 \text{ g } \text{H}_2$$

$$\frac{75.0 \text{ g } \text{N}_2}{91.1 \text{ g compound}} \times 100 = \boxed{82.3\% \text{ N}_2}$$

$$\frac{16.1 \text{ g } \text{H}_2}{91.1 \text{ g compound}} \times 100 = \boxed{17.7\% \text{ H}_2}$$

8. Find the percentage composition of a compound formed when 0.4 moles of potassium are reacted with 8.96 liters of  $\text{O}_2$  gas and  $2.41 \times 10^{22}$  atoms of S.

$$\frac{0.4 \text{ mol K}}{1 \text{ mol K}} \left| \begin{array}{c} 39.1 \text{ g K} \\ 1 \text{ mol K} \end{array} \right| = 15.64 \rightarrow$$

$$\frac{15.6}{29.7} \times 100 = \boxed{52.59\% \text{ K}}$$

$$\frac{8.96 \text{ L } \text{O}_2}{22.4 \text{ L } \text{O}_2} \left| \begin{array}{c} 1 \text{ mol } \text{O}_2 \\ 1 \text{ mol } \text{O}_2 \end{array} \right| \frac{32 \text{ g } \text{O}_2}{1 \text{ mol } \text{O}_2} = 12.8 \text{ g } \text{O}_2 \rightarrow$$

$$\frac{12.8}{29.7} \times 100 = \boxed{43.1\% \text{ O}}$$

$$\frac{2.41 \times 10^{22} \text{ atoms S}}{6.02 \times 10^{23} \text{ atoms S}} \left| \begin{array}{c} 1 \text{ mol S} \\ 1 \text{ mol S} \end{array} \right| \frac{32.1 \text{ g S}}{1 \text{ mol S}} = 1.285 \rightarrow$$

$$\frac{1.3}{29.7} \times 100 = \boxed{4.377\% \text{ S}}$$

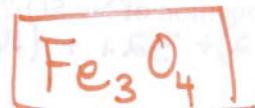
$$15.6 + 12.8 + 1.3 = \frac{29.7 \text{ g}}{1 \text{ mol total}}$$

**Mole-6: Empirical Formulas**

1. Determine the empirical formula of a compound with 72.4% Fe and 27.6% Oxygen.

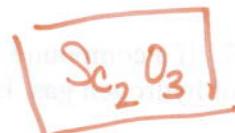
$$\frac{72.4\text{g Fe}}{55.8\text{g Fe}} \left| \frac{1\text{mol Fe}}{1\text{mol Fe}} \right. = \frac{1.297}{1.297} = 1 + 3 = 3$$

$$\frac{27.6\text{g O}}{16.0\text{g O}} \left| \frac{1\text{mol O}}{1\text{mol O}} \right. = \frac{1.725}{1.297} = 1.3 * 3 = 4$$



2. Determine the empirical formula of a compound with 65.2% Sc and 34.8% O

$$\frac{65.2\text{g Sc}}{45.0\text{g Sc}} \left| \frac{1\text{mol Sc}}{1\text{mol Sc}} \right. = \frac{1.45}{1.45} = 1 \times 2 = 2$$



$$\frac{34.8\text{g O}}{16.0\text{g O}} \left| \frac{1\text{mol O}}{1\text{mol O}} \right. = \frac{2.175}{1.45} = 1.5 \times 2 = 3$$

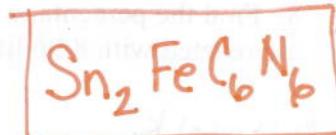
3. Determine the empirical formula of a compound with 52.8% Sn, 12.4% Fe, 16% C and 18.8% N.

$$\frac{52.8\text{g Sn}}{118.7\text{g Sn}} \left| \frac{1\text{mol Sn}}{1\text{mol Sn}} \right. = \frac{0.4448}{0.2222} = 2$$

$$\frac{12.4\text{g Fe}}{55.8\text{g Fe}} \left| \frac{1\text{mol Fe}}{1\text{mol Fe}} \right. = \frac{0.2222}{0.2222} = 1$$

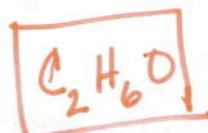
$$\frac{16.0\text{g C}}{12.0\text{g C}} \left| \frac{1\text{mol C}}{1\text{mol C}} \right. = \frac{1.333}{0.2222} = 6.000$$

$$\frac{18.8\text{g N}}{14.0\text{g N}} \left| \frac{1\text{mol N}}{1\text{mol N}} \right. = \frac{1.34}{0.2222} = 6$$



4. Determine the empirical formula of a compound that contains 2.61-g of carbon, 0.65-g of hydrogen, and 1.74-g of oxygen

$$\frac{2.61\text{g C}}{12.0\text{g C}} \left| \frac{1\text{mol C}}{1\text{mol C}} \right. = \frac{0.2175}{0.10875} = 2$$

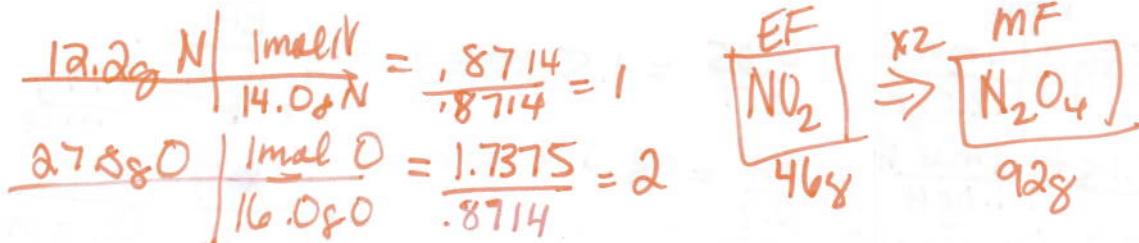


$$\frac{0.65\text{g H}}{1.0\text{g H}} \left| \frac{1\text{mol H}}{1\text{mol H}} \right. = \frac{0.65}{0.10875} = 5.97 = 6$$

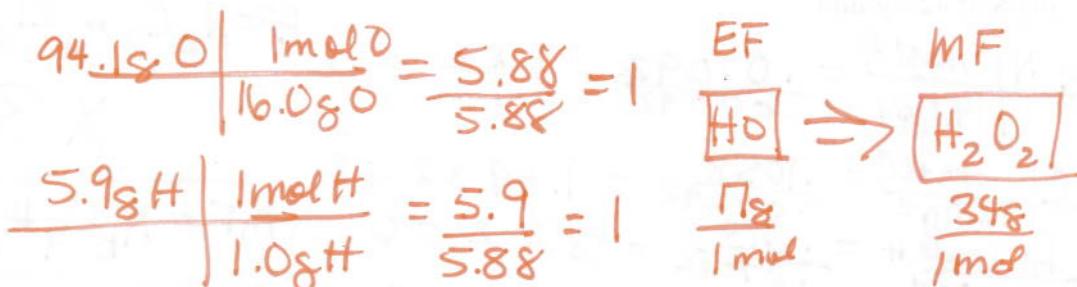
$$\frac{1.74\text{g O}}{16.0\text{g O}} \left| \frac{1\text{mol O}}{1\text{mol O}} \right. = \frac{0.10875}{0.10875} = 1$$

## Mole-7 Molecular Formula

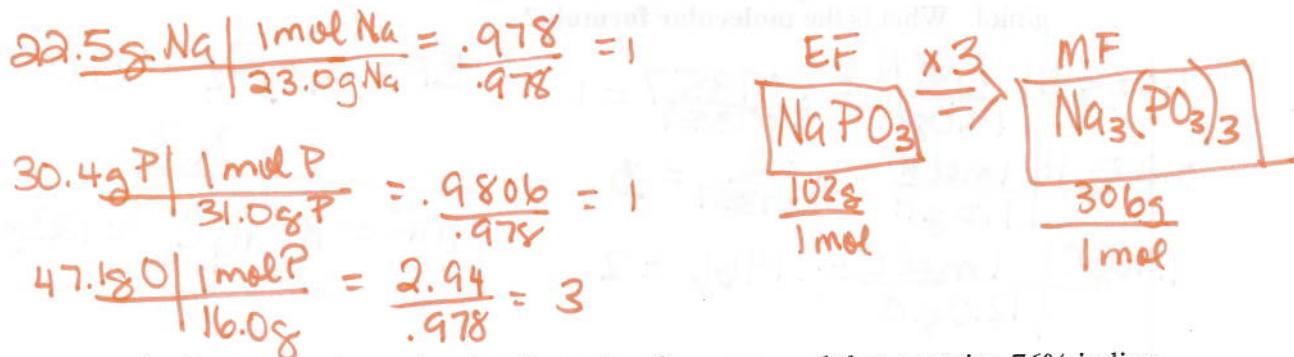
1. Determine the molecular formula for a compound that contains 12.2-g Nitrogen, 27.8-g Oxygen, and a molecular mass of 92.0 g/mol.



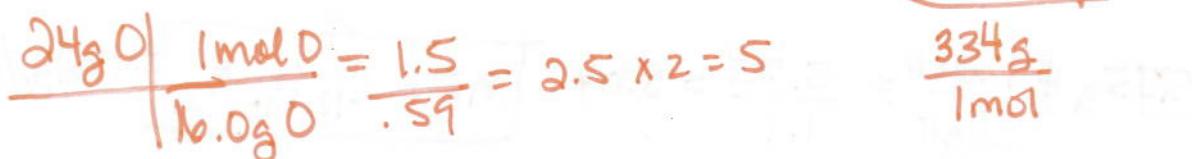
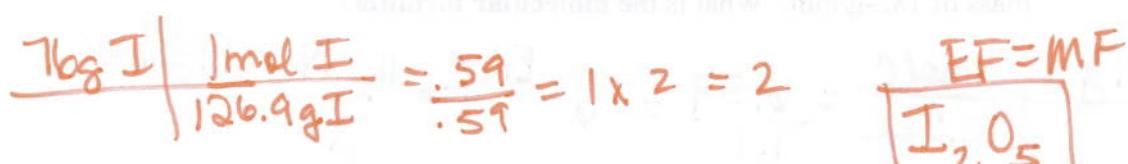
2. Determine the **molecular** formula for a compound that contains 94.1% oxygen and 5.9% hydrogen and a molecular mass of 34 g/mol.



3. Determine the **molecular** formula for a compound that contains 22.5% Na, 30.4% P and 47.1% O and a molar mass of 306 g/mol



4. Determine the **molecular formula** of a compound that contains 76% iodine and 24% oxygen and has a molar mass of 334g/mol.



5. Determine the molecular formula of a compound that contains 48.6% carbon, 8.1% hydrogen, and 43.2% oxygen and has a molar mass of 296-g/mol.

$$\frac{48.6\text{g C}}{12.0\text{g C}} \times \frac{1\text{ mol C}}{1\text{ mol C}} = \frac{4.05}{2.7} = 1.5 \times 2 = 3$$

$$\frac{\text{EF}}{\text{C}_3\text{H}_6\text{O}_2} = \frac{74.8}{\text{mole}}$$

$$\frac{8.1\text{g H}}{1.0\text{g H}} \times \frac{1\text{ mol H}}{1\text{ mol H}} = \frac{8.1}{2.7} = 3 \times 2 = 6$$

$$\frac{43.2\text{g O}}{16.0\text{g O}} \times \frac{1\text{ mol O}}{1\text{ mol O}} = \frac{2.7}{2.7} = 1 \times 2 = 2$$

$$\boxed{\text{C}_{12}\text{H}_{24}\text{O}_8 \text{ z MF } \frac{296\text{g}}{\text{mole}}} \quad \times 4$$

6. Determine the molecular formula of a compound that contains 0.993-g nitrogen, 1.27-g carbon, 0.213-g hydrogen, 2.52-g chlorine and has a molar mass of 423-g/mol.

$$\frac{0.993\text{g N}}{14.0\text{g N}} \times \frac{1\text{ mol N}}{1\text{ mol N}} = \frac{0.07092}{0.07092} = 1 \times 2 = 2$$

$$\text{EF} = \text{N}_2\text{C}_3\text{H}_6\text{Cl}_2 = \frac{141.8}{1\text{ mole}}$$

$\times 3$

$$\frac{1.27\text{g C}}{12.0\text{g C}} \times \frac{1\text{ mol C}}{1\text{ mol C}} = \frac{0.1058}{0.07092} = 1.49 \times 2 = 3$$

$$\frac{0.213\text{g H}}{1.0\text{g H}} \times \frac{1\text{ mol H}}{1\text{ mol H}} = \frac{0.213}{0.07092} = 3 \times 2 = 6$$

$$\frac{2.52\text{g Cl}}{35.5\text{g Cl}} \times \frac{1\text{ mol Cl}}{1\text{ mol Cl}} = \frac{0.07098}{0.07092} = 1 \times 2 = 2$$

$$\boxed{\text{MF} = \text{N}_6\text{C}_9\text{H}_{18}\text{Cl}_6}$$

7. A sample of TNT, a common explosive is analyzed and found to contain 1.03-g of nitrogen, 0.220-g hydrogen, and 1.76-g of carbon. The molar mass is 123-g/mol. What is the molecular formula?

$$\frac{1.03\text{g N}}{14.0\text{g N}} \times \frac{1\text{ mol N}}{1\text{ mol N}} = \frac{0.07357}{0.07357} = 1$$

$$\text{EF} = \text{N}_1\text{H}_3\text{C}_2 = 41\text{g / 1mol}$$

$\times 3$

$$\frac{0.220\text{g H}}{1.0\text{g H}} \times \frac{1\text{ mol H}}{1\text{ mol H}} = \frac{0.22}{0.07357} = 3$$

$$\frac{1.76\text{g C}}{12.0\text{g C}} \times \frac{1\text{ mol C}}{1\text{ mol C}} = \frac{0.1466}{0.07357} = 2$$

$$\boxed{\text{MF} = \text{N}_3\text{H}_9\text{C}_6} = 123\text{g / mol}$$

8. Azobenzene is an important intermediate in the manufacture of dyes. It contains 79.1% carbon, 5.55% hydrogen, and 15.4% nitrogen. It has a molar mass of 182-g/mol. What is the molecular formula?

$$\frac{79.1\text{g C}}{12.0\text{g C}} \times \frac{1\text{ mol C}}{1\text{ mol C}} = \frac{6.59}{1.1} = 6 \quad \text{EF} = \text{C}_6\text{H}_5\text{N} = 91\text{g / mol}$$

$\times$

$2$

$$\frac{5.55\text{g H}}{1.0\text{g H}} \times \frac{1\text{ mol H}}{1\text{ mol H}} = \frac{5.55}{1.1} = 5.04 \quad \boxed{\text{MF} = \text{C}_{12}\text{H}_{10}\text{N}_2 = 182\text{g / mol}}$$

$$\frac{15.4\text{g N}}{14.0\text{g N}} \times \frac{1\text{ mol N}}{1\text{ mol N}} = \frac{1.1}{1.1} = 1$$