TUTORIAL 5-1 **HELP**

ANSWER TO QUESTION 1 ON TUTORIAL 5-1:

Question 1. Find the percent composition by mass of sodium phosphate, Na_3PO_4.

Step 1: Find the molar mass of Na_3PO_4 (*The mass of one mole of* Na_3PO_4 *molecules*)

Molar Mass = 3(23.0) + 31.0 + 4(16.0) = 164 g/mol .

Step 2: Find the total mass of all the sodium atoms in one mole of the compound.
To do this, multiply the *atomic mass* of sodium by the *subscript* of sodium in the formula.($Na_{3...}$)

Mass of sodium = 23.0 g/mol x 3 mol = 69.0 g of sodium

Step 3: Divide the *mass of sodium* by the *molar mass of* Na_3PO_4 and multiply by 100% to get percent mass.

$$\text{Percent mass of sodium} = \frac{69.0\ g}{164\ g} \times 100\% = 42.1\ \%\ Na$$

Step 4: Find the total mass of all the phosphorus atoms in one mole of the compound.
To do this, multiply the *atomic mass* of phosphorus by the *subscript* of phosphorus in the formula.(...P..) (*no subscript, so call it "1"*)

Mass of phosphorus = 31.0 g/mol x 1 mol = 31.0 g of phosphorus

Step 5: Divide the *mass of phosphorus* by the *molar mass of* Na_3PO_4 and multiply by 100% to get percent mass.

$$\text{Percent mass of phosphorus} = \frac{31.0g}{164\ g} \times 100\% = 18.9\ \%\ P$$

Step 6: Find the total mass of all the oxygen atoms in one mole of the compound.
To do this, multiply the *atomic mass* of oxygen by the *subscript* of oxygen in the formula.(...O_4)

Mass of oxygen = 16.0 g/mol x 4 mol = 64.0 g of oxygen

Step 7: Divide the *mass of oxygen* by the *molar mass of* Na_3PO_4 and multiply by 100% to get percent mass.

$$\text{Percent mass of oxygen} = \frac{64.0\ g}{164\ g} \times 100\% = 39.0\ \%\ O$$

Now, we can summarize the percent composition by mass of Na_3PO_4.

So the percent composition by mass of Na_3PO_4 is: **42.1 % Na, 18.9% P and 39.0 % O**

ANSWER TO QUESTION 2 ON TUTORIAL 5-1

Question 2 Find the percent composition by mass of the compound ammonium phosphate, $(NH_4)_3PO_4$.

Step 1: Find the molar mass of $(NH_4)_3PO_4$ (*The mass of one mole of* $(NH_4)_3PO_4$ *molecules*)

Molar Mass = 3(14.0) + 12(1.0) + 31.0 + 4(16.0) = 149 g/mol .

Step 2: Find the total mass of all the nitrogen atoms in one mole of the compound.
To do this, multiply the *atomic mass* of nitrogen by the *number of nitrogen atoms* in the formula. $(NH_4)_{3...}$ = 3 x 1 = 3

Mass of nitrogen = 14.0 g/mol x 3 mol = 42.0 g of nitrogen

Step 3: Divide the *mass of nitrogen* by the *molar mass of* $(NH_4)_3PO_4$ and multiply by 100% to get percent mass.

$$\text{Percent mass of nitrogen} = \frac{42.0\text{ g}}{149\text{g}} \times 100\% = 28.2\%\text{ N}$$

Step 4: Find the total mass of all the hydrogen atoms in one mole of the compound.
To do this, multiply the *atomic mass* of hydrogen by the *number* of hydrogen atoms in the formula. $(NH_4)_{3...}$ 3 x 4 = 12 "H" atoms.

Mass of hydrogen = 1.0 g/mol x 12 mol = 12.0 g of hydrogen

Step 5: Divide the *mass of hydrogen* by the *molar mass of* $(NH_4)_3PO_4$ and multiply by 100% to get percent mass.

$$\text{Percent mass of hydrogen} = \frac{12.0\text{g}}{149\text{ g}} \times 100\% = 8.1\%\text{ H}$$

Step 6: Find the total mass of all the phosphorus atoms in one mole of the compound.
To do this, multiply the *atomic mass* of phosphorus by the *subscript* of phosphorus in the formula.(...P...) 1 atom of "P".

Mass of phosphorus = 31.0 g/mol x 1 mol = 31.0 g of phosphorus

Step 7: Divide the *mass of phosphorus* by the *molar mass of* $(NH_4)_3PO_4$ and multiply by 100% to get percent mass.

$$\text{Percent mass of phosphorus} = \frac{31.0\text{ g}}{149\text{g}} \times 100\% = 20.8\%\text{ P}$$

Step 8: Find the total mass of all the oxygen atoms in one mole of the compound.
To do this, multiply the *atomic mass* of oxygen by the *subscript* of oxygen in the formula.(...O_4)

Mass of oxygen = 16.0 g/mol x 4 mol = 64.0 g of oxygen

Step 9: Divide the *mass of oxygen* by the *molar mass of* $(NH_4)_3PO_4$ and multiply by 100% to get percent mass.

$$\text{Percent mass of oxygen} = \frac{64.0\text{ g}}{149\text{ g}} \times 100\% = 43.0\%\ \text{O}$$

Now, we can summarize the percent composition by mass of $(NH_4)_3PO_4$

$(NH_4)_3PO_4$ is **28.2 % N , 8.1% H, 20.8 % P and 43.0 % O** by mass.

NOTE: Add up all these percentages and we should get very close to 100%.
(If you try it this time, you will come up with 100.1% which is close enough. Remember that each one of the percentages were rounded to 1 decimal place in this example.)

ANSWER TO QUESTION 3 ON TUTORIAL 5-1

Question 3

Find the mass of Na in 568 g of Na_3PO_4

First, the conversion factor is: $\frac{3(23.0)\text{ g of Na}}{3(23.0) + 31.0 + 4(16.0)\text{ g of } Na_3PO_4}$ < -- *(3 x the atomic mass of Na)* < --*(molar mass of Na_3PO_4)*

$$= \frac{69.0\text{ g of Na}}{164\text{ g of } Na_3PO_4}$$

Final step: $568\text{ g } Na_3PO_4 \times \frac{69.0\text{ g of Na}}{164\text{ g of } Na_3PO_4} =$ **239 g of Na**

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ANSWER TO QUESTION 4 ON TUTORIAL 5-1
Question 4

Given the following molecular formulas, find the empirical formulas.

Molecular Formula	Empirical Formula
P_4O_{10}	P_2O_5
$C_{10}H_{22}$	C_5H_{11}
$C_6H_{18}O_3$	C_2H_6O
$C_5H_{12}O$	$C_5H_{12}O$
N_2O_4	NO_2

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ANSWER TO QUESTION 5 ON TUTORIAL 5-1.
Question 5

The empirical formula for a compound is CH_2O and the molar mass is 90.0. Find the molecular formula. First we find the mass of the empirical formula:

C H_2 O

12.0 + 2(1.0) +16.0 = **30** g/mol is the *mass of the empirical formula*

Now try to find a ***simple whole number*** that you multiply the mass of the empirical formula by to get the molar mass:

mass of the empirical formula x ? = *molar mass*

30 **x ? = 90**

You can see that in this case the simple whole number is "**3**"

Now, multiply all subscripts in the empirical formula by this whole number: ("3" in this case)

Empirical formula x 3 = Molecular Formula

CH_2O x 3 = $C_3H_6O_3$

	Empirical	Molecular
Formula	CH_2O **x 3** →	**$C_3H_6O_3$**
Mass	30.0 **x 3** →	90.0

A good thing to do now is to figure out the molecular mass using your molecular formula ($C_3H_6O_3$) and make sure it is the same as the molar mass given (*90.0 g/mol*):

C_3 H_6 O_3

3(12.0) + 6(1.0) +3(16.0) = **90** g/mol is the molar *mass*.

So ***$C_3H_6O_3$*** must be the correct molecular formula for this compound.

ANSWERS TO THE SELF-TEST ON TUTORIAL 5-1

1. Determine the ***percent composition*** of the compound calcium nitrate ($Ca(NO_3)_2$)
(That is, find the % calcium, the % nitrogen and the % oxygen in this compound.)
Solution:

First, find the *molar mass* of $Ca(NO_3)_2$. In this formula there is 1 Ca, 2 "N"s and 6 "O"s

The molar mass is : 40.1 + 2(14.0) + 6(16.0) = 164.1 g/mol

The % Ca = $\frac{40.1}{164.1}$ x 100% = 24.4 %

The % N = $\frac{2(14.0)}{164.1}$ x 100% = 17.1 %

The % O = $\frac{6(16.0)}{164.1}$ x 100% = 58.5 %

So, the percent composition of calcium nitrate is 24.4% "Ca", 17.1% "N" and 58.5% "O".

2. Find the mass of carbon contained in 336.16 grams of CO_2.

Solution:

There is 1 mole of "C" atoms in a mole of CO_2

The mass of 1 mole of C atoms is 12.0 grams (atomic mass of C)

The mass of one mole of CO_2 (molar mass) is 12.0 + 2(16.0) = 44.0 grams.

So we have a conversion factor: $\frac{12.0 \text{ g C}}{44.0 \text{ g } CO_2}$

So we can now go: 336.16 g CO_2 x $\frac{12.0 \text{ g C}}{44.0 \text{ g } CO_2}$ = 91.68 grams of C = **91.7 grams of C**

So there are 91.68 grams of C in 336.16 grams of CO_2.

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3. Find the mass of oxygen contained in 860.0 grams of magnesium nitrate ($Mg(NO_3)_2$)
Solution:

The molar mass of $Mg(NO_3)_2$ is 24.3 + 2(14.0) + 6(16.0) = 148.3 g/mol .

The mass of "O" in one mole of the compound is 6(16.0) = 96.0 g

The conversion factor we can use is $\frac{96.0 \text{ g "O"}}{148.3 \text{ g "Mg(NO}_3)_2\text{"}}$

We can now find the answer:

860.0 g $Mg(NO_3)_2$ x $\frac{96.0 \text{ g "O"}}{148.3 \text{ g } Mg(NO_3)_2}$ = 556.7 g "O" = **557 g "O"**

4. A compound used in photography is called potassium persulphate. A 0.8162 gram sample of the compound was analyzed and found to contain 0.2361 grams of potassium, 0.1936 grams of sulphur and the rest was oxygen.

a) Find the mass of oxygen in the sample.

Solution:

The mass of oxygen = [Total mass of sample] - [(mass of K) + (mass of S)]

= [0.8162 g] - [(0.2361) + (0.1936)]

= [0.8162 g] - [0.4297]

= **0.3865 grams of oxygen**

b) Determine the empirical formula for this compound.

Element	Mass	Atomic Mass	Moles	Moles / Smallest moles	Simplest Whole # Ratio
potassium	0.2361 g	39.1 g/mol	0.00604 mol	$\frac{0.00604}{0.00603} = 1.00$	**1**
sulphur	0.1936 g	32.1 g/mol	0.00603 mol	$\frac{0.00603}{0.00603} = 1.00$	**1**
oxygen	0.3865 g	16.0 g/mol	0.0242 mol	$\frac{0.0242}{0.00603} = 4.01$	**4**

So the empirical formula is KSO_4

c) The molar mass of this compound is 270.4 g/mol. Determine the molecular formula.

Solution:
The mass of the empirical formula (KSO_4) is 39.1 + 32.1 + 4(16.0) = 135.2 g/mol

Dividing the *molar mass* by the *mass of the empirical formula*:

$\frac{270.4}{135.2} = \mathbf{2}$

We get the whole number "**2**".

Therefore, we multiply (*all the subscripts in*) the empirical formula by "**2**":

KSO_4 x **2** = $K_2S_2O_8$

So the molecular formula for the compound is $K_2S_2O_8$.

NOTE: We can check by finding the molar mass of this formula and seeing if it adds up to the given molar mass (270.4 g/mol). Try it!

	Empirical	**Molecular**
Formula	KSO_4 **x 2** →	**$K_2S_2O_8$**
Mass	135.2 **x 2** →	270.4

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