Empirical Formula Worksheet

Directions: Answer each of these problems on a separate sheet of paper. Show all work, give units with your final answer (where appropriate), circle your final answer and give the answer with the correct number of significant figures.

1. What is the empirical formula for a compound that is 43.4 % C, 1.2% H, 38.6% O, and 16.9% N?

2. Calculate the % composition for magnesium hydroxide.

3. A compound made of nitrogen and oxygen is found to be 74.1 % oxygen. Find the empirical formula. List three possible molecular formulas for this compound.

4. How many nitrogen atoms are in 59.0 g of ammonium phosphate?

5. A sample of calcium hydroxide is needed that will contain 3.59×10^{24} hydroxide ions. Find the mass of the sample.

6. A sample of aluminum sulfate is needed that will contain 2.59 g of aluminum. Find the mass of the sample.

7. For the following compounds, determine three or four possible molecular formulas for each given empirical formula:
   A. CH_2
   B. N_2O
   C. P_2O_5
   D. CH_3O

8. Can a compound have the same empirical formula and molecular formula? Explain.

9. The compound methyl butanoate (an ester) smells like apples. It's percent composition is: 58.8 % C, 9.9 % H, and 31.3 % O. If it's molecular mass is 306 g/mole, what is the molecular formula?

10. A forensic scientist is given a white substance that is thought to be cocaine. The substance is found to have the following percent composition: 49.48% C, 5.19 % H, 28.85 % N, and 16.48 % O. What is the empirical formula for this substance. Is the substance cocaine? (The formula for cocaine is $C_{17}H_2NO_4$) Bonus: What is the substance?

MOLECULAR FORMULAS WORKSHEET
(Chemistry 11)

1) A compound is composed of 7.20g of C, 1.20g of H, and 9.60g O. The molar mass of the compound is 180.g. Find the empirical and molecular formula for this compound.

2) A compound is composed of 16.66g C and 3.49g H. The molar mass of the compound is 58g. Find the empirical and molecular formulas for this compound.

3) A compound contains 62.0% C, 10.4% H, and 27.5% O. Determine the empirical formula for this compound. After analysis, it was found that the compound's molar mass is 58.1g. What is the compound's molecular formula?

4) Glucose, one of the main sources of energy used by living organisms, has a molecular mass of 180.2g. Chemical analysis shows that glucose is 40.0% C, 6.71% H and 53.3% O. Determine glucose's molecular formula.

5) A class of compounds called sodium metaphosphates were used as additives to detergents to improve cleaning ability. One of them has a molecular mass of 612g. Analysis shows the composition to be 22.5% Na, 30.4% P, and 47.1% O. Determine the molecular formula of this compound.

6) Find the molecular formula for a compound that has a molecular mass of 92g.mole. The % composition of the compound is 30.4% N, and 69.6% O.

7) Find the molecular formula for a compound that has a GMM of 99g/mole. Its % composition is 24.2% C, 4.0% H, and 71.7% Cl.

Empirical Formula Worksheet

1. $\frac{43.4\text{g C} \mid 1\text{mol C}}{12.0\text{g C}} = 3.62\text{mol C}$

$\frac{1.2\text{g H} \mid 1\text{mol H}}{1.0\text{g H}} = 1.2\text{mol H}$

$\frac{38.6\text{g O} \mid 1\text{mol O}}{16.0\text{g O}} = 2.41\text{mol O}$

$\frac{16.9\text{g N} \mid 1\text{mol N}}{14.0\text{g N}} = 1.21\text{mol N}$

$C_{3.62}H_{1.2}O_{2.41}N_{1.21}$

$\div 1.2$

$C_3H_1O_2N_1 = \boxed{C_3HO_2N}$

2. $Mg(OH)_2 = 58.3\text{g}$

$\frac{24.3\text{g Mg}}{58.3} \times 100 = 41.7\%$

$\frac{32.0\text{g O}}{58.3} \times 100 = 54.9\%$

$\frac{2.0\text{g H}}{58.3} \times 100 = 3.4\%$

100%

3. $\frac{25.9\text{ g N}}{14.0\text{ g N}} \left| \frac{1\text{ mol N}}{} \right. = 1.85\text{ mol N}$

$\frac{74.1\text{ g O}}{16.0\text{ g O}} \left| \frac{1\text{ mol O}}{} \right. = 4.63\text{ mol O}$

$N_{1.85} O_{4.63} = N O_{2.5} \times 2$

$\div 1.85$ $\quad = N_2O_5$

N_2O_5 , N_4O_{10} , N_6O_{15}

4. $\frac{59.0\text{ g } (NH_4)_3PO_4}{149.0\text{ g } (NH_4)_3PO_4} \left| \frac{42.0\text{ g N}}{14.0\text{ g N}} \right. \left| \frac{6.02\times10^{23}\text{ atoms}}{} \right.$

$= 7.15 \times 10^{23}$ atoms N

or

$\frac{59.0\text{ g } (NH_4)_3PO_4}{149.0\text{ g}} \left| \frac{1\text{ mol}}{1\text{ mol}} \right. \left| \frac{6.02\times10^{23}\text{ units}}{1\text{ unit } (NH_4)_3PO_4} \right. \left| \frac{3\text{ atoms}}{} \right.$

$= 7.15 \times 10^{23}$ atoms

5. $Ca(OH)_2$ $\quad \frac{3.59\times10^{24}\text{ OH}^-}{6.02\times10^{23}\text{ OH}^-} \left| \frac{1\text{ mol}}{2\text{ mol OH}^-} \right. \left| \frac{1\text{ mol } Ca(OH)_2}{} \right.$

$\frac{74.1\text{ g}}{1\text{ mol } Ca(OH)_2} = 221\text{ g } Ca(OH)_2$

6. $Al_2(SO_4)_3 = 342.3\ g$

$$\frac{2.59\ g\ Al \mid 342.3\ g\ Al_2(SO_4)_3}{54.0\ g\ Al} = 16.4\ g\ Al_2(SO_4)_3$$

or $\frac{54.0}{342.3} = .158$ $\quad .16 \times X = 2.59$

$x = 16.4\ g\ Al_2(SO_4)_3$

7.

a)	b)	c)	d)
CH_2	N_2O	P_2O_5	CH_3O
C_2H_4	N_4O_2	P_4O_{10}	$C_2H_6O_2$
C_3H_6	N_6O_3	P_6O_{15}	$C_3H_9O_3$
C_4H_8	N_8O_4	P_8O_{20}	$C_4H_{12}O_4$

8. yes, it is possible for the lowest ratio to be the molecular formula. Ex = CH_4 - methane

9.
$$\frac{58.8\ g\ C \mid 1\ mol}{12.0\ g\ C} = 4.9\ mol$$

$$\frac{9.9\ g\ H \mid 1\ mol}{1.0\ g\ H} = 9.9\ mol$$

$$\frac{31.3\ g\ O \mid 1\ mol}{16.0\ g\ O} = 1.96\ mol$$

$C_{4.9}H_{9.9}O_{1.96} = C_{2.5}H_{3.96}O_1 \times 2 = C_5H_8O_2$

$C_5H_8O_2 = 100.0\ g$ $\quad \frac{306}{100} = 3.06$

$C_{15}H_{24}O_6$

10. $\frac{49.48\text{ g C}}{12.0\text{ g C}} \times \frac{1\text{ mol}}{} = 4.12$ $\div 1.03 = 4$

$\frac{5.19\text{ g H}}{1.0\text{ g H}} \times \frac{1\text{ mol}}{} = 5.19$ $\div 1.03 = 5$

$\frac{28.85\text{ g N}}{14.0} \times \frac{1\text{ mol}}{} = 2.06$ $\div 1.03 = 2$

$\frac{16.48\text{ g O}}{16.0\text{ g O}} \times \frac{1\text{ mol}}{} = 1.03$ $\div 1.03 = 1$

$C_4H_5N_2O$

This is not a possible empirical formula for cocaine. The substance is not cocaine.

$C_8H_{10}N_4O_2$ is Caffeine

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1. $\frac{7.20\text{ g C}}{12.0\text{ g C}} \times \frac{1\text{ mol}}{} = .6\text{ mol}$

$\frac{1.20\text{ g H}}{1.0\text{ g H}} \times \frac{1\text{ mol}}{} = 1.20\text{ mol}$

$\frac{9.60\text{ g O}}{16.0\text{ g O}} \times \frac{1\text{ mol}}{} = .6\text{ mol}$

CH_2O

$= 30\text{ g/mol}$

$\frac{180}{30} = 6$

$C_6H_{12}O_6$

2. $16.66\,g\,C \mid 1\,mol / 12.0\,g\,C = 1.39\,mol$ → 1

$3.49\,g\,H \mid 1.0\,mol / 1.0\,g\,H = 3.49\,mol$ → 2.5

÷ 1.39

$C_2H_5 = 29.0\,g$ $\quad \frac{58}{29} = 2$ $\quad \boxed{C_4H_{10}}$

3. $62.0\,g\,C \mid 1\,mol / 12.0\,g\,C = 5.2\,m$ → 3

$10.4\,g\,H \mid 1\,mol\,H / 1.0\,g\,H = 10.4\,mol$ → 6

$27.5\,g\,O \mid 1\,mol\,O / 16.0\,g\,O = 1.72\,mol$ → 1

÷ 1.72

$C_3H_6O = 58.0\,g$ $\quad \frac{58.1}{58} = 1$ $\quad \boxed{C_3H_6O}$

4. $40.0\,g\,C \mid 1\,mol\,C / 12.0\,g\,C = 3.33$ → 1

$6.71\,g\,H \mid 1\,mol\,H / 1.0\,g\,H = 6.71$ → 2

$53.3\%\,O \mid 1\,mol\,O / 16.0\,g = 3.33$ → 1

÷ 3.33

$CH_2O = 30$ $\quad 180.2 \div 30 = 6$

$C_6H_{12}O_6$

5. $\frac{22.5\text{ g Na}}{23.0\text{ g}} \mid \frac{1\text{ mol Na}}{} = .978\text{ mol}$ 1

$\frac{30.4\text{ g P}}{31.0\text{ g P}} \mid \frac{1\text{ mol}}{} = .980\text{ mol}$ $\div .978$ 1

$\frac{47.1\text{ g O}}{16.0\text{ g}} \mid \frac{1\text{ mol}}{} = 2.94$ 3

$NaPO_3 = 102 \quad 612 \div 102 = 6$

$Na_6P_6O_{18}$

6. $\frac{30.4\text{ g N}}{14.0\text{ g}} \mid \frac{1\text{ mol}}{} = 2.17\text{ mol}$ 1

$\frac{69.6\text{ g O}}{16.0\text{ g O}} \mid \frac{1\text{ mol}}{} = 4.35\text{ mol}$ $\div 2.17$ 2

$NO_2 = {}^{46.0} \quad 92 \div {}^{46.0} = {}^{2}$

N_2O_4

7. $\frac{24.2\text{ g C}}{12.0\text{ g C}} \mid \frac{1\text{ mol}}{} = 2.02$ 1

$\frac{4.0\text{ g H}}{1\text{ g H}} \mid \frac{1\text{ mol H}}{} = 4.0$ $\div 2.02$ 1.98

$\frac{71.7\text{ g Cl}}{35.5\text{ g Cl}} \mid \frac{1\text{ mol Cl}}{} = 2.02$ 1

$CH_2Cl = 49.5 \quad 99 \div 49.5 = 2$

$C_2H_4Cl_2$