11)

CHEM 1305 - Chapter 08 - Handout

Memorize:
Atomic weights of: hydrogen, carbon, oxygen, nitrogen

Define the following terms; explain the following concepts, and answer the following questions:

1) "amu" is the abbreviation for ATOMIC MASS UNIT.

2) "amu" is a unit of weight. 1 amu = 1.66 X 10^{-24} g.

3) Based on the Periodic Chart, how many "amu" do one of each of the following atoms/molecules weigh, to two decimal places):

   a) oxygen --> 16.00

   b) hydrogen --> 1.01

   c) H_20 --> 18.02 (There are two H's and one oxygen: 2•1.01 + 1•16.00 = 18.02)

   d) carbon --> 12.01

   e) sodium --> 22.99

   f) chlorine --> 35.45

   g) sodium chloride --> 58.44 (NaCl: 22.99 + 35.45 = 58.44)

4) The number associated with one mole of a substance is 6.022 x 10^{23}.

5) The name associated with that number is AVOGADRO'S NUMBER.

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6) Scaling up from individual particles to moles: Molar Mass (the mass of one mole of a substance):

   a) One atom of carbon weighs 12.01 amu, and one mole of carbon weights 12.01 g.

   b) One atom of calcium weighs 40.08 amu, and one mole of calcium weights 40.08 g.

   c) One atom of gold weighs 197.0 amu, and one mole of gold weights 197.0 g.

   d) One atom of chlorine weighs 35.5 amu, and one mole of chlorine weights 35.5 g.

   e) One molecule of water weighs 18.02 amu, and one mole of water weights 18.02 g.

7) Relating to counting and weighing:

   a) How many particles are in one mole of carbon? 6.02×10^{23}

   b) How many particles are in one mole of calcium? 6.02×10^{23}

   c) How many particles are in one mole of gold? 6.02×10^{23}

   d) How many particles are in one mole of chlorine? 6.02×10^{23}

   e) How many particles are in two moles of carbon? 1.20×10^{24}

   f) How many particles are in three moles of carbon? 1.81×10^{24}

   g) How many particles are in four moles of carbon? 2.41×10^{24}

8) Problems

   a) 1 mole of sodium weights 22.99 g.

   b) 2.7 moles of sodium weighs 62.07 g. $\left[\frac{2.7 mol}{1} \bullet \frac{22.99\ g}{1 mol} = 62.07\ g \right]$

   c) The molar mass (mass of one mole) of a compound with the formula CH_4 is: $\frac{16.05\ g}{mol}$.

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d) Calculate the mass of 4.85 mol of acetic acid, which has the formula $HC_2H_3O_2$ is?
   i) The molar mass of acetic acid is calculated to be 60.06 g/mol.
   ii) Using dimensional analysis to complete the calculation:

$$\left[\frac{4.85\ mol}{1} \bullet \frac{60.06\ g}{1mol} = 291\ g\right]$$

e) The formula for formaldehyde is H_2CO. How many moles of formaldehyde are in a 7.55 g sample?
   i) The molar mass of acetic acid is calculated to be 30. g/mol.
   ii) Using dimensional analysis:

$$\left[\frac{7.55\ g}{1} \bullet \frac{mol}{30.\ g} = 0.25\ mol\right]$$

9) Give a generalized formula for calculating Percent

$$\frac{parts}{whole} \bullet 100 = \%$$

--or--

$$fraction \bullet 100 = \%$$

10) What is the percentage of oxygen in water?

$$\frac{parts}{whole} \bullet 100 = \frac{16}{16 + 2 \bullet 1} \bullet 100 = 89\%$$

11) Compare and contrast the terms Empirical Formula and Molecular Formula.

Molecular Formula refers to the formula of the molecule of interest. However, the Empirical Formula for a molecule of interest refers to the formula of the smallest repeating moiety (or "piece") in the molecule.

Any analogy, Molecular Formula is to a chain, what Empirical Formula is to one of the chain's links.

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12) Consider the two formulas $C_6H_{12}O_6$ and CH_2O. One is the empirical formula for glucose, the other the molecular formula. Which is which?

Upon close inspection, one could postulate that one $C_6H_{12}O_6$ molecule could be made from six CH_2O moieties. $\{6(CH_2O) = 6\ (C_1H_2O_1) = C_6H_{12}O_6\}$

Hence, $C_6H_{12}O_6$ would be the Molecular Formula, and CH_2O the Empirical Formula.

13) A 3.450 g sample of nitrogen reacts with 1.970 g of oxygen. What is the empirical formula of the resulting compound?

a) 3.450 g sample of nitrogen is equivalent to 0.2463 mol N.

$$\left[\frac{3.450\ g}{1} \bullet \frac{mol}{14.01\ g} = 0.2463\ mol\ N\right]$$

b) 1.970 g of oxygen is equivalent to 0.2231 mol O.

$$\left[\frac{1.970\ g}{1} \bullet \frac{mol}{16.00\ g} = 0.1231\ mol\ O\right]$$

c) The formula for the "nitrogen oxide" molecule is:

$$\{ N_{0.2463} O_{0.1231} \text{ --> } N_{0.2463/0.1231} O_{0.1231/0.1231} \approx N_2O_1 = N_2O \}$$

nitrogen monoxide.

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14) What is the empirical formula for an amino acid found to have the following mass percents:

32.00% carbon --> $\left[\frac{32.00\ g}{1} \bullet \frac{mol}{12.00\ g} = 2.67\ mol\ C \right]$

6.714% hydrogen --> $\left[\frac{6.714\ g}{1} \bullet \frac{mol}{1.01\ g} = 6.65\ mol \right]$

42.63% oxygen --> $\left[\frac{42.63\ g}{1} \bullet \frac{mol}{16.00\ g} = 2.66\ mol\ O \right]$

18.66% nitrogen --> $\left[\frac{18.66\ g}{1} \bullet \frac{mol}{14.01\ g} = 1.33\ mol\ O \right]$

$C_{2.67} H_{6.65} O_{2.66} N_{1.33}$ -->
$C_{2.67/1.33} H_{6.65/1.33} O_{2.66/1.33} N_{1.33/1.33}$ -->
$C_{2.00} H_{5.00} O_{2.00} N_{1.00}$ -->

Ans. = $\mathbf{C_2 H_5 O_2 N}$

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15) The empirical formula for a compound is $Cl_2C_2H_4$. The molar mass is 98.96 g. What is the molecular formula?

a) Empirical formula weight = 2•35.45 + 2•12.00 + 4•1.01 = 98.94 g
b) Molecular weight = 98.96 g (given)
c) Number of empirical units (*n*) in molecular formula = 1

$$n = \frac{molecular\ weight}{empirical\ weight} = \frac{98.96}{98.94} = 1$$

d) Therefore, the molecular formula = $1(Cl_2C_2H_4)$ = **$Cl_2C_2H_4$**

(The molecular and empirical formulas are identical. Continuing from the above analogy, our "chain" only has one link.)