OWL Homework and Quiz 1

- Chapter 3 HW assigned in OWL…….Due September 20 at 11:55 PM

- Quiz 1 – Due Today at 11:59 PM
  - ✓ Available in canvas (Go to your class in Canvas and Click quizzes in Canvas navigation bar, Then you will direct to Quiz 1)
  - ✓ Duration 15 minutes, 6 MCQs, covers chapters 1 and 2, and two attempts
  - ✓ No extensions

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(Q.10)

Which sample has more molecules?

1) 341 g SO_3
2) 10.2 g H_2O
3) 207 g NaCl

Answer: 341 g SO_3

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Elemental Analysis: Determining Empirical and Molecular Formulas

- Empirical formulas can be determined from an elemental analysis
  - An elemental analysis measures the mass percentage of each element in a compound

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Example Problem

- Nitroaniline had been observed in experiments on biomass from pine needles and can be used as a precursor for pharmaceuticals
  - It contains 52.17% carbon, 4.38% hydrogen, 20.28% nitrogen, and 23.17% oxygen by mass

Determine the empirical formula of nitroaniline

Consider a 100 g sample of nitroaniline. Convert each of the masses to moles

$$52.17\ \text{g C} \times \frac{1\ \text{mol C}}{12.011\ \text{g C}} = 4.344\ \text{mol C in 100 g nitroaniline}$$

$$4.38\ \text{g H} \times \frac{1\ \text{mol H}}{1.008\ \text{g H}} = 4.35\ \text{mol H in 100 g nitroaniline}$$

$$20.28\ \text{g N} \times \frac{1\ \text{mol N}}{14.007\ \text{g N}} = 1.448\ \text{mol N in 100 g nitroaniline}$$

$$23.17\ \text{g O} \times \frac{1\ \text{mol O}}{15.999\ \text{g O}} = 1.448\ \text{mol O in 100 g nitroaniline}$$

- Divide all four numbers by 1.448 to obtain small whole number ratio

$$\frac{4.344 \text{ mol C}}{1.448} = 3.00$$

$$\frac{4.35 \text{ mol H}}{1.448} = 3.00$$

$$\frac{1.448 \text{ mol N}}{1.448} = 1$$

$$\frac{1.448 \text{ mol O}}{1.448} = 1$$

The result is a small whole number ratio: 3 moles C: 3 moles H: 1 mole N: 1 mole O

So the empirical formula = C_3H_3NO

Determining Molecular Formula

- A molecular formula is a whole number multiple of the empirical formula
  - Molar mass for the molecular formula is a whole number multiple of the molar mass for the empirical formula

(Q. 1) If the empirical formula of a compound is CH_2 and its molar mass is 42 g/mol, what is its molecular formula?

$$n = \frac{\text{Molar mass}}{\text{Empirical formula mass}} = \frac{42 \text{ g/mol}}{14.027 \text{ g/mol}} = 3.0$$

Therefore, **Molecular formula = $(CH_2)_3 = C_3H_6$**

Molarity

- Molarity or molar concentration, *M*, is the number of moles of solute per liter of solution

$$\text{Molarity } (M) = \frac{\text{moles of solute}}{\text{liter of solution}}$$

  - If we know any two of these quantities, we can determine the third one

$$n = M \times V$$

n = Number of solute moles, M = Molarity, and V = volume in liters

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Example Problem

1. A solution is prepared by dissolving 45.0 g of NaClO in enough water to produce exactly 750 mL of solution. What is the molarity of this solution?

First, we compute the moles of solute:

$$45.0 \text{ g NaClO} \times \frac{1.00 \text{ mol NaClO}}{74.44 \text{ g NaClO}} = 0.605 \text{ mol NaClO}$$

Then, convert the solution volume from mL to L:

$$750 \text{ mL} \times \frac{1.00 \text{ L}}{1000 \text{ mL}} = 0.750 \text{ L}$$

Finally, calculate the molarity:

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}} = \frac{0.605 \text{ mol}}{0.750 \text{ L}} = 0.806 \text{ M NaClO}$$

Dilution

- Dilution is the process in which solvent is added to a solution to decrease the concentration of the solute
  - The number of moles of solute is the same before and after dilution

$$M_i \times V_i = M_f \times V_f$$

Units: M = mol/L, V = L

The subscripts denote: i = Initial, and f = final

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Example Problem

- A chemist requires 1.5 M hydrochloric acid, HCl, for a series of reactions. The only solution available is 6.0 M HCl. What volume of 6.0 M HCl must be diluted to obtain 5.0 L of 1.5 M HCl?

Initial concentration of HCl: $M_i = 6.0\ M$

Final concentration of HCl: $M_f = 1.5\ M$

Final volume of solution: $V_f = 5.0\ L$

The unknown is the initial volume, V_i. Rearranging Equation

$$V_i = \frac{M_f \times V_f}{M_i}$$

Inserting the known quantities on the right-hand side,

$$V_i = \frac{1.5\ M \times 5.0\ L}{6.0\ M} = 1.3\ L$$

To obtain the desired quantity of diluted HCl, the chemist should begin with 1.3 L of the concentrated solution and add enough water to bring the volume up to 5.0 L.