Chemistry 112

Learning Opportunities

June 8 – 12

Solution Concentrations

The concentration of a solution is a ratio that compares the quantity of solute to the quantity of the solution. Solutions with a small quantity of solute per unit of solution are dilute and solutions with a large quantity of solute per unit of solution are concentrated.

Molarity

Molarity (M) is a measurement of concentration reported on mol/L. It is the moles of solute per liter of solution.

M = $\frac{n}{v}$

n is the number of moles

v is the volume in liters. (mL ÷ 1000 = L)

Example

1. Calculate the molarity, M, of a sodium chloride solution that has a volume of 300.0 mL and contains 25.0 g of NaCl.

$NaCl$

$$1 \times Na = 1 \times 22.99\,g/mol = 22.99$$
$$1 \times Cl = 1 \times 35.45\,g/mol = \underline{35.45}$$
$$58.44\,g/mol$$

$$25.0\,g\ NaCl \times \frac{1\,mol}{58.44\,g} = 0.43\,mol\ NaCl$$

$$300.0\,mL \times \frac{1\,L}{1000\,mL} = 0.300\,L$$

$$M = \frac{n}{v} = \frac{0.43\,mol}{0.300\,L} = 1.43\,mol/L\ NaCl$$

2. What mass of $NaNO_3$ is needed to make 2.0 liters of a 1.5 M solution?

$$M = \frac{n}{v} \xrightarrow{\text{rearrange}} n = M \cdot v$$

$$1 \times Na = 1 \times 22.99\,g/mol = 22.99$$
$$1 \times N = 1 \times 14.01\,g/mol = 14.01$$
$$3 \times O = 3 \times 16.00\,g/mol = \underline{48.00}$$
$$85.00\,g/mol$$

$$n = M \cdot v$$
$$n = (1.5\,M)(2.0\,L)$$
$$n = 3.0\,mol$$

$$3.0\,\cancel{mol} \times \frac{85.00\,g}{1\,\cancel{mol}} = 255\,g\ NaNO_3$$

% weight/volume

Concentrations measured in % w/v reports the number of grams of solute per 100 mL of solution.

% w/v = $\frac{mass\ of\ solute\ (in\ g)}{volume\ of\ solution\ (in\ mL)}$ x 100

Example

1. What mass of salt is present in 750 mL of a 10% W/V solution?

$$\% \frac{w}{v} = \frac{\text{mass solute}}{\text{volume solution}} \times 100\%$$

$$10\% \frac{w}{v} = \frac{\text{mass salt}}{750\ mL} \times 100\%$$

$$\div 100\% \qquad \div 100\%$$

$$0.10 = \frac{\text{mass salt}}{750\ mL} \times 750$$

$$\times 750$$

$$75g = \text{mass salt}$$

2. What is the % w/v of a solution that has 7.5 g of sodium chloride diluted to 100 mL with deionized water?

$$\% \ w/v = \frac{\text{mass solute}}{\text{volume solution}} \times 100\%$$

$$\% \frac{w}{v} = \frac{7.5g}{100mL} \times 100\%$$

$$\% \frac{w}{v} = 7.5\% \ w/v$$

ppm

Parts per million is used to report very small concentrations. It is the number of milligrams (10^{-3}g) of solute per liter of solution.

ppm = $\frac{mass\ of\ solute (in\ mg)}{volume\ of\ solution\ (in\ L)}$

g ÷ 1000 = mg

Example

1. A solution has a concentration of 4.5ppm of dissolved oxygen. What volume of water would contain 100 mg of oxygen?

$$ppm = \frac{\text{mass solute}}{\text{volume solution}} \xrightarrow{\text{rearrange}} \text{volume} = \frac{\text{mass}}{ppm}$$

$$\text{volume} = \frac{100\ mg}{4.5ppm}$$

$$\text{volume} = 22.2L$$

2. Hard water contains 120 ppm of dissolved minerals. If 2.0 L of hard water in a kettle is boiled dry, what mass of minerals is left?

$$ppm = \frac{mass}{volume} \xrightarrow{rearrange} mass = ppm \cdot volume$$

$$\begin{aligned} mass &= ppm \cdot volume \\ &= (120 ppm)(2.0 L) \\ &= 240 mg \end{aligned}$$

<u>Practice problems</u>

1. Find the molarity when 734 grams of Li_2SO_4 are dissolved to make 2500 mL of solution.
2. What mass of $Ca(OH)_2$ is needed to make 5.0 liters of a 0.1 M solution?
3. Calculate the molarity of 198 g of $BaBr_2$ in 2.0 L of solution.
4. 25.0 grams of sodium chloride (NaCl) is dissolved in 100 mL of solution. What is the concentration of the solution in parts per million (ppm)?
5. The concentration of a solution is 284,000 ppm. How many grams of solute is contained in 100 mL of solution?
6. 2.0 L of an aqueous solution of potassium chloride contains 45.0 g of KCl. What is the weight/volume percentage concentration of this solution?
7. 15 mL of an aqueous solution of sucrose contains 750 mg sucrose. What is the weight/volume percentage concentration of this solution?