Chapter 4
Solution Concentration

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Concentrations of Solutions

- A solution is solute dissolved in a solvent.
- To quantify and know exactly how much of a solute is present in a certain amount of solvent, one will need to calculate concentrations.
- Concentrations are given in
  - percent solutions
    - mass/mass % - (g of solute/g of solution) x 100%
    - mass/volume % - (g of solute/mL of solution) x 100%
    - volume/volume % - (mL of solute/mL of solution) x 100%
  - Molarity (mol/L of solution)- used more in Chemistry
  - Molality (mol/Kg of solution) – this is used more in Biology

Molar Concentration, Molarity (M)

In this chapter we will study **Molarity** – which is moles in a L of solution.

- Molarity is represented by M and the formula is given below

$$\text{Molarity} = \frac{moles\ of\ solute}{L\ of solution}$$

- Moles are converted to grams in order to make the solution in the lab.
- To prepare a solution, add the measured amount of solute to a volumetric flask, then add water to bring the solution to the mark on the flask.
- A 3M solution of NaCl means there are 3 moles of NaCl in the solution.
- If you have a 200 mL of 2 M HCl – that means that there are 2 mols of HCl in 1 L solution. If you want to know how many grams of HCl you have in 200 mL then you will have to calculate the amount of moles in 200 mL of that solution using the Molarity equation; then you can calculate the grams from those moles.

Example: You place a 1.52−g of potassium dichromate, $K_2Cr_2O_7$, into a 50.0−mL volumetric flask. You then add water to bring the solution up to the mark on the neck of the flask. What is the molarity of $K_2Cr_2O_7$ in the solution?

Molar mass of $K_2Cr_2O_7$ is 294 g/mol

$$\frac{1.52\ \text{g}\ \frac{1\ \text{mol}}{294\ \text{g}}}{50.0\times10^{-3}\ \text{L}} = \mathbf{0.103}\ \boldsymbol{M}$$

Example: A solution of sodium chloride used for intravenous transfusion (physiological saline solution) has a concentration of 0.154 *M* NaCl. How many moles of NaCl are contained in 500.−mL of physiological saline? How many grams of NaCl are in the 500.−mL of solution?

$$M = \frac{mol}{L}$$

$$\text{mol} = M \bullet \text{L}$$

$$= 0.154\ M \bullet 0.500\ \text{L}$$

$$= 0.0770\ \text{mol NaCl}$$

$$\text{Molar mass NaCl} = 58.4\ \text{g}$$

$$0.0770\ \text{mol}\ \frac{58.4\ \text{g}}{1\ \text{mol}}$$

$$= 4.50\ \text{g NaCl}$$

Example: Calculate the molarity of a solution prepared by dissolving 45.00 grams of KI into a total volume of 500.0 mL.

$$\frac{45.00\text{ g KI}}{500.0\text{ mL}} \times \frac{1\text{ mol KI}}{166.0\text{ g KI}} \times \frac{1000\text{ mL}}{1\text{ L}} = 0.5422\ M$$

Example: How many milliliters of 3.50 *M* NaOH can be prepared from 75.00 grams of the solid?

$$75.00\text{ g NaOH} \times \frac{1\text{ mol NaOH}}{40.00\text{ g NaOH}} \times \frac{1\text{ L}}{3.50\text{ mol NaOH}} \times \frac{1000\text{ mL}}{1\text{ L}} = 536\text{ mL}$$

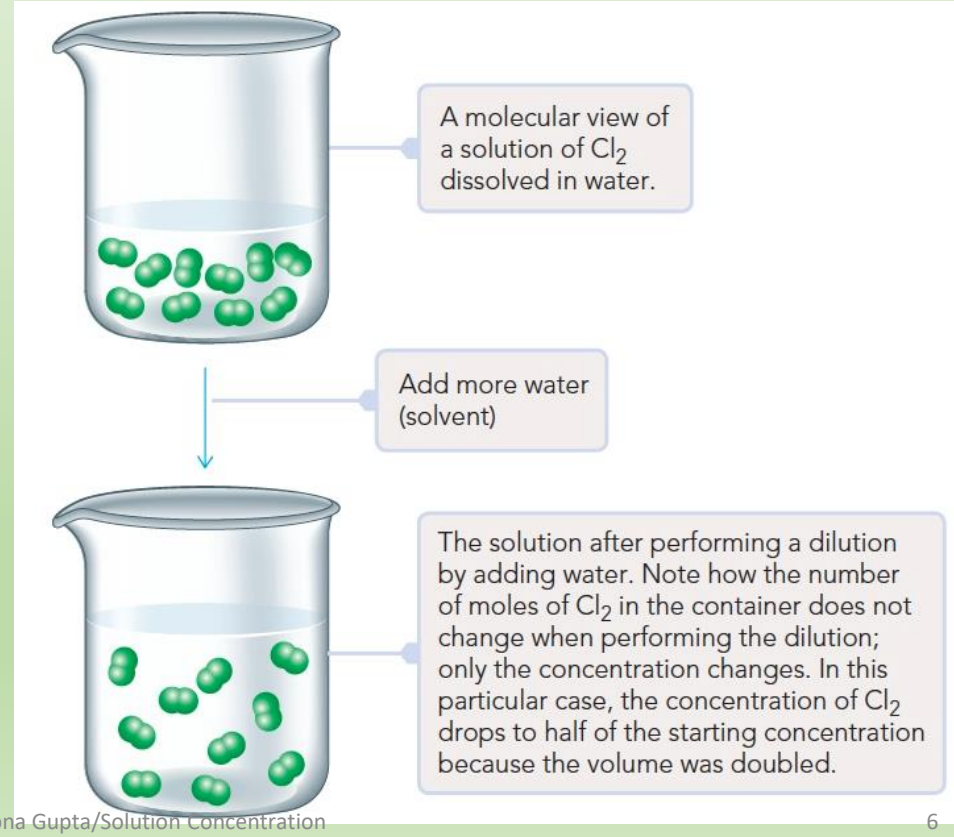
Dilution

- When a higher concentration solution is used to make a less–concentration solution, the moles of solute are determined by the amount of the higher–concentration solution.
- The number of moles of solute remains constant when more water is added.

$$M_i V_i = M_f V_f$$

Note:

The units on V_i and V_f must match.



Diluting a solution quantitatively requires specific glassware.

The photo at the right shows a volumetric flask used in dilution.

Example: A saturated stock solution of NaCl is 6.00 *M*. How much of this stock solution is needed to prepare 1.00–L of physiological saline solution (0.154 *M*)?

$$M_i V_i = M_f V_f$$

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

$$V_i = \frac{(0.154\ M)(1.00\ \text{L})}{6.00\ M}$$

$$V_i = 0.0257\ \text{L or } 25.7\ \text{mL}$$

Example: For the next experiment the class will need 250. mL of 0.10 *M* $CuCl_2$. There is a bottle of 2.0 *M* $CuCl_2$. Describe how to prepare this solution. How much of the 2.0 *M* solution do we need?

Concentrated: 2.0 *M* use ? mL (V_c)

Diluted: 250. mL of 0.10 *M*

$$M_c V_c = M_d V_d$$

$$(2.0\ M)\ (V_c) = (0.10\ M)\ (250.\text{mL})$$

$$V_c = 12.5\ \text{mL}$$

12.5 mL of the concentrated solution are needed; add enough distilled water to prepare 250. mL of the solution.

Key Words/Concepts

- Solutions
  - Solvent
  - Solute
- Molarity (mol/L)
- Dilutions ($M_iV_i = M_fV_f$)