Concentrations Units

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Lecture 3

4.Concentrations Units

- In using a solution in the laboratory or in administering the proper dose of a liquid medication, we must know its concentration—how much solute is dissolved in a given amount of solution.
- Concentration can be measured in several different ways that use mass, volume, or moles.

4.1. Weight/Volume Percent

- One of the most common measures of concentration is **weight/volume percent concentration, (w/v)%**—that is, the number of grams of solute dissolved in 100 mL of solution. Mathematically, weight/volume percent is calculated by dividing the number of grams of solute in a given number of milliliters of solution, and multiplying by 100%.

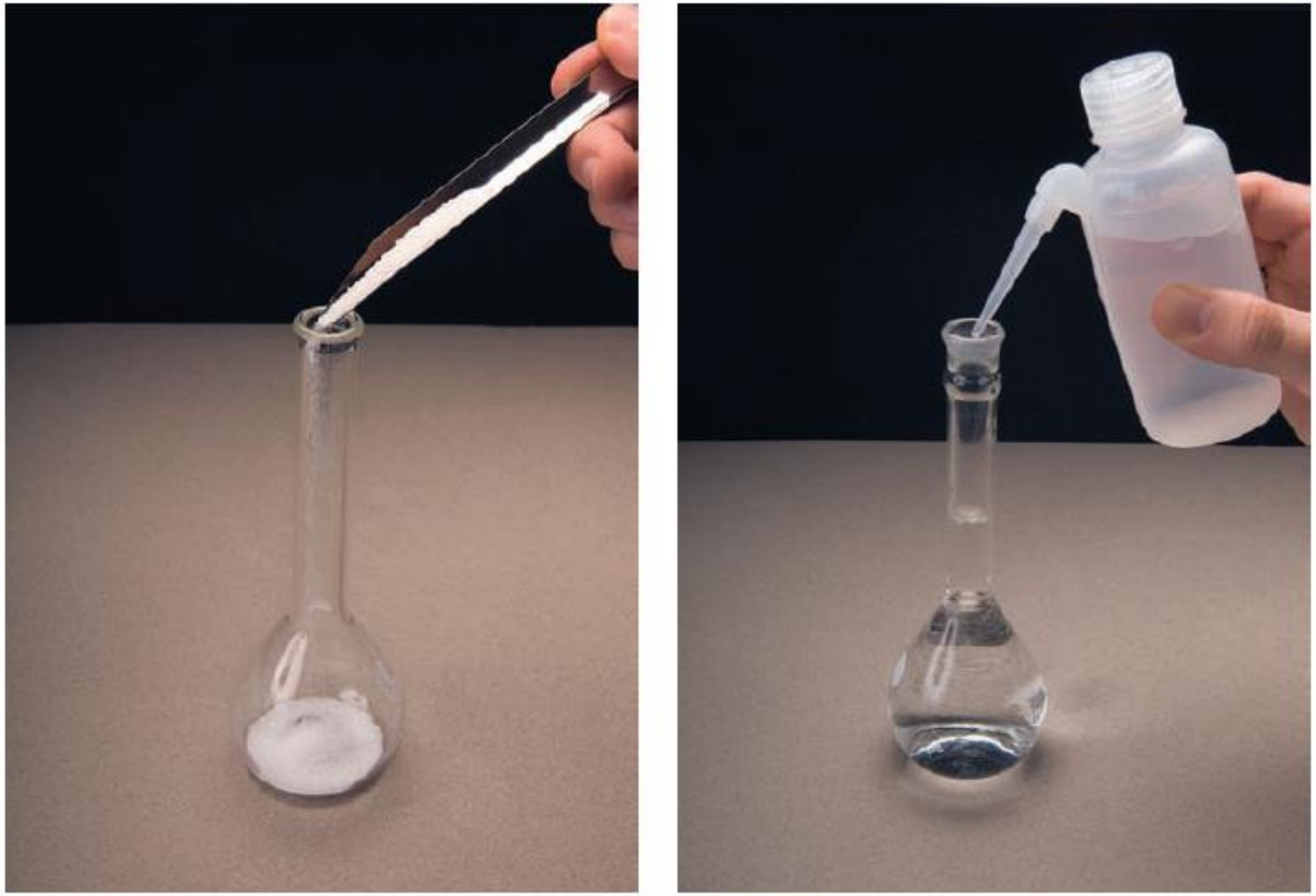
Weight/volume percent concentration

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

For example, vinegar contains 5 g of acetic acid dissolved in 100 mL of solution, so the acetic acid concentration is 5% (w/v).

$$(w/v)\% = \frac{5\text{ g acetic acid}}{100\text{ mL vinegar solution}} \times 100\% = 5\%\text{ (w/v) acetic acid}$$

a. Add the solute. b. Add the solvent.



To make a solution of a given concentration: (a) add a measured number of grams of solute to a volumetric flask; (b) then add solvent to dissolve the solid, bringing the level of the solvent to the calibrated mark on the neck of the flask.

PROBLEM

A commercial mouthwash contains 4.3 g of ethanol and 0.021 g of antiseptic in each 30mL portion. Calculate the weight/volume percent concentration of each component.

HEALTH NOTE

Mouthwash, sore throat spray, and many other over-the-counter medications contain ingredients whose concentrations are reported in (w/v)%.

4.2. Volume/Volume Percent

- When the solute in a solution is a liquid, its concentration is often reported using **volume/volume percent concentration, (v/v)%**—that is, the number of milliliters of solute dissolved in 100 mL of solution. Mathematically, volume/volume percent is calculated by dividing the number of milliliters of solute in a given number of milliliters of solution, and multiplying by100%.

Volume/volume percent concentration

$$(v/v)\% = \frac{\text{volume of solute (mL)}}{\text{volume of solution (mL)}} \times 100\%$$

For example, a bottle of rubbing alcohol that contains 70 mL of 2-propanol in 100 mL of solution has a 70% (v/v) concentration of 2-propanol.

$$(v/v)\% = \frac{\text{70 mL 2-propanol}}{\text{100 mL rubbing alcohol}} \times 100\% = 70\%\ (v/v)\ \text{2-propanol}$$

4.3. Using a Percent Concentration as a Conversion Factor

- Percent concentration can be used as a conversion factor to relate the amount of solute (either grams or milliliters) to the amount of solution. For example, ketamine, an anesthetic especially useful for children, is supplied as a 5.0% (w/v) solution, meaning that 5.0 g of ketamine are present in 100 mL of solution. Two conversion factors derived from the percent concentration can be written.

$$\underbrace{5.0\%\ \text{(w/v) ketamine}}_{\text{weight/volume percent concentration}} \qquad \frac{5.0\ \text{g ketamine}}{100\ \text{mL solution}} \quad \text{or} \quad \frac{100\ \text{mL solution}}{5.0\ \text{g ketamine}}$$

HEALTH NOTE

Ketamine is a widely used anesthetic in both human and veterinary medicine. It has been illegally used as a recreational drug because it can produce hallucinations.

PROBLEM

A saline solution used in intravenous drips for patients who cannot take oral fluids contains 0.92% (w/v) NaCl in water. How many grams of NaCl are contained in 250 mL of this solution?

PROBLEM

A cough medicine contains 0.20% (w/v) dextromethorphan, a cough suppressant, and 2.0% (w/v) guaifenisin, an expectorant. How many milligrams of each drug would you obtain from 3.0 tsp of cough syrup? (1 tsp = 5 mL)

4.4. Parts Per Million (ppm)

- When a solution contains a very small concentration of solute, concentration is often expressed in parts per million (ppm). Whereas percent concentration is the number of parts per million is the number of "parts" in 1,000,000 parts of solution. The "parts" may be expressed in either mass or volume units as long as the same unit is used for both the numerator and denominator.

Parts per million

$$\text{ppm} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 10^6$$

or

$$\text{ppm} = \frac{\text{volume of solute (mL)}}{\text{volume of solution (mL)}} \times 10^6$$

A sample of seawater that contains 1.3 g of magnesium ions in 10^6 g of solution contains 1.3 ppm of magnesium.

$$\text{ppm} = \frac{1.3 \text{ g magnesium}}{10^6 \text{ g seawater}} \times 10^6 = 1.3 \text{ ppm magnesium}$$

PROBLEM

What is the concentration in parts per million of DDT in each of the following?

a. 0.042 mg in 1,400 g plankton

b. 5×10^{-4} g in 1.0 kg minnow tissue

c. 2.0 mg in 1.0 kg needlefish tissue

d. 225 μg in 1.0 kg breast milk

4.5. Molarity and Normality

- The most common measure of concentration in the laboratory is molarity—***the number of moles of solute per liter of solution, abbreviated as M.***
- A solution that is formed from 1.00 mol (58.4 g) of NaCl in enough water to give 1.00 L of solution has a molarity of 1.00 M. A solution that is formed from 2.50 mol (146 g) of NaCl in enough water to give 2.50 L of solution is also a 1.00 M solution. Both solutions contain the *same number of moles per unit volume*.

$$M = \frac{\text{Moles of } Solute\ (mol)}{V(L)}$$

$$M = \frac{Weight(wt.)}{M.Wt}\ x\ \frac{1000}{V(ml)}$$

$$N = \frac{Equivelents\ of\ Solute\ (Eq)}{V(L)}$$

$$N = \frac{Weight(wt.)}{Eq.Wt}\ x\ \frac{1000}{V(ml)}$$

PROBLEM

Calculate the molarity of each aqueous solution with the given amount of NaCl (molar mass 58.4 g/mol) and final volume.

a. 1.0 mol in 0.50 L

b. 2.0 mol in 250 mL

c. 0.050 mol in 5.0 mL

d. 12.0 g in 2.0 L

Home Work

Which solution has the higher concentration, one prepared from 10.0 g of NaOH in a final volume of 150 mL, or one prepared from 15.0 g of NaOH in a final volume of 250 mL of solution?

- ***Molarity is a conversion factor that relates the number of moles of solute to the volume of solution it occupies.*** Thus, if we know the molarity and volume of a solution, we can calculate the number of moles it contains. If we know the molarity and number of moles, we can calculate the volume in liters.
- To calculate the volume of solution… …rearrange the equation for molarity (M):

$$\mathrm{V}(L) = \frac{\text{Moles of } Solute\ (mol)}{M}$$

- To calculate the moles of solute… …rearrange the equation for molarity (M):

$$\text{Moles of } Solute\ (mol) = \mathrm{M \times V(L)}$$

PROBLEM

How many milliliters of a 1.5 M glucose solution contain each of the following number of moles?

a. 0.15 mol
b. 0.020 mol
c. 0.0030 mol
d. 3.0 mol

How many moles of NaCl are contained in each volume of aqueous NaCl solution?

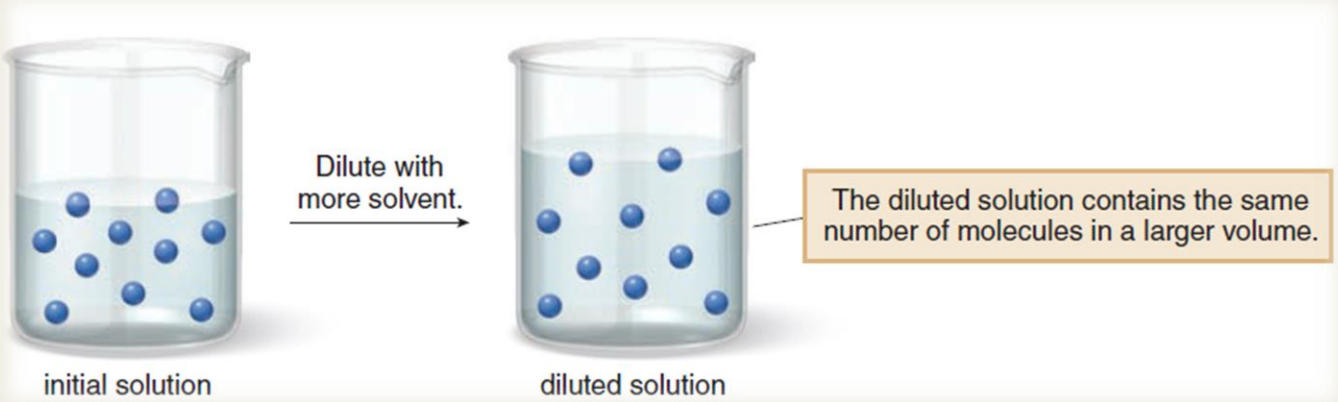
a. 2.0 L of a 2.0 M solution
b. 2.5 L of a 0.25 M solution
c. 25 mL of a 2.0 M solution
d. 250 mL of a 0.25 M solution

5. Dilution

- Sometimes a solution has a higher concentration than is needed. Dilution is the addition of solvent to decrease the concentration of solute.
- **For example**, a stock solution of a drug is often supplied in a concentrated form to take up less space on a pharmacy shelf, and then it is diluted so that it can be administered in a reasonable volume and lower concentration that allows for more accurate dosing.
- **Diluted formocresol** is the most widely recommended primary tooth pulpotomy medicament

Some cleaning products are sold as concentrated solutions, which are then diluted prior to use.

- A key fact to keep in mind is that the amount of solute is constant. Only the volume of the solution is changed by adding solvent.



- In using molarity as a measure of concentration in Section 4.5, we learned that the number of moles of solute can be calculated from the molarity and volume of a solution. Moles of solute = Molarity x Volume

- Thus, if we have initial values for the molarity and volume (M1 and V1), we can calculate a new value for the molarity or volume (M2 or V2), since the product of the molarity and volume equals the number of moles, a constant.

$$M_1V_1 = M_2V_2$$

initial values final values

PROBLEM

What is the concentration of a solution formed by diluting 25.0 mL of a 3.8 M glucose solution to 275 mL?

Home Work 2

How many milliliters of a 6.0 M NaOH solution would be needed to prepare each solution?

a. 525 mL of a 2.5 M solution

b. 750 mL of a 4.0 M solution

c. 450 mL of a 0.10 M solution

d. 25 mL of a 3.5 M solution

End