

PAL Worksheet- Chem 6A

Concentration and Dilution

Principle: solutes dissolve in solvents to produce solutions with a given solute concentration. Concentration is defined as the amount (mass, moles, volume) of solute dissolved in a solvent or solution (mass, moles, volume).

Concentration is a property of any solution, regardless of solute or solvent units, or physical state of the solute or solvent. It's important to understand that concentration is ALWAYS a ratio of some amount of solute to some amount of solvent, which forms the solution. The challenge in working with concentration is to 1) identify the solute and the solvent and 2) use the right units for each.

The most common concentration units in chemistry use mass/volume (many versions), and mol/L, also known as molarity. A specific type of mass/volume concentration, % mass/volume (% m/v) is particularly common in nursing. Note that some calculations use solvent volume in the denominator and others use solution volume (after the solute is dissolved in the solvent). These are not exactly the same thing but either one is always in the denominator of a concentration. In the exercises that follow, note that concentration – in any units – can be used like a conversion factor.

I. Calculations involving mass/volume ratio.

In this type of concentration, the solute is expressed with a mass unit, e.g. mg or g, and the solvent or solution is expressed with a volume unit, e.g. mL or L. These types of concentrations are extremely common in nursing and use a wide variety of units, as indicated in the problems below.

1. Circle any of the following expressions that refer to concentration expressed as mass/volume.
mL/min g/mol mg/dL msec/L drops/second $\mu\text{g/mL}$ kg/mm
2. Calculate the concentration of a solution containing 4.5 g of MgCl_2 dissolved in 50.0 mL of water.

3. 150 mL of a glucose solution has a concentration of 3.0 mg/mL. What mass of glucose was used to make the solution?

4. A normal total blood cholesterol concentration is 185 mg/dL. What is the concentration expressed as g/L? Hint: convert the numerator first and then the denominator.

5. Magnesium sulfate has several clinical uses, including treating pre-eclampsia and ventricular tachycardia. What volume of water should be added to 420 mg of magnesium sulfate to produce a concentration of 5.0 mg/mL?

Percent mass/volume

A specific type of mass/volume concentration is **percent mass/volume**, also known as % **m/v**. % m/v is defined as g/100 mL. For example, a 5% m/v solution of dextrose, a common IV solution, is equal to 5 g/100 mL. 5 g/100 mL is also 0.05 g/mL.

Examples

A. How many grams are in 120 mL of 0.35% m/v NaCl?

First we need to translate 0.35% into concentration units: 0.35 g/100 mL. Then we can calculate the grams in 120 mL:

$$120 \text{ mL} \times \frac{0.35 \text{ g}}{100 \text{ mL}} = 0.42 \text{ g}$$

B. What % m/v is 25 mg/dL?

Here, we need to get our concentration into g/mL and then multiply by 100 to get % m/v.

$$\frac{25 \text{ mg}}{1 \text{ dL}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{10 \text{ dL}}{100 \text{ mL}} = 0.025 \text{ g/mL}$$

Then, $0.025 \text{ g/mL} \times 100 = 2.5\% \text{ (m/v)}$

- How many milliliters are needed to make a 0.350 % solution of NaCl (saline) that contains 0.250 g of NaCl?
- What is the % m/v of a 550 $\mu\text{g/mL}$ solution of sodium bicarbonate? Hint: convert the concentration to g/mL first.

II. Calculations involving molarity.

Molarity is defined as moles (mol) of solute per liter of solution, and is denoted as M. When doing calculations involving molarity, **it is very important to always replace M with mol/L so you can clearly see your units.**

1. What is the molarity of a solution containing 0.45 moles in 250 L?
2. What is the molarity of a solution containing 35 μ moles in 680 mL? Hint: convert μ moles to moles and mL to L.

3. How many moles are in 150 mL of a 0.25 M solution?
4. What volume of 0.130 M solution contains 5.7 moles?
5. What is the molarity of a solution that contains 48 g of potassium chloride in 250 mL?

III. Conversions between different units of concentration.

1. Dextrose (glucose) is a common saline solution used in IV drug delivery at a concentration of 5.0% (m/v). What is the molarity of a 5.0% dextrose solution? The formula for dextrose is $C_6H_{12}O_6$.
2. Convert 15.0 M dextrose ($C_6H_{12}O_6$) to mg/dL.

IV. Dilution.

Dilution refers to reducing the concentration of a solution by adding more solvent to it. The amount of solute is unchanged but the solution volume has increased so the concentration is reduced. For example, the concentration of a solution containing 5 g of sugar in 50 mL of

water is 0.1 g/mL. If we add 50 additional mL of water to this solution, we still have 5 g of sugar but now it is dissolved in 100 mL and its concentration is 0.05 g/mL. We can use an equation to solve many dilution problems, $C_1V_1 = C_2V_2$, where C_1 and V_1 are the concentration and volume of the original solution and C_2 and V_2 are the concentration and volume of the dilute solution. C_1 and C_2 must have the same concentration units. Likewise, V_1 and V_2 must have the same volume units. When doing dilutions with solutions expressed in molarity, we can use the same equation but substitute $M_1V_1 = M_2V_2$. In this case, both M values must be in mol/L and both V values must be in L.

Example from above paragraph:

$$C_1 = 0.1 \text{ g/mL} \quad V_1 = 50 \text{ mL} \quad C_2 = \text{unknown} \quad V_2 = 50 \text{ mL} + 50 \text{ mL} = 100 \text{ mL}$$

$$\text{We are solving for } C_2: \quad C_2 = \frac{C_1V_1}{V_2} = \frac{0.1 \text{ g/mL}(50 \text{ mL})}{100 \text{ mL}} = 0.05 \text{ g/mL}$$

1. Draw a picture of the two solutions in the example above. Represent the 5 g of sugar as individual particles.
2. 120 mL of water is added to 55 mL of a 0.065 g/mL solution of calcium chloride. What is the new concentration?
3. 40.0 mL of 0.15 M solution of acetic acid is diluted to 85.0 mL. What is the final concentration?

- 4 50.0 mL of a 0.25 g/mL solution of antacid was diluted to 0.15 g/mL. What volume was **added** to the solution?
5. A nurse is asked to prepare 1.0 L of 0.90% saline IV solution using a 20.0% concentrated saline solution. Explain how the nurse needs to prepare this solution. Your answer should include both the volume of 20.0% saline and the volume of water needed in the dilution.
6. Draw a picture that represents the preparation of the solution in question 5 above.