Solutions

Explore

How do you calculate concentrations of solutions using molarity, mass percent, volume percent, and parts-per-million (ppm)?

Additional Methods for Calculating Concentrations

In the sample problem above, concentration was calculated using **molarity**, molality, and **mole fraction**. Other methods of calculating concentrations are related to the mass and volume of the **solution**'s components, instead of molar values.

Mass percent is the mass of a given **solute** divided by the mass of the solution. The mass percent of each component in a solution should add up to equal 100%.

$$\text{mass } \% = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$$

Another method, **volume percent**, is often used to describe the concentrations of liquid solutions. For example, you may have seen 70% isopropyl alcohol in a first aid kit. It is made using a ratio of 70 parts isopropyl alcohol and 30 parts water. Because volumes do not always increase when solutions are formed, the volume percent concentrations of each solute in a solution may not add up to be exactly 100%.

If a solution is formed from liquid or gas components, the volume of the solute is used to calculate volume percent concentration.

$$\text{volume } \% = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

Molarity is generally used when the concentration of a solute is very high. Using another method, referred to as parts per million (ppm), is better suited for solutions with low concentrations of a solute. This concentration is calculated using ratio of the mass of solute to the mass of solution, then applying the ratio to a quantity of 1

million particles. In other words, the calculation shows how many parts of solute would be found in one million parts of solution.

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

Calculating Concentrations: Sample Problem

A solution is formed when 5.000 g of sodium bicarbonate, $NaHCO_3$, is added to 2.000 L of water. Calculate the mass percent of sodium bicarbonate in solution. What is the concentration of sodium bicarbonate, in ppm? Assume 1 liter of water has a mass of 1 kilogram.

Solution:

To calculate the mass percent of sodium bicarbonate in solution, the mass of the solution must first be determined. The mass of the solute is given as 5.000 g. The mass of the **solvent** must be determined in kilograms, and then converted to grams.

$$\text{mass of solvent} = 2.000 \cancel{\text{L}} \times \frac{1.0 \text{ kg}}{1 \cancel{\text{L}}} = 2.000 \text{ kg}$$

$$\text{mass of solvent} = 2.000 \cancel{\text{kg}} \times \frac{1000 \text{ g}}{1 \cancel{\text{kg}}} = 2000 \text{ g}$$

The total mass of the solution, then, combines the two values.

mass of solute + mass solution = total mass of solution

5.000 g + 2.000 × 10^3 g = 2,005 g

Next, we substitute the correct values into the equation for mass percent.

$$\text{mass percent} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$$

$$= \frac{5.000 \text{ g}}{2{,}005 \text{ g}} \text{ x } 100\%$$

$$= 0.2494\%$$

The mass percent of the sodium bicarbonate in the solution is 0.2494%.

To determine the concentration of the $NaHCO_3$ solution in parts per million, the mass values used above are substituted into this equation.

$$\text{parts per million} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$$
$$= \frac{5.000\ \text{g}}{2005\ \text{g}} \times 10^6$$
$$= 2,494\ \text{ppm}$$

For every million parts of solution, there are 2,494 parts of solute.
