Solution Concentration

Concentration is the measure of how much solute is dissolved in a specific amount of solvent or solution.

Concentration can be described qualitatively using ____________ or ____________.

Concentration can be described quantitatively using a variety of concentration ratios.

<table>
<thead>
<tr>
<th>Concentration Description</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent by Mass</td>
<td>( \frac{\text{mass of solute}}{\text{mass of solution}} \times 100 )</td>
</tr>
<tr>
<td>Percent by Volume</td>
<td>( \frac{\text{volume of solute}}{\text{volume of solution}} \times 100 )</td>
</tr>
<tr>
<td>Molarity (M)</td>
<td>( \frac{\text{moles of solute}}{\text{liters of solution}} )</td>
</tr>
<tr>
<td>Molality (m)</td>
<td>( \frac{\text{moles of solute}}{\text{kilograms of solvent}} )</td>
</tr>
<tr>
<td>Mole Fraction (X)</td>
<td>( \frac{\text{moles of solute}}{\text{moles of solute} + \text{moles of solvent}} )</td>
</tr>
</tbody>
</table>

Examples – Percent by Mass
In order to maintain a sodium chloride concentration similar to that of ocean water, an aquarium must contain 3.6 g NaCl per 100.0 g of water. What is the percent by mass of NaCl in the solution?

You have 1500.0 g of a bleach solution. The percent by mass of the solute sodium hypochlorite, NaOCl, is 3.62%. How many grams of NaOCl are in the solution?
**Examples – Percent by Volume**
If you have 100.0 mL of a 30.0% aqueous solution of ethanol, what volumes of water and ethanol are in the solution?

What is the percent by volume of isopropyl alcohol in a solution that contains 24 mL of isopropyl alcohol in 1.1 L of water?

**Examples – Molarity**
A 100.5 mL intravenous (IV) solution contains 5.10 g of glucose ($C_6H_{12}O_6$). What is the molarity of this solution? The molar mass of glucose is 180.16 g/mol.

What is the molarity of a bleach solution containing 9.5 g of NaOCl per liter of bleach?

Calculate the molarity of 1.60 L of a solution containing 1.55 g of dissolved KBr.
Examples – Preparing Molar Solutions
How many grams of CaCl$_2$ would be dissolved in 1.0 L of a 0.10 M solution of CaCl$_2$?

A liter of 2 M NaOH solution contains how many grams of NaOH?

Diluting Solutions
You can use concentrated solutions of standard molarities (__________ ____________) to prepare less concentrated solutions by adding more solvent. This increases the number of solvent particles while the solute particles stay the same, causing a decrease in concentration.

Because the total number of moles of solute does not change during dilution, moles of solute in the stock solution equal the moles of solute after dilution.

\[ M_1V_1 = M_2V_2 \]

\[ \begin{align*}
M_1 &= \text{molarity of stock solution} \\
V_1 &= \text{volume of stock solution} \\
M_2 &= \text{molarity of dilute solution} \\
V_2 &= \text{volume of dilute solution}
\end{align*} \]

Example
What volume, in mL of 2.00 M calcium chloride (CaCl$_2$) stock solution would you use to make 0.50 L of 0.300 M calcium chloride solution?
Examples – Molality
In the lab, a student adds 4.5 g of sodium chloride (NaCl) to 100.0 g of water. Calculate the molality of the solution.

What is the molality of a solution containing 30.0 g of naphthalene (C\textsubscript{10}H\textsubscript{8}) dissolved in 500.0 g of toluene?

Examples – Mole Fraction
What is the mole fraction of NaOH in an aqueous solution that contains 22.8% NaOH by mass?

An aqueous solution of NaCl has a mole fraction of 0.21. What is the mass of NaCl dissolved in 100.0 mL of solution?