Concentration Conversions

The most important skill required for a concentration conversion problem is being able to define and rewrite the concentration units into their simplest forms. You must know the definitions of the individual concentration units and how to rewrite the units.

(a) **Molarity (M)**

\[ M = \text{moles of solute/liters of solution} \]

e.g., 0.750 M NaCl can be expressed as (0.750 moles NaCl / 1 L solution)

(b) **Molality (m):**

\[ m = \frac{\text{moles solute}}{\text{Kg of solvent}} \]

e.g., 0.250 m KBr can be expressed as (0.250 moles KBr / 1 Kg solvent)

(c) **Mole Fraction (X)**

\[ X_A = \frac{\text{moles A}}{\text{total moles of all species present (solute + solvent)}} \]

\[ X_A + X_B + X_C = 1 \]

e.g., \( X_{Na^+} = 0.150 \) in a NaCl\(_{aq}\) solution can be expressed as (0.15 moles Na\(^+\) / 1 mole total) or (0.15 moles Na\(^+\) / (0.15 moles Na\(^+\) + 0.15 moles Cl\(^-\) + 0.70 moles H\(_2\)O))

note: total moles = moles Na\(^+\) + moles Cl\(^-\) + moles H\(_2\)O because NaCl dissociates into Na\(^+\) and Cl\(^-\). Likewise, moles Na\(^+\) = moles Cl\(^-\), because of the chemical formula.

(d) **Mass Percent, Percent by Weight, Percent by Mass:**

\[ \text{mass} \% = \frac{\text{mass solute}}{\text{mass solution}} \times 100 \]

e.g., 15.5 \% Na\(_2\)S (aq) can be expressed as (0.155 g Na\(_2\)S / 1 g soln) or (15.5 g Na\(_2\)S / 100 g soln)

Related units:

\[ \text{ppm (parts per million)}, \quad \text{ppm} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^6 \]
\[ \text{ppb (parts per billion)}, \quad \text{ppb} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^9 \]

(e) **Volume Percent, Percent by Volume (\%v/v)**

\[ \text{Volume} \% = \frac{\text{volume solute}}{\text{volume solution}} \times 100\% \]

e.g., 40 \% EtOH (aq) can be expressed as (0.40 L EtOH/1 L soln) or (40 mL EtOH / 100 mL Soln)

Related unit:

alcohol proof, \( \text{proof} = 2 \times \text{vol}\% \)
Stepwise Approach to Concentration Unit Conversion Calculations:

Using the Table

(a) Identify the solute and solvent
(b) Rewrite concentration units given into simplest units and species
(c) Enter in values (numerator, denominator) into the appropriate box on table
(d) Identify and rewrite desired concentration units in simplest units and species
(e) Use table to find these quantities
(f) Once individual values have been determined, divide them by each other to get unit.

<table>
<thead>
<tr>
<th></th>
<th>Solute</th>
<th>Solvent</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes on Concentration Table:
WATCH LABELS! Pay attention to differences between solute, solvent, and solution
Solution = solute + solvent

grams ↔ moles: use Molar Mass as Conversion (xx grams A / 1 mole A)
There is no such thing as Molar Mass of a solution
(no conversion between moles soln and g soln)

grams ↔ mL: use density as Conversion (xx grams A / 1 mL A)
Unless told otherwise only grams + grams and moles + moles are additive!
(no adding volumes, vol + vol)

Without the Table

(a) Identify the solute and solvent
(b) Rewrite concentration units given into simplest units and species
(c) Identify and rewrite desired concentration units in simplest units and species
(d) Using the numerator or denominator of the given concentration units as a starting point,
    convert to the individual numerator of the desired concentration unit
(e) Using the numerator or denominator of the given concentration units as a starting point,
    convert to the individual denominator of the desired concentration unit
(f) Once individual numerator and denominator have been determined, divide them by each
    other to get value of the concentration.