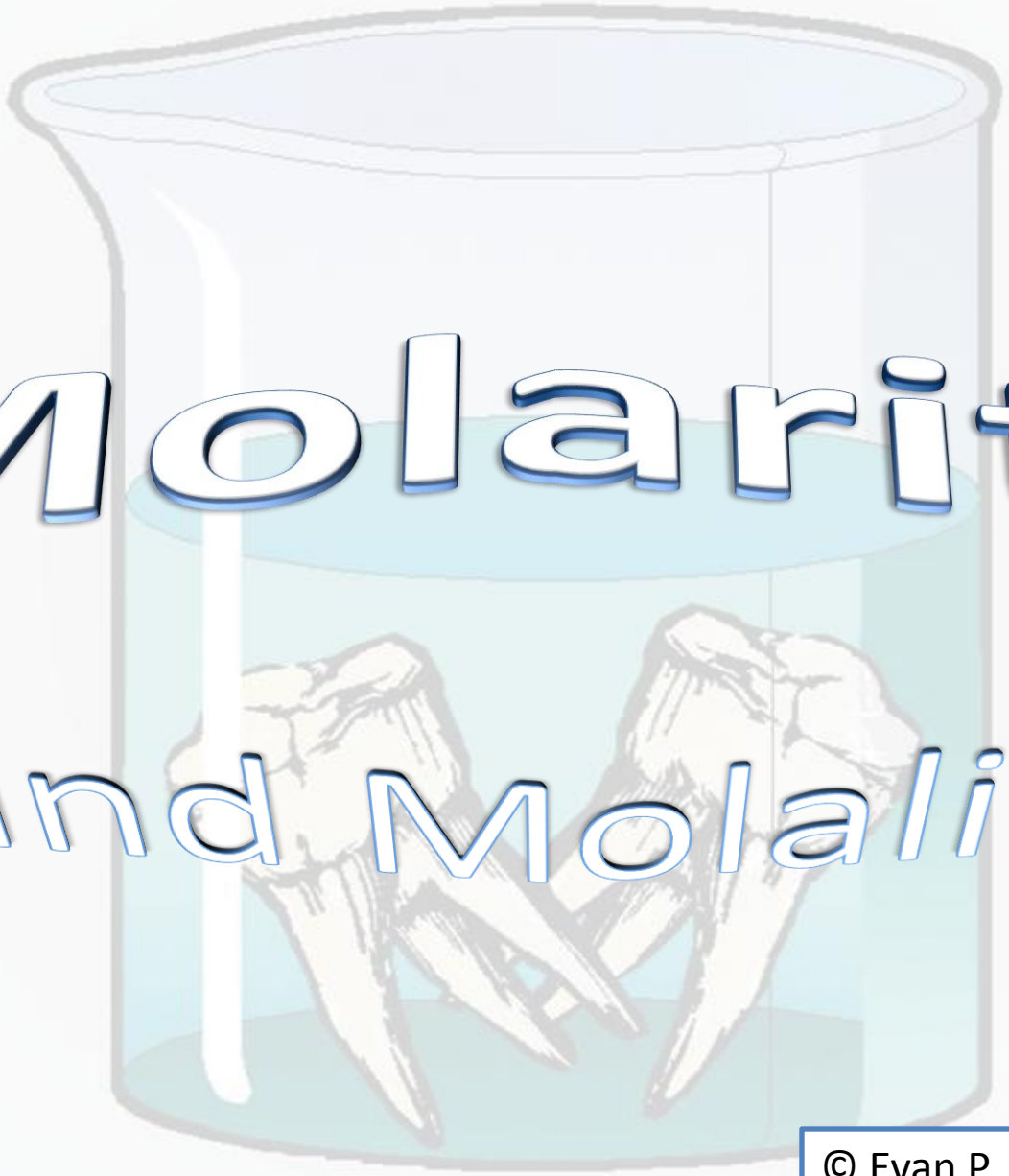
Molarity

and Molality



MOLARITY

Another Type of Concentration

- Recall the quantitative definition of concentration:

$$Concentration = \frac{Mass\ of\ Solute\ (g)}{Volume\ of\ Solvent\ or\ Solution}$$

- Recall also that there is a relationship between mass and moles.
- The amount of solute can be expressed as moles instead of grams.
- The new measure of concentration is called molarity.

Defining Molarity

- To determine molarity:
  - The amount of solute is expressed in moles (*mol*).

and

  - The amount of solution is expressed in liters (*L*).

- Molarity (*M*) is the number of moles of solute per liter of solution.

$$M = \frac{\textbf{mol (solute)}}{\textbf{L (solution)}}$$

Related Relationships

- Considering that $M = \frac{mol}{L}$, find moles.

$$mol = M \times L$$

- Considering that $M = \frac{mol}{L}$ and $mol = \frac{g}{GFM}$, find molarity by substituting for moles.

$$M = \frac{g}{GFM \times L}$$

- Find grams by using algebra .

$$g = M \times GFM \times L$$

Sample Problem 1

Find the molarity of 100. mL of a solution that contains 0.25 moles of dissolved solute.

- **Step 1:** Convert all volumes to liters

$$100.\ mL \times \frac{0.001\ L}{1\ mL} = 0.100\ L$$

- **Step 2:** Substitute values into the definitional equation

$$M = \frac{0.25\ mol}{0.100\ L} = 2.5\ M$$

Sample Problem 2

Find the molarity of 250. mL of a solution that contains 4.0 g of dissolved sodium hydroxide (NaOH).

- **Step 1:** Find the GFM

  Na = 23 × 1 = 22.99
  O = 16 × 1 = 16.00
  H = 1 × 1 = 1.01
  40.00

- **Step 2:** Convert all volumes to liters

$$250.\ mL \times \frac{0.001\ L}{1\ mL} = 0.250\ L$$

- **Step 3:** Substitute values into the correct equation

$$M = \frac{g}{GFM \times L}$$

- **Step 2:** Do factor label

$$\frac{(4.0\ g)(1\ \text{mol})(1\ mL)}{(40.0\ g)(250.\ mL)(0.001\ L)} = 0.40\ M$$

or

$$M = \frac{4.0\ g}{(40.00\ {}^{g}/_{mol})(0.250\ L)} = 0.40\ M$$

Sample Problem 3

How many moles of solute are dissolved in 30 mL of a 2 M solution?

- **Step 1:** Convert all volumes to liters

$$30\ mL \times \frac{0.001\ L}{1\ mL} = 0.03\ L$$

- **Step 2:** Substitute values into the correct equation*

$$mol = M \times L$$

$$mol = (2\ M)(0.03\ L) = 0.06\ mol$$

NOTE: Since M = $^{mol}/_{L}$, the units cancel properly

* This is really the same as factor label

$$\frac{(2\ mol)(0.03\ L)}{(1\ L)} = 0.06\ mol$$

Sample Problem 4

How many grams of silver nitrate ($AgNO_3$) are needed to prepare 200. mL of a 0.10 M solution?

- **Step 1:** Find the GFM

  Ag = 107.87 × 1 = 107.9
  N = 14.01 × 1 = 14.01
  O = 16 .00× 3 = 48.00
  169.9

- **Step 2:** Convert all volumes to liters

$$200.\ mL \times \frac{0.001\ L}{1\ mL} = 0.200\ L$$

- **Step 3:** Substitute values into the correct equation

$$g = M \times GFM \times L$$

- **Step 2:** Do factor label

$$\frac{(0.10\ mol)(169.9\ g)(200.\ mL)(0.001\ L)}{(1\ L)(1\ \text{mol})(1\ mL)} = 3.4\ g$$

or

$$g = (0.10\ M)(169.9\ {}^{g}/_{mol})(0.200\ L)$$
$$= 3.4\ g$$

NOTE: Since M = $^{mol}/_{L}$, the units cancel properly

MOLALITY

Yet Another Type of Concentration

- Recall the quantitative definition of concentration is also:

$$Concentration = \frac{Mass\ of\ Solute\ (g)}{Mass\ of\ Solvent\ or\ Solution}$$

- Since there is a relationship between mass and moles, the amount of solute can be expressed as moles instead of grams.
- The amount of solvent is 1,000 g or 1 kg
- The new measure of concentration is called molality.

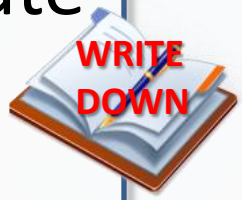
Defining Molality

- To determine molality:
  - The amount of solute is expressed in moles (*mol*).

and

  - The amount of solvent is expressed in kilograms (*kg*).

- Molality (*m*) is the number of moles of solute per kilogram of solvent.



$$m = \frac{\textbf{mol (solute)}}{\textbf{kg (solvent)}}$$

Sample Problem 5

Find the molality of a solution that contains 0.35 moles of solute dissolved in 200. g of water .

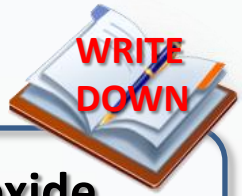
- **Step 1:** Convert the amount of solvent to kilograms

$$200.\ g \times \frac{1\ \text{kg}}{10^3\ g} = 0.200\ kg$$

- **Step 2:** Substitute values into the definitional equation

$$m = \frac{0.35\ mol}{0.200\ kg} = 1.8\ m$$

Sample Problem 6



Find the molality of a solution that contains 33.35 g of calcium hydroxide [$Ca(OH)_2$] dissolved in 300. g of water.

- **Step 1:** Find the GFM

  Ca = 40.08 × 1 = 40.08
  O = 16.00 × 2 = 32.00
  H = 1.01 × 2 = 2.02
  74.10

- **Step 2:** Convert the mass of solute to moles.

$$33.35\ g \times \frac{1\ mol}{74.10\ g} = 0.450\ mol$$

- **Step 3:** Convert the amount of solvent to kilograms.

$$300.\ g \times \frac{1\ kg}{10^3\ g} = 0.300\ kg$$

- **Step 4:** Substitute values into the definitional equation.

$$m = \frac{0.450\ mol}{0.300\ kg} = 1.5\ m$$