Introduction to Physical Science

Molarity

Presented by Robert Wagner

Solutions

- A solution is a homogeneous mixture
- Concentration
  - Relative amount of a given component of the solution
- Solvent
  - Component of solution that has a vastly greater quantity than other components (aqueous solution - dissolved in water)
- Solute
  - Component of the solution that is a much lower quantity
    - Dilute - low concentration
    - Concentrated - high concentration

Molarity

- Molarity is defined as the number of moles of solute in exactly 1 liter of solution
-

Example

- A 355 mL soft drink contains 0.133 mol of sucrose. What is the molar concentration of sucrose in the beverage?

$V = 355\ mL = 0.355\ L$

$0.133\ mol\ sucrose$

$$M = \frac{mol\ solute}{L\ solution} = \frac{0.133\ mol}{0.355\ L}$$

$M = 0.375\ M$

Example

- How many moles of sugar are contained in a sip (10 mL) of the soft drink from the previous example?

$M = 0.375\ M\ ;\ V = 10\ mL = 0.01\ L$

$$M = \frac{mol\ solute}{L\ solution}$$

$$mol\ solute = M\ x\ L\ solution$$

$$mol\ solute = 0.375\ \frac{mol\ sugar}{L} x 0.01\ L$$

$$mol\ solute = 0.004\ mol\ sugar$$

Example

- White vinegar is acetic acid ( ) in water. A 0.500 L vinegar solution contains 25.2 g of acetic acid. What is the molarity of the solution?

$V = 0.500\ L\ ;\ m = 25.2\ g$

C: 2x12.01 ; O: 2x16.00 ; H: 4x1.008
24.02+32.00+4.032 = 60.052 g/mol

$$M = \frac{mol\ solute}{L\ solution}$$

$$M = \frac{25.2\ g\ CH_3CO_2H x \frac{1\ mol\ CH_3CO_2H}{60.052\ g\ CH_3CO_2H}}{0.500\ L\ solution}$$

$M = 0.839\ M$

Example

- How many grams of NaCl are contained in 0.250 L of a 5.30 M solution?

$V = 0.250\ L\ ;\ M = 5.30\ M$

$$M = \frac{mol\ solute}{L\ solution}\ ;\ mol\ solute = M\ x\ L\ solution$$

$$mol\ solute = 5.30 \frac{mol\ NaCl}{L} x 0.250\ L = 1.325\ molNaCl$$

Na: 1x22.99 ; Cl: 1x35.45
Formula mass = 58.44

$$1.325\ mol\ NaCl\ x \frac{58.44\ g\ NaCl}{mol\ NaCl} = 77.4\ g\ NaCl$$

Example

- The molarity of an acetic acid solution is 0.839 M. What volume of vinegar contains 756 g of acetic acid?

$m = 75.6\ g\ ;\ M = 0.839\ M$

$$g\ solute\ x \frac{mol\ solute}{g\ solute} = mol\ solute$$

$$mol\ solute\ x \frac{L\ solution}{mol\ solute} = L\ solution$$

$$g\ solute\ x \frac{mol\ solute}{g\ solute} x \frac{L\ solution}{mol\ solute} = L\ solution$$

$$75.6\ g\ CH_3CO_2H\ x\ \frac{mol\ CH_3CO_2H}{60.05\ g} x\ \frac{L\ solution}{0.839\ mol\ CH_3CO_2H}$$

$1.50\ L\ solution$

Dilution of solutions

- Dilution occurs when more solvent is added, lowering the concentration of the solution
  - Dilution equation
  -
  - C = concentration ; V = volume

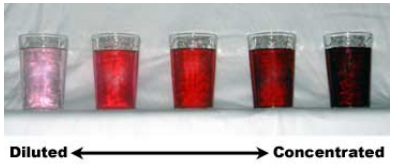

Image Credit: en:User:FirstPrinciples, Public domain, via Wikimedia Commons

Example

- If 0.850 L of a 5.00 M solution of copper nitrate ( ) is diluted to a volume of 1.80 L by the addition of water, what is the molarity of the diluted solution?

$C_1 = 5.00\,M\,;\ V_1 = 0.850\,L\,;\ V_2 = 1.80\,L$

$C_1V_1 = C_2V_2$

$C_2 = \dfrac{C_1V_1}{V_2}$

$C_2 = \dfrac{5.00\ \frac{mol}{L}}{1.80\,L} = 2.36\,M$

Example

- What volume of 0.12 M HBr can be prepared from 11 mL of 0.45 M HBr?

$V_1 = 11\,mL = 0.011\,L$
$C_1 = 0.45\,M\,;\ C_2 = 0.12\,M$

$C_1V_1 = C_2V_2$

$V_2 = \dfrac{C_1V_1}{C_2}$

$V_2 = \dfrac{(0.45\,M)(0.011\,L)}{(0.12\,M)} = 0.041\,L$

Example

- What volume of 1.59 M KOH is required to prepare 5.00 L of 0.100 M KOH?

$V_2 = 5.00\,L\,;\ C_2 = 0.100\,M\,;\ C_1 = 1.59\,M$

$C_1V_1 = C_2V_2$

$V_1 = \dfrac{C_2V_2}{C_1}$

$V_1 = \dfrac{(0.100\,M)(5.00\,L)}{(1.59\,M)} = 0.314\,L$

Summary

- The relative amount of a given solution component is called its concentration
- The solvent has the significantly greater concentration ; the solute has a much smaller concentration
- The molarity of a solution is the number of moles of the solute in one liter of the solution