

Quantities in Solutions

Aim

- to calculate the concentration of a solution, including molarity, percent, and ppm

Notes

Concentration

- ★ Definition:

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

- ★ Molarity

- ☆ definition: $M = \frac{\text{moles(solute)}}{L(\text{solution})}$

- ☆ related equations

- ☆ $M = \frac{g}{GFM \times L}$

- ☆ $\text{moles} = M \times L$

- ☆ $L = \frac{\text{moles}}{M}$

- ☆ $g = M \times GFM \times L$

- ☆ examples

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

$$100 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.1 \text{ L}$$

Step 2: Substitute values into the definitional equation

$$M = \frac{\text{moles}}{L} = \frac{0.25 \text{ moles}}{0.1 \text{ L}} = 2.5$$

M

L

0.1 L

Sample Problem 2

Find the molarity of 250 mL of a solution that contains 4 g of dissolved sodium hydroxide (NaOH).

Step 1: Find the GFM

$$\text{Na} = 23 \times 1 = 23$$

$$\text{O} = 16 \times 1 = 16$$

$$\text{H} = 1 \times 1 = \frac{1}{40}$$

Step 2: Convert all volumes to liters

$$250 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.25 \text{ L}$$

Step 3: Substitute values into the correct equation

$$M = \frac{g}{GFM \times L} = \frac{4 \text{ g}}{40 \text{ g/mole} \times 0.25 \text{ L}} = 0.4 \text{ M}$$

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

$$30 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.03 \text{ L}$$

Step 2: Substitute values into the correct equation

$$\text{moles} = M \times L = (2 \text{ moles/L})(0.03 \text{ L}) = 0.06 \text{ moles}$$

Sample Problem 4

How many grams of silver nitrate (AgNO₃) are needed to prepare 200 mL of a 0.1 M solution?

Step 1: Find the GFM

$$\begin{array}{rclcl} \text{Ag} & = & 108 & \times & 1 & = & 108 \\ \text{N} & = & 14 & \times & 1 & = & 14 \\ \text{O} & = & 16 & \times & 3 & = & \frac{48}{170} \end{array}$$

Step 2: Convert all volumes to liters

$$200 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.2 \text{ L}$$

Step 3: Substitute values into the correct equation

$$g = M \times GFM \times L = (0.1 \text{ mole/L})(170 \text{ g/mole})(0.2 \text{ L}) = 3.4 \text{ g}$$

- ★ Percent solution and parts per million (ppm)

- ☆ Percent by mass:

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

Sample Problem

What is the percent by mass of a solution containing 2.3 g of ethanol (C₂H₅OH) dissolved in 10.0 g of water?

Step 1: Find the mass of the solution

$$10.0 \text{ g} + 2.3 \text{ g} = 12.3 \text{ g}$$

Step 2: Divide the mass of the solute by the mass of the solution and multiply by 100 %

$$\text{percent mass} = \frac{2.3 \text{ g}}{12.3 \text{ g}} \times 100\% = 19\%$$

☆ Percent by volume:

$$\text{percent volume} = \frac{\text{volume}(\text{solute})}{\text{volume}(\text{solution})} \times 100\%$$

Sample Problem

What is the percent by volume of a solution containing 18.2 mL of glycerine (C₃H₈O₃) dissolved in 85.0 mL of water?

Step 1: Find the volume of the solution.
18.2 mL + 85.0 mL = 103.2 mL

Step 2: Divide the volume of the solute by the volume of the solution and multiply by 100%

$$\text{percent volume} = \frac{18.2\text{mL}}{103.2\text{mL}} \times 100\% = 17.6\%$$

☆ Parts per million

$$\text{ppm} = \frac{\text{mass}(\text{solute})}{\text{mass}(\text{solution})} \times 1,000,000 \text{ ppm}$$

Sample Problem

About 0.0035 g of hydrogen sulfide are dissolved in 10.0 g of water. Express this in parts per million.

Step 1: Find the mass of the solution
10.0 g + 0.0035 g = 10.0035 g

Step 2: Divide the mass of the solute by the mass of the solution and multiply by 1,000,000 ppm.

$$\text{ppm} = \frac{0.0035\text{g}}{10.0035\text{g}} \times 1,000,000 \text{ ppm} = 350 \text{ ppm}$$

Answer the questions below by circling the number of the correct response

- How many grams of H₂SO₄ are contained in 1.00 liter of 0.500 M sulfuric acid? (1) 22.4 (2) 98.0 (3) 49.0 (4) 196
- In a 2.0 M solution of KOH, how many moles of KOH are contained in 500 milliliters of the solution? (1) 1 (2) 2 (3) 0.5 (4) 4
- If 0.25 mole of sodium chloride is dissolved in a liter of solution, the molarity of the solution would be (1) 1M (2) 0.50 M (3) 0.25 M (4) 0.125 M
- If 0.5 liter of water is added to 0.5 liter of 2.0 m KBr solution, the molarity of the resulting solution will be (1) 1.0 (2) 2.0 (3) 0.5 (4) 1.5
- 29 grams of NaCl are added to enough water to make 1,000. ml of solution. What is the molarity of the solution? (1) 1.00 M (2) 0.29 M (3) 0.50 M (4) 5.00 M
- What is the molarity of a solution of hydrochloric acid that contains 3.65 grams of HCl dissolved in 1.0 liter of solution? (1) 0.10 M (2) 0.20 M (3) 0.80 M (4) 0.40 M
- A 1 M solution contains 40 grams of a compound in 500 ml of solution. What is the molecular mass of this compound? (1) 20 (2) 40 (3) 60 (4) 80
- A 500 ml solution containing 28 grams of KOH is diluted with water to 1,000. ml. What is the molarity of the resulting solution? (1) 1.0 M (2) 2.0 M (3) 0.25 M (4) 0.50 M
- One liter of a sodium hydroxide solution contains 100 grams of NaOH. The molarity of the solution is (1) 1.0 M (2) 0.25 M (3) 2.5 M (4) 0.50 M
- When 20.0 grams of NaOH is dissolved in 500 mL of solution, the concentration of the solution is (1) 1.0 M (2) 20 M (3) 0.50 M (4) 4.0 M
- If 49 grams of pure H₂SO₄ are added to enough water to make 1,000 ml of solution, what is the molarity of the solution? (1) 1.0 M (2) 0.25 M (3) 0.50 M (4) 0.10 M
- The number of moles of KCl in 1,000 ml of 3 molar solution is (1) 1 (2) 2 (3) 3 (4) 1.5
- How many moles of H₂SO₄ are present in 250 mL of a 2.00 M solution? (1) 0.50 (2) 2.00 (3) 1.25 (4) 8.00
- If 500 mL of 1.0 M H₂SO₄ is diluted with H₂O to a new volume of 1,000 mL, the molarity of the new solution is (1) 1.0 (2) 2.0 (3) 0.25 (4) 0.50
- One liter of a solution of nitric acid contains 126 grams of solution. The molarity of the solution is (1) 1.00 (2) 2.00 (3) 1.26 (4) 0.500
- How much ethanol C₂H₅OH must be added to water to make 1.0 liter of 0.5 molar solution of ethanol? (1) 0.5 gram (2) 46 grams (3) 23 grams (4) 92 grams
- What mass of NaOH (formula mass = 40 g.) is needed to prepare 500 mL of 0.50 M solution? (1) 10. grams (2) 20 grams (3) 25 grams (4) 40 grams
- Two liters of a solution of sulfuric acid contain 98 grams of H₂SO₄. The molarity of this solution is (1) 1.0 (2) 2.0 (3) 0.50 (4) 1.5
- How many moles of AgNO₃ are dissolved in 10 mL of a 1 M AgNO₃? (1) 1 (2) 0.1 (3) 0.01 (4) 0.001