Quantities in Solutions

Aim

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

Notes

Concentration

★ Definition:

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

★ Molarity

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

☆ related equations

★ $M = \frac{g}{GFM \times L}$

★ $moles = M \times L$

★ $L = \frac{moles}{M}$

★ $g = M \times GFM \times L$

☆ 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

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

Step 2: Substitute values into the definitional equation

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

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

Na	= 23	×	1	= 23
O	= 16	×	1	= 16
H	= 1	×	1	= 1
				40

Step 2: Convert all volumes to liters

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

Step 3: Substitute values into the correct equation

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

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

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

Step 2: Substitute values into the correct equation

moles = M × L = (2 moles/L)(0.03 L) = 0.06 moles

Sample Problem 4

How many grams of silver nitrate ($AgNO_3$) are needed to prepare 200 mL of a 0.1 M solution?

Step 1: Find the GFM

Ag	= 108	×	1	= 108
N	= 14	×	1	= 14
O	= 16	×	3	= 48
				170

Step 2: Convert all volumes to liters

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

Step 3: Substitute values into the correct equation

g = M × GFM × L =

(0.1 mole/L)(170g/mole)(0.2 L) = 3.4 g

★ Percent solution and parts per million (ppm)

☆ Percent by mass:

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

Sample Problem

What is the percent by mass of a solution containing 2.3 g of ethanol (C_2H_5OH) dissolved in 10.0 g of water?

Step 1: Find the mass of the solution

10.0 g + 2.3 g = 12.3 g

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

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

☆ Percent by volume:

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

Sample Problem

What is the percent by volume of a solution containing 18.2 mL of glycerine ($C_3H_6O_3$) 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%

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

☆ Parts per million

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

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.

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

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

1. How many grams of H_2SO_4 are contained in 1.00 liter of 0.500 M sulfuric acid? (1) 22.4 (2) 98.0 (3) 49.0 (4) 196
2. 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
3. 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
4. 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
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
6. 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
7. 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
8. 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
9. 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
10. 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
11. If 49 grams of pure H_2SO_4 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
12. The number of moles of KCl in 1,000 ml of 3 molar solution is (1) 1 (2) 2 (3) 3 (4) 1.5
13. How many moles of H_2SO_4 are present in 250 mL of a 2.00 M solution? (1) 0.50 (2) 2.00 (3) 1.25 (4) 8.00
14. If 500 mL of 1.0 M H_2SO_4 is diluted with H_2O 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
15. 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
16. How much ethanol C_2H_5OH 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
17. 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
18. Two liters of a solution of sulfuric acid contain 98 grams of H_2SO_4. The molarity of this solution is (1) 1.0 (2) 2.0 (2) 0.50 (4) 1.5
19. How many moles of $AgNO_3$ are dissolved in 10 mL of a 1 M $AgNO_3$? (1) 1 (2) 0.1 (3) 0.01 (4) 0.001