Concentration units

Concentration: → amount of solute present in a given amount of solution.

Types of concentration-unit

Mole fraction(X):→ $A=X_A$

$$X_A = \frac{\text{moles of A}}{\text{sum of moles of all component}}$$

- Mole fraction → unit less

Molarity (M) → number of moles of solute in 1 liter of solution.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liter of solution}}$$

Unit of molarity → mole / liter.

Molality (m):→ number of moles of solute dissolved in 1 Kg of solvent.

$$\text{Molality} = \frac{\text{moles of solute}}{\text{mass of solvent (Kg)}}$$

Unit of molality → mole / Kg

Percent by mass: → the ratio of the mass of a Salute to the mass of solution.

$$\text{Percent by mass} = \frac{\text{mass of solute}}{\text{mass of solute+mass of solvent}} * 100$$

$$= \frac{\text{mass of solute}}{\text{mass of solution}} * 100$$

Percent by mass: → unit less because it is the ratio between two similar quantities.

Example

A Sample 0.892 gm of (KCl) is dissolved in 54.6 gm of H_2O , what is the percent by mass of KCl in solution?!

Solution

$$\text{Percent by mass} = \frac{\text{mass of solute}}{\text{mass of solution}} * 100$$

$$= \frac{0.892}{54.6+0.892} * 100 = 1.61\%$$

Example

Calculate the molality of sulfuric acid solution containing 24.4 gm. of sulfuric acid in 198 gm. of water (the molar mass of sulfuric acid is 98.09 gm.)

Solution

$$m = \frac{\text{moles of solute}}{\text{mass of solvent (Kg)}}$$

$$\text{Number of moles of } H_2SO_4 = \frac{\text{mass}}{\text{molar mass}}$$

$$= \frac{24.4}{98.09} = 0.249 \text{ mole}$$

$$\text{Molality} = \frac{0.249}{0.198} = 1.26 \text{ mole / Kg}$$

☒Comparison of concentration unit

It is desirable to convert one concentration unit of solution to another.

Examples

The density of 2.45 molar of aqueous solution of methanol (CH_3OH) is 0.979 gm/L. what the molality of the solution is?! (The molar mass of methanol is 32.04 gm.)

Solution

1) Molarity = $\frac{\text{number of moles}}{\text{volume per litre}}$

Suppose volume of solution = 1 liter

$2.45 = \frac{\text{no.of moles}}{1}$

Number of moles = 2.45 mole.

2) Density = $\frac{\text{mass}}{\text{volume}}$

$0.976 = \frac{\text{mass}}{1000\ \text{ml}}$

Mass of solution = 976 gm.

3) Mass of solvent = mass of solution – mass of solute

Mass of solute = number of moles * molar mass

$\therefore$ mass of solute $= (2.45 * 32.04)$

$\therefore$ mass of solvent $= 976 - (2.45 * 32.04) = 898$ gm

$= 0.898$ Kg.

$\therefore$ molality $= \frac{\text{moles of solute}}{\text{mass of solvent Kg}} = \frac{2.45}{0.898} = 2.73\ \frac{\text{mole}}{\text{Kg}}$.

Calculate the molality of a 35.4 percent by mass aqueous solution of H_3PO_4, (the molar mass 97.99 gm.).

Solution

1) Percent by mass = $\frac{\text{mass of solute}}{\text{mass of solution}} * 100$

Assume mass of aqueous = 100 gm.

$\therefore$ mass of solute $= 35.4$ gm

Mass of solvent = 100 – 35.4 = 64.6 gm.

2) Number of moles of $H_3PO_4 = \frac{\text{mass}}{\text{molar mass}} = \frac{35.4}{97.99} = 0.361$ mol

3) Molality = $\frac{0.361}{0.0646} = 5.59m$

Choose

1) The unit of molality…….. , While the unit of mole fraction…….. .

A) unit less , mole/L
C) unit less , unit less
B) mole/Kg , mole
D) mole/Kg , unit less

2) The unit of molarity……

A) mole
C) mole/L
B) mole/Kg
D) mole/cm

3) What is the molarity of a solution of 10% by mass cadmium sulfate ($CdSO_4$) (molar mass = 208.46 g/mol) by mass? The density = 1.10 gm/ml

A) 0.528 M
C) 0.436 M
B) 0.479 M
D) 0.048 M

Solution

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{mass}}{1000} = 1.1$$

$$\therefore \text{mass} = 1100 \text{ gm}$$

$$\text{Percent by mass} = 100 * \frac{\text{mass of solute}}{\text{mass of solution}}$$

$$\therefore \frac{10}{100} = \frac{\text{mass of solute}}{1100} = 110 \text{ gm}$$

$$\text{Number of moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{110}{208.46} = 0.528 \text{ mole}$$

$\frac{0.527}{1} = 0.528$ M Molarity = $\frac{\text{moles of solute}}{\text{volume per litre}}$ =

4) What is the molarity of a solution that is 26% by mass phosphoric acid (H_3PO_4) and that has a density of 1.155 g/ml?

A) $2.3 * 10^{-3}$ M C) 0.3 M

B) 2.3 M D) 3.06 M

Solution

- density = $\frac{\text{mass}}{\text{volume}} = \frac{\text{mass}}{1000} = 1.155$
- Mass = 1155 gm.
- Percent by mass = $100 * \frac{\text{mass of solute}}{\text{mass of solution}}$

$$\therefore \frac{26}{100} = \frac{\text{mass of solute}}{1155}$$

- Mass of solute = 300.3 gm.
- Number of moles = $\frac{\text{mass}}{\text{molar mass}} = \frac{300.3}{97.99} = 3.06$ mole
- Molarity = $\frac{\text{moles of solute}}{\text{volume per litre}} = \frac{3.06}{1} = 3.06$ Molar

5) What is the percent $CdSO_4$ by mass in a 1.0 molal a queous $CdSO_4$ solution?

A) 0.001 %
C) 17.2%
B) 0.10 %
D) 20.8 %

Solution

- Molality = $\frac{\text{moles of solute}}{\text{mass of solvent (Kg)}}$
- Let mass of solvent = 1 Kg.
- Moles of solute = 1 moles.
- Mass of solute = no . of moles * molar mass = 1 *208.46
  = 208.46 gm.
- Percent by mass = $100 * \frac{\text{mass of solute}}{\text{mass of solution}}$

$$= \frac{208.46}{208.46+1000} * 100 = 17.2\%$$

6) What is the percent (CsCl) by mass in a 0.711 M (CsCl)solution that a density of 1.091 g/ml?

A) $3.87 * 10^{-4}$ %
C) 11%
B) $3.87 * 10^{-1}$ %
D) 1.1%

7) Calculate the percent by mass of potassium nitrate in a solution made from 45 gm. (KNO_3) and 295 ml of water, the density of water is 0.997 g/ml.

A) 1.51%
C) 13.3%
B) 7.57%
D) none of them

8) Which of the following has the greater molal concentration (molality) ?!

A) 1 m KNO_3
C) both have the same molality
B) 1 M KNO_3
D) None of them

9) calculate the molality of a solution containing 14.3 gm. of (NaCl) in 42.2 gm. of water.

A) $2.45 * 10^{-4}$ m
C) 5.80 m
B) $5.8 * 10^{-4}$ m
D) 103 m

Solution

- Number of moles = $\frac{\text{mass}}{\text{molar mass}} = \frac{14.3}{58.5} = 0.24$ mole
- Molality = $\frac{\text{moles of solute}}{\text{mass of solvent (Kg)}}$

$= \frac{0.24}{0.0422} = 5.79$