



Concentration Units

Chapter # 10
Chemistry XI FDC
Ms. Sidra Javed

Concentraion

**Amount of solute dissolved in
given amount of solution**

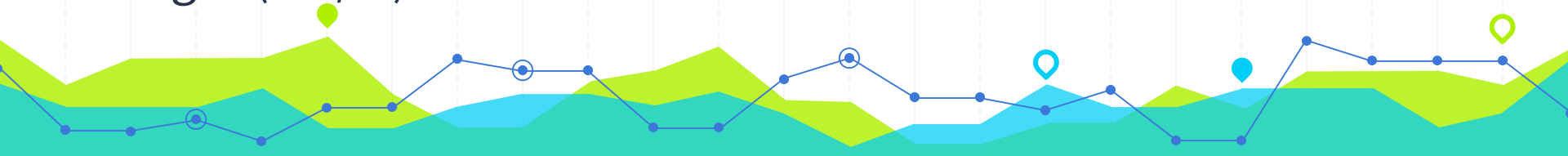


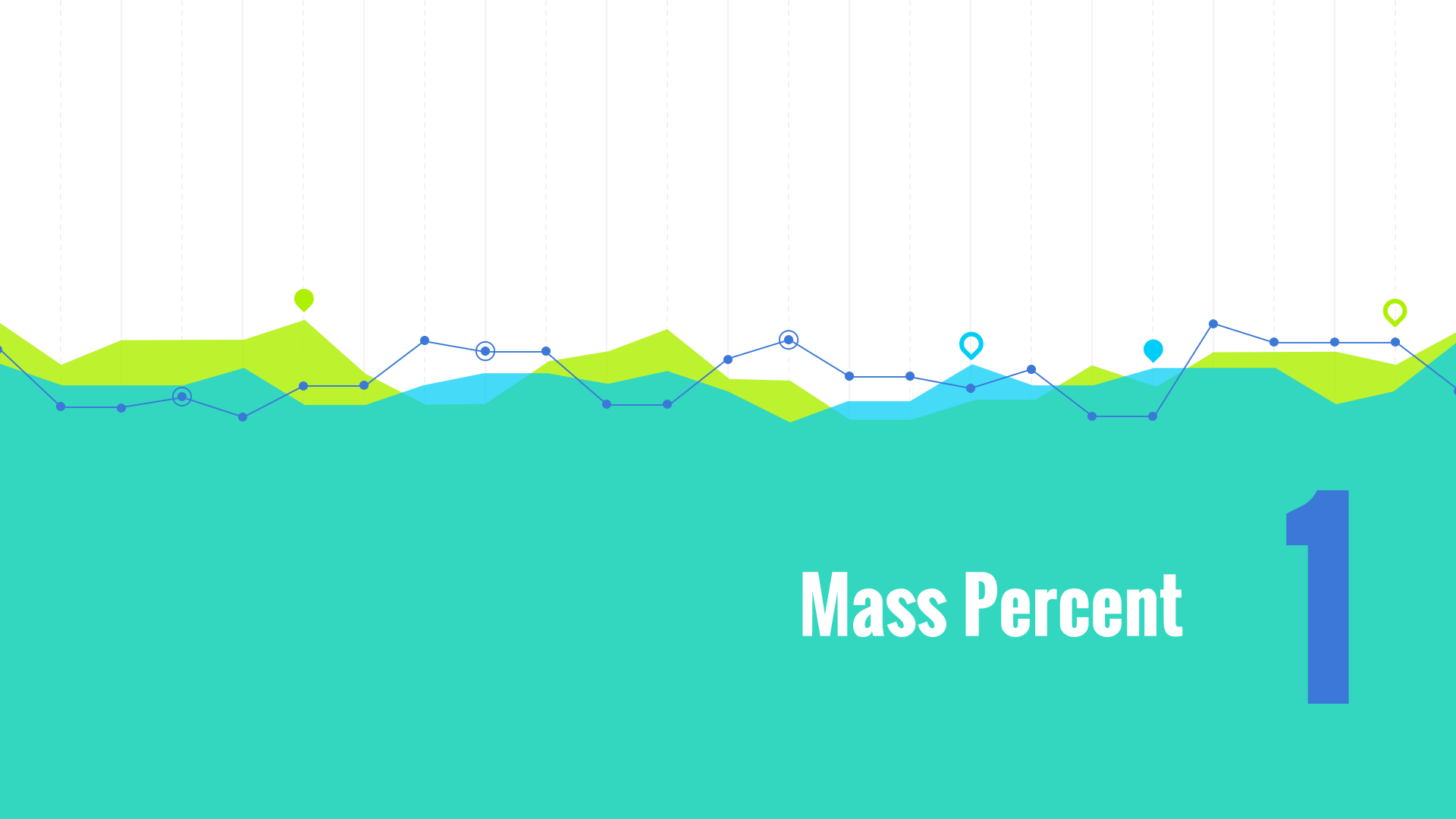
Units of concentration

- Mass percent (%w/w)
- Percent weight by volume (%w/v)
- Percent volume by volume (%v/v)
- Percent volume by weight (%v/w)

- Molarity
- Molality
- Mole Fraction

- Parts per million
- Parts per billion
- Parts per billion





Mass percent

- “The mass of solute present in 100g of solution”
- Percent weight by weight - % w/w

$$\text{Mass percent} = \frac{\text{Grams of solute}}{\text{Grams of solution}} \times 100$$

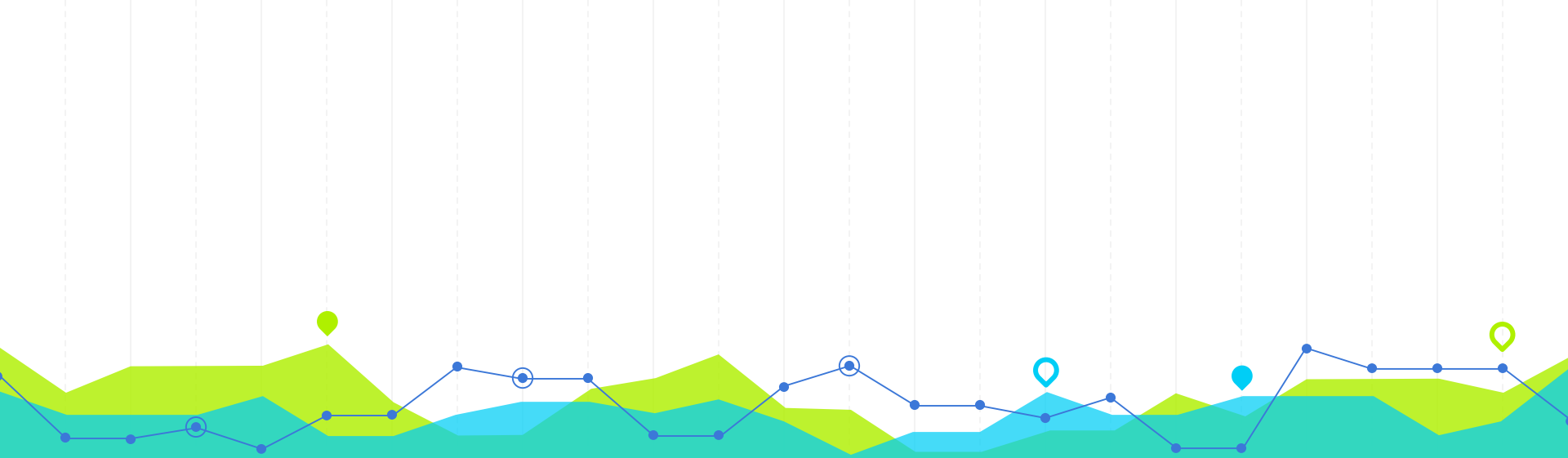


Example 10.2: Calculate mass percent of a solution containing 10 g sugar dissolved in 100 g water.

- Mass of sugar = 10 g
- Mass of water = 100 g
- Mass of solution = 10 g sugar + 100 g water = 110 g

$$\text{Mass percent} = \frac{\text{Grams of sugar}}{\text{Grams of solution}} \times 100$$

$$\text{Mass percent} = \frac{10}{110} \times 100 = 9.09\%$$



Percent weight by volume

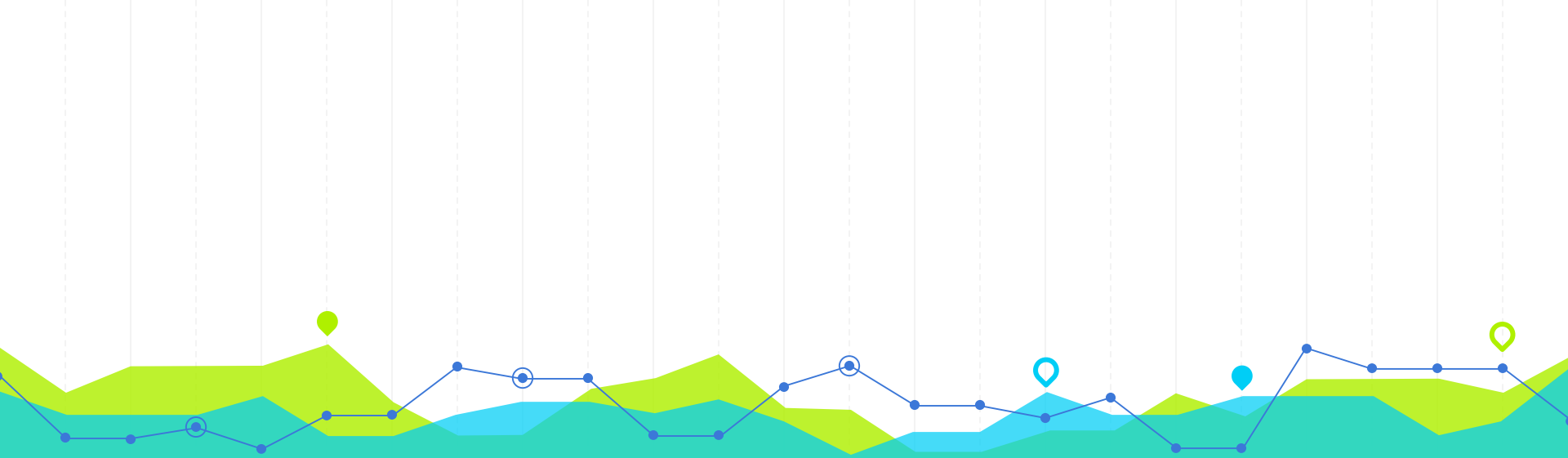
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Percent Weight by Volume

◦ “The mass of a solute dissolved per 100 parts by volume of a **solution** is called %w/v”

$$\text{Percent w/v} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (cm}^3\text{)}} \times 100$$





Percent volume by volume

3

Percent Volume by Volume

◦“The volume of a solute dissolved per 100 parts by volume of a **solution** is called %v/v”

$$\text{Percent v/v} = \frac{\text{Volume of solute (cm}^3\text{)}}{\text{Volume of solution (cm}^3\text{)}} \times 100$$





Percent volume by weight

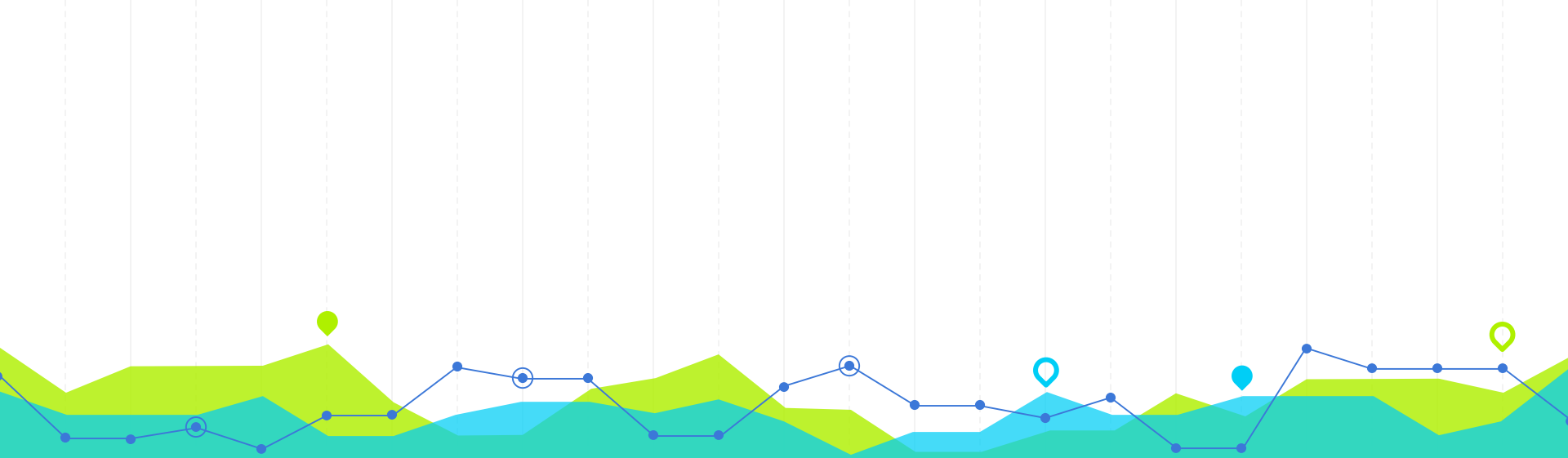
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Percent Volume by Weight

◦ “The volume of a solute dissolved per 100 g of solution is called %v/w”

$$\text{Percent v/w} = \frac{\text{Volume of solute (cm}^3\text{)}}{\text{Mass of solution (g)}} \times 100$$





**Molarity or Molar
concentration**

5

Molarity (M)

◦“The number of moles of solute dissolved per dm³ of the solution”

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{dm}^3 \text{ of solution}}$$

$$\text{Molarity} = \frac{\text{mass of solute}}{\text{Molar mass of solute} \times \text{dm}^3 \text{ of solution}}$$

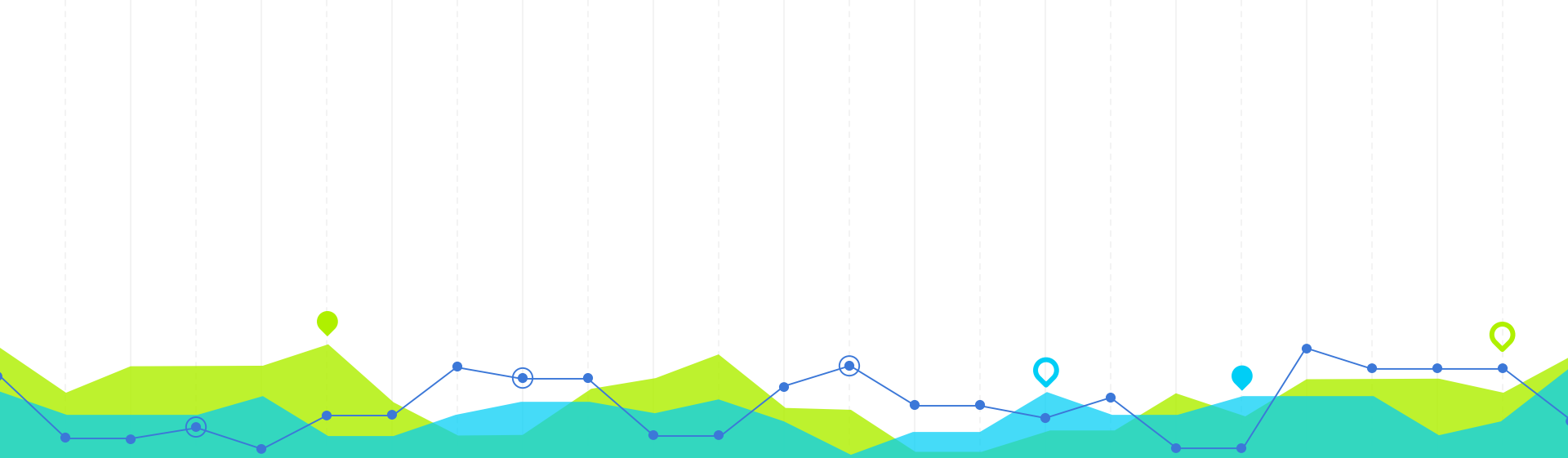


Example 10.3: What is the Molarity of 0.25 g of NaHCO_3 in 100 cm^3 of solution

- Mass of $\text{NaHCO}_3 = 0.25 \text{ g}$
- molar mass of $\text{NaHCO}_3 = 84 \text{ g/mol}$
- Volume of solution = $100 \text{ cm}^3 = 100/1000 = 0.1 \text{ dm}^3$

$$\text{Molarity} = \frac{\text{mass of solute}}{\text{Molar mass of solute} \times \text{dm}^3 \text{ of solution}}$$

$$\text{Molarity} = \frac{0.25}{84 \times 0.1} = 0.0298 \text{ M}$$



Molality or Molal concentration

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Molality (m)

◦ “The number of moles of solute dissolved per 1 Kg (1000g) of solvent”

$$\text{Molality} = \frac{\text{moles of solute}}{\text{kg of solution}}$$

$$\text{Molality} = \frac{\text{mass of solute}}{\text{Molar mass of solute} \times \text{kg of solution}}$$



Example 10.4: Ethanol is an excellent solvent. It is used to prepare tinctures and in the extraction of medicinal compounds from plants. For this purpose either pure ethanol or its aqueous solutions are used. A solution is prepared by mixing 1.00 g of ethanol ($\text{C}_2\text{H}_5\text{OH}$) with 100 g of water. Calculate Molality of this solution.



Example 10.4: Solution

Mass of $\text{C}_2\text{H}_5\text{OH} = 1.00 \text{ g}$

Molar mass of $\text{C}_2\text{H}_5\text{OH} = 46 \text{ g/mol}$

Moles of $\text{C}_2\text{H}_5\text{OH} = \frac{1.00 \text{ g}}{46 \text{ g/mol}} = 2.17 \times 10^{-2} \text{ mol}$

Mass of water = $100 \text{ g} = \frac{100}{1000} = 0.1 \text{ kg}$

Molality of solution = $\frac{\text{Moles of } \text{C}_2\text{H}_5\text{OH}}{\text{Kg of water}}$

Molality of solution = $\frac{2.17 \times 10^{-2} \text{ mol}}{0.1 \text{ kg}}$

Molality of solution = 0.217 m

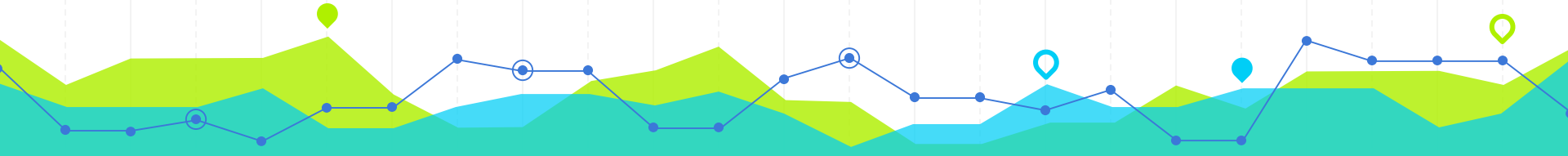
Temperature effect

Molarity

- Moles of solute/volume of solution in dm^3
- Temperature dependent

Molality

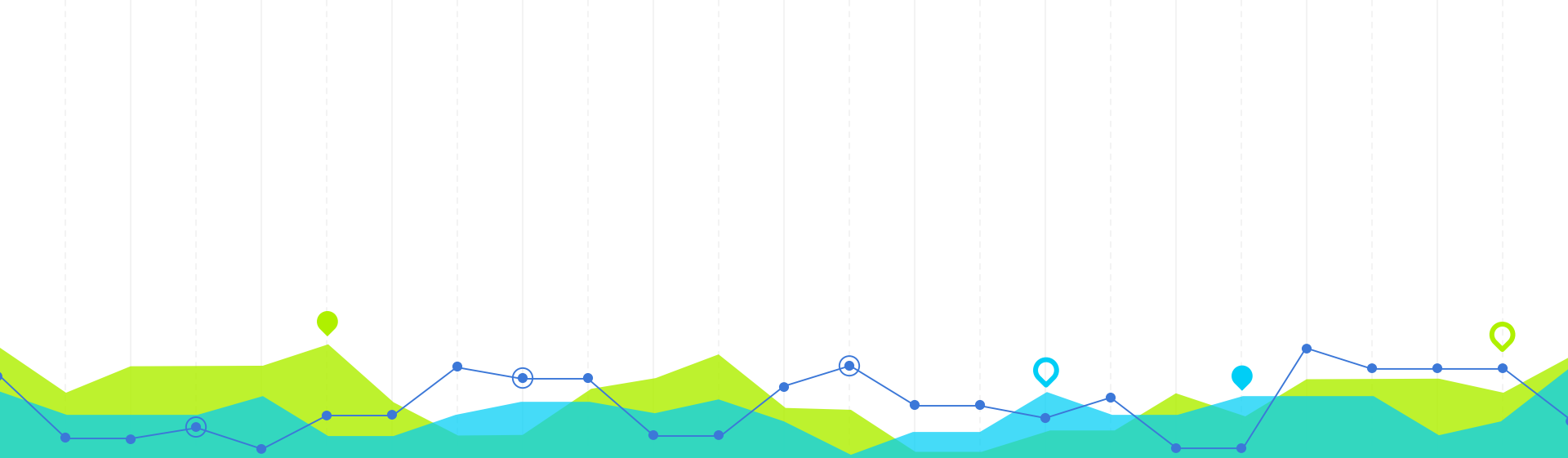
- Moles of solute/Mass of solvent in kg
- Temperature Independent



Temperature effect

◦As temperature is increase the amount of solute remains same but the volume of a solution increases slightly as liquid expands hence the Molarity decreases slightly due to inverse relation.





Mole Fraction

7

Mole Fraction (X)

◉ “The ratio of the number of moles of a given component to the total number of moles of a solution”

$$\text{Mole Fraction of solute} = X_1 = \frac{n_1}{n_1 + n_2}$$

$$\text{Mole Fraction of solvent} = X_2 = \frac{n_2}{n_1 + n_2}$$

$$X_1 + X_2 = 1$$

Example 10.5: An aqueous solution containing 100 g ethanol per dm^3 of solution has a density of 0.99 g/cm^3 . Calculate mole fraction of each component of solution.

$$\text{volume of solution} = 1 \text{ dm}^3 = 1000 \text{ cm}^3$$

$$\text{mass of ethanol} = 100 \text{ g}$$

$$\text{mass of solution} = \text{Density} \times \text{Volume of solution}$$

$$\text{mass of solution} = 0.984 \text{ gcm}^{-3} \times 1000 \text{ cm}^3$$

$$\text{mass of solution} = 984 \text{ g}$$

$$\text{mass of water} = 984 \text{ g} - 100 \text{ g} = 884 \text{ g}$$

$$\text{No. of moles of water} = \frac{884 \text{ g}}{18 \frac{\text{g}}{\text{mol}}} = 49.1 \text{ mol}$$



Example 10.5: Continued..

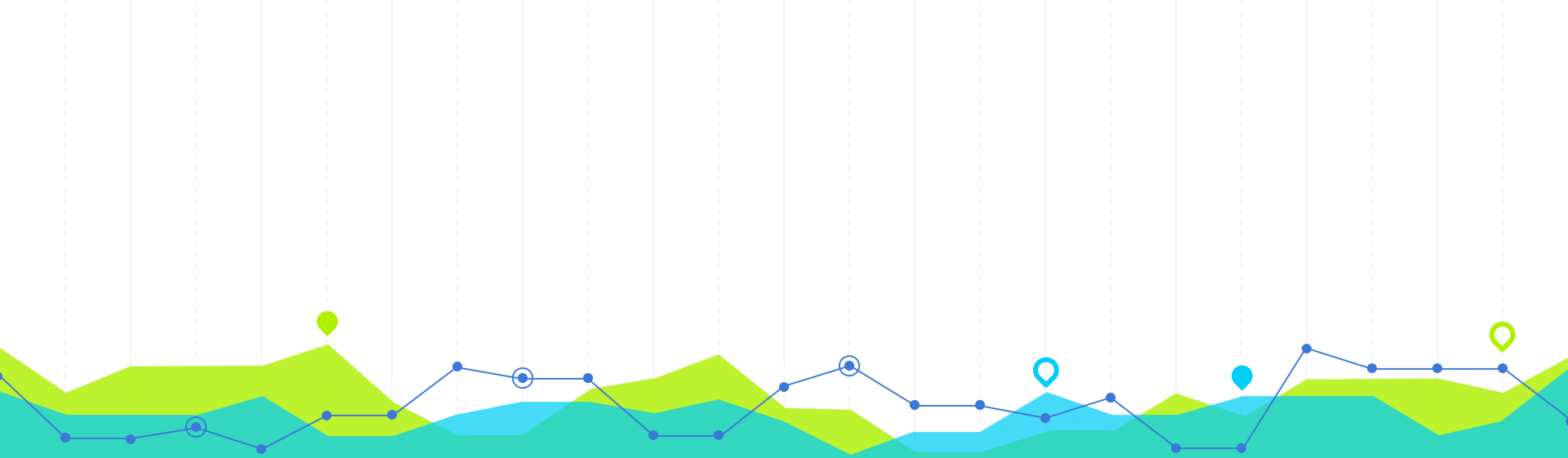
$$\text{No. of moles of ethanol} = \frac{100 \text{ g}}{46 \frac{\text{g}}{\text{mol}}} = 2.17 \text{ mol}$$

$$\begin{aligned} \text{total no. of moles in solution} &= 49.1 + 2.17 \\ &= 51.27 \text{ moles} \end{aligned}$$

$$X_{H_2O} = \frac{49.1}{51.27} = 0.958$$

$$X_{C_2H_5OH} = \frac{2.17}{51.27} = 0.042$$





Parts per million

8

Parts per million

◉ “The number of parts by weight (or vol) of a solute per million parts by weight (or volume) of the solution”

$$\text{ppm} = \frac{\text{Mass or volume of solute}}{\text{Mass or volume of solution}} \times 10^6$$



Example 10.6: An atmospheric chemist reports that one dm^3 of air in an urban area are contained $3.5 \times 10^{-4} \text{ cm}^3$ of CO. what was the concentration of CO in ppm?

$$\text{ppm} = \frac{\text{Volume of CO in cm}^3}{\text{Volume of air in cm}^3} \times 10^6$$

$$\text{ppm} = \frac{3.5 \times 10^{-4} \text{ cm}^3}{10^3 \text{ cm}^3} \times 10^6$$

$$\text{ppm} = 0.35 \text{ ppm}$$





Parts per billion

◉ “The number of parts by weight (or vol) of a solute per billion parts by weight (or volume) of the solution”

$$\text{ppb} = \frac{\text{Mass or volume of solute}}{\text{Mass or volume of solution}} \times 10^9$$



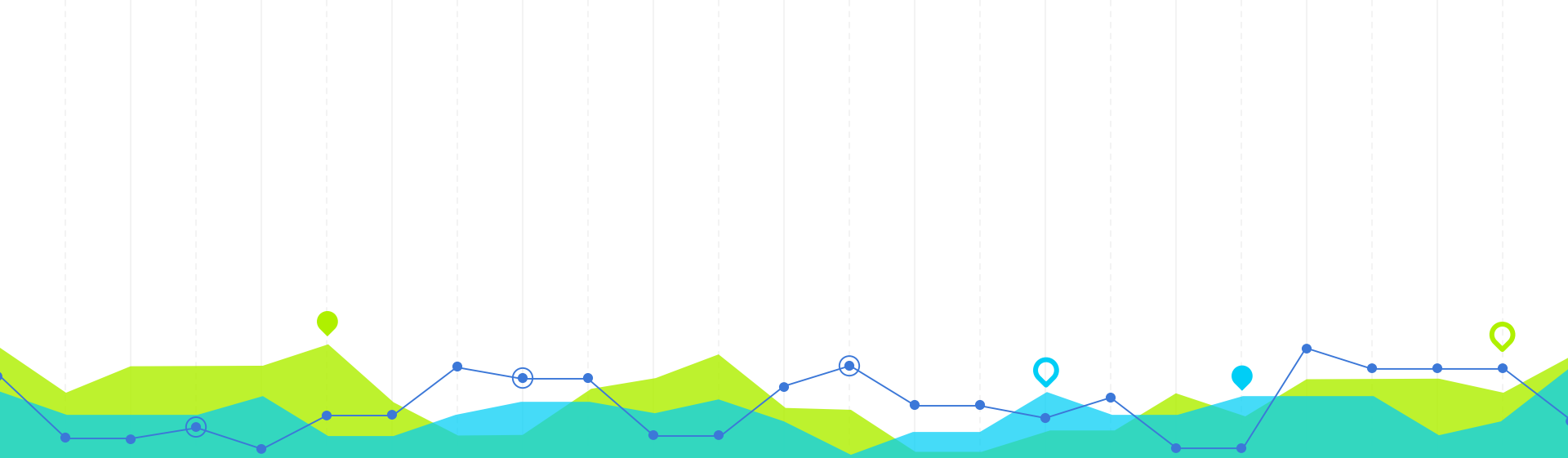
Example 10.7: If the concentration of ozone in atmosphere reaches 0.5 ppb. What mass of ozone be present per kg of air?

$$\text{ppb} = \frac{\text{Mass of ozone (g)}}{\text{Mass of air (g)}} \times 10^9$$

$$0.5 = \frac{\text{Mass of ozone (g)}}{1000(\text{g})} \times 10^9$$

$$\text{Mass of ozone} = 0.5 \times 1000 \times 10^{-9} = 5 \times 10^{-7} \text{ g}$$





Parts per billion

9

Parts per trillion

◉ “The number of parts by weight (or vol) of a solute per trillion parts by weight (or volume) of the solution”

$$\text{ppt} = \frac{\text{Mass or volume of solute}}{\text{Mass or volume of solution}} \times 10^{12}$$





Inter Conversion of Various Concentration Units of Solution

Example 10.8: Calculate the Molality of 15% w/w glucose ($C_6H_{12}O_6$) solution

$$\text{mass percent of glucose} = 15\% \frac{w}{w}$$

$$\text{mass of glucose} = 15 \text{ g}$$

$$\text{mass of solution} = 100 \text{ g}$$

$$\begin{aligned} \text{mass of water} &= 100 - 15 = 85 \text{ g} = \frac{85}{1000} \\ &= 0.085 \text{ kg} \end{aligned}$$

Example 10.8: Continued..

$$\text{molar mass of glucose}(\text{C}_6\text{H}_{12}\text{O}_6) = 180 \frac{\text{g}}{\text{mol}}$$

$$\text{molality} = \frac{\text{mass of glucose}}{\text{molar mass of glucose} \times \text{kg of water}}$$

$$\text{molality} = \frac{15 \text{ g}}{180 \frac{\text{g}}{\text{mol}} \times 0.085 \text{ kg}} = 0.98 \text{ m}$$



Example 10.9: Sulfuric acid is known as king of chemicals. It is used in the manufacture of many chemicals, drugs, dyes, paints, disinfectants, explosives, synthetic fibers etc. It is prepared commercially by contact process and is normally **98%** by weight. If its density is **1.84 gcm^{-3}** , what is its **Molarity**?



Example 10.9: Solution

$$\text{molar mass of } H_2SO_4 = 98 \frac{g}{mol}$$

$$\text{percentage of } H_2SO_4 \text{ solution} = 98\%$$

$$\text{Density of } H_2SO_4 \text{ solution} = 1.84 \text{ g cm}^{-3}$$

$$1 \text{ cm}^3 \text{ } H_2SO_4 \text{ solution} = 1.84 \text{ g}$$

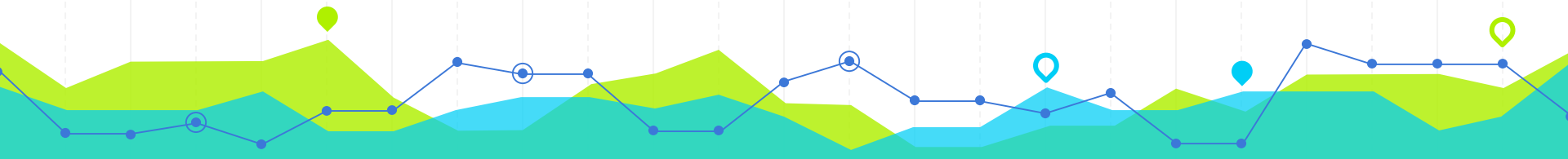
$$\begin{aligned} 1000 \text{ cm}^3 \text{ } H_2SO_4 \text{ solution} &= 1.84 \times 1000 \\ &= 1840 \text{ g } H_2SO_4 \end{aligned}$$

Example 10.9: Solution

$$\begin{aligned}\text{mass of } H_2SO_4 \text{ in solution} &= 1840 \times \frac{98}{100} \\ &= 1803.02 \text{ g}\end{aligned}$$

$$\begin{aligned}\text{moles of } H_2SO_4 \text{ in solution} &= \frac{1803.02}{98} \\ &= 18.4 \frac{\text{moles}}{1000 \text{ cm}^3}\end{aligned}$$

$$\begin{aligned}\text{molarity of } H_2SO_4 \text{ solution} &= 18.4 \frac{\text{mol}}{\text{dm}^3} \\ &= 18.4 \text{ M}\end{aligned}$$



Example 10.10: Commercial HCl is 12 molar (density = 1.17 gcm⁻³). Calculate the mass percent of HCl in this solution.

$$\text{molarity of HCl} = 12 \text{ M}$$

$$d = \frac{m}{v} \quad \therefore m = d \times v$$

thus mass of HCl solution in 1 dm³ or 1000 cm³:

$$1.17 \frac{\text{g}}{\text{cm}^3} \times 1000 \text{ cm}^3 = 1170 \text{ g}$$



Example 10.10: Solution

$$\text{molar mass of HCl} = 36.5 \frac{\text{g}}{\text{mol}}$$

mass of HCl in solution

$$\begin{aligned} &= \text{molarity} \times \text{molar mass} = 12 \times 36.5 \\ &= 438 \text{ g} \end{aligned}$$

$$\text{mass percent of HCl} = \frac{438 \times 100}{1170} = 37.44\%$$

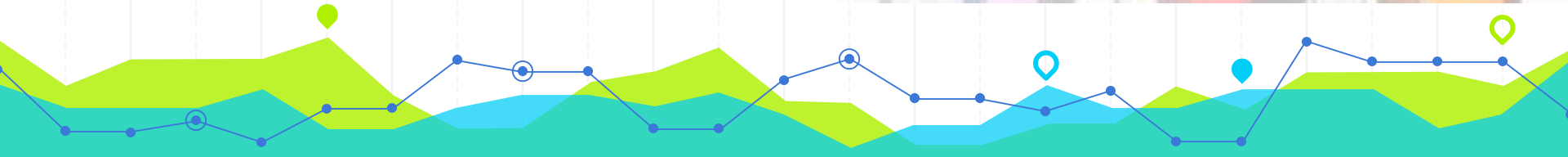




Dilution

**To dilute a solution means to add more solvent
without the addition of more solute.**

Example 10.11: Sodium hydroxide solutions are used to neutralize acids, to treat cellulose in the preparation of rayon and to remove potato peels in commercial use. 250 cm^3 of 2M NaOH is mixed with 250 cm^3 of water. Calculate the Molarity of resulting solution.



Example 10.11 : Solution

molarity of NaOH = 2M

moles of NaOH in 250 cm³

$$= \frac{2\text{mol}}{1000\text{cm}^3} \times 250\text{cm}^3 = 0.5 \text{ moles}$$

total volume of solution = 250 cm³ + 250 cm³

$$= 500 \text{ cm}^3 = \frac{500}{1000} = 0.5 \text{ dm}^3$$

Molarity of resulting solution = $\frac{0.5 \text{ moles}}{0.5 \text{ dm}^3}$

$$= 1 \text{ M}$$


THE END

Any questions?

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