بسم الله الرحمن الرحيم

Concentration, preparation of solutions

Solutions

- **Homogeneous mixtures**
- ***Solvent* = dissolving medium**
  - **often liquid; frequently water**
  - **gas in air and other gas solutions**
  - **rarely a solid**
- ***Solute(s)* = dissolved material(s)**
  - **solids, liquids, and/or gases**
  - **often more than one solute**

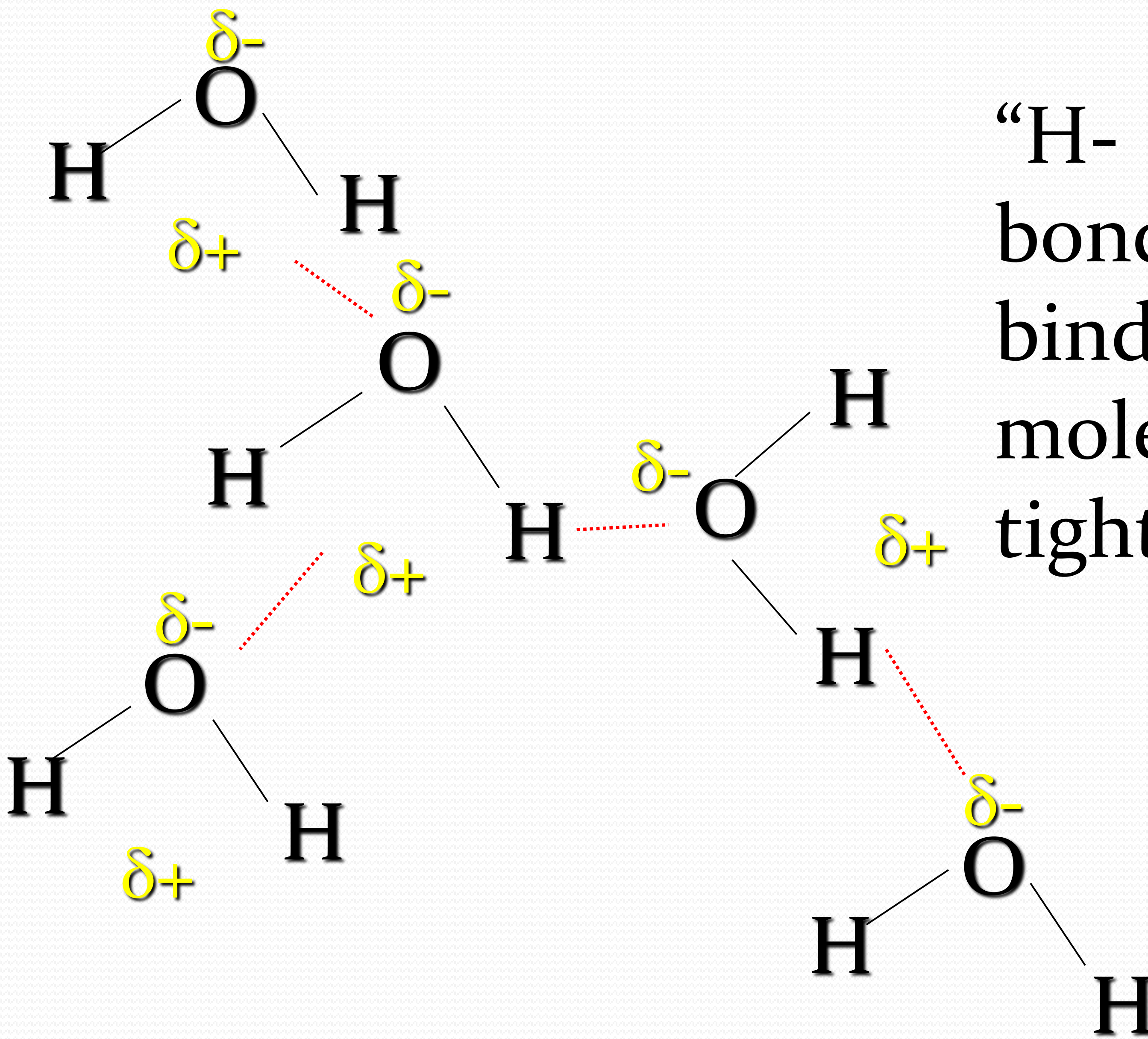
Introduction

A solution is a homogeneous mixture created by dissolving one or more solutes in a solvent. The chemical present in a smaller amount, the solute, is soluble in the solvent (the chemical present in a larger amount).

Water as Solvent

- **Form *aqueous solutions***
- **One of best solvents for dissolving ionic substances**
- **Poor solvent for non-polar covalent substances.**

Water



"H-bonding" binds water molecules tightly.

Water

- Water is one of best solvents for ionic material (electrolytes)
- Water’s polar molecular structure interacts strongly with charged io

Solution Concentrations

- ***Dilute***
  - Small amount of solute for given solvent
- ***Concentrated***
  - Large amount of solute for given solvent
- ***Saturated***
  - Maximum amount of solute for given solvent
- But these terms are qualitative, not quantitative, and are open to interpretation.

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

grams

Concentration = $\dfrac{\text{Amount of solute}}{\text{Total amount of solution}}$

mL

$\boxed{(\%,\ w/v)}$

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

mass (grams)

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

(%, *w*/*w*)

mass unit (grams)

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

mg

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

(mg %)

dL

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

moles

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

Liters

(Molarity, *M*)

Solution Concentrations

% Concentration has multiplier of 100 to place ratio on "parts per 100" basis:

$$\%,\ w/v = \frac{\text{Grams of solute}}{\text{mL of solution}} \times 100$$

‰ Concentration has multiplier of 1000 to place ratio on “parts per 1000 total” basis:

$$‰ = \frac{\text{Grams of solute}}{\text{mL of solution}} \times 1000$$

Solution Concentrations

ppm concentration has multiplier of 10^6 to place ratio on "parts per million total" basis:

$$\textbf{ppm} = \frac{\text{Grams of solute}}{\text{mL of solution}} \times 10^6$$

Practice situation:

4.75 grams of NaCl is dissolved in sufficient water to make 750 mL of solution. What is the % (*w/v*) concentration of this solution?

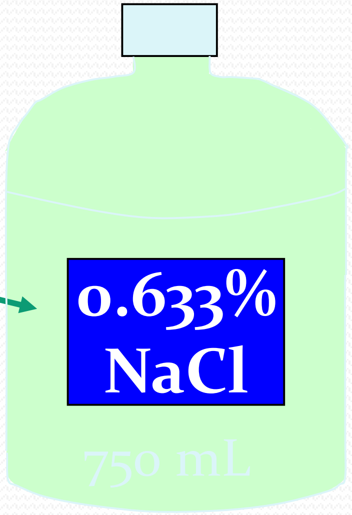
$$\%, w/v = \frac{\text{Grams of solute}}{\text{mL of solution}} \times 100$$

$$\% = \frac{4.75 \text{ g}}{750 \text{ mL}} \times 100 = 0.633\ \%$$

The g/mL units are understood but not included.

4.75 grams of NaCl is dissolved in sufficient water to make 750 mL of solution. What is the % (*w*/v) concentration of this solution?

The concentration is 0.633 % (*w/v*).



Solution Concentrations

Another:

12.5 grams of H_2SO_4 is dissolved in sufficient water to make 0.500 liters of solution. What is the % (*w*/v) concentration of this solution?

$$\%,\ w/v = \frac{\text{Grams of solute}}{\text{mL of solution}} \quad \text{X 100}$$

Solution volume units must be converted from liters to mL before doing calculations: 0.500 L = 500 mL.

$$\% = \frac{12.5\ \text{g}}{500\ \text{mL}} \quad \text{X 100} \quad = 2.50\ \%$$

The g/mL units are understood but not included.

Solution Concentrations

- Once known, the solution concentration works as a conversion factor.
  - Establishes the "relationship" between amount of solute and volume of solution.
  - For % (*w*/*v*) concentrations, conversion factors derive from this relationship:

"%-Value" grams of solute = 100 mL solution

Once known, the solution concentration work as a conversion factor.

Examples (all are *wt/vol* percents):

0.85 % NaCl
means…
0.85 g NaCl = 100 mL solution
and the conversion factors are…

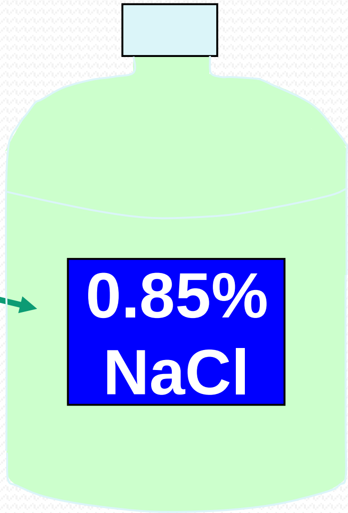
$$\frac{0.85\ \text{g NaCl}}{100\ \text{mL solution}} \quad \textit{or} \quad \frac{100\ \text{mL solution}}{0.85\ \text{g NaCl}}$$

Using the concentration as a conversion factor:

Examples (all are *wt/vol* percents):

What mass of NaCl is present in 2000 mL of 0.85% NaCl solution?

How much dissolved NaCl is in this 2000 mL of saline solution?



Using the concentration as a conversion factor:

Examples (all are *wt/vol* percents):

What mass of NaCl is present in 2000 mL of 0.85% NaCl solution?

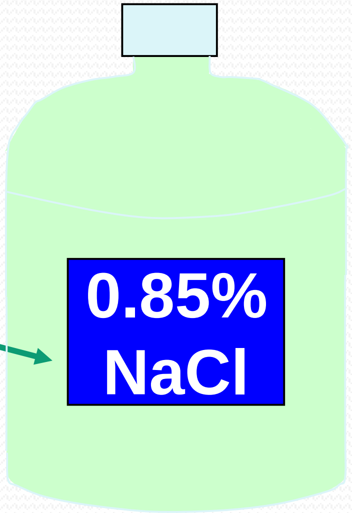
$$2000 \text{ mL } \cancel{\text{soln}} \times \frac{0.85 \text{ g NaCl}}{100 \text{ mL } \cancel{\text{solution}}} = 17.0 \text{ g NaCl}$$

Using the concentration as a conversion factor:

Examples (all are *wt/vol* percents):

What mass of NaCl is present in 2000 mL of 0.85% NaCl solution?

17.0 grams of dissolved NaCl is present in 2000 mL of this solution

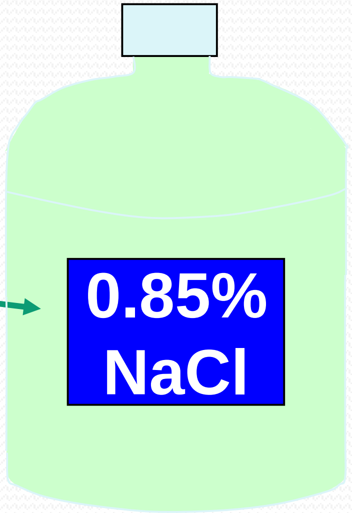


Using the concentration as a conversion factor:

Examples (all are *wt/vol* percents):

What volume of 0.85% NaCl solution should contain 2.50 grams of dissolved NaCl?

What volume will contain 2.50 grams of dissolved NaCl?



Using the concentration as a conversion factor:

Examples (all are *wt/vol* percents):

What volume of 0.85% NaCl solution should contain 2.50 grams of dissolved NaCl?

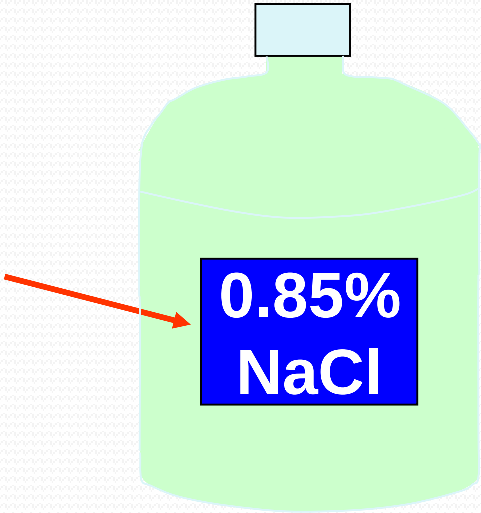
$$2.50\ \text{g}\ \cancel{\text{NaCl}} \times \frac{100\ \text{mL solution}}{0.85\ \text{g}\ \cancel{\text{NaCl}}} = \textbf{294 mL soln}$$

Using the concentration as a conversion factor:

Examples (all are *wt/vol* percents):

What volume of 0.85% NaCl solution should contain 2.50 grams of dissolved NaCl?

294 mL of this solution contains 2.50 grams of dissolved NaCl.



Ways of Expressing Concentration

Mass Percentage

- All methods involve quantifying amount of solute per amount of solvent (or solution).
- Generally amounts or measures are masses, moles or liters.

$$\textbf{mass \% of component} = \frac{\textbf{mass of component in solution}}{\textbf{total mass of solution}} \times 100$$

Ways of Expressing Concentration

- **Mole Fraction, Molarity, and Molality**

$$\text{Mole fraction of component} = \frac{\text{moles of component in solution}}{\text{total moles of solution}}$$

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

$$\text{Molality}, m = \frac{\text{moles solute}}{\text{kg of solvent}}$$

Solution Compositions

- **s = solute ; A = solvent; V = Tot. Vol. of solution.**
- **Weight %:**

$$w_s\% = \frac{w_s}{w_s + w_A} x100$$

- **Mole Fraction:**

$$\chi_s = \frac{n_s}{n_s + n_A}$$

- **Molarity:**

$$M_s = \frac{n_s}{V}$$

- **Molality:**

$$m_s = \frac{n_s}{kg\ A}$$

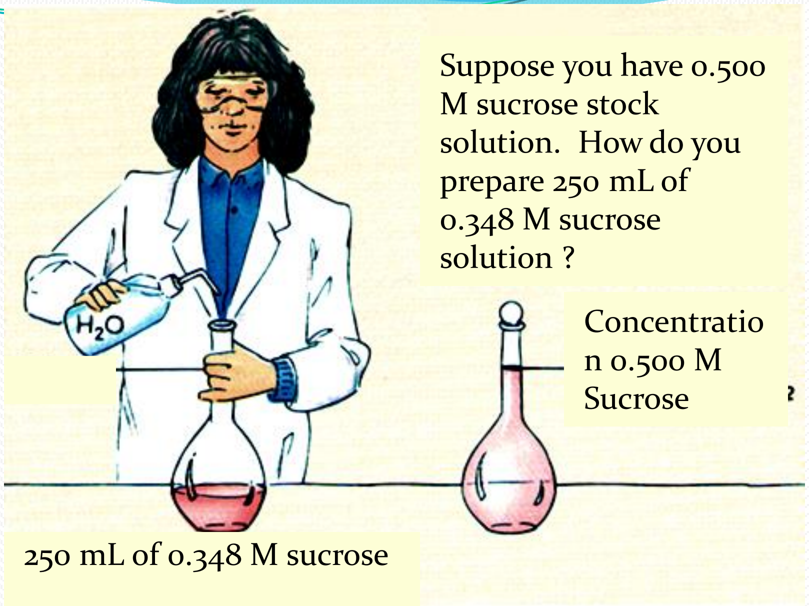
Dilution

When a solution is diluted, solvent is added to lower its concentration.

The amount of solute remains constant before and after the dilution:

moles BEFORE = moles AFTER

$$C_1V_1 = C_2V_2$$



A bottle of 0.500 M standard sucrose stock solution is in the lab.

Give precise instructions to your assistant on how to use the stock solution to prepare 250.0 mL of a 0.348 M sucrose solution.

Thank you