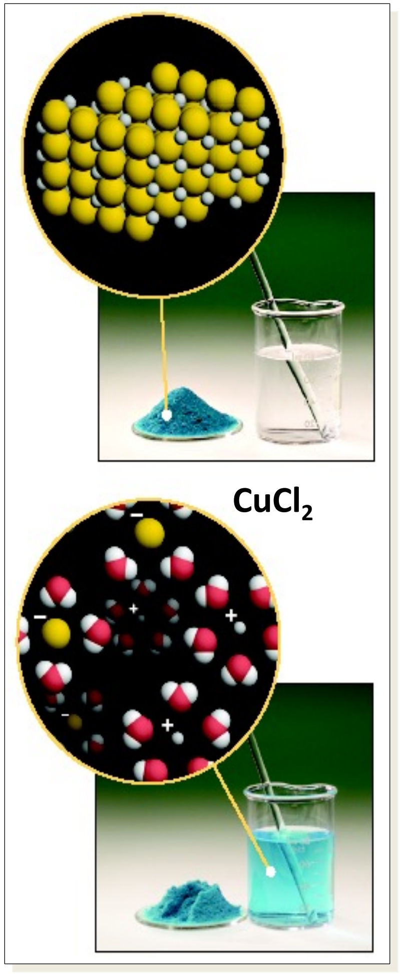
Medical Chemistry

Solutions & Colloids

Definitions

- A **SOLUTION** (soln)**:** is a mixture of 2 or more substances in a single phase.
- One constituent is usually regarded as the **SOLVENT** and the others as **SOLUTES**.
- **SOLUTE:** the part of a solution that is being dissolved (usually the lesser amount).
- **SOLVENT:** the part of a solution that dissolves the solute (usually the greater amount).
- Solutions in which the solvent is **WATER** are called **AQUEOUS SOLUTIONS**.



Types of Solutions

Solute	Solvent	Appearance of solution	Example
Solid	Solid	Solid	14-carat gold (Cu/Ag/Au) Brass alloy (Zn/Cu)
Solid	Liquid	Liquid	Salt water
Liquid	Liquid	Liquid	Alcohol in water
Gas	Liquid	Liquid	Soda (CO_2 in water)
Gas	Gas	Gas	Air (N_2, O_2, …)

CAN A SOLUTION BE SOLID?

Characteristics of Solutions

1. Distribution of particles is uniform.
2. Components do not separate on standing.
3. Components cannot be separated by filtration.
4. It is possible to make solutions of many different solute/solvent compositions.
5. Solutions are transparent (even if colored).
6. Solutions can be separated into pure components (e.g., distillation, chromatography). This separation is a physical change.

Concentration Units 1

- **Concentration:** **is the amount of solute in a given amount of solution (rarely "in amount of solvent").**

UNITS:

1. Percent Composition:

a. % mass (w/w) = (mass of solute/mass of soln) x 100

b. % volume (v/v) = (volume of solute/volume of soln) x 100

c. % mass/volume (w/v) = (mass of solute/volume of soln) x 100

2. Molarity (M) = moles of solute/liter of soln (v)

Concentration Units 2

3. **Molality (m)** = moles of solute/kg of **SOLVENT**
4. **Parts per million (ppm)** = (mass of solute/mass of soln) x 10^6
5. **mole fraction (*x*)** = moles of solute/total moles of soln
6. **Mass per volume (mg/L)** = mass of solute/liter of soln
7. **Normality (N)** = equivalents of solute/liter of soln

Concentration Units 3

- **M = m** when the solvent is distilled H_2O since its density = 1 then, 1 L = 1 kg (NOT salt H_2O).
- ppm = 10^3 ppb (part per billion) = 10^6 ppt (part per trillion)
- Mass (moles) of soln = mass (moles) of solute + mass (moles) of solvent
- Common mass ratios for solutions and solids are:

Units	Solutions		Solids	
ppm	**mg/L**	**µg/mL**	**mg/kg**	**µg/g**
ppb	**µg/L**	**ng/mL**	**µg/kg**	**ng/g**
ppt	**ng/L**	**pg/mL**	**ng/kg**	**pg/g**

Example 1: An IV soln is prepared by dissolving 5.0 g glucose ($C_6H_{12}O_6$) in dist. H_2O to make 100 mL soln. Calculate (a) molarity M, (b) % w/v, and (c) ppm of the IV soln.

Solution:

(a) Convert: g → moles of glucose.

Since, molar mass of $C_6H_{12}O_6$ = 180.0 g/mol.

Then, 5.0 g x (1 mol/180.0 g) = 2.78 x 10^{-2} mol.

Thus, M = moles of solute/L of soln

= 2.78 x 10^{-2} mol/1.00 X 10^{-2} L = 2.78 M

(b) % w/v = (mass of solute/volume of soln) x 100 %

= (5.0 g glucose/ 100 mL soln) x 100 %

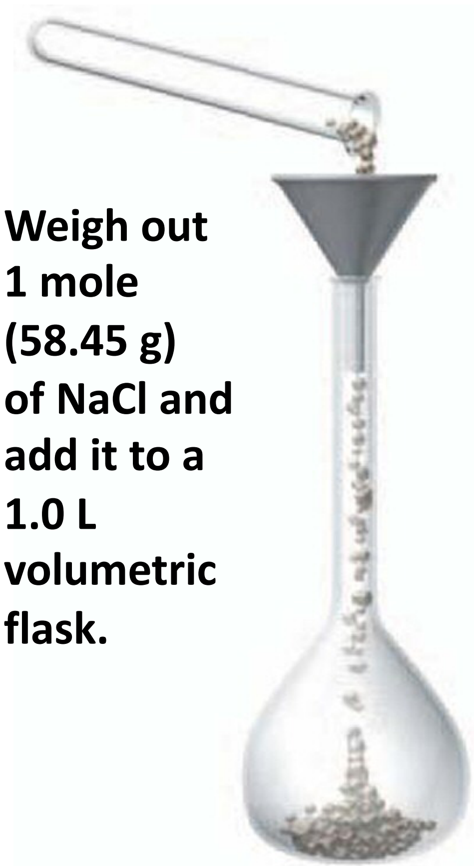
= 5.0 %

(c) ppm = (mass of solute/mass of soln) x 10^6 = (5.0 g/100 g) x 10^6

= 5.0 x 10^4 [since d(H_2O) = 1, 100 mL = 100 g]

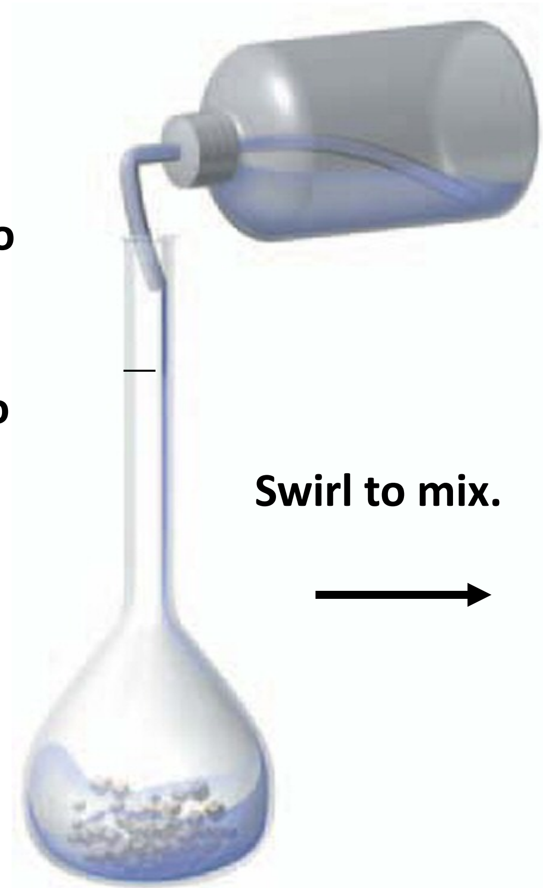
Preparing Solutions (1.0 M NaCl)

Weigh out 1 mole (58.45 g) of NaCl and add it to a 1.0 L volumetric flask.



STEP 1

Add water to dissolve the NaCl, then add water to the mark.



STEP 2

Swirl to mix.

STEP 3

Dilution

- **Dilution:** is adding extra solvent to decrease the concentration of a soln.
- The amount of solute remains constant before and after dilution, but the concentration decreases.

Before dilution After dilution

$$Conc_1 \times Vol_1 = Conc_2 \times Vol_2$$

$$M_1 \times V_1 = M_2 \times V_2$$

$$\%_1 \times V_1 = \%_2 \times V_2$$

- Concentrations and volumes can be most units as long as they are consistent.

Example: **How do we prepare 200 mL of a 3.5 M soln of acetic acid if we have a bottle of conc acetic acid (6.0 M) ?**

Given:

	Initial soln	***Final soln***
Concentration:	6.0 M	3.5 M
Volume:	? L	0.20 L

Find: **L of initial acetic acid**

Solve: $M_1 \times V_1 = M_2 \times V_2$

$$6.0\ M \times V_1 = 3.5\ M \times 0.20\ L$$

$$V_1 = 3.5\ M \times 0.20\ L / 6.0\ M = 0.12\ L$$

- **Put 0.12 L (120 mL) of conc acetic acid in a 200-mL volumetric flask, add some water and mix, and then fill to the mark with water.**

How H_2O Dissolves Ionic Compounds

- Consider NaCl (solute) dissolving in water (solvent).
- The water H-bonds have to be interrupted,
- NaCl dissociates into Na^+ and Cl^-,
- Cat/Anions attract oppositely charged ends of H_2O molecules ($Na^+....^{\delta-}OH_2$ and $Cl^-....^{\delta+}H_2O$).
- When attraction forces of ions to H_2O molecules is greater than ionic bond (keeping ion in crystal), the ion will be completely removed from the crystal and surrounded by H_2O molecules (**HYDRATED** ions).
- Such interaction between solute and solvent is generally called **SOLVATION**.

How H_2O Dissolves Covalent Compounds

- **Molecules should have no more than 3 C atoms for each O, N, or F atom.**
- **Examples: Acetic Acid CH_3COOH is soluble but benzoic acid C_6H_5COOH is not.**
- **Although table sugar, $C_{12}H_{22}O_{11}$, contains a large number of C atoms, it is very soluble in H_2O because it has many O atoms and O-H bonds that can form many H-bonds with H_2O.**

2. Compounds rarely react with H_2O giving ions

E.g. 1 $HCl(g) + H_2O(l) \rightarrow Cl^-(aq) + H_3O^+(aq)$

E.g. 2 $SO_3(g) + 2H_2O(l) \rightarrow HSO_4^-(aq) + H_3O^+(aq)$