Chapter 15 – Solutions

15.1 Definitions related to Solutions

- **Solution** - uniform mixture of two or more substances. A solution is composed of a solute(s) dissolved in a solvent.
- **Solute** – the substance present in lesser amount in a solution.
- **Solvent** – the substance present in greatest amount in a solution. Water is the most common solvent.
- **Soluble** – when a solid dissolves in a solvent. An example is salt is soluble in water.
- **Insoluble** – when a solid does not dissolve in a solvent. An example is gold metal in water. Gold is insoluble in water.
- **Miscible** – when two liquids mix together. An example is tonic and vodka.
- **Immiscible** – when two liquids do not mix but rather form layers. An example is oil and vinegar.
- **Dilute** – when there is not a lot of solute in the solvent we say the solution is dilute.
- **Concentrated** – when there is a lot of solute in the solvent we say the solution is concentrated. An example would be very strong coffee.
- **Concentration** – a measurement that gives a number and unit as to how concentrated or dilute a solution is. Concentration can be measured in mass mass percent (nursing) or molarity (chemistry).

The physical states of the solute and solvent can be solid, liquid or gas: CO_2 gas dissolved in liquid soda (gas in liquid), gin and tonic (2 liquids), Brass is Cu and Zn (2 solids), salt water is NaCl dissolved in water (solid in liquid), air is N_2 and O_2 gases primarily with hundreds of trace gases (gas in gas).

15.2 Like Dissolves Like

The "Like dissolves like" rule says that

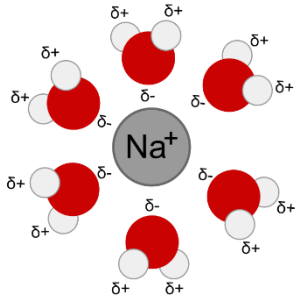
- Polar solutes dissolve in polar solvents
- Nonpolar solutes dissolve in nonpolar solvents
- Nonpolar and polar substances don't mix or dissolve in one another.

Ionic solids often dissolve in polar solvents – check solubility rules on your periodic table to see if the solid dissolves in water. But ionic solids do not dissolve in nonpolar solvents because ions have charges while nonpolar solvents have no charges at all. So they are not alike and therefore do not mix.

	polar solvent	nonpolar solvent
polar liquid	miscible	immiscible
nonpolar liquid	immiscible	miscible
polar solid	soluble	insoluble
nonpolar solid	insoluble	soluble
ionic solid	Check Solubility Rules!	insoluble

15.3 The Dissolving Process

As an ionic solid solute is dropped into a liquid solvent such as water, the solvent molecules begin to attack and pull apart the solute ions. The water molecules align themselves so that opposite charges attract. In the picture to the right we see how the water aligns with the δ- oxygens pointing in towards the Na+1 ion because opposite charges attract.



YouTube videos that shows how a salt dissolves in water and a second one.

15.4 Mass Mass Percent

The concentration of a solution may be expressed quantitatively as a mass/mass %:

$$\text{Mass Percent} = \frac{\text{g solute}}{\text{g solution}} \times 100\% = \frac{\text{g solute}}{\text{g solute} + \text{g solvent}} \times 100\%$$

⇒ Note that the mass of solution = mass of solute plus mass of solvent

YouTube videos on Mass Mass Percent 1 and Mass Mass Percent 2

15.5 Molarity

The concentration of a solution can also be expressed quantitatively as molarity:

$$\text{Molarity} = M = \frac{\text{moles solute}}{\text{Liters of solution}} \qquad \text{Units}: M = \frac{\text{mol}}{\text{Liter}}$$

Quite often the problem with give you grams of solute so you have to convert grams to moles using the molar mass.

YouTube video on Molarity

Practice Problems

Ex. 1: Indicate whether the following are **soluble / insoluble** in or **miscible / immiscible** with water:

vegetable oil:	AgI(s):
NaCl(s):	HBr (l):
C_5H_{12}(l):	grease(s):
Br_2 (l):	$Mg(OH)_2$(s):

Ex. 2 Circle all of the following that would be soluble in or miscible with vegetable oil:

I_2 (s) KCl(s) P_4 (s) grease(s) HBr(l) $MgBr_2$(s)

1) A solution is prepared by dissolving 12.3 g of Na_2SO_4 in 71.6 g of water.

   a) The solute is _____, and the solvent is _____.

   b) What is the mass percent for this solution?

2) If a normal IV glucose solution is 5.00 % glucose, what is the mass of solution that contains 15.0 g of glucose?

3) What mass of solute is required to prepare 150.0 g of a 2.50% KCl solution?

4) What mass of water is required to dissolve 5.00 g of NaOH to prepare a 10.0% NaOH solution?

5) Find the molarity of a solution prepared by dissolving 0.250 moles of NaOH in 100.0 mL of solution:

6) Find the molarity of a solution prepared by dissolving 30.6 g of NaOH in 350 mL of solution.

Answers

Ex. 1:

vegetable oil: **immiscible**	AgI: **insoluble**
NaCl: **soluble**	HBr (l): **miscible**
C_5H_{12} (l): **immiscible**	grease (s): **insoluble**
Br_2 (l): **immiscible**	$Mg(OH)_2$: **insoluble**

Ex. 2 I_2 (s) KCl(s) P_4 (s) grease (s) HBr(l) $MgBr_2$(s)

1) The solute is **Na_2SO_4** , and the solvent is **H_2O** .

$$\text{mass \%} = \frac{12.3\,g}{12.3g + 71.6\,g} \times 100\% = \frac{12.3\,g}{83.9\,g} \times 100\% = \mathbf{14.7\ \%}$$

2) $5.00 = (15.0 / x) * 100$

$5.00x = 15.0 * 100$

$x =$ **3.00×10^2 g solution**

3) $2.50 = (x / 150.0) * 100$

$2.50 * 150.0 = x * 100$

$x =$ **3.75 g KCl**

4) $10.0 = (5.00 / x) * 100$

$10.0x = 5.00 * 100$

x = grams solution total = 50.0 g = g solute + g solvent

Now 50.0 g solution – 5.00g solute = **45.0 g solvent water**

5) Find the molarity of a solution prepared by dissolving 0.250 moles of NaOH in 100.0 mL of solution:

$$100.0mL\left(\frac{1\text{L}}{1000\text{ mL}}\right) = 0.1000\text{ L}$$

$$\text{M} = \frac{\text{mol solute}}{\text{L solution}} = \frac{0.250\,\text{mol NaOH}}{0.1000\,\text{L}} = \mathbf{2.50\ M\ NaOH}$$

6) Find the molarity of a solution prepared by dissolving 30.6 g of NaOH in 350 mL of solution.

$$30.6g\left(\frac{1\text{mol NaOH}}{40.0\,\text{g NaOH}}\right) = 0.765\text{ mol NaOH}$$

$$350\text{ mL}\left(\frac{1L}{1000\,mL}\right) = 0.350\text{ L}$$

$$\text{M} = \frac{\text{mol solute}}{\text{L solution}} = \frac{0.765\text{ mol NaOH}}{0.350\text{ L}} = \mathbf{2.19\ M\ NaOH}$$