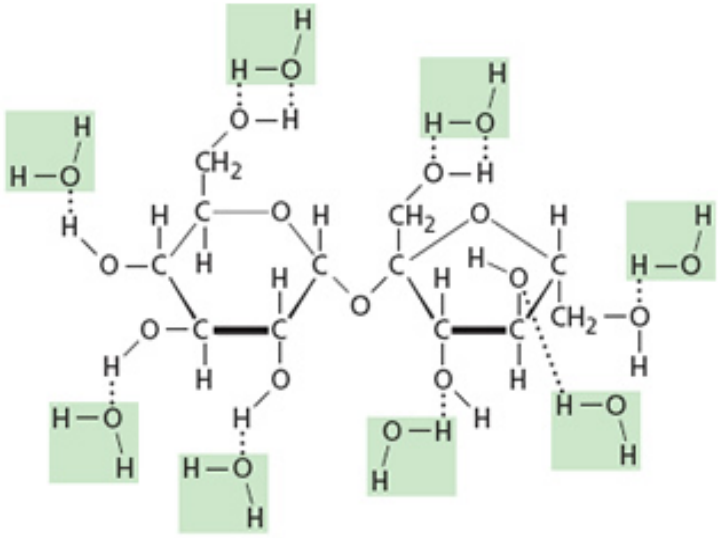
Unit 4 - Solutions and Solubility

4.1 - Characteristics of Solutions

pg 439-445 in Heath
pg 452-458 in Matter and Change

sugar cube dissolving in water



Basic Definitions:

Heat of Solution - the overall heat energy change that occurs during the solution process formation

Solvation - the interaction between solute and solvent particles

A **solution** is two or more substances combined to form a homogeneous mixture (made up of solvent and solute). Solutions can be gaseous, liquid or solid (or a combination of two or more states).

Recall that a **homogeneous mixture** is uniform and the individual parts of the mixture are indistinguishable.

ex)

These are opposed to **heterogeneous mixtures** where you can see the separate components of the mixture.

ex)

In any given solution, there are always the following two parts:

i. **Solvent** - this is the most abundant substance.

ii. **Solute** - this is the least abundant substance(s).

These roles in a solution can be reversed if the composition of the solution changes.

For example, in a 5% alcohol solution, water is the solvent and alcohol is the solute. However, if more alcohol is added to make a 70% alcohol solution then the alcohol will be the solvent and the water will be the solute.

Examples of Mixtures:

Liquid -

Gas -

Solid -

Solid and liquid -

Gas and liquid -

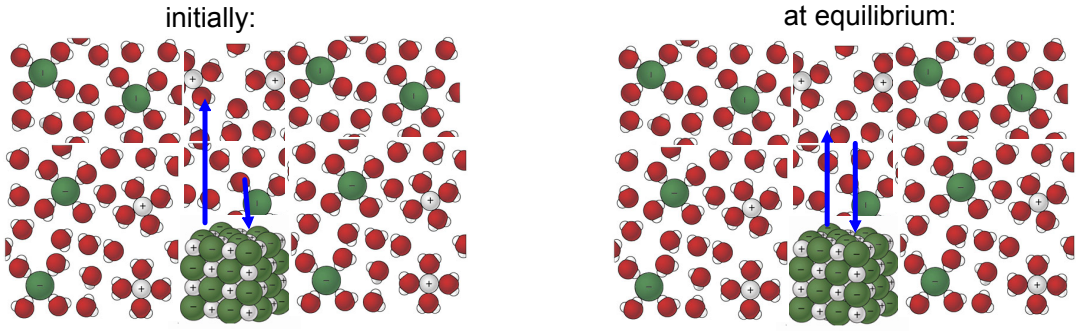
An **aqueous solution** is a solution in which the solvent is water. We will deal with aqueous solutions frequently.

When a solute (like NaCl) is introduced to a solvent (like water) the solute will begin to dissolve. If you are able to keep adding a solute to a solution, the solution is called **unsaturated**.

Eventually, if you keep adding a solute, it will not be able to dissolve into the solution anymore. At this point, we call the solution **saturated**.

When a solution becomes saturated, it reaches **equilibrium**. A solution that is at equilibrium means the rate at which a solute enters the solution is equal to the rate at which it drops out of the solution.

For example, a saturated solution of salt and water appears as if undissolved salt sits at the bottom of the solution.



However, at the molecular level, dissolved salt is constantly leaving the water and being replaced by undissolved salt. **When a system is in equilibrium, the rate at which dissolved solute is replaced by undissolved solute is the same.**

Equilibrium equations look like:

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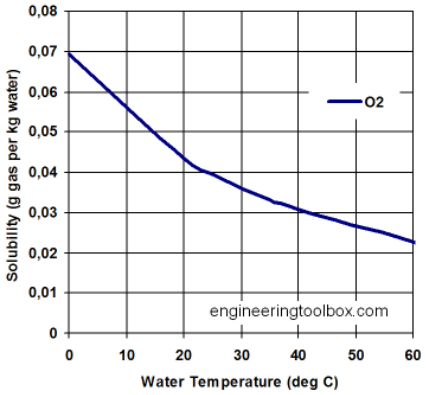
Solubility refers to the amount of substance needed to make a **saturated** solution at a specific temperature.

At a specific temperature, the amount of solid solute capable of dissolving in a given volume of solvent is fixed. That is, at a given temperature, if too much solute is added it will generally accumulate at the bottom of the solution.

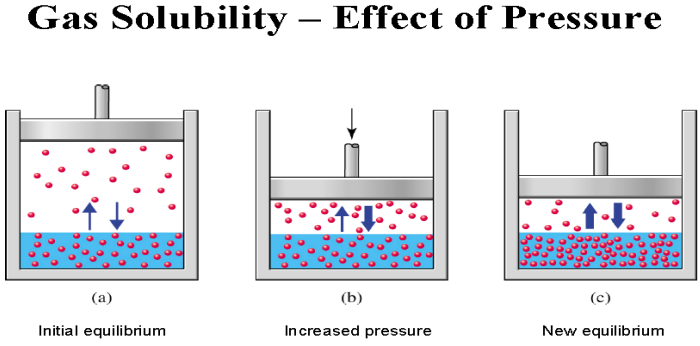
In general, an increase in Temperature will increase the solubility of solids in liquids, but decrease the solubility of gasses in liquids.

- For example, the amount of oxygen in a river is dependant on the temperature of the water.



However, increase in pressure will increase the solubility of gasses.

- For example, if pop is pressurized there will be a lot of gas in the pop (it will taste fizzy). Once it is open, the solubility of gas is decreased so gas escapes (it gets flat).



Substances that have similar bonds **between molecules** (not within molecules) tend to make good solutions.

This is often stated as **like dissolves like**. That is if two substances have intermolecular bonds that are alike, they will make a solution.

For example, if two substances have polar bonds, they will mix well together.

When mixing some substances together, sometimes there is no apparent limit to the solubility of solute in the solvent.

For example, no matter the proportion of ethanol in water, you will always have a solution. This is because both the water molecules and ethanol molecules are polar, so they arrange themselves so that the positive side of water is attracted to the negative side of ethanol.

Components of a solution that act as water and ethanol do together are called **miscible**.

However, when two substance are mixed together and form distinct layers that is they do not dissolve in each other, are called **immiscible**.

- This is due to one component being polar and the other being non-polar
  - > For example, water and vegetable oil are immiscible.

Thus, non-polar substances dissolve best in non-polar substances and visa versa. Or, **like dissolves like.**

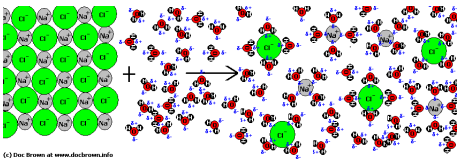
Forming Solutions

Solvation of Ionic Solids (Dissociation)

– When ionic solids are added to water, the charged ions are surrounded by water (hydration), and eventually the ions are separated and the crystal structure is decomposed (dissociation)

– These solutions conduct electricity; therefore, they are known as <u>electrolytes</u>.

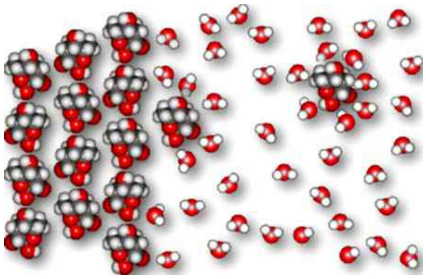
$$NaCl_{(s)} \xrightarrow{H_2O} Na^+_{(aq)} + Cl^-_{(aq)}$$



Solvation of Molecular Solids

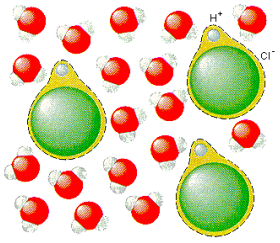
i) _____

- the "rule of thumb" is "like dissolves like".
- Molecular substances enter solution, molecular form remains.
- Polar substances will not mix with non-polar substances as the particles in each substance are not attracted to one another.
- Polar substances will dissolve in each other, and the same occurs with non-polar substances.



ii) _____

- Molecular substances enter solution, ions form that were not previously present
- Most often occurs with acids (ie. HCl)
- Molecular substances that are not acids do not ionize or dissociate; therefore, do not form ion solutions



2.1 - Characteristics of Solutions Assignment

READING: How Solutions are Formed: *Read Handout and create concept map based on the information in the notes and in the handout. Key words that need to be included: solution, dissolving, dissociation, ionization, solute-solvent, solute-solute, solvent-solvent, endothermic, exothermic, electrolytes, non-electrolytes, molecular substance, ionic substance.*

4.1 - Characteristics of Solutions

Determine whether each of the following substances will undergo dissociation, ionization or dissolving. Then write solvation equations for each of the substances when mixed with water. Show **physical states** of the products and balance the equations.

1. sodium chloride - Ionic; therefore will undergo dissociation in water

$NaCl_{(s)} \xrightarrow{H_2O} Na^+_{(aq)} + Cl^-_{(aq)}$

2. carbon tetrachloride

3. sodium hydroxide

4. ammonium acetate

5. potassium hydroxide

6. sulfuric acid

7. potassium dichromate

8. nitric acid

9. copper (II) sulfate pentahydrate

10. potassium permanganate

11. sodium bicarbonate

12. sulfur dioxide

13. hydrochloric acid