Kinds of solutions.

All the three states of matter (gas, liquid or solid) may behave either as solvent or solute. Depending on the state of solute or solvent, mainly there may be following nine types of binary solutions.

Solvent	Solute	Example
Gas	Gas	Mixture of gases, air.
Gas	Liquid	Water vapors in air, mist.
Gas	Solid	Sublimation of a solid into a gas, smoke.
Liquid	Gas	CO_2 gas dissolved in water (aerated drinks).
Liquid	Liquid	Mixture of miscible liquids, e.g., alcohol in water.
Liquid	Solid	Salt in water, sugar in water.
Solid	Gas	Adsorption of gases over metals; hydrogen over palladium.
Solid	Liquid	Mercury in zinc, mercury in gold, $CuSO_4.5H_2O$.
Solid	Solid	Homogeneous mixture of two or more metals (alloys), e.g., copper in gold, zinc in copper.

Among these solutions the most significant type of solutions are those which are in liquid phase and may be categorizedas: (i) Solid in liquid solutions, (ii) Liquid in liquid solutions and (iii) Gas in liquid solutions.

(i) **Solid in liquid solutions**: For the solid in liquid solutions the solid is referred to as solute. The amount of solute that is dissolved in $100\,g$ of a solvent, to form a saturated solution at a particular temperature is called **solubility**. The solubility of a solid solute in liquid depends upon

(a) Nature of solute and solvent

(b) Temperature: Usually the solubility of the solute increases with increase in temperature

(e.g., KI, KNO_3, NH_4Br) but in some cases increase in solubility is negligible (e.g. $NaCl$) and in cases of some salts (e.g., $NaOH$, Na_2SO_4, $CeSO_4$) solubility decreases with increase in temperature.

Cause of miscibility of solids in liquids **:** The basic cause of solubility of solid solute in liquid solvent can be summed up in one line, i.e., "Similia similibus solvanter" meaning **like dissolves like** which implies that polar solvents dissolve polar solutes and non-polar solvents dissolve non-polar solutes.

For ionic solutes, the solubility, in general, is related to the magnitude of **hydration(or salvation) energy** and **lattice energy**. In general if the magnitude of hydration energy is greater than lattice energy, the solute is soluble otherwise it is insoluble.

(ii) **Liquid in liquid solutions:**When two liquids are mixed, the mixture may be of the following types:

(a) The two components may be almost immiscible: In this case, one of the liquids is polar while the other is of non-polar nature. For example, benzene and water.

(b) The miscibility of the component may be partial: If the intermolecular attraction of one liquid is different from intramolecular attraction of the other, there may be a partial miscibility of the two liquids. For example, ether and water.

(c) The two components may be completely miscible: In this case, the two liquids are of the same nature, i.e., they are either polar (like alcohol and water) or non-polar (like benzene and hexane).

Cause of Miscibility of Liquids

(a) Chemically alike liquids dissolve in one another more freely as compared to others, for example, alkanes are miscible in all proportions with one another. Alkanes are however, not miscible with water because they cannot form H-bonds with water molecules.

(b) Dipole-Dipole interactions also play an important role in forming liquid solutions.

(c) Molecular sizes of liquids which are mutually soluble, are also approximately same.

(iii) **Gas in Liquid solutions**:Most of the gases are soluble in water to some extent. The solubility of gas in water generally depends upon the following factors

(a) Nature of the gas: In general the gases which are easily liquefiable are more soluble in water.
(b) Temperature: The dissolution of gas in water is exothermic process. Hence, the solubility of gas decreases with rise in temperature.
(c) Pressure: Effect of pressure on the solubility of gas is explained by "**Henry's law**". According to Henry's law "mass of gas dissolved in a given volume of solvent, at a constant temperature, is proportional to the pressure of the gas with which it is in equilibrium."
Solubility $\propto$ Pressure; $S = KP$ where K is Henry's constant.
Higher the value of K at given pressure, the lower is the solubility of the gas in the liquid. Value of K increases with increase in temperature while solubility of gas decreases. It is due to this reason that aquatic species are more comfortable in cold water rather than hot water.

Applications of Henry's law**:** Henry's law finds several applications in industry and explains some biological phenomena. Notable among these are:
(i) To increase the solubility of CO_2 in soft drinks and soda water, the bottle is sealed under high pressure.
(ii) To minimize the painful effects accompanying the decompression of deep sea divers, oxygen diluted with less soluble helium gas is used as breathing gas.
(iii) In lungs, where oxygen is present in air with high partial pressure of oxygen to form oxohaemoglobin. In tissues where partial pressure of oxygen is low. Oxohaemoglobin releases oxygen for utilization in cellular activities.