Solutions

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(Chemistry Notes)

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The Solution Process

A solution is a homogenous mixture of solute and solvent.

Solutions may be gases, liquids, or solids.

The solvent is the component present in the largest amount. The other components are the solutes.

The interaction between solvent and solute is called **solvation.**

If water is the solvent, the interaction is called **hydration.**

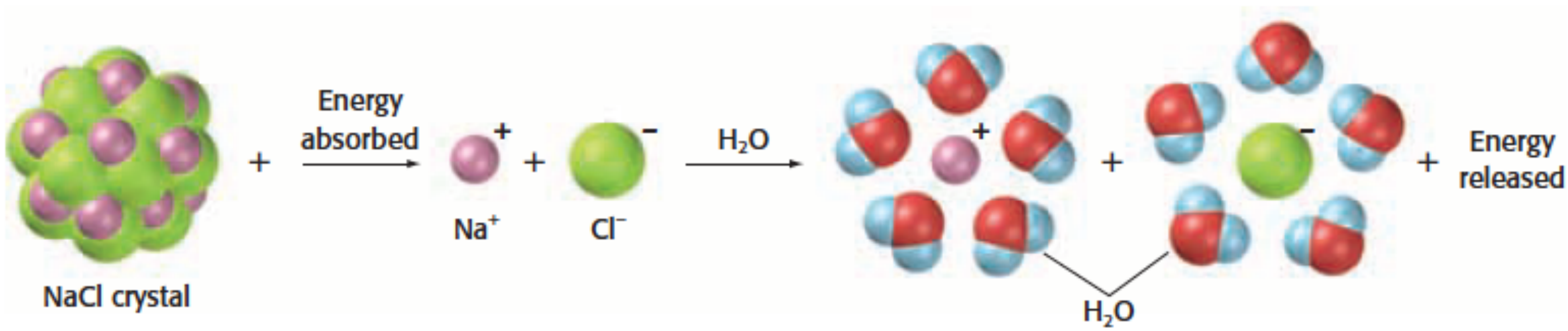
Solutions in which water is the solvent are called aqueous solutions. The word aqueous (aq) comes from aqua, meaning dissolved (water or surrounded by water molecules).

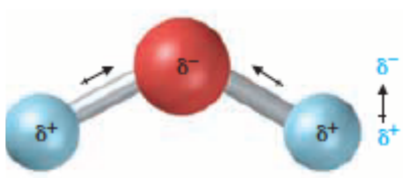
Consider NaCl (solute) dissolving in water (solvent):

- Ion-dipole forces form between the Na^+ and the negative end of the water dipole.
- Similar ion-dipole interactions form between the Cl^- and the positive end of the water dipole.

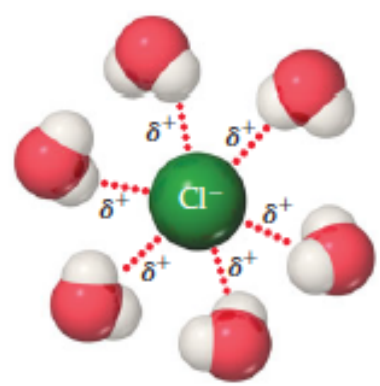
$$NaCl\,(s) + H_2O\,(l) \longrightarrow Na^+\,(aq) + Cl^-\,(aq)$$

$$NaCl\ (s) + H_2O\ (l) \longrightarrow Na^{+}\ (aq) + Cl^{-}\ (aq)$$

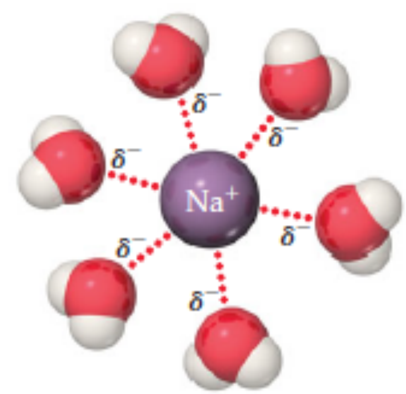




Water, H_2O
(overall molecular dipole)



Positive ends of polar molecules are oriented toward negatively charged anion



Negative ends of polar molecules are oriented toward positively charged cation

“Like Dissolves Like”

Non-polar substances are more likely to be soluble in non-polar solvents.

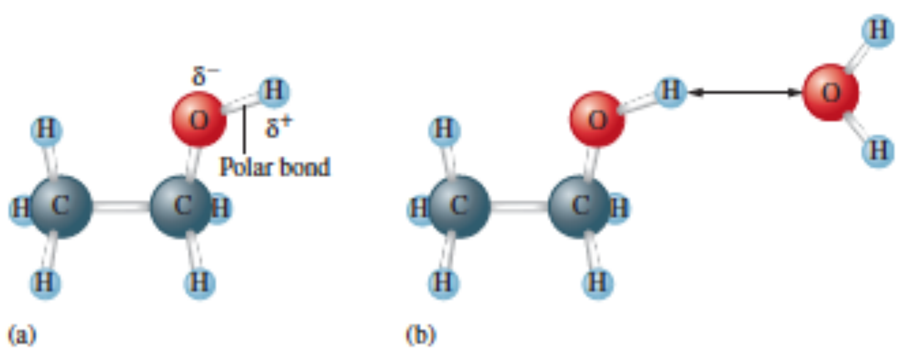
Ionic and polar substances are more likely to be soluble in polar solvents.

The greater the number of –OH groups along the chain within a solute molecule, the more solute-water H-bonding is possible, the greater its solubility in water.

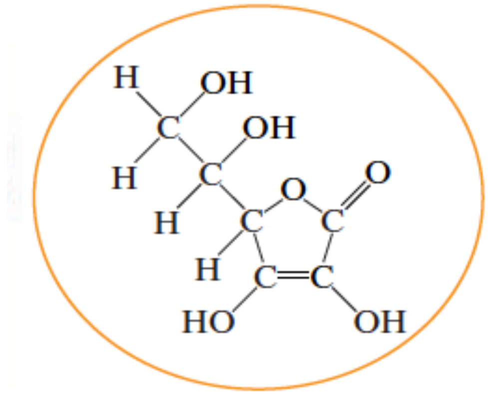
Example: Ethanol (C_2H_5OH) is very soluble in water.

The molecule contains a polar O-H bond like those in water (a).

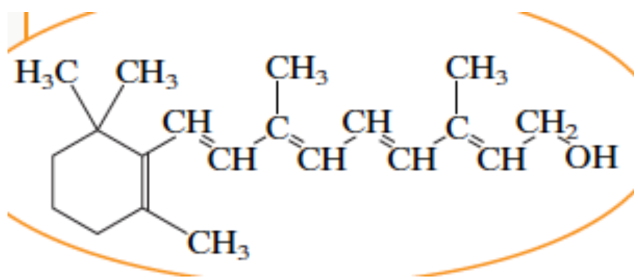
The interaction of water with ethanol is a hydrogen bond as represented in (b)



Vitamin C is soluble in water. It has 4 -OH groups that make it polar. Excess intake of vitamin A will be excreted by the kidney.



Vitamin A is a fat soluble vitamin. It ha a long, non-polar carbon-hydrogen chain, which makes it very soluble in oils and fats. Excess of vitamin A in the diet builds up in the body fat and not easily eliminated from the body.



Surfactant

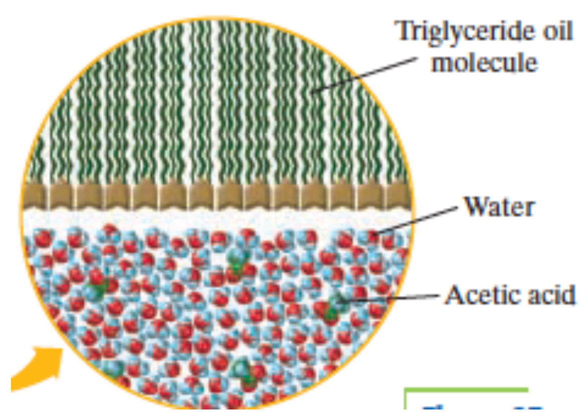
a) Soap belongs to a general class of substances called surfactants.

A surfactant is a compound the concentrates at the boundary surface between two immiscible phases, either the solid-liquid, liquid-liquid or gas-liquid.

b) Soap is also a natural product detergent. Detergent is a water-soluble cleaner that can emulsify dirt and oil. Soaps are sodium or potassium salts of fatty acids with long hydrocarbon chain. The formula for a typical soap, sodium palmitate is shown below:

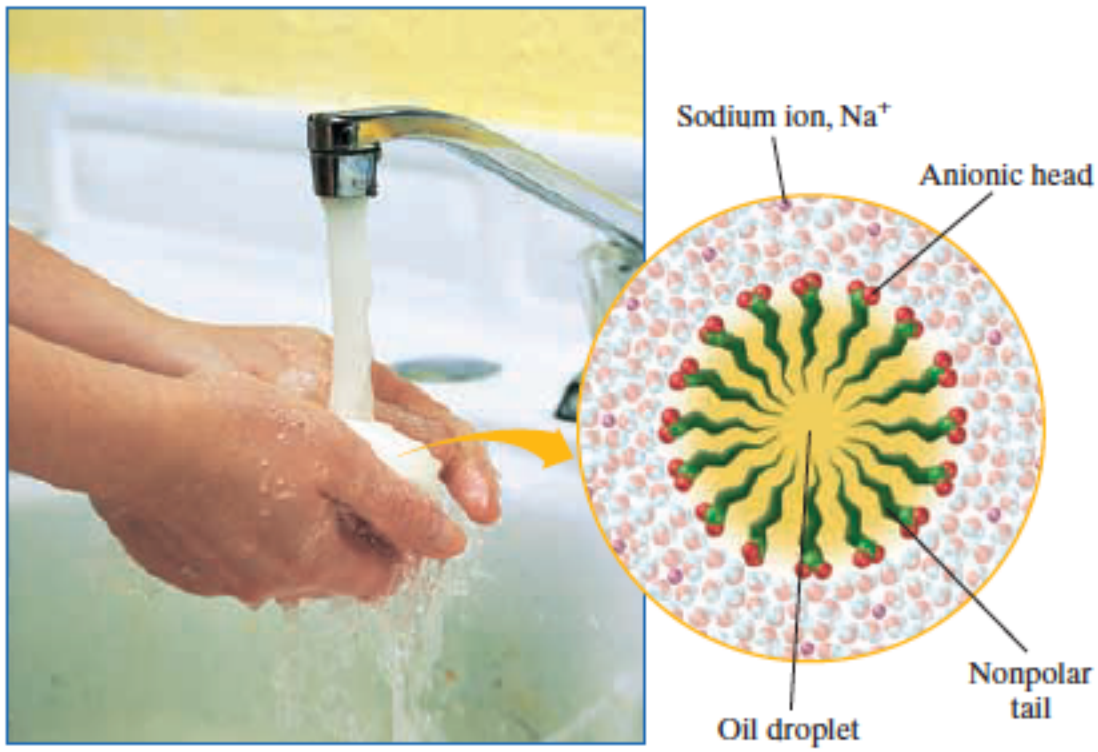
$$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COO^- Na^+$$

Without an emulsifying agent, polar and non polar molecules remain separate. Example: oil and vinegar (acetic acid) separate into two layer.



c) Soap is an emulsifying agent.

When you wash with soap, you create an emulsion of oil droplets dispersed in water and stabilized by the soap (emulsifying agent, detergent, surfactant).

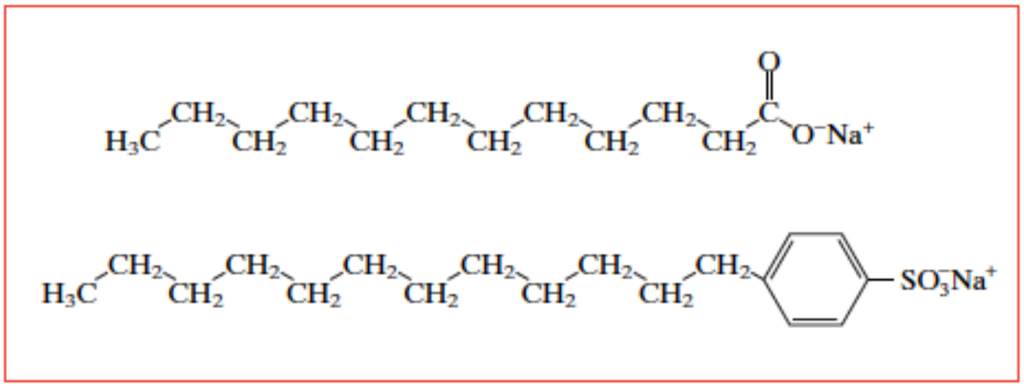


Hard Water Limits Soap's Detergent Ability

Hard water has a large concentration of the cations calcium, magnesium and iron (II). Soap or palmitate ion form insoluble salts with these cations, such as the one shown in the following equation.

$$2C_{12}H_{25}COO^{-}\ (aq) + Ca^{2+}\ (aq) \longrightarrow (C_{12}H_{25}COO^{-})_2Ca\ (s)$$

Synthetic Detergents Outperform Soaps in Hard Water.



The structure of sodium laureate (top) is a typical soap. The carboxylate anion -COO-, reacts with water to form an insoluble precipitate.

Sodium dodecylbenzene sulfonate (bottom) is a synthetic detergent. The sulfonate anion, -SOOO-, does not form an insoluble precipitate with hard water.