

WATER: ITS STRUCTURE AND LIFE SUPPORTING PROPERTIES

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Water: Its structure and life supporting properties

- Learning Objectives:
 - *Describe* the chemical structure of water.
 - *Illustrate* the properties of water.
 - *Understand* solutions

Water: Its structure and life supporting properties

- Learning Objectives:
 - *Describe* the chemical structure of water
 - The simple structure and properties of water molecule
 - *Illustrate* the properties of water
 - In particular, the chemical properties as a solvent in an aqueous solution
 - Ionization of water molecules
 - *Understand* solutions
 - In contrast to suspensions

Water in the body

- ❑ Water is a solvent in the body
- ❑ In blood
- ❑ In cells
- ❑ In temperature regulation
- ❑ In saliva
- ❑ In synovial fluid (in the knee joint)
- ❑ In hydrolysis reactions

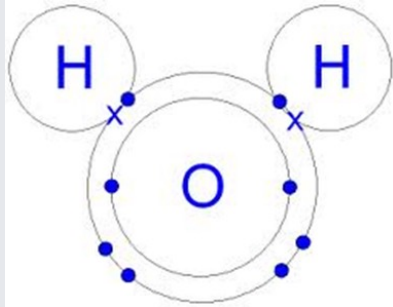


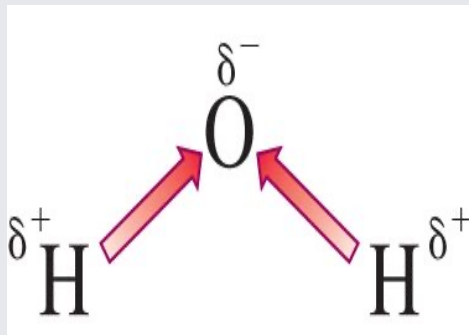
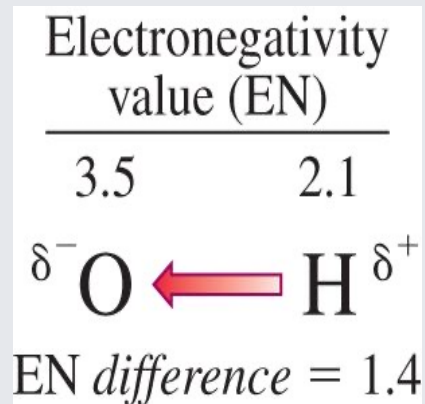
Water: Its structure and life supporting properties

- Learning Objectives:
 - ***Describe the chemical structure of water.***
 - *Illustrate the properties of water.*
 - *Understand solutions*
 - *Calculate concentrations*

The simple structure of water

- $2 \text{ hydrogen} + 1 \text{ oxygen} \rightarrow \text{water}$
- The 2 hydrogen atoms each share a pair of electrons with the oxygen by covalent bonding;
- The oxygen still has 2 pairs of unshared electrons;
- The oxygen is thus an “electronegative” atom compared to the two hydrogen



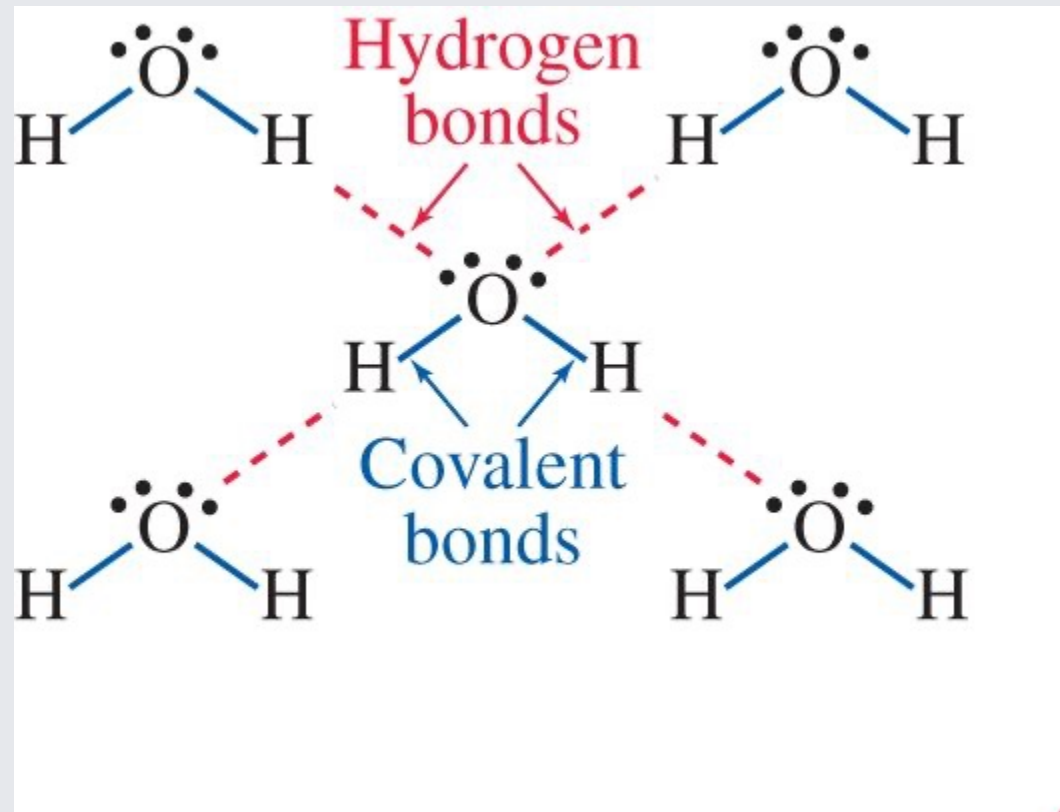


The polarity of water

- Due to the uneven distribution of electron density, water is a “polar” molecule;
- There is a partial “-ve” charge near the oxygen, and a partial “+ve” charge near the hydrogen atoms;
- Hence the electrostatic attraction occurs between water molecules.

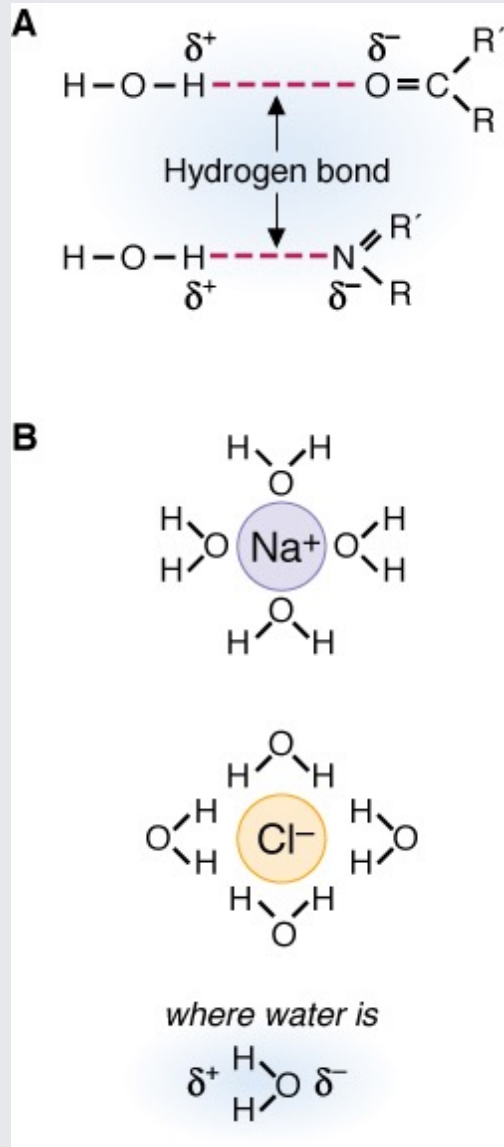
The polarity of water

- Hydrogen bond is formed due to the electrostatic attraction !



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A. Hydrogen bonds between water and polar molecules. R denotes additional atoms.

B. Hydration shells surrounding anions and cations.

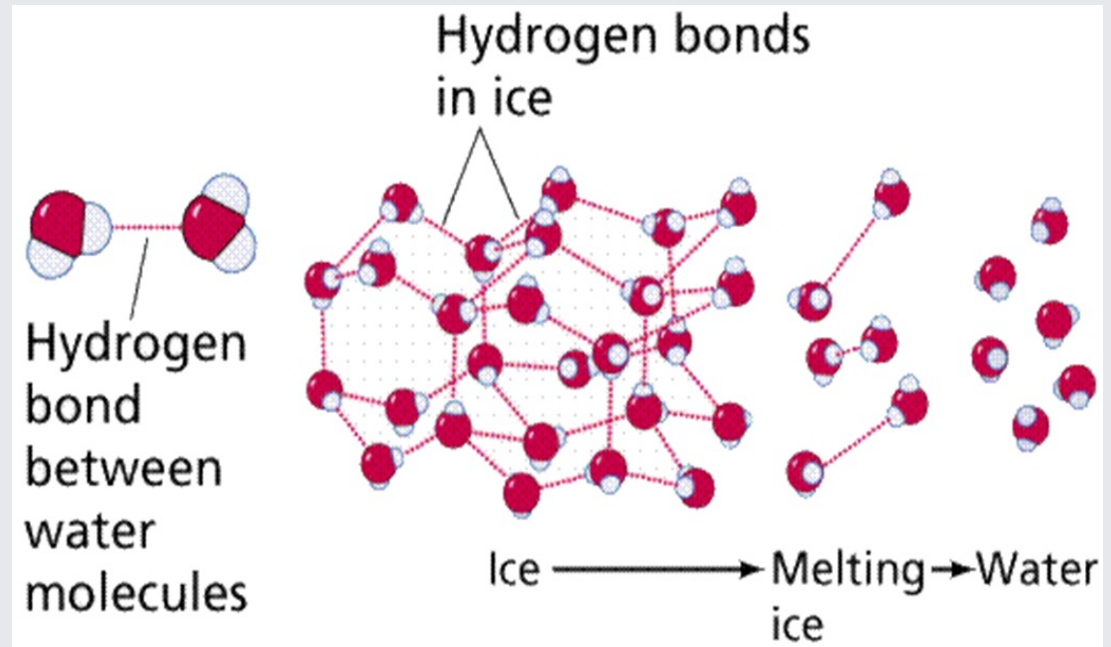
The Unique properties of water

Many unique physical properties of water is due to the hydrogen bonding:

- High heat of vaporization;
- Strong surface tension;
- High specific heat,
- As a near universal solvent

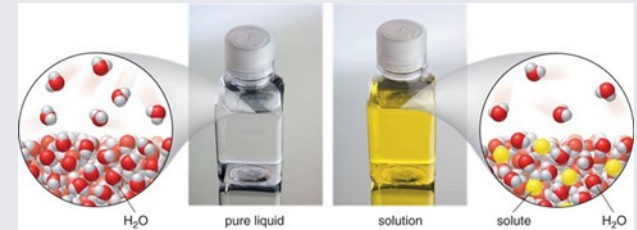
Many unique chemical properties of water is also due to the hydrogen bonding

- Hydrophobic effect



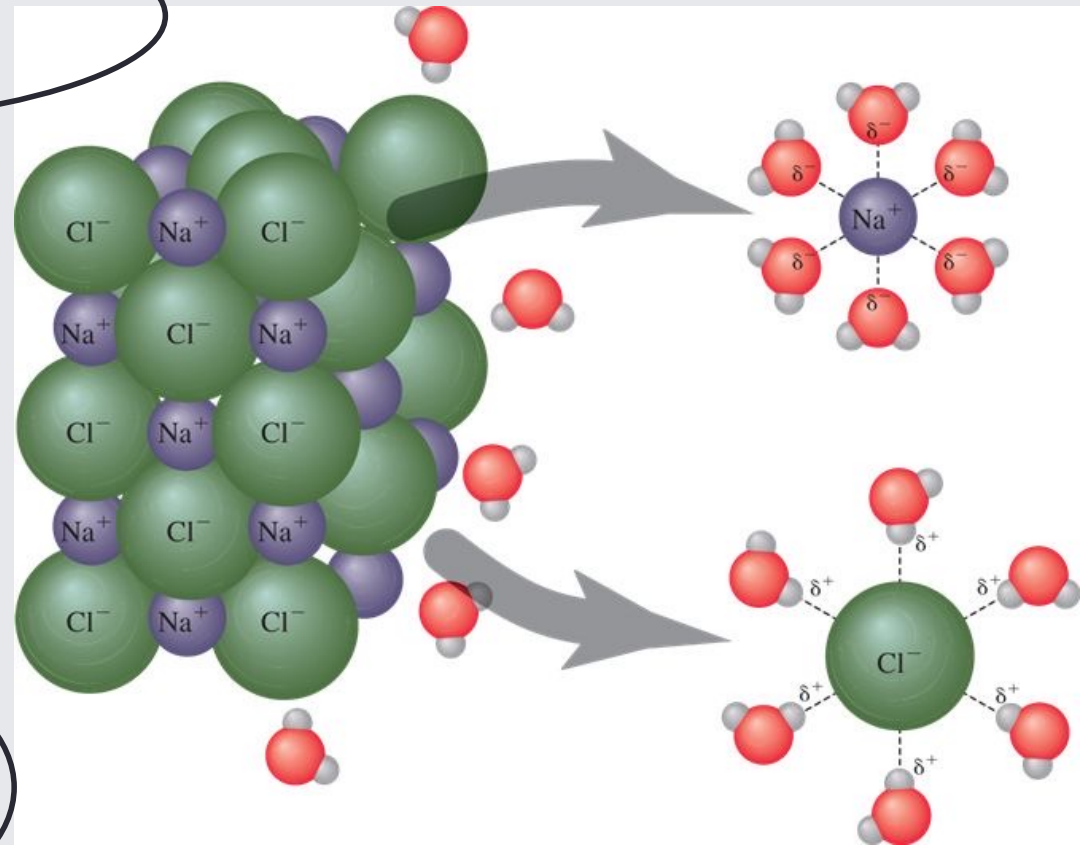
Water as a solvent

* A minor component of a solution, dissolved in the solvent.



- Solvent:
- It is a liquid in which a ***solute** is dissolved to form a ****solution**.

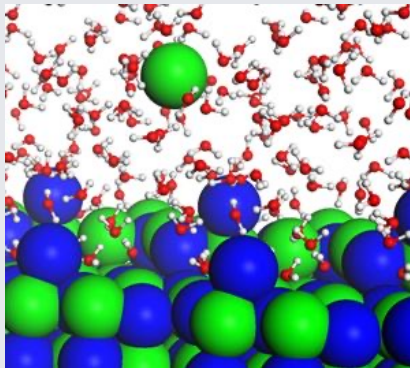
**A liquid mixture in which minor solute is uniformly distributed within the solvent.



When water is used as a solvent, it is called an aqueous solution

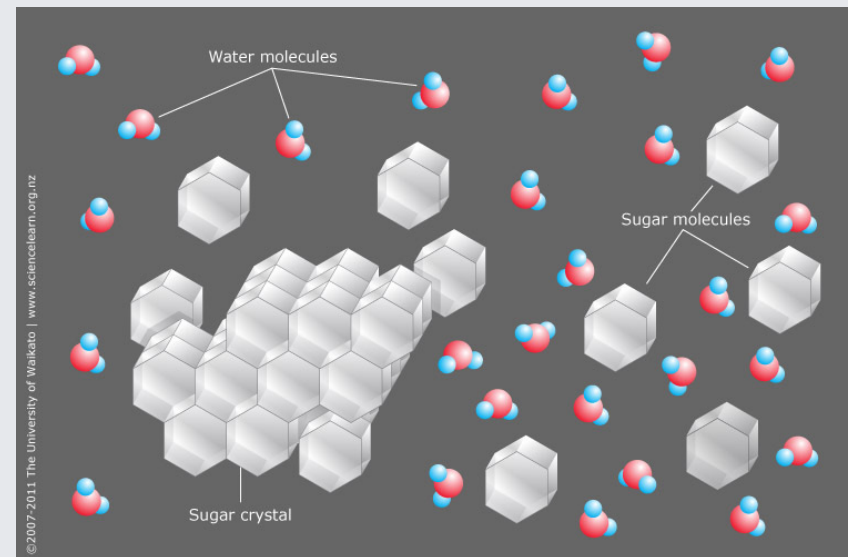
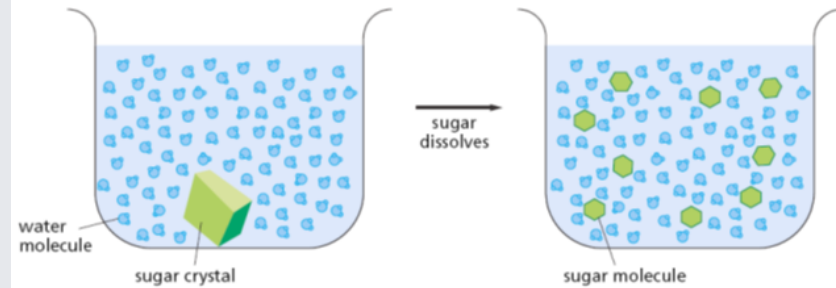
Water as a solvent

Salt water



Sugar water

Many substances, such as household sugar, **dissolve** in water. That is, their molecules separate from each other, each becoming surrounded by water molecules.



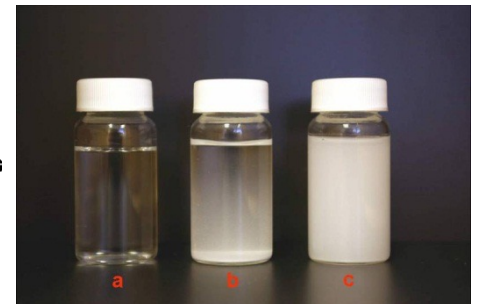
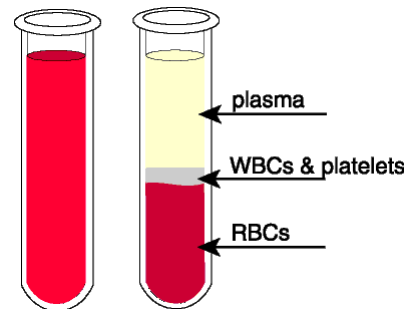
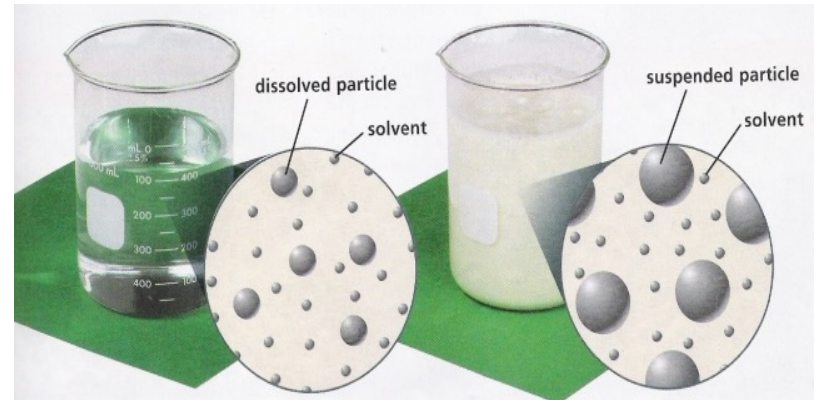
What is a suspension?

Suspension:

It is a mixture in which particles are dispersed throughout the bulk of a fluid.

It differs from a solution, in that the particles are finely divided, BUT NOT dissolved.

e.g. blood; some drugs..



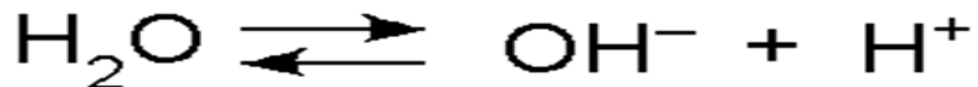
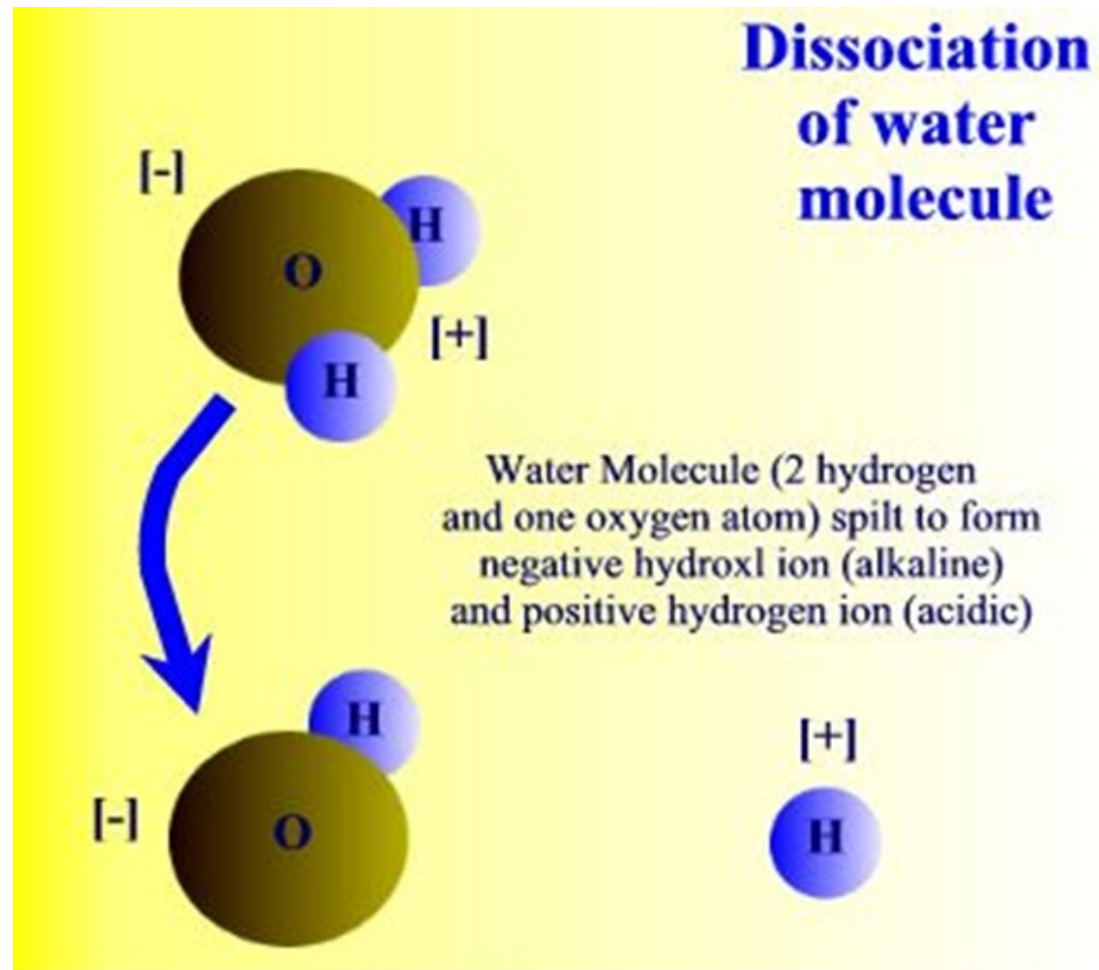
The ionization of water

Water molecules exist in equilibrium with hydrogen ions and hydroxide ions.

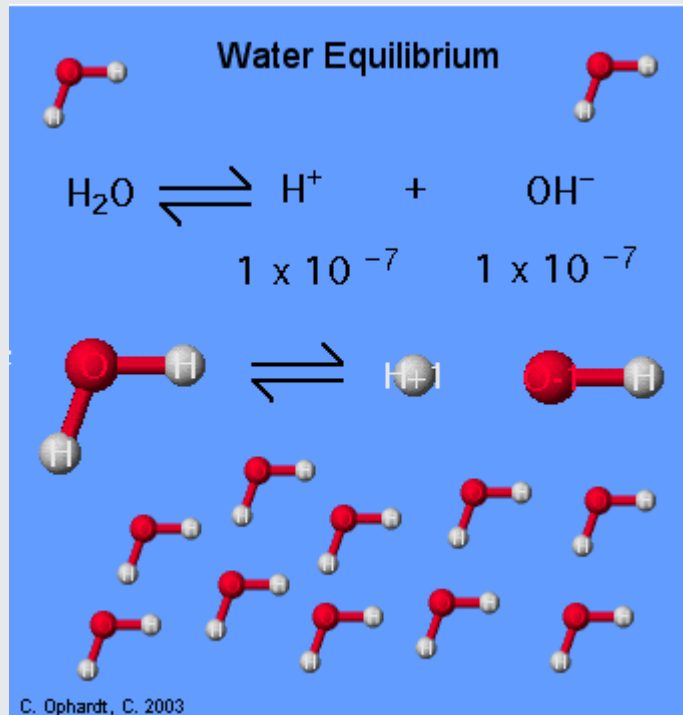


The water equilibrium constant is written as:

$$K_w = [\text{H}^+] [\text{OH}^-]$$



The ionization of water



- For pure water, experimentally, it has been found that the concentration of:
- $\text{H}^+ = \text{OH}^- = 10^{-7}$
- Thus indicates that the equilibrium favors the reactant (water molecules).
- In other words, only very small amounts of H^+ and OH^- ions are present.

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Solution – major features

- A solution is a homogeneous mixture that contains small dissolved particles. Any phase of matter can form solutions. The substance present in the lesser amount is called the solute, and the substance present in the larger amount is the solvent.
- A solution conducts electricity if it contains dissolved ions, but does not conduct electricity if it contains atoms or neutral molecules.

Solubility rules – in general

- One rule summarizes solubility: “Like dissolves like.”
- Most ionic compounds are soluble in water. If the attractive forces between the ions and water are stronger than the attraction between the ions in the crystal, an ionic compound dissolves in water.
- Small polar compounds that can hydrogen bond are soluble in water.
- Nonpolar compounds are soluble in nonpolar solvents. Compounds with many nonpolar C—C and C—H bonds are soluble in nonpolar solvents.

| | ECF ^a (mmol/L) | ICF (mmol/L) |
|-------------------------------|---------------------------|--------------|
| Cations | | |
| Na ⁺ | 145 | 12 |
| K ⁺ | 4 | 150 |
| Anions | | |
| Cl ⁻ | 105 | 5 |
| HCO ₃ ⁻ | 25 | 12 |
| Inorganic phosphate | 2 | 100 |

Distribution of Ions in Body Fluids

ECF, extracellular fluid; *ICF*, intracellular fluid.

^aThe content of inorganic ions is very similar in plasma and interstitial fluid, the two components of the ECF.