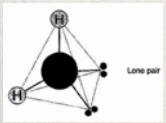
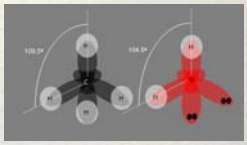
Water and the Environment

Properties of Water

Introduction

- What makes water special?





The Polarity Of Water Molecules Results From Hydrogen Bonding

- In a water molecule two hydrogen atoms form single polar covalent bonds with an oxygen atom.
- What effect does electronegativity have on water's properties?

Hydrogen Bonds

- Water has a variety of unusual properties because of attractions between these polar molecules.

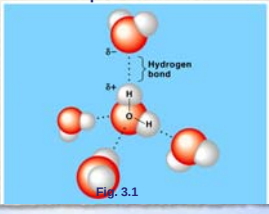


Fig. 3.1

Organisms Depend On The Cohesion Of Water Molecules

- Hydrogen bonds hold the substance together, a phenomenon called cohesion.

Cohesions Role in Plants

- Cohesion among water molecules plays a key role in the transport of water against gravity in plants.
  - Adhesion
    Sticking of water to another surface


Fig. 3.2

Surface Tension

- Surface tension, a measure of the force necessary to stretch or break the surface of a liquid, is related to **cohesion**.

Fig. 3.3

Water Moderates Temperatures On Earth

- Water stabilizes air temperatures by absorbing heat from warmer air and releasing heat to cooler air.

Energy and Water

- While there are several ways to measure heat energy, one convenient unit is the calorie (cal).
  - What about nutritional Calories?
- Another common energy unit, the joule (J), is equivalent to 0.239 cal.

Cohesion and Specific Heat

- The specific heat of a substance is the amount of heat that must be absorbed or lost for 1g of that substance to change its temperature by 1oC.
  - Why a high specific heat?

Heat of Vaporization

- Heat of vaporization is the quantity of heat that a liquid must absorb for 1 g of it to be converted from the liquid to the gaseous state.
  - 580 cal of heat is to evaporate 1g of water at room temperature.
  - This is double the heat required to vaporize the same quantity of alcohol or ammonia.
  - Why?

Application of Cohesion

- As a liquid evaporates, the surface of the liquid that remains behind cools - evaporative cooling.
- Evaporative cooling moderates temperature in lakes and ponds and prevents terrestrial organisms from overheating.

Oceans and lakes don't freeze solid because ice floats

- Why?

Why?

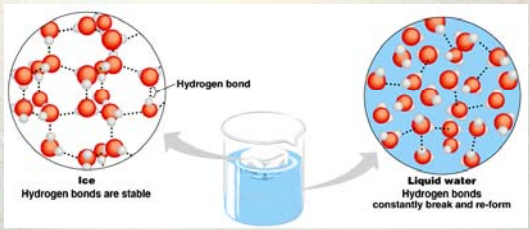


Fig. 3.5

Benefits

- Therefore, ice floats on the cool water below.
- This oddity has important consequences for life.

Fig. 3.6

Water Is The Solvent Of Life

- The dissolving agent is the solvent and the substance that is dissolved is the solute.
  - In our example, water is the solvent and sugar the solute.
- In an aqueous solution, water is the solvent.
- Water is not a universal solvent, but it is very versatile because of the polarity of water molecules.

Solvent Properties

- Water is an effective solvent because it so readily forms hydrogen bonds with charged and polar covalent molecules.

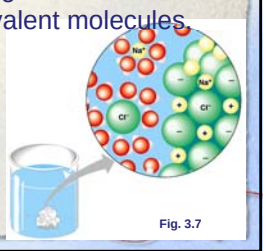


Fig. 3.7

Dissolve and Hydration

- Each dissolved ion is surrounded by a sphere of water molecules, a hydration shell.
- Even large molecules, like proteins, can dissolve in water if they have ionic and polar regions.

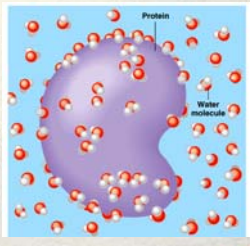
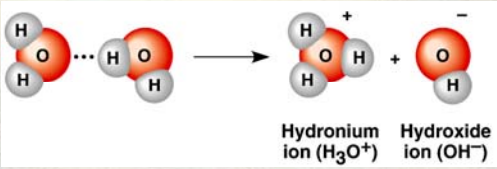


Fig. 3.8

Hydrophillic/Hydrophobic

- Any substance that has an affinity for water is hydrophilic.
  - For example, cotton is hydrophilic because it has numerous polar covalent bonds in cellulose, its major constituent.
  - Water molecules form hydrogen bonds in these areas.

Water and pH



Unnumbered Fig. 3.47

Organisms Are Sensitive To Changes In pH

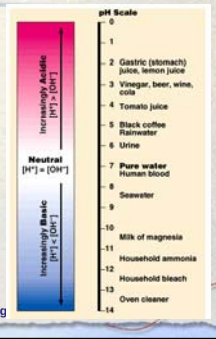
- An acid is a substance that increases the hydrogen ion concentration in a solution.
  - When hydrochloric acid is added to water, hydrogen ions dissociate from chloride ions:
    - HCl -> H+ + Cl-
- Addition of an acid makes a solution more acidic.

Organisms Are Sensitive To Changes In pH

- Any substance that reduces the hydrogen ion concentration in a solution is a base.
- Some bases reduce H+ directly by accepting hydrogen ions.
  - NH3 + H+ <=> NH4+
- Other bases reduce H+ indirectly by dissociating to OH- that combines with H+ to form water.
  - NaOH -> Na+ + OH- OH- + H+ -> H2O
- Solutions with more OH- than H+are basic solutions.

pH Scale

- In a neutral solution [H+] = 10-7 M, and the pH = 7.
- Values for pH decline as [H+] increase.
- While the pH scale is based on [H+], values for [OH-] can be easily calculated from the product relationship.

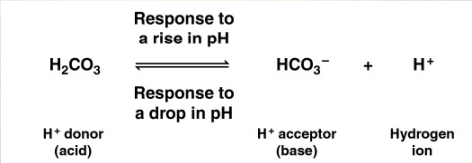


Fig

Buffers

- Buffers resist changes to the pH of a solution when H+ or OH- is added to the solution.
  - Buffers accept hydrogen ions from the solution when they are in excess and donate hydrogen ions when they have been depleted.

- Buffers typically consist of a weak acid and its corresponding base.



Acid Precipitation Threatens The Fitness Of The Environment

- Acid precipitation is a serious assault on water quality and therefore the environment for all life where this problem occurs.
  - Uncontaminated rain has a slightly acidic pH of 5.6.
  - The acid is a product of the formation of carbonic acid from carbon dioxide and water.
- Acid precipitation occurs when rain, snow, or fog has a pH that is more acidic than 5.6.

Water Cycle