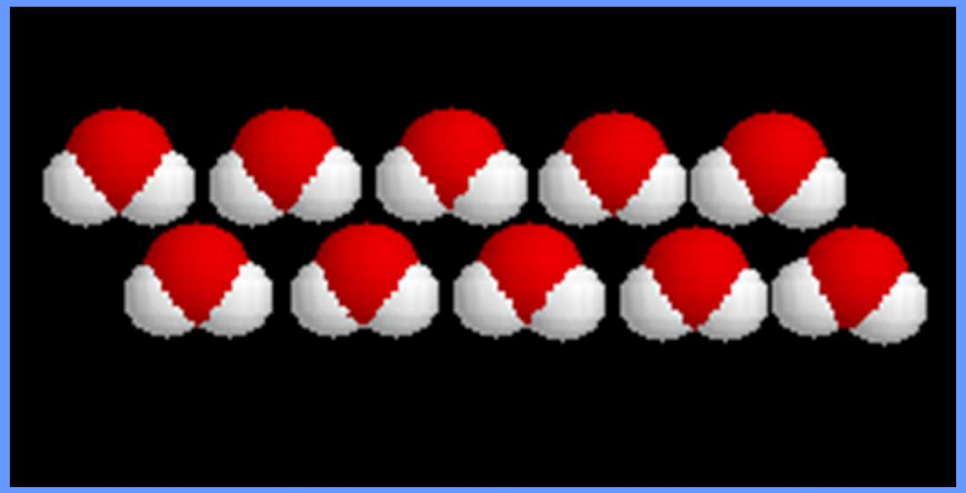
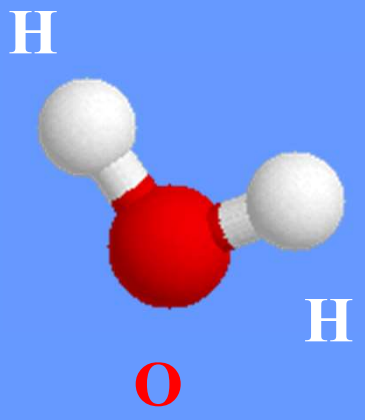
The Extraordinary Properties of Water

Water

- A water molecule (H_2O), is made up of three atoms --- one oxygen and two hydrogen.



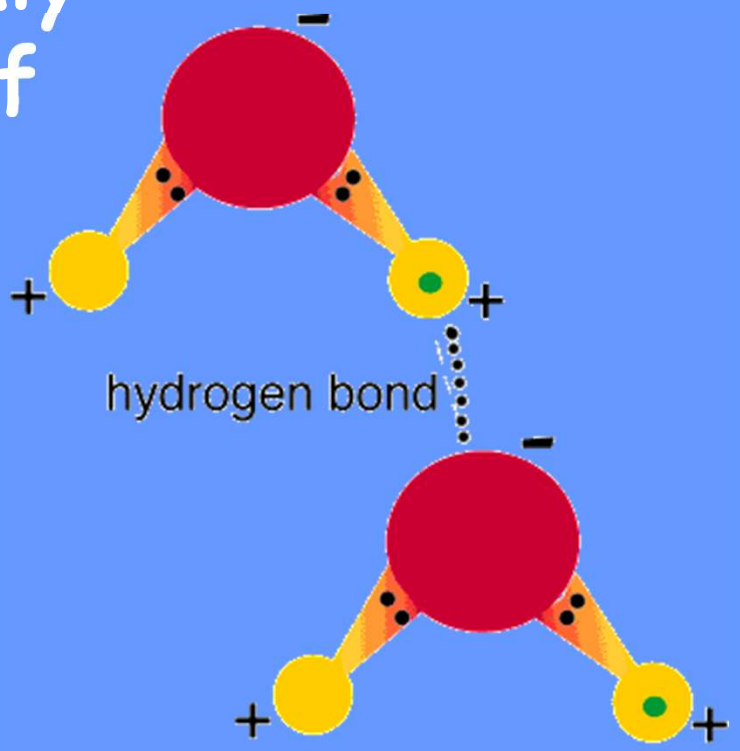


Water is Polar

- In each water molecule, the **oxygen atom attracts more** than its "fair share" of **electrons**
- The **oxygen** end "acts" **negative**
- The **hydrogen** end "acts" **positive**
- Causes the water to be **POLAR**
- However, Water is **neutral** (equal number of e- and p+) --- **Zero Net Charge**

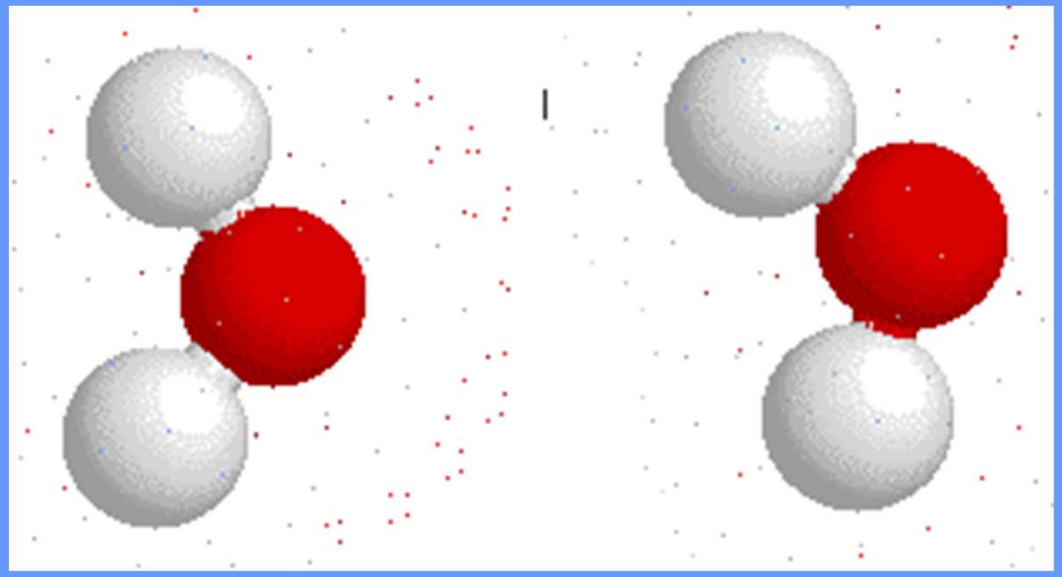
Hydrogen Bonds Exist Between Water Molecules

- Formed between a highly **Electronegative atom** of a polar molecule and a **Hydrogen**
- **One** hydrogen bond is **weak** , but **many** hydrogen bonds are **strong**

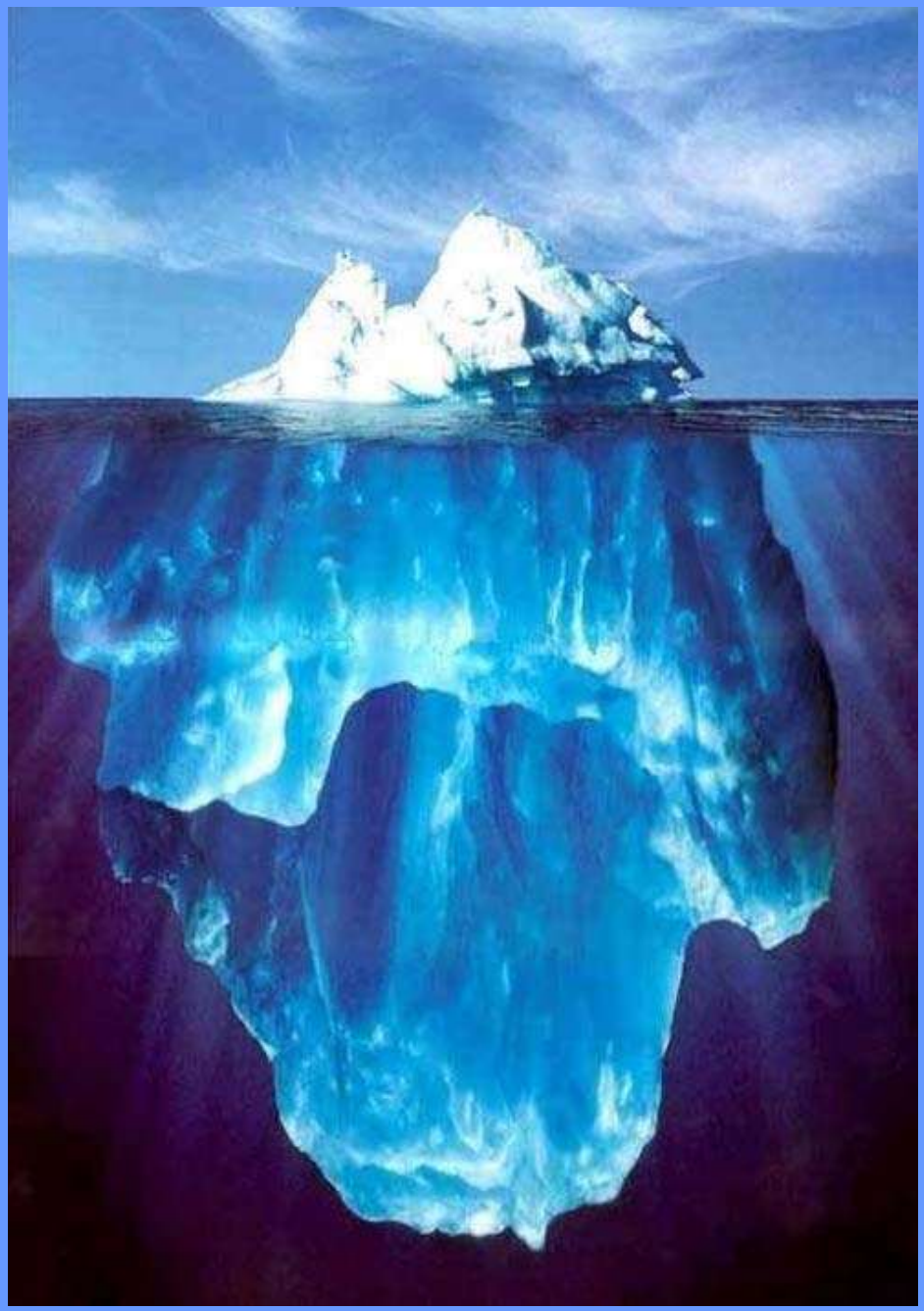


Interaction Between Water Molecules

Negative Oxygen end of one water molecule is attracted to the Positive Hydrogen end of another water molecule to form a HYDROGEN BOND



What are the Properties of Water?



Properties of Water

- At sea level, pure water boils at 100 °C and freezes at 0 °C.
- The boiling temperature of water decreases at higher elevations (lower atmospheric pressure).
- For this reason, an egg will take longer to boil at higher altitudes

Properties of Water

- Cohesion

Properties of Water

- Cohesion
- Adhesion

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- High Specific Heat

Properties of Water

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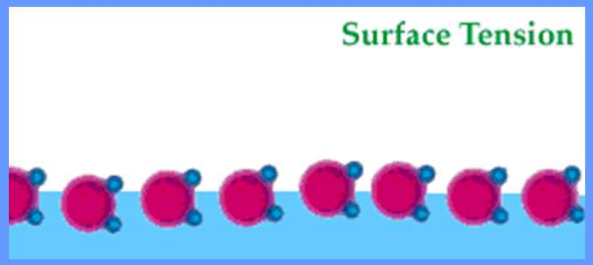
Properties of Water

- Cohesion
- Adhesion
- High Specific Heat
- High Heat of Vaporization
- Less Dense as a Solid

Cohesion

- Attraction between particles of the same substance (why water is attracted to itself)
- Results in Surface tension (a measure of the strength of water's surface)
- Produces a surface film on water that allows insects to walk on the surface of water



Cohesion …

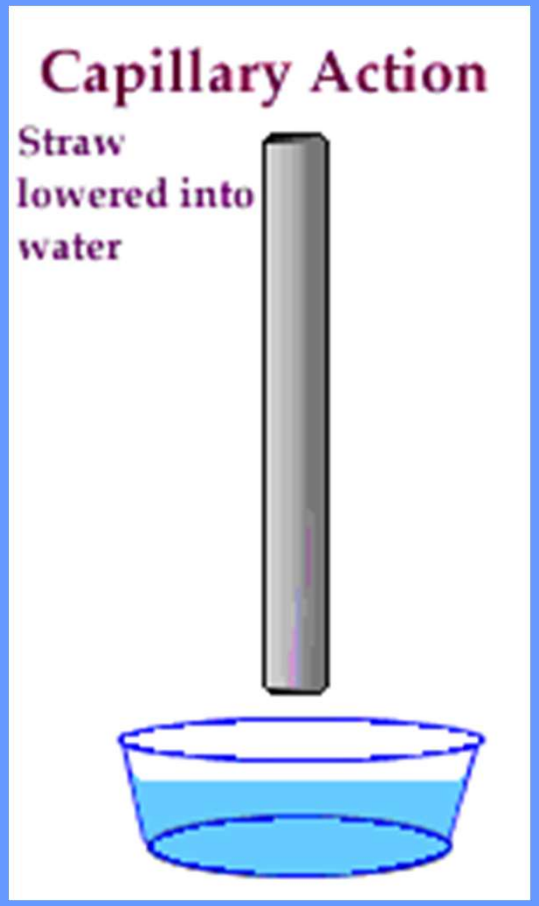
Helps insects walk across water

Adhesion

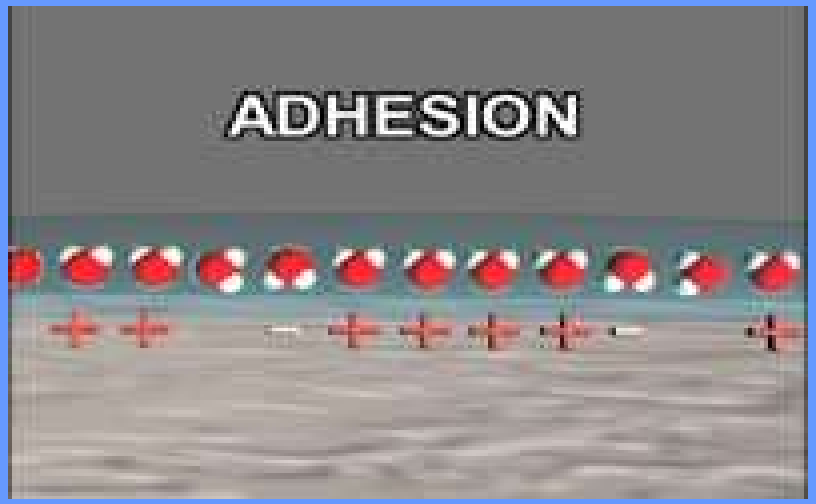
- **Attraction between two different substances**.
- Water will make **hydrogen bonds with other surfaces** such as glass, soil, plant tissues, and cotton.
- **Capillary action**-water molecules will "tow" each other along when in a thin glass tube.
- Example: **transpiration** process which plants and trees remove water from the soil, and paper towels soak up water.

Adhesion Causes Capillary Action

Which gives water the ability to "climb" structures



Adhesion Also Causes Water to …



Form spheres & hold onto plant leaves

Attach to a silken spider web

High Specific Heat

- **Amount of heat** needed to raise or lower **1g** of a substance **1° C**.
- Water **resists temperature change**, both for heating and cooling.
- Water can absorb or release large amounts of heat energy with little change in actual temperature.

High Heat of Vaporization

- Amount of energy to convert 1g or a substance from a **liquid to a gas**
- In order for water to evaporate, **hydrogen bonds must be broken**.
- **As water evaporates**, it removes a lot of **heat** with it.

High Heat of Vaporization

- Water's heat of vaporization is **540 cal/g.**
- In order for water to **evaporate**, each gram must **GAIN 540** calories (temperature doesn't change --- 100°C).
- **As water evaporates**, it removes a lot of **heat** with it **(cooling effect)**.

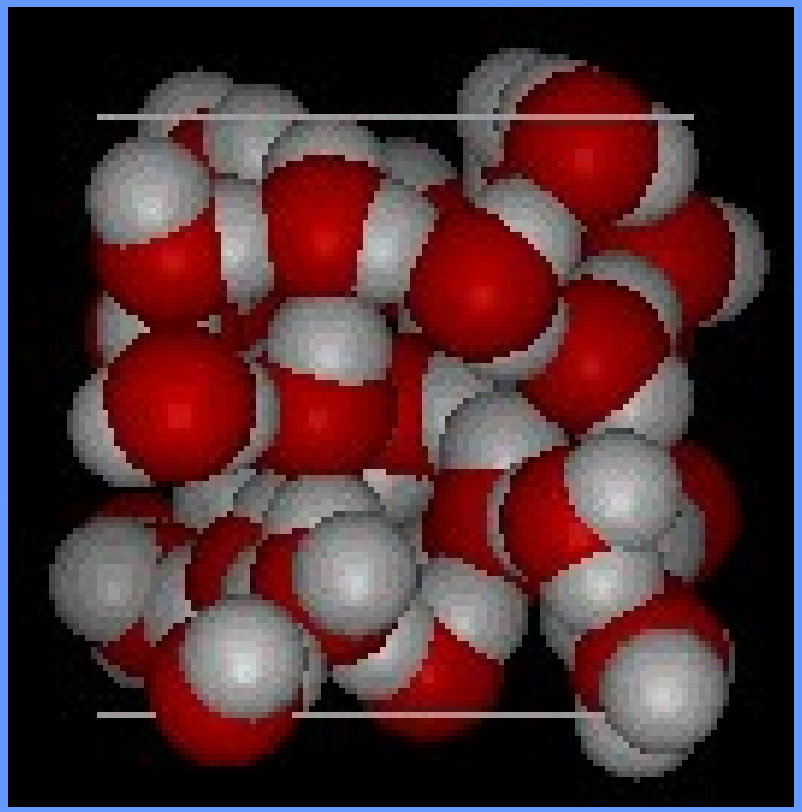
- **Water vapor** forms a kind of global "blanket" which helps to keep the **Earth warm**.
- **Heat radiated from the sun** warmed surface of the earth is **absorbed and held by the vapor**.

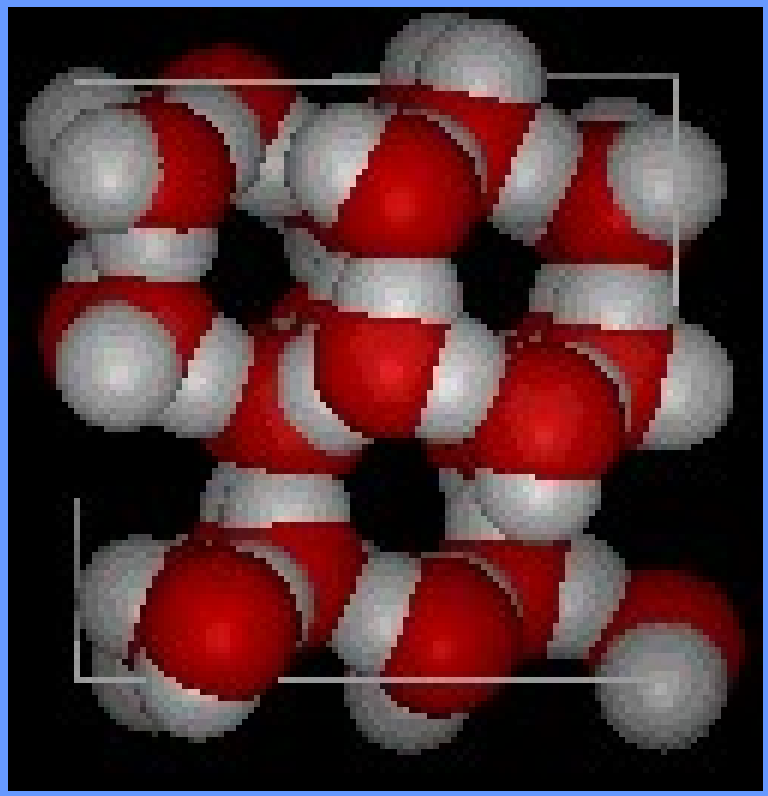
Water is Less Dense as a Solid

- **Ice is less dense** as a solid than as a liquid (ice floats)
- Liquid water has **hydrogen bonds** that are **constantly being broken and reformed.**
- **Frozen water** forms a **crystal-like lattice** whereby molecules are set at fixed distances.

Water is Less Dense as a Solid

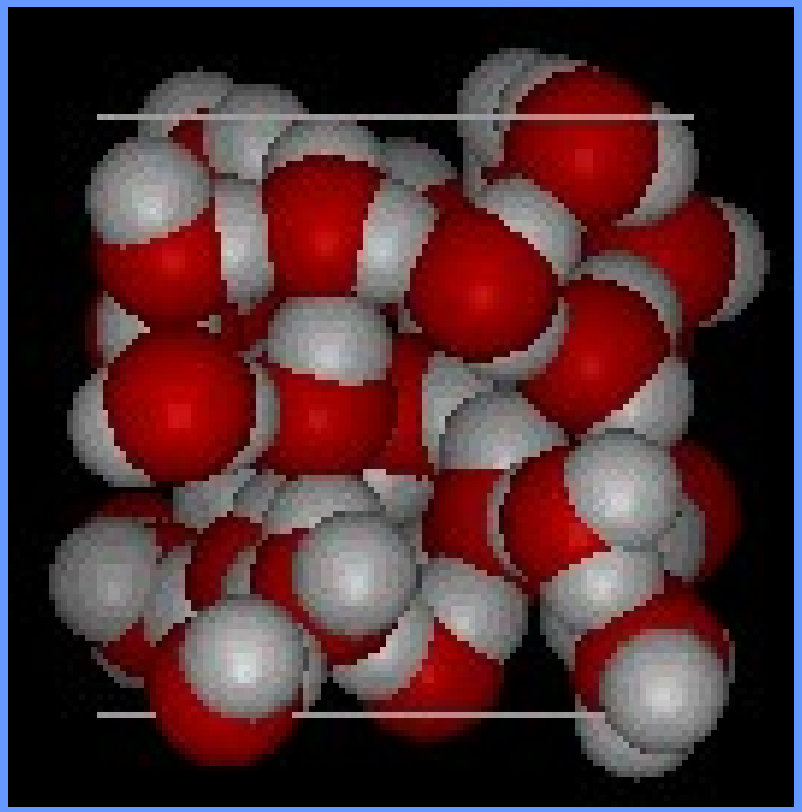
- Which is ice and which is water?

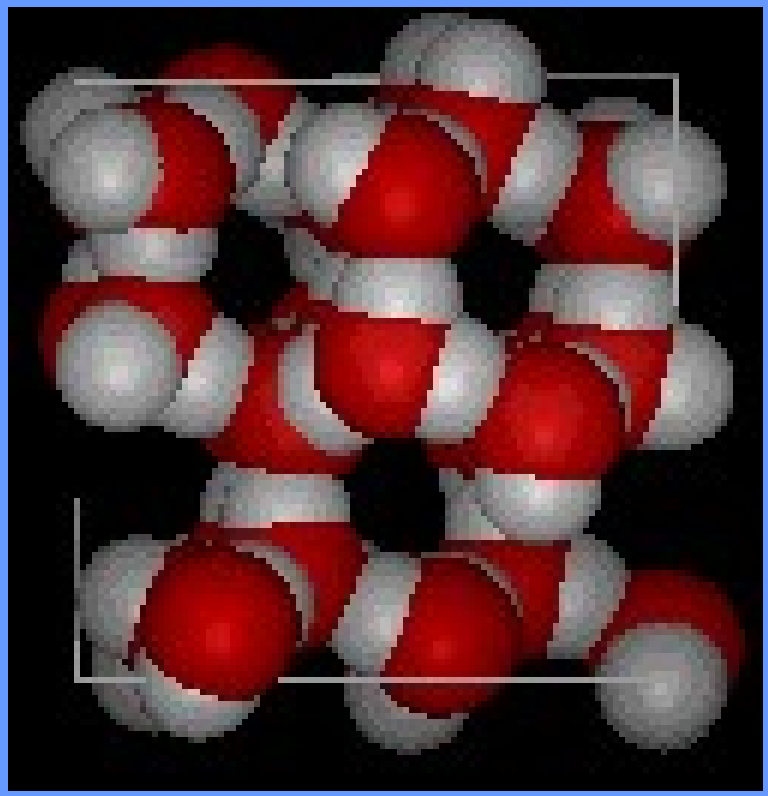




Water is Less Dense as a Solid

Water **Ice**





Homeostasis

- Ability to maintain a **steady state** despite changing conditions
- Water is important to this process because:
  a. Makes a **good insulator**
  b. Resists temperature change
  c. **Universal solvent**
  d. Coolant
  e. Ice protects against temperature extremes (**insulates** frozen lakes)

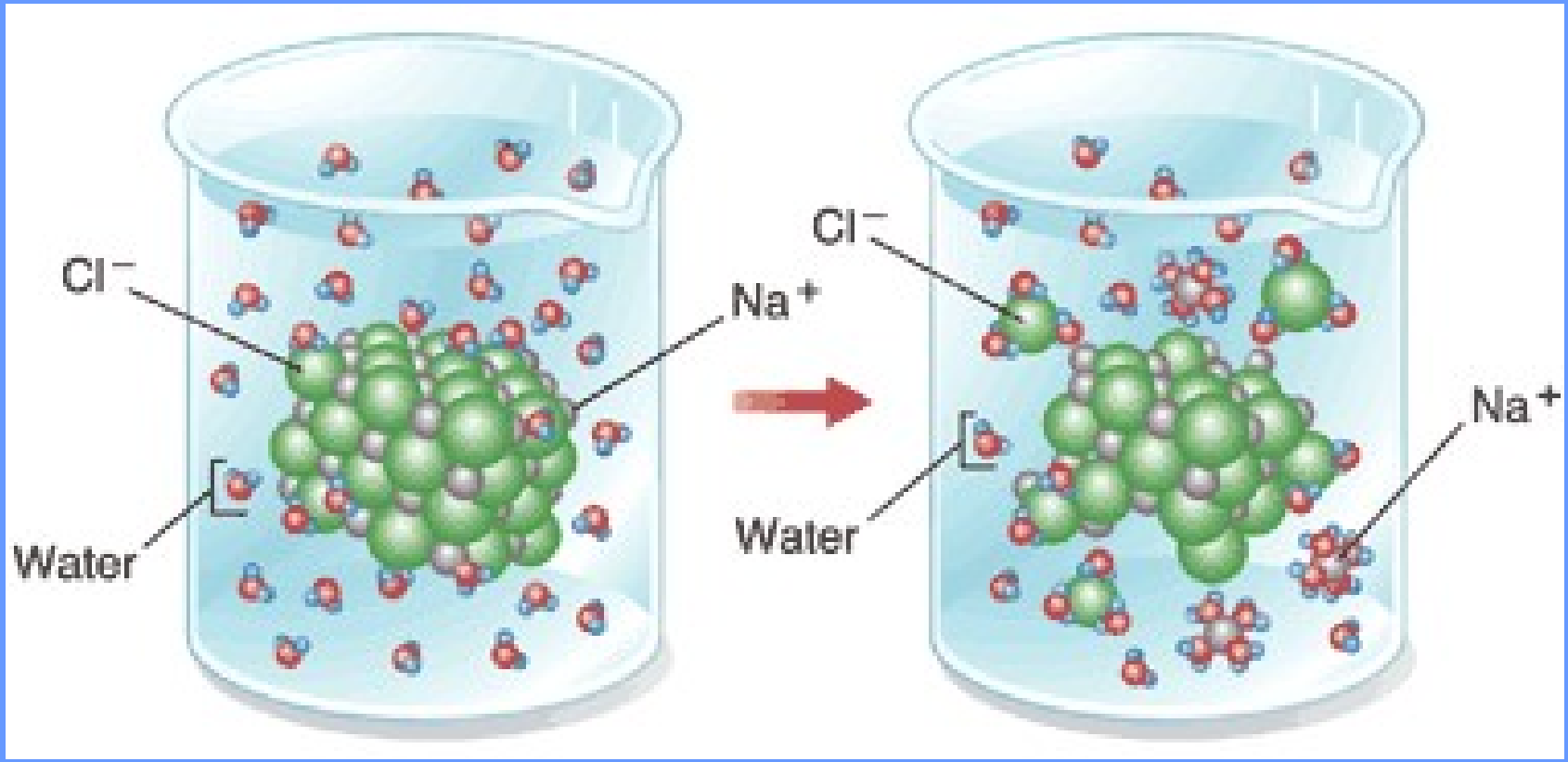
Solutions & Suspensions

- Water is usually part of a **mixture.**
- There are two types of mixtures:
  - **Solutions**
  - **Suspensions**

Solution

- Ionic compounds disperse as **ions** in water
- Evenly distributed
- SOLUTE
  - Substance that is being dissolved
- SOLVENT
  - Substance into which the solute dissolves

Solution

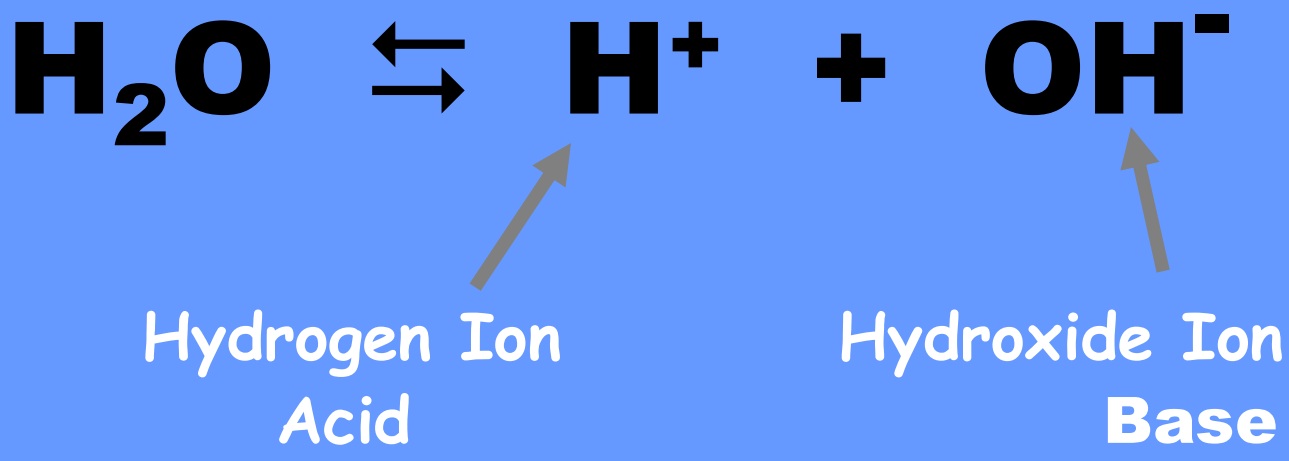


Suspensions

- Substances that **don't dissolve but separate** into tiny pieces.
- **Water keeps the pieces suspended** so they don't settle out.

Acids, Bases and pH

One water molecule in 550 million naturally **dissociates** into a Hydrogen Ion (H+) and a Hydroxide Ion (OH-)

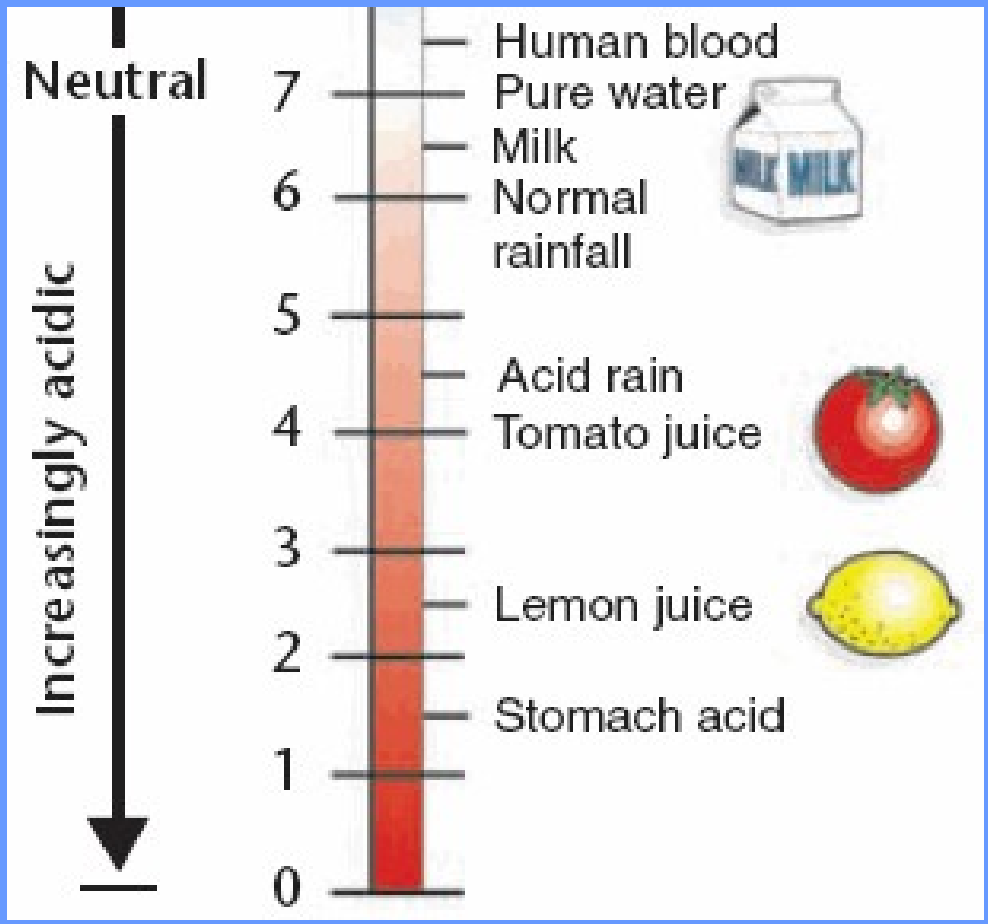


The pH Scale

- Indicates the concentration of H^+ ions
- Ranges from 0 – 14
- pH of 7 is neutral
- pH 0 up to 7 is acid … H^+
- pH above 7 – 14 is basic… OH^-
- Each pH unit represents a factor of 10X change in concentration
- pH 3 is 10 x 10 x 10 (1000) stronger than a pH of 6

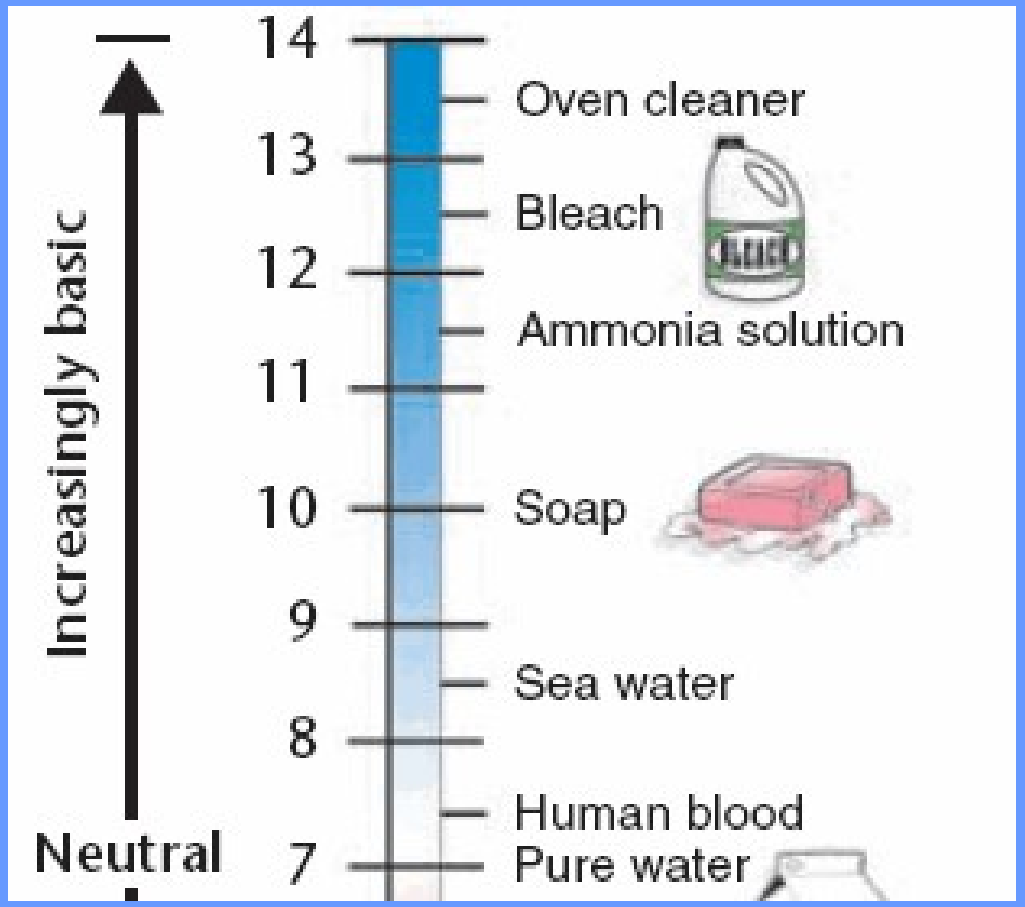
Acids

- **Strong Acids** have a pH of **1-3**
- Produce **lots of H^+ ions**



Bases

- **Strong Bases** have a pH of **11 to 14**
- Contain **lots of OH^- ions** and fewer H+ ions



Buffers

- Weak acids or bases that react with strong acids or bases to prevent sharp, sudden changes in pH **(neutralization).**
- **Produced naturally by the body** to maintain homeostasis

Weak Acid

Weak Base