Unit 1: Chemistry of Life

Make the first page of your notebook dedicated to Unit 1 with the title and some doodles you think go with the unit

Review the notes and copy the slides with a highlighted title in your notebook

Structure of Water and Hydrogen Bonding

Unit 1

topic 1 notes

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Chemistry Review

Matter

Anything that takes up space and has mass

- Rocks, metals, oils, gasses, organisms, etc. are all forms of matter

Element

A substance that cannot be broken down into other substances by chemical reactions

- 92 elements occur in nature
- Periodic table

Compound

A substance consisting of two or more different elements combined in a fixed ratio

- H_2O
- NaCl

Essential elements: of the 92 naturally occurring elements 20-25% are essential to survive and reproduce. CHON make up 96% of living matter

Trace elements: of the 92 naturally occurring elements, these are required by an organism in very small quantities

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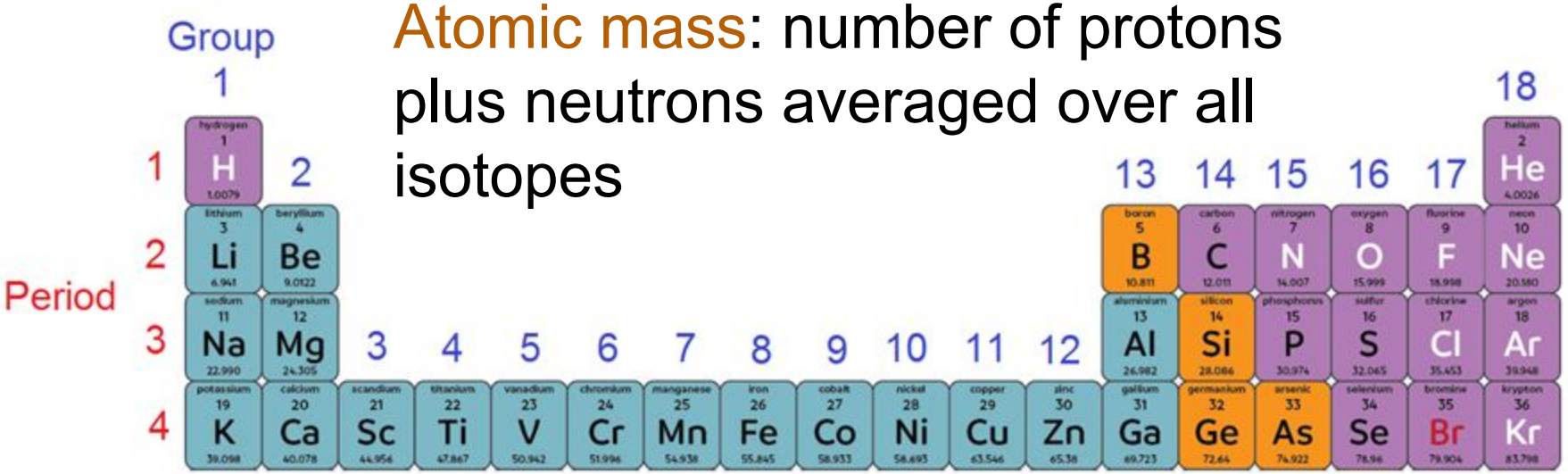
Chemistry Review



Element symbol

Atomic number: number of protons

Atomic mass: number of protons plus neutrons averaged over all isotopes



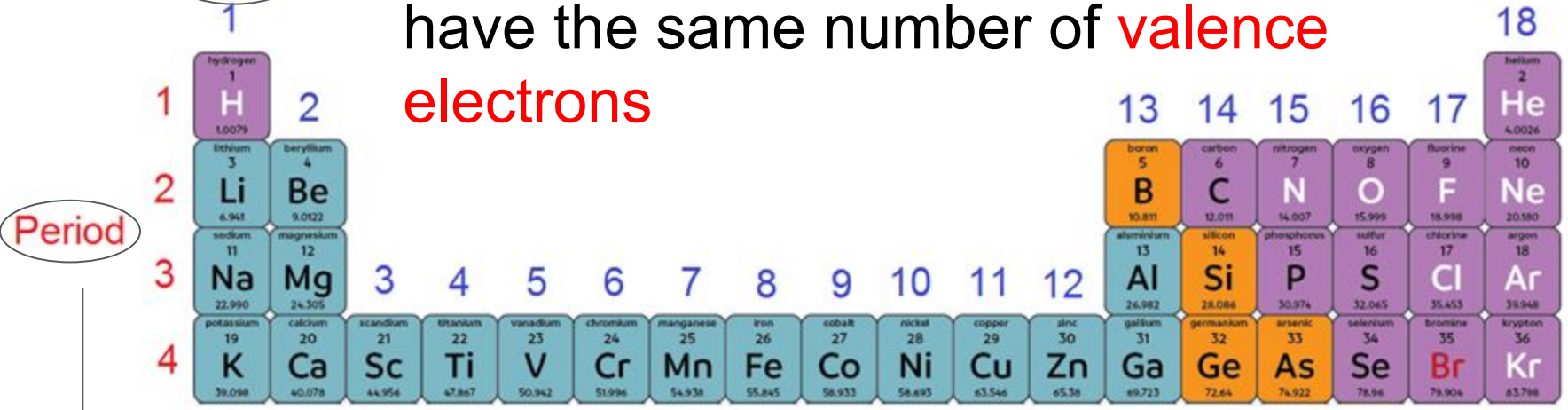
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Chemistry Review

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Group

Elements in the same vertical column have the same number of valence electrons



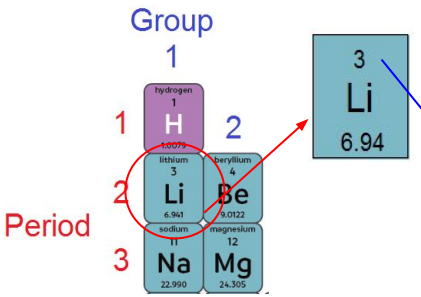
Period

Elements in the same horizontal row have the same total number of electron shells

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Chemistry Review

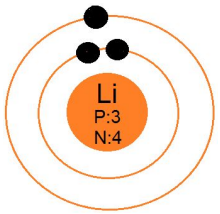
Example:Lithium



Period 2 = 2 shells
Group 1 = 1 valence e^-
3 protons = 3 electrons

Bohr Model

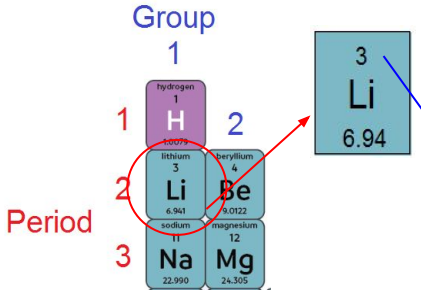
- Show electrons orbiting the nucleus of an atom
- Electrons are placed on shells around the nucleus
- Each shell is a different energy level and can hold up to a certain number of electrons
  - 1st shell: 2 e^-
  - 2nd shell: 8 e^-
  - 3rd shell: 18e^-



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Chemistry Review

Example:Lithium



Period 2 = 2 shells

Group 1 = 1 valence e^-

3 protons = 3 electrons

Lewis Dot Model

- Simplified Bohr diagrams
  - Does not show energy levels



- Only shows electrons in the valence shell (outermost shell)
- Electrons are placed around the element symbol

Elements want to be stable

How do elements achieve this? → Atoms with incomplete valence shells can interact → Form chemical bonds

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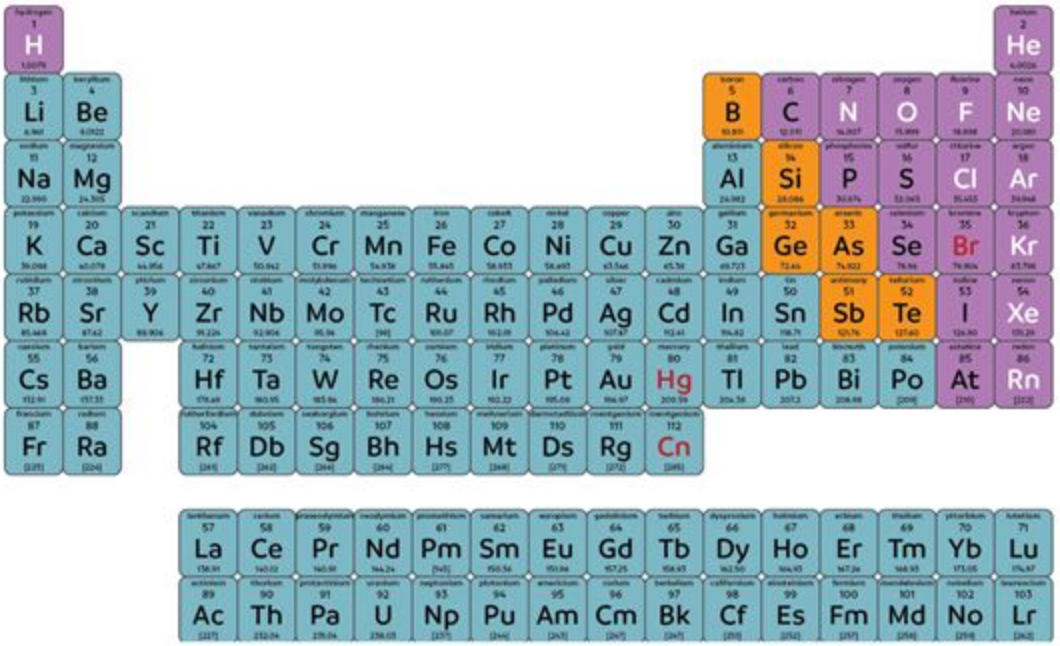
Chemistry Review

Chemical Bonds: an attraction between two atoms, resulting from the sharing or transferring of valence electrons

Electronegativity: the measure of an atom's ability to attract electrons to itself

Electronegativity increases →

Electronegativity decreases ↓



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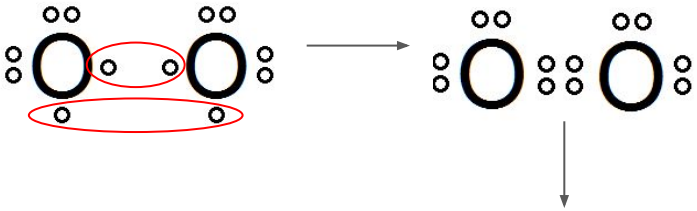
Covalent Bonds

Sharing of electrons by two atoms

Nonpolar covalent

Electrons are shared equally between between two atoms

- O_2

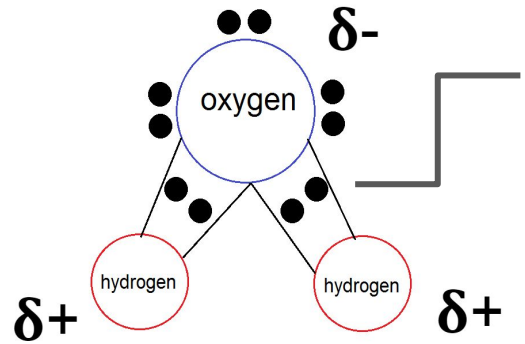


Polar covalent

Electrons are not shared equally between two atoms

- H_2O

Results in partial charges



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Covalent Bonds

Sharing of electrons by two atoms

- Form molecules and compounds

Single bond: 1 pair of shared e^-

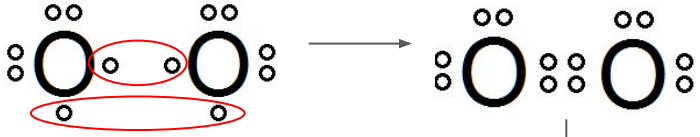
Double bond: 2 pairs of shared e^-

Triple bond: 3 pairs of shared e^-

Nonpolar covalent

Electrons are shared equally between between two atoms

- O_2

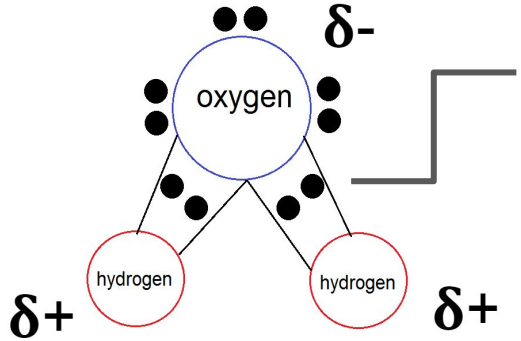


Double bond: 2 pairs shared e^-

Polar covalent

Electrons are not shared equally between two atoms

- H_2O



Unequal sharing of e- results in partial charges on oxygen and hydrogen

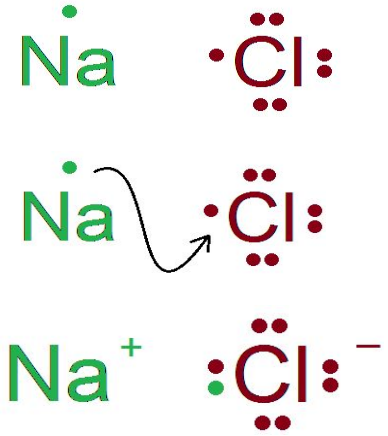
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Ionic Bonds

The attraction between oppositely charged atoms (ions)

Transfer of electrons from one atom to another

- Cation: positive charge
- Anion: negative charge



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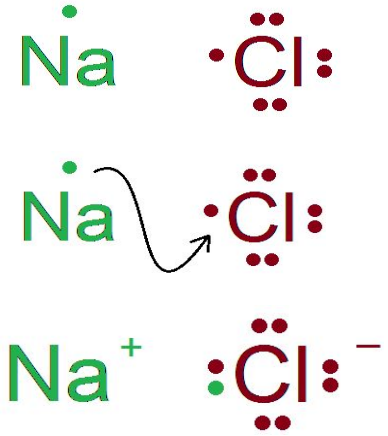
Ionic Bonds

The attraction between oppositely charged atoms (ions)

- Forms ionic compounds and salts
  - NaCl
  - LiF

Transfer of electrons from one atom to another atom forms ions

- Cation: positively charged ion
- Anion: negatively charged ion
  - The attraction between the anion and cation forms the ionic bond



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Hydrogen Bonding

The partially positive hydrogen atom in one polar covalent molecule will be **attracted** to an electronegative atom in another polar covalent molecule

- Hydrogen has a partial positive charge
- The electronegative atom has a partial negative charge

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Hydrogen Bonding

The partially positive hydrogen atom in one polar covalent molecule will be **attracted** to an electronegative atom in another polar covalent molecule

- Intermolecular bond: bond that forms between molecules

Why does this happen?

When a hydrogen atom is bonded to an electronegative atom (usually O, N, or F) the electrons are not being shared equally between atoms (remember: this is a polar covalent bond)

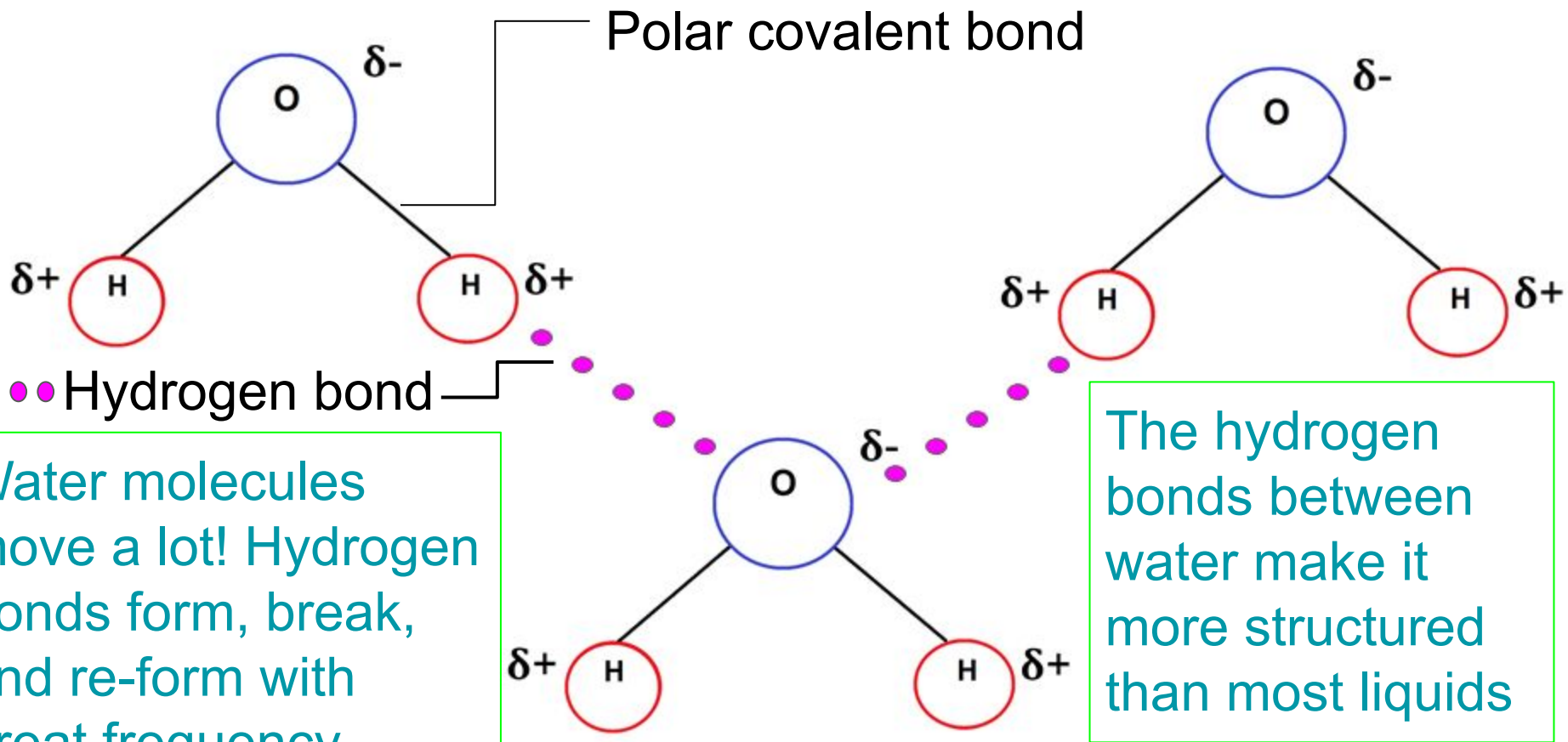
- This causes the hydrogen to have a partial positive charge and the electronegative atom to have a partial negative charge

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Hydrogen Bonding

Draw the water molecules and label the bonds

Example: hydrogen bonds between water molecules



Water molecules move a lot! Hydrogen bonds form, break, and re-form with great frequency

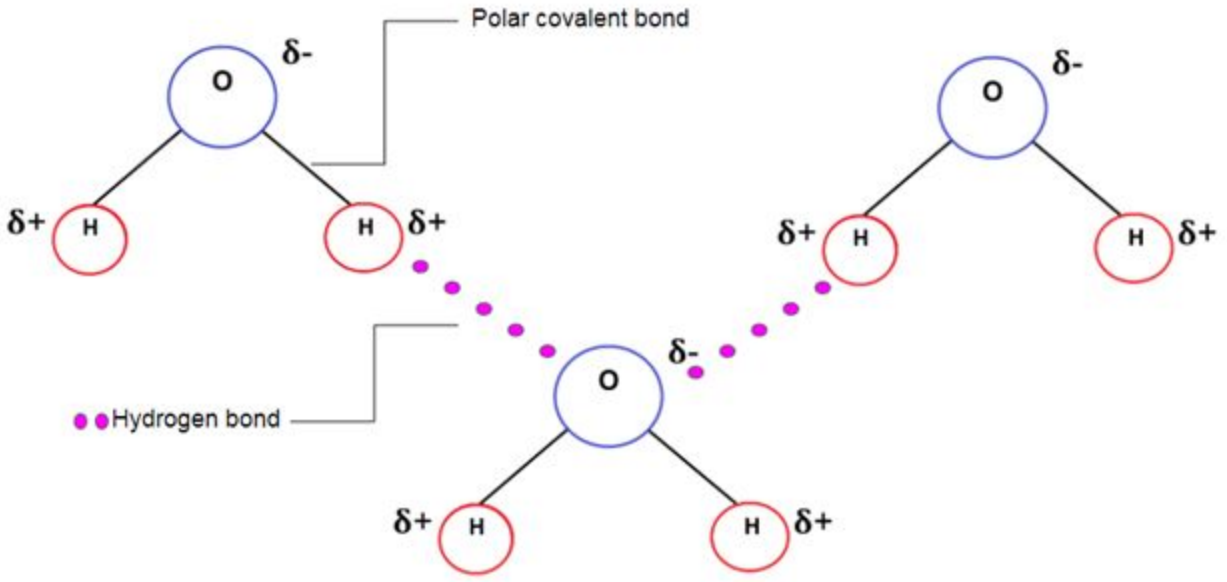
The hydrogen bonds between water make it more structured than most liquids

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Properties of water

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Properties of Water



Polarity

Unequal sharing of the electrons

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Properties of Water

Cohesion

Attraction of molecules for other molecules of the same kind

- Hydrogen bonds between H_2O molecules hold them together and increase cohesive forces
- Responsible for surface tension
  - Property allowing liquid to resist external force

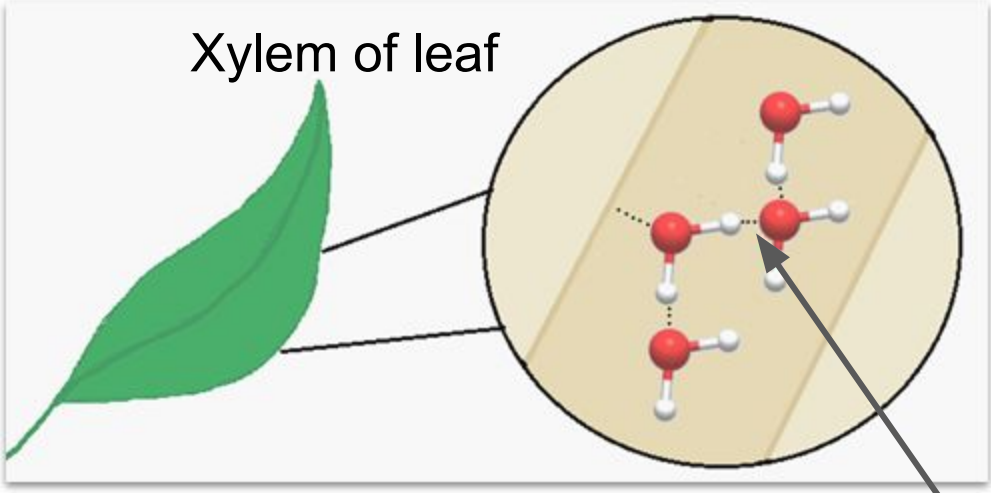
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Properties of Water

Cohesion

Attraction of molecules for other molecules of the same kind

- Hydrogen bonds between H_2O molecules hold them together and increase cohesive forces



- Allows for the transport of H_2O and nutrients <u>against gravity</u> in plants
- Responsible for <u>surface tension</u>

Cohesion: H_2O molecules stick together

Property allowing liquid to resist external force

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Properties of Water

Adhesion

The clinging of one molecule to a different molecule

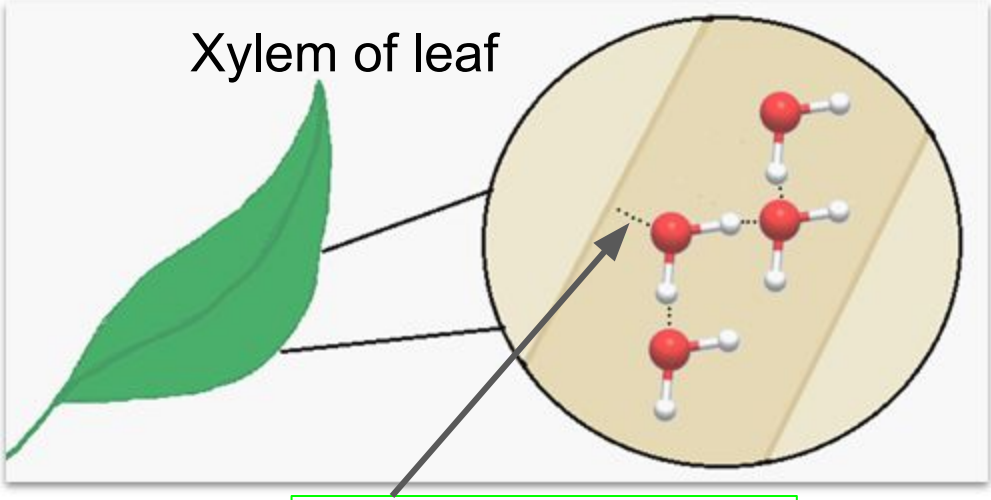
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Properties of Water

Adhesion

The clinging of one molecule to a different molecule

- Due to the polarity of H_2O
- In plants, this allows water to cling to the cell walls to resist the downward pull of gravity



Adhesion: H_2O molecules stick to the xylem wall

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Properties of Water

Capillary Action

The upward movement of water due to the forces of cohesion, adhesion, and surface tension

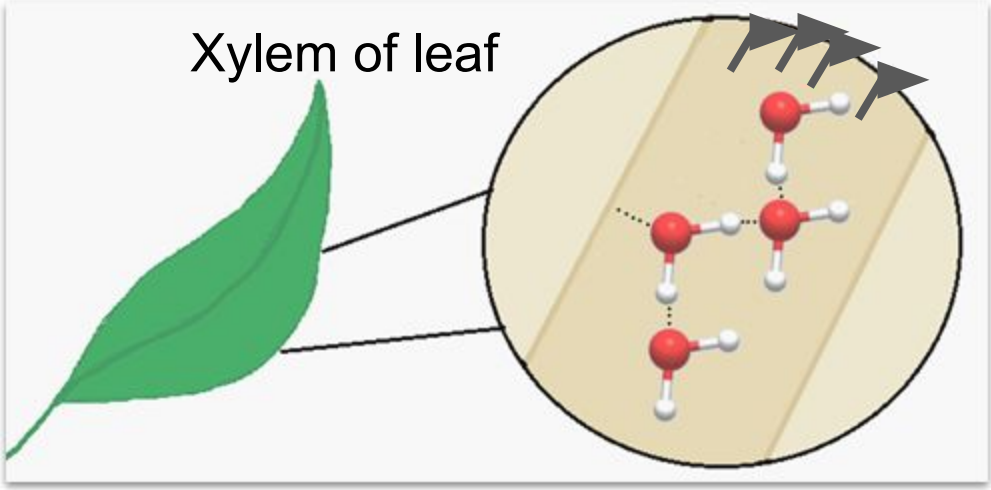
- Occurs when adhesion is greater than cohesion

Properties of Water

Capillary Action

The upward movement of water due to the forces of cohesion, adhesion, and surface tension

- Occurs when adhesion is greater than cohesion
  - Important for transport of water and nutrients in plants



Capillary action occurs moving water upwards

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Properties of Water

Temperature Control

High Specific Heat

- H_2O resists changes in temperature through hydrogen bonds
- Heat must be absorbed to break H bonds, but heat is released when H bonds form

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Properties of Water

Temperature Control

High Specific Heat

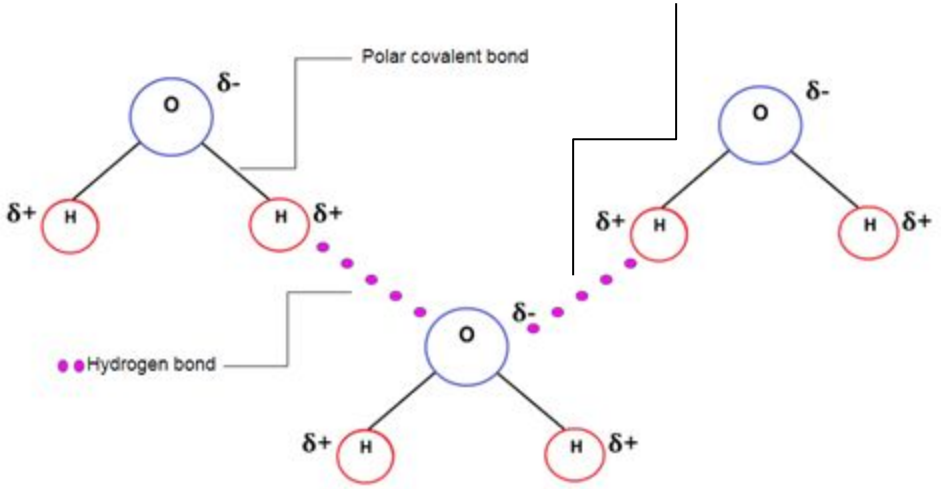
H_2O resists changes in temperature

How?

- Hydrogen bonds! Heat must be absorbed to break hydrogen bonds, but heat is released when hydrogen bonds form

1. Moderates air temperature
- Large bodies of water can absorb heat in the daytime and release heat at night

Temp control properties of H_2O stem from these hydrogen bonds



2. Stabilizes ocean temp
- Benefits marine life

3. Organisms (which are made primarily of H_2O) can <u>resist</u> changes in their own internal temp

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Properties of Water

Evaporative Cooling

- Water has a high **heat of vaporization** (bc of H bonds)
- The molecules with the highest kinetic energy leave as gas

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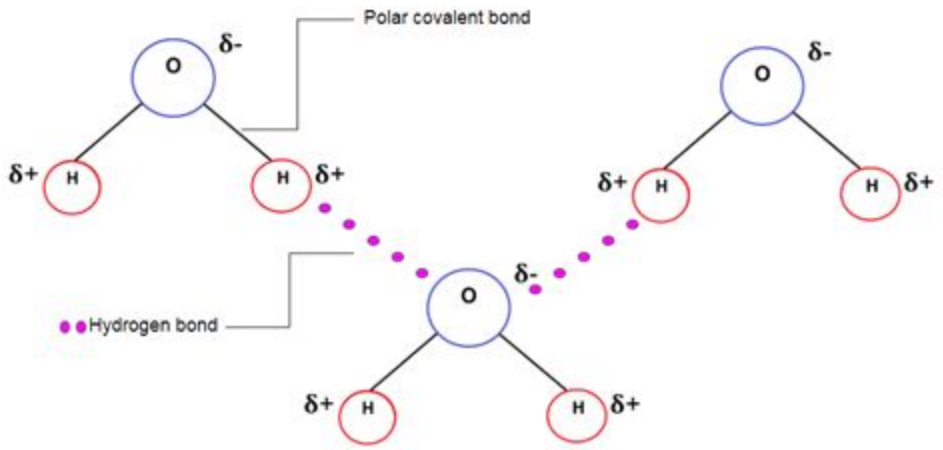
Properties of Water

Evaporative Cooling

Water has a high **heat of vaporization** (same reasons as high specific heat)

The molecules with the highest kinetic energy leave as gas

- Moderates Earth's climate
- Stabilizes temp in lakes and ponds



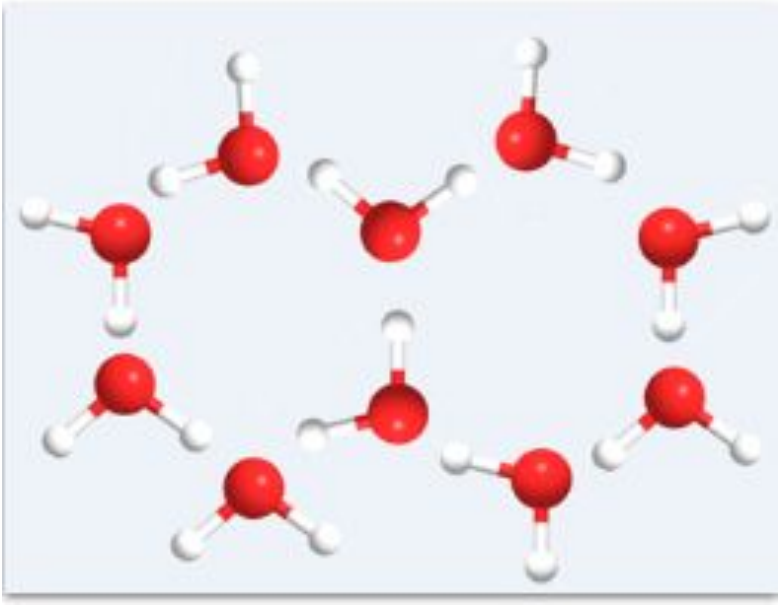
- Prevents terrestrial organisms from overheating (think sweating in humans)
- Prevents leaves from becoming too warm in the sun

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Properties of Water

Floating Ice

- As water solidifies it expands and becomes less dense (bc of H bonds)
- Causes water molecules to form a crystalline structure



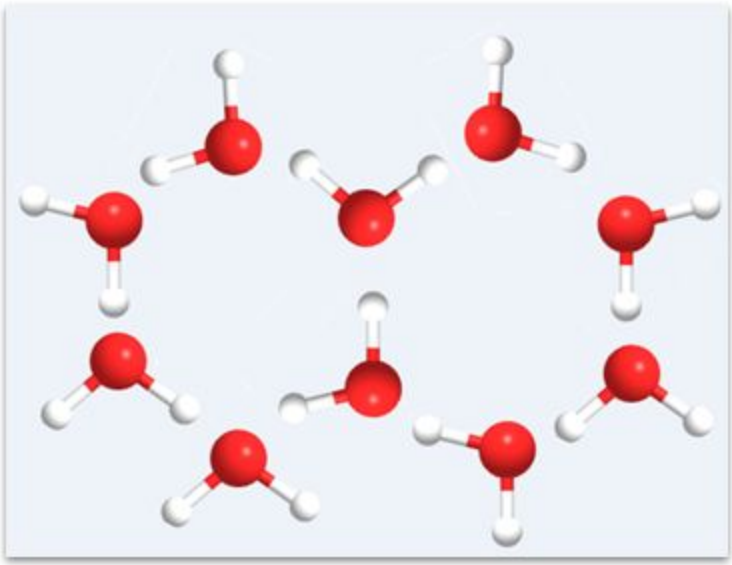
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Properties of Water

Floating Ice

As water solidifies it expands and becomes less dense

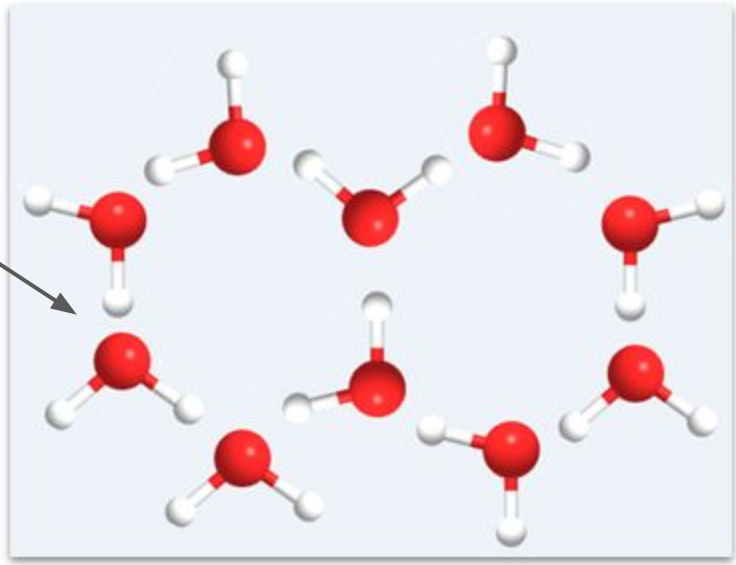
- Due to the hydrogen bonds
  - When cooled, H_2O molecules move too slowly to break the bonds
    - Allows marine life to survive under floating ice sheets



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Properties of Water

Hydrogen bonds cause water molecules to form a crystalline structure



Quick! Think, Pair, Share

Imagine the 3D crystalline structure of ice. How many hydrogen bonds can one molecule of water make with its neighboring water molecules?

Answer: four

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Properties of Water

Solvent

Versatile solvent: its polar molecules are attracted to ions and other polar molecules it can form H bonds with

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Properties of Water

Solvent

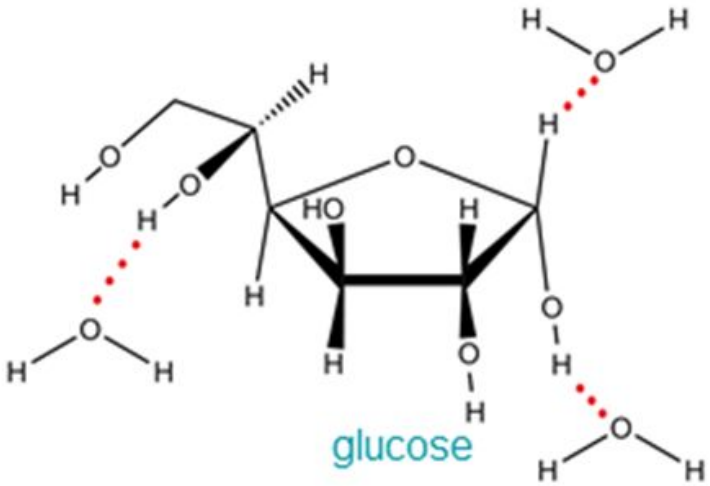
Water is a versatile solvent: its polar molecules are attracted to ions and other polar molecules it can form hydrogen bonds with

Solution: homogenous mix of 2+ substances
Solvent: dissolving agent in a solution
Solute: substance that is dissolved

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Properties of Water

- “Like dissolves like”
- Can interact with sugars or proteins containing many O and H
  - Forms H bonds with the sugar or protein to dissolve it

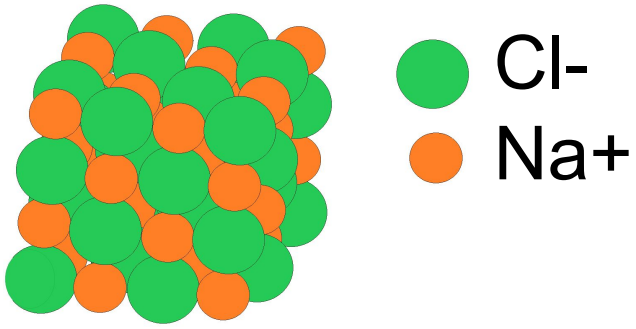


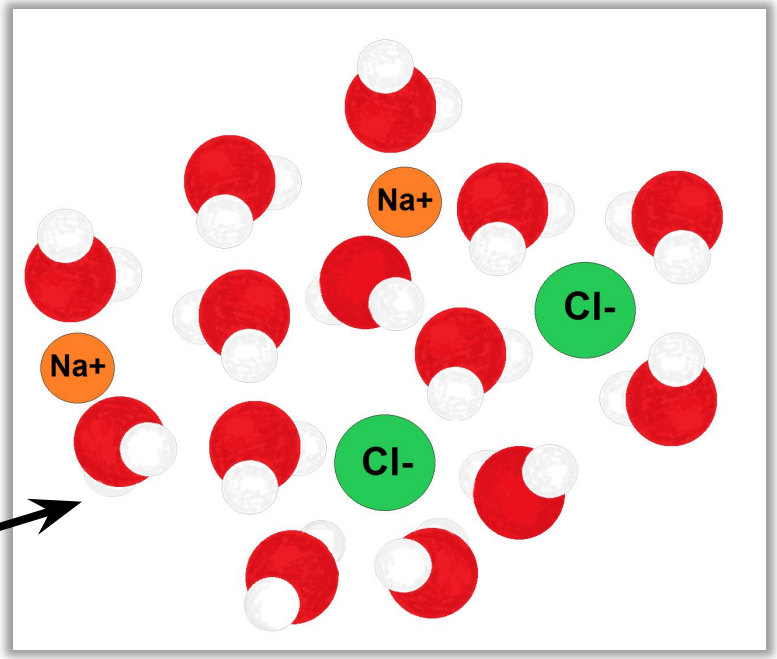
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Properties of Water

Ionic compounds

- Partially (-) O in H_2O will interact with a (+) atom
- Partially (+) H in H_2O will interact with a (-) atom
- Dissolves ions





Na+ surrounded by oxygen

Cl- surrounded by hydrogen

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