Life' asis

OH NO!!!! CHEMISTRY!!!

Impacts, Issues: What Are You_Worth_

- Each of us is a collection of elements
- Elements are fundamental substances that consist of only one kind of atom
- An atom is the smallest unit of an element that still retains the element's properties

Impacts, Issues:
What Are You Worth?

- Fifty-eight elements make up the human body

All of the elements in the human body could be bought for $118.63.

Elements in a Human Body

Element	Number of Atoms (x 10^{15})	Retail Cost
Hydrogen	41,808,044,129,611	$ 0.028315
Oxygen	16,179,356,725,877	0.021739
Carbon	8,019,515,931,628	6.400000
Nitrogen	773,627,553,592	9.706929
Phosphorus	151,599,284,310	68.198594
Calcium	150,207,096,162	15.500000
Sulfur	26,283,290,713	0.011623
Sodium	26,185,559,925	2.287748
Potassium	21,555,924,426	4.098737
Chlorine	16,301,156,188	1.409496
Magnesium	4,706,027,566	0.444909
Fluorine	823,858,713	7.917263
Iron	452,753,156	0.054600
Silicon	214,345,481	0.370000
Zinc	211,744,915	0.088090
Rubidium	47,896,401	1.087153
Strontium	21,985,848	0.177237
Bromine	19,588,506	0.012858
Boron	10,023,125	0.002172
Copper	6,820,886	0.012961
Lithium	6,071,171	0.024233
Lead	3,486,486	0.003960
Cadmium	2,677,674	0.010136
Titanium	2,515,303	0.010920
Cerium	1,718,576	0.043120
Chromium	1,620,894	0.003402
Nickel	1,538,503	0.031320
Manganese	1,314,936	0.001526
Selenium	1,143,617	0.037949
Tin	1,014,236	0.005387
Iodine	948,745	0.094184
Arsenic	562,455	0.023576
Germanium	414,543	0.130435
Molybdenum	313,738	0.001260
Cobalt	306,449	0.001509
Cesium	271,772	0.000016
Mercury	180,069	0.004718
Silver	111,618	0.013600
Antimony	98,883	0.000243
Niobium	97,195	0.000624
Barium	96,441	0.028776
Gallium	60,439	0.003367
Yttrium	40,627	0.005232
Lanthanum	34,671	0.000566
Tellurium	33,025	0.000722
Scandium	26,782	0.058160
Beryllium	24,047	0.000218
Indium	20,972	0.000600
Thallium	14,727	0.000894
Bismuth	14,403	0.000119
Vanadium	12,999	0.000322
Tantalum	6,654	0.001631
Zirconium	6,599	0.000830
Gold	6,113	0.001975
Samarium	2,002	0.000118
Tungsten	655	0.000007
Thorium	3	0.004948
Uranium	3	0.000103
Total	67,179,218,505,055 x 10^{15}	**$118.63**

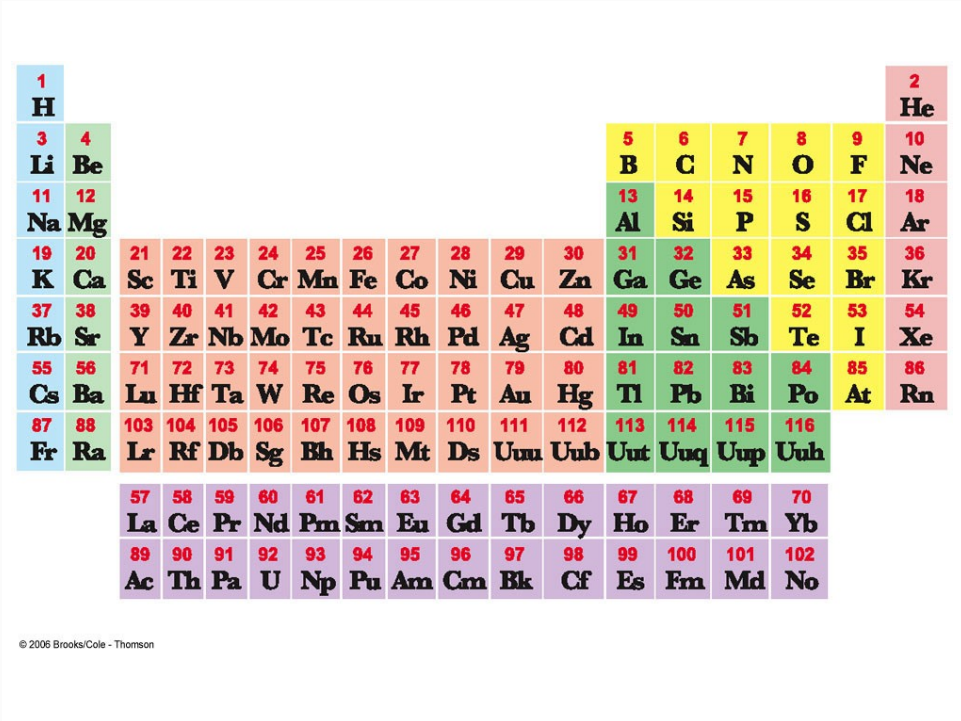
Most Common Elements in Living Organisms

Oxygen

Hydrogen

Carbon

Nitrogen



The periodic table is an arrangement of elements based on their chemical properties

Elements

- Fundamental forms of matter
- Can’t be broken apart by normal means
- 92 occur naturally on Earth

Characteristics of Atoms

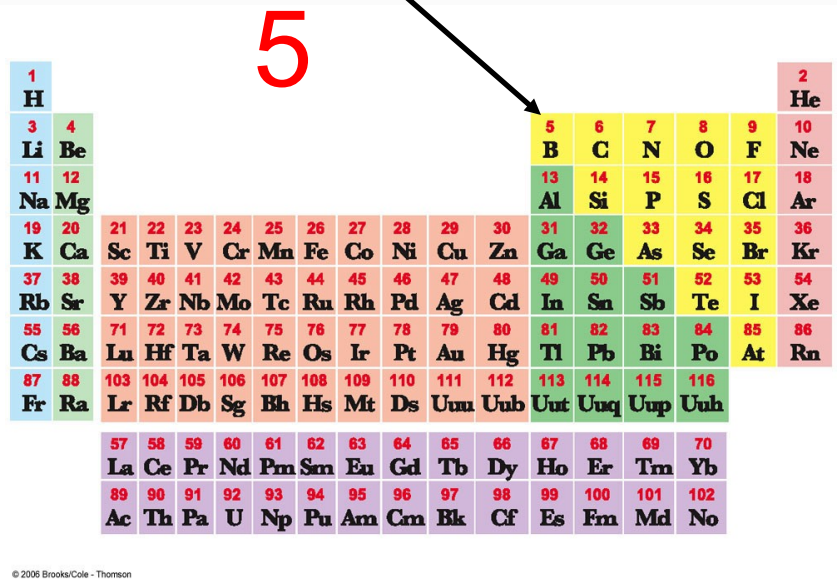
- **Atoms** are the building blocks of all substances
  - Made up of electrons, protons and neutrons
- **Electrons (e^-)** have a negative charge
  - Move around the nucleus
- **Charge** is an electrical property
  - Attracts or repels other subatomic particles

Characteristics of Atoms

- The **nucleus** contains protons and neutrons
  - **Protons (p^+)** have a positive charge
  - **Neutrons** have no charge
- Atoms differ in number of subatomic particles
  - **Atomic number** (number of protons) determines the element
    - Atomic number of hydrogen = 1
    - Atomic number of carbon = 6
  - **Elements** consist only of atoms with the same atomic number

What's the atomic number of Boron (B)?

5



How many protons does Boron have?

5

Characteristics of Atoms

- **Isotopes**
  - Different forms of the same element, with different numbers of neutrons
    - Carbon 12 has 6 protons, 6 neutrons
    - Carbon 14 has 6 protons, 8 neutrons
- **Mass number**
  - Total protons and neutrons in a nucleus
  - Used to identify isotopes

6

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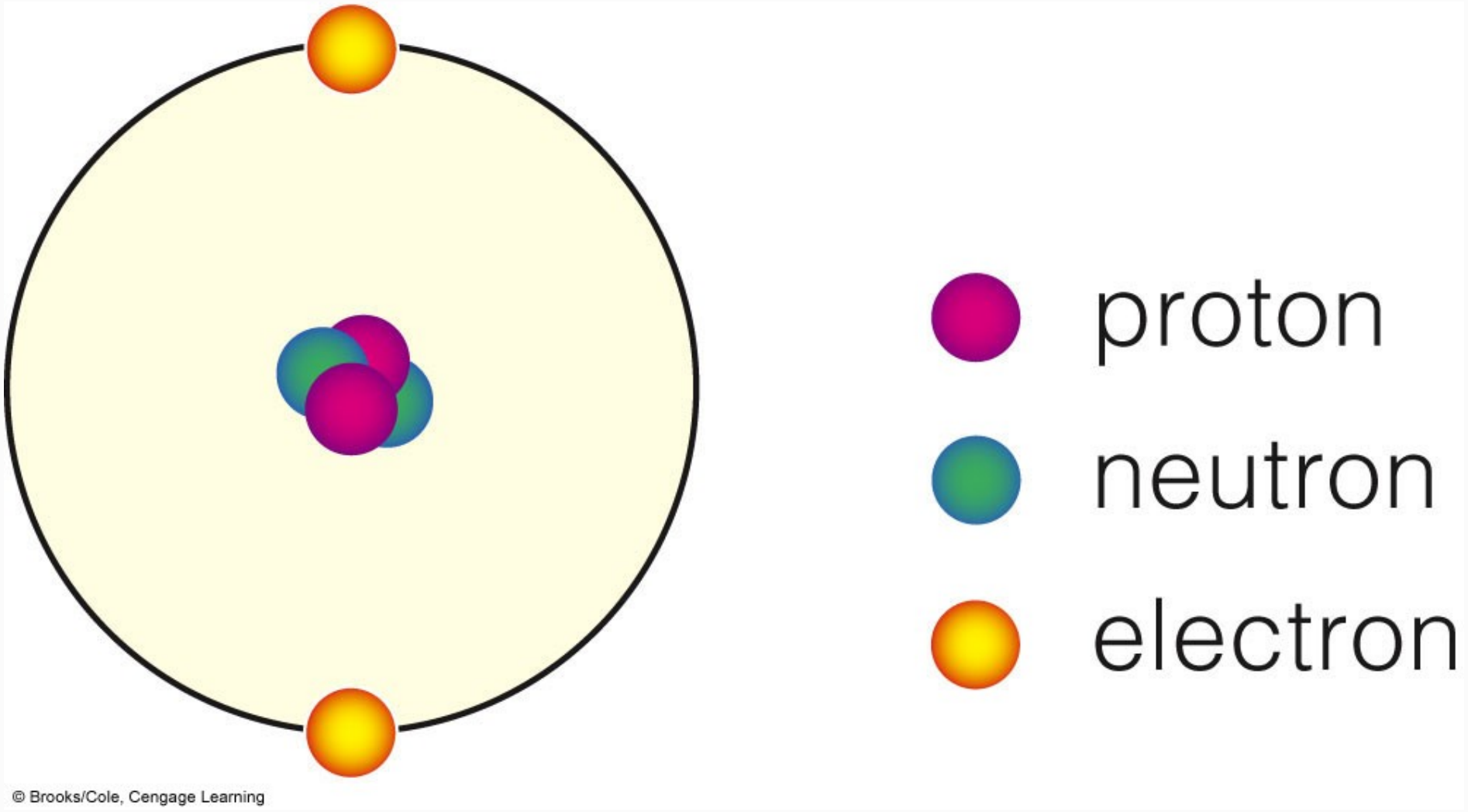
How many protons does Carbon 16 have?
How many neutrons does Carbon 16 have?
What is the mass number of an atom with 8 protons and 12 neutrons?

Atoms



Key Concepts:
Atoms and Elements

- *Atoms are particles that are the building blocks of all matter; they can differ in numbers of protons, electrons, and neutrons*

- *Elements are pure substances, each consisting entirely of atoms with the same number of protons*

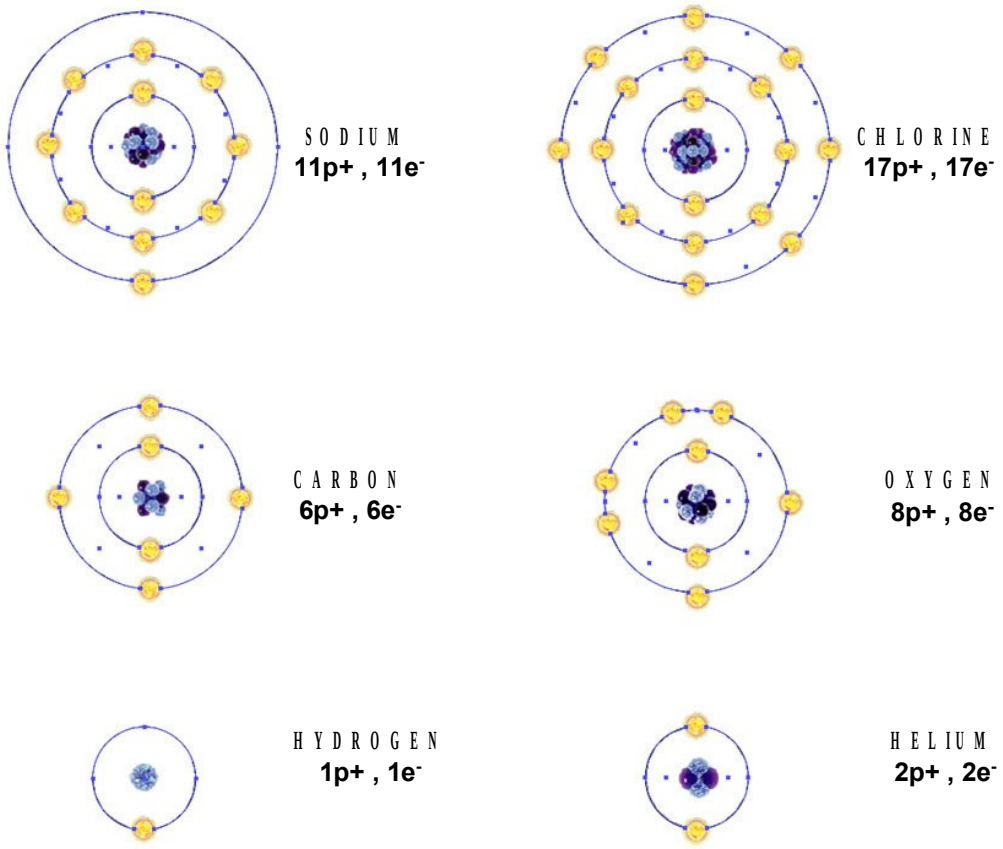
Why Electrons Matter

- Atoms acquire, share, and donate electrons
- Whether an atom will interact with other atoms depends on how many electrons it has

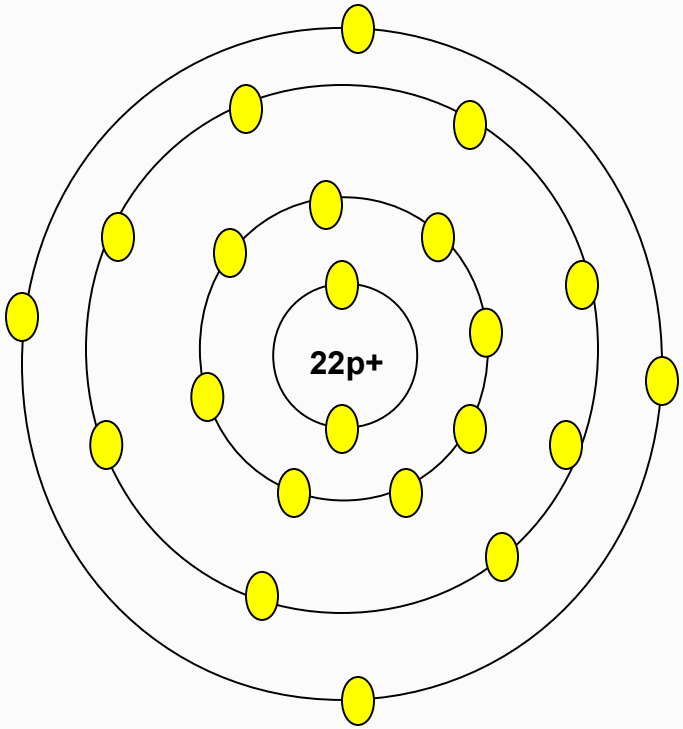
Shell Model

Problem: Draw a shell model for the made up atom Renfieldium, which has 22 protons.

- First shell
  - Lowest energy
  - Holds 1 orbital with up to 2 electrons
- Second shell
  - 4 orbitals hold up to 8 electrons



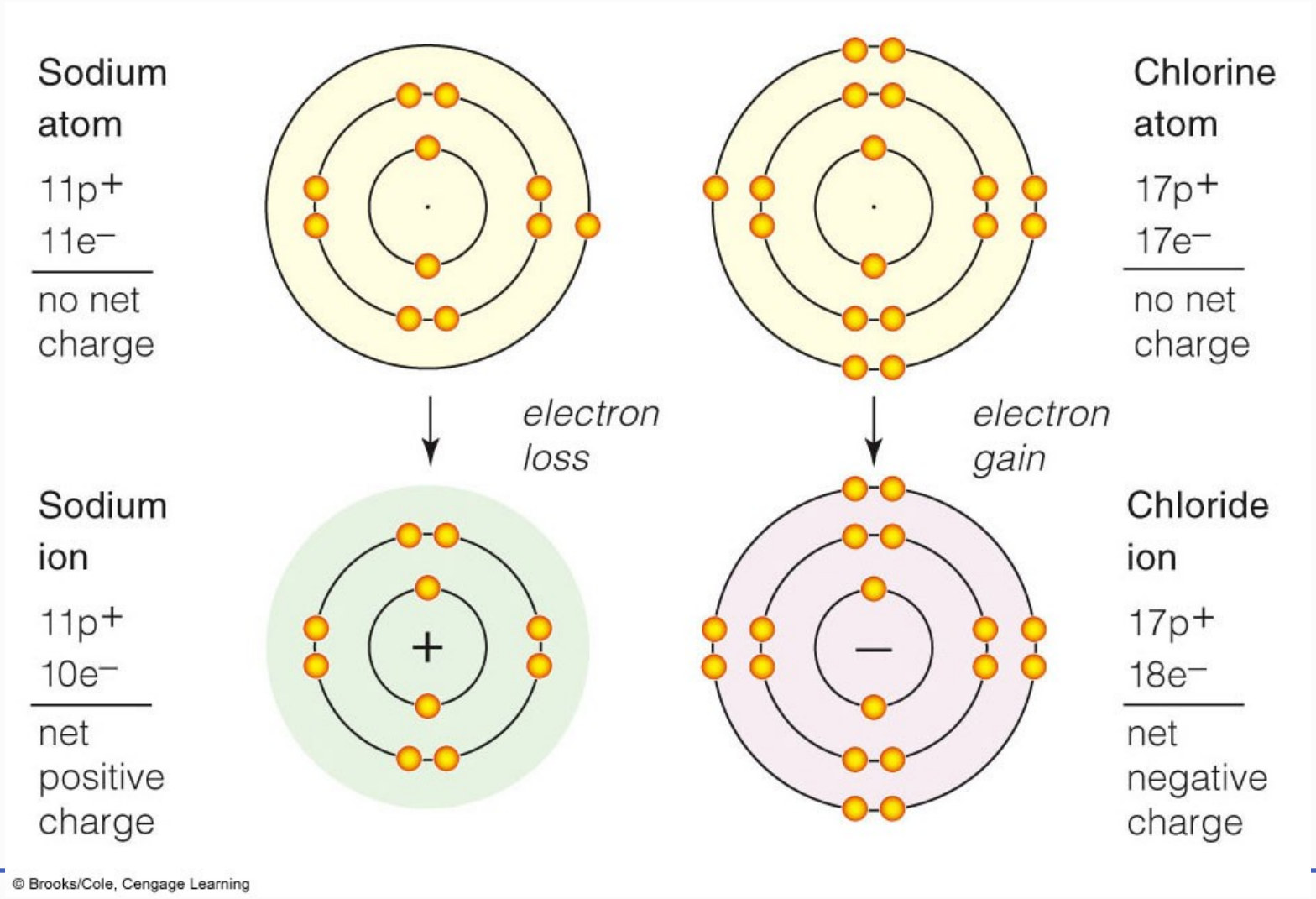
An atom of Renfieldium has 22 protons, which means it has 22 electrons



Atoms and Ions

- **Ion**
  - An atom with a positive or negative charge due to loss or gain of electrons in its outer shell
  - *Examples:* Na^+, Cl^-

Ion Formation



From Atoms to Molecules

- **Chemical bond**
  - An attractive force existing between two atoms when their electrons interact
- **Molecule**
  - Two or more atoms joined in chemical bonds

Important Bonds in Biological Molecules

Ionic Bonds

Covalent Bonds

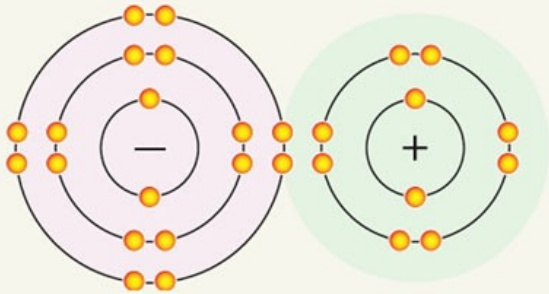
Hydrogen Bonds

Ionic Bonding

- **Ionic bond**
  - A strong mutual attraction between two oppositely charged ions (an electron is not transferred)
  - *Example:* NaCl (table salt)

Ionic Bonds

A A crystal of table salt is a cubic lattice of many sodium and chloride ions.



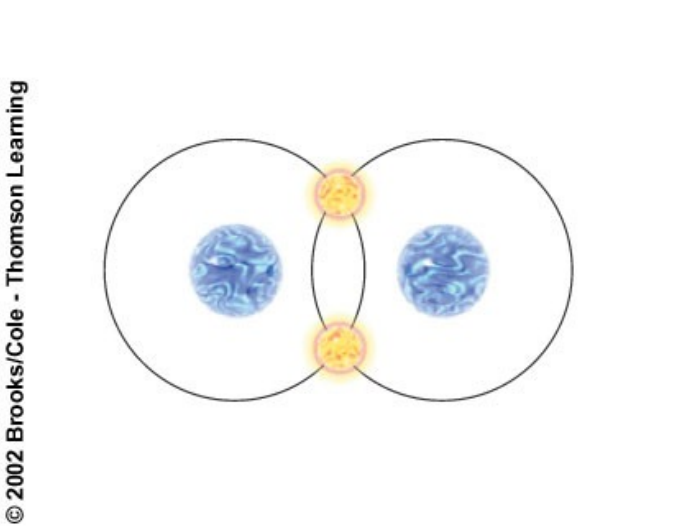
Chloride ion
$17p^+$, $18e^-$

Sodium ion
$11p^+$, $10e^-$

B The mutual attraction of opposite charges holds the two kinds of ions together in a lattice.

Covalent Bonding

Atoms share a **pair or pairs** of electrons to fill outermost shell

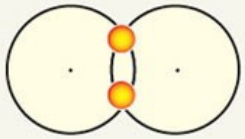


- Single covalent bond
- Double covalent bond
- Triple covalent bond

Characteristics of Covalent Bonds

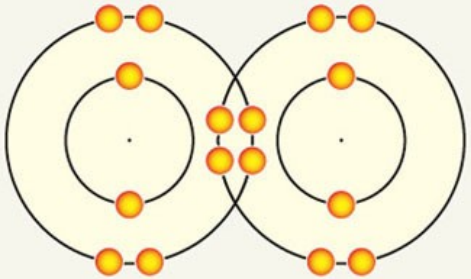
- **Nonpolar covalent bond**
  - Atoms sharing electrons equally
- **Polar covalent bond**
  - Atoms do not share electrons equally; one atom has a more negative charge, the other is more positive

Covalent Bonds



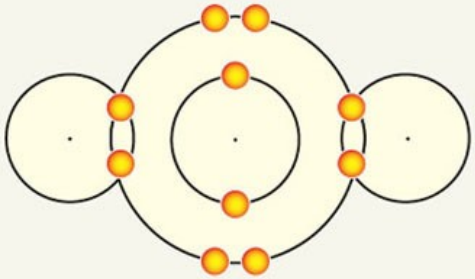
Molecular hydrogen (H—H)

Two hydrogen atoms, each with one proton, share two electrons in a nonpolar covalent bond.



Molecular oxygen (O = O)

Two oxygen atoms, each with eight protons, share four electrons in a double covalent bond.



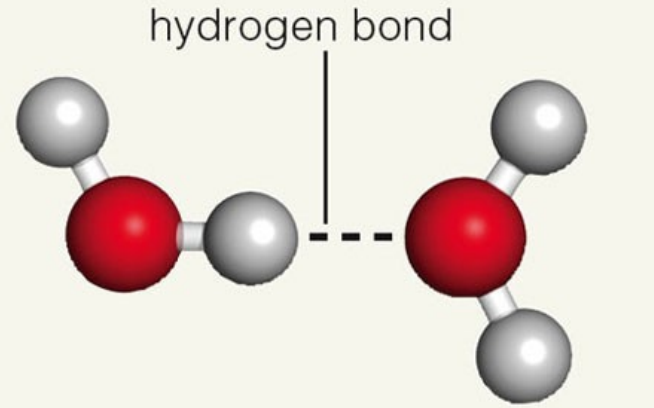
Water molecule (H—O—H)

Two hydrogen atoms share electrons with an oxygen atom in two polar covalent bonds. The oxygen exerts a greater pull on the shared electrons, so it has a slight negative charge. Each hydrogen has a slight positive charge.

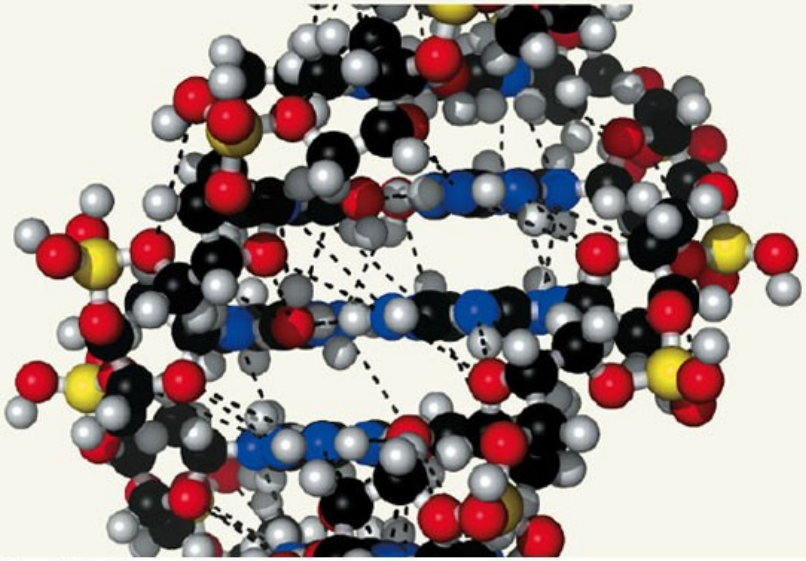
Hydrogen Bonding

- **Hydrogen bond**
  - A weak attraction between an atom and a hydrogen atom taking part in a separate polar covalent bond
  - Hydrogen bonds do not form molecules and are not chemical bonds
  - Hydrogen bonds stabilize the structures of large biological molecules

Hydrogen Bonds



A A hydrogen (H) bond is an attraction between an electronegative atom and a hydrogen atom taking part in a separate polar covalent bond.



B Hydrogen bonds are individually weak, but many of them form. Collectively, they are strong enough to stabilize the structures of large biological molecules such as DNA, shown here.

Yay Water!!!

Life began in water
Single most important molecule on Earth
All organisms are 70-90% water
Water has unique properties that make it a life-supporting substance.

Properties of Water

Polarity

Solvent

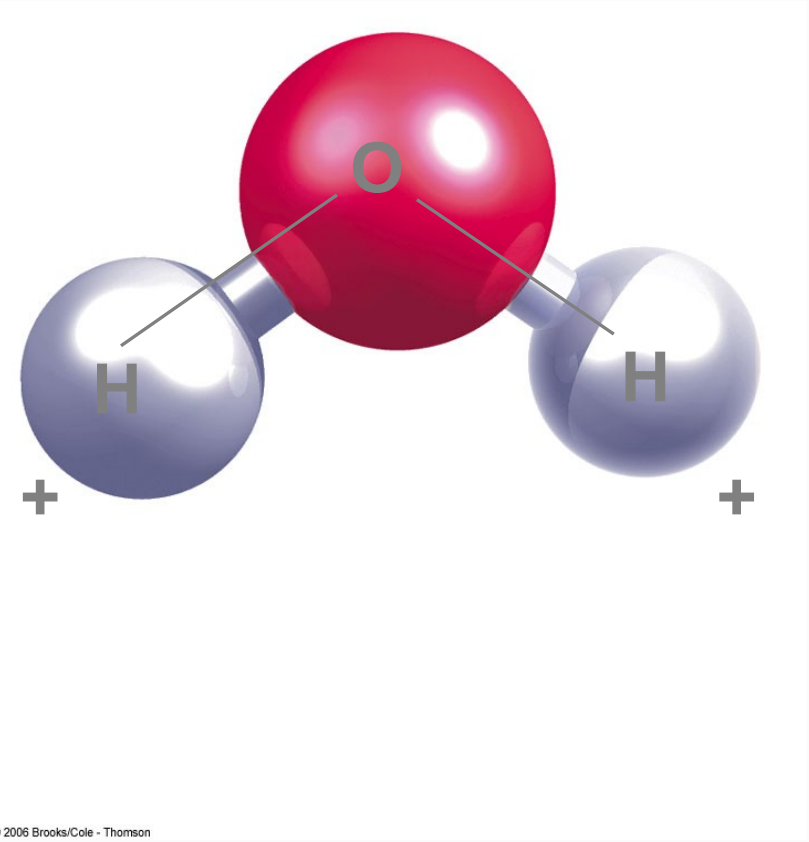
Temperature-Stabilizing

Cohesive & Adhesive

Varying Densities

Water Is a Polar Covalent Molecule

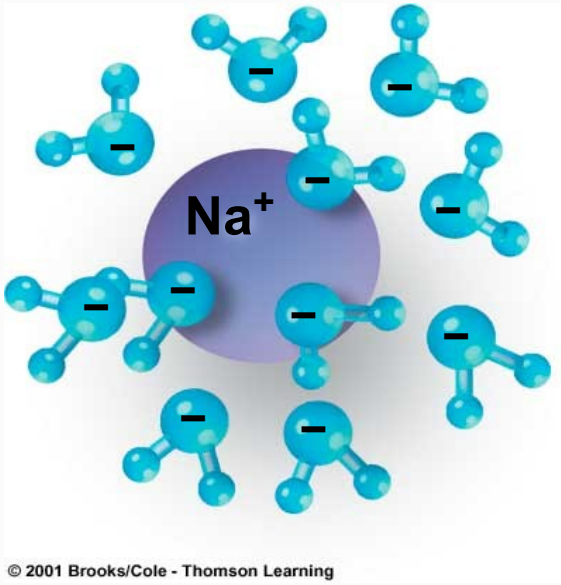
- Molecule has no net charge
- Oxygen end has a slight negative charge
- Hydrogen end has a slight positive charge
- Why do you think this is important?

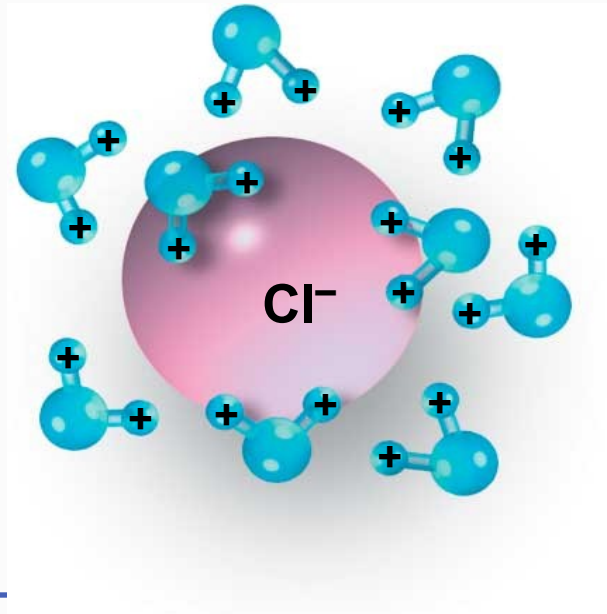


Water Is a Good Solvent

- Some molecules dissolve easily in water

- When solute dissolves, water molecules cluster around its ions or molecules and keep them separated
  - Polar molecules dissolved by water are **hydrophilic** (water-loving)
  - Nonpolar **(hydrophobic)** molecules are not dissolved by water



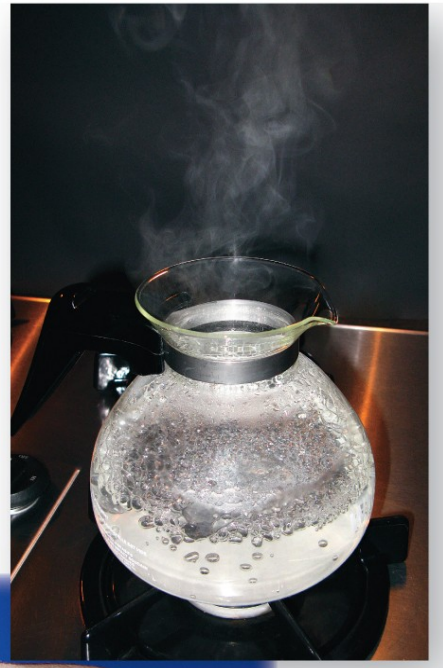


Temperature-Stabilizing Effects

- Liquid water can absorb much heat before its temperature rises
- Why?
- Much of the added energy disrupts hydrogen bonding rather than increasing the movement of molecules
- Temperature of water rises and falls slowly
- Why do you think this is important?

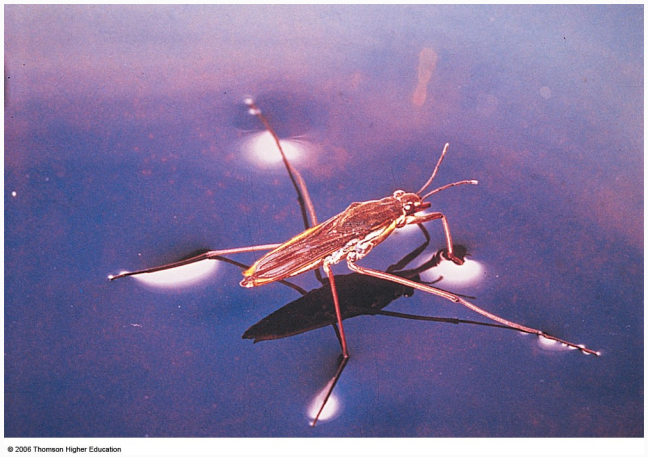
Evaporation of Water

- Large energy input can cause individual molecules of water to break free into air
- As molecules break free, they carry away some energy (lower temperature)
- Evaporative water loss is used by mammals to lower body temperature



Water Cohesion & Adhesion

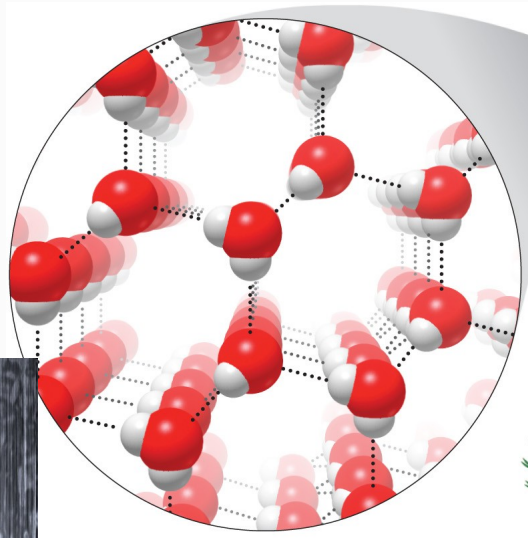
- Hydrogen bonding holds molecules in liquid water together
- Water is an excellent transport system both inside and outside organisms.
- Why is this important?

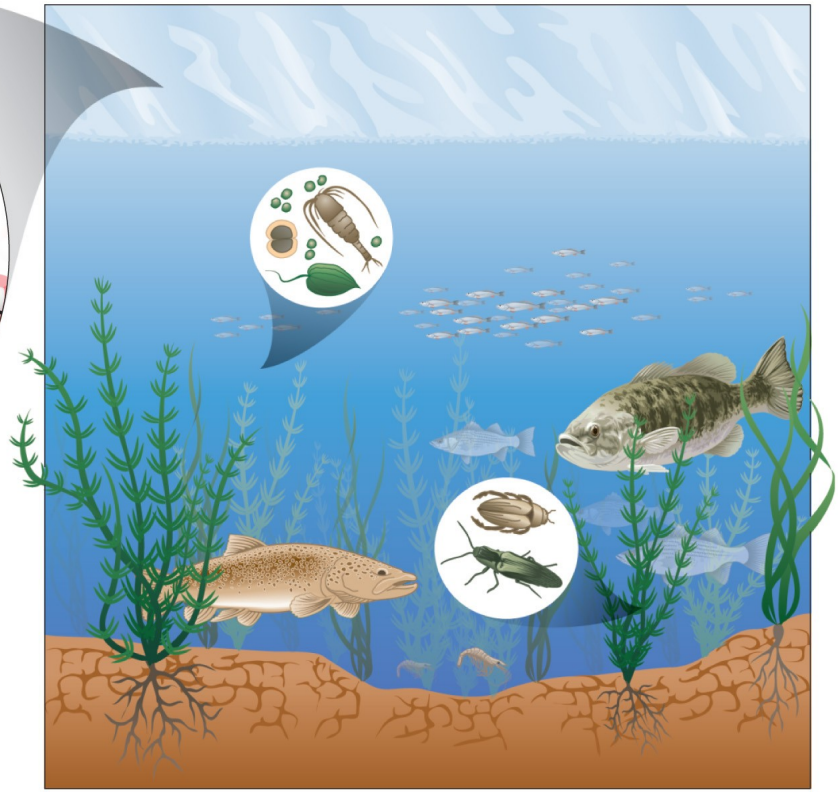


Water's Varying Density

- Water is less dense than ice. Ice floats.

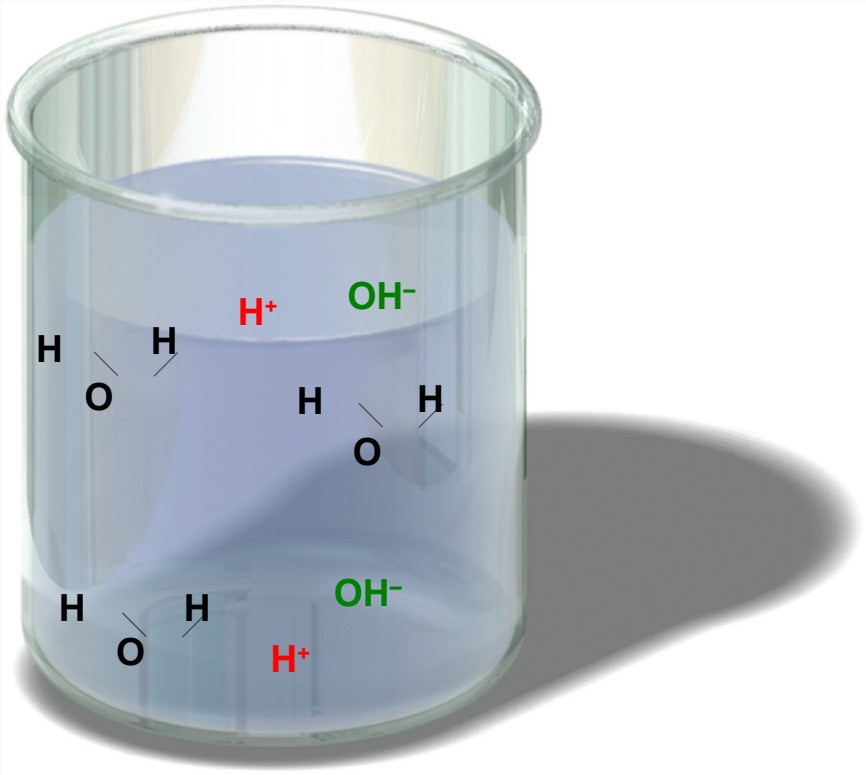
- Why is this important?





Acids and Bases

- Water dissociates into an equal number of hydrogen ions (H^+) and hydroxide ions (OH^-)



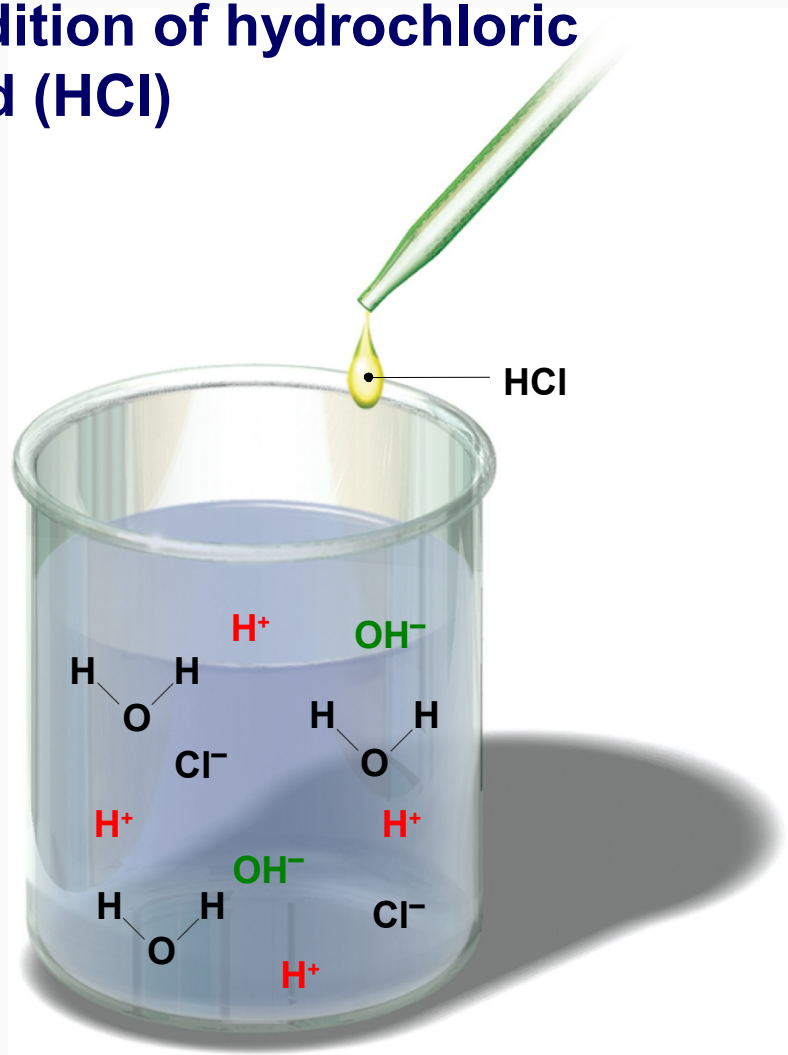
Acids

- Substances that dissociate in water, releasing H^+ ions
- Adding an acid to water increases the number of H^+ ions.
- What are some examples of acids?

$$HCl \longrightarrow H^+ + Cl^-$$

Hydrochloric acid

Addition of hydrochloric acid (HCl)



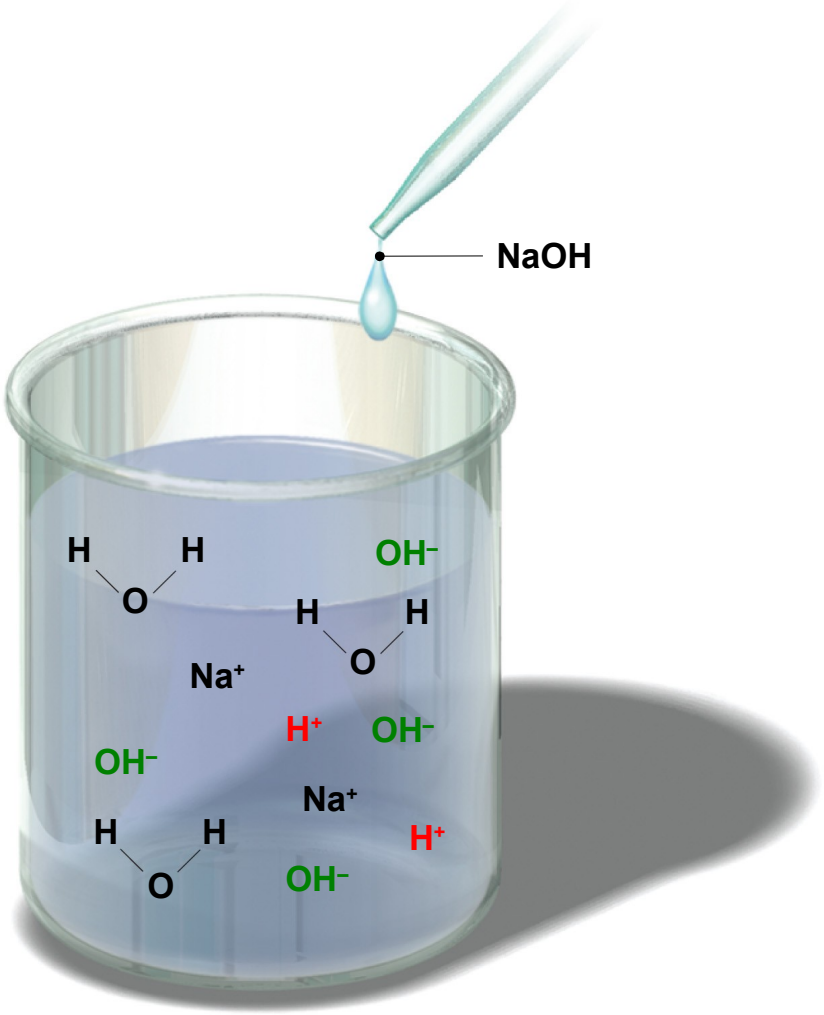
Bases

- Substances that either take up hydrogen ions or release hydroxide ions
- Adding a base to water either increases the number of OH^- ions or decreases the number of H^+ ions.

$$NaOH \longrightarrow Na^+ + OH^-$$

Sodium hydroxide

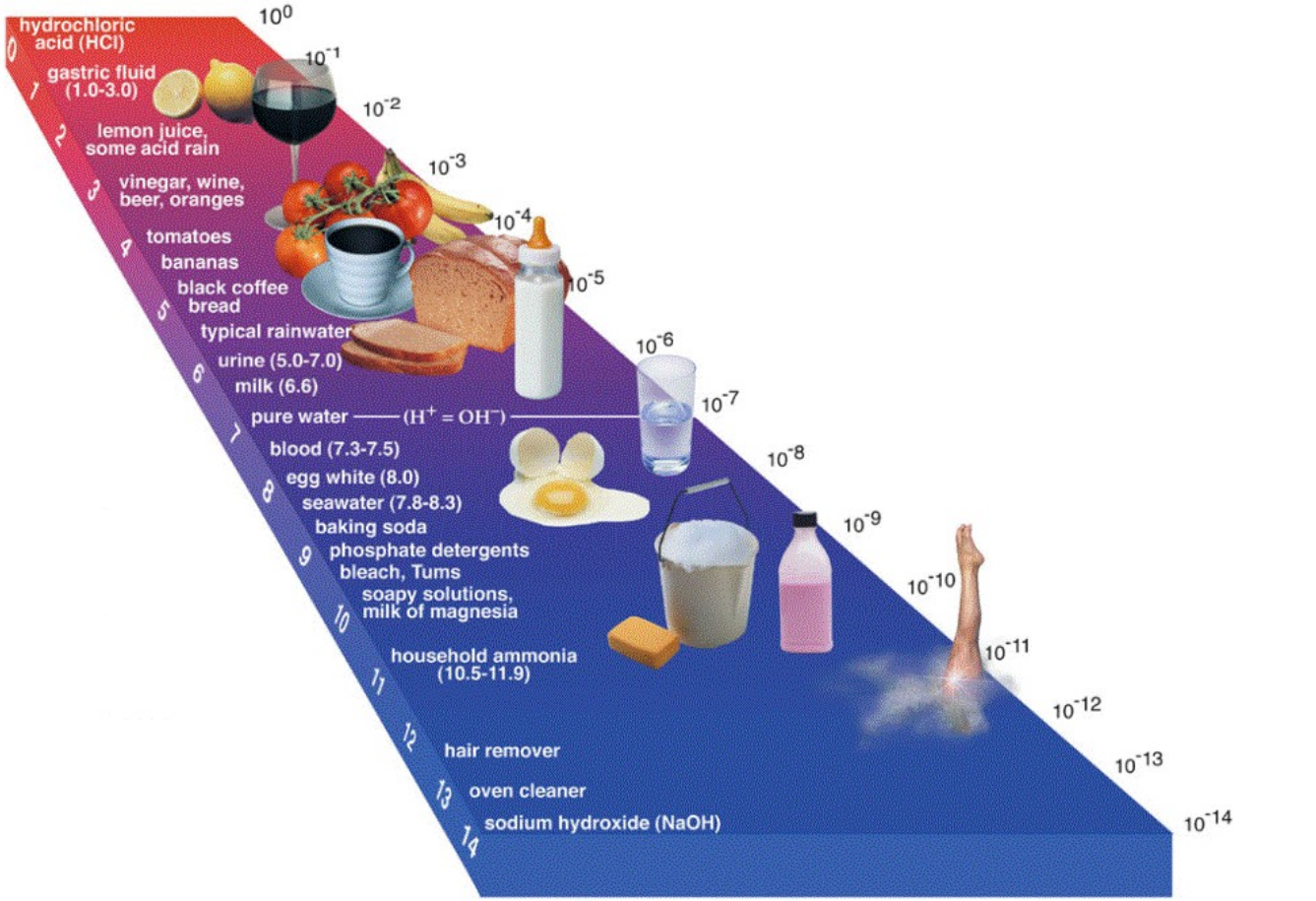
Addition of sodium hydroxide (NaOH), a base



The pH Scale

- **pH** is a measure of the number of hydrogen ions in a solution
  - pH scale ranges from 0 to 14
    - pH below 7 acidic – more $[H^+]$ than $[OH^-]$
    - pH above 7 basic – more $[OH^-]$ than $[H^+]$
    - pH of 7 neutral – $[H^+]$ equal to $[OH^-]$

The pH Scale



Salts & Buffers

- Salts are compounds that release ions other than H^+ and OH^- when dissolved in water
- Example: NaCl releases Na^+ and Cl^-

- Buffers are substances that keep pH within normal limits. They resist pH change by taking up excess H+ or OH-
  - For example, buffers in the blood maintain the pH of blood at 7.4
  - Why is this important?

Importance of buffers – an example

- If the pH of the body gets too low (below 7.4), a condition known as acidosis results.
- Many of the chemical reactions that occur in the body, especially those involving proteins, are pH-dependent.
- If the pH drops below 6.8 or rises above 7.8, death may occur.