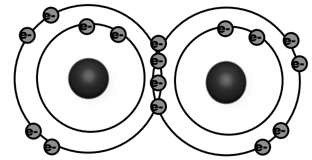
Topics

- Water- life's elixir
- Introduction to Organic Chemistry
  - Acids / Bases
  - Buffers
  - Hydrocarbons
  - Functional groups

Review: Covalent vs. Ionic bonds

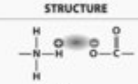
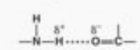
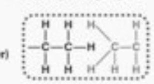
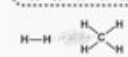


- Two or more atoms joined in a bond are now referred to as a **molecule**
- Covalent bonds are stronger than ionic bonds
- Ionic bonds: steal e-   Covalent bonds: share e-
- Atoms will typically share the same number of electrons they need to fill their outer orbital

Equal Sharing is NONpolar

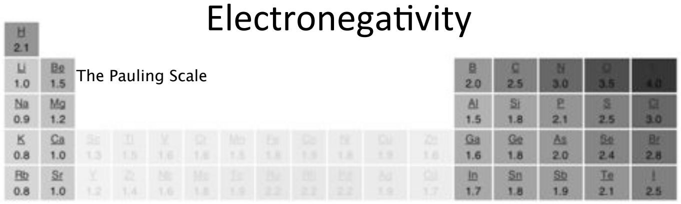
The hydrogen atoms have equal **electronegativity**. The negatively charged electrons are shared **equally**. This is a **nonpolar** covalent bond.

TABLE 2.1 Chemical Bonds and Interactions

NAME	BASIS OF INTERACTION	STRUCTURE	BOND ENERGY*
Ionic attraction	Attraction of opposite charges		3–7
Covalent bond	Sharing of electron pairs		50–110
Hydrogen bond	Sharing of H atom		3–7
Hydrophobic interaction	Interaction of nonpolar substances in the presence of polar substances (especially water)		1–2
van der Waals interaction	Interaction of electrons of nonpolar substances		1

*Bond energy is the amount of energy (Kcal/mol) needed to separate two bonded or interacting atoms under physiological conditions.

Electronegativity



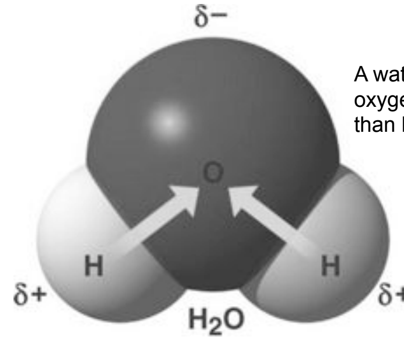
Element	Strength
F	4.0
O	3.5
N	4.0
S	2.5
C	2.5
H	2.1
P	2.1

* A difference of less than 0.5 results in mostly ***equal*** sharing (nonpolar)

Polar covalent bonds: unequal sharing of electrons

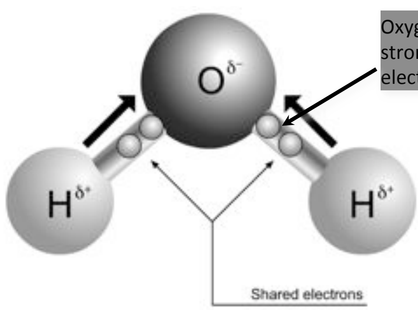
Electronegativity is the attraction of an atom for electrons.

There is a partial negative charge on the oxygen and partial positive charges on the hydrogen atoms.



A water molecule is polar because oxygen is more electronegative than hydrogen.

Oxygen Does Not Share Well- Polar covalent bond



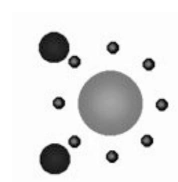
Oxygen's **electronegativity** is stronger and pulls the electrons closer

The hydrogen and oxygen atoms have **unequal** electronegativity. The negatively charged electrons are closer to the oxygen and give it a **partial negative charge** (δ^-).

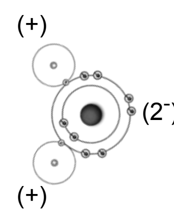
Water is a Polar Substance

- Because the water molecule does not share electrons equally, it is "**polar**".
- Molecules containing covalent bonds with powerfully electronegative atoms will be polar.

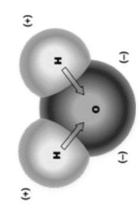
(most important ones are **Oxygen** and **Nitrogen**)



Water



Water



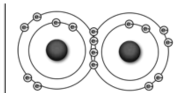
Water

Electronegativity

Element	Strength
F	4.0
O	3.5
N	3.0
S	2.5
C	2.5
H	2.1
P	2.1

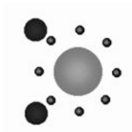
H_2

NONpolar



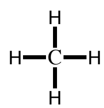
O_2

NONpolar



H_2O

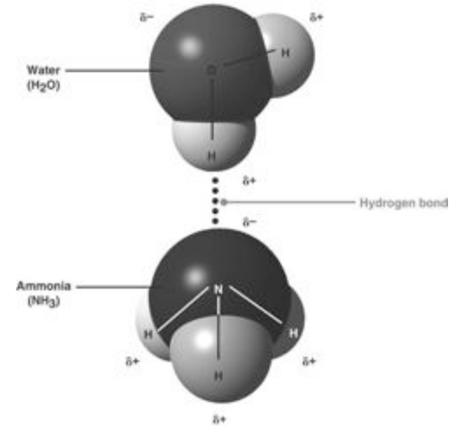
POLAR



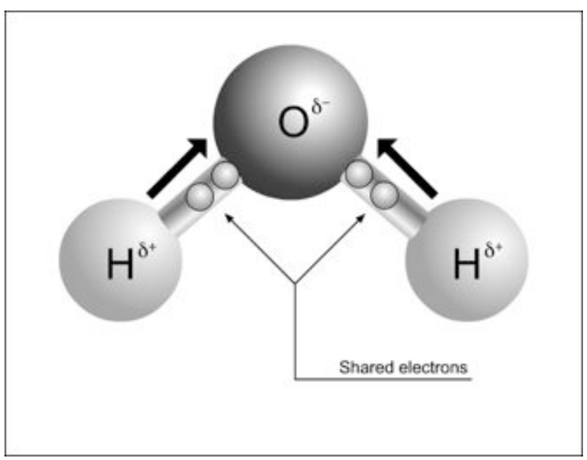
CH_4 (Methane)

NONpolar

Hydrogen Bonds



Polar covalent bonds vs. **hydrogen bonds**

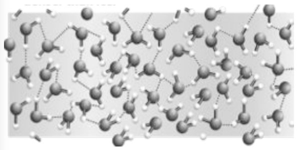


State of Water is Determined by Hydrogen Bonds

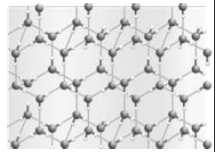
All three states of water exist on Earth

Hydrogen Bonds Account for High Heat Capacity of Water

Liquid water



Ice



Less dense H-bonds

All four hydrogen bonds must be broken for liquid water to become vapor, resulting in **high heat of vaporization**

Water vapor at boiling

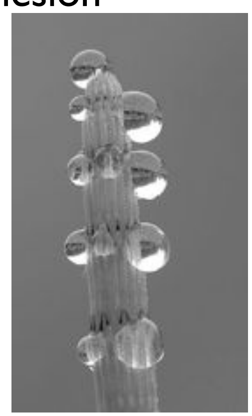
Hydrogen Bonds Create Water Tension

Cohesion vs. Adhesion

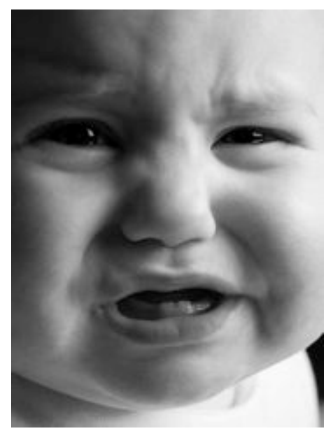
Because of water's excellent solvent properties, and powerful hydrogen bonds, it is excellent at cohesion, adhesion, and **capillary action**.

Cohesion, the binding together of like molecules. Gives water the ability to resist coming apart when under pressure.

Adhesion, the binding together of different molecules.



Capillary Action

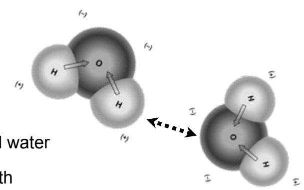


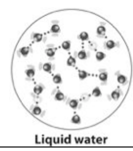
Crying would be impossible without the capillary action of water.

Tiny **cannaliculi** transfer the liquid tears.

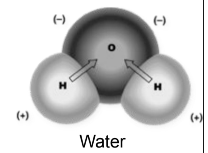
Hydrogen Bonds Account For Much of Water’s Properties

- **Cohesion/Adhesion** - The binding together of molecules, often by hydrogen bonds.
  - Surface tension
  - Capillary action
- The three states of water
  - Solid, liquid, vapor
  - Ice is less dense than liquid water
  - All three states exist on earth
- High **heat capacity**
  - High **heat of vaporization**



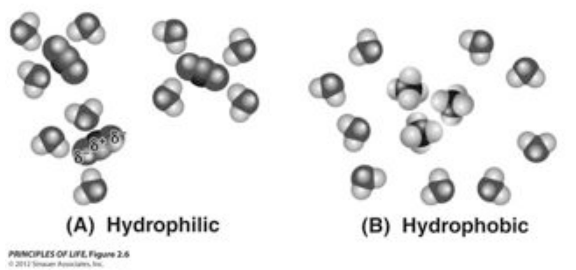


Polar and nonpolar substances



- Polar substances
  - Water interacts through H-bonds
  - Any polar substance can interact with others through H-bonds
  - Hydrophilic- water loving
- Nonpolar substances
  - Nonpolar interacts with nonpolar
  - Aggregate with one another and not with water
  - Hydrophobic- water hating

Hydrophillic vs Hydrophobic



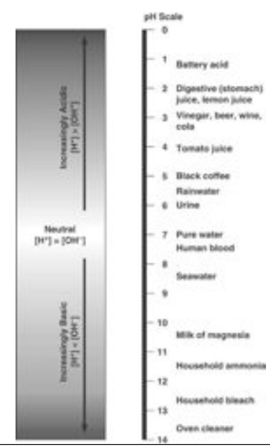
Molecules with polar covalent bonds are attracted to water
= **hydrophillic**
Molecules with nonpolar covalent bonds are more attracted to each other
= **hydrophobic**

Understanding acids and bases

Important definitions:

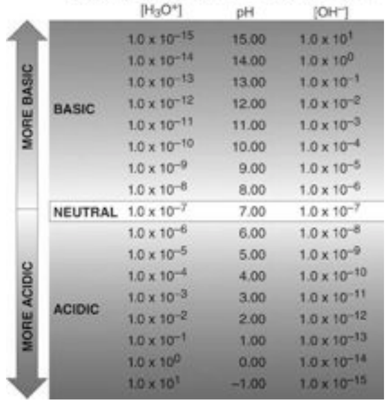
Hydronium ion (H_3O^+ or H^+)
Acids
Bases
pH scale

$$pH = -\log[H^+]$$



Understanding acids and bases

Typical scale ranges from pH of 0-14



	$[H_3O^+]$	pH	$[OH^-]$
	1.0×10^{-15}	15.00	1.0×10^{1}
	1.0×10^{-14}	14.00	1.0×10^{0}
	1.0×10^{-13}	13.00	1.0×10^{-1}
BASIC	1.0×10^{-12}	12.00	1.0×10^{-2}
	1.0×10^{-11}	11.00	1.0×10^{-3}
	1.0×10^{-10}	10.00	1.0×10^{-4}
	1.0×10^{-9}	9.00	1.0×10^{-5}
	1.0×10^{-8}	8.00	1.0×10^{-6}
NEUTRAL	1.0×10^{-7}	7.00	1.0×10^{-7}
	1.0×10^{-6}	6.00	1.0×10^{-8}
	1.0×10^{-5}	5.00	1.0×10^{-9}
	1.0×10^{-4}	4.00	1.0×10^{-10}
	1.0×10^{-3}	3.00	1.0×10^{-11}
ACIDIC	1.0×10^{-2}	2.00	1.0×10^{-12}
	1.0×10^{-1}	1.00	1.0×10^{-13}
	1.0×10^{0}	0.00	1.0×10^{-14}
	1.0×10^{1}	−1.00	1.0×10^{-15}

Definitions of Acids and Bases

An acid is a substance that donates a proton H^+.

A base is a substance that accepts a proton H+.

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

acid *base*

$H_2O + NH_3 \rightarrow OH^- + NH_4^+$

Hydronium ion (H_3O^+, or H^+): a water molecule that has gained a proton. Such a molecule has an extra proton and carries a full positive charge.

Hydroxide ion (OH^-): a water molecule that has lost a proton. Such a molecule has an extra electron and carries a full negative charge.

pH Is a Way To Measure Acidity

pH { *p* = log (negative), *H* = H+ concentration

pH = −log[H⁺]

[H+] = .0000001 pH = 7 • pH of 7 is **neutral**

[H+] = .001 pH = 3 • pH less than 7 is **acidic**

[H+] = .00000000000001 pH = 14 • pH greater than 7 is **basic**

Definitions of Acids and Bases- in context of water

An acid is a substance that dissolves in water to increase the concentration of H^+ (aka H_3O^+).

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

A base is a substance that dissolves in water to increase the concentration of OH-.

$NaOH + H_2O \rightarrow OH^- + Na^+ + H_2O$

$NH_3 + H_2O \rightarrow OH^- + NH_4^+$

The pH scale: the pH of an aqueous solution is defined as the negative log of the hydronium ion concentration.

pH = -log[H+]

Mol of H^+/ L	pH	
0.00000000000001	14	↑
0.0000000000001	13	
0.000000000001	12	Increasingly basic
0.00000000001	11	
0.0000000001	10	
0.000000001	9	
0.00000001	8	Neutral–neither acidic nor basic
0.0000001	7	
0.000001	6	
0.00001	5	
0.0001	4	
0.001	3	Increasingly acidic
0.01	2	
0.1	1	
1.0	0	↓

$[H^+] \times [OH^-] = 10^{-14}$

In a neutral solution, pH = 7.

As the concentration of hydronium ions increases, pH decreases;

As the concentration of hydronium ions decreases, pH increases

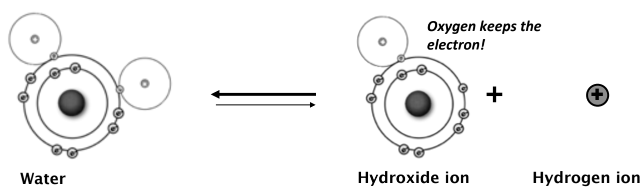
pH = -log[H+]

$[H^+] \times [OH^-] = 10^{-14}$

IF we know $[H^+]$, **THEN** we can deduce $[OH^-]$.
IF we know $[OH^-]$, **THEN** we can deduce $[H^+]$.
Hint: Add the exponents.

An aqueous solution has an $[H^+] = 10^{-4}$. Calculate $[OH^-]$ and pH.

Water can "dissociate"

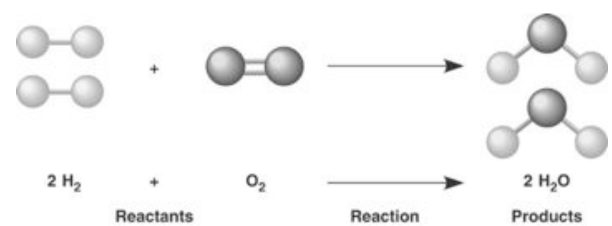


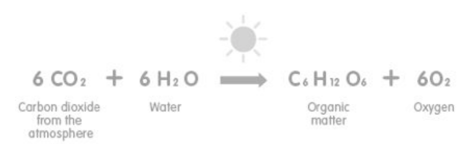
$H_20 \rightleftharpoons OH^- + H^+$

So, in pure water **$[OH^-] = [H^+]$**

The covalent bond of hydrogen to oxygen is not as "strong" as some covalent molecules, due to the unequal sharing of electrons by oxygen

Chemical reactions

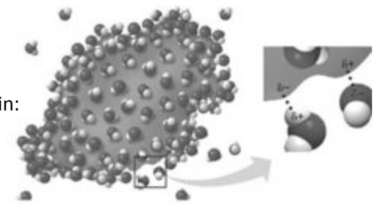




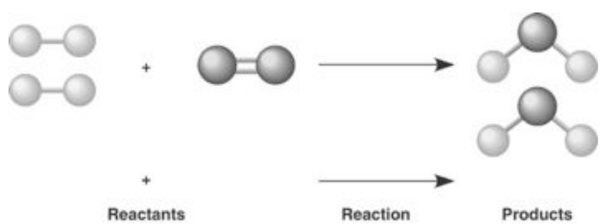
The SOLUTE is what YOU put in the SOLVENT

Dissolving table salt in water:
H+ are attracted to Cl-
O- are attrated to Na+
Hydration shell forms around the ions

Dissolving a water-soluble protein:



Chemical reactions



H_20 + NaOH + HCl $\rightleftharpoons$ Na^+ + Cl^- +$2H_20$

$H_20 \rightleftharpoons OH^- + H^+$

H_20 + HCl $\rightleftharpoons$ Cl^- + H^+ + H_20

[H+] is increased!
HCl is an acid
In acid **[H+] > [OH-]**

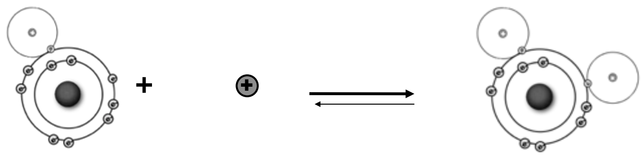
H_20 + NaOH $\rightleftharpoons$ OH^- + Na^+ + H_20

[OH−] is increased (which reduces [H+]).
NaOH is a base
In base **[OH-] > [H+]**

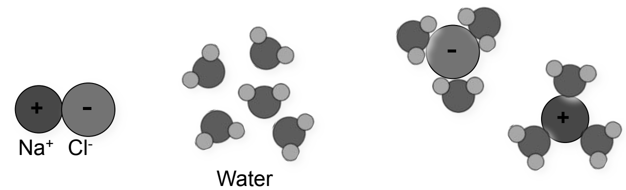
When mixed, Acids and Bases Create **Water**

acids + bases create water

H_20 + NaOH + HCl $\rightleftharpoons$ Na^+ + Cl^- +$2H_20$



Sodium Chloride does not affect [H^+]



Solute ***Solvent*** ***Solution***

NaCl + H_20 $\rightleftharpoons$ Cl^- + Na^+ + H_20

([H^+] not changed)

Strong vs. Weak Acid/Base

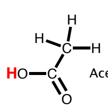
- A strong acid/base dissociates completely in water

H_20 + HCl $\xrightarrow{100\%}$ Cl^- + H^+ + H_20

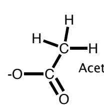
H_20 + NaOH $\xrightarrow{100\%}$ OH^- + Na^+ + H_20

- Weak acids/bases vary in their degree of dissociation

$HC_2H_3O_2$ + H_20 $\rightleftharpoons$ $C_2H_3O_2$- + H^+ + H_20



Acetic acid (vinegar)



Acetate

Buffers

pH ~2-3

pH ~3

Why doesn't Coca-Cola (or wine) make your blood acidic?

Buffers are substances that **resist a change in pH.**