Chemical components of the cell

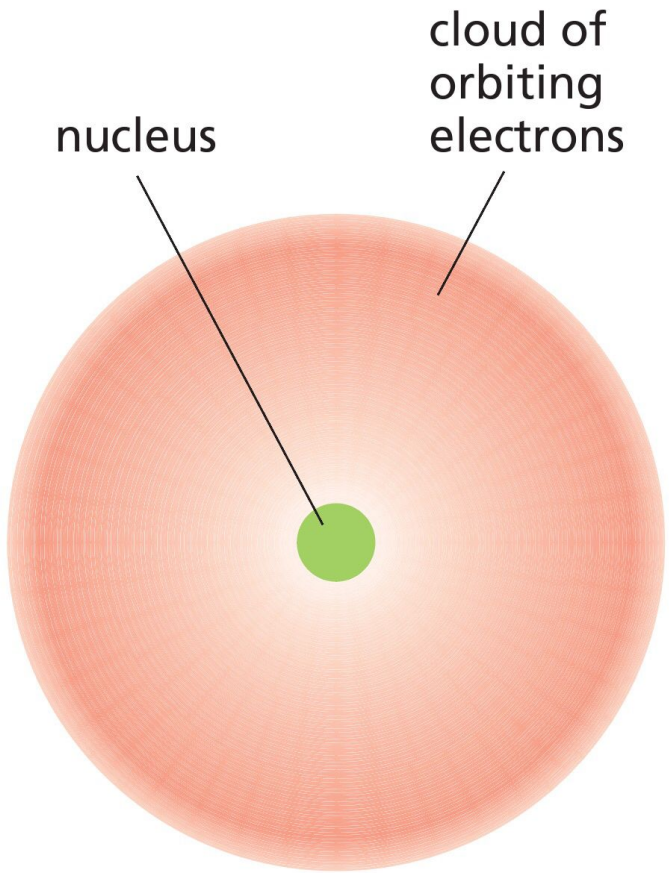
Arnat Balabiyev

PhD Student

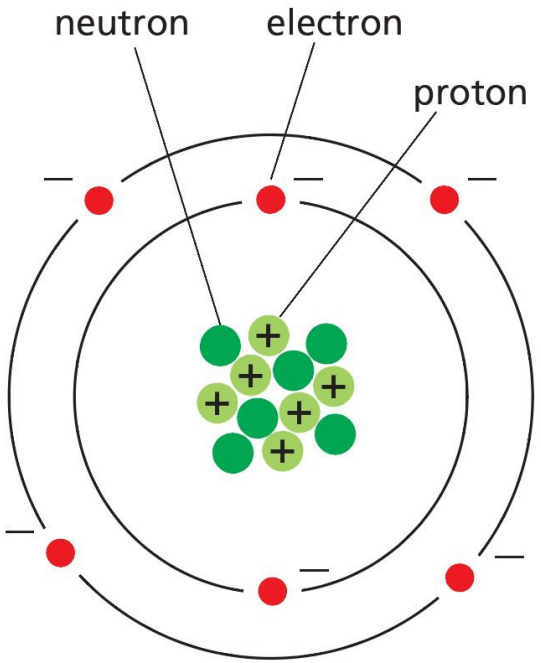
Arizona State University

Chemical bonds

- Chemical bonds occur between atoms (identical or different)
- An atom= nucleus+electrons
- Nucleus = protons+neutrons
- Protons-positively charged particles (+)
- Neutrons – uncharged particles (0)
- Electrons – negatively charged particles (-)

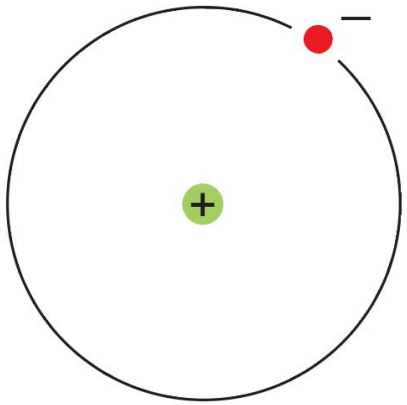


- The distance between nucleus and electrons is huge!! Coin and radius of a city
- The electrons have very little mass, which is often negligible
- The #protons=# electrons
- The # of neutrons can vary



carbon atom

atomic number = 6
atomic weight = 12



hydrogen atom

atomic number = 1
atomic weight = 1

- The Atomic number = # of protons or electrons at neutral state
- Atomic weight = #protons+#neutrons
- Neutrons don't alter the characteristic of an atom
- An atom with different # of neutrons is an **isotope**

Other properties of the atom

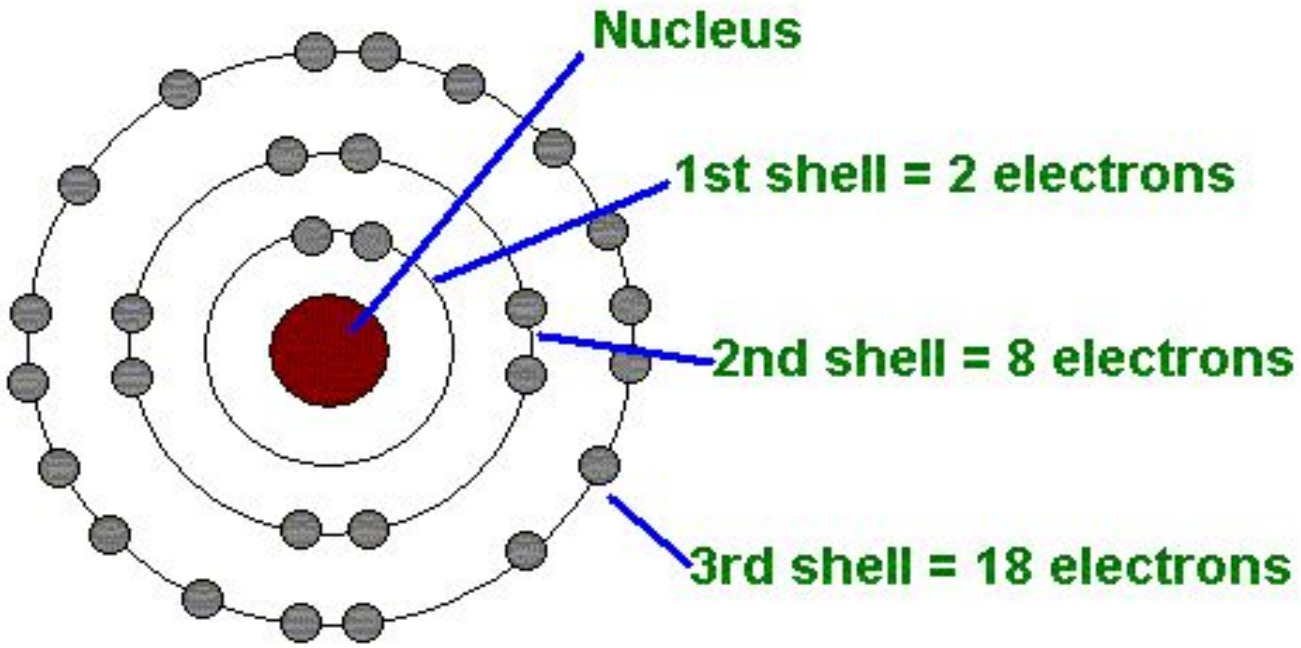
- Atomic weight/Molecular weight is defined in ***daltons .***
- ***Atomic weight of hydrogen is 1 dalton.***
- ***The mass of hydrogen atom is 1/6*10^23 gram. So 1 gram of hydrogen contains 6*10^23 atoms of hydrogen.***
- ***Mole = mass (g)/ molecular weight***
- ***Ex: 1 mole of H = 1 gram / 1 dalton(in periodic table)***
- ***It means that 1 mole of any atom/molecule has 6*10^23 of that substance***

Molarity

- If we put 1 mole of glucose in 1 liter of water, we obtain 1 molar solution of glucose.
- It means we have 6*10^23(avagardo#) of glucose molecules in 1 liter of water.

- 1 mole=Avagardo# of atom/molecule

Atom electron shells



- If the outer shell is fully filled, the atom becomes unreactive

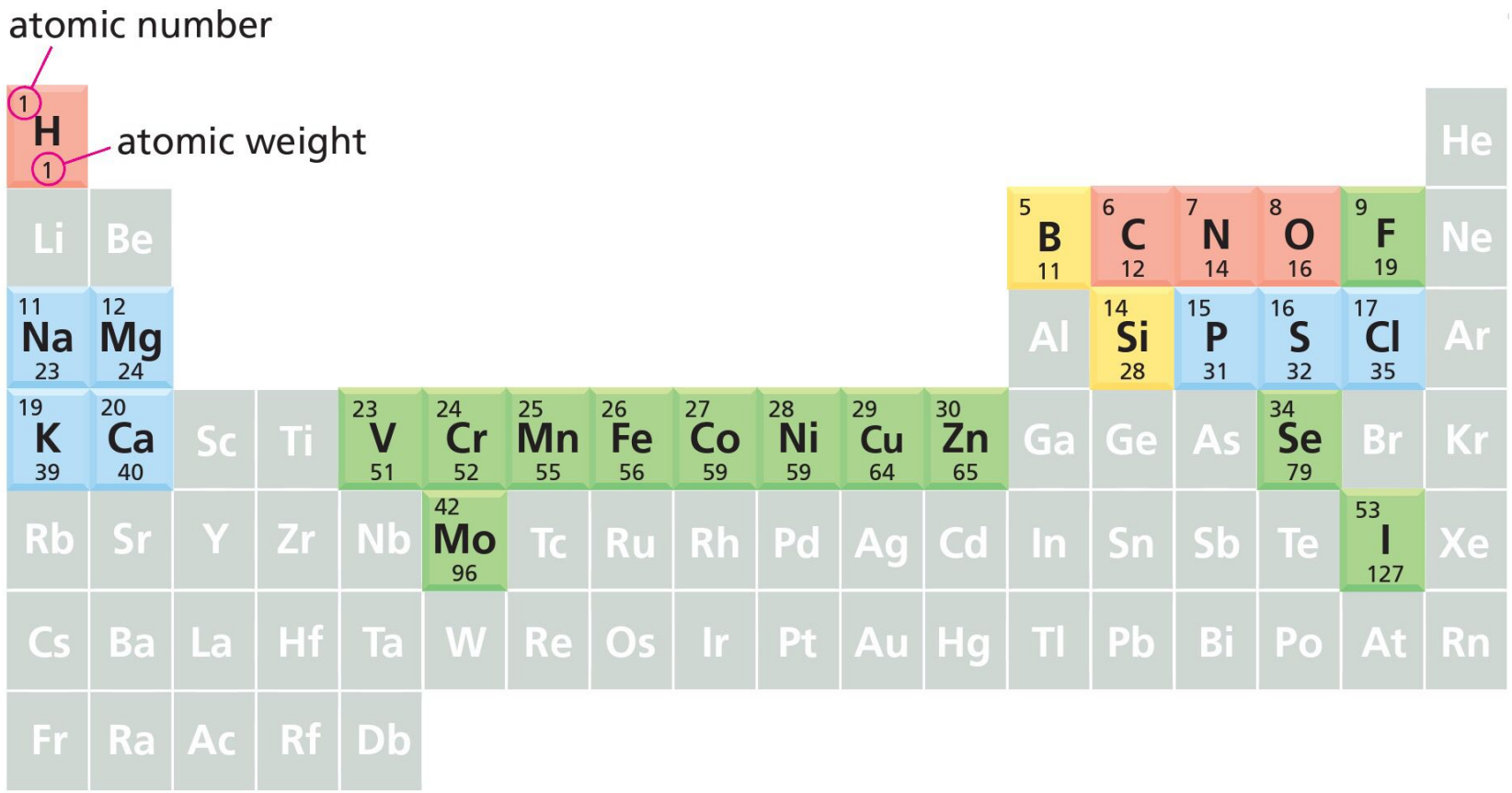
- The electrons occupy a specific shell around nucleus
- The 1st shell can hold only 2 electrons and 2nd only 8 electrons, the third 18 electrons…

- Closer the electron to the nucleus, stronger the attraction of an electron to the nucleus

atomic number

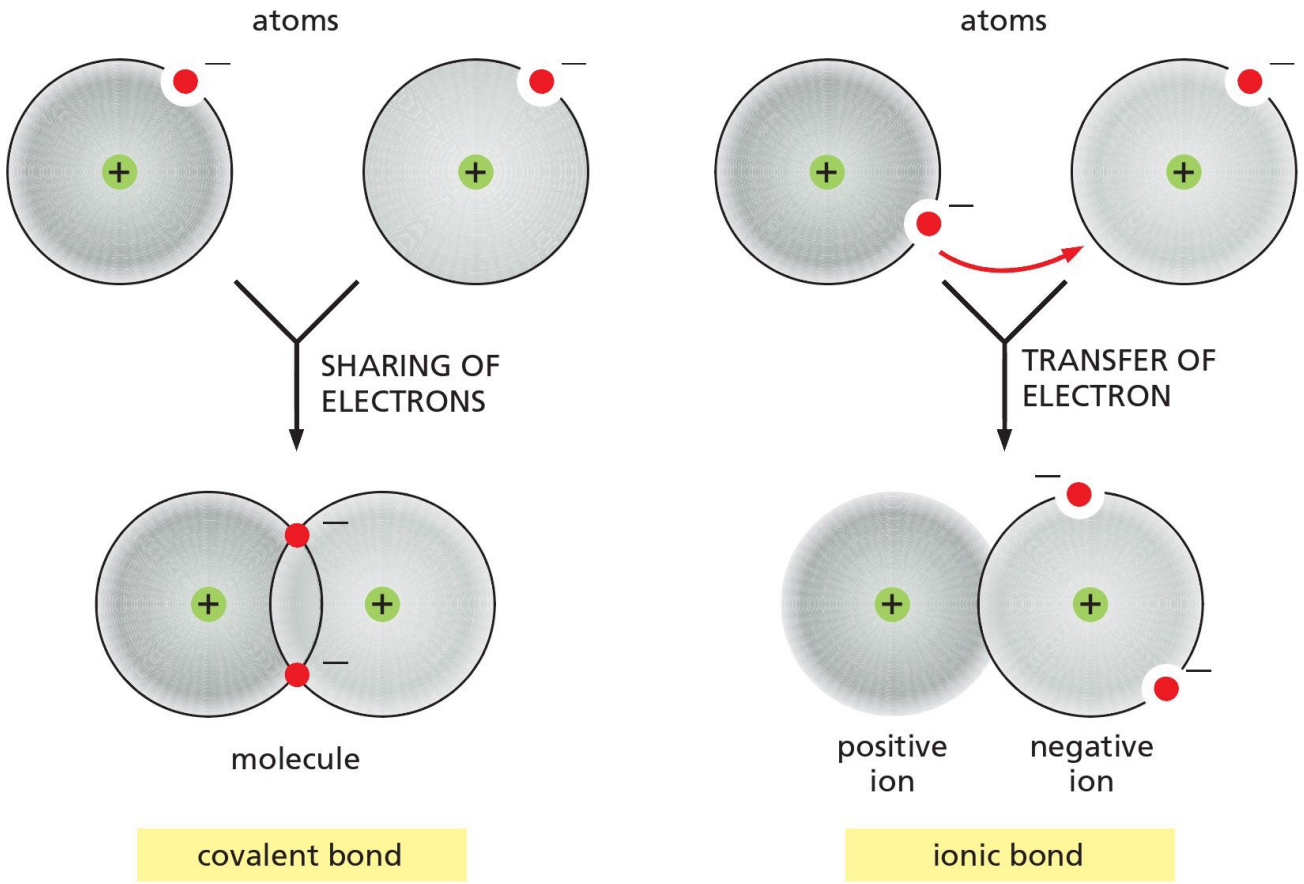
	element	electron shell I	II	III	IV
1	Hydrogen (H)	●			
2	Helium (He)	●●			
6	Carbon (C)	●●	●●●●		
7	Nitrogen (N)	●●	●●●●●		
8	Oxygen (O)	●●	●●●●●●		
10	Neon (Ne)	●●	●●●●●●●●		
11	Sodium (Na)	●●	●●●●●●●●	●	
12	Magnesium (Mg)	●●	●●●●●●●●	●●	
15	Phosphorus (P)	●●	●●●●●●●●	●●●●●	
16	Sulfur (S)	●●	●●●●●●●●	●●●●●●	
17	Chlorine (Cl)	●●	●●●●●●●●	●●●●●●●	
18	Argon (Ar)	●●	●●●●●●●●	●●●●●●●●	
19	Potassium (K)	●●	●●●●●●●●	●●●●●●●●	●
20	Calcium (Ca)	●●	●●●●●●●●	●●●●●●●●	●●

- Atoms with not entirely filled shells can react to form bonds.
- Ex: Carbon misses 4 electrons on 2nd shell, that means it can potentially can form 4 single bonds
- Ex 2: Sodium(Na) have only 1 electron on the 3rd shell. If it gives up this electron to another atom, it will become a full filled atom.
- So, atoms tend to be full filled with electrons and therefore make bonds with other atoms.

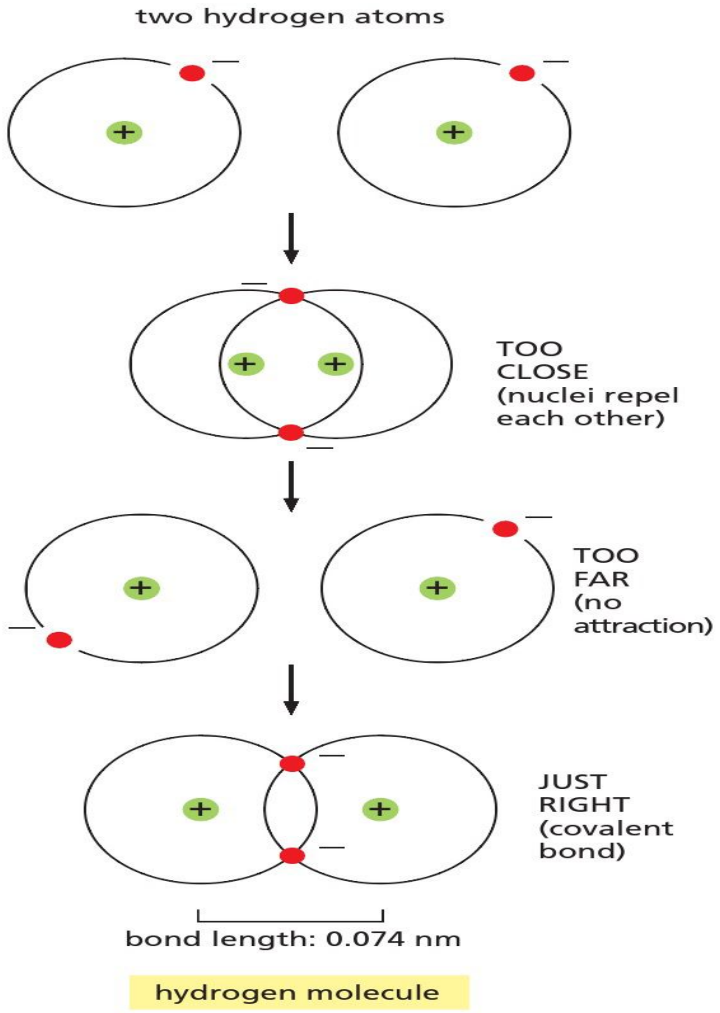


The atoms positioned vertically can form the number of bonds.
Ex: Hydrogen and Potassium can form only 1 bond.
In red: 96% , blue 0.9%,
Other colors: the rest of our body.

Atom get more stable when form bonds with each other

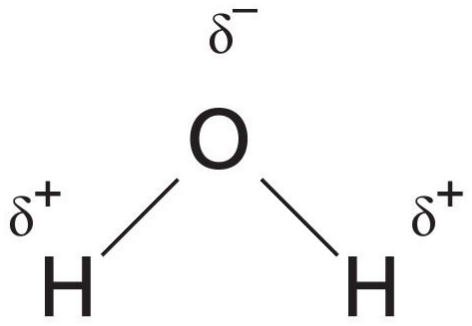


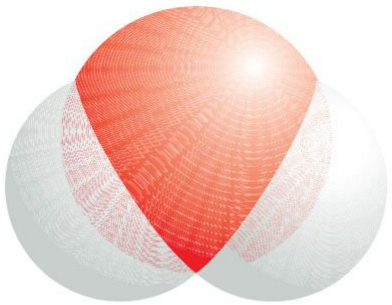
Covalent bonds form by sharing the electrons



- The covalent bond between two atoms is formed at specific distance.
- This is why the bond length differ upon different atoms.

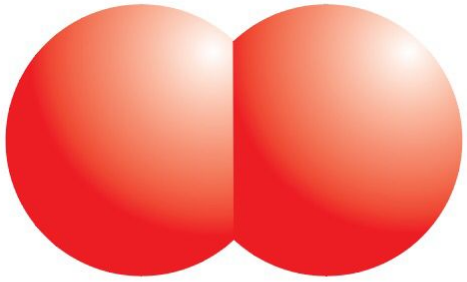
There are two kinds of covalent bond





water

Polar

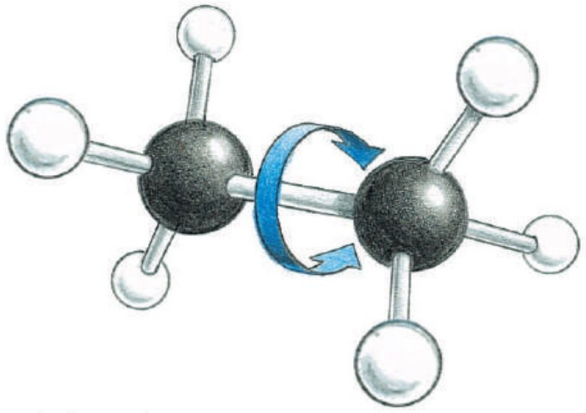


oxygen

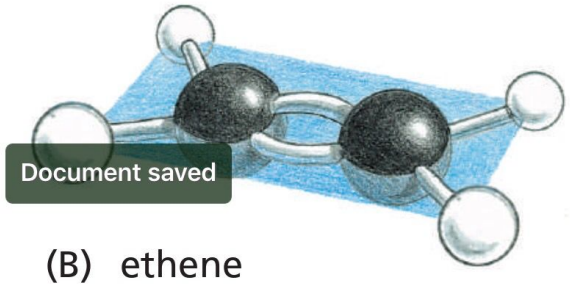
Nonpolar

- Oxygen has greater power to attract an electron compared to hydrogen atom.
- This is why oxygen has more negative charge and hydrogens are more positive

Multiplicity of bonds and their flexibility



(A) ethane



(B) ethene

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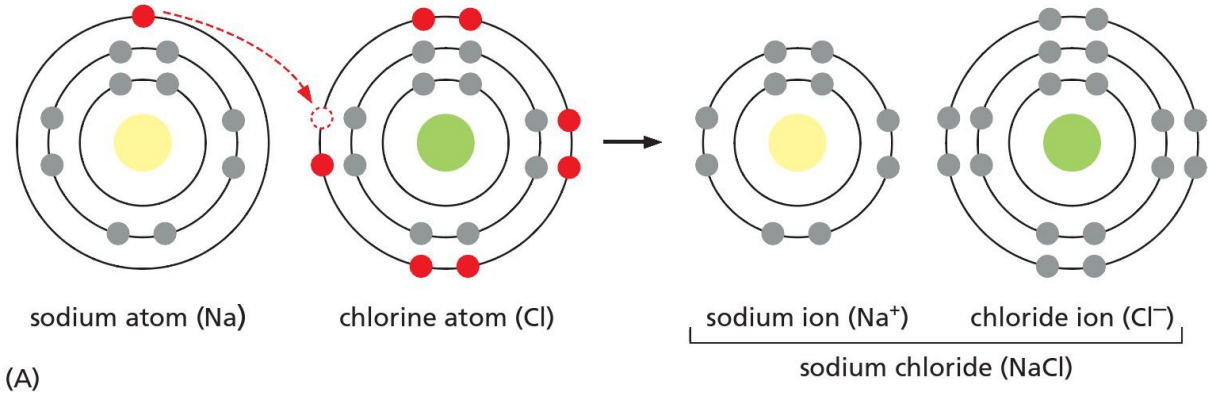
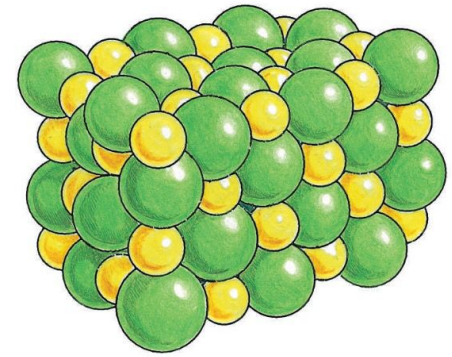
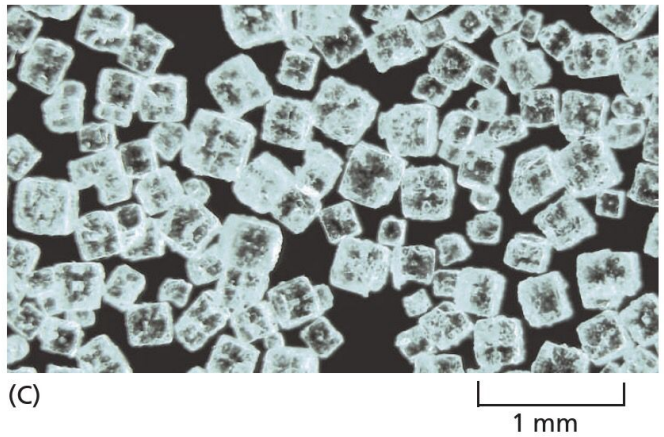
- Single bonds are weaker and flexible. Therefore, the rotation is possible
- Double bonds are stronger and shorter. The rotation is hardly possible
- The bond strength is measured in kcal/mole
- Kcal is the energy amount needed to raise the temp of 1L of water by 1C

Ionic bond

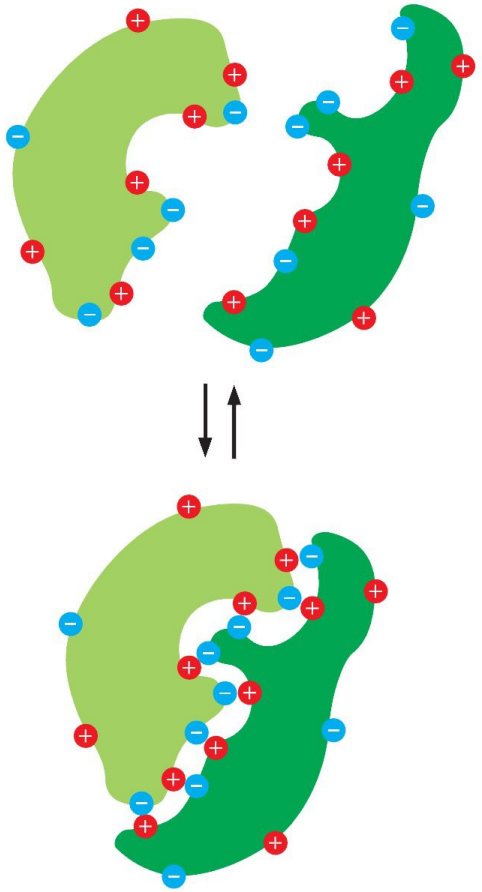



(B)



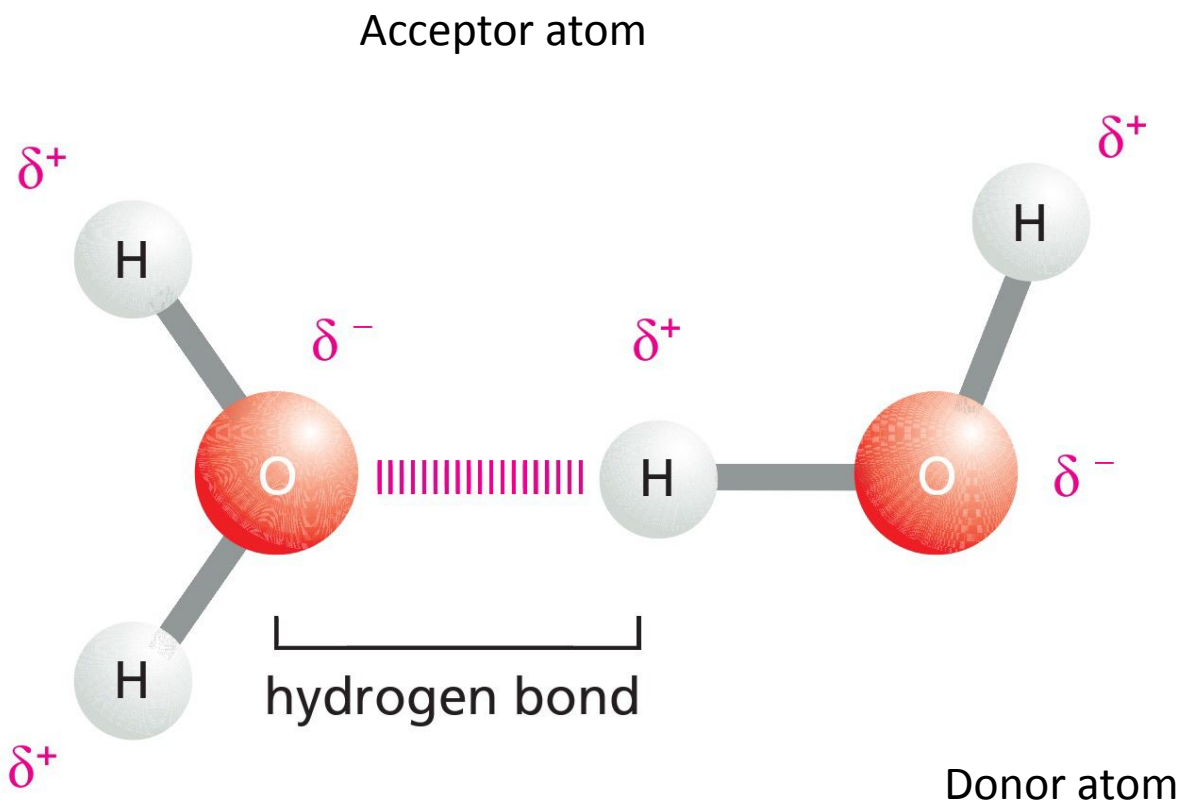
- Is formed by the gain or loss of electrons.
- The gained atom becomes fully negatively charged, whereas lost atom fully positively charged
- The atoms that connected to each other only by ionic bonds are called as ***salts, rather than molecules***

Ionic bond=Electrostatic interaction



- Positively charged ions: cations
- Negatively charged ions: anions

Hydrogen bond



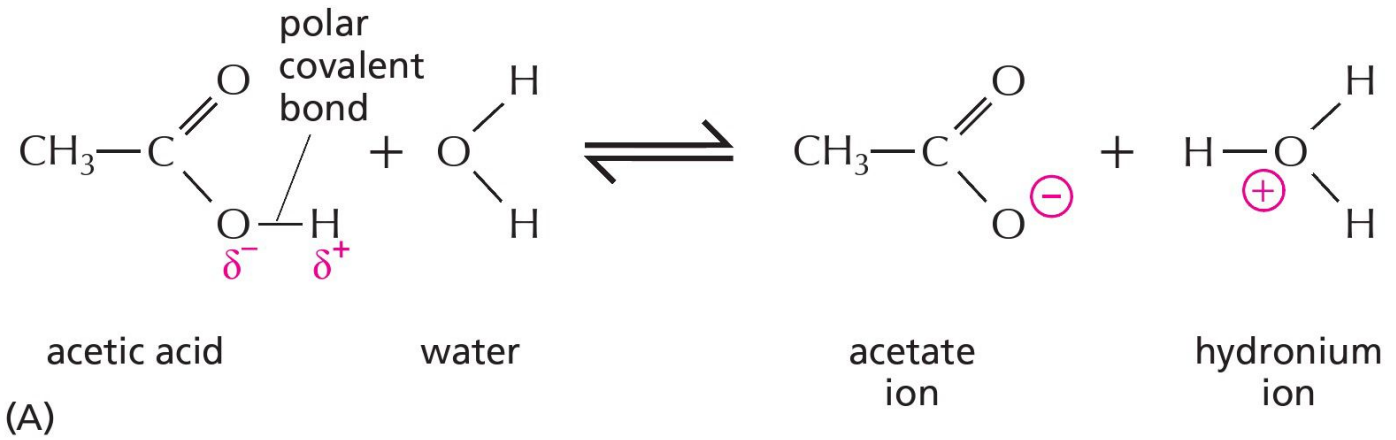
- Like ionic bond, the hydrogen bond is non-covalent bond.
- The bond is formed due to attraction of partially charged atoms.
- O-H-O
- N-H-O
- F-H-O
- Donor atom: covalently bonded to hydrogen
- Acceptor atom: attracted to hydrogen atom
- Hydrogen is always sandwiched in between

The comparison of bond characteristics

TABLE 2–1 LENGTH AND STRENGTH OF SOME CHEMICAL BONDS			
Bond type	Length* (nm)	Strength (kcal/mole)	
		in vacuum	in water
Covalent	0.10	90 [377]**	90 [377]
Noncovalent: ionic bond	0.25	80 [335]	3 [12.6]
Noncovalent: hydrogen bond	0.17	4 [16.7]	1 [4.2]

*The bond lengths and strengths listed are approximate, because the exact values will depend on the atoms involved.
**Values in brackets are kJ/mole. 1 calorie = 4.184 joules.

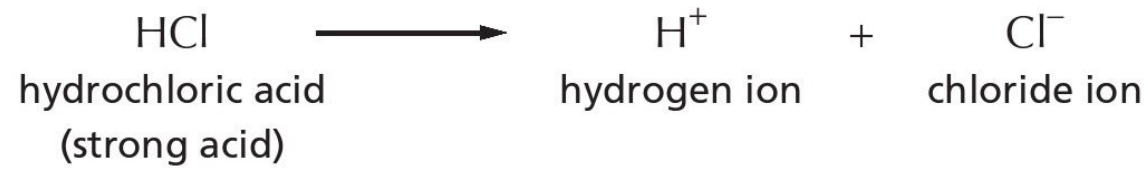
General properties of acids and bases



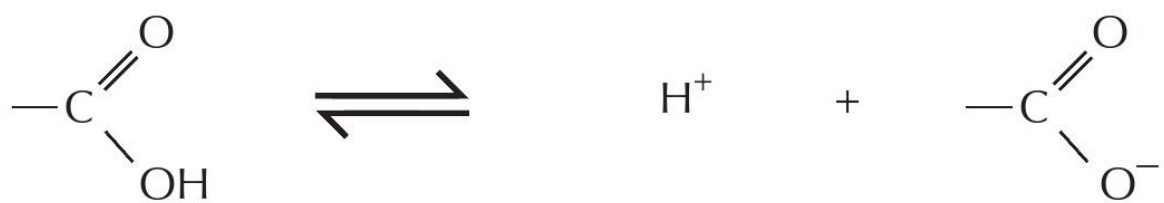
- Hydronium ion is considered as a "proton"
- Acids give up proton in aqueous solution
- More easily it gives, stronger it is
- Bases bind proton, and forms free hydroxyl ions in aqueous solution
- More easily it binds, stronger it is

ACIDS

Substances that release hydrogen ions (protons) into solution are called acids.



Many of the acids important in the cell are not completely dissociated, and they are therefore weak acids—for example, the carboxyl group (–COOH), which dissociates to give a hydrogen ion in solution.



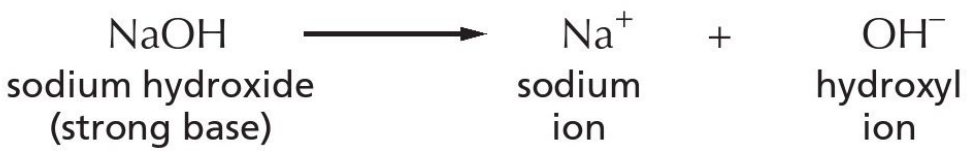
(weak acid)

Note that this is a reversible reaction.

BASES

Substances that reduce the number of hydrogen ions in solution are called bases. Some bases, such as ammonia, combine directly with hydrogen ions.

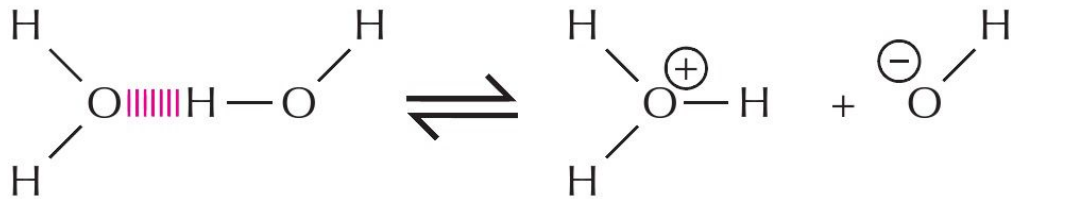
Other bases, such as sodium hydroxide, reduce the number of H^+ ions indirectly, by making OH^- ions that then combine directly with H^+ ions to make H_2O.



Many bases found in cells are partially associated with H^+ ions and are termed weak bases. This is true of compounds that contain an amino group ($-NH_2$), which has a weak tendency to reversibly accept an H^+ ion from water, thereby increasing the concentration of free OH^- ions.

HYDROGEN ION EXCHANGE

Positively charged hydrogen ions (H^+) can spontaneously move from one water molecule to another, thereby creating two ionic species.



hydronium ion hydroxyl ion

often written as: $H_2O \rightleftharpoons H^+ + OH^-$

hydrogen ion hydroxyl ion

Because the process is rapidly reversible, hydrogen ions are continually shuttling between water molecules. Pure water contains equal concentrations of hydronium ions and hydroxyl ions (both 10^{-7} M).

pH

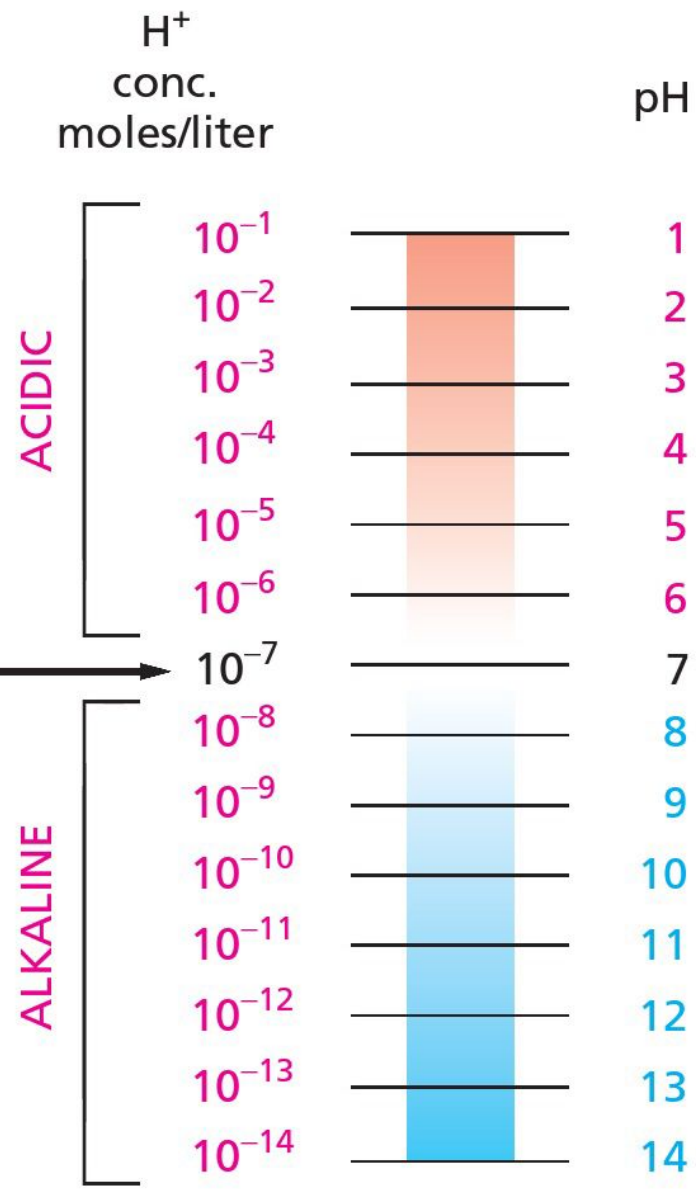
The acidity of a solution is defined by the concentration of hydronium ions (H_3O^+) it possesses, generally abbreviated as H^+. For convenience, we use the pH scale, where

$$pH = -\log_{10}[H^+]$$

For pure water

$[H^+] = 10^{-7}$ moles/liter

$pH = 7.0$



Reference

- Essential Cell Biology: Chapter 2, Page 39-50