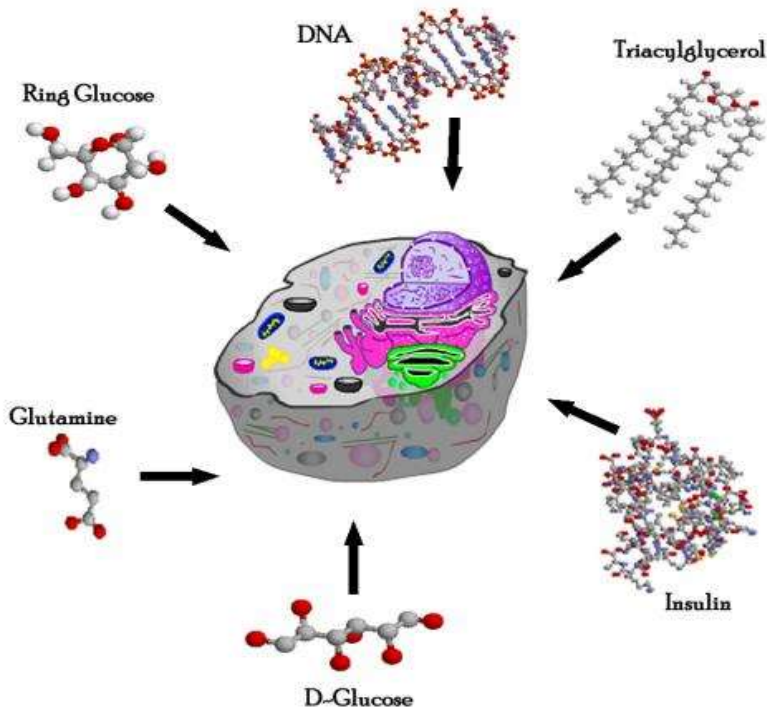


SBI4U

UNIT#1 : BIOCHEMISTRY

LECTURE #1 (INTRO TO BIO CHEM.)



**ATOMS, ELEMENTS,
COMPOUNDS, CHEMICAL
BONDING AND
BIOCHEMICAL REACTIONS**

**FAUZIA AKHTER,
MEnvSc, MSc, BEd**

MATTER:

Definition: Anything that has mass and occupies space.

Q. Can you name some matter from this picture?



ATOM, ELEMENT, COMPOUND AND MOLECULE

❑ **Atom:** A unit of matter; the smallest unit of a chemical element OR an **atom** is the basic unit of an element. E.g. hydrogen atom (**H**).

❑ **Element:** A pure substance that can not be broken down into simpler parts by chemical methods. E.g. Iron (**Fe**)

The most common elements that are found in living things are:
Hydrogen (H) 59%, Oxygen (O) 24%, Carbon (C), 11%, Nitrogen (N) 4%, Others such as phosphorus (P) and sulphur (S) 2% combined.

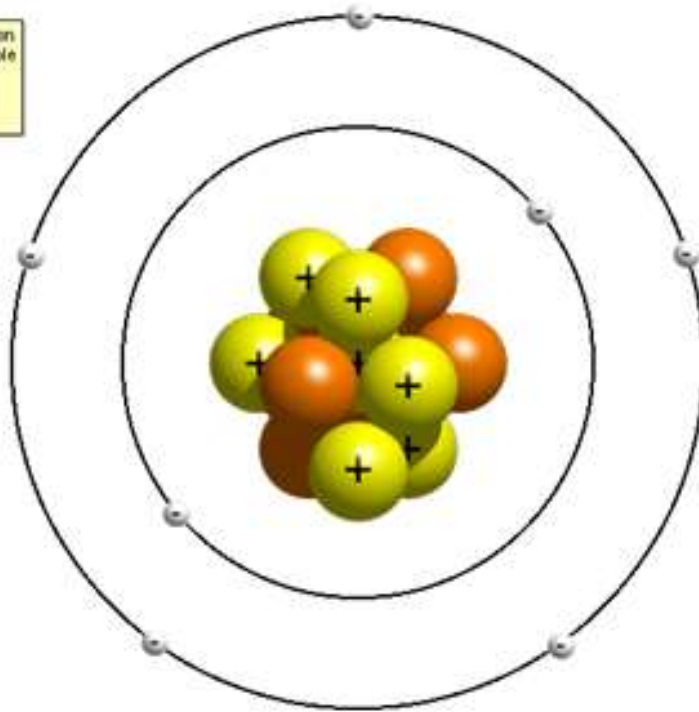
❑ **Compound:** A pure substance made of two or more different elements that are chemically combined. E.g. Water (**H₂O**)

❑ **Pure substance:** Matter that contains only one kind of particle. E.g. Oxygen (**O₂**)

❑ **Mixture:** Matter that contains more than one kind of particles/elements. E.g. Salt water (salt + water)

STRUCTURE OF THE ATOM

Nitrogen's Electron
Configuration Table
 $1s^2$
 $2s^2 2p^3$

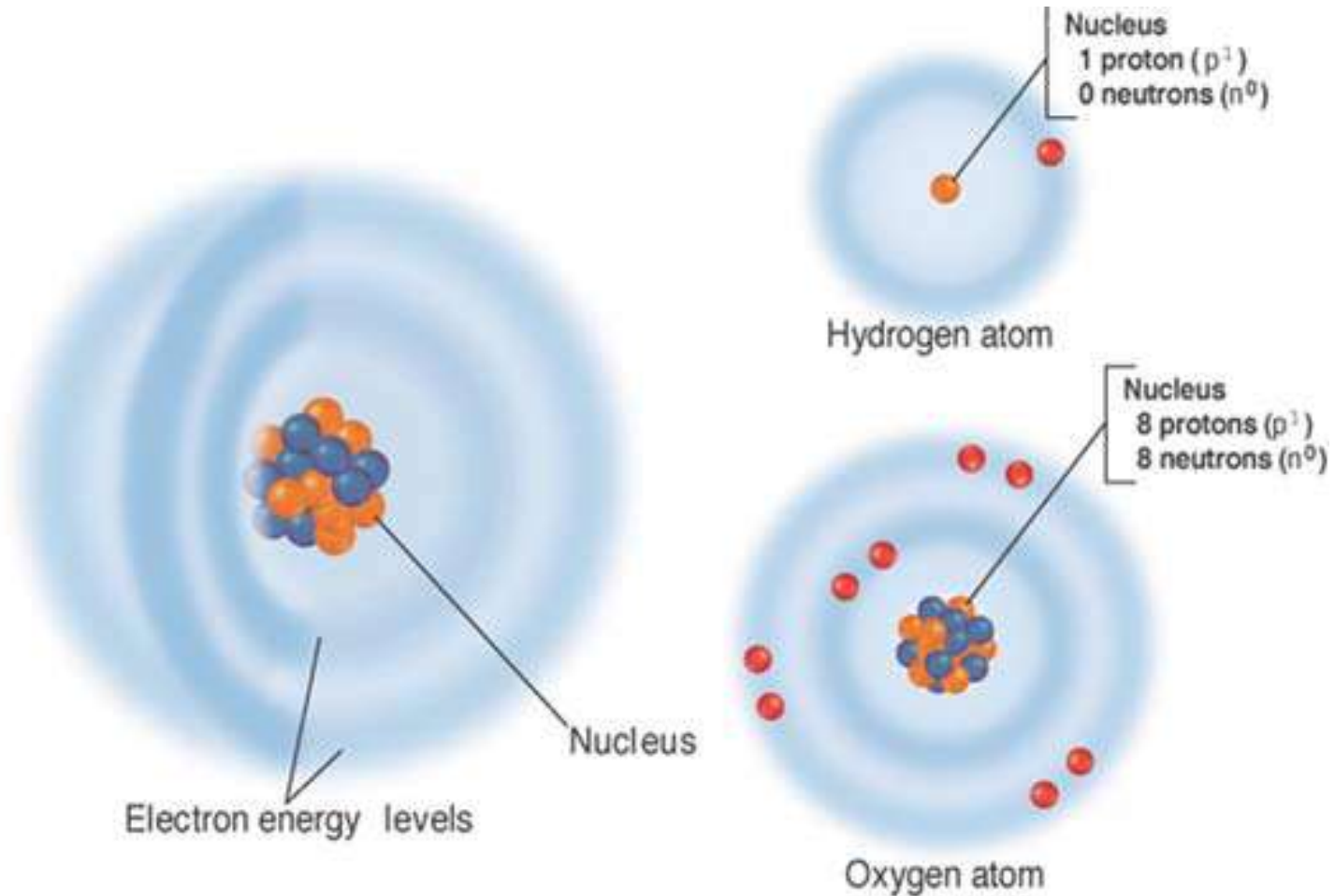


${}^7\text{N}$

**Atomic Number = #
of Protons = # of
Electrons**

**Atomic Mass = #
of Protons + # of
Neutrons**

INSIDE OF AN ATOM



^1H

ISOTOPES VS. RADIOACTIVE ISOTOPES

Isotopes: Atoms of the same element that contain a different number of neutrons are called **isotopes**.

^1H

^2H

^3H

^{12}C

^{13}C

^{14}C

Hydrogen isotopes

Carbon isotopes

Radioactive isotopes: The isotopes are unstable and will decay or breakdown are called **radioactive isotopes**. e.g ^{14}C

Uses: nuclear medicine to scan the images of cells to diagnose and treat various medical conditions. e.g cancer and heart disease.

ISOTOPES VS. RADIOACTIVE ISOTOPES

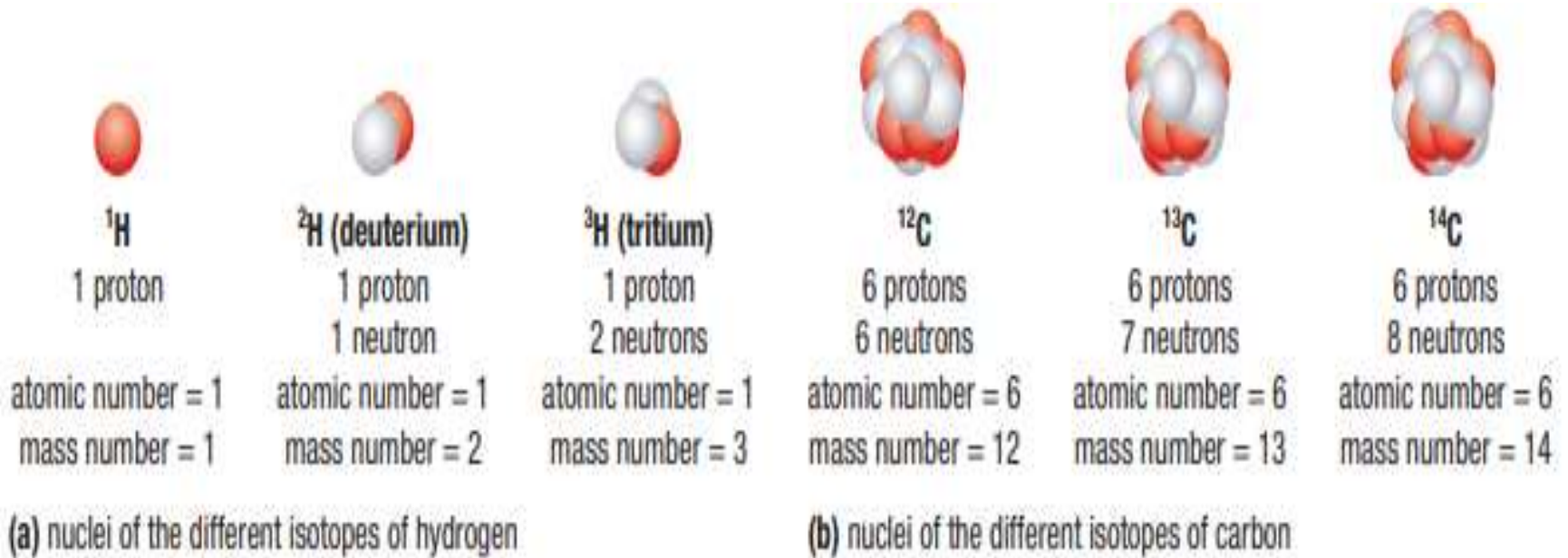


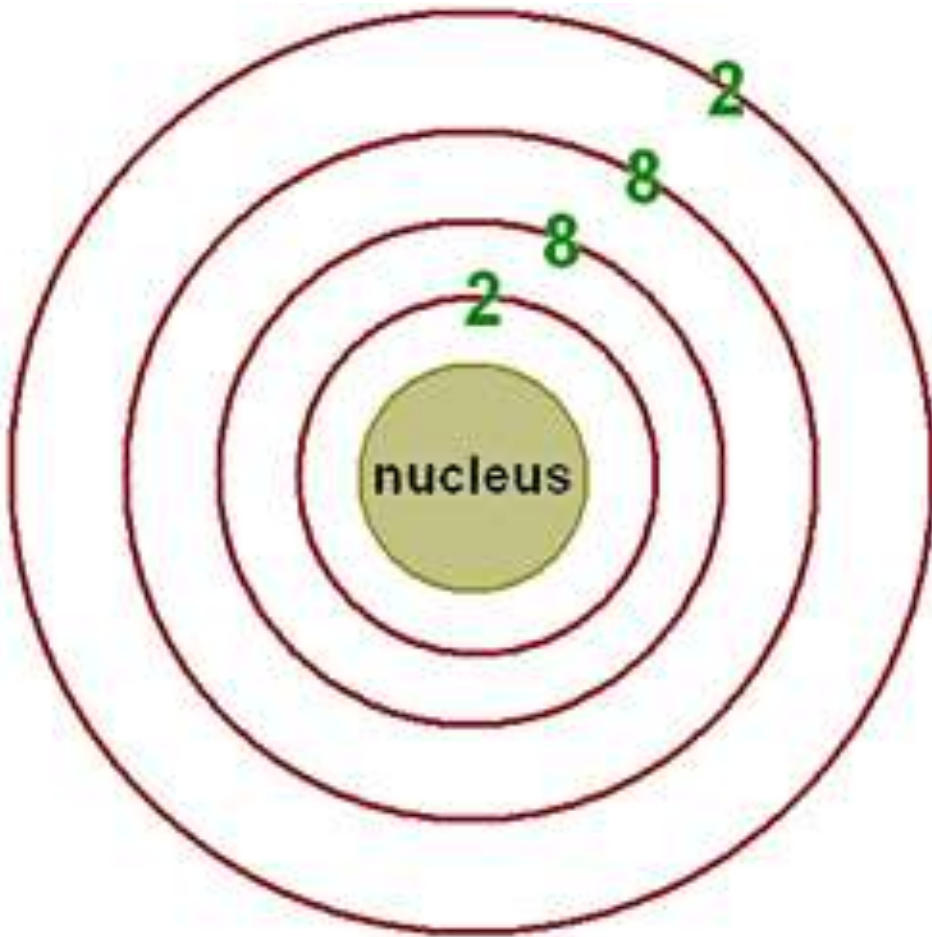
Figure Comparison of the nuclei of different isotopes of (a) hydrogen and (b) carbon

ACTIVITY#1

Using a periodic table, fill in a chart similar to the one below:

Name of Atom	Atomic Number	Atomic Mass	Number of Protons	Number of Neutrons	Number of Electrons
Magnesium					
	16				
			20		
		3			
			7		
					10

DISTRIBUTION OF ELECTRONS



The electrons in the outer most orbital of an atom are called **valence electrons**.

Elements in the same group (vertical row of the periodic table) have the same number of valence electrons.

LEWIS DOT DIAGRAMS

Lewis dot diagrams are used to represent an element's valence electrons.

1	2	13	14	15	16	17	18
H·							He:
Li·	·Be·	·B·	·C·	:N·	:O·	:F·	:Ne:
Na·	·Mg·	·Al·	·Si·	:P·	:S·	:Cl·	:Ar:
K·	·Ca·				:Se·	:Br·	:Kr:
Rb·	·Sr·				:Te·	:I·	:Xe:
Cs·	·Ba·						

CHEMICAL BONDS:

Definition: The forces that hold atoms together and form compounds are bonds or chemical bonds.

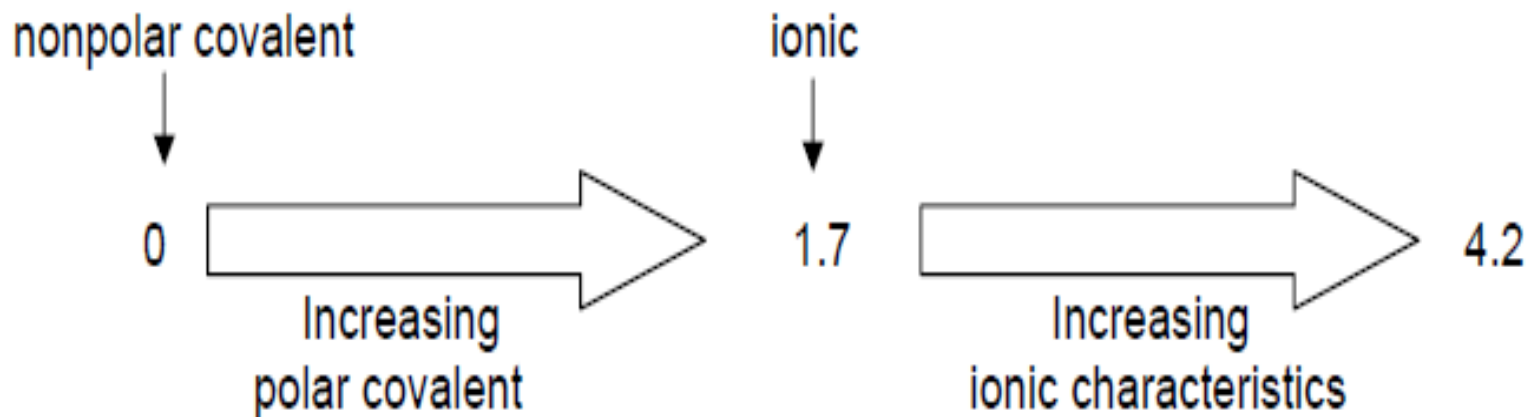
Affinity of atoms: the greater the affinity for electrons, the greater the electronegativity of the element.

e.g. Noble gases, have an electronegativity of zero and this is written as $E^n = 0$.

RELATIONSHIP BETWEEN ELECTRONEGATIVITY AND BONDING

Which bonding???

The difference in electronegativity between two atoms, determines whether it will create a nonpolar covalent, polar covalent, or ionic bond.



ELECTRONEGATIVITY TABLE

Electronegativity

0.6 - 0.9	2.5 - 2.9
1.0 - 1.4	3.0 - 3.5
1.5 - 1.9	3.6 - 3.9
2.0 - 2.4	4.0 +

1	2												3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	8 (18)	
H 2.1																			He --
Li 1.0	Be 1.6												B 2.0	C 2.5	N 3.0	O 3.5	F 4.0		Ne --
Na 0.9	Mg 1.3	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Al 1.6	Si 1.9	P 2.2	S 2.5	Cl 3.0			Ar --
K 0.8	Ca 1.3	Sc 1.4	Ti 1.5	V 1.6	Cr 1.7	Mn 1.6	Fe 1.8	Co 1.9	Ni 1.9	Cu 1.9	Zn 1.7	Ga 1.6	Ge 2.0	As 2.2	Se 2.6	Br 2.8			Kr --
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.3	Nb 1.6	Mo 2.2	Tc 2.1	Ru 2.2	Rh 2.3	Pd 2.2	Ag 1.9	Cd 1.7	In 1.8	Sn 2.0	Sb 2.1	Te 2.1	I 2.7			Xe 2.6
Cs 0.8	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 2.0	Pb 2.3	Bi 2.0	Po 2.0	At 2.2			Rn --
Fr 0.7	Ra 0.9	Ac 1.1	Rf --	Db --	Sg --	Bh --	Hs --	Mt --	Uun --	Uuu --	Uub --		Uuq						

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

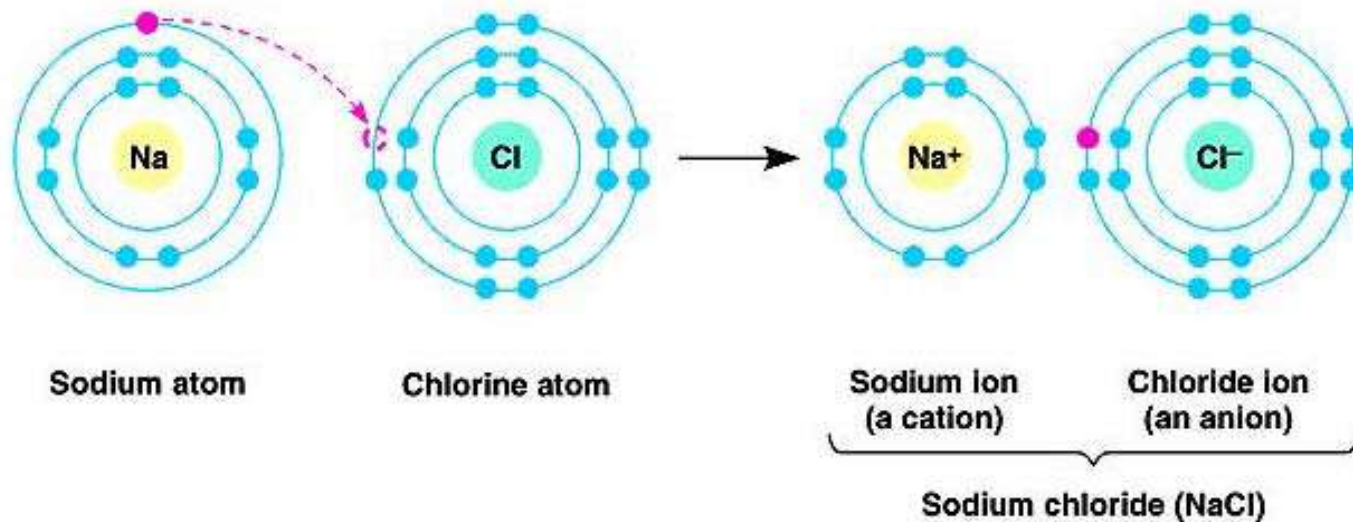
TYPES OF INTRAMOLECULAR BONDS

Intramolecular forces: the attraction hold atoms together in a molecule.

A. Ionic Bonds: occur when there is a great difference in electronegativity.

Example:

A metal and non-metal (electronegativity difference of 1.7 or greater)

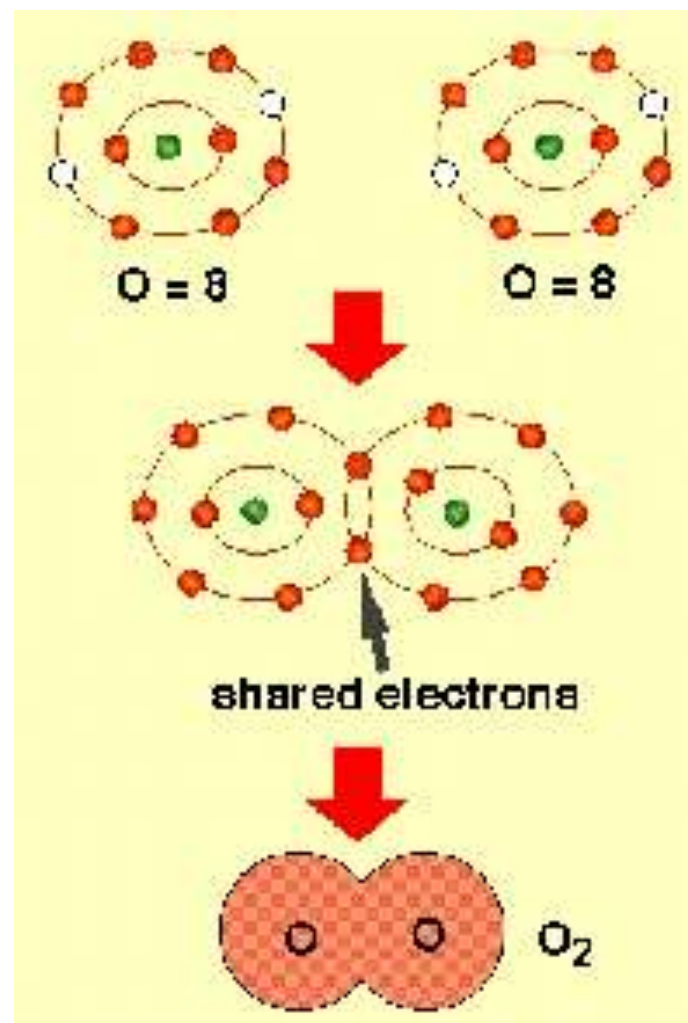


TYPES OF INTRAMOLECULAR BONDS

B. Covalent Bonds:

- a) **Non – Polar Covalent Bonds** – electrons are shared equally between atoms.

This occurs when a bond is formed between two atoms of the same element because they have the same electronegativity therefore; they share the electrons equally.



TYPES OF INTRAMOLECULAR BONDS

B. Covalent Bonds:

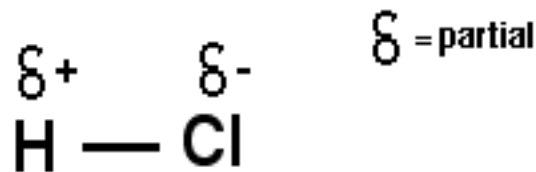
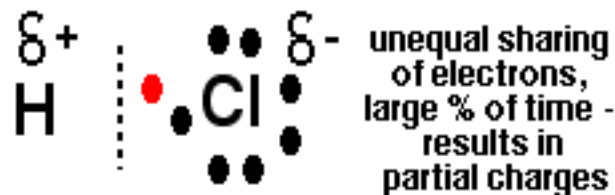
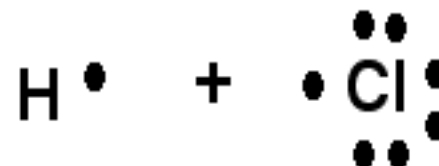
b) **Polar Covalent Bonds** – a covalent bond between 2 different atoms with two different electronegativities.

The sharing of electrons is NOT equal.

Example:

E.g. H ($E_n = 2.1$); Cl ($E_n = 3.0$)
The difference in electronegativity is 0.9 ($E_n = 3.0 - 2.1 = 0.9$) which means that the bond is polar covalent.

Polar Covalent Hydrogen Chloride, HCl

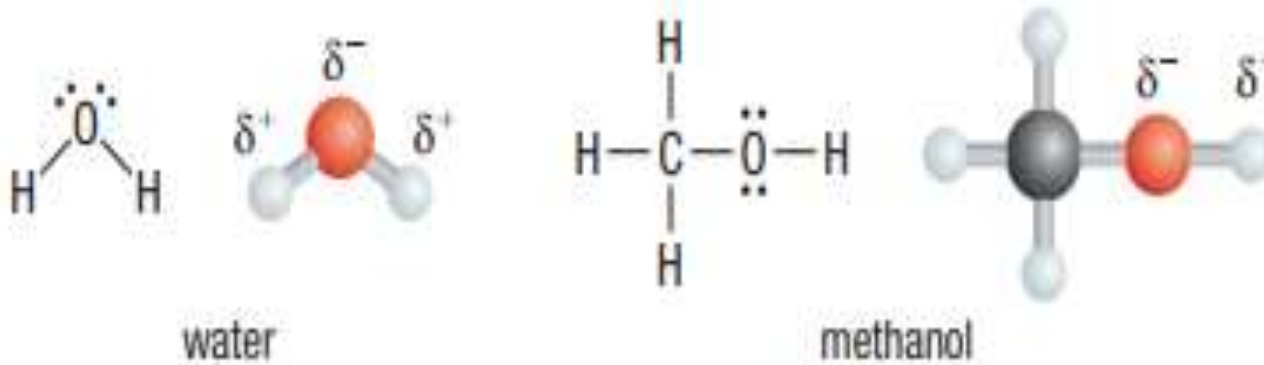


POLAR VS. NON POLAR BONDS

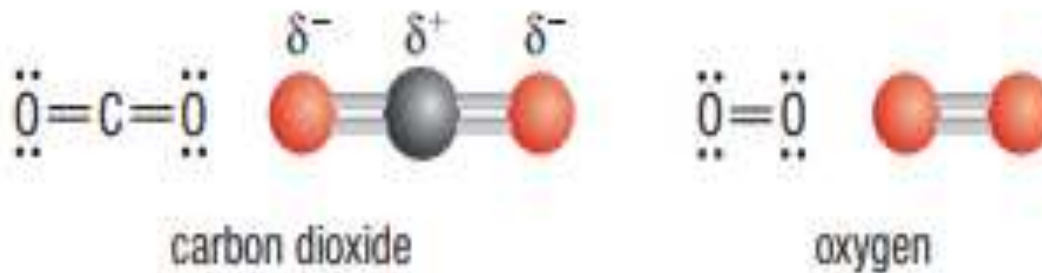
Table Electronegativity Differences of Selected Bonds

Bond	Electronegativity difference (ΔEN)
H—H	0.0
C—H	0.4
C—N	0.5
N—H	0.8
C—O	0.9
O—H	1.2

POLAR VS. NON POLAR BONDS



(a) polar molecules



(b) non-polar molecules

Figure Comparison of (a) polar and (b) non-polar biological molecules. The lowercase Greek letter delta (δ) is used to indicate a partial charge. The symbol δ^+ indicates partially positive atoms, and the symbol δ^- indicates partially negative atoms.








MOLECULAR SHAPE

VSEPR theory (Valence Shell Electron Pair Repulsion):
(developed by the Canadian chemist Ronald J. Gillespie)

“Negatively charged valence electrons will repel one another and move as far apart as possible.”

- Most atoms of biological importance has 4 valence electron pairs around a central atom (except phosphorous which has 5).
- Nonbonding pairs of electrons will occupy more space than bonding pairs and which will compress the bond angles of the bonding pair of electrons.

MOLECULAR SHAPE

Molecule	Electron-Dot Structure	Bonded Atoms	Molecular Shape (angle)	
Two (2) electron groups around the central atom				
BeCl ₂	$\text{:}\ddot{\text{Cl}}\text{: Be :}\ddot{\text{Cl}}\text{:}$	2	linear (180°)	
CO ₂	$\text{:}\ddot{\text{O}}\text{: :C:}\ddot{\text{O}}\text{:}$	2	linear (180°)	
Three (3) electron groups				
BF ₃	$\begin{array}{c} \text{:}\ddot{\text{F}}\text{:} \\ \text{:}\ddot{\text{F}}\text{: B :}\ddot{\text{F}}\text{:} \end{array}$	3	trigonal planar (120°)	
SO ₂	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\ \text{:}\ddot{\text{O}}\text{: S :} \\ \text{:}\ddot{\text{O}}\text{:} \end{array}$	2	bent (120°)	
Four (4) electron groups around the central atom				
CH ₄	$\begin{array}{c} \text{H} \\ \text{H:}\ddot{\text{C}}\text{:H} \\ \text{H} \end{array}$	4	tetrahedral (109°)	
NH ₃	$\begin{array}{c} \text{H:}\ddot{\text{N}}\text{:H} \\ \text{H} \end{array}$	3	pyramidal (109°)	
H ₂ O	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:H} \\ \text{H} \end{array}$	2	bent (109°)	

MOLECULAR POLARITY

❑ **Symmetrical molecules** always produce non-polar molecules (whether their covalent bonds are polar or non-polar).



Symmetrical (CCl_4)

❑ **Asymmetrical molecules** will be polar or non-polar depending on their bonds.

✓ An asymmetrical molecule with no polar bonds is considered a non-polar molecule

✓ An asymmetrical molecule with at least one polar bond is considered a polar molecule.

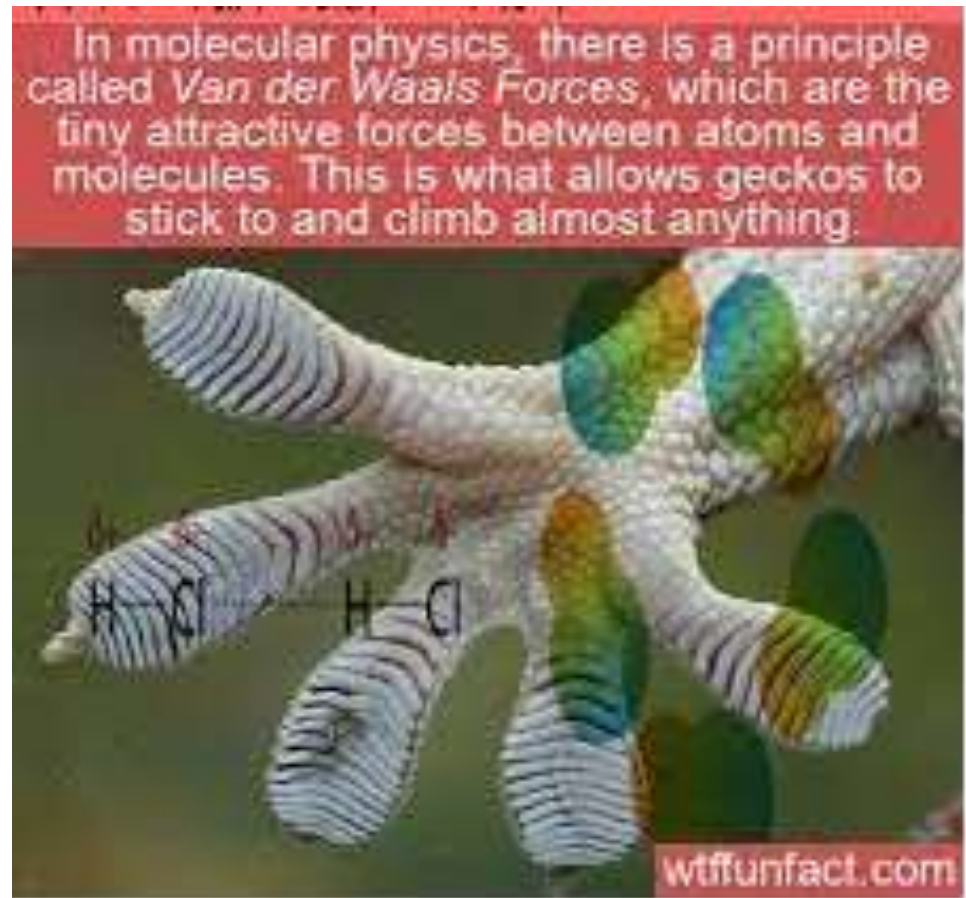


Asymmetrical (NH_3 and CO_2)

INTERMOLECULAR BONDS (VAN DER WAALS FORCES)

Intermolecular bonds or van der Waals forces: Bonds between molecules and are much weaker than intramolecular bonds.

Intermolecular bonds determine the physical state of substances at a given temperature and pressure. They are broken when solids melt into liquids or when liquids evaporate into gases.



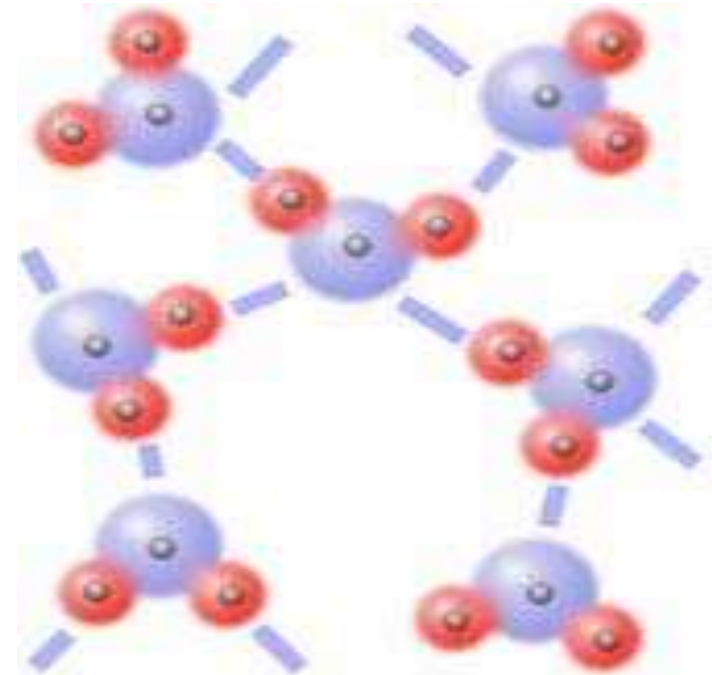
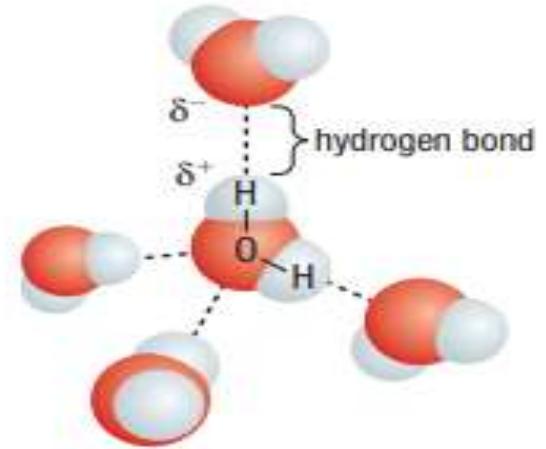
<https://www.youtube.com/watch?v=DhagapTUjUM>

INTERMOLECULAR BONDS (VAN DER WAALS FORCES)

Hydrogen Bonds: The attractive force between a partially positive charged hydrogen atom and a partially negatively charged atom in another molecule.

Although weak, they are the strongest type of intermolecular forces.

Hydrogen bonds are the force that holds water molecules together, and what gives water its unique properties. e.g High melting and boiling points; very high heat capacity; cohesion & adhesion; surface tension.



<https://www.youtube.com/watch?v=08kGgrqaZXA>

Major Intermolecular Forces

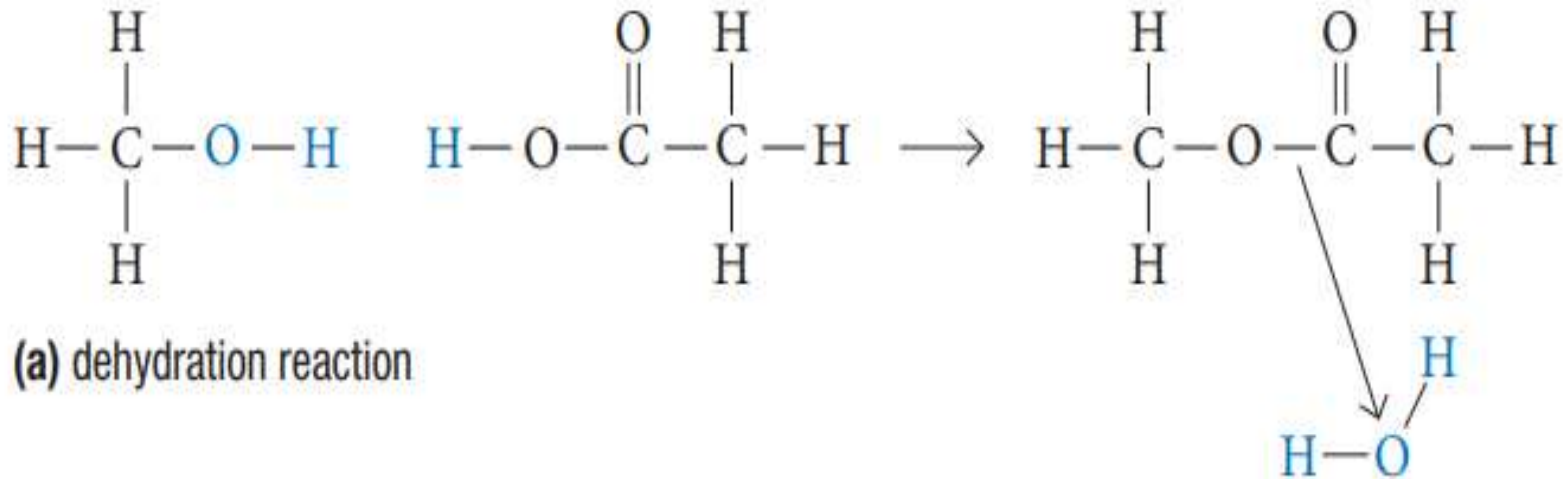
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VSEPR Theory

<https://www.youtube.com/watch?v=keHS-CASZfc>

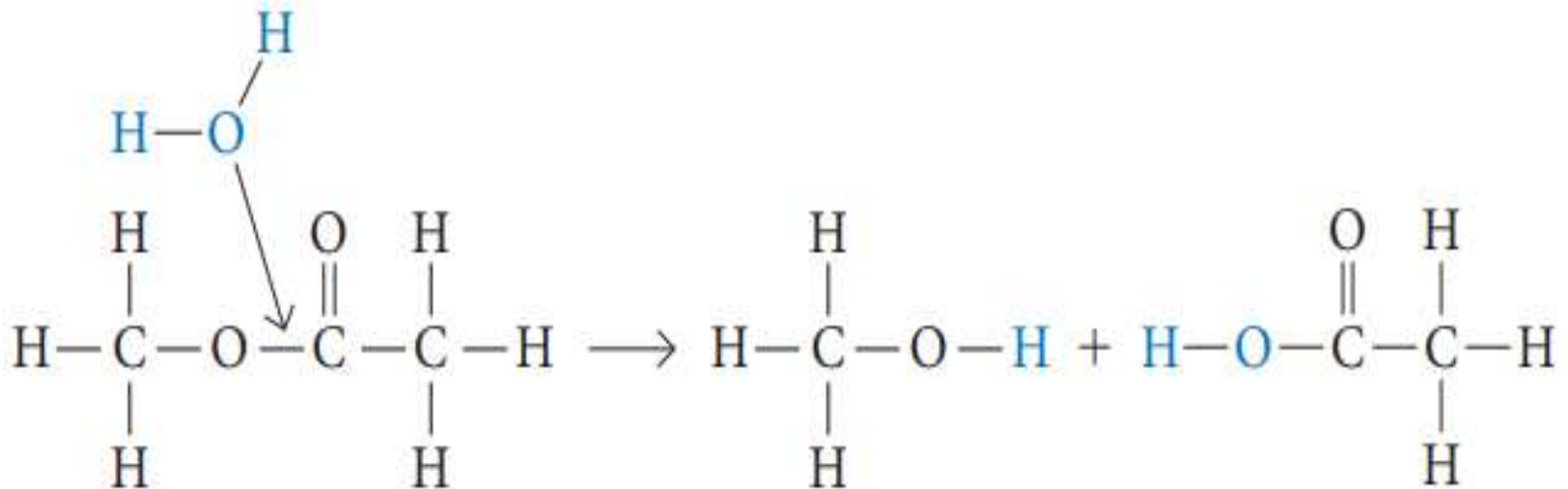
CHEMICAL REACTIONS:

A. Dehydration reactions: A chemical reaction in which subunits of a larger molecule are joined by the removal of water; also called a Condensation reaction.



CHEMICAL REACTIONS:

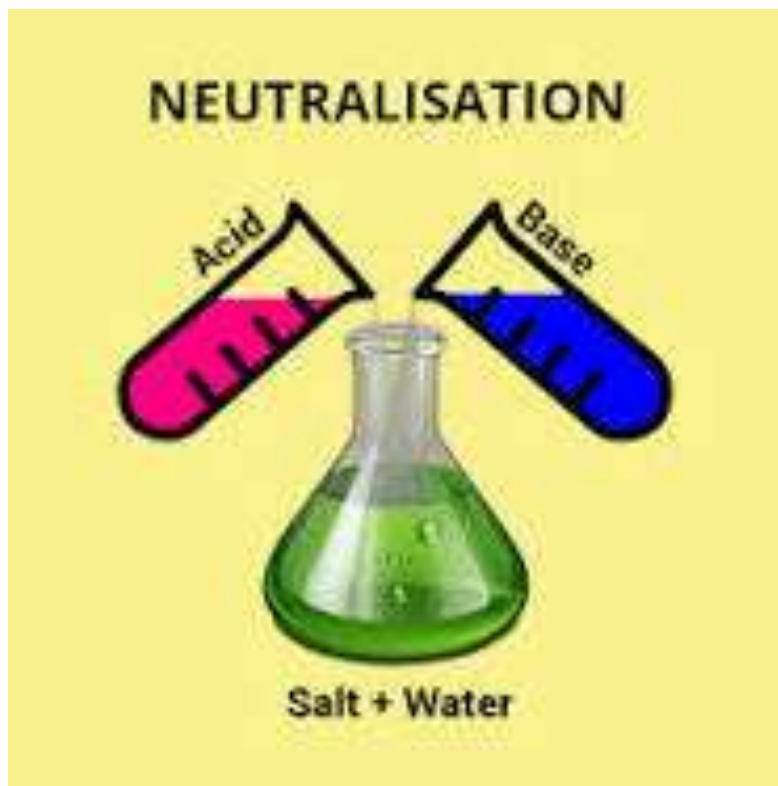
B. Hydrolysis reactions: A chemical reaction in which water is used as reactant to split a larger molecule into smaller subunits.



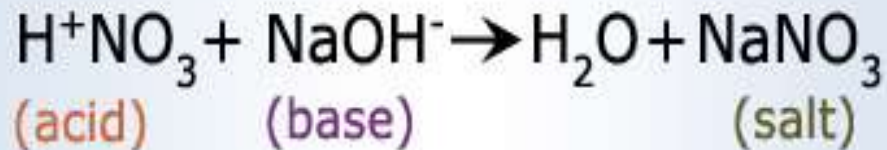
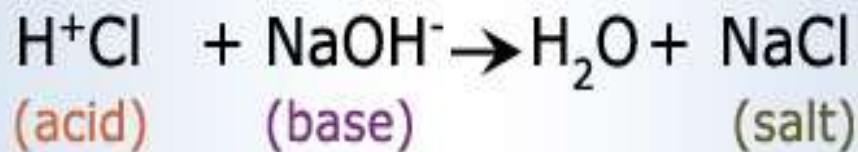
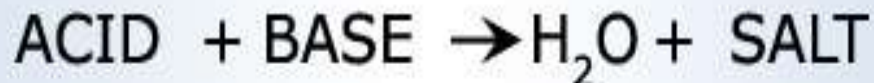
(b) hydrolysis reaction

CHEMICAL REACTIONS:

C. Neutralization reactions: A chemical reaction in which an acid and a base combine to create a salt and water.



NEUTRALIZATION REACTION



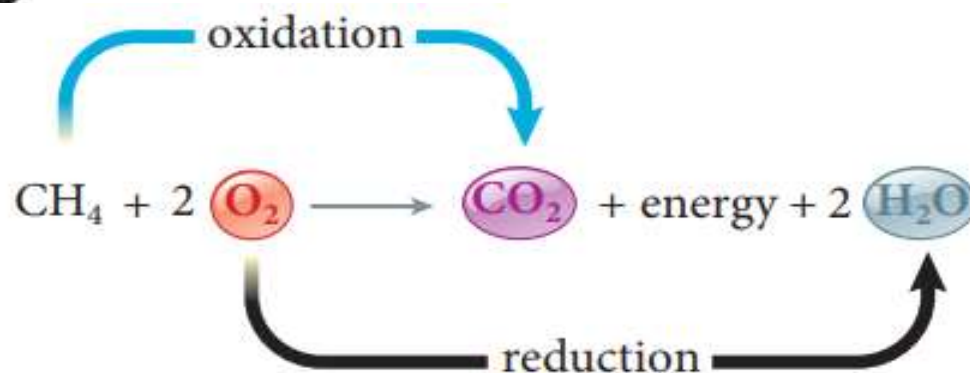
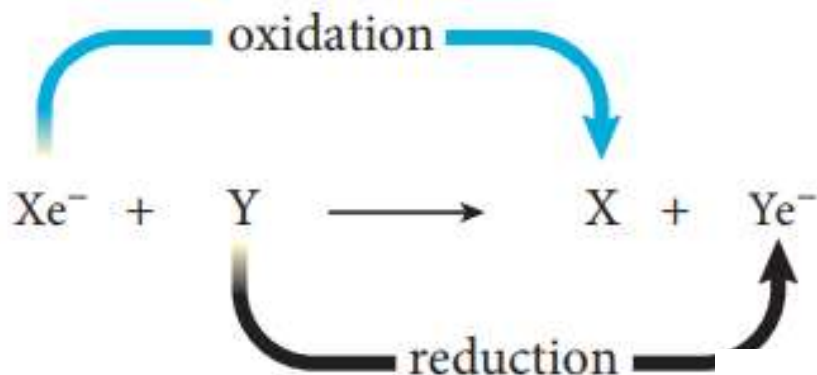
CHEMICAL REACTIONS:

D. Redox reactions: An electron transfer reaction.

“LEO the lion says GER”

Loss of Electron= Oxidation

Gain of Electron= Reduction



WATER: LIFE'S SOLVENT



Q. Why the water is so important in living cell?

70% of the brain, 90% of the lungs, and 22% of bone tissue is water.

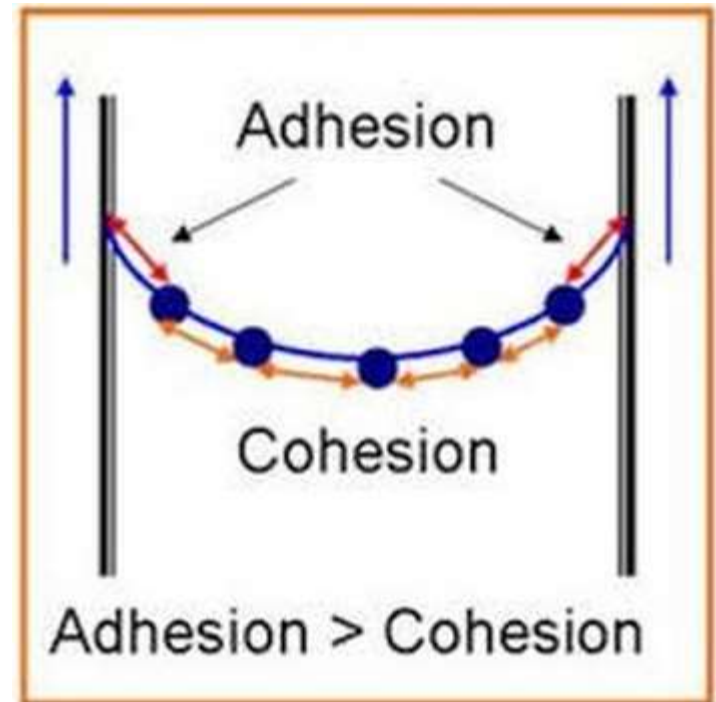
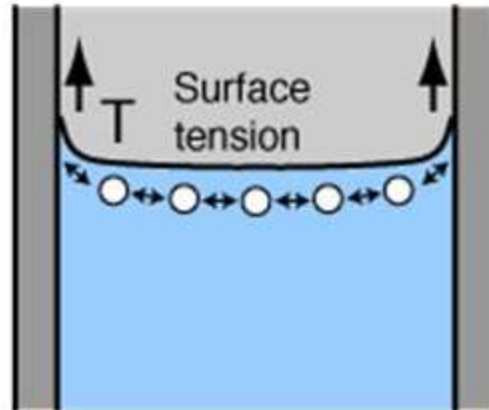
Properties of Water

Table The Unique Properties of Water

Characteristic	Property	Explanation	Effect	Example
Water clings.	cohesion	Water molecules form hydrogen bonds with each other.	high surface tension	<ul style="list-style-type: none"> • A water strider walks on the surface of a pond.
	adhesion	Water molecules form hydrogen bonds with other polar molecules.	capillary action and solubility of polar compounds	<ul style="list-style-type: none"> • Capillary action causes water to move up the xylem tubes in plants. • Polar substances, such as sugars, are highly soluble in water.
Water absorbs thermal energy.	high specific heat capacity	Hydrogen bonding causes water to absorb large amounts of thermal energy as its temperature increases, or lose large amounts of thermal energy as its temperature decreases.	temperature moderation	<ul style="list-style-type: none"> • High heat capacity helps organisms maintain a constant body temperature.
	high specific heat of vaporization	Hydrogen bonding causes liquid water to absorb large amounts of thermal energy and become a vapour (gas).	evaporation and cooling	<ul style="list-style-type: none"> • Many organisms, including humans, dissipate body heat by the evaporation of water from the surface of the body, often by sweating.
Solid water is less dense than liquid water.	highest density at 4 °C	As water molecules cool below 0 °C, they form an ice water lattice. The hydrogen bonds keep the water molecules spread apart, reducing the density so that it is below the density of liquid water.	ice floats on water	<ul style="list-style-type: none"> • Fish and other aquatic organisms survive in winter because water freezes from the top down. • Snow is a very good insulator. It provides protection from extreme cold for many organisms.

Cohesion and Adhesion

- **Cohesion:** The attraction between like molecules
- **Adhesion:** The attraction between unlike molecules.



Adhesion between water and glass is higher than cohesion between water molecules.

<https://www.youtube.com/watch?v=rjbmIXnP5vY>

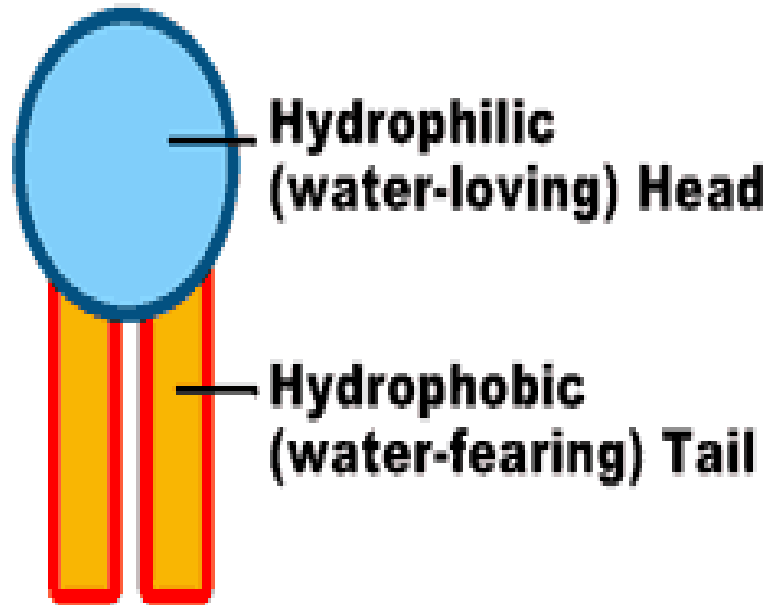
Cohesion and Adhesion

<https://www.youtube.com/watch?v=VHnFMPxteGo>

Aqueous solutions

A. Hydrophilic molecule:
Polar or charged
molecules that are strongly
attracted to the water

B. Hydrophobic molecules:
Non-polar or charged
molecules that are strongly
repel to the water



IONIZATION AND pH

Autoionization: The process in which a molecule spontaneously dissociates into ions

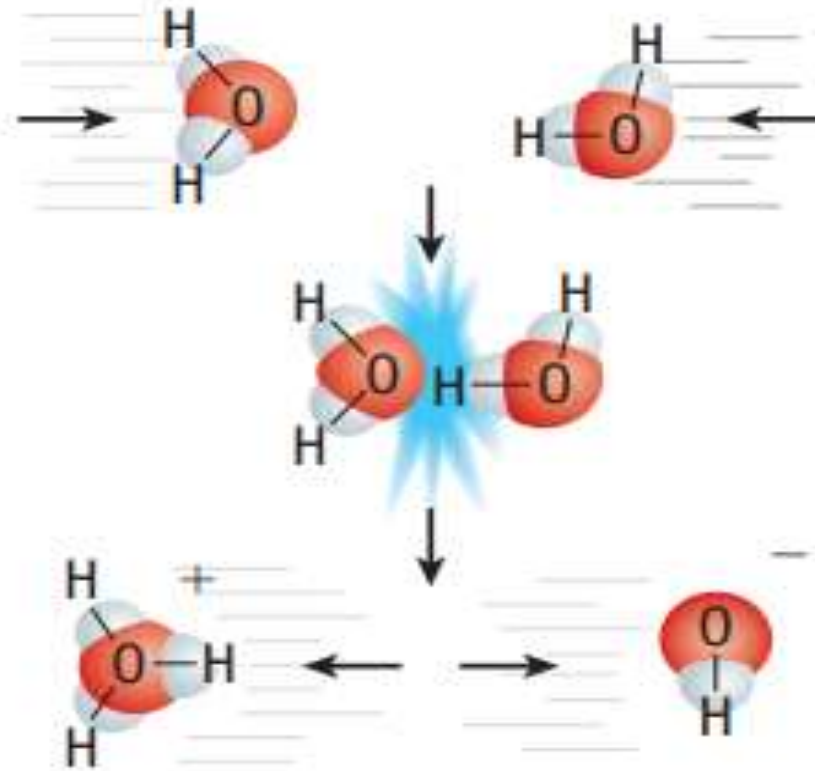
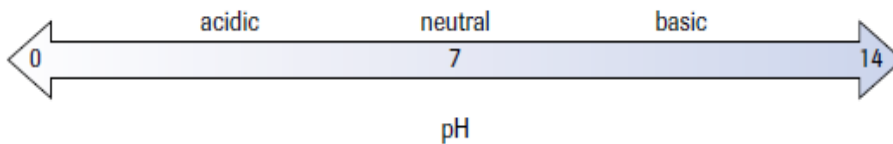


Figure The autoionization of water

STRONG ACID VS. STRONG BASE

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



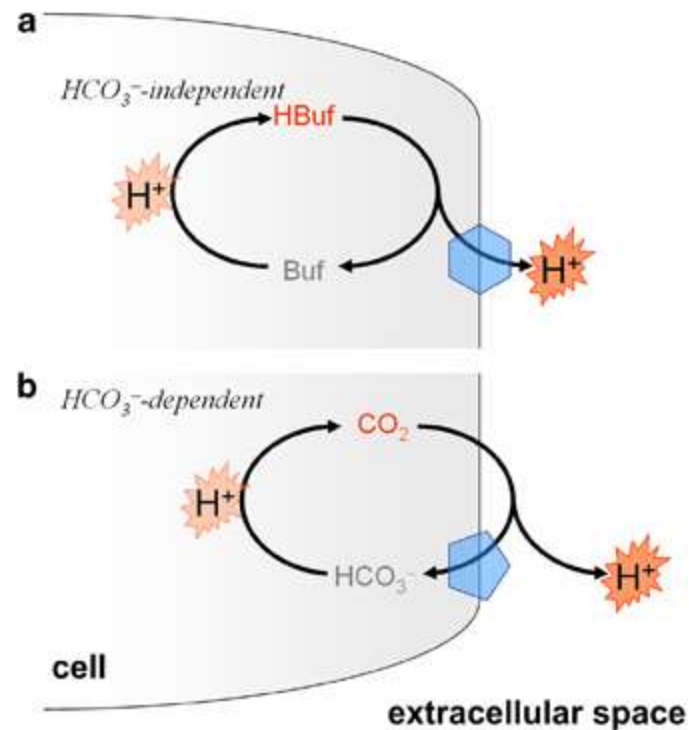
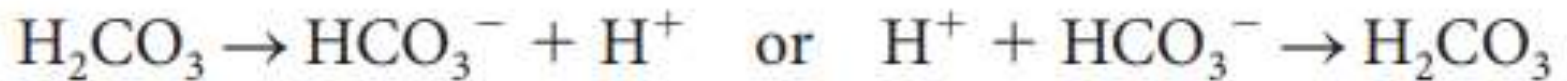
pH scale



Figure The pH values of common substances

NEUTRALIZATION REACTIONS AND BUFFERS

Buffer: A chemical that compensates for pH changes in a solution by accepting or donating H⁺ ions



ACTIVITY#2

C.W.

Pg# 63

Q. 1, 2,3,4,5,6,12,13,14

Pg# 64

Q. 1-9, 38,39



THE END