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chemical bonds

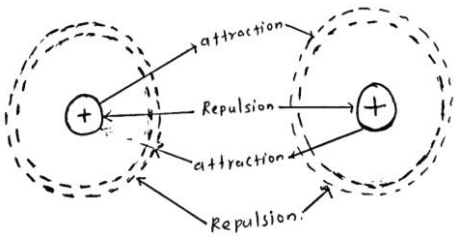
Chemical Bonding

What is chemical Bond?

A Chemical bond is defined as the attractive force that holds two or more atoms together in a molecule or an ion.

Why do atoms combine?

Atoms combine chemically for the following reason.



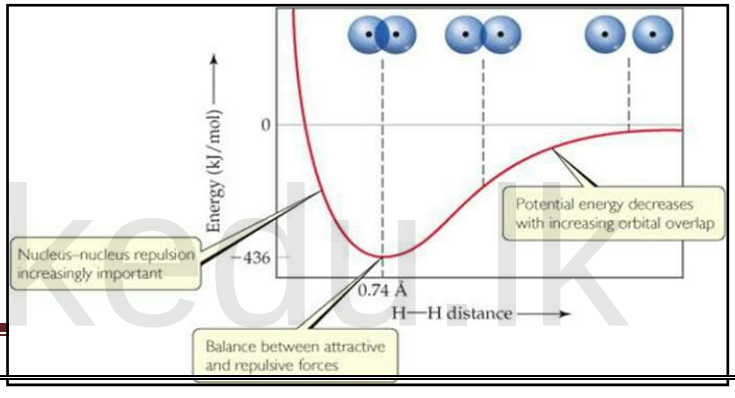
1. Net attractive force between atoms.
   - Atoms consist of strongly positive nucleus and negative electrons.
   - When two atoms come closer to combine with each other to form a bond between them. The attractive force are between the electrons of one atom and the nucleus of the other atom while the repulsive forces are between the electrons or the nuclear of the two atoms.
   - When the two atoms approach closer to each other, these forces counteract each other
   - The net result of these forces may be either attraction or repulsion between the two atoms.
   - If the attractive forces become dominant over the repulsive forces the net result is the attraction between the atoms and hence they combine together to from a chemical bond between them.
   - On the other hand if the repulsive forces become dominant over the attractive forces the net result is attraction and hence no chemical bond is established between them.

     For example: In case of hydrogen atoms the net result is attraction and hence two H atoms combine together to form H_2 Molecules. On the other hand incase of the atoms, the net result is repulsion and hence two He atoms do not combine together to form He_2 molecule
2. Octet rule or rule of eight.
3. Lowering of energy of combining atoms.

   The process of chemical bonding between the two atoms decreases the energy of the combining atoms and given rise to the formation of a system which has lower energy and hence has greater stability

Potential Energy curve

- The trend of the curve from right to left should be observed. When two atoms A and B are far away. Say at an infinitive distance, from each other, the attraction between them is zero & hence, by convention the energy of each of the atoms arbitrarily taken to be zero



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and for stable system it is negative. There is no possibility of the formation of any bond between them. At point X.

- As the two atoms are brought closer to each other ie, as the distance between the atoms is decreased, the attractive forces between two electrons and the nucleus become more dominant than repulsive forces operating between the electrons of the two atoms and hence the energy of two system goes on decreasing as shown by the downward trend of the curve.
- This decrease of energy continues tilla certain minimum value show by point Y in the curve is obtained. Now if the atoms are brought still closer together the repulsive forces between the two nucler at such small inter nuclear distance (inter nuclear distance between the nuclear of the two atoms) becomes dominant and hence the energy of the system starts increasing as shown by the upward trend of the curve.

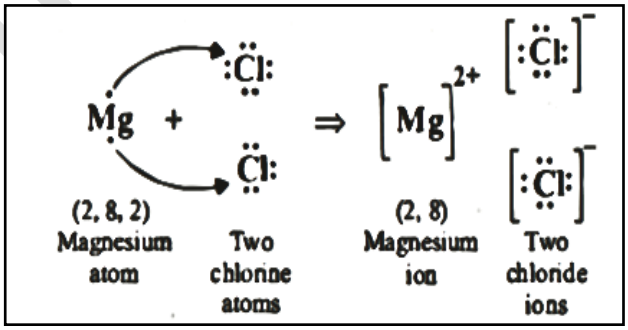
  Point Y which is the minimum of the curve has the following characteristics.

  a) At this point the attractive and repulsive forces are in equilibrium and hence a bond is said to be established between the atoms at this point.
  b) The overlapping between the orbitals of the two atom is maximum at this point.
  c) The energy of the system at this point is minimum and hence AB molecule is in the stables position. The inter nuclear distance is also minimum at this point. The minimum energy value and inter nuclear distance corresponding to this point are called respectively bond energy and bond length of AB molecule.

What is Ionic Bond?

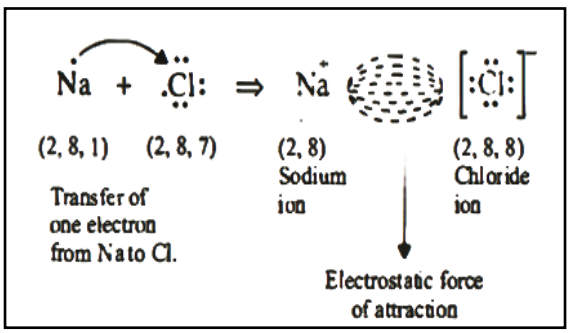
The chemical bond formed between two atoms by the transfer of one or more valance electrons from one atom to other is called ionic bond. This bond is also called electrovalent or polar bond.

Eg: $CaCl_2$, MgO, CaF_2, KF, Al_2O_3, BeF_2,



Factors favouring the formation of ionic compounds.

1. Number of valance electrons
   - A → Converted into A^+ should poses 1,2,0r 3
   - B→ Converted into (B^-). VA. VIA, VIIA, I, II, III
2. The ionization energy of the metal atom should be low.
3. Electron affinity of the non-metal should be high.
4. Electron negativity difference of A and B should behigh (2- 16)
5. The lattice energy of the ionic compound formed should be high. Coulomb's law the force of attrition



$$(F)/L = \frac{q_1 q_2}{d^2} = \frac{q1q2}{(r^+_A + r^-_3)^2}$$

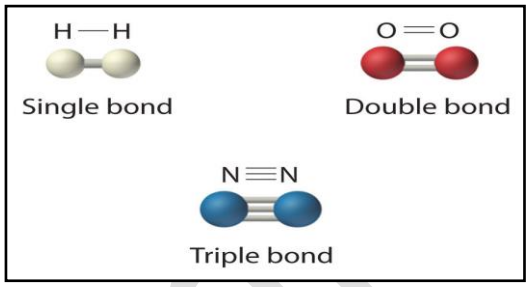
- **F α q_1q_2 Charges increase lattice energy increasing**

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- **Mg^{2+}. O^{2-} Na^{+}, Cl^{+} → Mg^{2+} O^{2-} ionic crystal is 4 times greater than between monovalent Na^{+}, Cl^{-} ions crystal.**
- Fα $1/r^2$ - r should be small. NaCl is more stable than CsCl.

Covalent bond

The chemical bond between two atoms in which the electrons (inpairs) are shared by both the participating atoms is called covalent bond.



Factors favouring the formation of Covalent compounds.

1. High ionization energy
2. High nuclear charge & small Inter nuclear / distance.
3. Number of valence electrons. (5, 6, 7)
4. Equal electro negativity .

Failure of Octet Rule

Molecules in which the octet remains incomplete	Molecules in which the octet is expanded.
$BeCl_2$, BF_3, BCl_3, $(CH_3)_3$ Ga	PCl_5, ClF_3, ICl_3, SF_6, IF_7

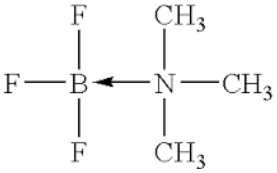
What is co-ordinate bond / Dative bond.

Co-ordination bond which is formed by the mutual sharing of two electrons both of which are provided entirely by one of the linked atoms or ions is called a co-ordinate bond.

- The pair of shared electrons is called lone pair.
- The atom which furnishes the electron pair is called donor aligand while the pther atom which accepts the electron pair is called acceptor.
- A coordinate bond is represented by on arrow which points away from

Eg: O_3, BF_4^- , CO, NH_4^+, H_3O^+, Al_2Cl_6, $LiAlH_4$, $NaBH_4$, NH_4Cl, $Cu(NH_3)_4^{++}$

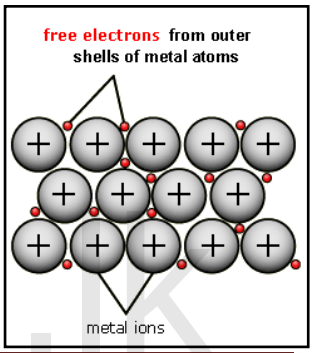
Conditions for formation of a co – ordinate bond.



1. The atom acting as a donar should have a lone pair of electrons
2. The atom acting as an accepter should have a vacant orbital to accept the electron pair donated by the donor.

Metallic Bond

- The bonding which holds the metal atoms firmly together as a result of the attraction between the positive metal ions and surrounding freely mobile electrons is called the metallic bond.



Condition for the formation of metallic Bond.

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- Lower ionization energies.
- Metal should have vacant valence orbitals.

Comparison of the properties of ionic & convent compound

Property	Ionic compounds	Covalent compounds
Physical state	These are crystalline solids at room temperature. They are never liquids or gases under the ordinary conditions.	Most of the covalent compounds exist the gases or liquids or solids.
Melting & boiling point	They have usually high melting & boiling point due to higher attraction force	With the exception of giant molecules. Other covalent solids have low m.p & b.p
Solvability	They are freely soluble in polar solvent & slightly soluble in non polar solvents (Solvation energy of the solvent is greater than the lattice energy of the ionic cpd.	They are insoluble in polar solvents is based on the principle like dissolve like convents solids current have lower density.
Electrical conductivity	These are bad conductors when they are in solid. However they conduct electricity in fused state or in solution in which their ions are free to migrate.	Consisting of glint molecules are poor conductors because they do not contained charges or electrons to carry the Molecules are poor conductor's because they donot contained charges or electrons to carry the current .
Hardness or density	Have high density	Have low density
Nature of reaction	They undergo ionic reaction	They undergo molecular …….
Crystal	The consists of three dimensional solid	They exist 1. Simple molecular 2. giant →diamond 3. Separate layers → graphite

Physical properties of Metal	Properties of co-ordinate compound.
• Metal good conducters of electricity • Metal good conductors of heat • Metals are malleable or plastic and ductile • Metals are solids and have high density. • Metals have intermidate melting point /S.B.P. • Metal forms alloys. • Metal are usually hard solids.	• Physical state these are gas, liquid, solids. • Semipolar character • Solubility – These are insoluble in pals. Solvents like water but solyble in non plalar solven. • Conductivity – they donot conduct electric current • Melting & boiling point higher than covalent conpound but lower than ionic compounds. • Undergo molecular reaction

Note: Metallic bond is depend on

1. Increase of valance electron

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2. Increase charge on nucleus
3. Decrease the size of metal positive ion
4. Alkaline earth metal is greater than alkaline metal

What is hydrogen bond?

The attractive electrostatic force between a hydrogen atom which is already covalently attached with a strongly electronegative(F,O,N)atom of a molecule (same molecule or different molecule) is known as hydrogen bond.

Properties of Hydrogen Bond. (Physical)

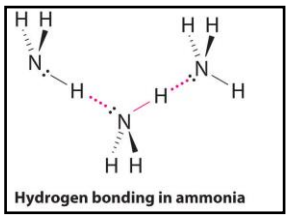
1. Association of molecules (Polymerization

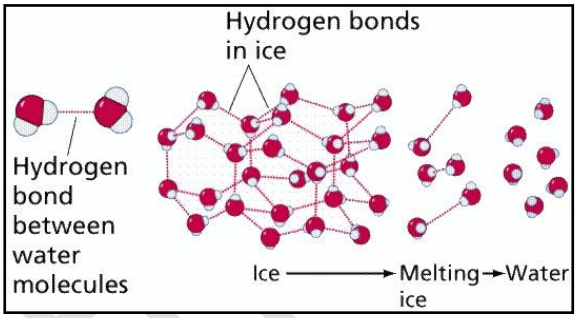
   (Polymerized molecule)

   a. Liquid NH_3

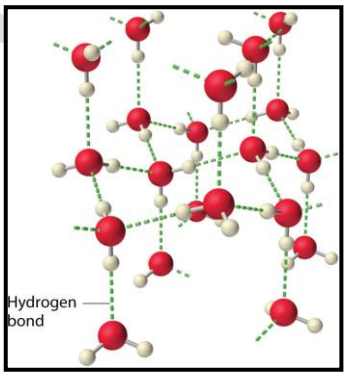
   b. H_2O Molecules

   c. Solid state of water (Ice)





   - Here each O atom of each H_2O is linked with two H atoms of it's own molecule by covalent bond S with two H atoms. Of neighboring H_2O molecules by H – bonds.
   - Therefor Ice get Tetrahedral structure
   - Ice are not packed very closely together have vacant space.



2. Liquid water has higher density than solid ice.

   Ice has vacant space in it. Which gives a large volume to a given mass of ice. When ice is melt some of the H – bond are broken & water molecules come closed to the each other. This result in a decrease of volume

   - hence density is increased. (Ice flots on liquid water.
   - Density of water is maximum at 4°C after that kinetic energy of H_2O increased, volume of water molecules increased density will decrease.
   - Association of HF molecules

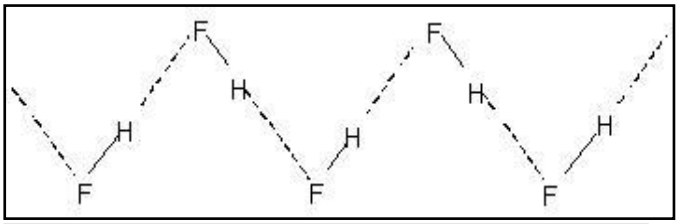
3. High solubilities of some cevolent compounds.
4. High viscosity, high heat of vaporization & high dielectric constant

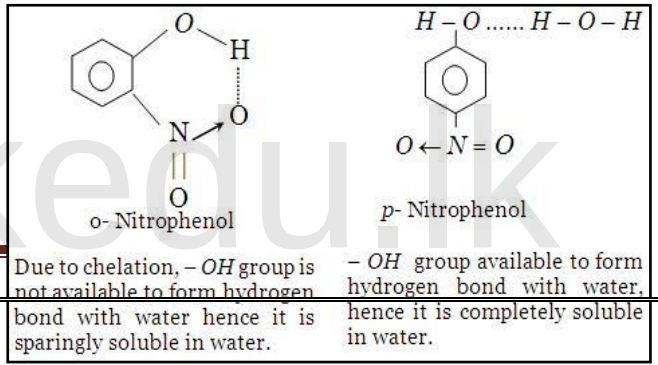
   Glycerol higher viscosity then C_2H_5OH.

   1. Inter Molecular H – Bond.

      E.g. NH_3, H_2O, HF

   2. Intra Molecular H – Bond.





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E.g. Otho – Nitrophenol

What are vender wals forces?

Vander wals forces are very short – lived inter molecule attractive forces which are belived to exist between all kinds of atoms, molecules, ions when they are sufficiently close to each other.

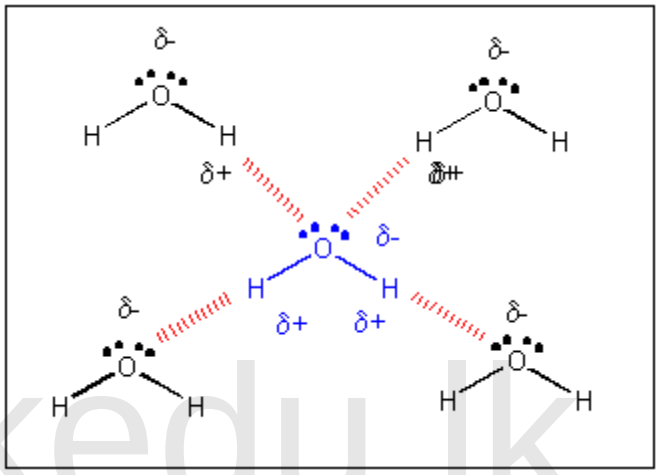
Eg: Inter gases He, Ne, Ar, Kr, Xe / molecules N_2, O_2, CO_2, H_2, CH_4,P_4, S_8, I_2 Factors affecting the strength and magnitude of vander wall forces.

1. Large mumber of electrons in molecule V.W.f. ∞ No.of e. s
2. Large molecule size (V.W.F. ∞M.S) ∞ M.P , B.P
3. Temperature & pressure (V.W.F.α 1/T) V.W.F.∞ P)
4. V.W.F. ∞ Surface area
5. Types of vander walls forces.
   a) Ion dipole interaction polar molecules are attacked towards ions the negative end of dipoles is attracted towards the action while the positive end towards the anion this is called ion – dipole interaction
      Eg: NaCl in H_2O
   b) Dipole dipole interactions → These forces are found in polar molecules having permanent polarity in them. Hcl in $_{H2O}$
   c) Ion – incluced dipole → I_2 in KI → I^- ….. I δ^+ …. $I^{\delta-}$
   d) Dipole – induced dipole.

Importance of H – bond inliving matter

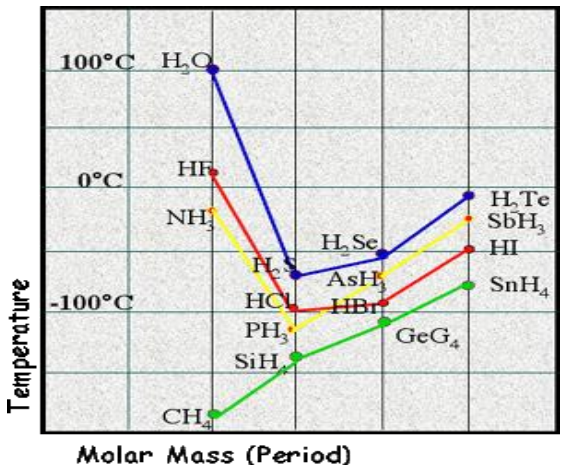
1. H_2O
2. Proteins
3. Nuclic acid
4. Corbohydrates
5. Lipids
6. DNA (Double – induced dipole HF> Hcl> Hbr> HI B.P
7. Special properties of living matter B.P NH3 < HF < H_2O But H – F > 0 – 4 > N – H

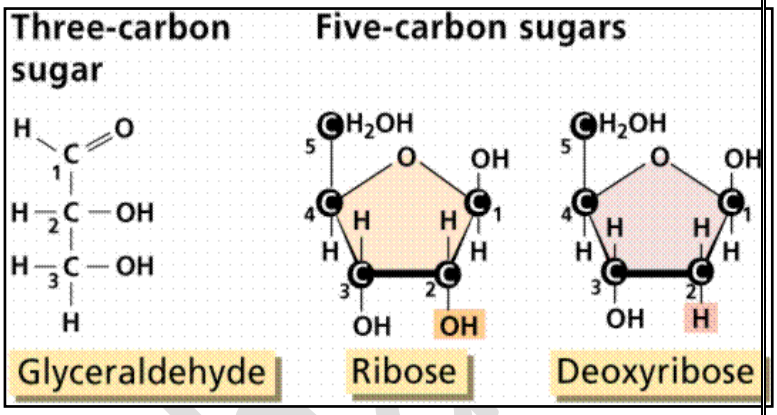
1. H_2O –
   1. All metabolic process water.
   2. Excellent solvent
2. H_2O – high specific heat capacity.
3. Density of ice less than H_2O
4. DNA is stable due to H-Bond (Double helix)



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5. Protein molecule can form H – bond among amino acids.

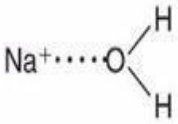
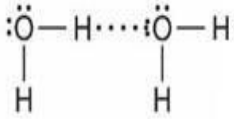
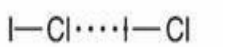
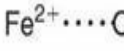
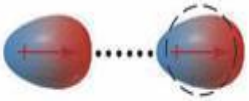
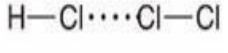
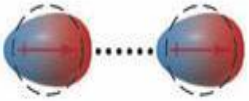




Comparison of the Energies Associated with Bonding (Intramolecular) Forces and Intermolecular Forces

FORCE	MODEL	BASIS OF ATTRACTION	ENERGY (kJ/mol)	EXAMPLE
Intramolecular				
Ionic		Cation–anion	400-4000	NaCl
Covalent		Nuclei–shared e^- pair	150-1100	H–H
Metallic		Cations–delocalized electrons	75-1000	Fe
Intermolecular				
Ion-Dipole		Ion charge–dipole charge	40-600	$Na^+ \cdots O(H)H$
H-Bonding	$\delta^- \; \delta^+ \; \delta^-$ A–H ····· :B–	Polar bond to H–dipole charge (high EN of N, O, F)	10-40	O–H···O–H
Dipole-Dipole		Dipole charges	5-25	H–Cl···H–Cl
Ion-Induce Dipole		Ion charge–polarizable e^- cloud	3-15	$Fe^{2+} \cdots O_2$
Dipole-Induced Dipole		Dipole charge–polarizable e^- cloud	2-10	H–Cl···Cl–Cl
Dispersion (London)		Polarizable e^- clouds	0.05-40	F–F···F–F

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Nonbonding (Intermolecular)				
Ion-dipole		Ion charge–dipole charge	40–600	
H bond		Polar bond to H–dipole charge (high EN of N, O, F)	10–40	
Dipole-dipole		Dipole charges	5–25	
Ion–induced dipole		Ion charge–polarizable e⁻ cloud	3–15	
Dipole–induced dipole		Dipole charge–polarizable e⁻ cloud	2–10	
Dispersion (London)		Polarizable e⁻ clouds	0.05–40	

Variable Covalence

- Generally the covalency of an element which has only S & P orbital its valancy – shell (eg: H, O, N, F) is a fixed quantity (not always) and is equal total nymber of unpaired e^{n}s is s or p orbitals for example
- 1. H = 1s1 → covalency → 1, N , $1s^2\ 2s^2\ 2p_n^1$ apy $ap^1y\ 2pz^1 = 3$

  O = $1s^2\ 2s^2\ 2p_n^2\ 2p_y^1\ 2p_z^1 = 2$, F = $1s^2\ 1s^2\ 2ps^2\ 2p_y^2\ 2p_z^1 = 1$

  Note → the element mentioned above has only s & P orbitals in their valence shells ie, these elements donot contain vacant d – orbitals. However the elements containing vacant d-orbitals in the valance shells of these elements. There for these elements shows different covalencies.

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