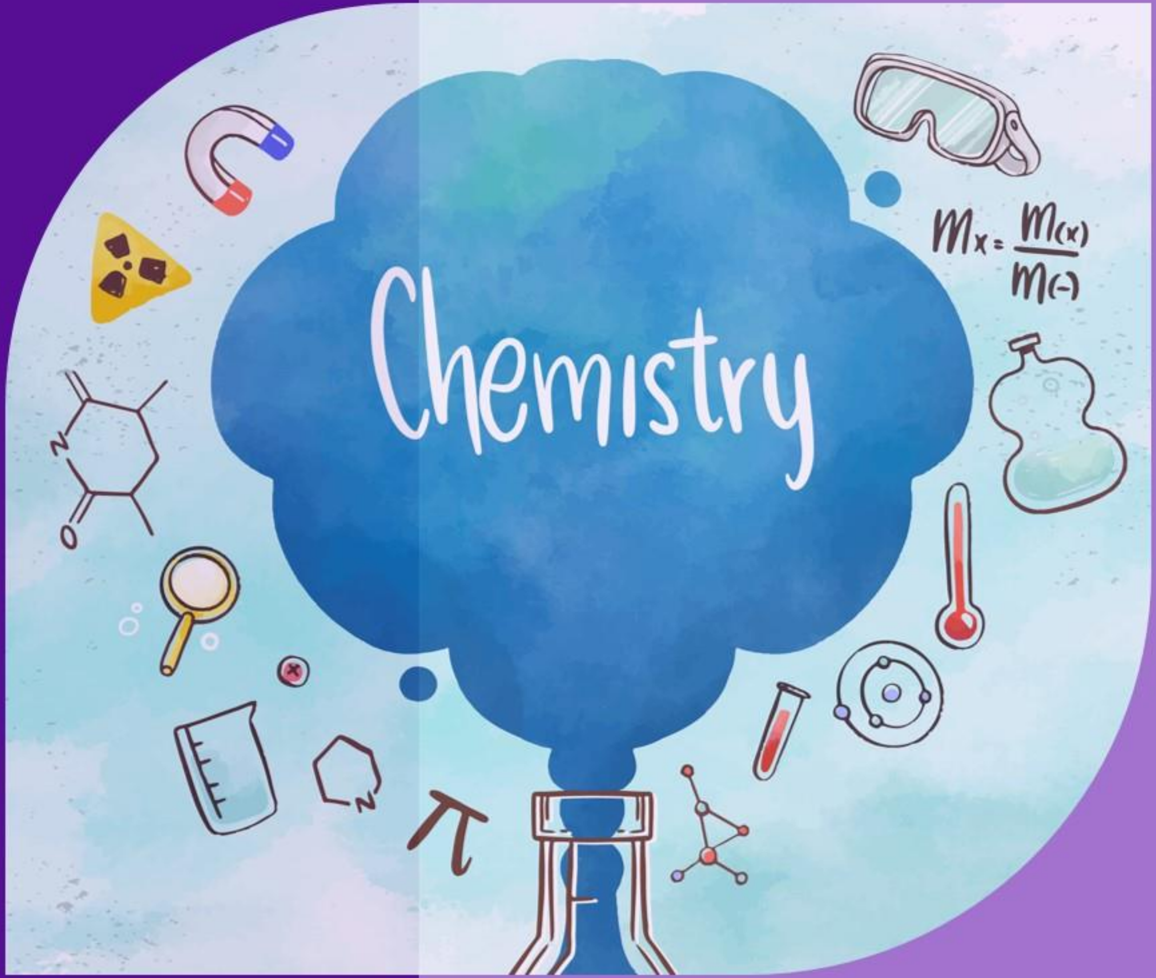
ENGINEERING ADMISSION PROGRAM 2020

CHEMISTRY

LECTURE : C-02

CHAPTER 03 : PERIODIC PROPERTIES OF ELEMENTS & CHEMICAL BOND (CHEMICAL BOND)



Bond

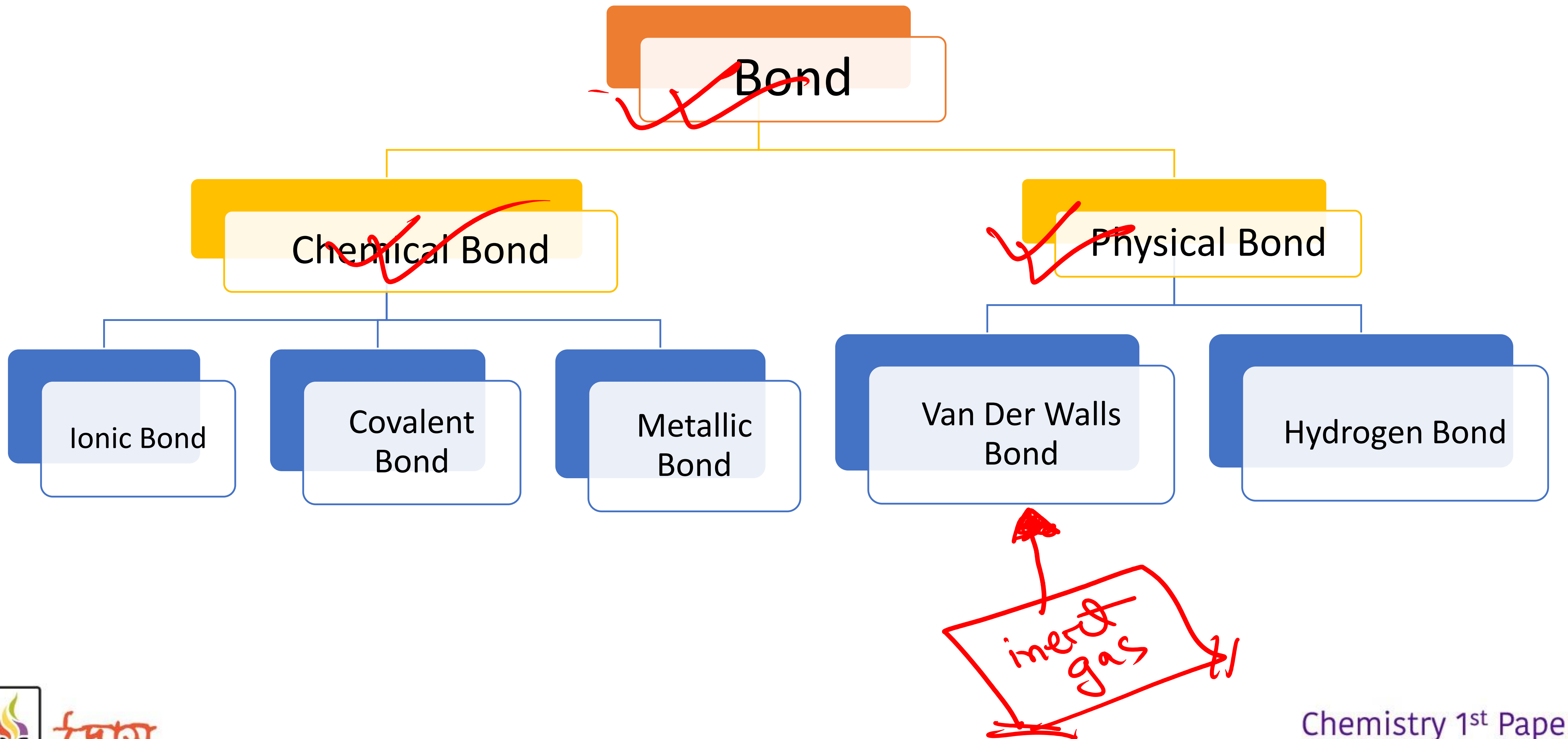
Bond:

Bonding is the process by which the molecules of matter are joined together by the force of attraction. The reasons of forming chemical bond are—

(i) The tendency of achieving stable electronic configuration of inert gases.

(ii) The tendency of elements having minimum static energy to achieve maximum stability.

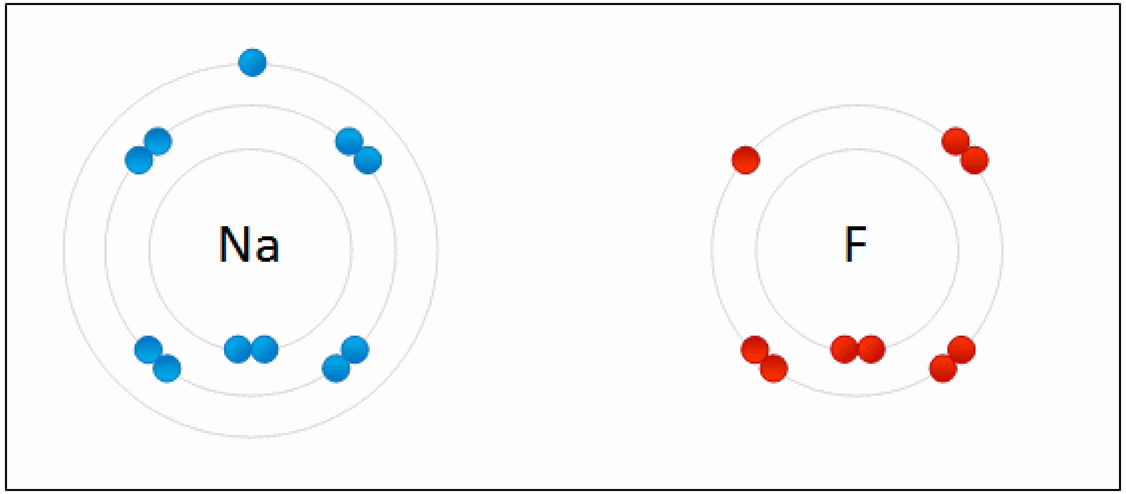
Bond


Bond
Chemical Bond
Physical Bond
Ionic Bond
Covalent Bond
Metallic Bond
Van Der Walls Bond
Hydrogen Bond
inert gas

Ionic Bond

Ionic Bond:

- formed by transfer of one or more electrons from the outer most shell
- oppositely charged ions
- electrstatic force of attraction.



Conditions for formation of ionic bond:

(i) metal atoms should have low ionization energy.

(ii) non-metal atoms should have high electron affinity.

(iii) The lattice energy of the crystals of ionic compounds must be high.

❑ Ionic Bond

General properties of ionic compounds :

(i) Melting and boiling points are very high.

(ii) They are non-volatile.

(iii) They are good conductor of electricity in molten state or in solution

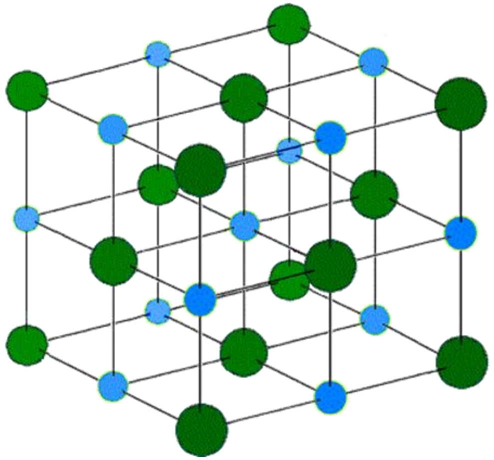
(iv) The rate of reaction is very high.

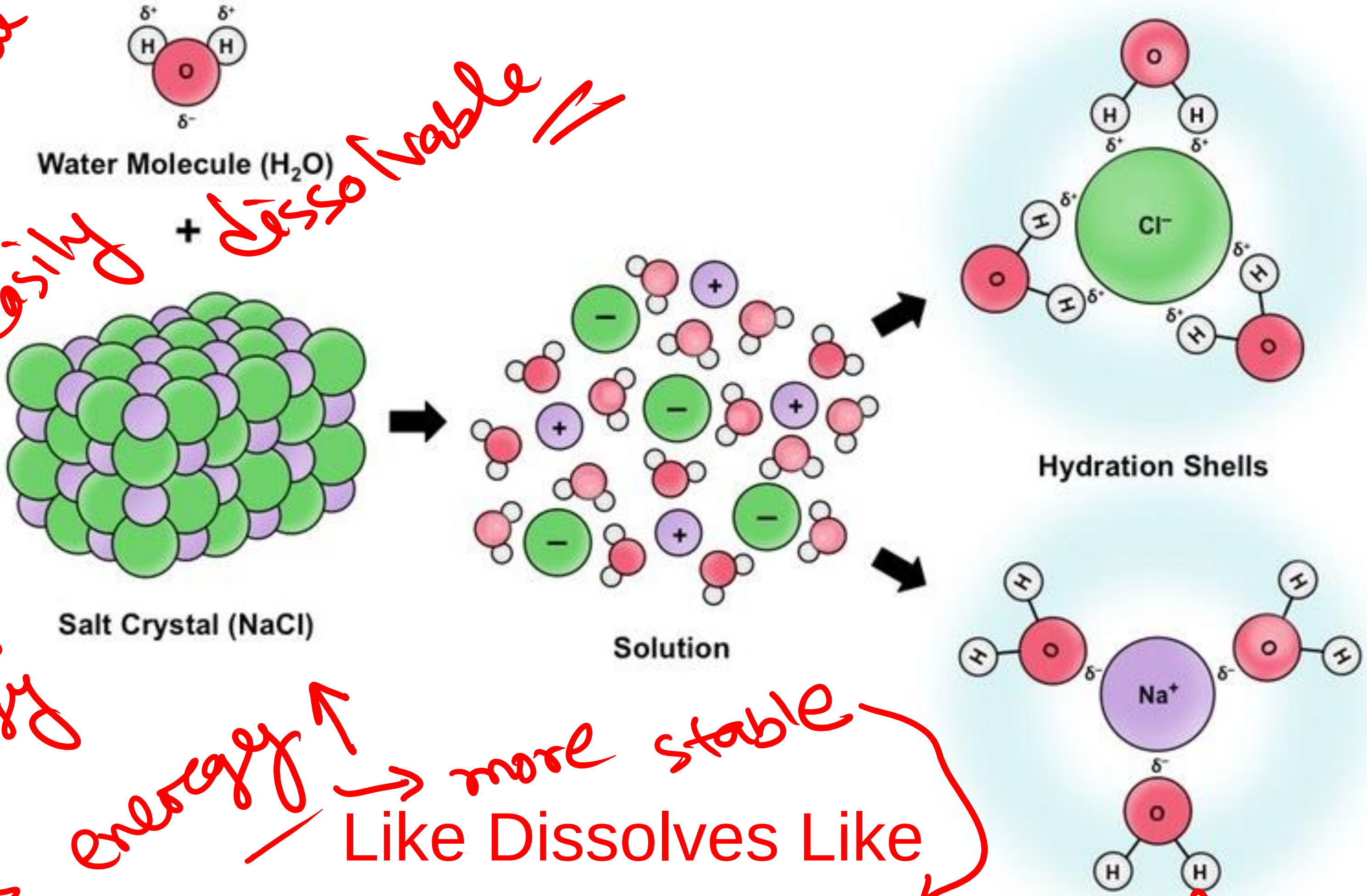
(v) In chemical reaction, the ions of that ionic compound retain their properties.

(vi) Isomorphism

Structure of NaCl & Solubility in water

NaCl → hyd en → ↑↑
lattis → ↓↓





inc → less stable → easily + dissolvable

hydration enthalpy energy ↑

lattis energy ↑ → more stable → not easily dissolvable

Like Dissolves Like

Metallic Bond

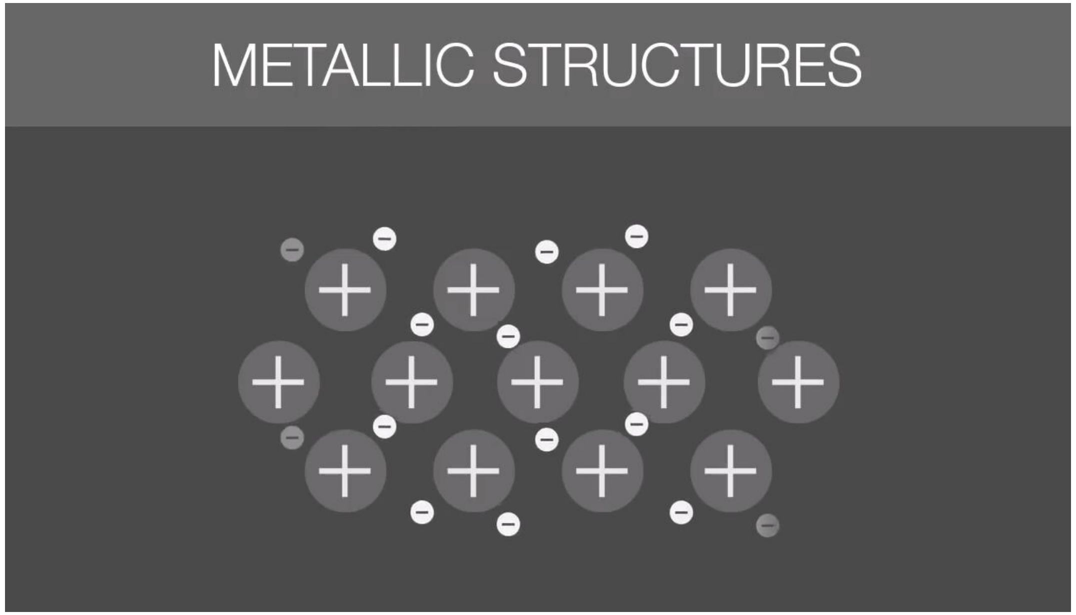
General Properties of Metallic Bond

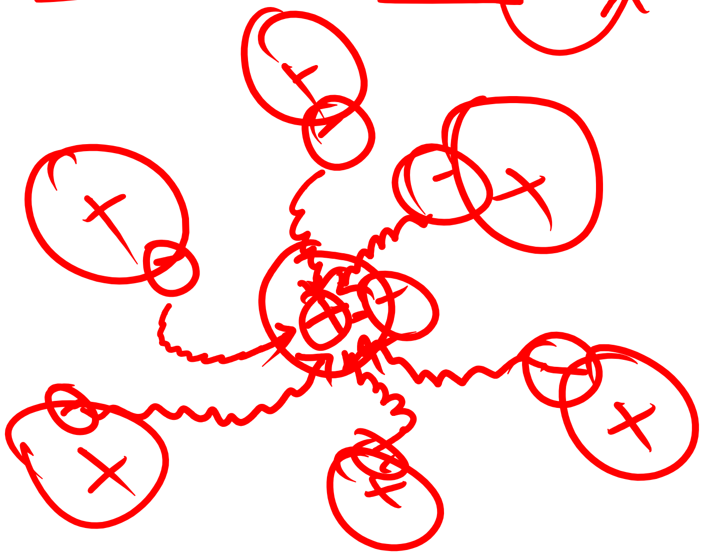
(i) Metals have crystalline structure

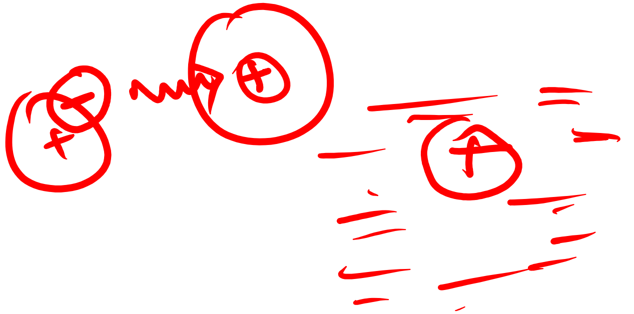
(ii) Metal is a good conductor of electricity

(iii) Metals have luster

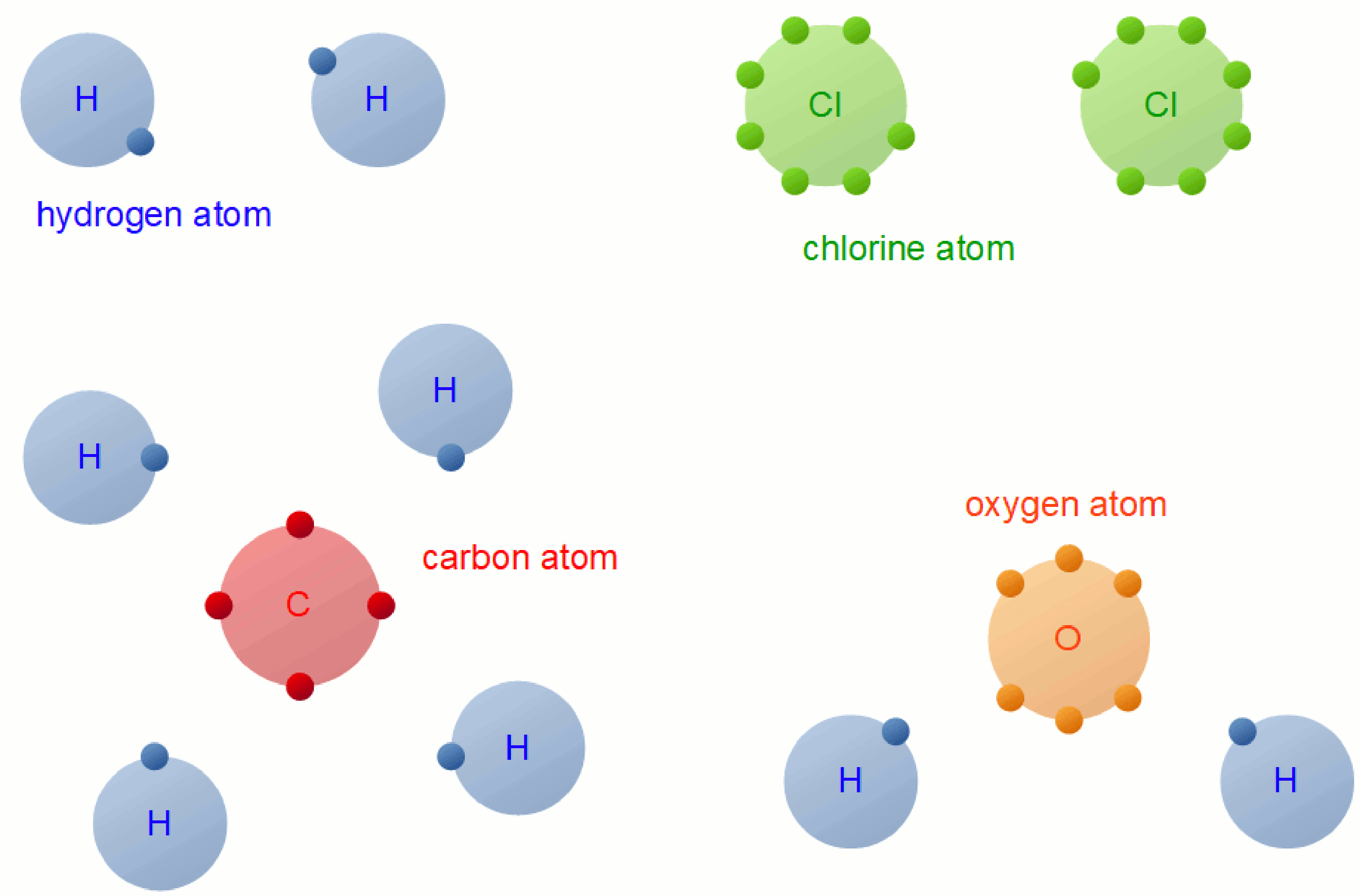
(iv) Metals are malleable and ductile(flexible)







Covalent Bond



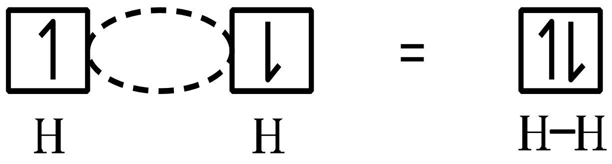
Theory of formation of Covalent Bond

(i) VSEPR theory

(ii) Valence Bond Theory

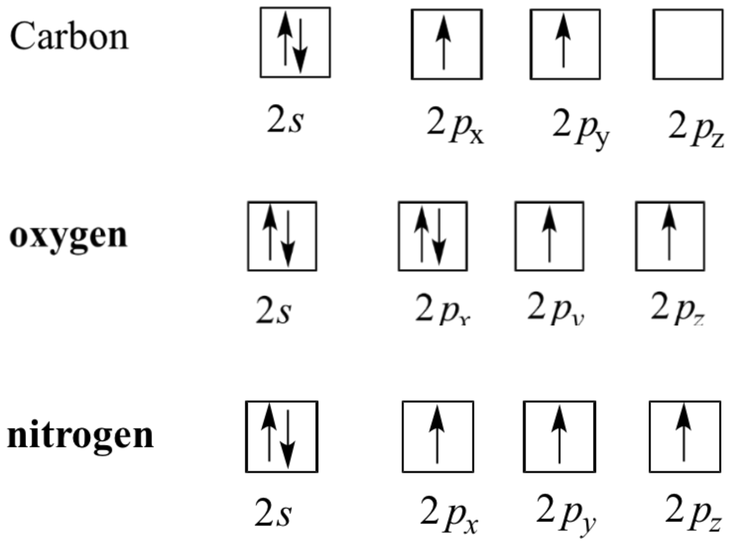
H(1) - $1s^1$

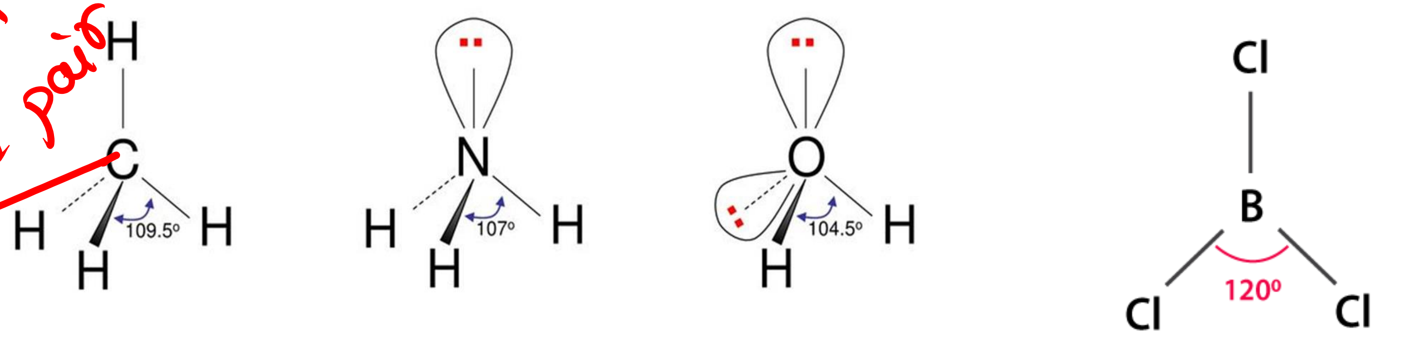
$H^{\bullet} + {}^{\times}H \rightarrow H\overset{\bullet}{\times}H = H{-}H$



VSEPR Theory (Valence Shell Electron Pair Repulsion)

lp-lp> lp-bp> bp-bp





CH_4, methane NH_3, ammonia H_2O, water

Poll Question 01

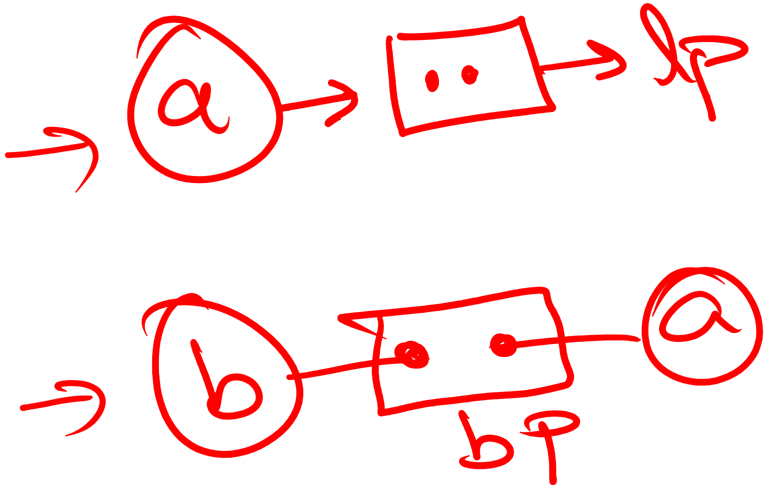
Which one of the following series of species is correct in order of increasing bond angle $(O - N - O)$? **[BUET'12-13]**

(a) $NO_2 < NO_2^- < NO_2^+$

(b) $NO_2^+ < NO_2 < NO_2^-$

(c) $NO_2^- < NO_2^+ < NO_2$

(d) $NO_2^- < NO_2 < NO_2^+$



Determination of nature of hybrid orbital

$x = 1/2\ [V+M-C+A]$

x = Number of hybrid orbital

V = Number of e^- in the valence shell of central atom

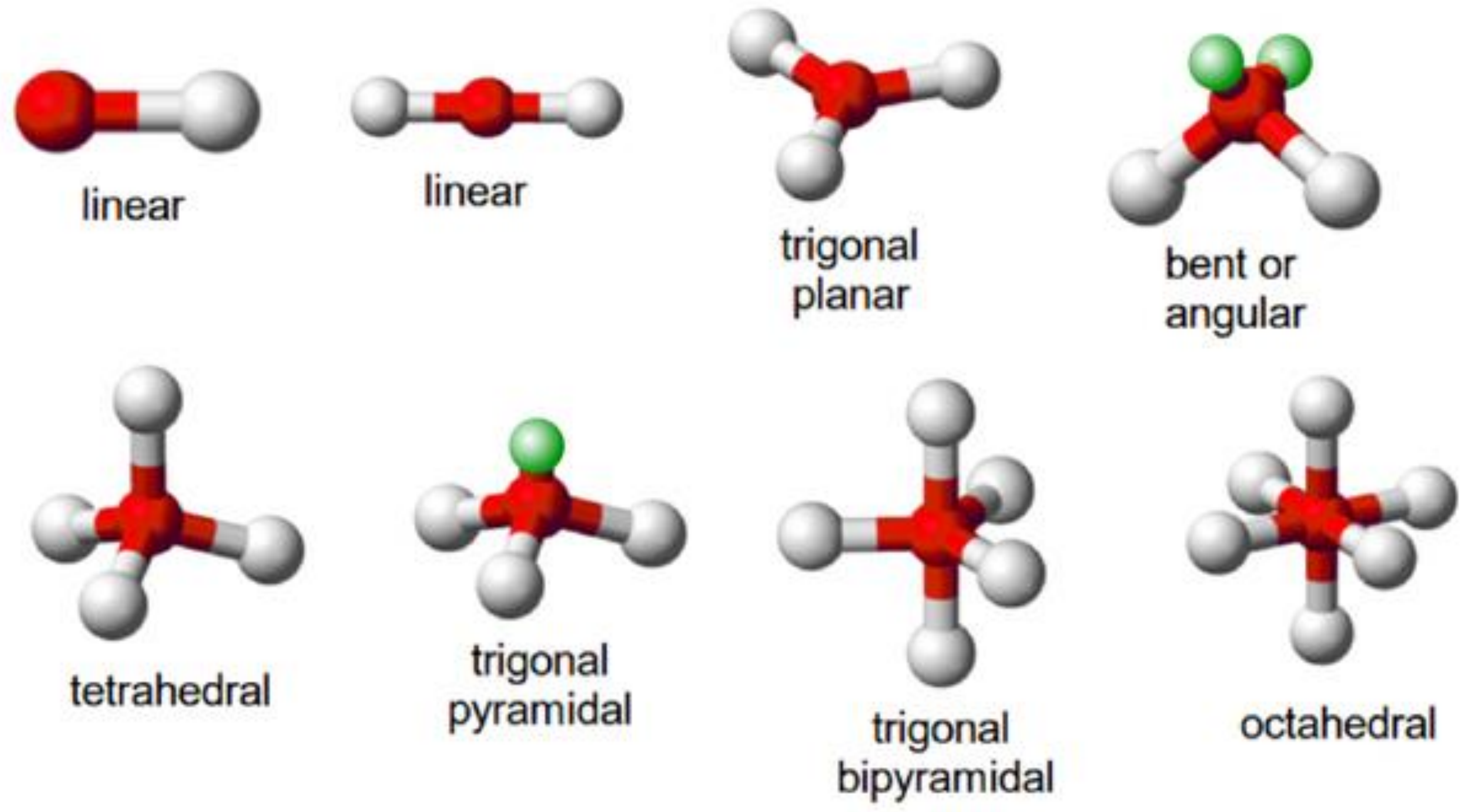
M = Number of monovalent atom in the molecule/Radical number

C = Charge of cation

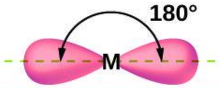
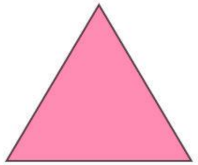
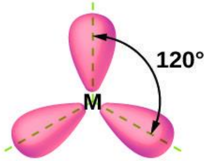
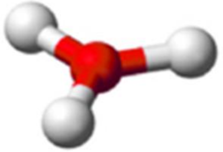
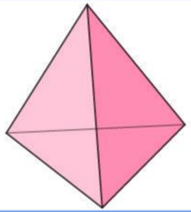
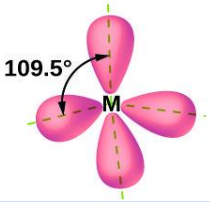
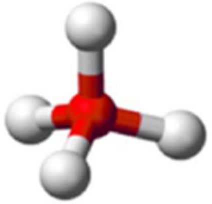
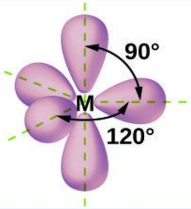
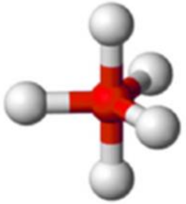
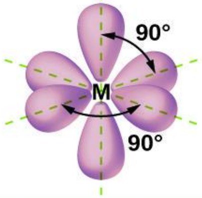
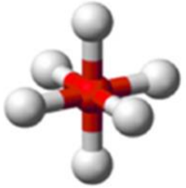
A = Charge of anion

x	2	3	4	5	6	7
Hybridization	sp	sp^2	sp^3	sp^3d	sp^3d^2	sp^3d^3
Geometric Shape of Molecule/ion	Linear	Trigonal Planar	Tetrahedral	Trigonal Bypyramidal	Octahedral	Pentagonal Bypyramidal

Geometric shapes of hybrid orbitals



Geometric shapes of hybrid orbitals

Regions of Electron Density	Arrangement		Hybridization		
2		Linear	*sp*		
3		Trigonal planar	sp^2		
4		Tetrahedral	sp^3		
5		Trigonal bipyramidal	sp^3d		
6		Octahedral	sp^3d^2		

Geometric shapes of hybrid orbitals

Rule-01:

Monovalent atoms around central atom

$CH_4, NH_3, H_2O, PCl_5, BeF_2, PCl_3, XeF_2, XeF_4, SF_6$

$V=6, M=2$

$C=A=0$ $\quad x = \frac{1}{2}[6+2] = 4$ $\quad sp^3$

$V=4$

$M=4$

$C=0$

$A=0$

$x = \frac{1}{2}[(4+4)-(0+0)] = 4$

sp^3

$V=8 \rightarrow 6$

$M=4$

$=4$

sp^3d^2

d^2sp^3

$S \rightarrow V \rightarrow 6$

$M \rightarrow 6$

$x = \frac{1}{2} \times 12 = 6$

sp^3d^2

উদ্ভাস
একাডেমিক এন্ড এডমিশন কেয়ার

Geometric shapes of hybrid orbitals

Rule-02:

Divalent atoms around central atom

SO_2, CO_2, XeO_3, SO_3

Rule-03:

Both monovalent & divalent atoms around central atom

$COCl_2, XeOF_2, XeOF_4, POCl_3$

Geometric shapes of hybrid orbitals

Rule-04:

Hybridization of Cations

NH_4^+, CH_3^+, H_3O^+

Rule-05:

Hybridization of Anions

CO_3^{2-}, NO_2^-, NO_3^-, SO_4^{2-}

Poll Question 02

What is the shape of the ion NH_4^+? [SUST'16–17]

(a) linear

(b) triangular

(c) tetrahedral

(d) trigonal pyramidal

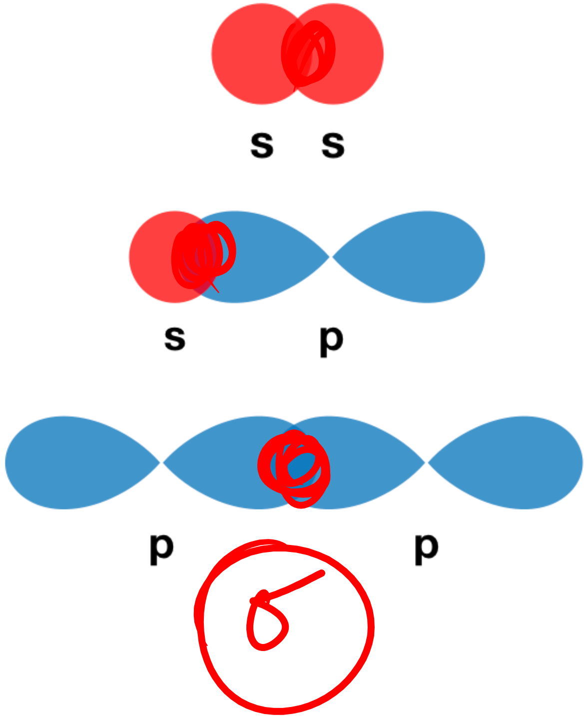
- Write down the name of shape of the following compounds: **[BUET’16-17]**

  (i) BCl_3 (ii) NH_3 (iii) PCl_5

- Mention the hybridization state of central atom of the following compounds:

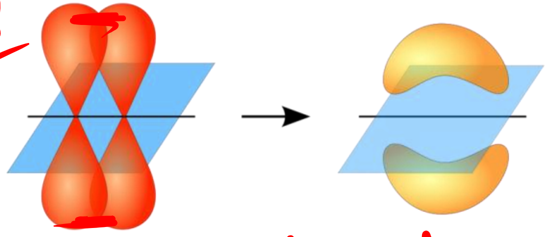
  (i) $K_3[Fe(CN)_6]$ (ii) SF_6

Overlapping of Orbitals (V.B.T) Sigma & Pi bonds

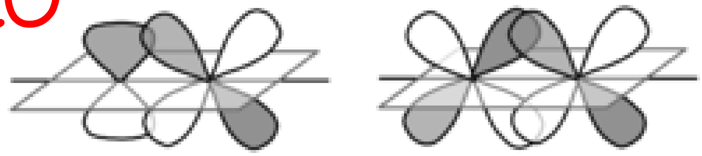


overlap → energy share → strong bond

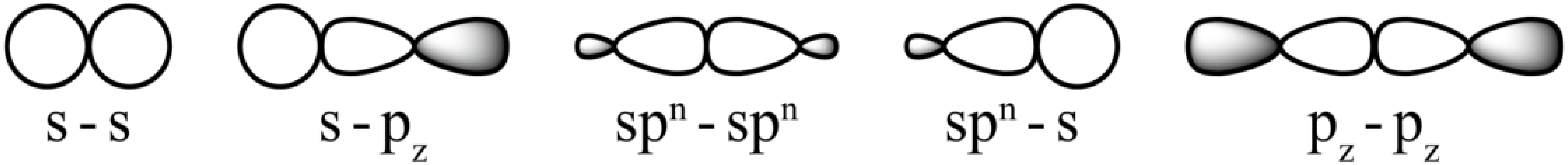
parallel



π → weak bond



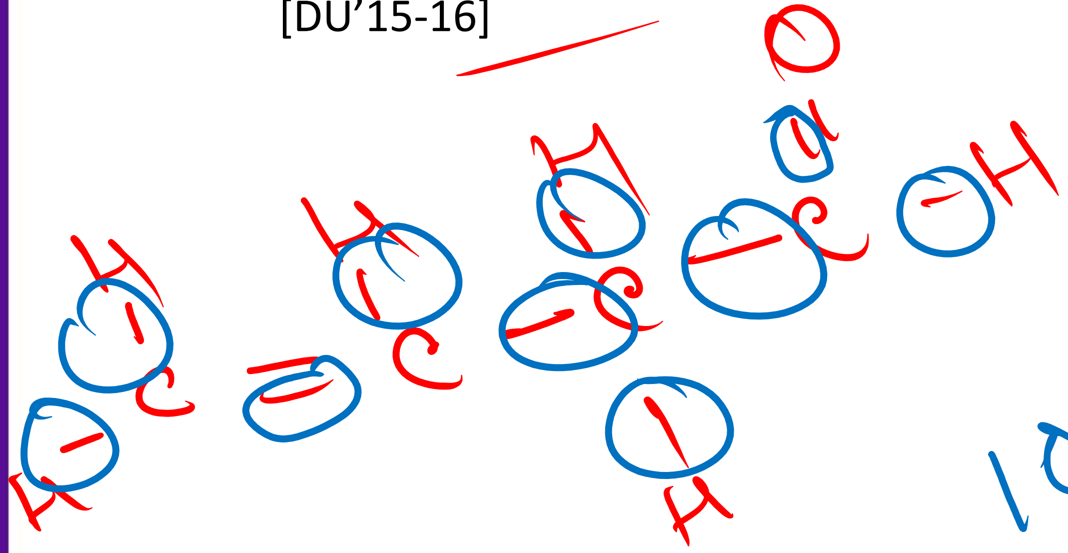
σ bonds



Counting sigma (σ) & pi(π) bonds

$CH_2 = CH - CH_2CHO$

[DU'15-16]



10 sigma
2 pi

CH_3CN →

[DU'12-13]

5 sigma
2 pi

C_3H_4

[DU'13-14]

6-S
2-π

Poll Question 03

In the following compound which carbons show sp3 hybridization

$$H_2C = CH - CH_2 - C \equiv C - CH_3$$

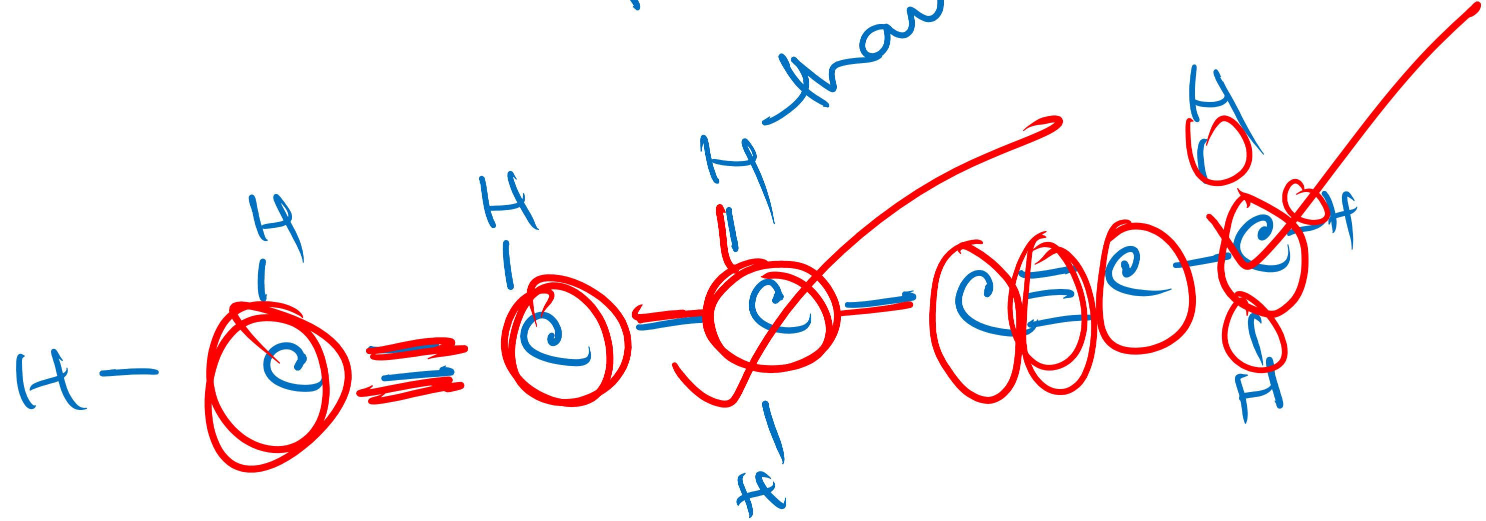
(a) 1 & 5

(b) 1 & 3

(c) 3 & 6

(d) 1 & 4

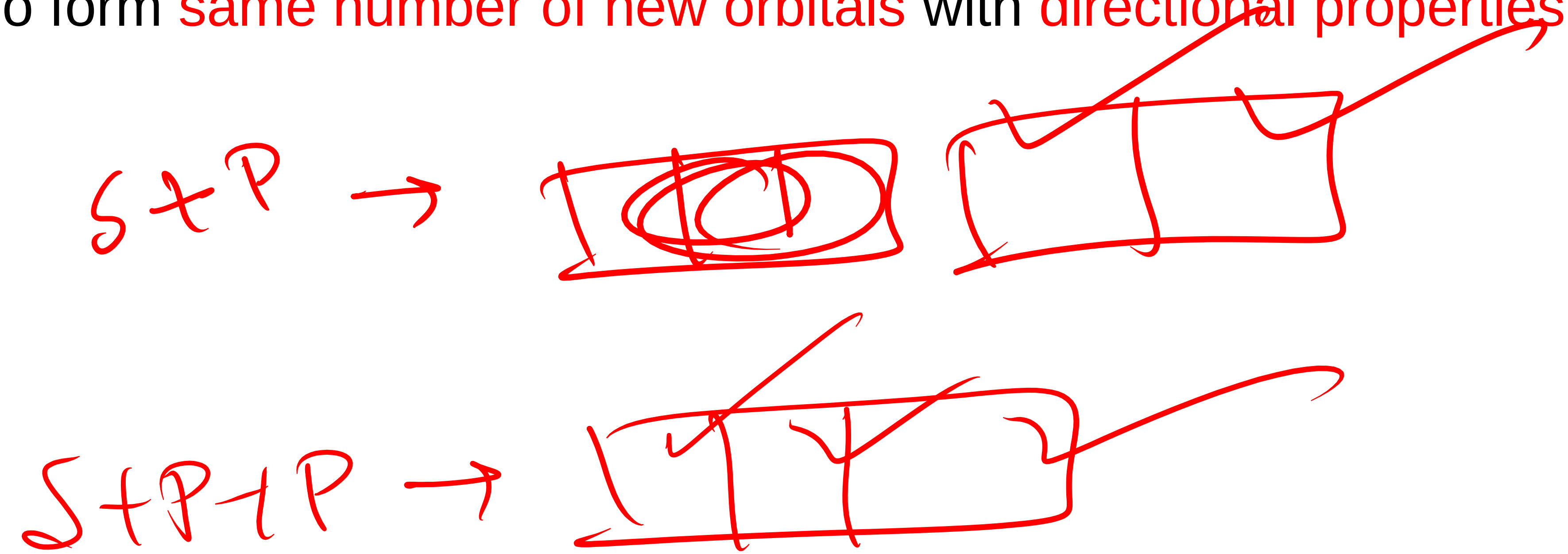
alkene is more priorityful than alkyne



Hybridization of Orbitals

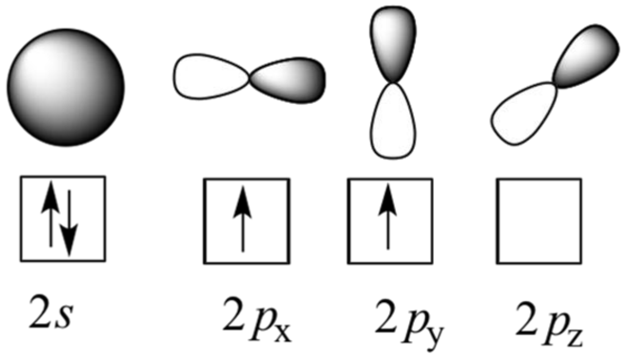
Orbitals of same energy levels in an atom mixes with each other

To form same number of new orbitals with directional properties



Hybridization of Carbons

Carbon



no hybridization → pure orbital

Poll Question 04

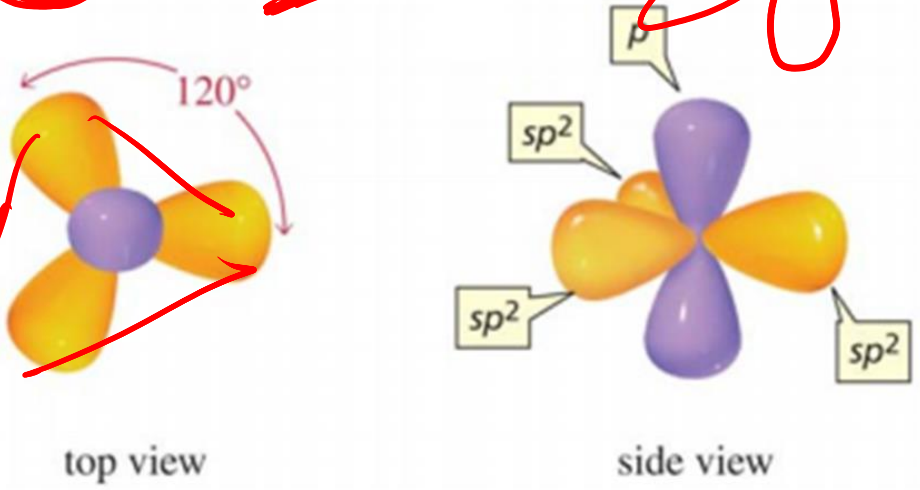
In sp^2 hybridized carbon atom what is the angle between sp^2 orbital and the p orbital? **[SUST'14-15]**

(a) 120^o

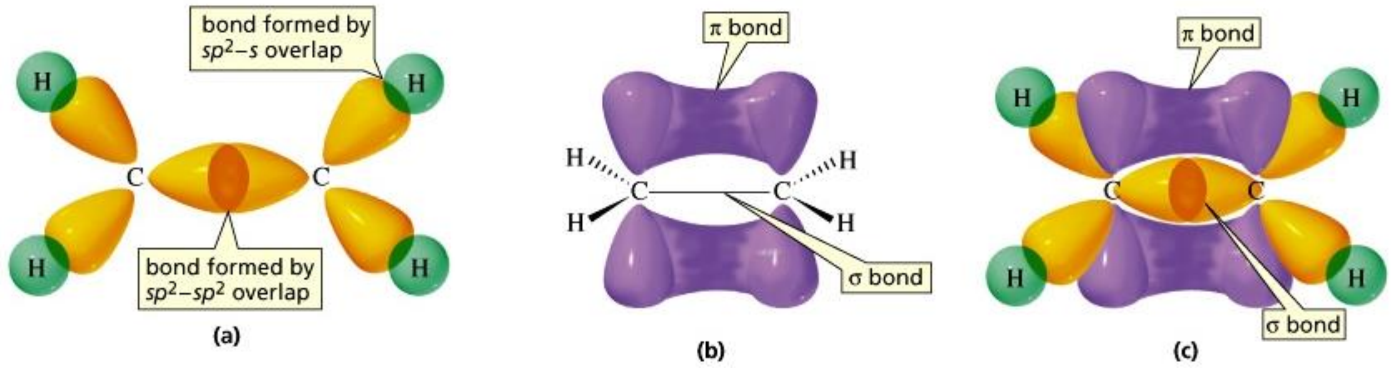
(b) 109.5^o

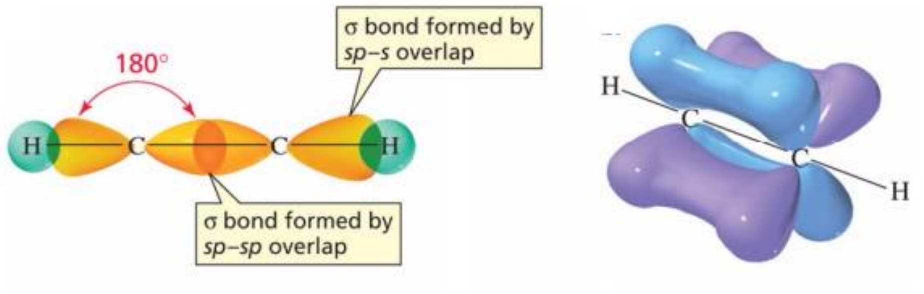
(c) 180^o

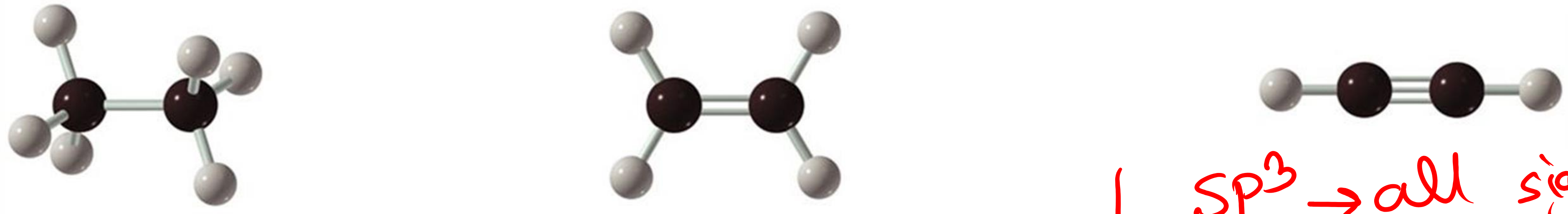
(d) 90^o

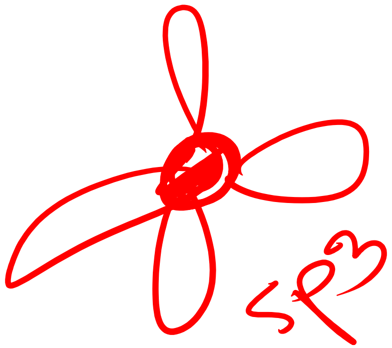


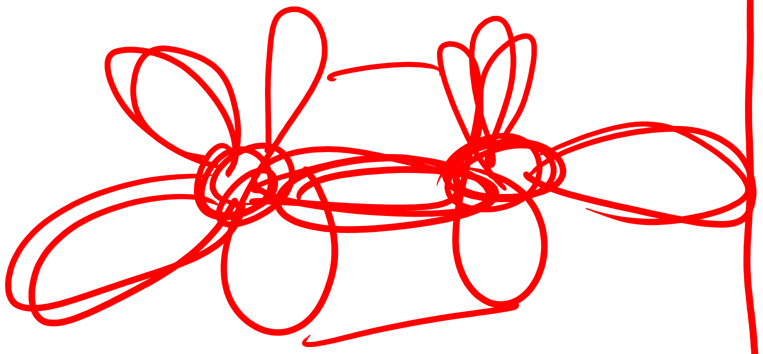
Comparison between sp^3, sp^2 & sp hybridization









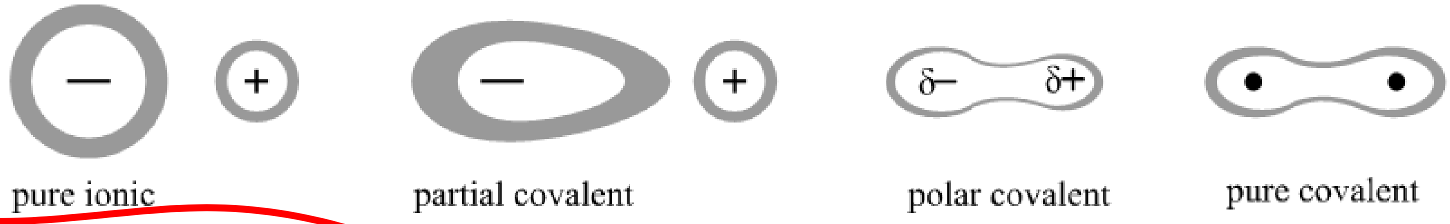


$sp^3 \rightarrow$ all sigma
no pi

$sp^2 \rightarrow$ one pi (double bond)

$sp \rightarrow$ two pi (threeple bond)

Ionic character of covalent compound (Polarity)



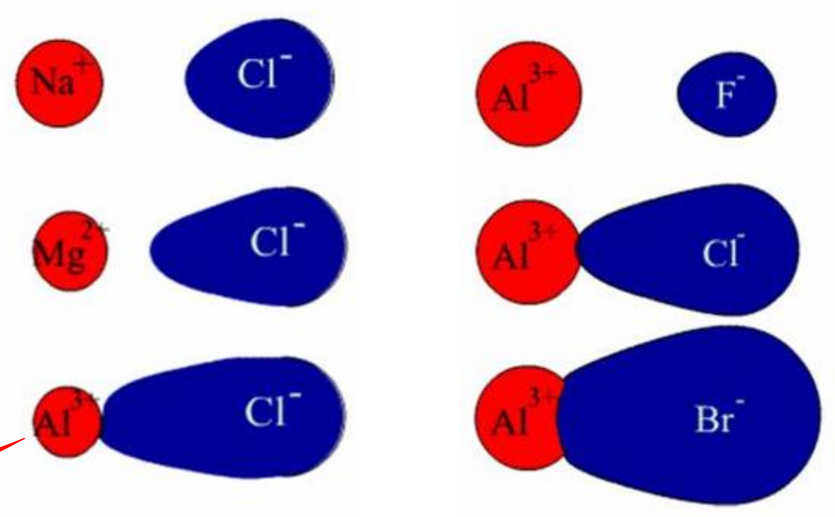
- ΔE.N = 0 (Purely covalent)
- ΔE.N < 0.5 (non-polar co-valent)
- 0.5 ≤ ΔE.N ≤ 1.7 (polar co-valent)
- ΔE.N > 1.7 (Almost Ionic)

Covalent character of ionic compound (Polarization)

(i) Higher charge in cation or in anion.

(ii) Smaller size of cation and larger size of anion

(iii) If the cations having $ns^2np^6(n-1)d^{10}$ electronic configuration



Poll Question 05

Which of the following is the correct thermal decomposition order? **[DU’16-17]**

(a) $BaCO_3 < SrCO_3 < CaCO_3 < MgCO_3 < BeCO_3$

(b) $BeCO_3 < MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$

(c) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3 > BeCO_3$

(d) $MgCO_3 > CaCO_3 > SrCO_3 > BeCO_3 > BaCO_3$

Co- Ordinate- Covalent Bond

Two necessary conditions for the formation of co-ordinate covalent bonds between two atoms, molecules, ions or groups are:

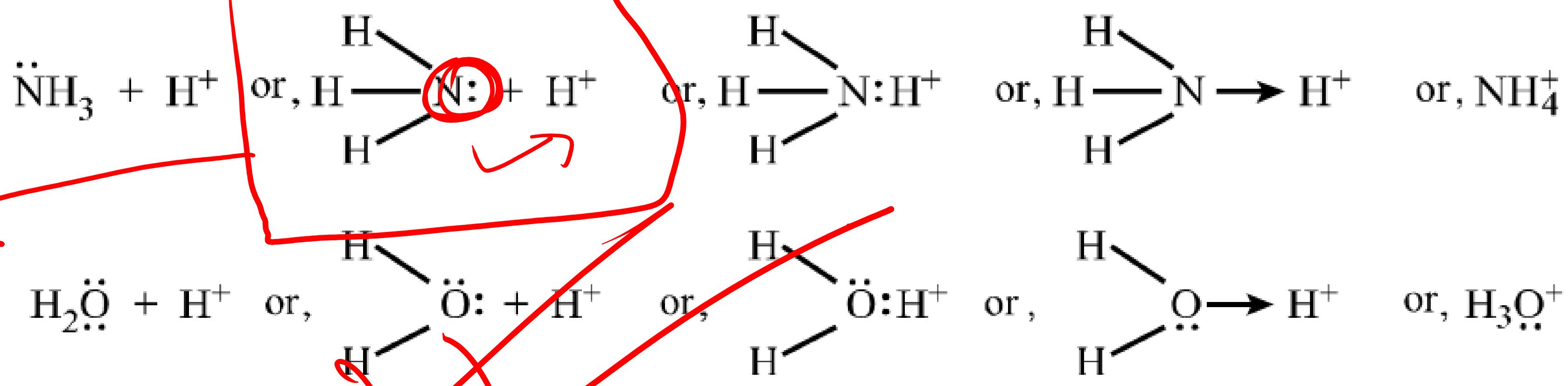
Such an atom should be present in the atom, molecule, ion, group or compound which contains one or more lone pair electron

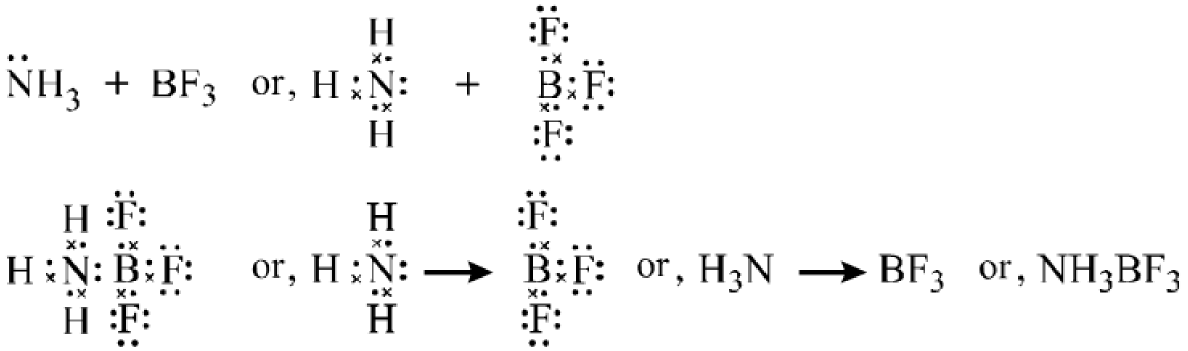
$:\ddot{A}r:,\ \dot{N}H_3,\ H_2\ddot{O},\ :\ddot{C}l^-:,\ :\ddot{F}^-:,\ C\bar{N},\ :\bar{N}H_2$

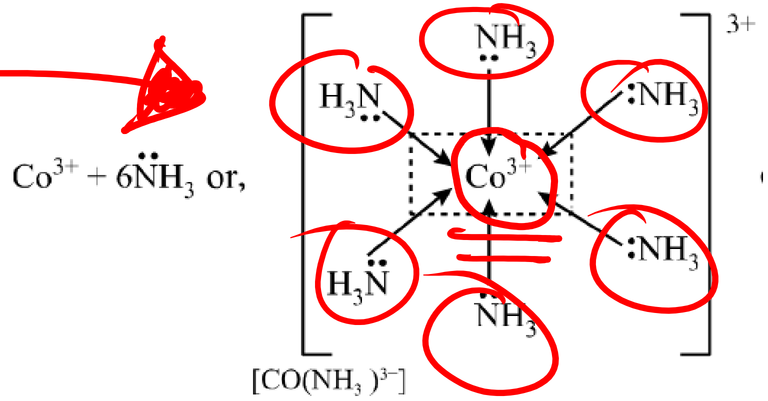
Such an atom should be present in the compound, molecule or ion whose valence shell has incomplete octet structure. So, it is possible for the atom to accept the electron pair from the donor group

$H^+, BF_3, AlCl_3, :\ddot{S}:, Fe^{2+}, Fe^{3+}, Co^{3+}, Ni^{2+}, Cu^{2+}, Ag^+$

Co- Ordinate- Covalent Bond







$[Co(NH_3)_6]^{3+}$ Hexaamincobalt (iii) ion

Finding different types of Chemical bonds in a compound

Ammonium chloride and Potassium Ferricyanide is formed by which types of bond? Mention their number. **[BUET'00-01]**

Poll Question 06

How many bonds are there in $[Co(NH_3)_5Cl]Cl_2$?

(a) 15

(b) 18

(c) 21

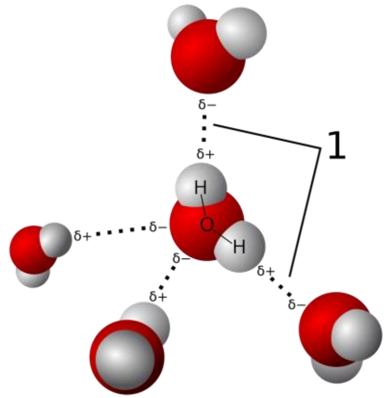
(d) 23

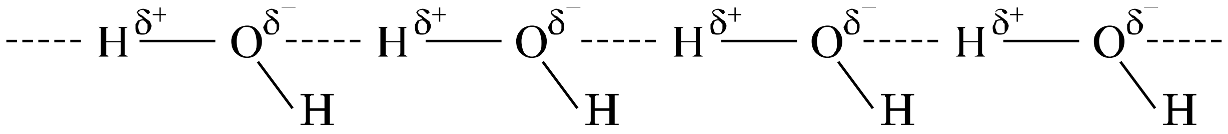
Hydrogen Bond

- The corresponding molecule should be with having H atom.
- The other atom with H should be more electronegative.
- The size of electronegative atom attached with H should be sufficiently small.

As Cl, Br, I, S, P etc. elements do not fulfill this conditions so they do not form H-bond. (They are relatively larger in size).

It is to be mentioned that H-bond is absent in HCl, HBr, HI, H_2S, PH_3 etc.

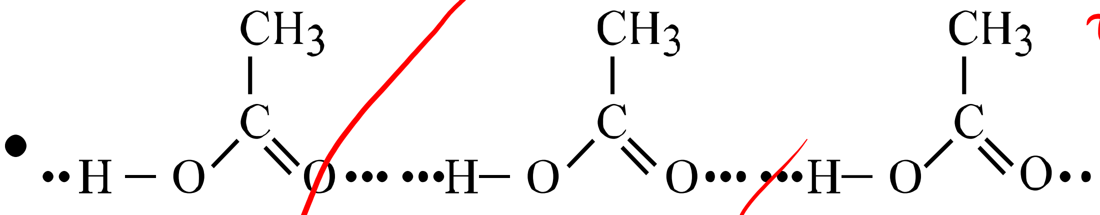


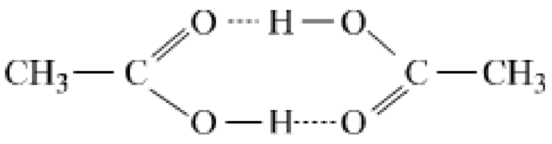


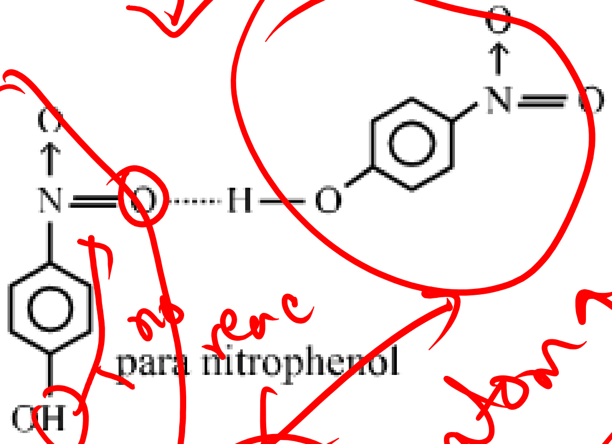
$$[-- -H^{\delta+} \text{———} F^{\delta-} \; --- -H^{\delta+} \text{———} F^{-\delta} \; -- -H^{\delta+} \text{———} F^{\delta-} \; --- -H^{\delta+} \text{———} F^{\delta-}]$$

Hydrogen Bond

Intermolecular Bond



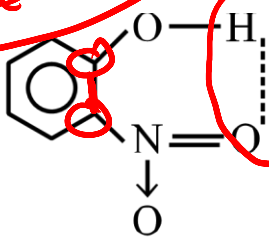




para nitrophenol

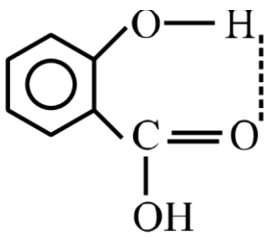
Melting Point 279°C

Intramolecular Bond

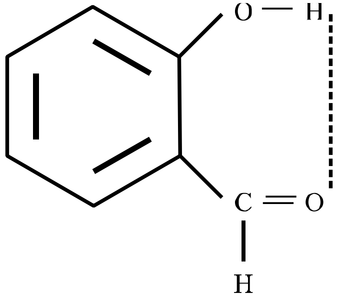


O-Nitrophenol

Melting Point 214°C



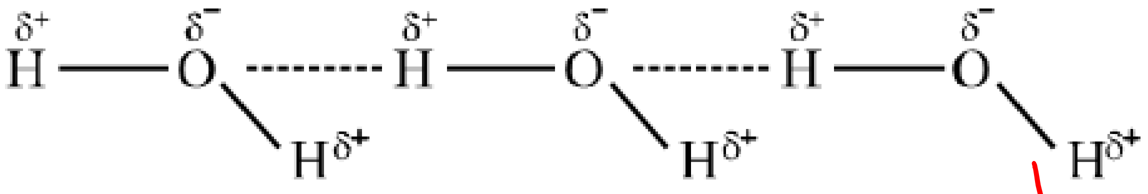
O-hydroxy-benzoic acid



O-hydroxy-benzaldehyde

Why water is liquid in normal condition but H_2S is gaseous?

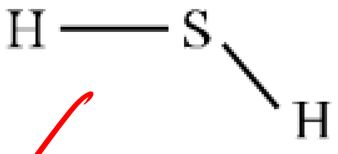
H_2O : Liquid



H-bond: Bunch of molecules

(Electronegativi : H = 2.1, O = 3.5 ∴ Dipole Creation)

H_2S : Gaseous



Discrete H_2 S molecule
No H-bond

Poll Question 07

Which one is the geometrical structure of ice? **[BUET'13–14]**

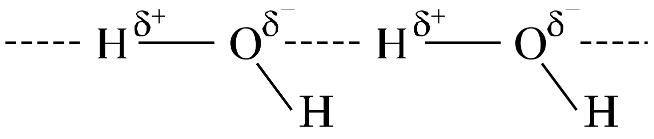
(a) Monoclinic

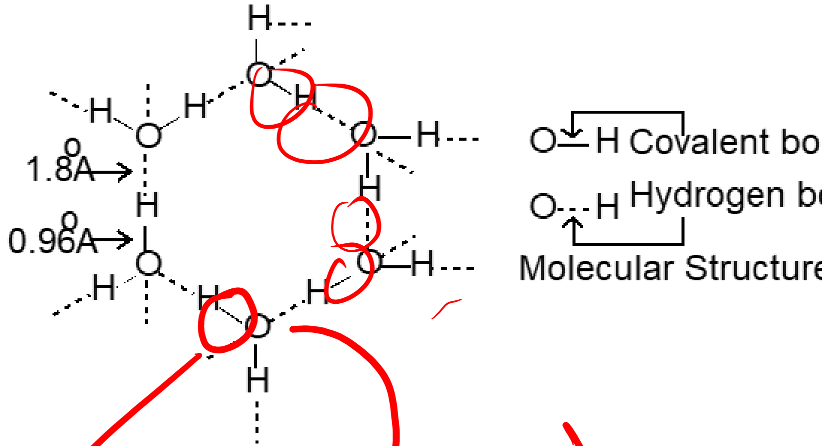
(b) Cubic

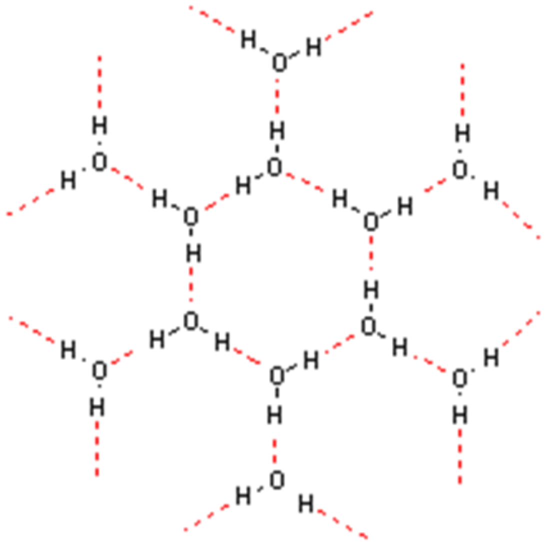
(c) Rhombohedral

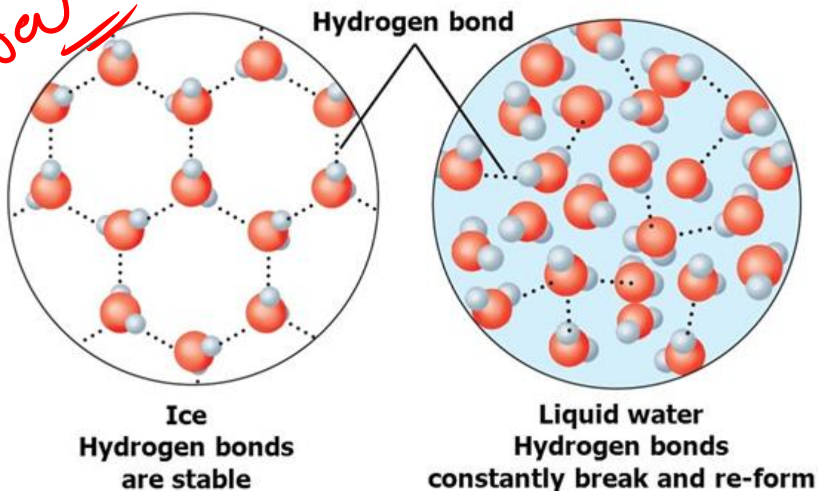
(d) Hexagonal

Why does ice float on water ?









লেগে থাকো সৎ ভাবে,
স্বপ্ন জয় তোমারই হবে।