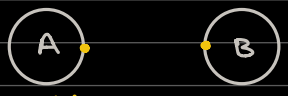
# COVALENT + DATIVE BONDING : CHEMICAL BONDING

## COVALENT

How covalent bonds are formed:




- Initially, A and B will repel because the two electron clouds, one of A and one of B, will repel each other

- If the initial kinetic energy possessed by the involved atoms is such that this repulsion can be overcome, A's electron cloud will be attracted to B's positively charged nucleus and B's electron cloud will be attracted to A's positively charged nucleus.

- However, once they get close enough, they will once again repel due to the positive charges of the nuclei.

- Hence, a covalent bond is the balance between the attractions of the two electrons (electron clouds) to the two nuclei and the repulsion between the two negatively charged electron clouds and the two positively charged nuclei.

  ↳ A "happy medium" is the stable covalent arrangement.

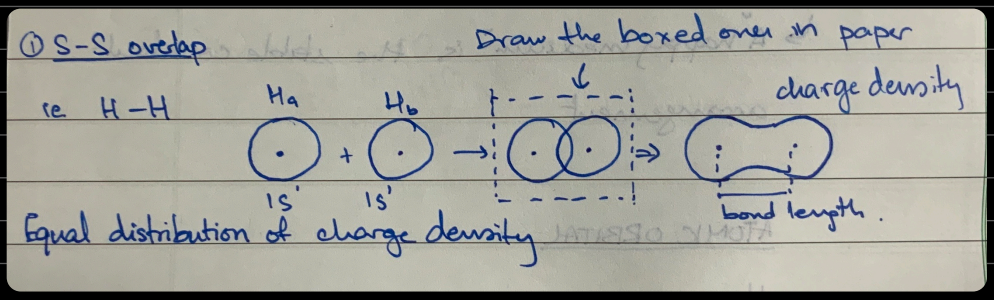
Some bond terminology:

Bond Length: The distance between the two nuclei of the two atoms that are covalently bonded
↳ $\frac{1}{2}$ the bond length is the atomic radius

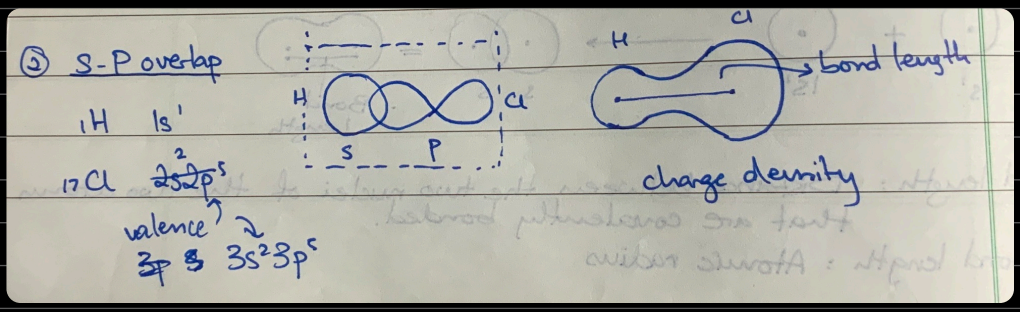
Bond Energy: is the energy required to break 1 mol of a given covalent bond in the gaseous state (endothermic)

Sigma ($\sigma$) bonds: Essentially single covalent bonds
↳ Formed by one of the following orbital overlaps

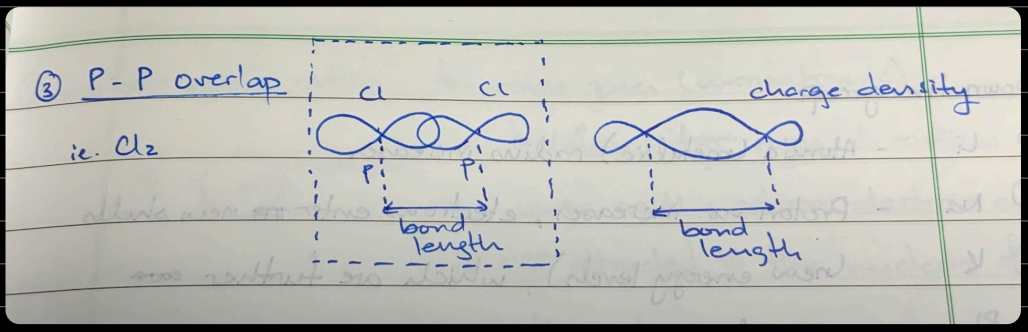
1. S-S overlap



## 2. S - p overlap

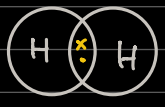



## 3 - P-P overlap

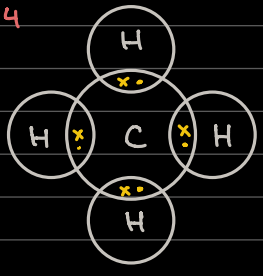



## Dot - Cross diagrams for some common molecules:

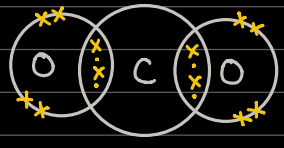
$H_2$



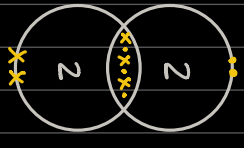

$CH_4$



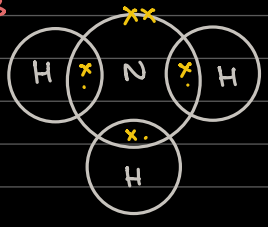

$CO_2$



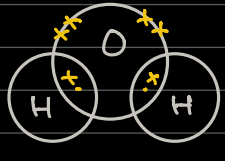

$N_2$



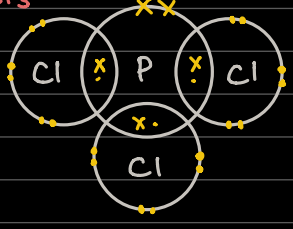

$NH_3$



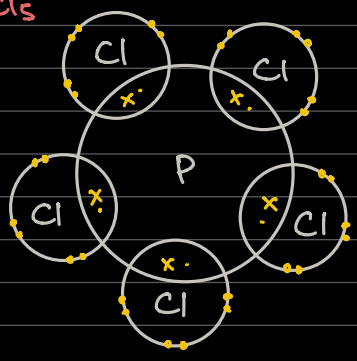

$H_2O$




$PCl_3$




$PCl_5$




→ P has $10e^-$ in it's valence shell → it expanded its octet

Note: Some non-metals (group 5, 6 & 7) can expand their octets if they have space in their orbitals to accept electrons

## DATIVE / COORDINATE

- A dative bond is a covalent bond in which the shared pair of electrons is provided by only one of the bonded atoms

- One atom is the donor and the other is the acceptor (of electrons)

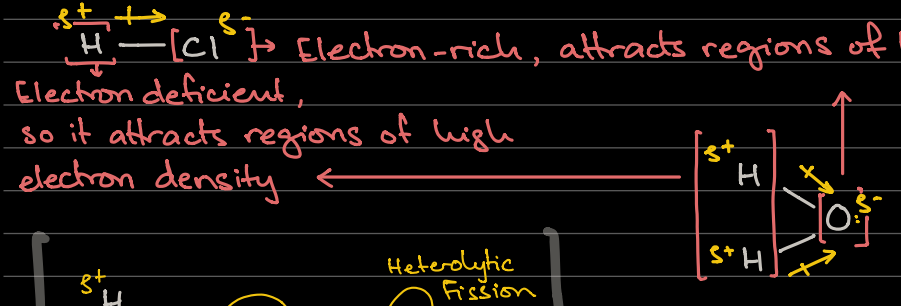
- Once the dative bond is formed, it is considered a normal covalent bond, ie. it has the same characteristics of a regular covalent bond

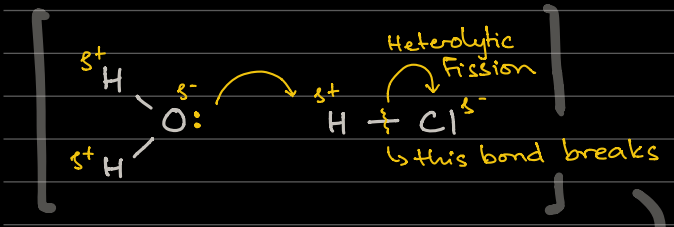
- For a dative bond to occur, the following conditions must be met:
  - The donor atom must have at least one lone pair of electrons
  - The acceptor atom must have at least one vacant orbital in it's outer shell

Example 1: Dissociation of acids in water

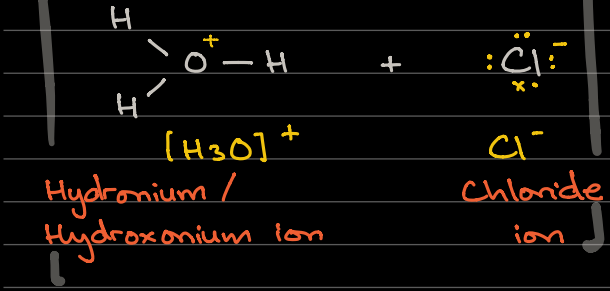
$$HCl \longrightarrow H^+ + Cl^-$$

- Acid dissociates in water to form hydrogen ions




Note: curly arrow shows movement of a pair of electrons




How dative bonding basically works:
(using the example of acid dissociation in water)

- HCl is a polar molecule

- The hydrogen of HCl is electron-deficient and has a partial positive charge

- The oxygen of $H_2O$ is electron rich and has a partial negative charge

- The partially negative oxygen of $H_2O$ is attracted to the electron deficient H of HCl and makes a dative bond with it using it's lone pair.

- As a result, the H–Cl bond breaks and both the shared electrons move to chlorine, forming the $Cl^-$ ion

Other acid examples:

1. $H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

$H_2SO_4 + 2H_2O \longrightarrow 2H_3O^+ + SO_4^{2-}$

2. $CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$

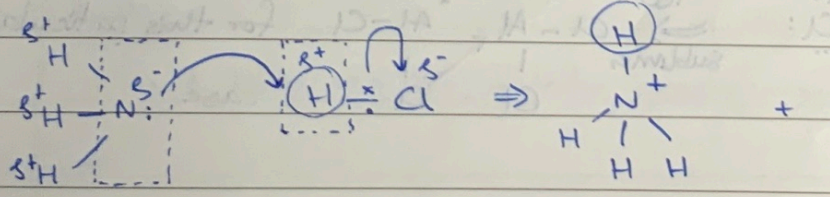
$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

SOME MORE EXAMPLES:

Ex 2

$NH_3 + HCl \longrightarrow NH_4Cl$ → ionic compound

base(g) acid(g) salt(s)



~~How does ammonium get a positive charge?~~

- In $NH_4Cl$ there are three types of bonds:

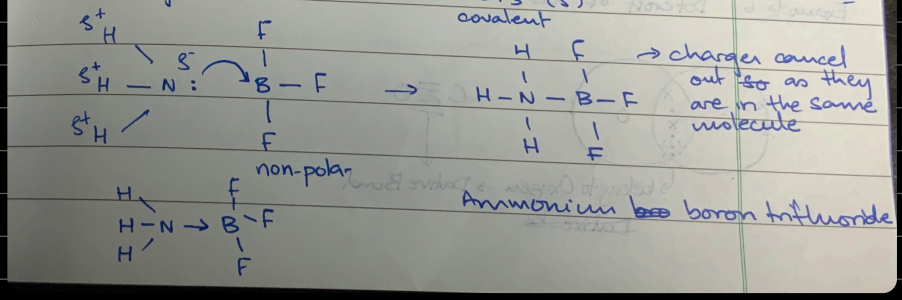
① 3 N–H single covalent bonds in the ammonium ion ($NH_4^+$)

② 1 N–H dative bond

③ 1 $NH_4^+ - Cl^-$ ionic bond (covalent)

Example 3

$NH_3(g) + BF_3(s) \longrightarrow H_3N{\cdot}BF_3(s)$ covalent



→ charges cancel out so as they are in the same molecule

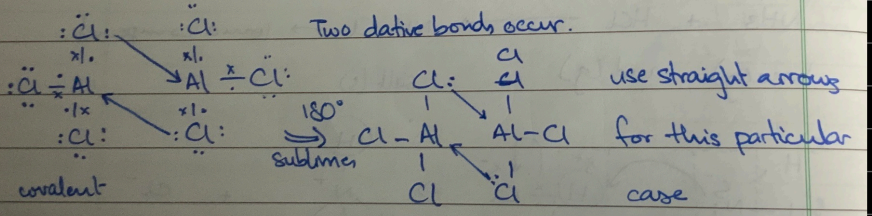
non-polar

Ammonium boron trifluoride

~~Example 4~~ Example 4

Formation of the $Al_2Cl_6$ dimer from $AlCl_3$

$2AlCl_3 \longrightarrow Al_2Cl_6$

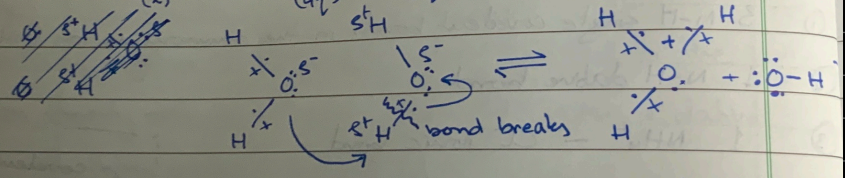



use straight arrows for this particular case

Note: A dimer is the compound formed when two similar molecules combine to form one large compound.

Example 5 Dissociation of water into its ion

$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$




$H_3O^+ + OH^-$

$2H_2O \rightleftharpoons H_3O^+ + OH^-$