At the end of this lesson, students should be able to :

a) Describe the formation of the following bonds using Lewis dot symbol.

i. Ionic or electrovalent bond

ii. Covalent bond

iii. Dative or coordinate bond

(b) Draw Lewis structure of covalent species with single, double and triple bonds.

(c) Compare the bond length between single, double and triple bonds.

(d) Determine the formal charge and the most plausible Lewis structure.

(e) Explain the exception to the octet rule: incomplete octet, expanded octet and odd number electrons.

(h) Explain the concept of resonance using appropriate examples.

Ionic or electrovalent bonding

Electrostatic attraction force between positive ion (cation) with negative ion (anion)

eg . Formation of NaCl .

$Na - e^- \longrightarrow Na^+$

(metal) (cation)

$Cl + e^- \longrightarrow Cl^-$

(non-metal) (anion)

Na^+Cl^-

Ionic bond

The formation of electrovalent bonds,

1. An ionic bond is formed by the electrostatic forces.

2. Ionic bond formed between 2 ions with different charge and through e transfer.

3. Metal elements will donate e while nonmetal elements receive e to achieve stability.

4. This happen because metals are more electropositive while non metals more electronegative.

Example :

$Na \longrightarrow Na^+ + e^-$

$1s^2 2s^2 2p^6 3s^1 \longrightarrow 1s^2 2s^2 2p^6$

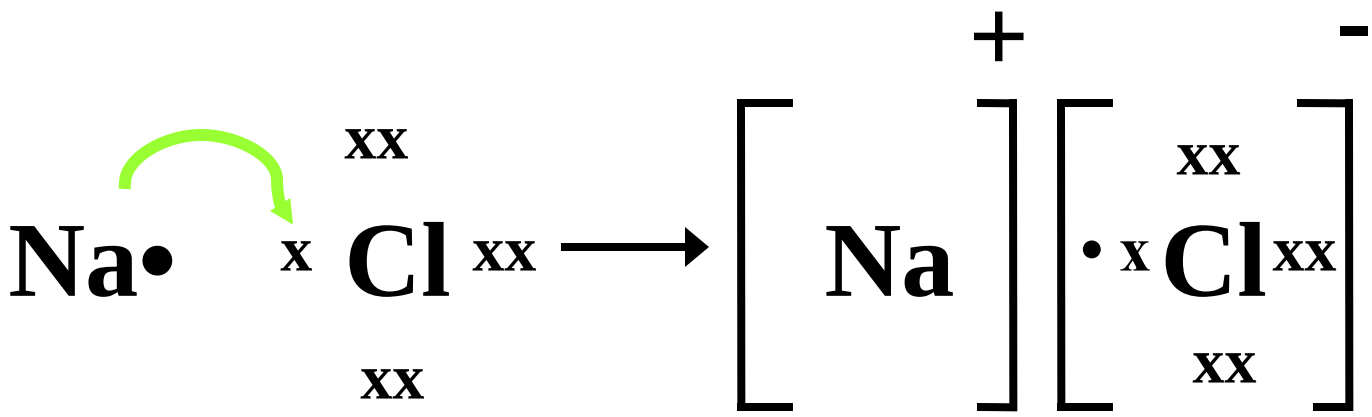
(obey the octet rule)

$Cl + e^- \longrightarrow Cl^-$

$1s^2 2s^2 2p^6 3s^2 3p^5 \longrightarrow 1s^2 2s^2 2p^6 3s^2 3p^6$

(obey the octet rule)

Formation can be described by Lewis structure – valence e^- represented as dot or cross.



(formation of electrovalent bond)

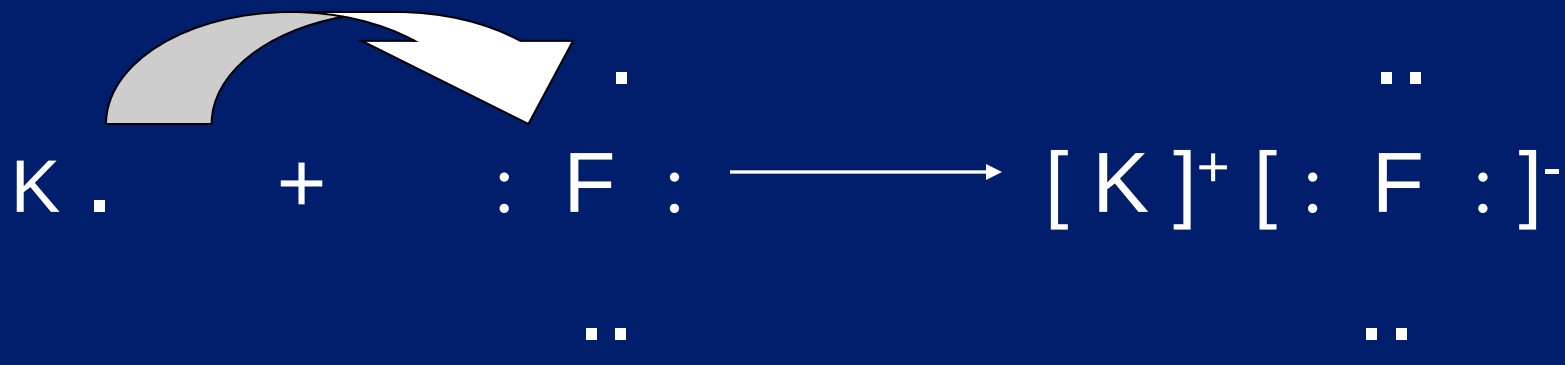
Properties of electrovalent compound

- ✓ Solid at room temperature
- ✓ High melting/ boiling point
- ✓ Soluble in water
- ✓ Molten ionic compounds conduct electricity because they contain mobile ions (cations & anions)

Excercise (ionic bond):

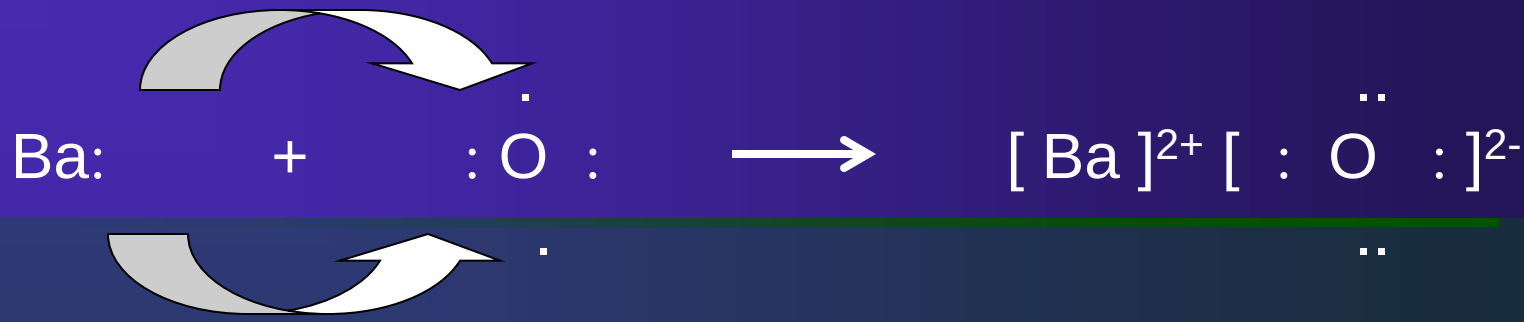
Draw Lewis structure for the formation of following ionic compounds.

a) KF



-When K and F atoms come in contact with each other, the outer $2s^1$ valence electron of K is transferred to F atom.

b) BaO

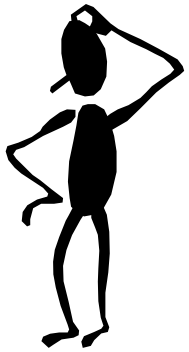


When Ba and O atoms come in contact with each other, 2 e of 2s orbital of Ba are transferred to O.

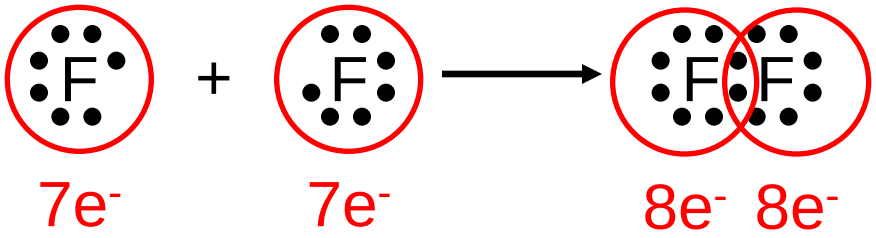
c) Na_2O

Covalent Bond

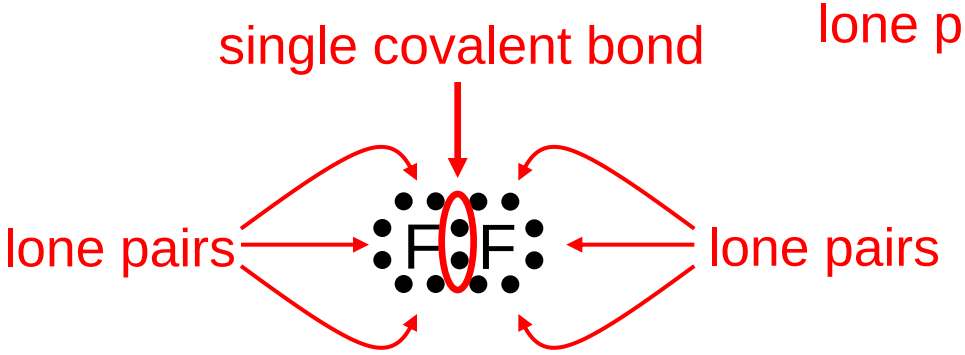
Formed by sharing 1 or more pairs of valence electrons between nonmetal atoms (group 14 , 15 , 16 , 17 ,18)

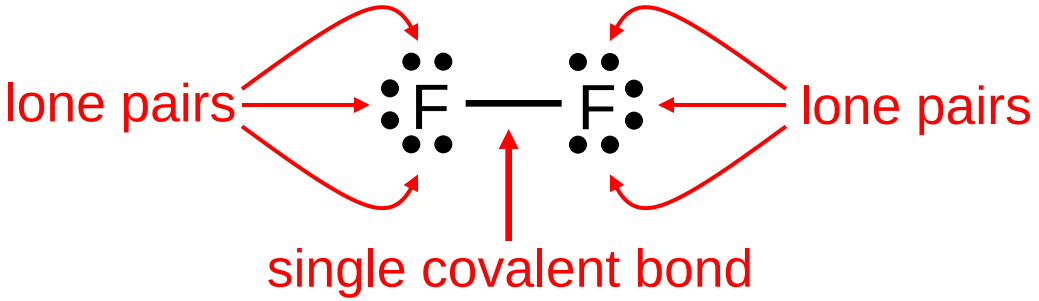


Why should two atoms share electrons?



Lewis structure of F_2





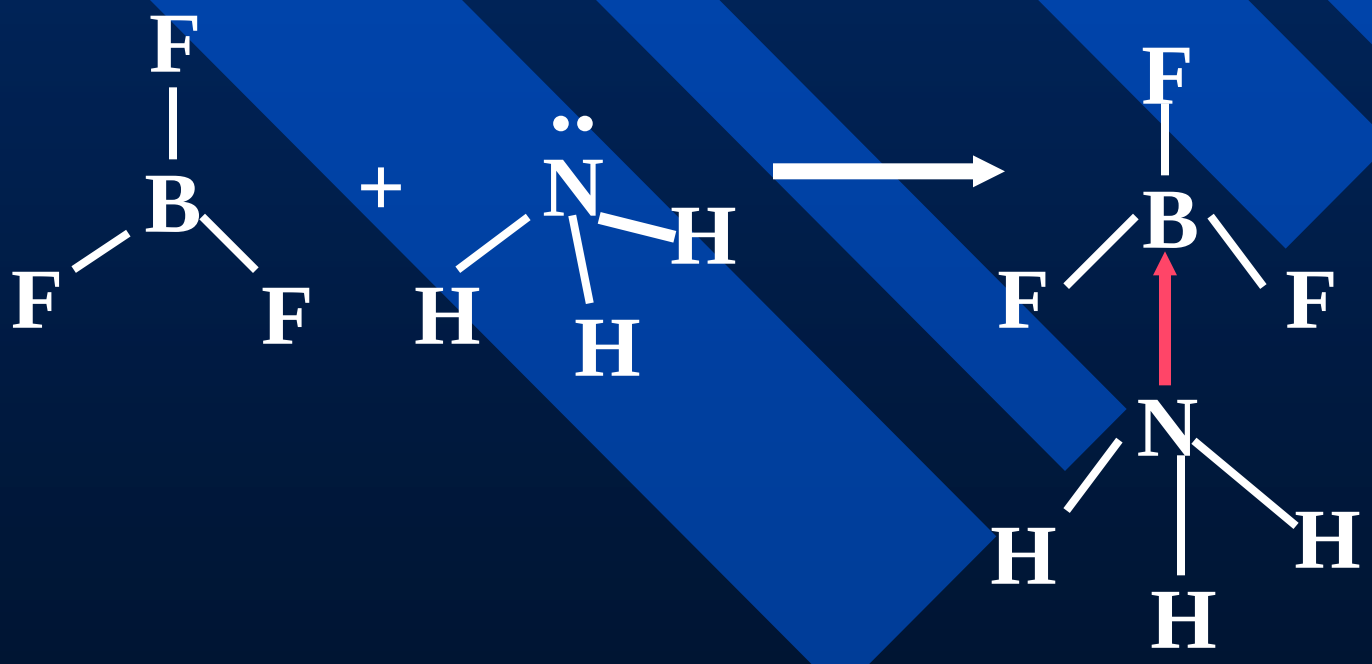
Coordinate covalent or dative bond

Def: A bond in which the pair of electrons is supplied by one of the two bonded atoms

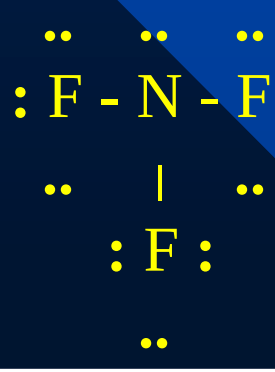
Eg: hydroxonium ion, H_3O^+

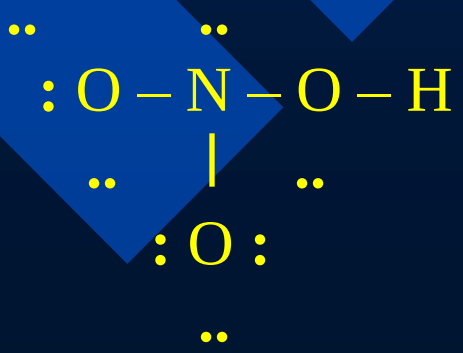
Eg : F_3BNH_3 molecule

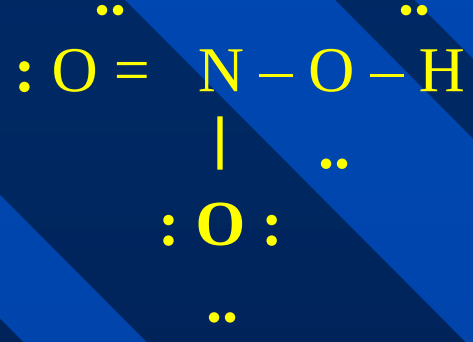
$$BH_3 + NH_3 \longrightarrow H_3BNH_3$$



How to draw the Lewis structure (step by step method)

Species	Step	
NF_3	1	Total no. of valence electron: 1 N atom = 1 x 5 = 5 3 F atoms = 3 x 7 = 21 26
	2	N is more electropositive than F. Skeletal structure: F N F F
	3	Draw a single bond. Complete the octets of the terminal atoms. 

HNO_3	1	Total no. of valence electron: 1 H atom = 1 x 1 = 1 1 N atom = 1 x 5 = 5 3 O atoms =3 x 6 = 18 24
	2	N is the most electropositive. Skeletal structure: O N O H O
	3	Draw a single bond. Complete the octets of the terminal atoms. 

	4	Move a lone pair to form another bond. 

Single Bond

- A covalent bond formed when 2 atoms share a pair of e
- Represent by dash (-) between 2 atom
- A single bond is made up of a sigma (σ) bond
- Example: HCl and HF

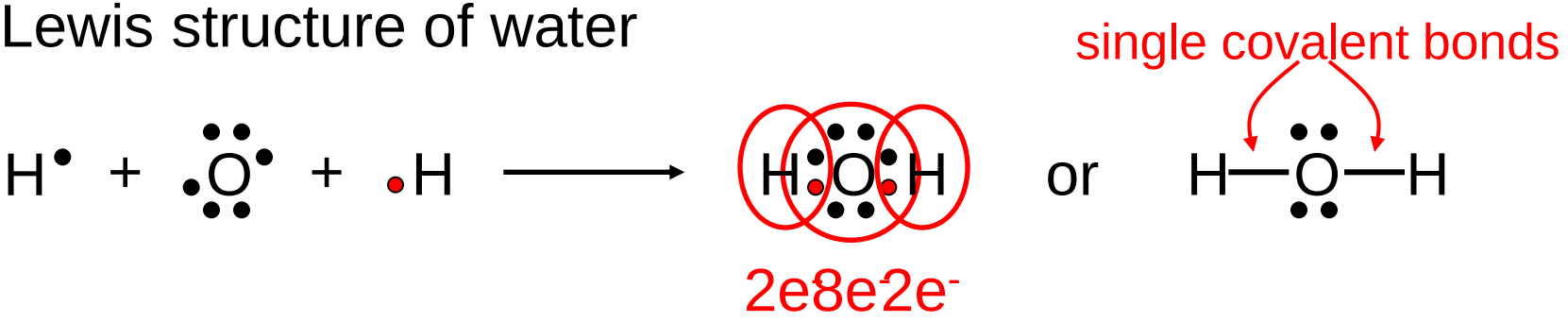
Double Bond

- A covalent bond formed when 2 atoms share 2 pairs of e
- Represent by double dash (=) between 2 atoms
- A double bond is made up of sigma bond (σ) and pi bonds (π)
- Example: O_2

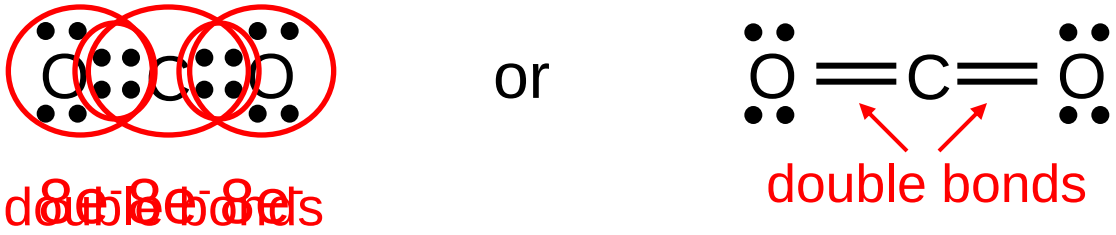
Triple bond

- A covalent bond formed when 2 atoms share 3 pairs of e
- Represent by triple dash (≡) between 2 atoms
- A triple bond is made up of 1 sigma bond (σ) and 2 pi bonds (π)
- Example : N_2

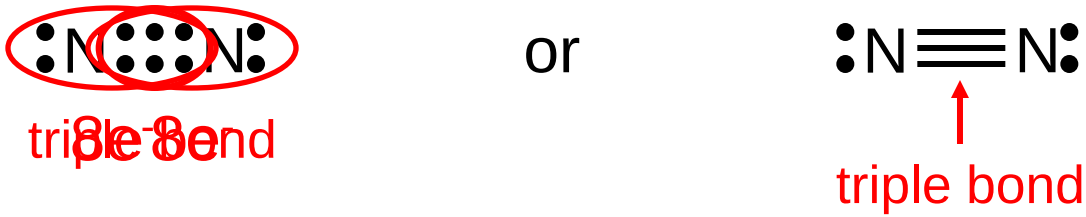
Lewis structure of water



Double bond – two atoms share two pairs of electrons



Triple bond – two atoms share three pairs of electrons



Comparison of the bond length between single, double and triple bonds.

- **Multiple bonds** are shorter than **single covalent** bonds.
- Bond length is defined as **the distance between the nuclei of two covalently bonded atoms in a molecule.** Refer figure given.

- For a given pair of atoms such as carbon and nitrogen, **triple bonds** are shorter than **double bond**, which, in turn are shorter than **single bond**. Refer table given.

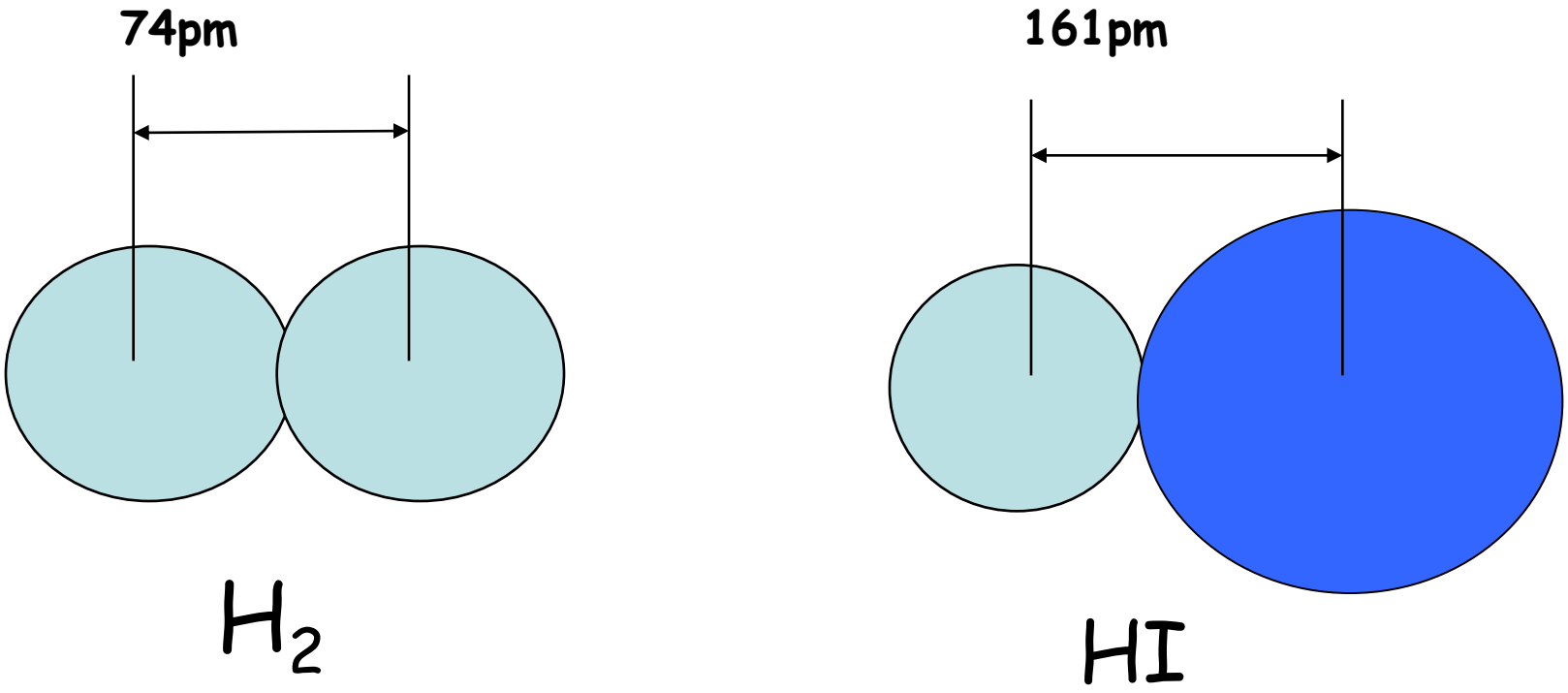


Figure : Bond length in H_2 and HI

Bond Type	Bond length(pm)	Bond Type	Bond length(pm)
C-H	107	C-O	143
C=O	121	C-C	154
C=C	133	C≡C	120
C-N	143	C=N	138
C≡N	116	N-0	136
N=O	122	O-H	96

Table : Comparison of the bond length

Exception to the octet rule

- In octet configuration , atom should have e configuration of noble gas
- But…there's an exception

  * incomplete octet
  * expanded octet
  *odd electron molecule

Incomplete octet

Elements in groups 2 & 13

- ✓ **Period 2**
- ✓ **Less metallic character**
- ✓ **Do not donate e but share e**
- ✓ **Central atom have less than 8 e (not achieve octet configuration)**

Eg : $BeCl_2$

Be shared e with Cl (covalent bond) but in $BeCl_2$ molecule Be only have 4 e in the outer shell (less than 8 e, does not achieve octet configuration)

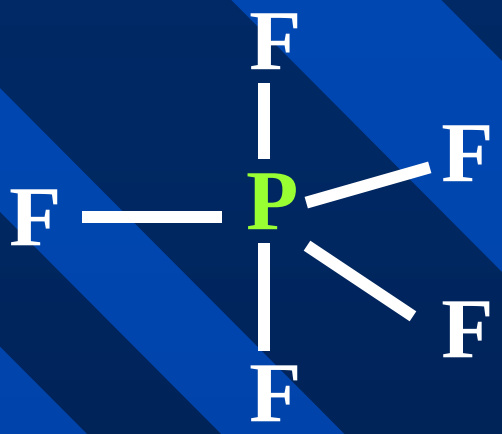
Expanded Octet

- ✓ **Involves period 3 and onwards (non metals)**
- ✓ **Has *d* orbital that involves in bonding**
- ✓ **Central atoms having 10 or even 12 valence e.**

eg : SF_6

S shared e with F (covalent bond) but in SF_6 molecule S have 12 e in the outer shell (more than 8 e, does not obeys octet rule)

PF_5

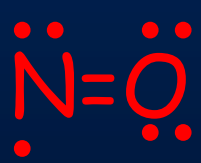


P shared e with F (covalent bond) but in PF_5 molecule P have 10 e in the outer shell (more than 8 e, does not obeys octet rule)

Odd electron molecule

- **Molecule with odd no. of e, complete pairing is impossible and an octet around each atom cannot be achieved**
- Mostly from an odd numbered group

  (Nitrogen- Group 15, Chlorine-Group 17)
- Example : nitric oxide (NO) and nitrogen dioxide (NO_2) :



- Since we need even no. of electrons for complete pairing (to reach 8)
- **The octet rule cannot be satisfied for all the atoms in any of these molecule**

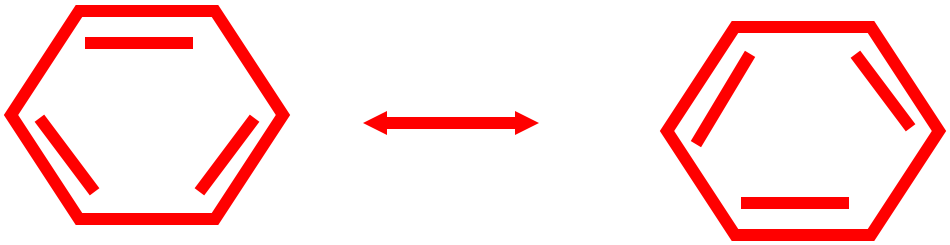
RESONANCE

- Same atomic structure but different arrangement of e

- Resonance structure : 2 or more Lewis structure for single molecule that cannot be represented with 1 accurate Lewis structure

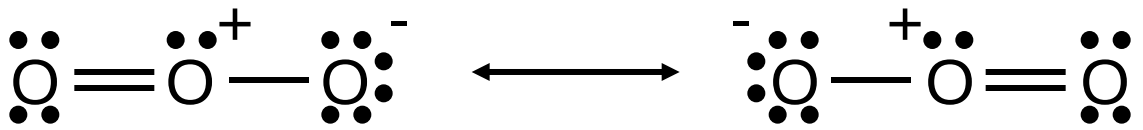
Eg: Sulphur dioxide, SO_2

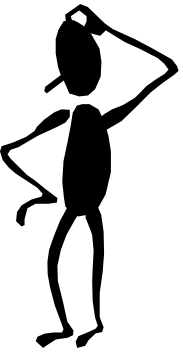
eg : C_6H_6



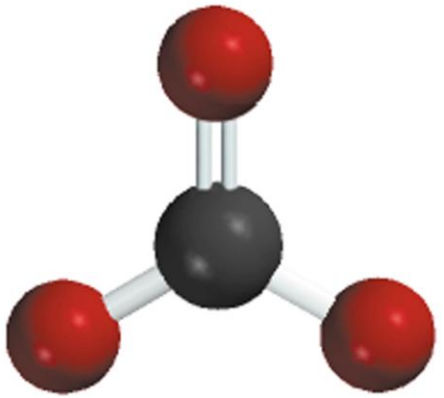
- **In resonance structure, double bond and single bond are equal in length.**

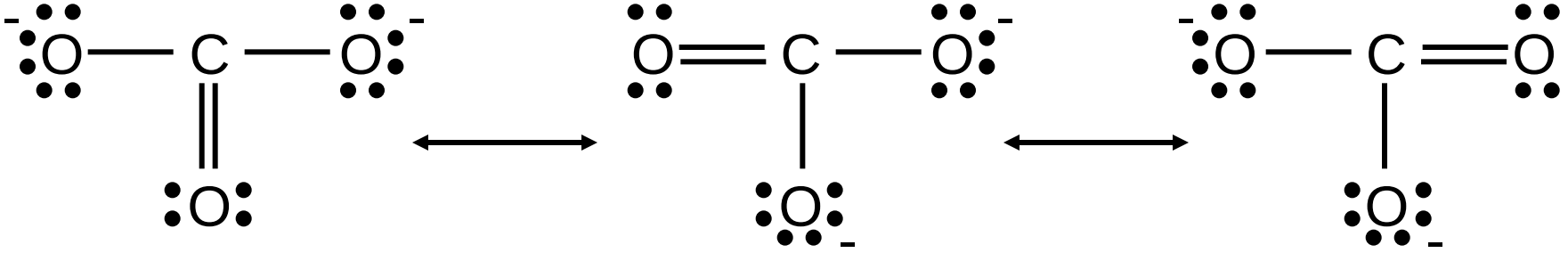
A ***resonance structure*** is one of two or more Lewis structures for a single molecule that cannot be represented accurately by only one Lewis structure.

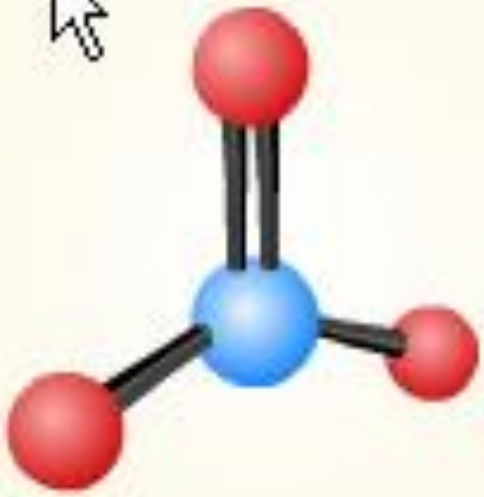




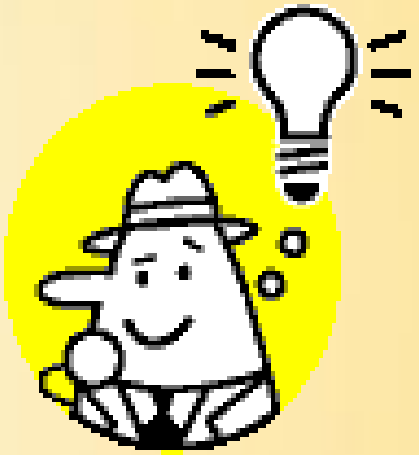
What are the resonance structures of the carbonate (CO_3^{2-}) ion?

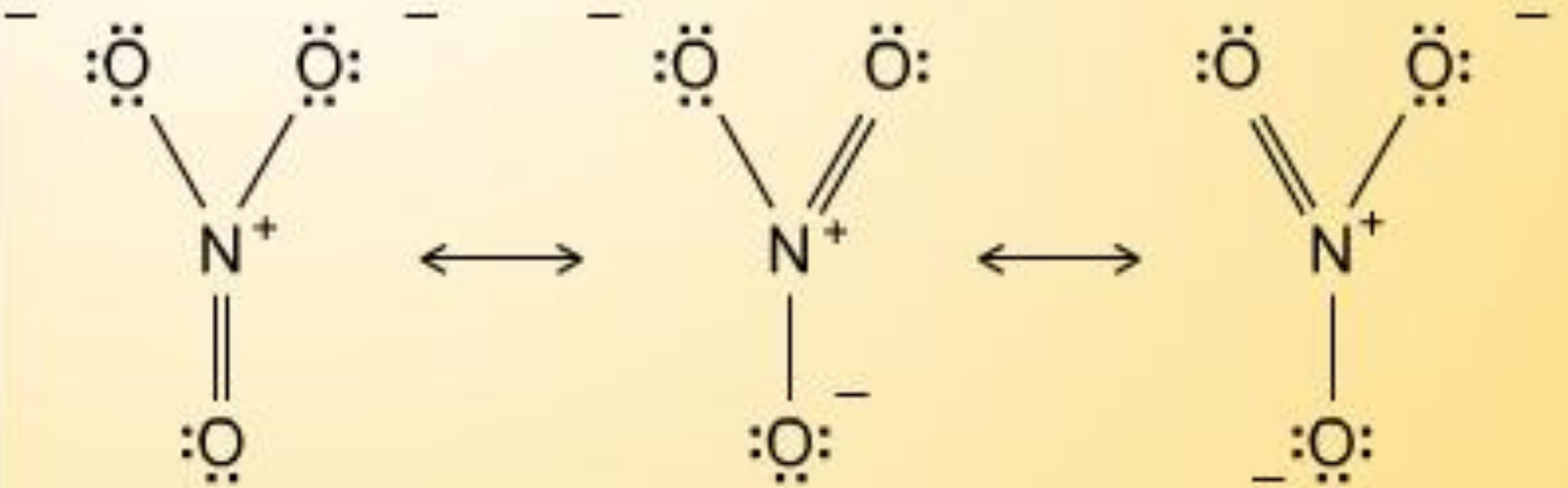


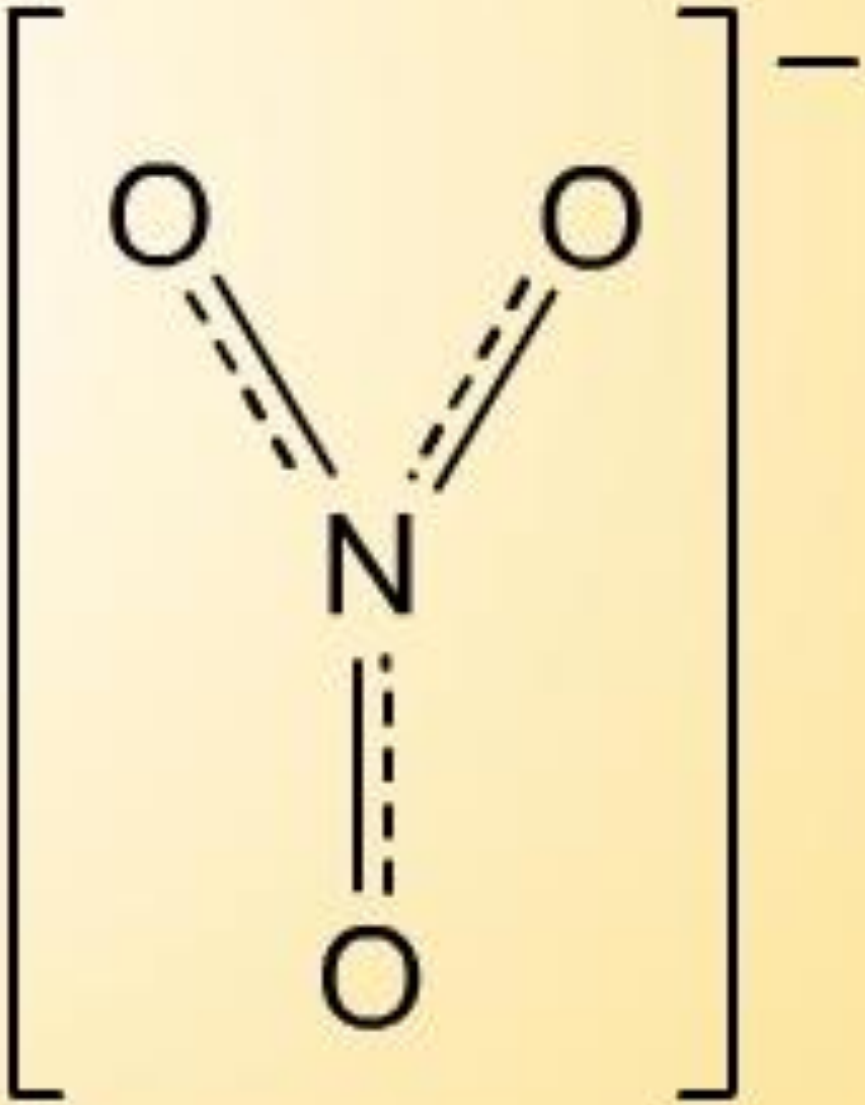




NO_3^-







Resonance hybrid