# Chemical Bonding and Molecular Structure

## Question1

Match List-I with List-II and select the correct option:

| List-I (Molecule / ion) | List-II (Bond order) |
|---|---|
| 1. NO | i. 15 |
| 2. CO | ii. 2.0 |
| 3. $O_2^-$ | iii. 2.5 |
| 4. $O_2$ | iv. 3.0 |

### KCET 2025

**Options:**

A. a-iii, b-iv, c-i, d-ii

B. a-i, b-iv, c-iii, d-ii

C. a-ii, b-iii, c-iv, d-i

D. a-iv, b-iii, c-ii, d-i

**Answer: A**

## Solution:

To calculate bond order, we use the formula:

Bond order $= \frac{1}{2}$(number of bonding electrons $-$ number of antibonding electrons)

Here's how the bond order is calculated for each molecule/ion:

For the NO molecule:

$BO = \frac{1}{2}(8 - 3) = 2.5$

For the CO molecule:

$BO = \frac{1}{2}(10 - 4) = 3.0$

For the $O_2^-$ ion:

BO $= \frac{1}{2}(6-3) = 1.5$

For the $O_2$ molecule:

BO $= \frac{1}{2}(6-2) = 2.0$

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# Question2

## The electronic configuration of X and Y are given below:

$X : 1s^2 2s^2 2p^6 3s^2 3p^3$
$Y : 1s^2 2s^2 2p^6 3s^2 3p^5$

## Which of the following is the correct molecular formula and type of bond formed between X and Y ?

## KCET 2025

**Options:**

A. $X_3Y$, ionic bond

B. $X_2Y_3$, coordinate bond

C. $XY_3$, covalent bond

D. $X_2Y$, covalent bond

**Answer: C**

## Solution:

The electronic configurations of elements $X$ and $Y$ are as follows:

$X : 1s^2 2s^2 2p^6 3s^2 3p^3$

$Y : 1s^2 2s^2 2p^6 3s^2 3p^5$

For element $X$, the configuration corresponds to phosphorus (P), which is in group 15 of the periodic table.
For element $Y$, the configuration corresponds to chlorine (Cl), which is in group 17.

Phosphorus (P) has a valency of 3 or 5.

Chlorine (Cl) has a valency of 1.

Given these valencies, possible compounds could form:

$PCl_3$, where phosphorus uses its valency of 3 to bond with three chlorine atoms.

$PCl_5$, where phosphorus uses an expanded valency of 5 to bond with five chlorine atoms.

Both $PCl_3$ and $PCl_5$ are covalent compounds. In both scenarios, sharing of electrons occurs between phosphorus and chlorine atoms, resulting in covalent bonds.

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# Question3

## The change in hybridization (if any) of the 'Al' atom in the following reaction is $AlCl_3 + Cl^- \rightarrow AlCl_4^-$

## KCET 2025

**Options:**

A. No change in the hybridization state

B. $sp^2$ to $sp^3$

C. $sp^3$ to $sp^3d$

D. $sp^3$ to $sp^2$

**Answer: B**

## Solution:

$$\begin{array}{cc} AlCl_3 + Cl^- & \rightarrow AlCl_4^- \\ sp^2 & sp^3 \\ (3\sigma \text{ bonds }) & (4\sigma \text{ bonds }) \end{array}$$

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# Question4

## A pair of isoelectronic species having bond order of one is

## KCET 2024

**Options:**

A. $N_2, CO$

B. $N_2, NO^+$

C. $O_2^{2-}, F_2$

D. $CO, NO^+$

**Answer: C**

## Solution:

Among the given isoelectronic species, $O_2^{2-}$ and $F_2$ contains $18e^-$each and their bond order is 1.

For $O_2^{2-}$B. O $= \frac{N_b - N_a}{2} = \frac{10-8}{2} = 1$

For $F_2$ B.O $= \frac{N_b - N_a}{2} = \frac{10-8}{2} = 1$

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# Question5

## Which of the following statement is incorrect?

## KCET 2023

**Options:**

A. Bond length of $O_2$ > Bond length of $O_2^{2+}$

B. Bond order of $O_2^+$ < Bond order of $O_2^{2-}$

C. Bond length of $O_2$ > Bond length of $O_2^{2-}$

D. Bond order of $O_2$ > Bond order of $O_2^{2-}$

**Answer: B**

## Solution:

| Compound | Bond order |
|---|---|
| $O_2$ | 2 |
| $O_2^+$ | 2.5 |
| $O_2^{2+}$ | 3 |
| $O_2^-$ | 1.5 |
| $O_2^{2-}$ | 1 |

We know that,

Thus, bond order $= O_2^{2+} > O_2^+ > O_2 > O_2^- > O_2^{2-}$

Bond length $\propto \frac{1}{\text{Bond order}}$

$\therefore$ Bond length $= O_2^{2+} < O_2^+ < O_2 < O_2^- < O_2^{2-}$

Thus, the incorrect statement is given in option(b) i.e. bonds order of $O_2^+$ < bond order of $O_2^{2-}$.

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# Question6

## Dimerisation of solute molecules in low dielectric constant solvent is due to

## KCET 2023

**Options:**

A. hydrogen bond

B. covaelent bond

C. co-ordinate bond

D. ionic bond

**Answer: A**

## Solution:

Dimerisation of solute molecules in low dielectric constant solvent is primarily due to intermolecular interactions such as van der Waals' forces and hydrogen bonding. These forces allow the solute molecules to overcome the electrostatic repulsion and form stable dimers.

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# Question7

## In oxygen and carbon molecule the bonding is

## KCET 2022

**Options:**

A. $O_2 : 2\sigma, 0\pi; C_2 : 0\sigma, 2\pi$

B. $O_2 : 1\sigma, 1\pi; C_2 : 0\sigma, 2\pi$

C. $O_2 : 0\sigma, 2\pi; C_2 : 2\sigma, 0\pi$

D. $O_2 : 1\sigma, 1\pi; C_2 : 1\sigma, 1\pi$

**Answer: B**

## Solution:

The bond order of $C_2$ consists of both pi bond because of the presence of the four electrons in two pi molecular orbitals. Whereas in most of the other molecules a double bond is made up of a sigma bond and a pi bond.Thus, option (b) is correct.

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# Question8

## Which of the following is an incorrect statement?

## KCET 2021

**Options:**

A. Hydrogen bonding is stronger than dispersion forces

B. Sigma bonds are stronger than $\pi$-bonds

C. Ionic bonding is non-directional

D. $\sigma$-electrons are referred to as mobile electrons

**Answer: D**

## Solution:

All the statements except (d) are correct.

The correct statement is $\pi$-electrons are referred to as mobile electrons.

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# Question9

## The correct order of boiling point in the following compounds is

## KCET 2021

**Options:**

A. $HF > H_2O > NH_3$

B. $H_2O > HF > NH_3$

C. $NH_3 > H_2O > HF$

D. $NH_3 > HF > H_2O$

**Answer: B**

## Solution:

The correct order of boiling point of given hydrides is as follows $H_2O > HF > NH_3$ Strength of H-bonding depends upon size and electronegativity of the atom. Smaller the size of the atom, greater is the electronegativity and stronger is the H-bonding.

But each $H_2O$ molecule has two hydrogen atom, whereas each HF molecule has only one hydrogen atom.

$\therefore$ Hydrogen bonding is more strong in $H_2O$ molecules. While $NH_3$ molecules due to less electronegativity. of 'N' atom than 'F' atom is less polar and hence, have weak hydrogen bonding than HF molecules.

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# Question10

**Bond enthalpies of $A_2$, $B_2$ and $AB$ are in the ratio $2:1:2$. If bond enthalpy of formation of $AB$ is $-100\ \text{kJ mol}^{-1}$. The bond enthalpy of $B_2$ is**

## KCET 2021

**Options:**

A. $100\ \text{kJ mol}^{-1}$

B. $50\ \text{kJ mol}^{-1}$

C. $200\ \text{kJ mol}^{-1}$

D. $150\ \text{kJ mol}^{-1}$

**Answer: C**

## Solution:

Given,

$(\text{BE})_{A_2} : (\text{BE})_{B_2} : (\text{BE})_{AB} = 2:1:2$

where, BE = Bond enthalpy

$(\Delta H_f)_{AB} = -100\ \text{kJ}$

Let the BE of $A_2$, $B_2$ and $AB$ be $2x$, $x$ and $2x$ respectively.

As we know, $\Delta_f H^\circ = \Sigma\Delta_{\text{diss}}\ \ H^\circ_R - \Sigma\Delta_{\text{diss}}\ \ H^\circ_P$

where, $\Delta_{\text{diss}}\ \ H^\circ$ = Enthalpy of dissociation

$$\frac{1}{2}A_2 + \frac{1}{2}B_2 \rightarrow AB$$

$$\therefore \quad -100 = \left(\frac{1}{2}2x + \frac{1}{2}x\right) - x$$

$$x = 200$$

$\therefore$ Bond enthalpy of $B_2$ is $200\ \text{kJ mol}^{-1}$.

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# Question11

## Bond angle is $PH_4^+$ is more than that of $PH_3$. This is because

## KCET 2020

**Options:**

A. lone pair - bond pair repulsion exists in $PH_3$

B. $PH_4^+$ has square planar structure

C. $PH_3$ has planar trigonal structure

D. hybridisation of P changes when $PH_3$ is converted to $PH_4^+$

**Answer: A**

## Solution:

Bond angle of $PH_4^+$ is more than that of $PH_3$ as in $PH_3$ due to greater lone pair-bond pair repulsions than the bond pair-bond pair repulsions, the tetrahedral angle decreases from $109^\circ 28'$ to $93.6^\circ$ and has a pyramidal structure. In $PH_4^+$, there are four bond pairs and no lone pair and due to the absence of lone pair-bond pair repulsions and presence of four identical bond pair-bond pair interactions $PH_4^+$ has tetrahedral geometry with bond angle $109^\circ$.

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# Question12

## Incorrectly matched pair is

## KCET 2020

**Options:**

A. $XeO_3$ pyramidal

B. $XeF_4$ tetrahedral

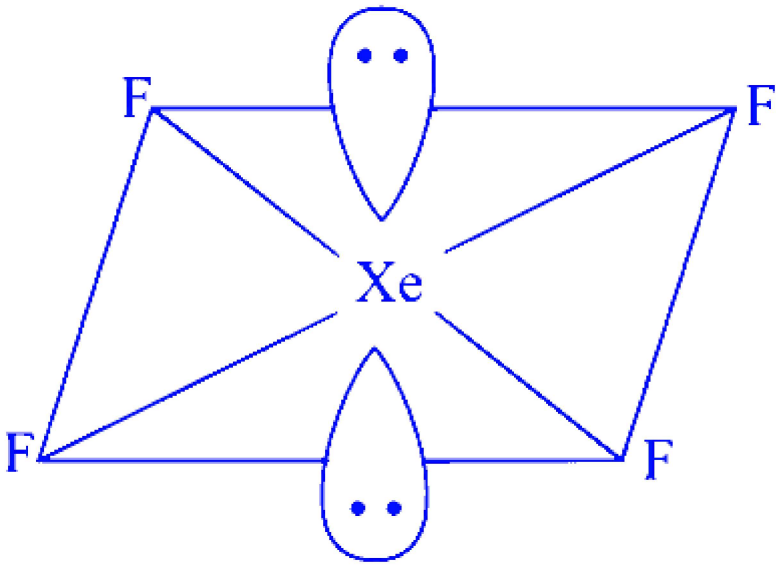
C. $XeF_6$ disorted octahedral

D. $XeOF_4$ square pyramidal

**Answer: B**

## Solution:

$XeF_4$ tetrahedral is the incorrectly matched pair as $XeF_4$ is actually having square plannar structure with $sp^3d^2$ hybridisation.

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# Question13

## Which of the following has the lowest boiling point?

## KCET 2020

**Options:**

A. $CH_3CH_2OH$

B. $CH_3 - CH_2 - NH_2$

C. $CH_3 - O - CH_3$

D. $HCOOH$

**Answer: C**

## Solution:

We are given alcohol, carboxylic acid, amine and ether. So, the boiling point of ether $(CH_3 - O - CH_3)$ will be lowest in alcohol and carboxyl acid and amines, there is H-bonding responsible for higher boiling point as compared to ether.

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# Question14

## The percentage of *s*-character in the hybrid orbitals of nitrogen in $NO_2^+, NO_3^-$ respectively are

## KCET 2020

**Options:**

A. $33.3\%, 50\%, 25\%$

B. $33.3\%, 25\%, 50\%$

C. $50\%, 33.3\%, 25\%$

D. $25\%, 50\%, 33.3\%$

**Answer: C**

## Solution:

$NO_2^+$ shows *sp*-hybridisation and as such the *s*-character here shall be $50\%$.

$NO_3^-$ shows $sp^2$ hybridisation, so the *s*-character shall be $33.3\%$.

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# Question15

## The formal charge on central oxygen atom in ozone is

## KCET 2020

**Options:**

A. $-1$

B. 0

C. +2

D. +1

**Answer: D**

## Solution:

The formal charge can be calculated as:

$$\text{Formal charge on atom in Lewis structure } [:\ddot{O}:\ddot{O}:\ddot{O}:] = \left[\begin{array}{l}\text{Total number of valence}\\ \text{electrons on free atom}\end{array}\right] - \frac{1}{2}\left[\begin{array}{l}\text{Total number of shared}\\ \text{electrons on atom}\end{array}\right] - \left[\begin{array}{l}\text{Total number of unshared}\\ \text{valence electron of the atom}\end{array}\right]$$

Here, formal charge on central oxygen in ozone

$= 6 - \frac{1}{2}(6) - 2 = +1$

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# Question16

## Which of the following possess net dipole moment?

## KCET 2019

**Options:**

A. $SO_2$

B. $BF_3$

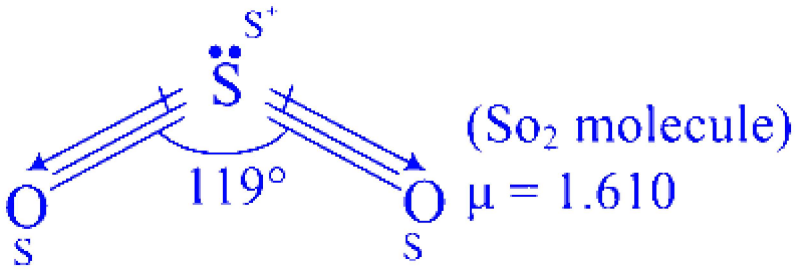
C. $BeCl_2$

D. $CO_2$

**Answer: A**

## Solution:

$SO_2$ molecule possess net dipole moment because $SO_2$ does not have linear molecular geometry. It has a bent structure. The two $O-H$ bonds are oriented at $119^\circ$ angle.




Other options such as $BF_3$, $BeCl_2$ and $CO_2$ possess no net dipole moment.

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# Question17

## Which of the following pair contains 2 lone pair of electrons on the central atom?

## KCET 2019

**Options:**

A. $I_3^+, H_2O$

B. $H_2O, NF_3$

C. $XeF_4, NH_3$

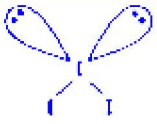
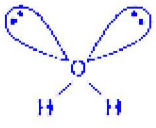
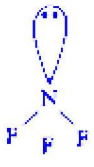
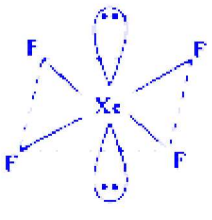
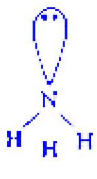
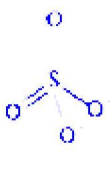
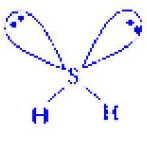
D. $SO_4^{2-}, H_2S$

**Answer: A**

## Solution:

$I_3^+$ and $H_2O$ pair contains two lone pair of electrons on the central atom.

Both possess bent structure due to the presence of two lone pairs. Structure of other molecules alongwith lone pairs are given below :

| S.N. | Molecule | Shape | Number of lone pair of electrons |
|---|---|---|---|
| 1. | $I_3^-$ |  | 2 |
| 2. | $H_2O$ |  | 2 |
| 3. | $NF_3$ |  | 1 |
| 4. | $XeF_4$ |  | 2 |
| 5. | $NH_3$ |  | 1 |
| 6. | $SO_3^{2-}$ |  | 0 |
| 7. | $H_2S$ |  | 2 |

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# Question18

## The intramolecular hydrogen bond is present in

## KCET 2018

**Options:**

A. phenol

B. o-nitrophenol

C. p-nitrophenol

D. p-cresol

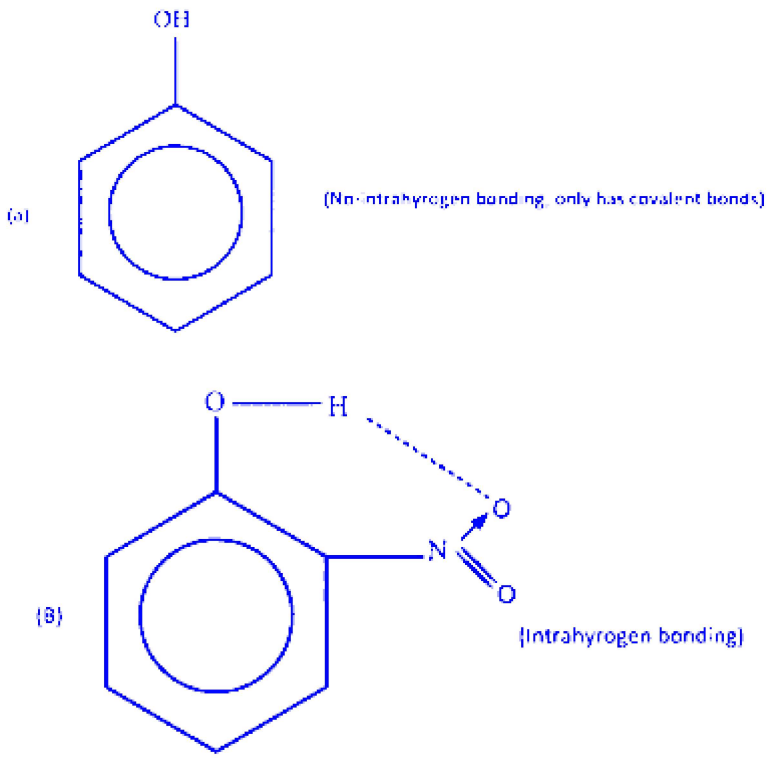
**Answer: B**

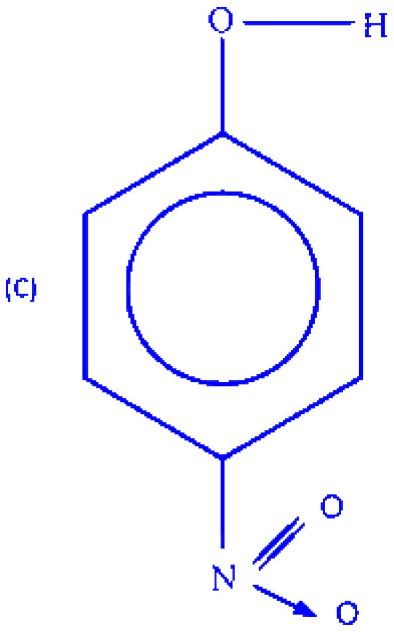
## Solution:

(b) Intrahydrogen bonding is present between the hydrogen-atom and a highly electronegative element (like F, O and N) present with in the molecule (near to each other) as a separate group.

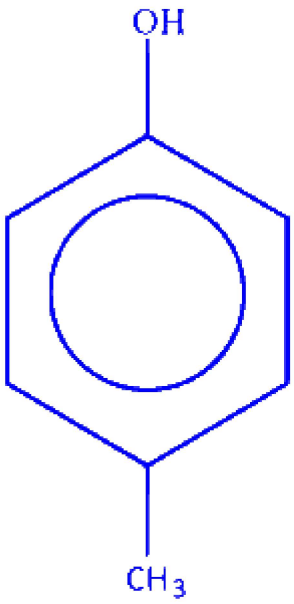
These are formed apart from covalent bonds.

In case of






(C) (No-intrahyrogen bonding)




(d) (No-intrahyrogen bonding)

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# Question19

## The state of hybrid orbitals of carbon in $CO_2$, $CH_4$ and $CO_3^{2-}$ respectively is

## KCET 2018

**Options:**

A. $sp^3$, $sp^2$ and $sp$

B. $sp^3$, $sp$ and $sp^2$

C. $sp$, $sp^3$ and $sp^2$

D. $sp^2$, $sp^3$ and $sp$

**Answer: C**

## Solution:

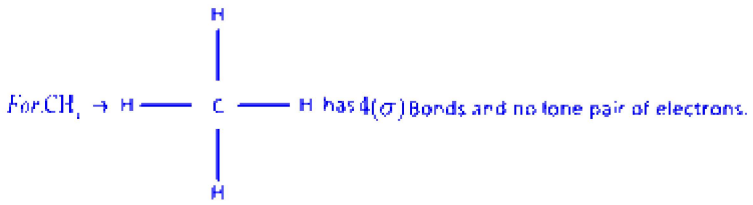
In short, hybridisation of the central element can be predicted as follows:

Hybridisation = Number of $(\sigma)$ bonds + Number of lone pair of electrons.

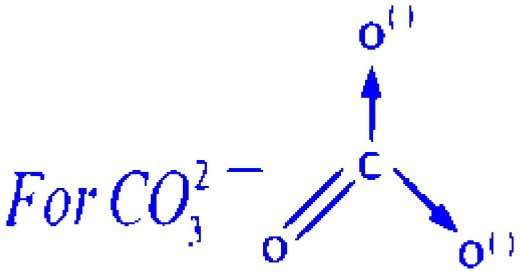
Thus,

For $CO_2 \rightarrow O \equiv C \equiv O$, has $2(\sigma)$ bonds and no lone pair of electrons.

$\therefore$ Hybridisation $= sp$




$\therefore$ Hybridisation $= sp^3$




has (3) $\sigma$ bonds and no lone pair over the central atom..$\therefore$ Hybridisation = $sp^2$Hence, correct order is $\rightarrow$ $sp$, $sp^3$ and $sp^2$ and (c) is the correct option.

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# Question20

## Acidity of $BF_3$ can be explained on which of the following concepts?

## KCET 2018

**Options:**

A. Arrhenius concept

B. Bronsted Lowry concept

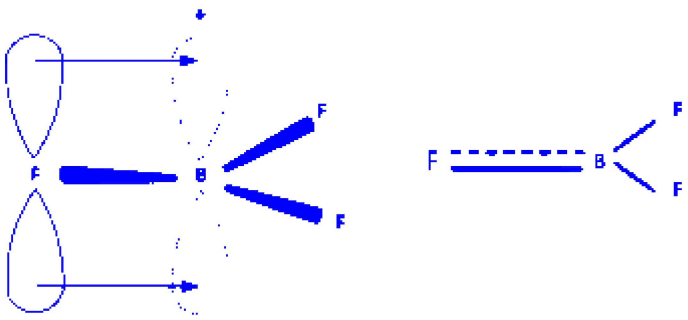
C. Lewis concept

D. Bronsted Lowry as well as Lewis concept

**Answer: C**

## Solution:

The structure of $BF_3$ is as follows:




It is clear from the structure that B-atom has an empty *p*-orbital, in which lone pair of electrons of F -atom can form the bond (known as back bonding).

As, central atom (i.e. B-atom) is accepting the lone pair of electrons, it behave as a Lewis acid.

Hence, (c) is the correct option.

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# Question21

## Which of the following structure of a molecule is expected to have three bond pairs and one lone pair of electrons?

## KCET 2017

**Options:**

A. Octahedral

B. Trigonal planar

C. Pyramidal

D. Tetrahedral

**Answer: C**

## Solution:

Pyramidal structure of a molecule is expected to have three bond pairs and one lone pair of electrons 3 bonds +1 lone pair = trigonal bipyramidal

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# Question22

## Which of the following elements forms $p_\pi - p_\pi$ bond with itself?

## KCET 2017

**Options:**

A. P

B. Se

C. N

D. Te

**Answer: C**

## Solution:

Nitrogen, being smaller in size can effectively from $p\pi - p\pi$ bonds with other atoms of itself and atoms of other elements with small size and high electronegativity such as oxygen and carbon. The other elements do not from $p\pi - p\pi$ bonds because of their relatively lager size.

In other words the $p$ orbital of there elements are larger in size.

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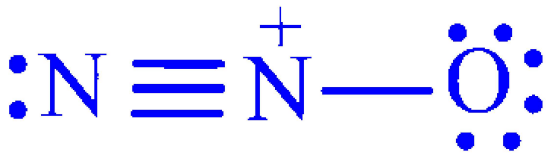
# Question23

## Which of the following is correct electron dot structure of $N_2O$ molecule?

## KCET 2017

**Options:**

A. 

B. 

C. 

D. 

**Answer: B**

## Solution:

The correct electron dot structure in which positive charge occupied. by less electronegative atom.

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