Chapter 4

Chemical Bonding and Molecular Structure

Solutions

SECTION - A

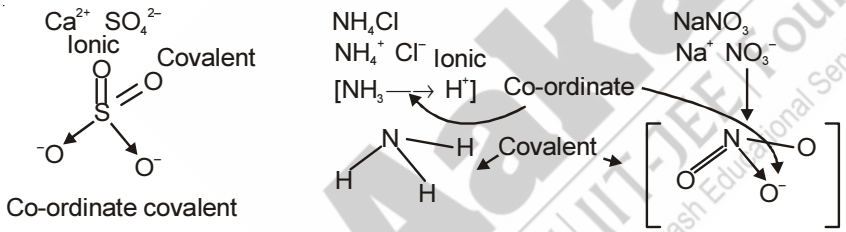
Objective Type Questions

(Kossel - Lewis Approach to Chemical Bonding, Ionic Bond, Bond Parameters)

1. According to octet rule the compound which contain ionic, covalent and coordinate bonds

   (1) $CaSO_4$ (2) NH_4Cl (3) $NaNO_3$ (4) All of these

Sol. Answer (4)



All have ionic, covalent and co-ordinate covalent bond

2. Which of the following molecule is having least ionic character?

   (1) $FeCl_2$ (2) $ZnCl_2$ (3) $MgCl_2$ (4) NaCl

Sol. Answer (2)

Full filled and half filled have maximum covalent character $\therefore$ $ZnCl_2$ have $3d^{10}$ configuration have maximum polarising power.

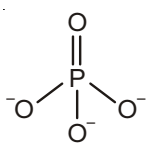
3. In PO_4^{3-} ion, the effective charge on each oxygen atom and P–O bond order respectively are

   (1) –0.75, 1.25 (2) –0.75, 1.0 (3) –0.75, 0.6 (4) –3, 1.25

Sol. Answer (1)

Effective charge = $\frac{-3}{4}$

B.O. = $1+\frac{1}{4} = \frac{5}{4} = 1.25$

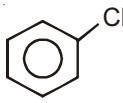


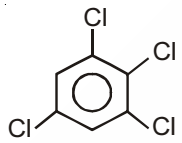
4. A certain diatomic molecule, AB has dipole moment 1.6 D and the internuclear distance is 100 pm. The percentage of electronic charge existing on more electronegative atom is

(1) 33% (2) 25% (3) 50% (4) 10%

Sol. Answer (1)

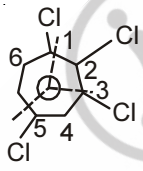
$$\% \text{ ionic} = \frac{\mu \text{ obsc}}{\mu \text{ cal}} = \frac{1.6 \times 10^{-18} \text{esu-cm}}{100 \times 10^{-18} \times 4.8 \times 10^{-10} \text{esu-cm}} = 33\%$$

5. Dipole moment of  is 1.1 D hence dipole moment of given compound will be



(1) 1.1 D (2) 4.4 D (3) 3.3 D (4) 2.56 D

Sol. Answer (1)



dipole moment of 1, 3, 5 chlorine will be cancelled due to symmetry
$\therefore$ dipole moment exist only due to C–2. i.e. 1.1 D

6. In the given structure of a compound, the correct various bond moments direction involving atoms are shown as

(1) $Br \leftarrow N \leftarrow CH_2 \rightarrow SiH_2 \leftarrow CH_2 \rightarrow O \leftarrow CH_3$ (2) $Br \leftarrow N \leftarrow CH_2 \leftarrow SiH_2 \leftarrow CH_2 \rightarrow O \leftarrow CH_3$

(3) $Br \rightarrow N \leftarrow CH_2 \leftarrow SiH_2 \rightarrow CH_2 \rightarrow O \leftarrow CH_3$ (4) $Br \leftarrow N \rightarrow CH_2 \rightarrow SiH_2 \leftarrow CH_2 \rightarrow O \rightarrow CH_3$

Sol. Answer (3)

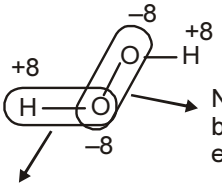
Electronegativity $\boxed{N > Br > C}$

7. Which molecule contains both polar and non-polar covalent bond?

(1) NH_4^+ (2) HCl (3) CH_4 (4) H_2O_2

Sol. Answer (4)

H_2O_2 have open book structure



Non-polar covalent bond because atoms of same electronegativity are present

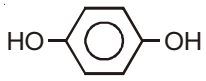
Polar covalent bond because different electronegativity atoms are present

8. Which of the following is a polar molecule?

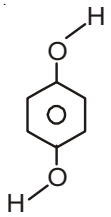
(1) Para dichlorobenzene

(2) Carbon tetrachloride

(3) Tetrachloroethene

(4) 

Sol. Answer (4)



(The Valence Shell Electron Pair Repulsion Theory, Valence Bond Theory, Hybridisation)

9. Which of the following is correct for XeO_2F_2 and PCl_5?

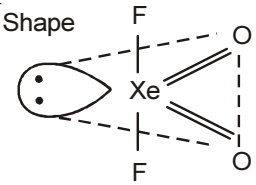
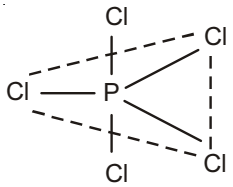
(1) Both have same hybridisation and shape

(2) Both have same hybridisation but different geometry

(3) Both have different hybridisation but same shape

(4) Both have same hybridisation but different shape

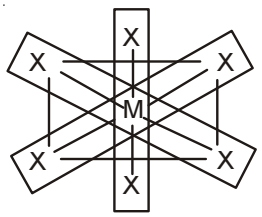
Sol. Answer (4)

XeO_2F_2	**PCl_5**
Hybridisation $= \frac{1}{2}[V + M - C + A]$	$H = \frac{1}{2}[V + M - C + A]$
$H = \frac{1}{2}[8 + 2 - 0 + 0]$	$H = \frac{1}{2}[5 + 5 - 0 + 0]$
$\frac{10}{2} = 5$ $[sp^3d]$	$H = 5$ sp^3d
Shape 	
See-saw shape	Trigonal bipyramidal

10. The maximum number of 180° angle possible between X-M-X bond for compounds with sp^3d^2 and sp^3d hybridisation respectively are

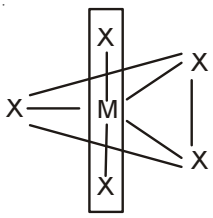
(1) 3, 3 (2) 3, 1 (3) 1, 3 (4) 3, 0

Sol. Answer (2)



X— M— X
180° =3.

sp^3d^2 octahedral



X— M— X
180°

sp^3d trigonal bipyramidal

11. Incorrect statement regarding hybridization is

(1) It is not possible for isolated atoms

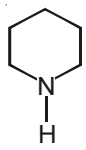
(2) Number of hybrid orbital formed is same as the number of orbitals combining

(3) Only the half filled orbitals and fully filled orbitals can participate not the empty orbital

(4) It is not a real physical process

Sol. Answer (3)

Fully filled, half filled, empty orbitals participate in 'H' in excited state e– excited to empty orbital.

12. In  hybrid state of N atom is

(1) sp^2 (2) sp^3 (3) sp^3d^2 (4) sp

Sol. Answer (2)

N have three bond pair and one lone pair

$\therefore$ its hybridisation will be sp^3

13. The shape of I_3^- is

(1) Linear

(2) Bent

(3) Pyramidal

(4) See saw

Sol. Answer (1)

$I_3^- = [I^- . I_2]$

 I_2

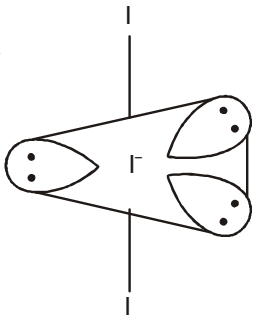
$H = \frac{1}{2}[V + M - C + A]$

I^- have 8 e^-

$= \frac{1}{2}[7 + 2 - 0 + 1] = \frac{10}{2} = sp^3d$

$\therefore$ by combining with two I_2, I^- have 3 LP and 2 BP

Structure of I_3^-

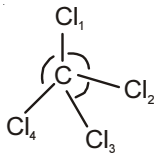


I_3^- have linear structure

14. Number of angles of 109°28′ is present in CCl_4

(1) 2 (2) 4 (3) 6 (4) 8

Sol. Answer (3)



109.28° will be in

Total '6'

$_1Cl - C - Cl_2$

$_1Cl - C - Cl_3$

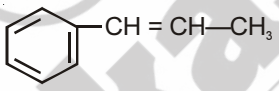
$_1Cl - C - Cl_4$

$_2Cl - C - Cl_3$

$_2Cl - C - Cl_4$

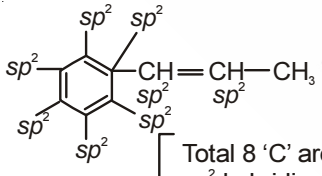
$_3Cl - C - Cl_4$

15. Number of carbon atoms present in sp^2 hybrid state of given molecule?



(1) 9 (2) 8 (3) 3 (4) 2

Sol. Answer (2)

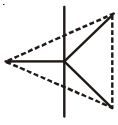


Total 8 'C' are present and have sp^2 hybridisation

16. In a regular trigonal bipyramidal MX_5, the number of X – M – X bonds at 180º is

(1) One (2) Two (3) Six (4) Four

Sol. Answer (1)



17. Some of the properties of the two species, NO_3^- and H_3O^+ are described below. Which one of them is correct?

(1) Dissimilar hybridization for the central atom with different structures

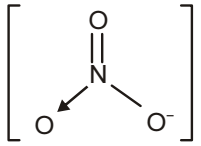
(2) Isostructural with same hybridization for the central atom

(3) Isostructural with different hybridization for the central atom

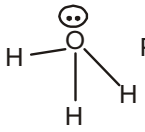
(4) Similar hybridization for the central atom with different structures

Sol. Answer (1)

Hybridisation NO_3^- = sp^2

Structure 

H_3O^+ = sp^3



Pyramidal

[Different hydridisation and different structural arrangement]

18. Which of the following is not a correct statement?

(1) Multiple bonds are always shorter than corresponding single bonds

(2) The electron-deficient molecules can act as Lewis acids

(3) The canonical structures have no real existence

(4) Every AB_5 molecules does in fact have square pyramid structure

Sol. Answer (4)

AB_5 molecule geometry also depends upon the no. of lone pair

$\therefore$ always AB_5 will not have square pyramid structure.

AB_5 = trigonal bipyramid, or square pyramid

19. Arrange the following species in increasing order of bond angle

NF_3 , NCl_3, NBr_3, NI_3

(1) $NF_3 < NCl_3 < NBr_3 < NI_3$

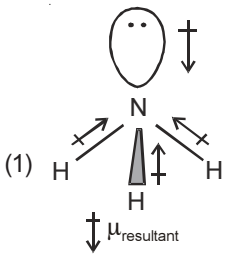
(2) $NF_3 < NBr_3 < NI_3 < NCl_3$

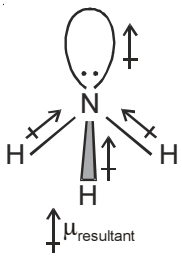
(3) $NI_3 < NBr_3 < NCl_3 < NF_3$

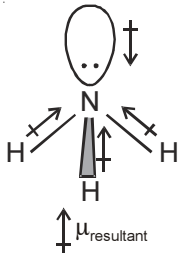
(4) $NBr_3 < NI_3 < NF_3 < NCl_3$

Sol. Answer (1)

20. Which of the following is correct representation of dipole moment of NH_3 molecule?

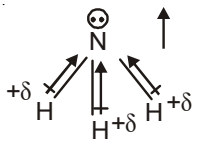
(1) 

(2) 

(3) 

(4) NH_3 being symmetrical will not show dipole moment

Sol. Answer (2)



[H is less electromagnetic than N
∴ Net dipole moment will be toward 'N' atom]

(Molecular Orbital Theory, Hydrogen Bonding)

21. The ground state electronic configuration of valence shell electrons in nitrogen molecule (N_2) is written as kk, $\sigma 2s^2$, $\sigma^* 2s^2$, $\begin{bmatrix}\pi 2p_y^2 \\ \pi 2p_z^2\end{bmatrix}$, $\sigma 2p_x^2$. Hence the bond order in nitrogen molecule is

(1) 2 (2) 3 (3) 0 (4) 1

Sol. Answer (2)

$$\text{Bond order} = \frac{\text{No. of bonding} - \text{No. of antibonding}}{2} = \frac{8-2}{2} = 3$$

Bond order of N_2 = 3

22. Which of the following statements are correct?

I. Bond order of NO is 2.5

II. Bond order of NO^+ is 3.0

III. Bond order of O_2 is 1.5

IV. Bond order of CO is 3.0

(1) I, II, III (2) II, III, IV (3) I, II, IV (4) II, IV

Sol. Answer (3)

NO = 15 = $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \sigma 2p_x^2 = \pi 2p_y^2, \pi 2p_x^1$ B.O = $\frac{10-5}{2} = 2.5$

NO^+ = 14 = $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \sigma 2p_x^2 = \pi 2p_y^2, \pi 2p_x^2, \pi^* 2p_x^0$ B.O = $\frac{10-4}{2} = 3$

O_2 = 16 = $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2 = \pi 2p_y^2, \pi 2p_x^0$ B.O = $\frac{10-6}{2} = 2$

CO = 14 = $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \pi^* 2_x^2 = \pi 2p_y^2, \sigma 2p_z^2, \sigma^* 2ps^2$ B.O = $\frac{10-4}{2} = 3$

3.0

∴ { NO 2.5
NO$^+$ 3
CO 3 }

23. The number of antibonding electron pairs in O_2^-

(1) 2 (2) 3

(3) 1 (4) 4

Sol. Answer (2)

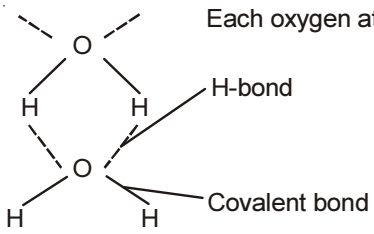
$O_2^- = 17 = \sigma1s^2, \sigma^*1s^2, \sigma2s^2, \sigma^*2s^2, \sigma2p_z^2, \pi2p_x^2 = \pi2p_y^2, \pi2p_x^2 \quad = \pi^*2p_y^1$

Number of antibonding electron pairs are 3.

24. How many bonds are formed by each oxygen atom in ice?

(1) 4 (2) 2 (3) 3 (4) May be 1 or 2

Sol. Answer (1)



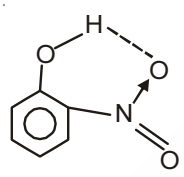
Each oxygen atom will form 4 bonds i.e.

25. o-nitrophenol is

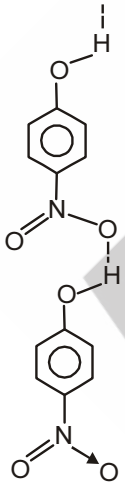
(1) More volatile than p-nitrophenol (2) Less volatile than p-nitrophenol

(3) Equally volatile as p-nitropheno (4) Non-volatile

Sol. Answer (1)



Intramolecular H-bonding (weaker bonding) as it is in the same molecule.



Intermolecular H-bonding (stronger bonding) as it is with in two molecules.

$\therefore$ o-nitrophenol will easily evaporated compared to p-nitrophenol

26. Which of the following pair consists of only paramagnetic species?

(1) H_2, O_2^+ (2) N_2, O_2

(3) CO, N_2 (4) H_2^+, O_2^-

Sol. Answer (4)

$H_2^+ = \sigma1s^1$ $\quad$ $O_2^- = \sigma1s^2 ... \pi2p_x^2 = \pi2p_y^2, \pi^*2p_x^2 = \pi^*2p_y^1$

$\downarrow$ $\quad$ $\downarrow$

1 unpaired electron in $\sigma1s$ $\quad$ 1 unpaired electron in $\pi^*2p_y^1$

SECTION - B

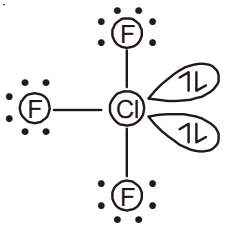
Previous Years Questions

1. In the structure of ClF_3, the number of lone pair of electrons on central atom 'Cl' is **[NEET-2018]**

(1) One (2) Two (3) Three (4) Four

Sol. Answer (2)

The structure of ClF_3 is



The number of lone pair of electrons on central Cl is 2.

2. Magnesium reacts with an element (X) to form an ionic compound. If the ground state electronic configuration of (X) is $1s^2\ 2s^2\ 2p^3$, the simplest formula for this compound is **[NEET-2018]**

(1) Mg_2X_3 (2) MgX_2 (3) Mg_3X_2 (4) Mg_2X

Sol. Answer (3)

Element (X) electronic configuration

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

So, valency of X will be 3.

Valency of Mg is 2.

Formula of compound formed by Mg and X will be Mg_3X_2.

3. Consider the following species :

CN^+, CN^-, NO and CN

Which one of these will have the highest bond order? **[NEET-2018]**

(1) NO (2) CN^- (3) CN (4) CN^+

Sol. Answer (2)

NO : $(\sigma 1s)^2$, $(\sigma^* 1s)^2$, $(\sigma 2s)^2$,$(\sigma^* 2s)^2$,$(\sigma 2p_z)^2$, $(\pi 2p_x)^2 = (\pi 2p_y)^2$,$(\pi^* 2p_x)^1 = (\pi^* 2p_y)^0$

$$BO = \frac{10-5}{2} = 2.5$$

CN^- : $(\sigma 1s)^2$, $(\sigma^* 1s)^2$, $(\sigma 2s)^2$,$(\sigma^* 2s)^2$, $(\pi 2p_x)^2$
$= (\pi 2p_y)^2$,$(\sigma 2p_z)^2$

$$BO = \frac{10-4}{2} = 3$$

CN : $(\sigma 1s)^2$, $(\sigma^* 1s)^2$, $(\sigma 2s)^2$,$(\sigma^* 2s)^2$, $(\pi 2p_x)^2$
$= (\pi 2p_y)^2$,$(\sigma 2p_z)^1$

$$BO = \frac{9-4}{2} = 2.5$$

CN^+ : $(\sigma 1s)^2$, $(\sigma^* 1s)^2$, $(\sigma 2s)^2$,$(\sigma^* 2s)^2$, $(\pi 2p_x)^2$
$= (\pi 2p_y)^2$

$$BO = \frac{8-4}{2} = 2$$

Hence, option(2) should be the right answer.

4. Which of the following pairs of compounds is isoelectronic and isostructural? **[NEET-2017]**

(1) $BeCl_2$, XeF_2 (2) TeI_2, XeF_2 (3) IBr_2^-, XeF_2 (4) IF_3, XeF_2

Sol. Answer (3)

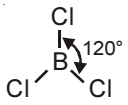
IBr_2^-, XeF_2

Total number of valence electrons are equal in both the species and both the species are linear also.

5. The species, having bond angles of 120° is **[NEET-2017]**

(1) PH_3 (2) ClF_3 (3) NCl_3 (4) BCl_3

Sol. Answer (4)



6. Which one of the following pairs of species have the same bond order? **[NEET-2017]**

(1) CO, NO (2) O_2, NO^+ (3) CN^-, CO (4) N_2, O_2^-

Sol. Answer (3)

$CN^{(-)}$ and CO have bond order 3 each.

7. Which one of the following compounds shows the presence of intramolecular hydrogen bond? **[NEET-Phase-2-2016]**

(1) H_2O_2 (2) HCN

(3) Cellulose (4) Concentrated acetic acid

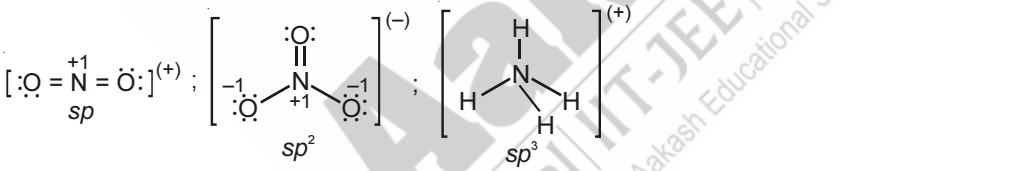
Sol. Answer (3)

Fact.

8. The hybridizations of atomic orbitals of nitrogen in NO_2^+, NO_3^- and NH_4^+ respectively are **[NEET-Phase-2-2016]**

(1) *sp*, sp^3 and sp^2 (2) sp^2, sp^3 and *sp* (3) *sp*, sp^2 and sp^3 (4) sp^2, *sp* and sp^3

Sol. Answer (3)

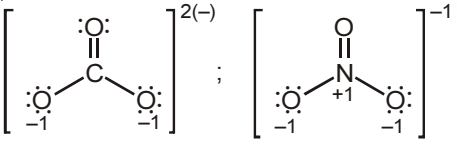


9. Which of the following pairs of ions is isoelectronic and isostructural? **[NEET-Phase-2-2016]**

(1) CO_3^{2-}, NO_3^- (2) ClO_3^-, CO_3^{2-} (3) SO_3^{2-}, NO_3^- (4) ClO_3^-, SO_3^{2-}

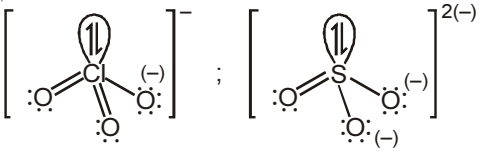
Sol. Answer (1, 4)

Option (1) :



Both have 32 electrons with trigonal planar structure.

Option (4) :



Both have 42 electrons with pyramidal structure.

10. The **correct** geometry and hybridization for XeF_4 are **[NEET-Phase-2-2016]**

(1) Octahedral, sp^3d^2

(2) Trigonal bipyramidal, sp^3d

(3) Planar triangle, sp^3d^3

(4) Square planar, sp^3d^2

Sol. Answer (1)

XeF_4, has octahedral geometry where hybridisation of Xe is sp^3d^2.

11. Among the following, which one is a **wrong** statement? **[NEET-Phase-2-2016]**

(1) PH_5 and $BiCl_5$ do not exist

(2) $p\pi$-$d\pi$ bonds are present in SO_2

(3) SeF_4 and CH_4 have same shape

(4) I_3^+ has bent geometry

Sol. Answer (3)

Shape of SeF_4 would be see saw whereas that of CH_4 would be tetrahedral.

12. Predict the **correct** order among the following. **[NEET-2016]**

(1) lone pair - bond pair > bond pair - bond pair > lone pair - lone pair

(2) lone pair - lone pair > lone pair - bond pair > bond pair - bond pair

(3) lone pair - lone pair > bond pair - bond pair > lone pair - bond pair

(4) bond pair - bond pair > lone pair - bond pair > lone pair - lone pair

Sol. Answer (2)

Fact

13. Consider the molecules CH_4, NH_3 and H_2O. Which of the given statements is false? **[NEET-2016]**

(1) The H – C – H bond angle in CH_4 is larger than the H – N – H bond angle in NH_3

(2) The H – C – H bond angle in CH_4, the H – N – H bond angle in NH_3, and the H – O – H bond angle in H_2O are all greater than 90°

(3) The H – O – H bond angle in H_2O is larger than the H – C – H bond angle in CH_4

(4) The H – O – H bond angle in H_2O is smaller than the H – N – H bond angle in NH_3

Sol. Answer (3)

Molecules	**Bond angle**
CH_4	$\longrightarrow$ 109.5°
NH_3	$\longrightarrow$ 107.5°
H_2O	$\longrightarrow$ 104.45°

14. Decreasing order of stability of O_2, O_2^-, O_2^+ and O_2^{2-} is **[Re-AIPMT-2015]**

(1) $O_2 > O_2^+ > O_2^{2-} > O_2^-$

(2) $O_2^- > O_2^{2-} > O_2^+ > O_2$

(3) $O_2^+ > O_2 > O_2^- > O_2^{2-}$

(4) $O_2^{2-} > O_2^- > O_2 > O_2^+$

Sol. Answer (3)

Stability $\propto$ bond-order.

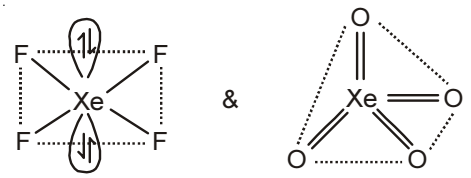
	O_2^+	> O_2	> O_2^-	> O_2^{2-}
Bond order :	2.5	2.0	1.5	1.0

15. In which of the following pairs, both the species are not isostructural? **[Re-AIPMT-2015]**

(1) NH_3, PH_3 (2) XeF_4, XeO_4

(3) $SiCl_4$, PCl_4^+ (4) Diamond, silicon carbide

Sol. Answer (2)



Square planar Tetrahedral

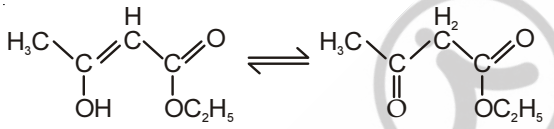
16. Maximum bond angle at nitrogen is present in which of the following? **[AIPMT-2015]**

(1) NO_3^- (2) NO_2 (3) NO_2^- (4) NO_2^+

Sol. Answer (4)

$NO_2^{\oplus}$ have linear geometry

17. The enolic form of ethyl acetoacetate as below has **[AIPMT-2015]**



(1) 9 sigma bonds and 1 pi-bond

(2) 18 sigma bonds and 2 pi-bonds

(3) 16 sigma bonds and 1 pi-bond

(4) 9 sigma bonds and 2 pi-bonds

Sol. Answer (2)

18. Which of the following species contains equal number of σ- and π-bonds? **[AIPMT-2015]**

(1) $CH_2(CN)_2$ (2) HCO_3^-

(3) XeO_4 (4) $(CN)_2$

Sol. Answer (3)

19. The correct bond order in the following species is **[AIPMT-2015]**

(1) $O_2^- < O_2^+ < O_2^{2+}$ (2) $O_2^{2+} < O_2^+ < O_2^-$

(3) $O_2^{2+} < O_2^- < O_2^+$ (4) $O_2^+ < O_2^- < O_2^{2+}$

Sol. Answer (1)

20. Which of the following pairs of ions are isoelectronic and isostructural? **[AIPMT-2015]**

(1) ClO_3^-, SO_3^{2-} (2) CO_3^{2-}, SO_3^{2-} (3) ClO_3^-, CO_3^{2-} (4) SO_3^{2-}, NO_3^-

Sol. Answer (1)

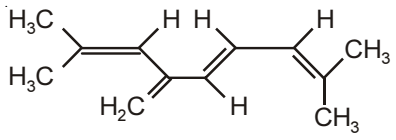
21. Which of the following options represents the correct bond order? **[AIPMT-2015]**

(1) $O_2^- < O_2 > O_2^+$ (2) $O_2^- > O_2 > O_2^+$

(3) $O_2^- < O_2 < O_2^+$ (4) $O_2^- > O_2 < O_2^+$

Sol. Answer (3)

22. The total number of π-bond electrons in the following structure is **[AIPMT-2015]**



(1) 16 (2) 4 (3) 8 (4) 12

Sol. Answer (3)

23. Which of the following molecules has the maximum dipole moment? **[AIPMT-2014]**

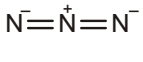
(1) CO_2 (2) CH_4 (3) NH_3 (4) NF_3

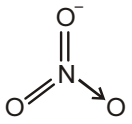
Sol. Answer (3)

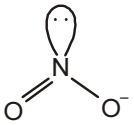
24. Which one of the following species has plane triangular shape? **[AIPMT-2014]**

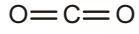
(1) N_3 (2) NO_3^- (3) NO_2^- (4) CO_2

Sol. Answer (3)





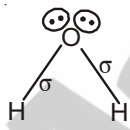




25. Which one of the following molecules contains no π bond? **[NEET-2013]**

(1) H_2O (2) SO_2 (3) NO_2 (4) CO_2

Sol. Answer (1)

H_2O have only sigma bond 

26. Which of the following is a polar molecule? **[NEET-2013]**

(1) SF_4 (2) SiF_4 (3) XeF_4 (4) BF_3

Sol. Answer (1)

27. Which of the following is paramagnetic? **[NEET-2013]**

(1) O_2^- (2) CN^-

(3) NO^+ (4) CO

Sol. Answer (1)

28. The pair of species with the same bond order is **[AIPMT (Prelims)-2012]**

(1) NO, CO (2) N_2, O_2

(3) O_2^{2-}, B_2 (4) O_2^+, NO^+

Sol. Answer (3)

O_2^{2-} = 18 = $\sigma1s^2, \sigma^*1s^2, \sigma2s^2, \sigma^*2s^2, \sigma2p_z^2, \pi2p_x^2 = \pi2p_y^2, \pi2p_x^2 = \pi^*2p_y^2$ $\quad B.O = \frac{10-8}{2} = 1$

B_2 = 10 = $\sigma1s^2, \sigma^*1s^2, \sigma2s^2, \sigma^*2s^2, \pi2p_x^1 = \pi2p_y^1$ $\quad B.O = \frac{6-4}{2} = 1$

O_2^{2-} and B_2 have same bond order

29. Bond order of 1.5 is shown by **[AIPMT (Prelims)-2012]**

(1) O_2^{2-} (2) O_2 (3) O_2^+ (4) O_2^-

Sol. Answer (4)

30. Which **one** of the following pairs is isostructural (*i.e.* having the same shape and hybridization)? **[AIPMT (Prelims)-2012]**

(1) [NF_3 and BF_3] (2) [BF_4^- and NH_4^+] (3) [BCl_3 and $BrCl_3$] (4) [NH_3 and NO_3^-]

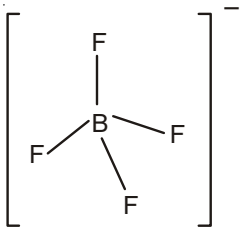
Sol. Answer (2)

BF_4^-

$H = \frac{1}{2}[3+4-0+1]$

$= \frac{8}{2} = 4 = sp^3$

Tetrahedral shape

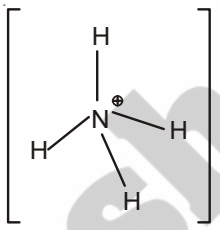


NH_4^+

$H = \frac{1}{2}[5+4-1+0]$

$= \frac{8}{2} = 4 = sp^3$

Tetrahedral shape



[Both are having tetrahedral shape and same hybridisation]

31. During change of O_2 to O_2^{2-} ion, the electron adds on which one of the following orbitals? **[AIPMT (Mains)-2012]**

(1) π^* orbitals (2) π orbitals (3) σ^* orbitals (4) σ orbitals

Sol. Answer (1)

$O_2 = 16 = \sigma 1s^2, \sigma^* 1s^2 ..... * 2p_x^1 = \pi^* 2p_y^1$

$\downarrow$

$O_2^{2-} = 18 = \sigma 1s^2, \sigma^* 1s^2 ..... * 2p_x^2 = \pi^* 2p_y^2$

e^- added in π^* orbital

32. Four diatomic species are listed below. Identify the correct order in which the bond order is increasing in them **[AIPMT (Mains)-2012]**

(1) $NO < O_2^- < C_2^{2-} < He_2^+$ (2) $O_2^- < NO < C_2^{2-} < He_2^+$

(3) $C_2^{2-} < He_2^+ < O_2^- < NO$ (4) $He_2^+ < O_2^- < NO < C_2^{2-}$

Sol. Answer (4)

33. Which of the following has the minimum bond length? **[AIPMT (Prelims)-2011]**

(1) O_2 (2) O_2^+ (3) O_2^- (4) O_2^{2-}

Sol. Answer (2)

Bond length $\propto \frac{1}{\text{Bond order}}$ Bond order $\left[\begin{array}{l} O_2 = 2 \\ O_2^+ = 2.5 \\ O_2^- = 1.5 \\ O_2^- = 1 \end{array}\right]$ by molecular orbital theory

$\therefore$ [O_2^+ have minimum bond length]

34. The correct order of increasing bond length of C – H, C – O, C – C and C = C is **[AIPMT (Prelims)-2011]**

(1) C – H < C – O < C – C < C = C (2) C – H < C = C < C – O < C – C

(3) C – C < C = C < C – O < C – H (4) C – O < C – H < C – C < C = C

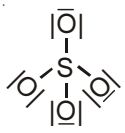
Sol. Answer (2)

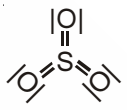
35. Which of the two ions from the list given below that have the geometry that is explained by the same hybridization of orbitals NO_2^-, NO_3^-, NH_2^-, NH_4^+, SCN^- **[AIPMT (Prelims)-2011]**

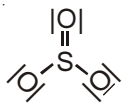
(1) NO_2^- and NH_2^- (2) NO_2^- and NO_3^- (3) NH_4^+ and NO_3^- (4) SCN^- and NH_2^-

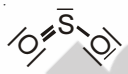
Sol. Answer (2)

36. Which of the following structures is the most preferred and hence of lowest energy for SO_3 ? **[AIPMT (Mains)-2011]**

(1) 

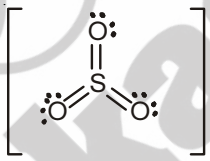
(2) 

(3) 

(4) 

Sol. Answer (2)

Molecule having covalent bond. Without resonance have maximum stability; minimum energy



37. The pairs of species of oxygen and their magnetic behaviours are noted below. Which of the following presents the correct description? **[AIPMT (Mains)-2011]**

(1) O_2^+, O_2 – Both paramagnetic (2) O_2, O_2^{2-} – Both paramagnetic

(3) O_2^-, O_2^{2-} – Both diamagnetic (4) O_2^+, O_2^{2-} – Both paramagnetic

Sol. Answer (1)

38. Which one of the following species does not exist under normal conditions? **[AIPMT (Prelims)-2010]**

(1) Be_2^+ (2) Be_2 (3) B_2 (4) Li_2

Sol. Answer (2)

39. In which of the following pairs of molecules/ions, the central atoms have sp^2 hybridization?

[AIPMT (Prelims)-2010]

(1) NO_2^- and NH_3 (2) BF_3 and NO_2^-

(3) NH_2^- and H_2O (4) BF_3 and NH_2^-

Sol. Answer (2)

40. In which one of the following species the central atom has the type of hybridization which is not the same as that present in the other three? **[AIPMT (Prelims)-2010]**

(1) SF_4 (2) $I_3^{\ominus}$ (3) $SbCl_3^-$ (4) PCl_5

Sol. Answer (3)

41. In which of the following molecules the central atom does not have sp^3 hybridization? **[AIPMT (Mains)-2010]**

(1) CH_4 (2) SF_4 (3) BF_4^- (4) NH^+_4

Sol. Answer (2)

42. Some of the properties of the two species, NO_3^- and H_3O^+ are described below. Which one of them is correct?

[AIPMT (Mains)-2010]

(1) Dissimilar in hybridization for the central atom with different structures

(2) Isostructural with same hybridization for the central atom

(3) Isostructural with different hybridization for the central atom

(4) Similar in hybridization for the central atom with different structures

Sol. Answer (1)

43. What is the dominant intermolecular force or bond that must be overcome in converting liquid CH_3OH to a gas?

[AIPMT (Prelims)-2009]

(1) Dipole-dipole interaction (2) Covalent bonds

(3) London dispersion force (4) Hydrogen bonding

Sol. Answer (4)

44. According to MO theory which of the following lists ranks the nitrogen species in terms of increasing bond order?

[AIPMT (Prelims)-2009]

(1) $N_2^{2-} < N_2^- < N_2$ (2) $N_2 < N_2^{2-} < N_2^-$

(3) $N_2^- < N_2^{2-} < N_2$ (4) $N_2^- < N_2 < N_2^{2-}$

Sol. Answer (1)

45. In which of the following molecules/ions BF_3, NO_2^-, NH_2^- and H_2O, the central atom is sp^2 hybridized ?

[AIPMT (Prelims)-2009]

(1) NH_2^- and H_2O (2) NO_2^- and H_2O

(3) BF_3 and NO_2^- (4) NO_2^- and NH_2^-

Sol. Answer (3)

46. In the case of alkali metals, the covalent character decreases in the order **[AIPMT (Prelims)-2009]**

(1) MF > MCl > MBr > MI (2) MF > MCl > MI > MBr

(3) MI > MBr > MCl > MF (4) MCl > MI > MBr > MF

Sol. Answer (3)

For same cation larger anion more will be covalent character

$\therefore$ MI > MBr > MCl > MF

47. Four diatomic species are listed below the different sequences. Which of these presents the correct order of their increasing bond order? **[AIPMT (Prelims)-2008]**

(1) $He_2^+ < O_2^- < NO < C_2^{2-}$ (2) $O_2^- < NO < C_2^{2-} < He_2^+$

(3) $NO < C_2^{2-} < O_2^- < He_2^+$ (4) $C_2^{2-} < He_2^+ < NO < O_2^-$

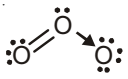
Sol. Answer (1)

48. The angular shape of molecule (O_3) consists of **[AIPMT (Prelims)-2008]**

(1) 2 sigma and 1 pi bond (2) 1 sigma and 2 pi bonds

(3) 2 sigma and 2 pi bonds (4) 1 sigma and 1 pi bond

Sol. Answer (1)



[O_3 have angular shape have two σ bond and 1 π bond]

49. The correct order of increasing bond angles in the following triatomic species is **[AIPMT (Prelims)-2008]**

(1) $NO_2^+ < NO_2^- < NO_2$ (2) $NO_2^- < NO_2^+ < NO_2$

(3) $NO_2^- < NO_2 < NO_2^+$ (4) $NO_2^+ < NO_2 < NO_2^-$

Sol. Answer (3)

50. The correct order of (C–O) bond length among CO, CO_3^{-2}, CO_2 is **[AIPMT (Prelims)-2007]**

(1) $CO < CO_2 < CO_3^{-2}$ (2) $CO_2 < CO_3^{-2} < CO$

(3) $CO < CO_3^{-2} < CO_2$ (4) $CO_3^{-2} < CO_2 < CO$

Sol. Answer (1)

51. In which of the following pairs, the two species are iso-structural ? **[AIPMT (Prelims)-2007]**

(1) BrO_3^- and XeO_3 (2) SF_4 and XeF_4 (3) SO_3^{2-} and NO_3^- (4) BF_3 and NF_3

Sol. Answer (1)

52. Which of the following is not a correct statement? **[AIPMT (Prelims)-2006]**

(1) The electron-deficient molecules can act as Lewis acids

(2) The canonical structures have no real existence

(3) Every AB_5 molecule does in fact have square pyramid structure

(4) Multiple bonds are always shorter than corresponding single bonds

Sol. Answer (3)

53. The number of unpaired electrons in a paramagnetic diatomic molecule of an element with atomic number 16 is **[AIPMT (Prelims)-2006]**

(1) 2 (2) 3 (3) 4 (4) 1

Sol. Answer (1)

54. Which of the following species has a linear shape ? **[AIPMT (Prelims)-2006]**

(1) NO_2^- (2) SO_2

(3) NO_2^+ (4) O_3

Sol. Answer (3)

55. The electronegativity difference between N and F is greater than that between N and H yet the dipole moment of NH_3 (1.5 D) is larger than that of NF_3 (0.2 D). This is because **[AIPMT (Prelims)-2006]**

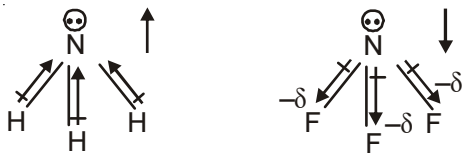
(1) In NH_3 as well as in NF_3 the atomic dipole and bond dipole are in the same direction

(2) In NH_3 the atomic dipole and bond dipole are in the same direction whereas in NF_3 these are in opposite directions

(3) In NH_3 as well as NF_3 the atomic dipole and bond dipole are in opposite directions

(4) In NH_3 the atomic dipole and bond dipole are in the opposite directions whereas in NF_3 these are in the same directions

Sol. Answer (2)



56. Which of the following molecules has trigonal planar geometry? **[AIPMT (Prelims)-2005]**

(1) IF_3 (2) PCl_3 (3) NH_3 (4) BF_3

Sol. Answer (4)

57. Which of the following would have a permanent dipole moment ? **[AIPMT (Prelims)-2005]**

(1) BF_3 (2) SiF_4 (3) SF_4 (4) XeF_4

Sol. Answer (3)

58. The correct order in which the O – O bond length increases in the following is **[AIPMT (Prelims)-2005]**

(1) $H_2O_2 < O_2 < O_3$ (2) $O_3 < H_2O_2 < O_2$

(3) $O_2 < O_3 < H_2O_2$ (4) $O_2 < H_2O_2 < O_3$

Sol. Answer (3)

59. The correct sequence of increasing covalent character is represented by **[AIPMT (Prelims)-2005]**

(1) $LiCl < NaCl < BeCl_2$ (2) $BeCl_2 < NaCl < LiCl$

(3) $NaCl < LiCl < BeCl_2$ (4) $BeCl_2 < LiCl < NaCl$

Sol. Answer (3)

60. Which one of the following oxides is expected to exhibit paramagnetic behaviour? **[AIPMT (Prelims)-2005]**

(1) CO_2 (2) SO_2 (3) ClO_2 (4) SiO_2

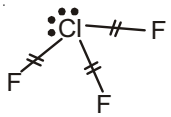
Sol. Answer (3)

61. Which of the following species contains three bond pairs and two lone pairs around the central atom?

(1) NH_2^- (2) ClF_3 (3) H_2O (4) BF_3

Sol. Answer (2)

ClF_3



[3 bond pairs and 2 lone pairs]

62. Bond order of 2.5 is shown by

(1) O_2^{2-} (2) O_2 (3) O_2^+ (4) O_2^-

Sol. Answer (3)

$O_2^+ = 15 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2 = \pi 2p_y^2, \pi^* 2p_x^1 = \pi^* 2p_y^0$

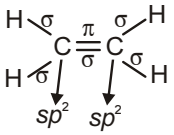
$$B.O = \frac{10-5}{2} = 2.5$$

63. The outer orbitals of C in ethene molecule can be considered to be hybridized to give three equivalent sp^2 orbitals. The total number of sigma (σ) and pi (π) bonds in ethene molecule is

(1) 1 sigma (σ) and 2 pi (π) bonds (2) 3 sigma (σ) and 2 pi (π) bonds

(3) 4 sigma (σ) and 1 pi (π) bonds (4) 5 sigma (σ) and 1 pi (π) bonds

Sol. Answer (4)

Ethene =  Total no. of σ bond = 5
π bond = 1

64. Which of the following is paramagnetic?

(1) C_2^{2-} (2) Na_2O_2 (3) NO_2 (4) CO

Sol. Answer (3)

C_2^{2-}, O_2^{2-}, CO have even number of electron will be diamagnetic, NO_2 have unpaired electron will be paramagnetic.

65. The geometry of electron pairs around I in IF_5 is

(1) Octahedral (2) Trigonal bipyramidal (3) Square pyramidal (4) Pentagonal planar

Sol. Answer (1)

IF_5 $H = \frac{1}{2}[7+5-0+0] = \frac{12}{2} = 6\ sp^3d^2$ Geometry = octahedral

66. In which of the following pair both the species have sp^3 hybridization?

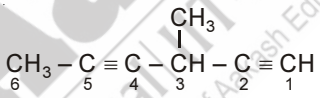
(1) H_2S, BF_3 (2) SiF_4, BeH_2 (3) NF_3, H_2O (4) NF_3, BF_3

Sol. Answer (3)

NH_3 $H = \frac{1}{2}[5+3-0+0] = \frac{8}{2} = sp^3$ H_2O $H = \frac{1}{2}[6+2-0+0] = \frac{8}{2} = sp^3$

[NH_3 and H_2O have same hybridisation but have different shape.]

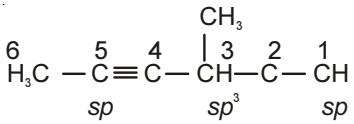
67. In the hydrocarbon



The state of hybridization of carbons 1, 3 and 5 are in the following sequence

(1) sp^3, sp^2, sp (2) sp^2, sp, sp^3 (3) sp, sp^3, sp (4) sp, sp^2, sp^3

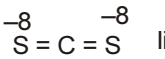
Sol. Answer (3)

 Hybridisation = $sp^{(3-\text{no. of } \pi \text{ bonds})}$

68. Which of the following molecule does not possess a permanent dipole moment?

(1) CS_2 (2) SO_3^{2-} (3) H_2S (4) SO_2

Sol. Answer (1)

$\mu = 0$ for CS_2  linear geometry
sp hybridisation

69. In which of the following compound there is more than one kind of hybridization (*sp*, sp^2, sp^3) for carbon?

(1) $CH_2 = CH–CH = CH_2$ (2) $H–C \equiv C–H$

(3) $CH_3CH_2CH_2CH_3$ (4) $CH_3–CH = CH–CH_3$

Sol. Answer (4)

$H_3C \overset{\sigma}{—} CH \overset{\pi}{=} CH \overset{\sigma}{—} CH_3$ contain both $sp \propto sp^3$

$sp^3 \quad sp^2 \quad sp^2 \quad sp^3$

70. Which of the following bonds has the highest energy?

(1) C–C (2) C≡C (3) C=C (4) C–H

Sol. Answer (2)

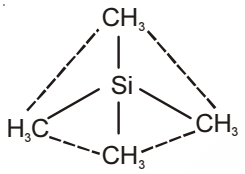
C ≡ C have two π bond and one σ bond, therefore will be more stronger.

71. The structure and hybridization of $Si(CH_3)_4$ is

(1) Octahedral, sp^3d (2) Tetrahedral, sp^3 (3) Bent, *sp* (4) Trigonal, sp^2

Sol. Answer (2)

$\left[Si(CH_3)_4\right]$ $H = \frac{1}{2}[4 + 4 - 0 + 0] = \frac{8}{2} = 4\ sp^3$



Tetrahedral and sp^3

72. The number of bonding electron pairs in N_2 on the basis of molecular orbital theory is

(1) 3 (2) 2 (3) 5 (4) 4

Sol. Answer (3)

$N_2 = 14 = \sigma1s^2, \sigma^*1s^2, \sigma2s^2, \sigma^*2s^2, \pi2p_x^2 = \pi2p_y^2, \sigma^*2p_z^2$

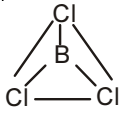
B B B B B

[No. of bonding pair = 5]

73. Which compound is electron deficient?

(1) NCl_3 (2) BCl_3 (3) CCl_4 (4) PCl_5

Sol. Answer (2)

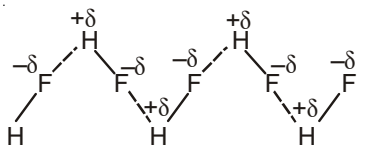
BCl_3 is electron deficient molecule 

Planar sp^2

74. Which compound form polymer due to H-bond?

(1) H_2S (2) NF_3 (3) HF (4) HCl

Sol. Answer (3)



[Polymeric due to H-bond]

75. Cation and anion combines in a crystal to form following type of compound

(1) Ionic (2) Metallic

(3) Covalent (4) Dipole-dipole

Sol. Answer (1)

Cation and anion form ionic bond in crystal.

76. Which compound has tetrahedral structure?

(1) XeF_4 (2) $XeOF_2$ (3) XeO_2F_2 (4) XeO_4

Sol. Answer (4)

XeO_4 $H = \frac{1}{2}[8+0-0+0]$

$\frac{8}{2} = 4\ sp^3$ tetrahedral structure

77. In which of the following bond angle is maximum?

(1) NH_3 (2) PCl_4^+ (3) BCl_3 (4) PCl_6^-

Sol. Answer (4)

$[PCl_6]^-$ $H = \frac{1}{2}[5+6-0+1] = \frac{12}{2} = 6\ sp^3d^2 = 180°$

As the bond angle is asked which is maximum in PCl_6^- i.e. 180° between linear pair.

78. In X – H ... Y, X and Y both are electronegative elements. Then

(1) Electron density on X will increase and on H will decrease

(2) In both electron density will increase

(3) In both electron density will decrease

(4) On X electron density will decrease and on H increases

Sol. Answer (1)

$\overset{-\delta}{X} - H \text{-------} \overset{-\delta}{Y}$ Electron density on X will increase and on H will decrease.

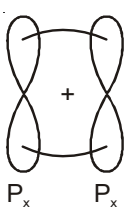
79. Main axis of a diatomic molecule is *z*, molecular orbital p_x and p_x overlap to form which of the following orbitals?

(1) π molecular orbital (2) σ molecular orbital

(3) δ molecular orbital (4) No bond will form

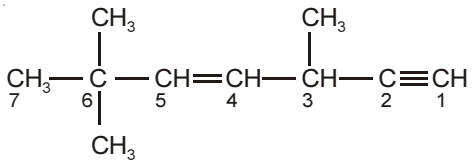
Sol. Answer (1)

π molecular orbital $P_x - P_x$



$(P_x - P_x)$

80. The state of hybridization of C_2, C_3, C_5 and C_6 of the hydrocarbon,



is in the following sequence

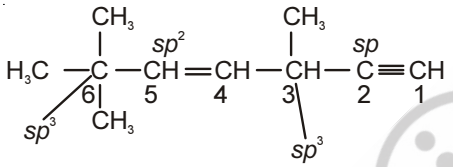
(1) *sp*, sp^2, sp^3 and sp^2

(2) *sp*, sp^3, sp^2 and sp^3

(3) sp^3, sp^2, sp^2 and *sp*

(4) *sp*, sp^2, sp^2 and sp^3

Sol. Answer (2)



81. For two ionics solids CaO and KI, identify the wrong statement among the following.

(1) CaO has high melting point

(2) Lattice energy of CaO is much larger than that of KI

(3) KI has high melting point

(4) KI is soluble in benzene

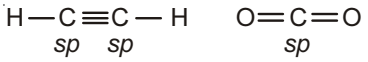
Sol. Answer (4)

82. Which of the following organic compounds has same hybridization as its combustion product –(CO_2)?

(1) Ethane (2) Ethyne

(3) Ethene (4) Ethanol

Sol. Answer (2)



SECTION - C

Assertion - Reason Type Questions

1. A : N_2, CO and CN^- are having same bond order.

R : Isoelectronic species always have same bond order.

Sol. Answer (3)

2. A : Bond angle of BF_3 and NF_3 are different.

R : Both the molecules are having different shape.

Sol. Answer (2)

3. A : CO_2 is resonance stabilized molecule.

R : Bond length of C–O in CO_2 is intermediate of single and double bond length.

Sol. Answer (3)

4. A : $BeCl_2$ in vapour phase is electron deficient molecule.

R : Any molecule in which central atom is having incomplete octet is known as electron deficient molecule.

Sol. Answer (1)

5. A : H–F forms stronger hydrogen bond than H_2O.

R : F is more electronegative than oxygen.

Sol. Answer (1)

6. A : Each molecule of H_2O forms four H-bond in the form of ice.

R : Ice is solid state of H_2O.

Sol. Answer (2)

7. A : Both methane and tetrachloromethane are nonpolar.

R : C–Cl bond is polar bond.

Sol. Answer (2)

8. A : N_2 is more stable than N_2^+.

R : Bond order of N_2 is 3 while N_2^+ is 2.5.

Sol. Answer (1)

9. A : Lattice energy of CaO is higher than LiCl.

R : Lattice energy of ionic compound is directly proportional to the product of charges of ion.

Sol. Answer (1)

10. A : All P–Cl bond lengths are equal in PCl_3 but different in PCl_5

R : Hybrid state of central atom is different in both molecules.

Sol. Answer (2)

11. A : Equal number of sigma and π bonds are present in ethyne.

R : π bond is stronger than σ bond.

Sol. Answer (4)

12. A : Bond order of H_2^+ is 0.5.

R : Electrons are removed from the antibonding molecular orbital from H_2.

Sol. Answer (3)

13. A : LiCl is more covalent than $BeCl_2$.

R : Li^+ ion is smaller than Be^{2+}.

Sol. Answer (4)

14. A : O_2 is paramagnetic.

R : N_2 is paramagnetic.

Sol. Answer (3)

15. A : PCl_5 exist but NCl_5 does not.

R : Nitrogen is highly inert.

Sol. Answer (2)

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