Chemical Bonding and Molecular Structure

Question1

The correct order of increasing bond lengths of $C-H$, $O-H$, $C-C$ and $H-H$ is

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Options:

A. $O-H < H-H < C-C < C-H$

B. $C-C < C-H < H-H < O-H$

C. $C-C < O-H < H-H < C-H$

D. $H-H < O-H < C-H < C-C$

Answer: D

Solution:

The correct order is,

$H-H < O-H < C-H < C-C$

$H-H$ is smallest due to small size of H atom.

$C-C$ is larger than both H and O thus this single bond is largest among the given options.

Question2

The sum of bond order of O_2^{2+}, O_2^{2-}, O_2^{+}, O_2^{-}, O_2 and sum of the unpaired electrons present in them respectively are

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Options:

A.

10,4

B.

10,6

C.

8,4

D.

8,6

Answer: A

Solution:

$O_2^{2+} = 14$ electron,

$O_2^{2-} = 18$ electrons, $O_2^{2-} = 15$ electrons
$O_2^- = 17$ electrons, $O_2 = 16$
electrons B.O. $\left(O_2^{2+}\right) = \frac{\text{B.E.} \quad - \text{A.B.E}}{2} = \frac{1}{2}(10-4) = 3$

B.O. $\left(O_2^{2-}\right) = \frac{1}{2}(10-8) = 1;$

B.O. $\left(O_2^{+}\right) = \frac{1}{2}(10-5) = 2.5$

B.O. $\left(O_2^{-}\right) = \frac{1}{2}(10-7) = 1.5;$

B.O. $(O_2) = \frac{1}{2}(10-6) = 2$

Unpaired electron

$O_2^{2+}, O_2^{2-} = O; O_2^{+}, O_2^{-} = I; O_2 = 2$

Sum of B.O. and unpaired electron

$3+1+2.5+1.5+2 = 10 \qquad \ldots(i)$

$0+0+1+1+2 = 4 \qquad \ldots(ii)$

Question3

Match the following

List-I (Molecule)		List-II (Dipole moment in D)	
(A)	HCl	(I)	1.85
(B)	NH_3	(II)	1.07
(C)	H_2O	(III)	0.23
(D)	NF_3	(IV)	1.47

The correct answer is

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Options:

A.

A-II, B-IV, C-I, D-III

B.

A-IV, B-III, C-I, D-II

C.

A-II, B-I, C-IV, D-III

D.

A-III, B-II, C-IV, D-I

Answer: A

Solution:

Let's match each molecule with its approximate dipole moment:

1. **HCl (Hydrogen Chloride)**: HCl is a diatomic molecule with a polar covalent bond. Chlorine is significantly more electronegative than hydrogen. This creates a net dipole moment. The experimentally observed dipole moment for HCl is approximately **1.08 D**.
    - Matching with List-II, **(II) 1.07 D** is the closest and most accurate value. So, **A - II**.
2. **NH_3 (Ammonia)**: NH_3 has a trigonal pyramidal geometry due to the presence of a lone pair on the nitrogen atom and three N-H bonds. Nitrogen is more electronegative than hydrogen, so the N-H bond dipoles point towards nitrogen. The lone pair also contributes significantly to the dipole moment, pointing away from the base of the pyramid. All these contributions add up constructively, resulting in a substantial net dipole moment. The experimentally observed dipole moment for NH_3 is approximately **1.47 D**.
    - Matching with List-II, **(IV) 1.47 D** is a perfect match. So, **B - IV**.

3. **H_2O (Water)**: H_2O has a bent (V-shaped) geometry due to two lone pairs on the oxygen atom and two O-H bonds. Oxygen is much more electronegative than hydrogen. The O-H bond dipoles point towards oxygen, and these dipoles, along with the lone pair contributions, add up constructively because of the bent shape, resulting in a very large net dipole moment. The experimentally observed dipole moment for H_2O is approximately **1.85 D**.
    - Matching with List-II, **(I) 1.85 D** is a perfect match. So, **C - I**.
4. **NF_3 (Nitrogen Trifluoride)**: NF_3 also has a trigonal pyramidal geometry, similar to NH_3. However, in NF_3, fluorine is more electronegative than nitrogen. Therefore, the N-F bond dipoles point *towards* the fluorine atoms, i.e., away from the nitrogen atom. The lone pair on nitrogen contributes a dipole moment pointing away from the base, similar to NH_3. However, the N-F bond dipoles oppose the dipole moment from the lone pair. This leads to a partial cancellation of dipoles, resulting in a much smaller net dipole moment compared to NH_3. The experimentally observed dipole moment for NF_3 is approximately **0.23 D**.
    - Matching with List-II, **(III) 0.23 D** is a perfect match. So, **D - III**.

Combining the matches:

- (A) HCl - (II) 1.07 D
- (B) NH_3 - (IV) 1.47 D
- (C) H_2O - (I) 1.85 D
- (D) NF_3 - (III) 0.23 D

Now, let's check the given options:

Option A: A-II, B-IV, C-I, D-III. This matches our derived connections.

The final answer is $\boxed{A}$

Question4

Which of the following sets are correctly matched?

	Molecule	Number of lone pair of electrons on central atom	Hybridisation
(I)	PCl_3	1	sp^3
(II)	SO_2	2	sp^3
(III)	SF_4	2	sp^3d^2
(IV)	ClF_3	2	sp^3d

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Options:

A.

I and II

B.

II and III

C.

II and IV

D.

I and IV

Answer: D

Solution:

Only PCl_3 and ClF_3 are correctly matched. While SO_2 and SF_4 are incorrect. Their correct match is

$SO_2 = 1$ lone pair $= sp^2$
$SF_4 = 1$ lone pair $= sp^3d$

Question5

The number of molecules having lone pair of electrons on central atom in the following is

$$BF_3, SF_4, SiCl_4, XeF_4, NCl_3, XeF_6, PCl_5, HgCl_2, SnCl_2$$

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Options:

A.

6

B.

3

C.

4

D.

5

Answer: D

Solution:

The number of molecules having lone pair of electrons on central atoms are 5 (five).

They are

$SF_4, NCl_3, XeF_6, XeF_4, SnCl_2$

Whereas $BF_3, SiCl_4, HgCl_2$ and $PCl_5 = 0$ lone pair

Question6

Observe the following molecules/ions
$NH_4^+, NH_3, BF_3, OH^-, CH_3^+, H^+, CO, C_2H_4$.

The number of Lewis bases in the above list is

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Options:

A.

2

B.

3

C.

4

D.

5

Answer: C

Solution:

There are 4 Lewis bases in the given molecules.

They are NH_3, OH, CO, C_2H_4

Lewis bases are molecules or ions that can donate an electron pair.

Question7

Identify the pair of molecules which have same hybridisation as the hybridisation in xenon (II) fluoride.

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Options:

A.

XeO_3, SF_4

B.

BrF_5, PF_5

C.

ClF_3, SF_4

D.

PCl_3, NH_3

Answer: C

Solution:

ClF_3 and SF_4 has hybridisation as that of xenon (II) flouride. Both has sp^3d hybridisation.

Question8

Identify the set containing isoelectronic species

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Options:

A.

N_2, O_2^{2-}, NO^+

B.

N_2, CO, NO^+

C.

F_2, O_2^{2-}, N_2

D.

N_2, O_2^{2+}, C_2

Answer: B

Solution:

N_2, CO, NO^+ are isoelectronic species.

Isoelectronic species are those species that have same number of electrons. N_2, Co, No^+, Au has 14 electrons.

Question9

A molecules has T -shape. The total number of electron pairs in the valence shell of central atom of it is

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Options:

A.

4

B.

5

C.

6

D.

3

Answer: B

Solution:

A molecule with T-shape has total-five electrons pairs in the valence shell of its central atom. This consists of three bond pairs and two lone pairs. This is in accordance with VSEPR theory.

Question10

The sum of bond order values of C_2 and O_2^{2+} is x, which is equal to sum of bond order values of a, b and c. What are a, b and c ?

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Options:

A.

O_2^-, O_2^+, O_2

B.

$B_2,\ N_2,\ F_2$

C.

$He_2^+, F_2,\ N_2$

D.

O_2^{2-}, N_2, Be_2

Answer: B

Solution:

Bond order is given by

B.O. $= \frac{1}{2}$ [Number of bonding electrons- number of antibonding electrons]

B.O. of $C_2 = 2$

B.O. of $O_2^{2+} = 2.5, x = 2 + 3 = 5$

B.O. $(a + b + c) = 4.5$

$a = B_2, b = N_2, C = F_2$

B.O. $= 1 + 3 + 1 = 5$

Question11

How many of the following molecules have two lone pairs of electrons on central atom?

$SF_6, BF_3, ClF_3, PCl_5, BrF_5, XeF_4, H_2O, SF_4$

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Options:

A.

5

B.

4

C.

3

D.

2

Answer: C

Solution:

Three molecules has two lone pairs of electrons on central atoms. These are ClF_3, XeF_4 and H_2O while SF_6, BF_3, PCl_5 has 0 lone pair and BrF_5, SF_4 has 1 lone pair.

Question12

The pair of molecules / ions with the same bond order value is

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Options:

A.

B_2, C_2

B.

O_2, C_2

C.

O_2^+, O_2^-

D.

H_2^+, Li_2

Answer: B

Solution:

The pair of molecules that have the same bond order are O_2 and C_2.

Bond order shows how many chemical bonds are between two atoms.

To find bond order, use this formula:

$$\text{Bond Order} = \frac{\text{Number of bonding electrons} - \text{Number of antibonding electrons}}{2}$$

For O_2:

Number of bonding electrons = 10,
Number of antibonding electrons = 6

$$\text{Bond Order} = \frac{10-6}{2} = 2$$

For C_2:

Number of bonding electrons = 8,
Number of antibonding electrons = 4

$$\text{Bond Order} = \frac{8-4}{2} = 2$$

So, both O_2 and C_2 have a bond order of 2.

Question13

How many of the following molecules / ions have trigonal planar structure?

$$BO_3^{3-}, NH_3, PCl_3, BCl_3, ClF_3, XeO_3$$

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Options:

A.

5

B.

2

C.

4

D.

3

Answer: B

Solution:

Among the given options, only two molecules/ions has trigonal planar structure.

$[BO_3]^{3-}, BCl_3$: Trigonal planar NH_3, PCl_3, XeO_3 : Trigonal pyramidal ClF_3 : T shape

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Question14

Consider the following

Assertion (A) Dipole moment of NF_3 is lesser than NH_3.

Reason (R) In NF_3, the orbital dipole due to lone pair of electrons is in the opposite direction to the resultant dipole moment of the three $N-F$ bonds.

The correct answer is

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Options:

A.

both (A) and (R) are correct and (R) is the correct explanation of (A)

B.

both (A) and (R) are correct but (R) is not the correct explanation of (A)

C.

(A) is correct but (R) is not correct

D.

(A) is not correct but (R) is correct

Answer: A

Solution:

Both (A) and (R) are correct and (R) is the correct explanation of (A).

Question15

Consider the following changes I and II

$$O_2^- \underset{II}{\longleftarrow} O_2 \underset{I}{\longrightarrow} O_2^+$$

The correct statements about these changes (I) and (II) in accordance with MO theory are

(A) In (I) bond order increases by 0.5 from the existing value

(B) In (II) bond order decreases by 1.0 from the existing value

(C) In both (I) and (II) magnetic property is not changed

(D) In both (I) and (II) magnetic property is changed

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Options:

A.

A, B and C only

B.

A and C only

C.

A and D only

D.

B and C only

Answer: B

Solution:

The reaction

$O_2^+ \underset{I}{\longleftarrow} O_2 \underset{II}{\longrightarrow} O_2^-$

O_2 : 16 electrons: Paramagnetic
O_2^+ : 15 electrons (1 removed);
Paramagnetic
O_2^- : 17 electrons (1 added) : Paramagnetic
$O_2^+ = \sigma ls^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2$
$\left(\pi 2p_x^2 = \pi 2p_y^2\right)\left(\pi^* 2p_x^1 = \pi^* 2p_y^0\right)$
$\text{B.O.} = \dfrac{10-5}{2} = 2.5$
$O_2^+ = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma * 2s^2 \sigma 2p_z^2$
$\left(\pi 2p_x^2 = \pi 2p_y^2\right)\left(\pi^* 2p_x^1 = \pi^* 2p_y^1\right)$
$\text{B.O.} = \dfrac{10-6}{2} = 2$
$O_2^- = \sigma ls^2 \sigma * 1s^2 \sigma 2s^2 \sigma * 2s^2 \sigma 2p_z^2$
$\left(\pi 2p_x^2 = \pi 2p_y^2\right)\left(\pi^* 2p_x^2 = \pi * 2p_y^1\right)$

$\text{B.O.} = \dfrac{10-7}{2} = 1.5$
Hence, statement A and C are correct.

Question16

The increasing order of number of lone pair of electrons on the central atom of the following molecules is

(I) ClF_3

(II) XeF_2

(III) SF_4

(IV) SiH_4

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Options:

A.

$IV < III < II < I$

B.

$I < II < III < IV$

C.

$II < I < III < IV$

D.

$IV < III < I < II$

Answer: D

Solution:

The correct order increasing of lone pair of electron on central atoms are

$SiH_4 < SF_4 < ClF_3 < XeF_2$

zero lone pair one lone pairs two lone pairs 3 lone pair

$IV < III < I < II$

Question17

Identify the correct set of molecules with zero dipole moment

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Options:

A.

CO_2, NH_3, H_2O

B.

NH_3, NF_3, BF_3

C.

PF_3, NH_3, CH_4

D.

CH_4, BF_3, CO_2

Answer: D

Solution:

CH_4, BF_3, CO_2 all has zero dipole moments.

Dipole moments is given by $\mu = \sqrt{n(n+2)}$ B.M. where, n is the number of unpaired electrons on central atom, in CH_4, C has 0 unpaired electrons,

Thus $\mu = \sqrt{0(0+2)} = 0$

Same is true for BF_3 and CO_2.

Question18

Identify the set of molecules in which the central atom has only one lone pair of electrons in their valence shells

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Options:

A. $BrF_5, SF_4, SnCl_2$

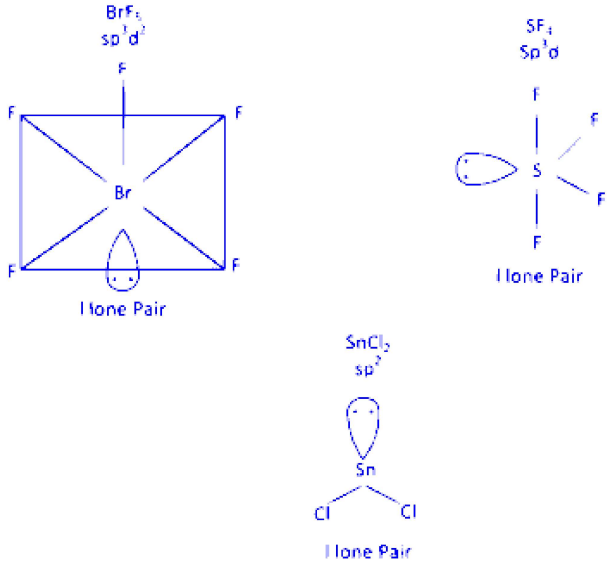
B. $BrF_5, XeF_4, SnCl_2$

C. XeF_4, NH_3, ClF_3

D. XeF_6, ClF_3, SF_4

Answer: A

Solution:



Question19

The bond order of which of the following two species is same?

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Options:

A. $O_2,\ N_2$

B. C_2, O_2

C. B_2, C_2

D. F_2, C_2

Answer: B

Solution:

The bond order (BO) is a calculation that indicates the strength and stability of a bond. It is determined using the formula:

$\text{BO} = \frac{1}{2}[\text{Number of bonding electrons} - \text{Number of antibonding electrons}]$

For calculating the bond order of different diatomic molecules:

For C_2:

The electronic configuration is:

$\left[\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p_x^2 \pi 2p_y^2\right]$

Number of bonding electrons (N_b) = 8

Number of antibonding electrons (N_a) = 4

Using the formula:

BO $= \frac{1}{2}[8-4] = 2$

For O_2:

The electronic configuration is:

$[\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \pi 2p_x^2 \pi 2p_y^2 \pi^* 2p_x^1 \pi^* 2p_y^1]$

Number of bonding electrons (N_b) = 10

Number of antibonding electrons (N_a) = 6

Using the formula:

BO $= \frac{1}{2}[10-6] = 2$

Both C_2 and O_2 have the same bond order of 2, indicating that both molecules have similar bond strength and stability.

Question20

Which of the following sets are correctly matched?

(i) B_2H_6 - electron deficient hydride

(ii) NH_3 - electron precise hydride

(iii) H_2O - electron rich hydride

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Options:

A. i,iii only

B. i, ii, iii

C. ii, iii, only

D. i, ii, only

Answer: A

Solution:

Here's how the three hydrides classify:

Electron-deficient hydrides

– Need multicenter (3c–2e) bonding because there aren't enough electrons for simple 2-center bonds.

– Example: B_2H_6

Electron-precise hydrides

– Have exactly the right number of electrons for one 2-center-2-electron bond per A–H link.

– Examples: CH_4, SiH_4 .

Electron-rich hydrides

– Carry extra lone-pair electrons on the central atom beyond those used in A–H bonds.

– Examples: NH_3, H_2O, $PH_3, \ldots$

Checking your list:

• (i) B_2H_6 – electron-deficient ✓

• (ii) NH_3 – actually electron-rich (it has a lone pair), so "electron-precise" is wrong

• (iii) H_2O – electron-rich ✓

Thus only (i) and (iii) are correctly matched ⇒ Option A.

Question21

Which of the following is /are ionic in nature?

(i) GeF_4

(ii) SnF_4

(iii) PbF_4

The correct option is

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Options:

A. (iii) only

B. (ii) (iii) only

C. (i) only

D. (i) (ii) only

Answer: B

Solution:

SnF_4 is ionic in nature based on Fajan's rule. There is large differerce in size as well as electronegativity of the atoms, which make the bond ionic between Sn and F .

PbF_4 is also ionic in nature based on Fajan's rule. According to Fajan's rule, an ionic bond is formed by a compound with low positive charge, a large cation and a small anion.

GeF_4 is covalent.

Question22

The number of lone pairs of electrons on the central atom of BrF_5, XeO_3, SO_2 respectively are

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Options:

A. $1, 1, 2$

B. $1, 2, 2$

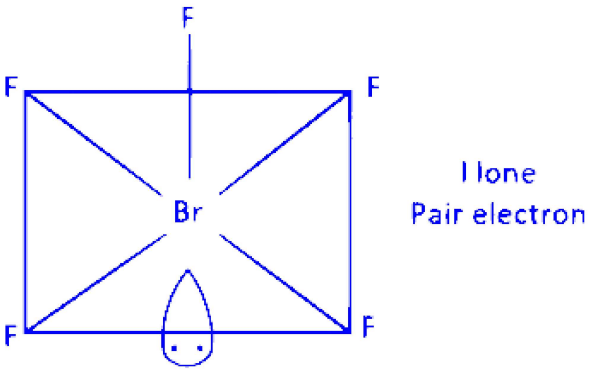
C. $2, 2, 1$

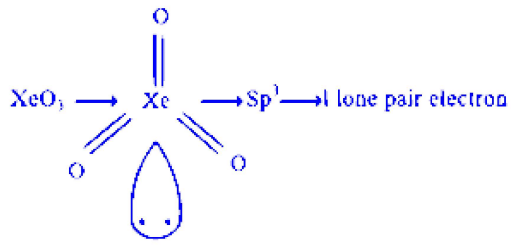
D. $1, 1, 1$

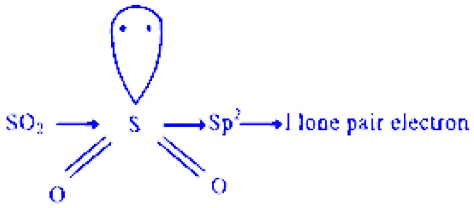
Answer: D

Solution:

$BrF_5 \longrightarrow sp^2d^2$







Question23

The shape of colourless neutral gas formed on thermal decomposition of ammonium nitrate is

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Options:

A. angular

B. linear

C. trigonal planar

D. trigonal pyramidal

Answer: B

Solution:

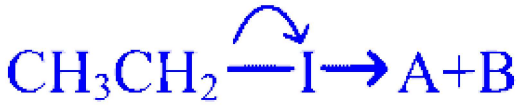
The decomposition of ammonium nitrate is,

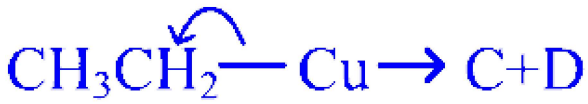
$NH_4NO_3 \longrightarrow N_2O + 2H_2O$

N_2O is colourless neutral gas.

Question24

Species A, B, C, D formed in the following bond cleavages respectively are





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Options:

A. $CH_3CH_2^+, I^-, CH_3CH_2^-, Cu^+$

B. $CH_3CH_2^+, I^-, CH_3CH_2^+, Cu^-$

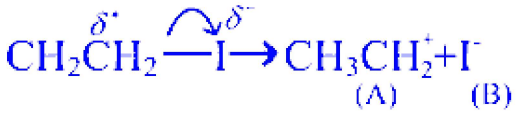
C. $CH_3CH_2^-, \quad I^+, CH_3CH_2^+, Cu^-$

D. $CH_3CH_2^-, \quad I^+, CH_3CH_2^-, Cu^+$

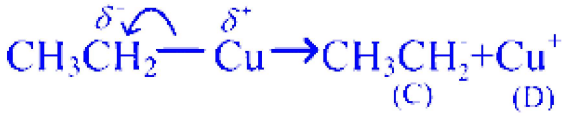
Answer: A

Solution:

The complete bond cleavage reaction is,



(Negative charge is more on iodine.)



(Negative charge is more on CH_3CH_2.)

$\therefore A = CH_3CH_2^+, B = I^-, C = CH_3CH_2^-, D = Cu^+$

Question25

The basicity of $H_3PO_2, H_3PO_3 \cdot H_3PO_4$ respectively is

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Options:

A. $2, 2, 3$

B. $2, 3, 3$

C. $1, 3, 3$

D. $1, 2, 3$

Answer: D

Solution:

Basicity of an acid is the number of replaceable hydrogen in the acid.

Question26

In which of the following, there is no change in hybridisation of the central atom ?

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Options:

A. $NH_3 + H^+ \rightarrow NH_4^+$

B. $BF_3 + F^- \rightarrow BF_4^-$

C. $PCl_3 + Cl_2 \rightarrow PCl_5$

D. $ClF_3 + F_2 \rightarrow ClF_5$

Answer: A

Solution:

For the given reaction below, the hybridisaion of central atom does not change.

$$\underset{sp^3}{NH_3} + H^+ \longrightarrow \underset{sp^3}{NH_4^+}$$

$$\underset{sp^2}{BF_3} + F \longrightarrow \underset{sp^3}{BF_4^-}$$

$$\underset{sp^3}{PCl_3} + Cl_2 \longrightarrow \underset{sp^3d}{PCl_5}$$

$$\underset{sp^3d}{ClF_3} + F_2 \longrightarrow \underset{sp^3d^2}{ClF_5}$$

Question27

In which of the following sets the sum of bond orders of three species is maximum ?

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Options:

A. B_2, CN^-, O_2^{2-}

B. $O_2,\ F_2, O_2^{2+}$

C. O_2^-, N_2, O_2^+

D. C_2, O_2, He_2^{2+}

Answer: C

Solution:

Explanation of Bond Order Calculation

Bond Order (B.O.) is calculated using the formula:

$$\text{Bond Order} = \frac{1}{2}(\text{number of electrons in bonding orbitals} - \text{number of electrons in antibonding orbitals})$$

Let's analyze each set:

Set (a): B_2, CN^-, O_2^{2-}

B_2:

$$\text{Number of bonding electrons} = 4, \text{Number of antibonding electrons} = 2$$

$$\text{B.O.} = \frac{1}{2}(4 - 2) = 1$$

CN^-:

$$\text{Number of bonding electrons} = 10, \text{Number of antibonding electrons} = 4$$

$$\text{B.O.} = \frac{1}{2}(10 - 4) = 3$$

O_2^{2-}:

$$\text{Number of bonding electrons} = 10, \text{Number of antibonding electrons} = 8$$

$$\text{B.O.} = \frac{1}{2}(10 - 8) = 1$$

Total Bond Order for Set (a):

$$1 + 3 + 1 = 5$$

Set (b): O_2, F_2, O_2^{2+}

O_2:

Number of bonding electrons $= 10$, Number of antibonding electrons $= 6$

B.O. $= \frac{1}{2}(10 - 6) = 2$

F_2:

Number of bonding electrons $= 10$, Number of antibonding electrons $= 8$

B.O. $= \frac{1}{2}(10 - 8) = 1$

O_2^{2+}:

Number of bonding electrons $= 10$, Number of antibonding electrons $= 4$

B.O. $= \frac{1}{2}(10 - 4) = 3$

Total Bond Order for Set (b):

$2 + 1 + 3 = 6$

Set (c): O_2^-, N_2, O_2^+

O_2^-:

Number of bonding electrons $= 10$, Number of antibonding electrons $= 7$

B.O. $= \frac{1}{2}(10 - 7) = 1.5$

N_2:

Number of bonding electrons $= 10$, Number of antibonding electrons $= 4$

B.O. $= \frac{1}{2}(10 - 4) = 3$

O_2^+:

Number of bonding electrons $= 10$, Number of antibonding electrons $= 5$

B.O. $= \frac{1}{2}(10 - 5) = 2.5$

Total Bond Order for Set (c):

$1.5 + 3 + 2.5 = 7$

Set (d): C_2, O_2, He_2^{2+}

C_2:

Number of bonding electrons $= 8$, Number of antibonding electrons $= 4$

B.O. $= \frac{1}{2}(8 - 4) = 2$

O_2:

Number of bonding electrons $= 10$, Number of antibonding electrons $= 6$

B.O. $= \frac{1}{2}(10 - 6) = 2$

He_2^{2+}:

Number of bonding electrons $= 2$, Number of antibonding electrons $= 0$

B.O. $= \frac{1}{2}(2-0) = 1$

Total Bond Order for Set (d):

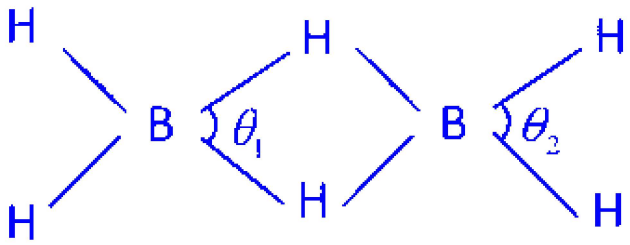
$2 + 2 + 1 = 5$

Conclusion

Set (c) has the maximum total bond order sum of 7.

Question28

In the given structure of diborane θ_1, θ_2 are respectively



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Options:

A. $101^\circ \cdot 118^\circ$

B. $118^\circ.101^\circ$

C. $97^\circ, 120^\circ$

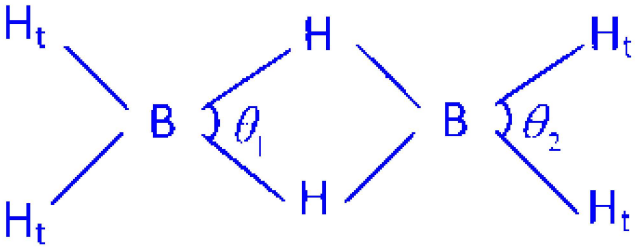
D. $120^\circ.97^\circ$

Answer: C

Solution:

Diborane - B_2H_6

Each boron atom is sp^3 hybridised.



$\theta_1 = 97^\circ$ and $\theta_2 = 120^\circ$

H_t is terminal hydrogen atom and two boron atoms lie in the same plane.

Question29

The correct order of covalent bond character of $BCl_3, CCl_4, BeCl_2, LiCl$ is

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Options:

A. $LiCl < BeCl_2 < BCl_3 < CCl_4$

B. $CCl_4 < BeCl_2 < BCl_3 < LiCl$

C. $CCl_4 < BCl_3 < BeCl_2 < LiCl$

D. $LiCl < BCl_3 < BeCl_2 < CCl_4$

Answer: A

Solution:

The correct order of covalent bond character is:

$LiCl < BeCl_2 < BCl_3 < CCl_4$

According to Fajan's rules, the covalent character of a bond increases with higher charge on the cation. In this sequence, as the charge on the cation increases from LiCl to CCl_4, the covalent character of the bonds also increases.

Question30

In which of the following pairs, both molecules possess dipole moment?

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Options:

A. CO_2, BCl_3

B. BCl_3, NF_3

C. CO_2, SO_2

D. SO_2, NF_3

Answer: D

Solution:

Dipole moment, mathematically given by, $\mu = \sqrt{n(n+2)}$ BM only occur when there is unpaired electron present in the ion/molecules.

For CO_2 and BCl_3 there is no unpaired electrons.

In BCl_3 and NF_3 pair only NF_3 has dipole' moment due to present of unpaired electron. (0.24 D)

In case of SO_2 and NF_3 both have unpaired electrons and hence, both have dipole moments, 1.60 D and 0.24 D respectively.

Question31

Which of the following orders are correct regarding their covalent character?

(i) $KF < KI$

(ii) $LiF < KF$

(iii) $SnCl_2 < SnCl_4$

(iv) $NaCl < CuCl$

The correct option is

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Options:

A. (i), (ii), (iii) only

B. (ii), (iii), (iv) only

C. (i). (iii), (iv) only

D. (i), (ii), (iv) only

Answer: C

Solution:

Statement given in (i), (iii) and (iv) are correct, while (ii) is incorrect. It's correct from is, Covalent character is the measure of the tendency of an atom to attract the shared pair of electron towards itself. LiF has more covalent character than KF because LiF has more electronegativity difference. Electronegativity difference is directly proportional to covalent character.

Question32

Observe the following sets.

Order	Property
(i) $NH_3 > H_2O > SO_2$	Bond angle
(ii) $H_2O > NH_3 > H_2S$	Dipole moment
(iii) $N_2 > O_2 > H_2$	Bond enthalpy
(iv) $NO^+ > O_2 > O_2^{2-}$	Bond order

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Options:

A. (i), (ii), (iv) only

B. (ii), (iii) only

C. (ii), (iii), (iv) only

D. (i), (iii), (iv) only

Answer: C

Solution:

The explanation involves analyzing the order of various properties among different molecules, and identifying which sequences are correct.

For sets (ii), (iii), and (iv), the sequences provided are correct:

(ii) Dipole Moment: The order $H_2O > NH_3 > H_2S$ is correct due to the polarity and shapes of the molecules, with water having the highest dipole moment.

(iii) Bond Enthalpy: The sequence $N_2 > O_2 > H_2$ is accurate because nitrogen gas has a triple bond, making it much stronger compared to the double bond in oxygen and the single bond in hydrogen.

(iv) Bond Order: The order $NO^+ > O_2 > O_2^{2-}$ correctly reflects the number of bonds between the atoms, with NO^+ having the highest bond order.

However, for set (i), the provided order for bond angles is incorrect. The correct order should be:

(i) Bond Angle: $H_2O < NH_3 < SO_2$, with numerical values $104.5^\circ < 107^\circ < 119^\circ$. This is based on the interplay of lone pair repulsion and the geometric configurations of the molecules.

Question33

Observe the following reactions. Identify the reaction in which the hybridisation of underlined atom is changed

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Options:

A. $NH_3 + H^+ \longrightarrow NH_4^+$

B. $PCl_3 + 3H_2O \longrightarrow H_3PO_3 + 3HCl$

C. $NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$

D. $XeF_6 + H_2O \longrightarrow \underline{XeOF}_4 + 2HF$

Answer: D

Solution:

In the reaction $XeF_6 + H_2O \longrightarrow XeOF_4 + 2HF$, the hybridization of the xenon (Xe) atom changes.

For XeF_6:

Calculating hybridization using the formula:

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

where:

V is the number of valence electrons of the central atom (Xe), which is 8.

M is the number of monovalent atoms attached, here 6 fluorine atoms.

C is the charge on the cation.

A is the charge on the anion.

$= \frac{1}{2}[8 + 6 - 0 + 0] = 7$

The hybridization for XeF_6 is sp^3d^3.

For $XeOF_4$:

The hybridization number is calculated to be 6, resulting in a hybridization of sp^3d^2.

Thus, the xenon atom goes through a change in hybridization from sp^3d^3 in XeF_6 to sp^3d^2 in $XeOF_4$.

Question34

Among the following species, correct set of isostructural pairs are $XeO_3, CO_3^{2-}, SO_3, H_3O^+, ClF_3$

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Options:

A. $\left(XeO_3, CO_3^{2-}\right)$ and (SO_3, H_3O^+)

B. (XeO_3, SO_3) and $\left(CO_3^{2-}, H_3O^+\right)$

C. $(XeO_3, H_3O^+)$and $\left(SO_3, CO_3^{2-}\right)$

D. (SO_3, ClF_3) and $\left(XeO_3, CO_3^{2-}\right)$

Answer: C

Solution:

Isostructural species have the same shape or structure. Here's how to determine the hybridization and shape of each species:

For XeO_3:

Hybridization formula: $\frac{1}{2}[V + M - C + A]$

$V =$ Valence electrons of the central atom (Xe), which is 8

$M =$ Number of monovalent atoms attached, which is 0

$C =$ Positive charge, which is 0

$A =$ Negative charge, which is 0

$= \frac{1}{2}[8 + 0 - 0 + 0] = 4 = \text{sp}^3$

Xe has one lone pair, resulting in a pyramidal shape.

For H_3O^+:

Apply the same hybridization formula:

$= \frac{1}{2}[6 + 3 - 1 + 0] = 4 = \text{sp}^3$

The structure is pyramidal.

For SO_3:

$= \frac{1}{2}[6 + 0 - 0 + 0] = 3 = sp^2$

Results in a trigonal planar shape.

For CO_3^{2-}:

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

Also results in a trigonal planar shape.

Conclusion:

XeO_3 and H_3O^+ both have a pyramidal shape.

SO_3 and CO_3^{2-} both have a trigonal planar shape.

These alignments help identify which species are isostructural pairs based on their shapes.

Question35

The correct order of bond angles of the molecules $SiCl_4, SO_3, NH_3, HgCl_2$ is

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Options:

A. $SO_3 > SiCl_4 > NH_3 > HgCl_2$

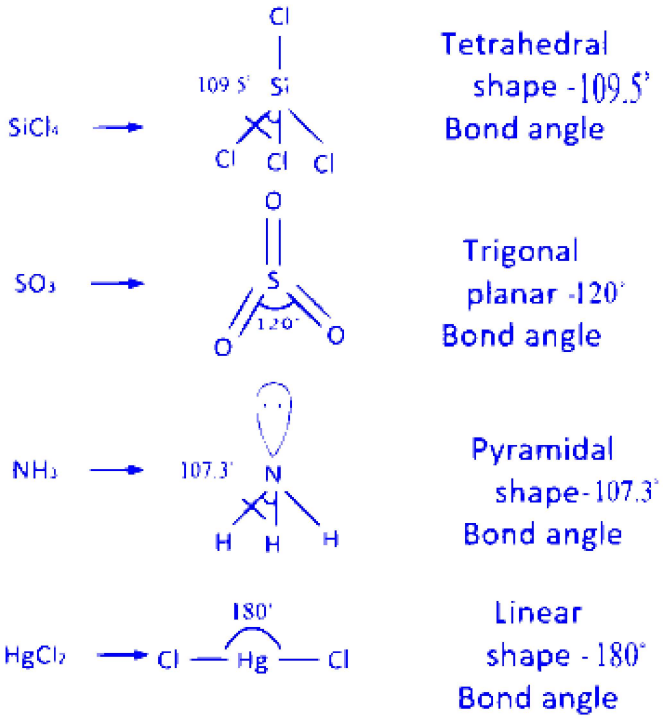
B. $SiCl_4 > NH_3 > HgCl_2 > SO_3$

C. $HgCl_2 > SO_3 > NH_3 > SiCl_4$

D. $HgCl_2 > SO_3 > SiCl_4 > NH_3$

Answer: D

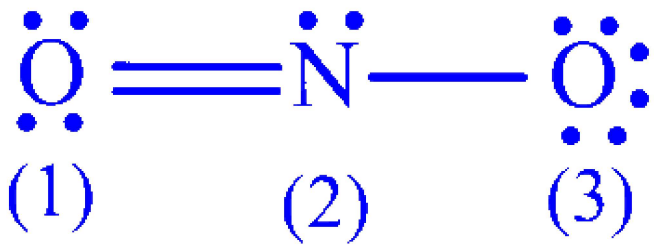
Solution:



The correct order of bond angle is
$HgCl_2 > SO_3 > SiCl_4 > NH_3$

Question36

Observe the following structure,



The formal charges on the atoms 1,2,3 respectively are

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Options:

A. $+1, 0, -1$

B. $0, 0, -1$

C. $-1, 0, +1$

D. $0, 0, 0$

Answer: B

Solution:

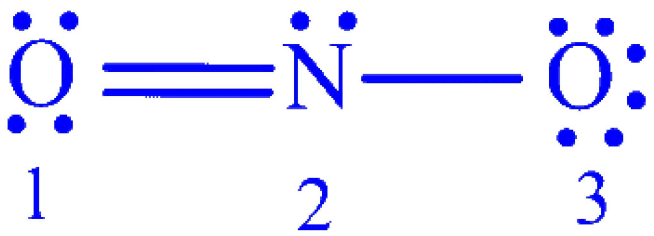
The formula of formal charge is

$\text{FC} = V - N - \frac{B}{2}$

$V =$ Number of valence electrons of neutral atom.

$N =$ Number of non-bonding electrons on this atom.

$B =$ Number of electrons shared in bond with other atom.



For 1st, $\text{FC} = 6 - 4 - \frac{1}{2} \times 4 = 0$

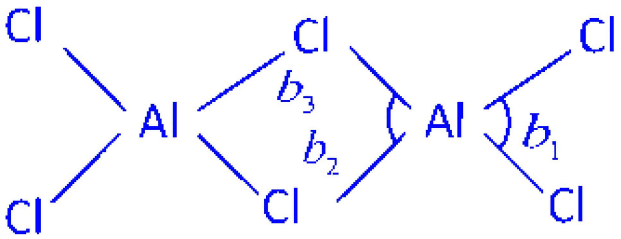
For 2 nd, $\text{FC} = 5 - 2 - \frac{1}{2} \times 6 = 0$

For 3 rd, $\text{FC} = 6 - 6 - \frac{1}{2} \times 2 = -1$

Hence, the formal charges are $0, 0, -1$.

Question37

The bond angles b_1, b_2 and b_3 in the given structure are respectively (in $^\circ$)



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Options:

A. $79, 101, 118$

B. $118, 101, 79$

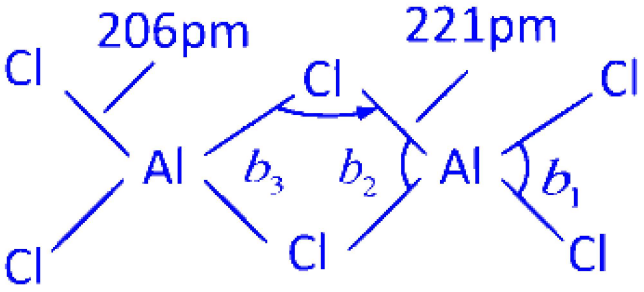
C. $79, 118, 101$

D. $118, 79, 101$

Answer: D

Solution:

Al_2Cl_6 (Dimer) is a sp^3 hybridised and tetrahedral at aluminum.



$b_1 = 118^\circ, b_2 = 79^\circ, b_3 = 101^\circ$

Question38

In which of the following sets of molecules, the centil atoms of molecules have same hybridisation?

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Options:

A. NH_3, ClF_3

B. SF_4, CH_4

C. H_2O, SO_3

D. XeF_6, IF_7

Answer: D

Solution:

Compound	Hybridisation of central atom
NH_3, ClF_3	Sp^3,sp^3d
H_2O, SO_3	Sp^3,sp^2
SF_4, CH_4	Sp^3d,sp^3
XeF_6, IF_7	Sp^3d^3,sp^3d^3

Hence, XeF_6 and IF_7 have same hybridisation of their central atoms.

Question39

The correct increasing order of number of lone pair of electrons on the central atom of $SnCl_2, XeF_2, ClF_3$ and SO_3 is

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Options:

A. $SO_3 < ClF_3 < SnCl_2 < XeF_2$

B. $SO_3 < SnCl_2 < ClF_3 < XeF_2$

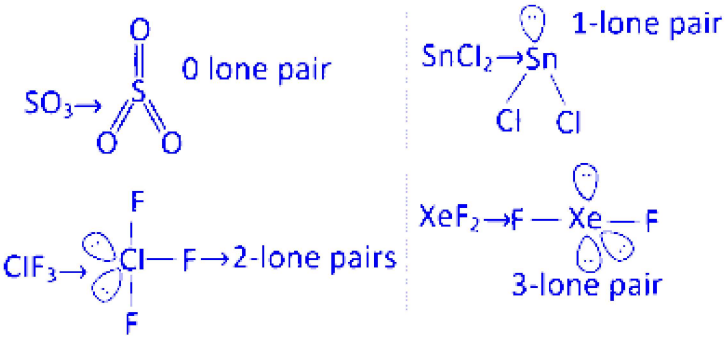
C. $XeF_2 < SnCl_2 < ClF_3 < SO_3$

D. $XeF_2 < ClF_3 < SnCl_2 < SO_3$

Answer: B

Solution:

The correct order is $SO_3 < SnCl_2 < ClF_3 < XeF_2$.



Question40

The bond lengths of diatomic molecules of elements X, Y and Z respectively are 143, 110 and 121 pm . The atomic numbers of X, Y, and Z respectively are

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Options:

A. $9, 7, 8$

B. $7, 8, 9$

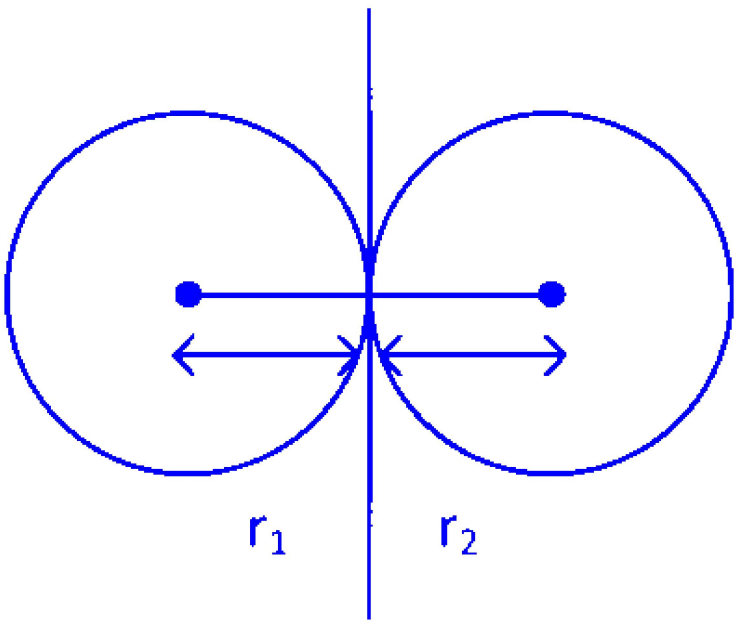
C. $9, 8, 7$

D. $7, 9, 8$

Answer: A

Solution:

Bond length/distance is defined as average distance between niaclei of two bonded atom in a molecules.



Bond length $= r_1 + r_2$

Element $(x) = 143$ pm means it is close to bond length of fluorine (F_2).

Atomic number $= 9$

Element $(Y) = 110$pm is equal to bond length of nitrogen (N_2).

Atomic number $= 7$

Element $(Z) = 121$ pm is equal to bond length of axygen (O_2).

Atomic number = 8

Question41

The correct formula used to determine the formal charge (Q) on an atom in the given Lewis structure of a molecule or ion is (V = number of valence electrons in free atom, U = number of unshared electrons on the atom, B = number of bonds around the atom)

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Options:

A. $Q_1 = V - \left(\frac{U}{B}\right)$

B. $Q_i = V + (U - B)$

C. $O_r = V - (\nu + B)$

D. $Q, = V - \left(\frac{B}{U}\right)$

Answer: C

Solution:

A formal charge is the charge assigned to an atom in a molecule in the covalent view of bonding assuming that electrons in all chemical bonds are shared equally between atoms regardless of relative electronegativity.

It is the difference between an atoms number of valence electrons in its neutral state and the number allocated to that atom in a Lewis structure.

$Q_f = v - (V + B)$

where, V is sumber of valence electron in free atom.

U = Number of unshared electron in atom.

B = Number of bond around the atom.

Question42

Match the following.

List - I (Bond)	List - II (Bond enthalpy (in $\mathrm{kJmol^{-1}}$)
A $Si - Si$	I 240
B $C - C$	II 297

C Sn – Sn	III 348
D Ge – Ge	IV 248

The correct answer is

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Options:

A. A-II, B-III, C-I, D-IV

B. A=II,B–N,C– III, D–1

C. A–11,B=11,C–D=N

D. A– III, B–L,C,N,D– II

Answer: A

Solution:

The correct match is

A-II, B-III, C-I, D-IV

Bond enthalpy also known as bond dissociation energy describes the amount of energy stored in a bond between atoms in a molecules.

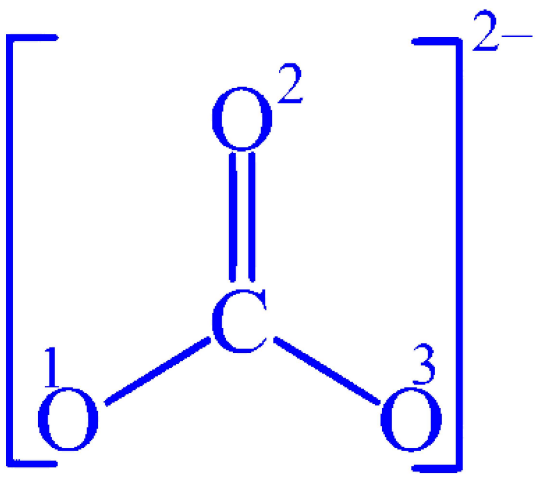
Specifically it is the energy required to be added for cleavage of bond in a gas phase.

$\mathrm{Si-Si} \longrightarrow 297\ \mathrm{kJ/mol}$
$\mathrm{C-C} \longrightarrow 348\ \mathrm{kJ/mol}$
$\mathrm{Sn-Sn} \longrightarrow 248\ \mathrm{kJ/mol}$
$\mathrm{Ge-Ge} \longrightarrow 260\ \mathrm{kJ/mol}$

Down the group, bond enthalpy decreases.

Question43

In the Lewis dot structure of carbonate ion shown under the formal charges on the oxygen atoms 1, 2 and 3 are respectively



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Options:

A. $-2, 0, 0$

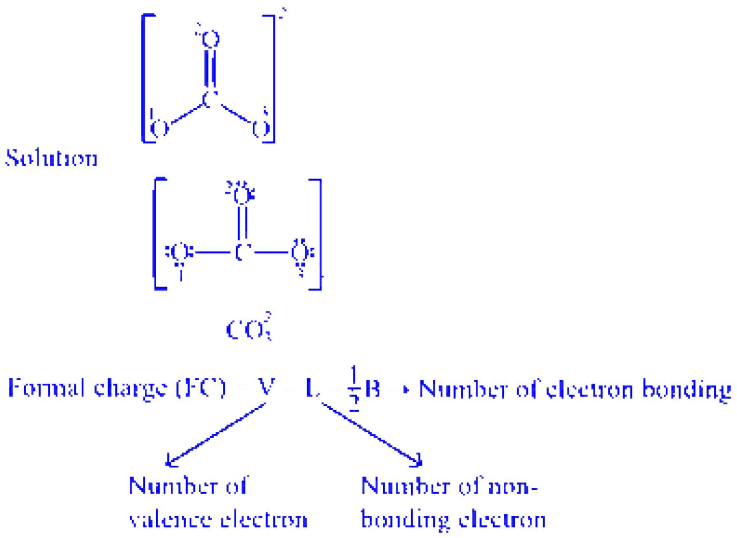
B. $-1, 0, -1$

C. $0, -1, -1$

D. $-3, 0, +1$

Answer: B

Solution:



$$\text{FC (oxygen 1)} = 6 - 6 - \frac{1}{2} \times 2 = -1$$

$$\text{FC (oxygen 2)} = 6 - 4 - \frac{1}{2} \times 4 = 6 - 6 = 0$$

$$\text{FC (oxygen 3)} = 6 - 6 - \frac{1}{2} \times 2 = -1$$

Question44

The set of species having only fractional bond order values is

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Options:

A. C_2^{2-}, N_2, O_2^{2-}

B. $O_2^{+}, O_2^{-}, N_2^{+}$

C. O_2^{2+}, O_2, C_2^{2-}

D. Li_2, H_2^{+}, C_2

Answer: B

Solution:

Bond order (BO) $= \frac{1}{2}$ (number of electron inbonding MO's $-$ number of electron in anti-bonding MO's)

C_2^{2-} : Total number of electrons $= 6 + 6 + 2 = 14$

Electronic configuration

Electronic configuration

$\sigma\left(1s^2\right), \sigma\left(1s^2\right), \sigma\left(2s^2\right), \sigma^2\left(2s^2\right), \pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2$

$\text{BO} = \frac{1}{2} \times (10 - 4) = \frac{1}{2} \times 6 = 3$

$\mathbf{N_2}$: Total number of electrons $= 7 + 7 = 14$

$\sigma\left(1s^2\right), \sigma^{\circ}\left(\left(s^2\right), \sigma\left(2s^2\right), \sigma^{*}\left(2s^2\right), \pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2\right.$

$\text{BO} = \frac{1}{2}(10 - 4) = \frac{6}{2} = 3$

O_2^{2-} : Total number of electron $= 8 + 8 + 2 = 18$

$\sigma\left(ls^2\right), \sigma'\left(1s^2\right), \sigma\left(2s^2\right), \sigma'\left(2s^2\right), \sigma 2p_z^2, \pi 2p_x^2 = \pi 2p_y^2,$

$\pi^2 2p_x^2 = \pi' 2p_y^2$

$$\text{BO} = \frac{1}{2}(10 - 8)$$

$$= \frac{1}{2} \times 2 = 1$$

Option (a) is incorrect.

O_2^+Total number of electrons $= 8 + 8 - 1 = 15$

$\sigma\left(s^2\right), \sigma^*\left(1s^2\right), \sigma\left(2s^2\right), \sigma^*\left(2s^2\right), \sigma\left(2p_z^2\right), \pi\left(2p_x^2\right)$

$= \pi\left(2p_y^2\right), \pi^{\cdot} 2p_x^1$

$\text{BO} = \frac{1}{2}(10 - 5) = \frac{1}{2} \times 5 = 2.5$

O_2^- Total number of electrons $= 8 + 8 + 1 = 17$

$\sigma\left(1s^2\right), \sigma^*\left(1s^2\right), \sigma\left(2s^2\right), \sigma^2\left(2s^2\right), \sigma\left(2p_z^2\right), \pi\left(2p_x^2\right)$

$\sigma\left(1s^2\right), \sigma\left(1s^2\right), \sigma\left(2s^2\right), \sigma\left(2s^2\right), \sigma\left(2p_z^2, \pi\left(22_x^2\right)\right.$

$= \pi\left(2p_y^2\right), \pi^*\left(2p_x^2\right) = \pi^*\left(2p_y^1\right)$

$$\text{BO} = \frac{1}{2}(10 - 7) = \frac{1}{2} \times 3 = 1.5$$

N_2^+ Total number of electron $= 7 + 7 - 1 = 13$

N_2 Total number

$\sigma\left(1s^2\right), \sigma\left(1s^2\right), \sigma\left(2s^2\right), \sigma\left(2s^2\right), \pi\left(2p_x^2\right) = \pi\left(2p_y^2\right), \sigma\left(2p_z^1\right)$

$$\text{BO} = \frac{1}{2}(9 - 4) = \frac{1}{2} \times 5 = 2.5$$

Option (b) is correct.

Similarly, bond order of $O_2 = \frac{1}{2}(10 - 6) = \frac{1}{2} \times 4 = 2$

Bond order of $Li_2 = \frac{1}{2}(4 - 2) = 1$

Bond order of $H_2^+ = \frac{1}{2}(1 - 0) = 0.5$

Bond order of $C_2 = \frac{1}{2}(8 - 4) = \frac{1}{2} \times 4 = 2$

Rest other options are incorrect, as they don't have bond order in fraction.

Question45

The set of molecules in which the central atom is not obeying the octet rule is

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Options:

A. $CO_2, SiH_4, BeCl_2$

B. H_2O, Cl_2O, CO_2

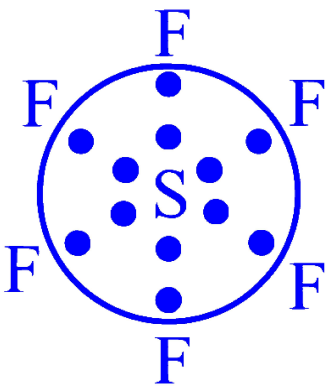
C. CH_4, NH_3, OF_2

D. SF_6, PCI_5, XeF_2^2

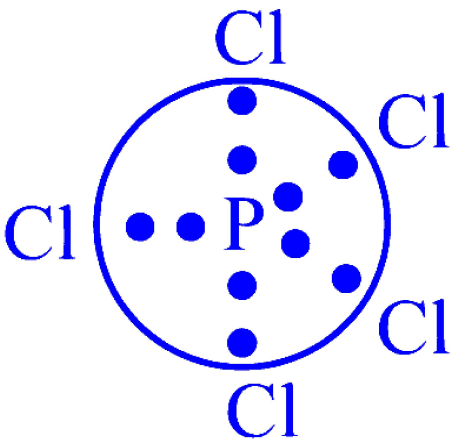
Answer: D

Solution:

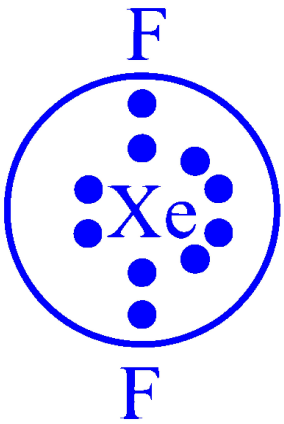
Lewis dot structure of SF_6 is Central atom, S has total 12 electrons. So, it does not obey octet rule.



Lewis dot structure of PCl_5 is central atom, P has total 10 electrons. So, it also does not obey octet rule.

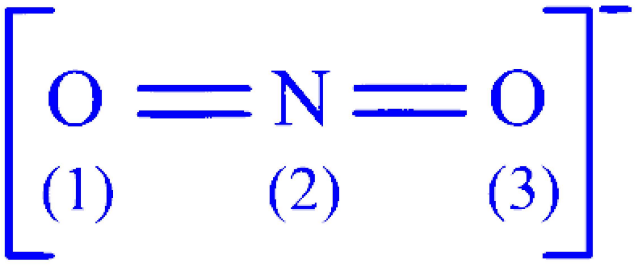


Lewis dot structure of XeF_2 is central atom, Xe has total 10 electrons. So, it does not obey octet rule.Hence, the set of molecules that does not obey octet rule-is SF_6, PCl_5 and XeF_2.



Question46

The formal charges of atoms (1), (2) and (3) in the ion



is

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Options:

A. 0, +2, −1

B. 0, +1, 0

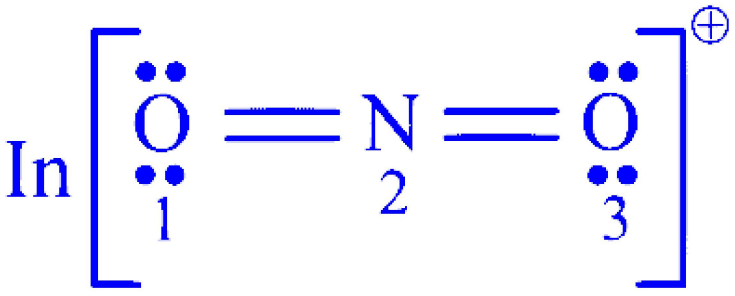
C. +2, 0, −1

D. +1, 0, 0

Answer: B

Solution:

Formal charge (FC) can be calculated by using formula : FC = (number of electrons in neutral atom) $-\frac{1}{2}$ (number of electrons in covalent bonds) - (number of electrons in lone pairs)



Formal charge on 1st atom i.e., oxygen is

$FC = 6 - \frac{1}{2} \times 4 - 4 = 6 - 2 - 4 = 0$

Formal charge on 2 nd atom i.e., nitrogen is

$FC = 5 - \frac{1}{2} \times 8 - 0 = 5 - 4 = +1$

Formal charge on 3rd atom i.e., oxygen is

$FC = 6 - \frac{1}{2} \times 4 - 4 = 6 - 2 - 4 = 0$

Hence, formal charge of atoms 1, 2 and 3 in the ion $[\underset{1}{O} = \underset{2}{N} = \underset{3}{O}]^+$ is 0, +1 and 0 respectively.

Question47

The hybridisations of carbon in graphite, diamond and C_{60} are respectively

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Options:

A. sp^2, sp^2, sp

B. sp^2, sp^3, sp^2

C. sp, sp^2, sp^3

D. sp, sp^3, sp

Answer: B

Solution:

In graphite, each carbon atom combines with three other carbon atoms with three sigma bonds. So, hybridisation is sp^2. In diamond, each carbon atom combines with four other carbon atoms with four sigma bonds. So, hybridisation is sp^3. In fullerene, hybridisation of carbon atoms is sp^2. Hence, the hybridisation of carbon in graphite, diamond and fullerene, C_{60} are sp^2, sp^3 and sp^2 respectively.

Question48

Choose the correct option from the following.

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Options:

A. KF is more covalent than KI

B. $SnCl_4$ is less covalent than $SnCl_2$

C. LiF is more covalent than KF

D. $ZnCl_2$ is less covalent than NaCl

Answer: C

Solution:

According to Fajan's rule; covalent character in ionic compound depends on

(i) size and charge of cation

(ii) size and charge of anion

(iii) pseudo-inert gas configuration

(a) Size of iodide (I^-) is more than F^-, so I^- has more polarisibility. Thus, KI is more covalent than KF . So, option (a) is incorrect.

(b) Charge on Sn in $SnCl_4$ is +4 and in $SnCl_2$ is +2 So, Sn has more polarising power in $SnCl_4$. Thus, $SnCl_4$ is more covalent than $SnCl_2$. So, option (b) is incorrect.

(c) Size of Li^+ is less than K^+. So, it has more polarising power. Thus, LiF is more covalent than KF. Hence, option (c) is correct.

(d) Charge on Zn is +2 and on Na is +1 . So, Zn has more polarising power. Thus, $ZnCl_2$ is more covalent than NaCl . Hence, option (d) is incorrect.

Question49

The bond lengths of C_2, N_2 and B_2 molecules are X_1, X_2 and X_3 pm respectively. The correct order of their bond lengths is

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Options:

A. $X_3 > X_1 > X_2$

B. $X_2 > X_3 > X_1$

C. $X_1 > X_2 > X_3$

D. $X_1 > X_3 > X_2$

Answer: A

Solution:

$$\text{Bond length } \propto \frac{1}{\text{Bond order (BO)}}$$

Electronic configuration of C_2 i.e. X_1 is $\sigma 1s^2 \sigma 1s^{*2} \sigma 2s^2 \sigma 2s^{*2} \pi 2p_x^2 \pi 2p_y^2$

So, bond order

$= \frac{\text{Numberofbondingorbitalelectrons} - \text{Numberofantibondingorbitalelectrons}}{2}$

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

Electronic configuration of i.e. N_2 i.e. X_2 is

$\sigma 1s^2 \sigma ls^{*2} \sigma 2s^2 \sigma 2s^{*2} \sigma 2p_z^2 \pi 2p_x^2 \pi 2p_y^2$

Bond order $= \frac{10-4}{2} = \frac{6}{2} = 3$

Electronic configuration of B_2 i.e. X_3 is

$\sigma ls^2 \sigma 1s^{*2} \sigma 2s^2 \sigma 2s^{*2} \pi 2p_x^1 2\pi 2p_y^1$

Bond order $= \frac{6-4}{2} = \frac{2}{2} = 1$

So, order of bond order (BO) is

$BO_2 > BO_1 > BO_3$

Now, since bond order and bond lengths are inversely proportional.Hence, order of bond length is

$X_3 > X_1 > X_2$

Question50

A covalent molecule 'XY' is found to have a dipole moment of $1.5 \times 10^{-29} \text{C} \cdot \text{m}$ and a bond length of 150 pm. The percent ionic character of the bond will be

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Options:

A. 50%

B. 62.5%

C. 75%

D. 80%

Answer: B

Solution:

Dipole moment $= 1.5 \times 10^{-29}$C. m (given)

Bond length $= 150$ pm $= 150 \times 10^{-12}$ m

Charge $= 1.602 \times 10^{-19}$C

$$\begin{aligned}\text{Ionic character} &= \frac{\text{Dipole moment}}{\text{Bond length} \times \text{Charge}} \\ &= \frac{1.5 \times 10^{-29}}{150 \times 10^{-12} \times 1.602 \times 10^{-19}} \\ &= 0.625\end{aligned}$$

Percentage ionic character

$= 0.625 \times 100$
$= 62.5\%$

Question51

The hybridisation of Se in SeF_4 and its geometry respectively are :

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Options:

A. sp^3d, see-saw shaped

B. sp^3d^2, octahedral

C. sp^3d^3, trigonal planar

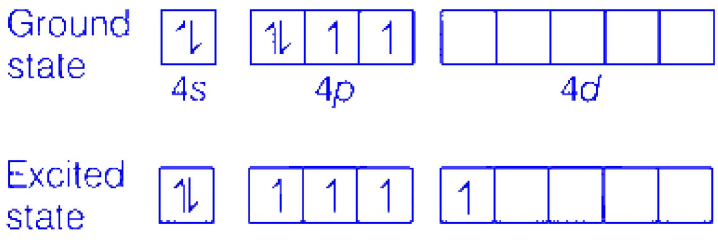
D. sp^3d^2, square planar

Answer: A

Solution:

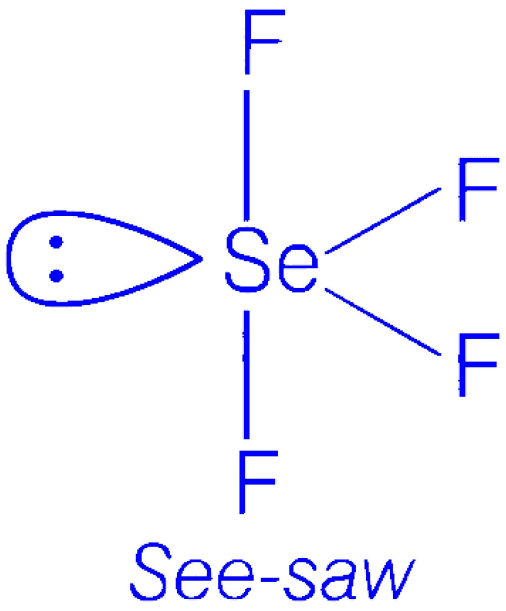
SeF_4

Se $= [Ar]3d^{10}4s^24p^4$



Selenium (Se) undergoes sp^3d hybridisation and form five sp^3d hybridised orbitals.

Out of five sp^3d orbitals one is completely filled and four are half filled.



Question52

Incorrect matching amongst the following is (according to geometry of molecules)

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Options:

A. H_2O, NH_3

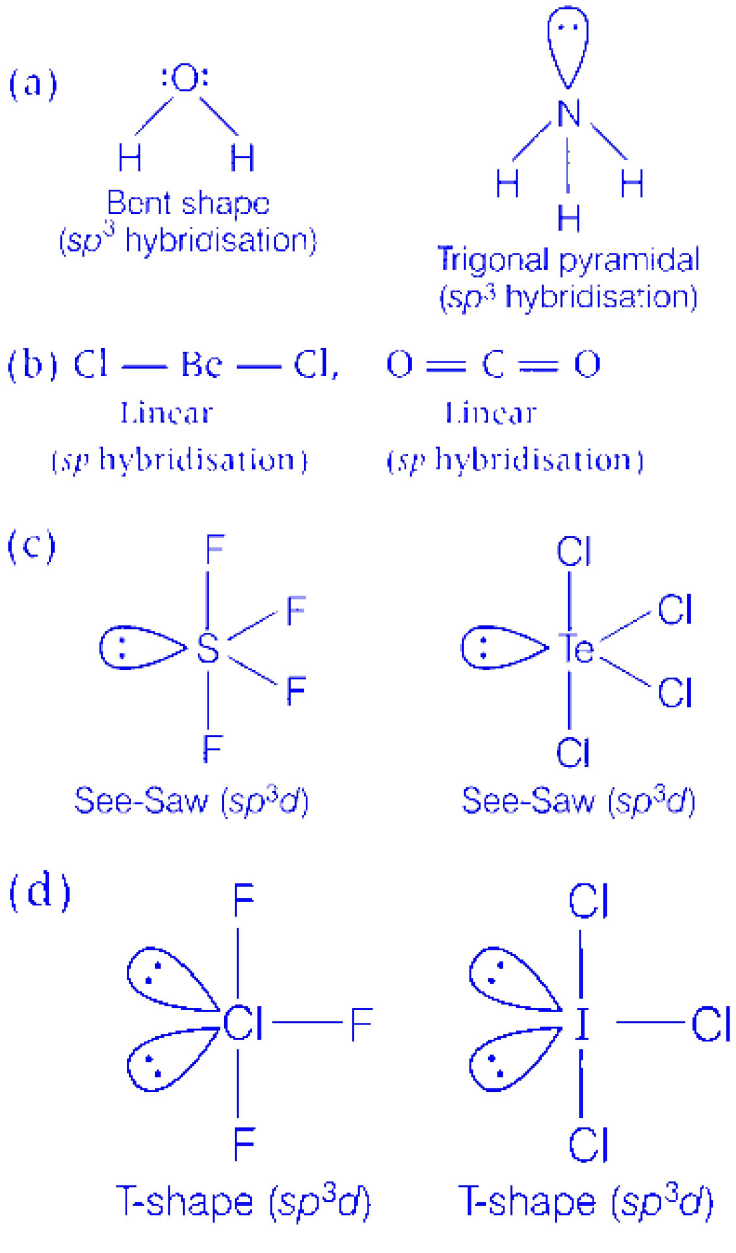
B. $BeCl_2, CO_2$

C. $SF_4, TeCl_4$

D. ClF_3, ICl_3

Answer: A

Solution:



Therefore, geometry of H_2O and NH_3 are different.

Question53

The element with maximum bond energy is

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Options:

A. C

B. Pb

C. Ge

D. Si

Answer: A

Solution:

Element with maximum bond energy is carbon because C − C bond is strongest as carbon atoms are smaller in size.

Question54

The correct order of electronegativity of carbon in various hybridisation states is

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Options:

A. $sp < sp^2 < sp^3$

B. $sp > sp^2 > sp^3$

C. $sp^2 > sp < sp^3$

D. $sp = sp^2 < sp^3$

Answer: B

Solution:

Correct order of electronegativity of hybridorbitals of carbon is

$sp > sp^2 > sp^3$

Electronegativity of carbon increases as the s-character of hybrid orbital increases.

Hybridisation	% of s
sp	50%
sp^2	33%

Hybridisation	% of s
sp^3	25%

Higher percentage of s-character indicates thathybrid orbital is more closer to the nucleus andthat's why it has higher electronegativity.

Question55

Bond order is an inverse measure of

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Options:

A. bond length

B. bond angle

C. bond dissociation energy

D. stability

Answer: A

Solution:

Bond length is inversely proportional to thebond order. Higher bond order results in strongerbond, which are accompanied by stronger forcesof attraction holding the atoms together.

Question56

Which of the following molecule has the maximum dipole moment?

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Options:

A. NH_3

B. CS_2

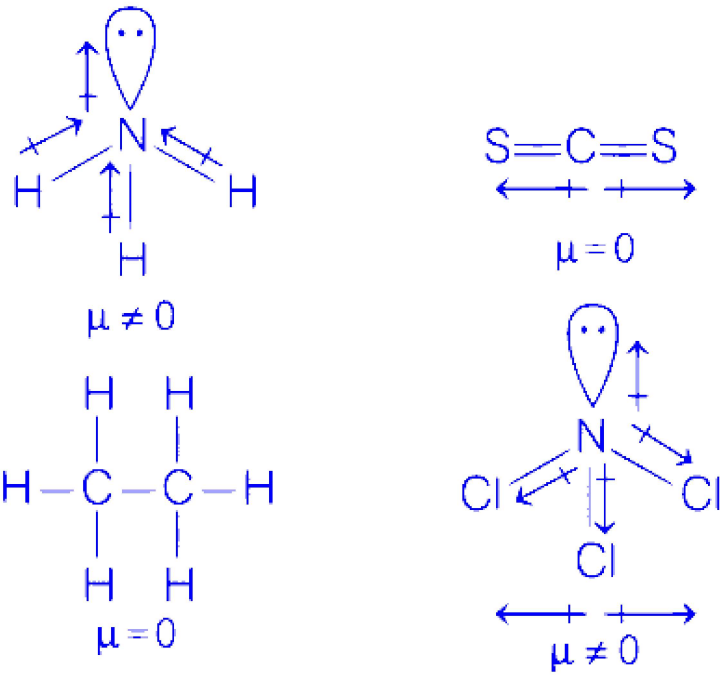
C. C_2H_6

D. NCl_3

Answer: A

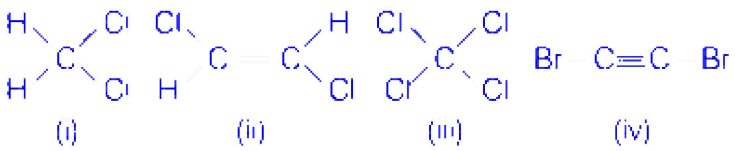
Solution:

Since, electronegativity difference is highest in case of N – N bonds, therefore NH_3 has highest dipole moment,



Question57

Which compound among the following willhave a permanent dipole moment?



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Options:

A. Only (i)

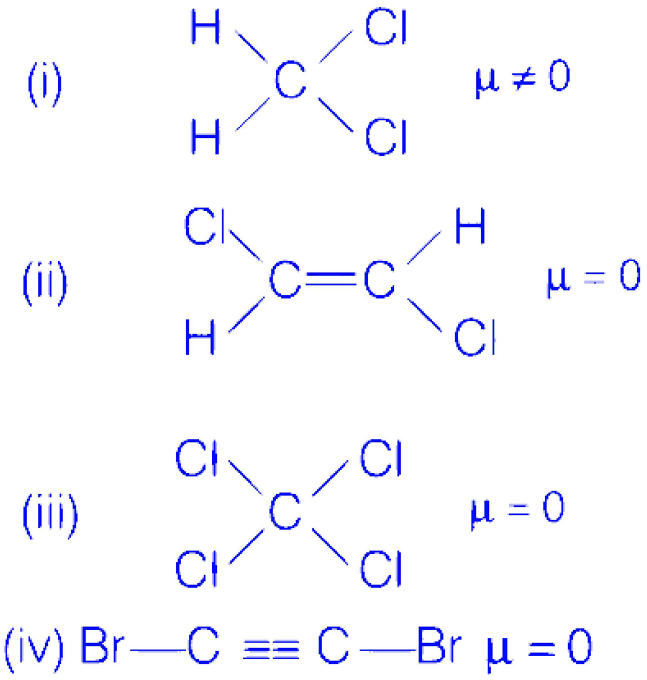
B. Only (ii)

C. Only (iii)

D. Only (iv)

Answer: A

Solution:



As dipole moment is vector quantity. Due toelectron density in opposite direction, net dipolemoment cancel out each other.

Question58

The correct order of sulphur-oxygen bond in SO_3, $S_2O_3^{2-}$ and SO_4^{2-} is

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Options:

A. $SO_4^{2-} < S_2O_3^{2-} < SO_3$

B. $SO_4^{2-} < SO_3 < S_2O_3^{2-}$

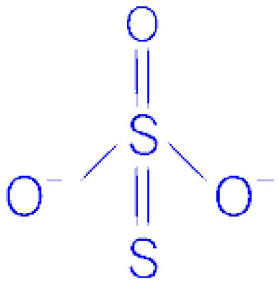
C. $S_2O_3^{2-} < SO_4^{2-} < SO_3$

D. $S_2O_3^{2-} < SO_3 < SO_4^{2-}$

Answer: C

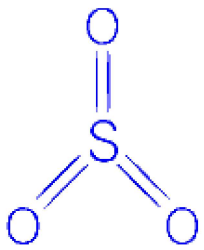
Solution:

$S_2O_3^{2-} \Rightarrow$



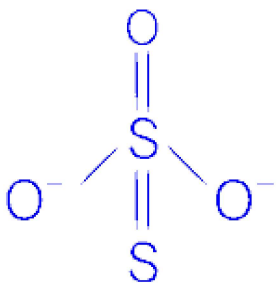
Average bond order = 6/4 = 1.5

$SO_3 \Rightarrow$



Average bond order = 6/3 = 2

$S_2O_3^{2-} \Rightarrow$



Average bond order = 4/3 = 1.33

Correct sequence of bond order is

$SO_3 > SO_4^{2-} > S_2O_3^{2-}$

Question59

Which compound among the following hasthe highest dipole moment?

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Options:

A. NH_3

B. SO_2

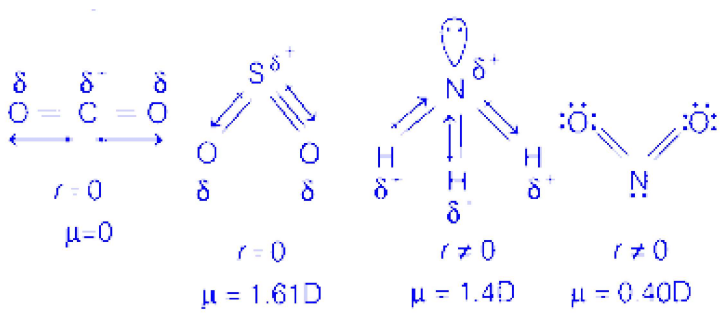
C. N_2O

D. CO_2

Answer: B

Solution:

The sulphur dioxide molecule have dipolemoment value of 161 debye. It is a bent moleculewith a sulphur atom placed in the centre and twoatoms of oxygen on the side, one oxygen atom isconnected by a double bond and the oxygen ion bya single bond.



Hence, among all SO_2, have highest dipole moment.

Question60

How many among the given species have a bond order of 0.5 ?

$H_2^+, He_2^+, He_2^-, B_2^+, F_2^-, Be_2^{2-}$

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Options:

A. 2

B. 3

C. 1

D. 4

Answer: D

Solution:

Bond order (BO) $= \frac{(\text{Number of electron in bonding MO}) - (\text{Number of electron in anti-bonding MO})}{2}$

S. No.	Molecule	BO
1.	H_2^+	$1 - 0/2 = 0.5$
2.	He_2^+	$2 - 1/2 = 0.5$
3.	He_2^-	$2 - 1/2 = 0.5$
4.	B_2^+	$3 - 2/2 = 0.5$
5.	F_2^-	$4 - 2/2 = 1$
6.	Be_2^{2-}	$3 - 1/2 = 1$

Hence, among all of these only $H_2^+, He_2^+, He_2^-, B_2^+$ give 0.5 bond order.

Question61

Match the following.

	Molecule		Geometry
(A)	$SnCl_2$	1.	Angular (or) bent
(B)	XeF_4	2.	See-saw
(C)	CIF_3	3.	Square pyramidal
(D)	IF_5	4.	T-shape
		5.	Square planar

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Options:

A. A - 1, B - 3, C - 5, D - 4

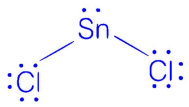
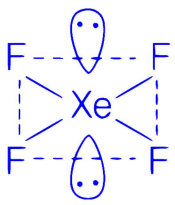
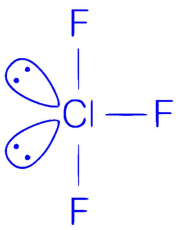
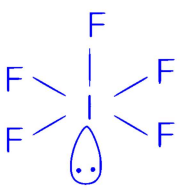
B. A - 4, B - 5, C - 1, D - 3

C. A - 1, B - 5, C - 4, D - 3

D. A - 4, B - 3, C - 2, D - 5

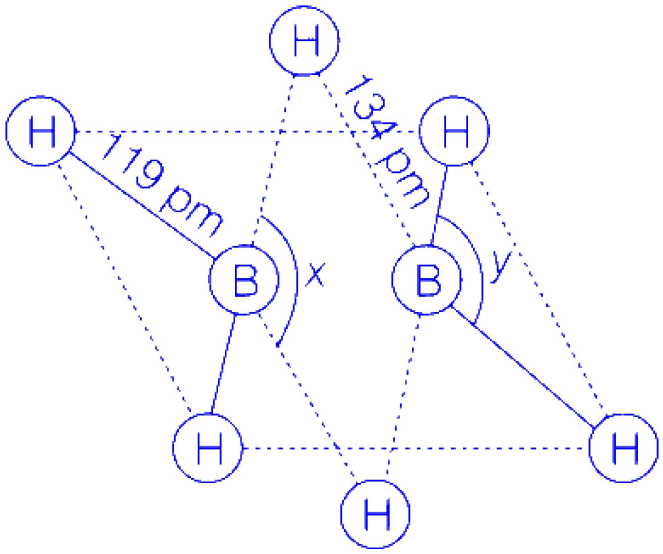
Answer: C

Solution:

S. No.	Molecule	Steric no.	Hybridisation	Structure	Shape
(A)	$SnCl_2$	3	sp^2		Angular or bent (1)
(B)	XeF_4	6	sp^3d^2		Square planar (5)
(C)	ClF_3	5	sp^3d		T-shape (4)
(D)	IF_5	6	sp^3d^2		Square pyramidal (3)

Question62

The structure of diborane B_2H_6 is givenbelow. Identify the bond angles of x and y. Indiborane, ... are commonly known asbanana-bonds.



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Options:

A. x = 101ϒ, y = 118ϒ and 2-centred-3-electron bonds

B. x = 97ϒ, y = 120ϒ and 3-centred-2-electron bonds

C. x = 118ϒ, y = 79ϒ and ionic bond between the two boron

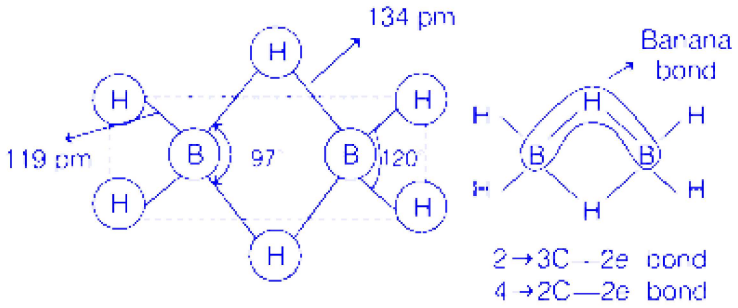
D. x = 79ϒ, y = 118ϒ and ionic bond between the two boron

Answer: B

Solution:

Diborane (B_2H_6) is one of the simplest boron hydride.

The structure of diborane molecule consist four H-atom and two boron atoms coming on the same plane. The boron atom present in sp^3 hybridised state and from these four hybrid orbitals, three of orbitals have one electron each, and one is an empty orbital. It will form B – H – B bonds called banana bond.



Question63

The incorrect statement(s) among the following is/are

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Options:

A. NCl_5 does not exist while PCl_5 does

B. Pb prefers to form tetravalent compounds

C. The three C – O bonds are equal in the CO_3^{2-} ion

D. Both O_2^+ and NO are paramagnetic

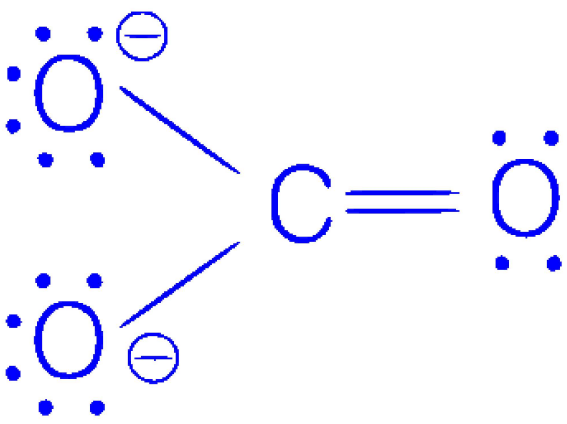
Answer: B

Solution:

(a) NCl_5 does not exist while PCl_5 does. This is correct due to N does not have vacant *d*-orbitals and it cannot expand its oxidation state but P has vacant *d*-orbitals.

(b) Pb prefer to form tetravalent compound. This is wrong as to lead prefers to form bivalent compounds due to inert pair effect.

(c) The three C – O bond are equal in carbonate ion. This is because the bonds are in resonance.



(d) Both O_2^+ and NO are paramagnetic as they contain unpaired electrons.

$O_2^+ \Rightarrow 15e^-$ (odd) paramagnetic

$NO \Rightarrow 15e^-$ (odd) paramagnetic

Hence, only (b) option is incorrect.

Question64

Due to $p\pi - p\pi$ bonding interactions, nitrogen for N_2. But phosphorus forms ..... and does not form a diatomic molecule.

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Options:

A. P_5

B. P_3

C. P_4

D. P_6

Answer: C

Solution:

$p\pi - p\pi$ bonding is weak bonding. Due to larger atomic size of phosphorus. It is unstable to form $\pi - \pi$ bond and so, it is tetra-atomic in which each p-atom is linked with 3 others P-atom by 3σ-bonds. In nitrogen, due to smaller atomic size N forms 1σ and 2π-bonds i.e. triple bonds with other N atom and exists as diatomic molecules. Hence, the bonding is responsible for that.Phosphorus from P_4 because in P_2, $p\pi$-$p\pi$ bond is weaker.

Question65

Identify the incorrect statements among the following?

(i) SF_6 does not react with water.

(ii) SF_6 is sp^3d hybridised.

(iii) $S_2O_3^{2-}$ is a linear ion.

(iv) There is no π-bonding in SO_4^{2-} ion.

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Options:

A. (ii), (iii) and (iv)

B. (i), (ii) and (iii)

C. (i) and (ii)

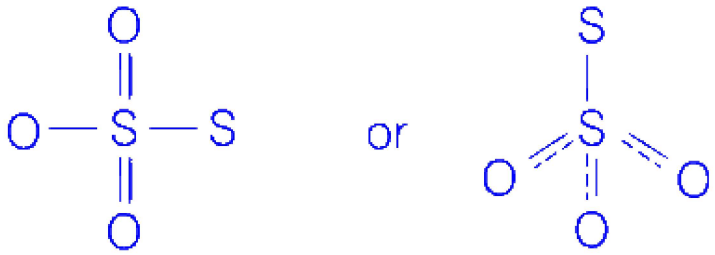
D. (iii) and (iv)

Answer: A

Solution:

In SF_6, the sulphur atom is shielded by 6 fluorine atoms which hinders kinetically any reaction with water, alkali hydroxide, ammonia or strong acid, as a result, it remains inert to these reagents.

SF_6 contain 6 steric number and sp^3d^2 hybridisation. $S_2O_3^{2-}$ is similar look like ammonia shape i.e. tetrahedral.



There are two π-bond present in $SO_4^{2-} \cdot SO_4^{2-}$ is a polyatomic ion as well as a non-polar covalent compound.

Question66

Given that ionisation potential and electrongain enthalpy of chlorine are 13eV and 4 eVrespectively. The electronegativity of chlorineon Mulliken scale, approximately equals to

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Options:

A. 8.5 eV

B. 6.0 eV

C. 3.0 eV

D. 1.5 eV

Answer: C

Solution:

According to Mulliken equation,

EN $= \frac{\text{IE}+\text{EA}}{5.6}$, ... (i)

when both IE and EA are taken in eV.

(Here, IE = Ionisation energy

EA = Electron gain enthalpy

EN = Electros negativity)

IE for chlorine $= 13\text{eV}$

EA for chlorine $= 4\text{eV}$

Put value in Eq. (i)

$$\text{EN} = \frac{13+4}{5.6} = \frac{17}{5.6}$$
$$= 3.03 \approx 3.0\text{eV}$$

Question67

Which of the following will have maximumdipole moment?

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Options:

A. NF_3

B. NCl_3

C. NBr_3

D. NH_3

Answer: D

Solution:

Dipole moment is a measure of polarity of abond. It is the product of charges and the distancebetween partial charge. Dipole moment of polarmolecule containing lone pairs is vector sum ofdipole of lone pair and net dipole moments ofbonds.

Electronegativity of F is more than that of N, thusthe direction of dipole moment of N-F bond willbe form F to N. So, net dipole moment of NF_3found be 0.24 D.

Due to less electronegativity of H in ammonia,it has maximum dipole moment.Dipole moment order :

$$\underset{(1.4D)}{NH_3} < \underset{(0.8D)}{NBr_3} < \underset{(0.6D)}{NCl_3} < \underset{(0.24D)}{NF_3}$$

Here, D = Debye or coulomb metre.

Question68

In which of the following molecules/ions, the central atom is sp^2 hybridised?

BF_3, NO_2^-, NH_2^- and H_2O

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Options:

A. NH_2^- and H_2O

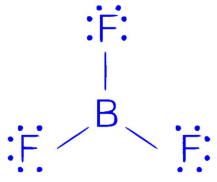
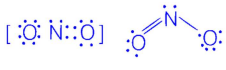
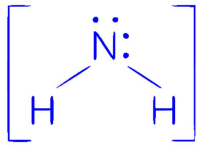
B. NO_2^- and H_2O

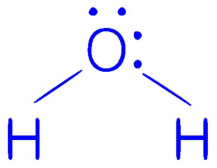
C. BF_3 and NO_2^-

D. NO_2^- and NH_2^-

Answer: C

Solution:

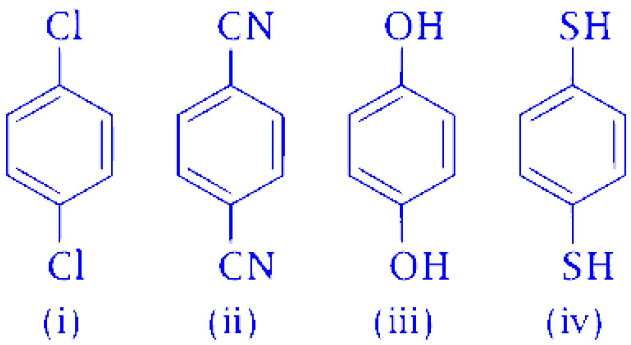
S. No.	Molecule	Steric number	Hybridisation	Shape	Structure
1	BF_3	$\frac{3+3}{2} = 3$	sp^2	Trigonal planar	
2.	NO_2^-	$\frac{5+1}{2} = 3$	sp^2	Bent shape	
3.	NH_2^-	$\frac{5+2+1}{2} = 4$	sp^3	Angular or V-shape	

S. No.	Molecule	Steric number	Hybridisation	Shape	Structure
4.	H_2O	$\frac{6+2}{2} = 4$	sp^3	V-shape or bent	

Hence, BR_3 and NO_2^- are sp^2 hybridised.

Question69

For which molecules among the following,the resultant dipole moment ($\propto$) $\neq$ 0 ?



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Options:

A. (iii) and (iv)

B. (i) and (ii)

C. (ii) and (iii)

D. Only (iv)

Answer: A

Solution:

For p-dichlorobenzene and p-cyanobenzene,the dipole moment of individual bonds canceleach other as they are equal in magnitude andopposite in direction. Hence, resultant dipolemoment of molecules is zero.

For p-hydroquinone and p-benzenedithiol, theO−H and S−H bond dipoles in these moleculesdo not cancel each other as they are not inopposite directions due to existence in differentconformation.