

Chemical Bonding and Molecular Structure

Question1

Observe the following list of molecules. Number of polar and non-polar molecules are respectively

NH_3 , BF_3 , NF_3 , H_2S , CO_2 , CH_4 , CHCl_3 , H_2O

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Options:

A.

4,4

B.

3,5

C.

5,3

D.

2,6

Answer: C

Solution:

Among the given molecules, total five molecules are polar in nature

NH_3 , NF_3 , H_2S , CHCl_3 , H_2O

Total three, are non-polar molecules

BF_3 , CO_2 , CH_4



Question2

The molecule ' X ' has see-saw shape with central atom in sp^3d hybridisation. What is ' X '?

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Options:

A.



B.



C.

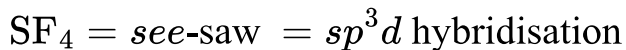
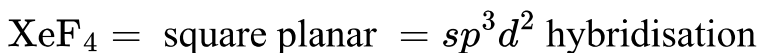
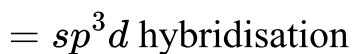
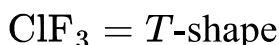


D.



Answer: C

Solution:



Question3

Identify the pair of molecules in which the hybridisation of the central atom is sp^2 with bent geometry.



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Options:

A.

H₂O, SO₂

B.

SO₂, O₃

C.

H₂O, O₃

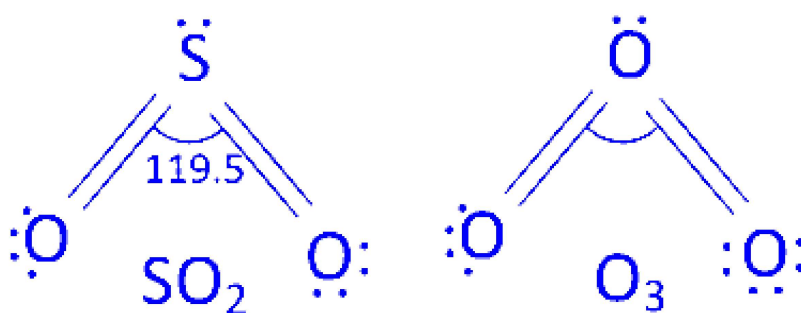
D.

N₂O, H₂O

Answer: B

Solution:

SO₂ and O₃ has sp^2 hybridisation with bent geometry.



Question4

Consider the following statements

I. In the conversion of O₂ to O₂²⁺ bond order decreases.

II. In the conversion of O₂ to O₂²⁺ magnetic property is not changed.

III. In the conversion of O_2 to O_2^{2+} bond length decreases.

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

Identify the correct statements

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Options:

A.

I and III only

B.

III and IV only

C.

II and III only

D.

I and IV only

Answer: C

Solution:

Statement given in III and IV are correct. While the statements given in I and II are incorrect. Their correct forms are

I. When O_2 is converted to O_2^{2+} , the bond order increases from 2 to 3. II. In conversion of O_2 to O_2^{2+} , the magnetic property changes from paramagnetic to diamagnetic.

Question5

According to molecular orbital theory, which of the following statements is not correct?

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Options:

- A. C_2 molecule is diamagnetic in nature
- B. Bond order of C_2 molecule is 2
- C. C_2^- ion is paramagnetic in nature
- D. C_2 consists of 1σ and 1π bonds

Answer: D

Solution:

Statement given in option (d) is incorrect according to MOT, rest all are correct. The correct form is, C_2 molecules consists of 2π bonds only.

Question6

The melting point of *o*-hydroxybenzaldehyde (*A*) is lower than that of *p*-hydroxybenzaldehyde (*B*). This is because

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Options:

- A. (*A*) has intermolecular H -bonding and (*B*) has intramolecols *H*-bonding.
- B. Both (*A*) and (*B*) have intermolecular H -bonding.
- C. Both (*A*) and (*B*) have intramolecular H -bonding.
- D. (*A*) has intramolecular H -bonding and (*B*) has intermoleovs *H*-bonding.

Answer: D

Solution:

The melting point of *o*-hydroxybenzaldehyde (*A*) is lower than that of *p*-hydroxybenzaldehyde (*B*). This is because *A* has intramolecular H -bonding and *B* has intermolecular H -bonding.



Question7

The bond angles $\text{H} - \text{O} - \text{N}$ and $\text{O} - \text{N} - \text{O}$ in the planar structure of nitric acid molecule are respectively

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Options:

A. $130^\circ, 102^\circ$

B. $102^\circ, 130^\circ$

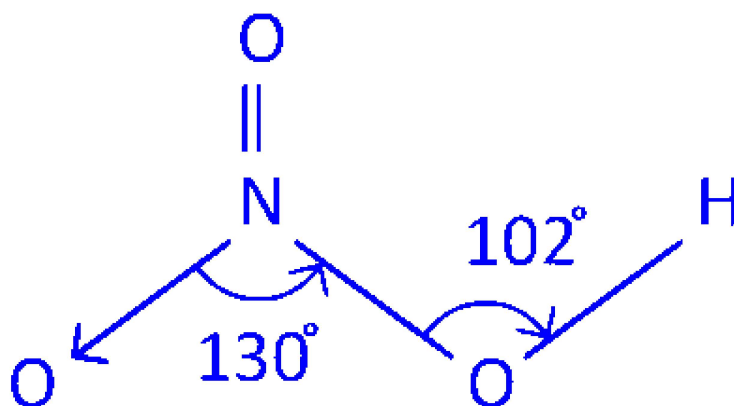
C. $134^\circ, 100^\circ$

D. $100^\circ, 134^\circ$

Answer: B

Solution:

The bond angles $\text{H} - \text{O} - \text{N}$ and $\text{O} - \text{N} - \text{O}$ in the planar structure of nitric acid are 102° and 130° respectively.



Question8

The number of lone pairs of electrons on central atom of ClF_3 , NF_3 , SF_4 , XeF_4 respectively are

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Options:

A. 0, 1, 0, 2

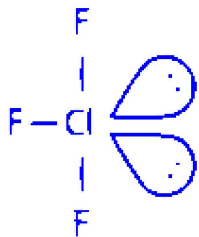
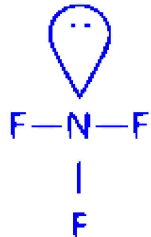
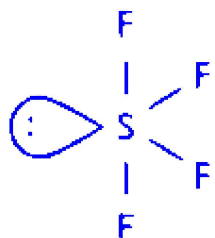
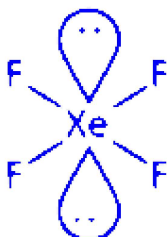
B. 2, 1, 0, 0

C. 2, 1, 1, 2

D. 2, 1, 1, 0

Answer: C

Solution:

Compound	Structure	No. of lone pairs on central atom
ClF_3		2
NF_3		1
SF_4		1
XeF_4		2



Question9

The hybridisation of central atom of BF_3 , SnCl_2 , HgCl_2 respectively is

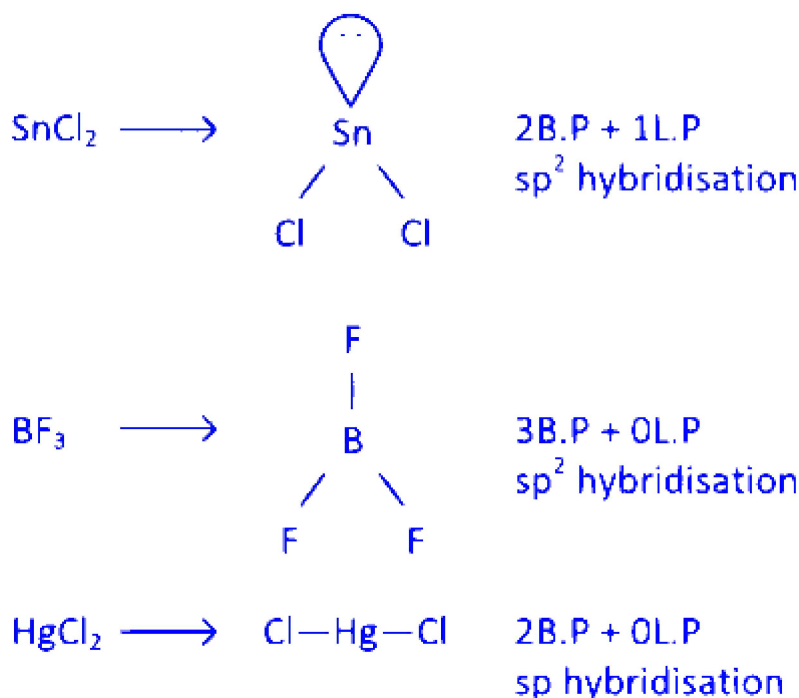
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Options:

- A. sp^2 , sp^2 , sp
- B. sp^3 , sp^2 , sp^2
- C. sp^2 , sp^2 , sp^2
- D. sp^3 , sp , sp^2

Answer: A

Solution:



Question10

The correct order of boiling points of hydrogen halides is

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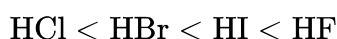
Options:

- A. $\text{HF} < \text{HCl} < \text{HBr} < \text{HI}$
- B. $\text{HI} < \text{HBr} < \text{HCl} < \text{HF}$
- C. $\text{HCl} < \text{HBr} < \text{HI} < \text{HF}$
- D. $\text{HBr} < \text{HCl} < \text{HI} < \text{HF}$

Answer: C

Solution:

The correct order of boiling points for hydrogen halides is:

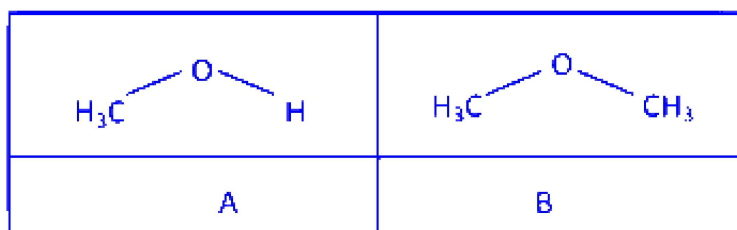


This order is due to the presence of strong hydrogen bonding between HF molecules. Hydrogen fluoride (HF) forms strong intermolecular hydrogen bonds because of the high electronegativity of fluorine (F), leading to an unusually high boiling point for HF compared to other hydrogen halides.

For the other hydrogen halides, the boiling points increase from HCl to HI as the size of the halogen atom increases from chlorine (Cl) to iodine (I). This increase in boiling points is attributed to the progressively stronger dispersion forces as the atomic size grows.

Question11

The C—O—H bond angle is A is X and C—O—H bond angle in B is y. What are X and Y?



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Options:

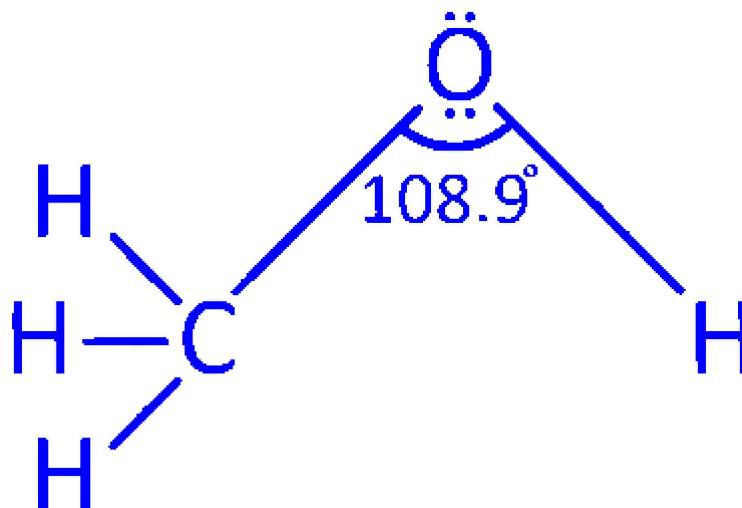
- A. $X > 109^{\circ}28', Y > 109^{\circ}28'$
- B. $X < 109^{\circ}28', Y < 109^{\circ}28'$
- C. $X < 109^{\circ}28', Y > 109^{\circ}28'$
- D. $X > 109^{\circ}28', Y < 109^{\circ}28'$



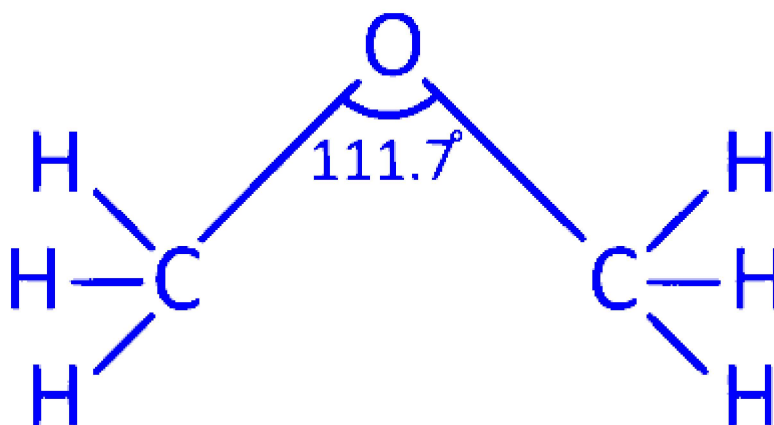
Answer: C

Solution:

The bond angle in $C - \ddot{O} - H$ in alcohol is slightly less than tetrahedral angle 108.9° . It is due to repulsion between the unshared electron pairs of oxygen. In alcohols, two lone pair of electrons are present.



The $C - O - C$ bond angle (111.7°) in ether is slightly greater than the tetrahedral angle due to repulsive interaction between the two bulky ($-A$) groups.



Hence $X < 109^\circ 28'$ and $Y > 109^\circ 28'$

Question12

Identify the set of molecules which are not in the correct order of their dipole moments

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Options:

- A. $\text{HF} > \text{HCl} > \text{HBr}$
B. $\text{H}_2\text{O} > \text{H}_2\text{S} > \text{CO}_2$
C. $\text{H}_2\text{S} > \text{HCl} > \text{HF}$
D. $\text{NH}_3 > \text{NF}_3 > \text{BF}_3$

Answer: C

Solution:

Among the given options, order of dipole moment given in option (c) is incorrect.

Dipole moment occurs due to the difference in electronegativity between two chemically bonded atom.

Fluorine is most electronegative hence the electronegativity difference with hydrogen is maximum and hence, the dipole moment will be maximum.

Question13

Match the following.

List I (Molecule) List II (Shape)

- | | |
|------------------|----------------------|
| A SF_4 | I. T-shaped |
| B ClF_3 | II. Square planar |
| C BrF_5 | III. See-saw |
| D XeF_4 | IV. Square pyramidal |

The correct answer is

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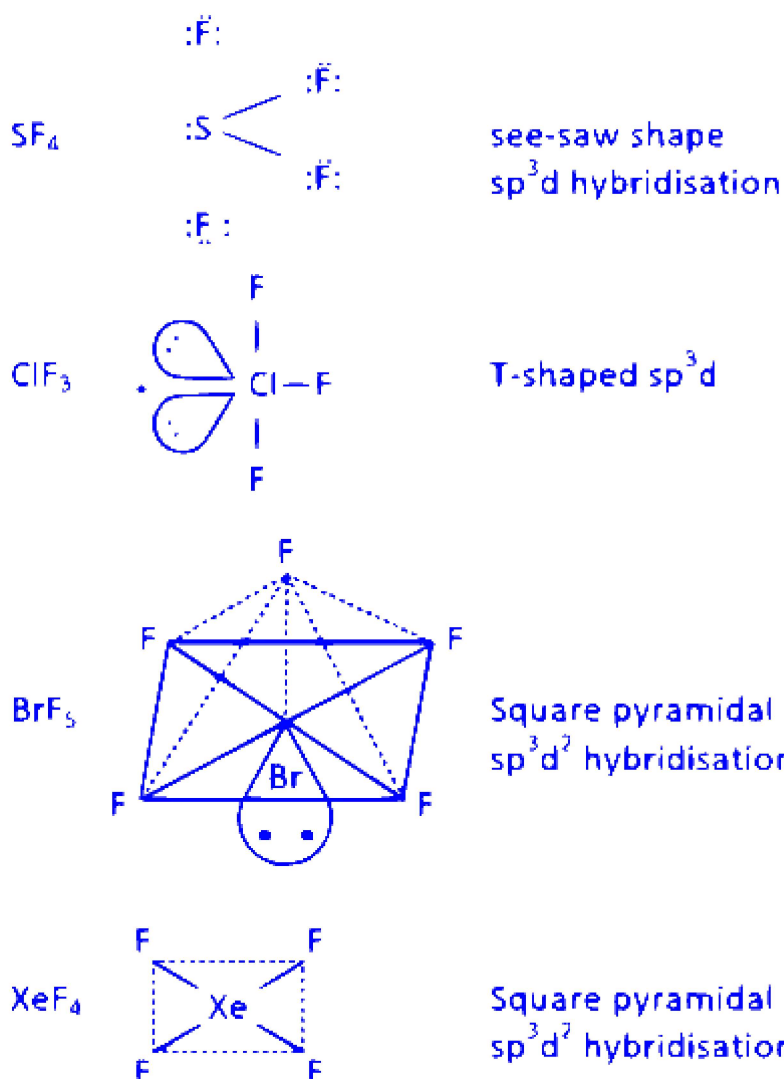
Options:

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

Answer: D

Solution:

The correct match is A-III, B-I, C-IV, D-II.



Question14

Identify the pair in which difference in bond order value is maximum.

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Options:

- A. O_2^- , O_2^+
- B. O_2 , O_2^{2+}
- C. O_2^{2-} , O_2^{2+}
- D. O_2^+ , O_2^{2+}



Answer: B

Solution:

According to MOT, the bond order is given by

$$BO = \frac{N_B - N_A}{2}$$

where, N_B and N_A are number of bonding electrons and antibonding electrons respectively.

The difference is greatest in O_2^{2-} and O_2^{2+}

from given sets of options.

$$\text{Bond order of } O_2^{2-} = \frac{N_B - N_A}{2}$$

$$N_B = 10, N_A = 8$$

$$BO(O_2^{2-}) = \frac{10 - 8}{2} = 1 \quad \dots \text{ (i)}$$

$$\text{Similarly, for } O_2^{2+} = \frac{N_B - N_A}{2}$$

$$N_B = 10, N_A = 4$$

$$BO(O_2^{2+}) = \frac{10 - 4}{2} = 3 \quad \dots \text{ (ii)}$$

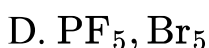
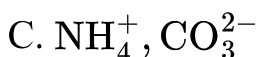
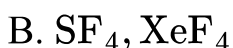
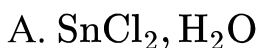
Hence, difference is 2 which is greatest among the given species.

Question 15

The pair of molecules/ions with same geometry but central atoms in them are in different states of hybridisation is

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Options:

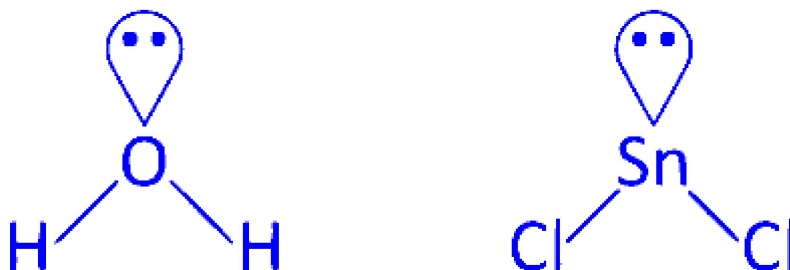
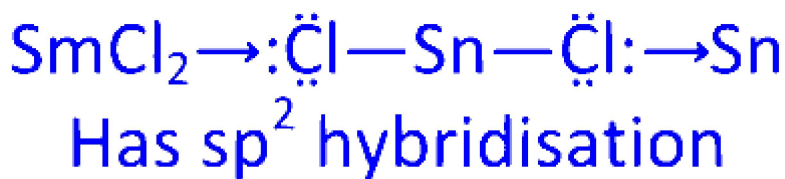


Answer: A



Solution:

Among the given pairs, SnCl_2 and H_2O has same geometry but central atoms in them has different state of hybridisation.



Geometry-trigonal pyramidal

Hybridisation in SnCl_2 is sp^2 while in H_2O is sp^3 .

Question 16

According to Fajan's rules, which of the following is not correct about covalent character?

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Options:

- A. $\text{KF} < \text{KI}$
- B. $\text{LiF} < \text{KF}$
- C. $\text{SnCl}_2 < \text{SnCl}_4$
- D. $\text{NaCl} < \text{CuCl}$

Answer: B

Solution:

According to Fajans' rule, covalent bond is favoured by small cation and large anion. Also large charge on cation and cation



with pseudo noble gas configuration will favour covalent bond. So, the correct covalent character is $\text{LiF} > \text{KF}$

Question 17

Consider the following pairs.

	Order	Property
(A)	$\text{NO}_2 > \text{O}_3 > \text{H}_2\text{O}$	Bond angle
(B)	$\text{HF} > \text{H}_2\text{O} > \text{NH}_3$	Dipole moment
(C)	$\text{I}_2 > \text{F}_2 > \text{N}_2$	Bond length

Which of the above pairs are correctly matched?

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Options:

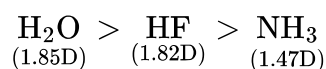
- A. A, B and C
- B. B and C only
- C. A and C only
- D. A and B only

Answer: C

Solution:

Correct order are given in *A* and *C* while *B* is incorrect. The correct form of *B* is,

The order of dipole moment is

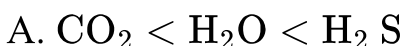


Question18

Identify the option in which the molecules are arranged in the correct order of their dipole moments

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Options:



Answer: C

Solution:

The correct order of dipole moment is $\text{BF}_3 < \text{NF}_3 < \text{NH}_3$

NH_3 and NF_3 have pyramidal geometry where central nitrogen has 3 bond pairs and 1 lone pair. Hence, both are sp^3 -hybridised.

NH_3 , dipole vector of bond and lone pair are in same direction while in NF_3 , they are in opposite direction. Hence, dipole moment of NH_3 is larger than NF_3 .

BF_3 is asymmetrical molecule where dipole vectors are arranged at 120° . Therefore, the resultant of two dipole vectors cancel out with the third dipole vector. Hence it's dipole moment will be zero.

Question19

The bond order of O_2^+ is x . The bond orders of O_2^- and O_2^{2+} are respectively

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Options:



A. $\frac{5}{3}x, \frac{5}{6}x$

B. $\frac{3}{5}x, \frac{6}{5}x$

C. $\frac{2}{5}x, \frac{3}{5}x$

D. $\frac{5}{2}x, \frac{5}{3}x$

Answer: B

Solution:

Bond Order Calculation

The bond order (BO) of a molecule is calculated using the formula:

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

Oxygen Molecule Configurations and Calculations

For O_2^+ :

Electronic configuration:

$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2 \approx \pi 2p_y^2, \pi^* 2p_x^1 \approx \pi^* 2p_y^0$$

Bond order calculation:

$$\text{BO} = \frac{1}{2} [10 - 5] = \frac{5}{2}$$

Given BO of O_2^+ is x . Therefore:

$$\frac{5}{2} = x \quad \dots(i)$$

For O_2^- :

Electronic configuration:

$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2 \approx \pi 2p_y^2, \pi^* 2p_x^2 \approx \pi^* 2p_y^1$$

Bond order calculation:

$$\text{BO} = \frac{1}{2} [10 - 7] = \frac{3}{2}$$

Using equation (i), the bond order of O_2^- is expressed as:

$$\text{BO} = \frac{3x}{5}$$

For O_2^{2+} :

Electronic configuration:

$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2 \approx \pi 2p_y^2$$



Bond order calculation:

$$BO = \frac{1}{2}[10 - 4] = 3$$

From equation (i), substituting for x , we can express it as related fractions of bond order in terms of x .

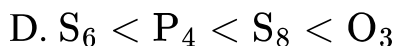
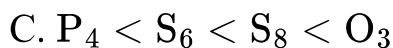
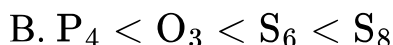
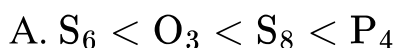
By understanding these calculations, you can determine the bond orders of O_2^- and O_2^{2+} based on the given x value and their respective electronic configurations.

Question20

In which of the following options, molecules are correctly arranged with respect to their bond angles.

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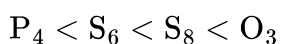
Options:



Answer: C

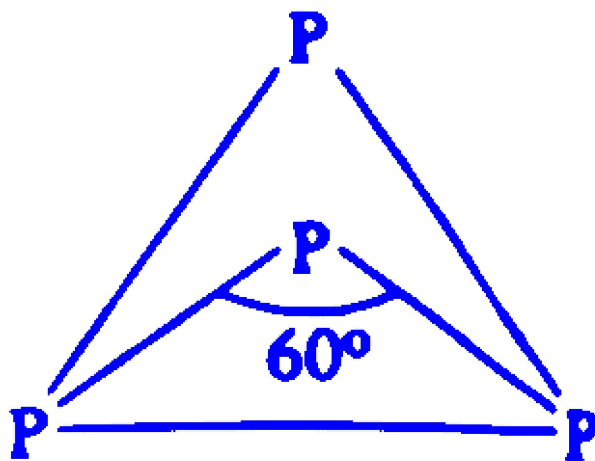
Solution:

The correct order of bond angles is

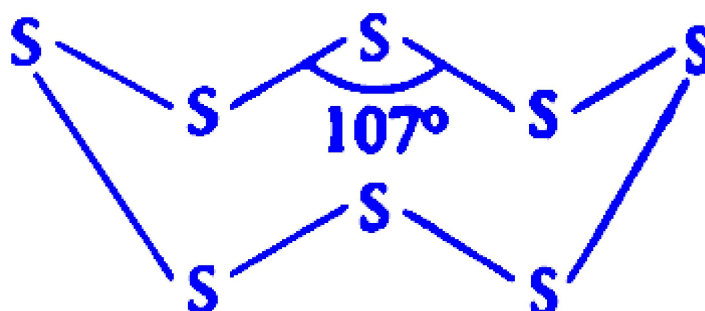


In P_4 , the four sp^3 hybridised P -atom lie at corner of regular tetrahedron with $\angle PPP = 60^\circ$.



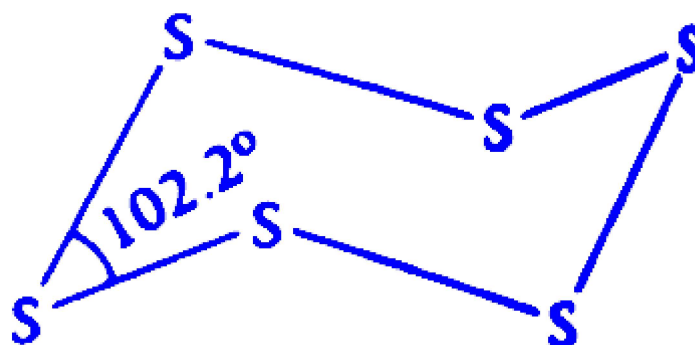


In S_8 , the eight S -atoms arranged in crown shaped structure with $\angle SSS = 107^\circ$.

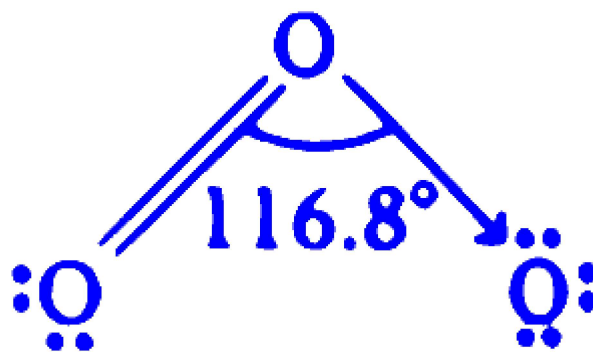


In S_6 , the six S -atoms arranged in chair form with

$\angle SSS = 102.2^\circ$



In O_3 , hybridisation of oxygen atom is sp^2 . So, angle between O -atom will be 120° but due to presence of one lone pair, the bond angle decreases from 120° to 116.8° .



Question21

The number of lone pair of electrons present in the valence shell of xenon ($Z = 54$) in XeOF_4 , XeF_4 , XeF_2 and XeF_6 are respectively

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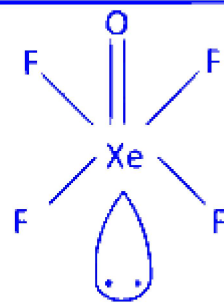
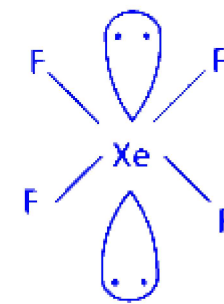
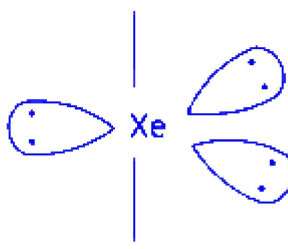
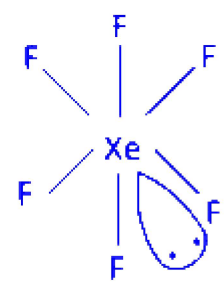
Options:

- A. 1, 2, 3, 1
- B. 2, 1, 2, 2
- C. 3, 1, 2, 1
- D. 1, 3, 2, 0

Answer: A

Solution:



Molecule	Bond pair	Lone pair	Structure
1. XeOF ₄	5σ-bond +1π-bond	1	
2. XeF ₄	4	2	
3. XeF ₂	2	3	
4. XeF ₆	6	1	

Question22

In which of the following set of molecules the hybridisation of central atoms is different?

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Options:



- A. H_2O , NH_3 , CH_4
- B. ClF_3 , XeF_2 , PCl_5
- C. CO_2 , CO , BeF_2
- D. SF_4 , XeF_4 , CH_4

Answer: D

Solution:

The set of molecules in option (d), consisting of SF_4 , XeF_4 , and CH_4 , has central atoms with different types of hybridization.

SF_4 :

$$\text{Calculation: } 4 + \frac{1}{2} \times (6 - 4) = 4 + 1$$

Hybridization: sp^3d

XeF_4 :

$$\text{Calculation: } 4 + \frac{1}{2} \times (8 - 4) = 4 + 2$$

Hybridization: sp^3d^2

(Square planar shape)

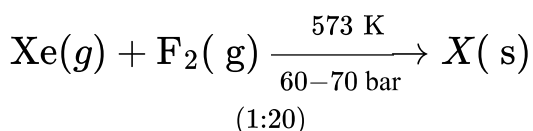
CH_4 :

$$\text{Calculation: } 4 + \frac{1}{2} \times (4 - 4) = 4$$

Hybridization: sp^3

This demonstrates that the hybridizations are sp^3d , sp^3d^2 , and sp^3 for SF_4 , XeF_4 , and CH_4 , respectively, indicating distinct hybridization states among the central atoms.

Question23



$\text{X} + \text{H}_2\text{O} \longrightarrow \text{Y} + \text{HF}$, $\text{X} + 3\text{H}_2\text{O} \longrightarrow \text{Z} + \text{HF}$ The correct statements regarding Y and Z are (I) Y has square pyramidal geometry. (II) Y has linear geometry. (III) Z has 3σ , 3π bonds and 1 lone pair of electrons on the central atom. (IV) Z has tetrahedral geometry.

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Options:

A. I and III only

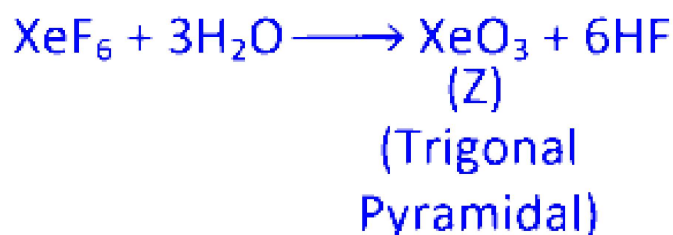
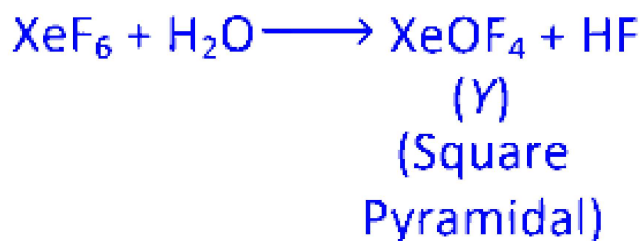
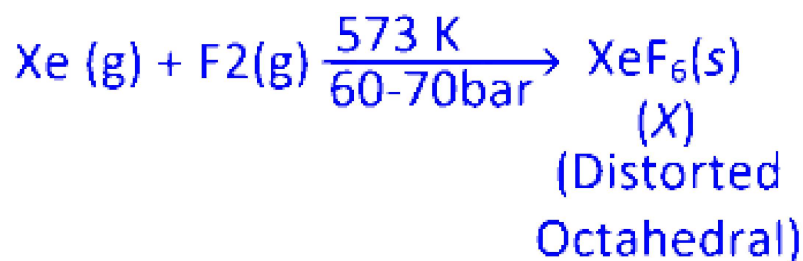
B. II and III only

C. III and IV only

D. I and IV only

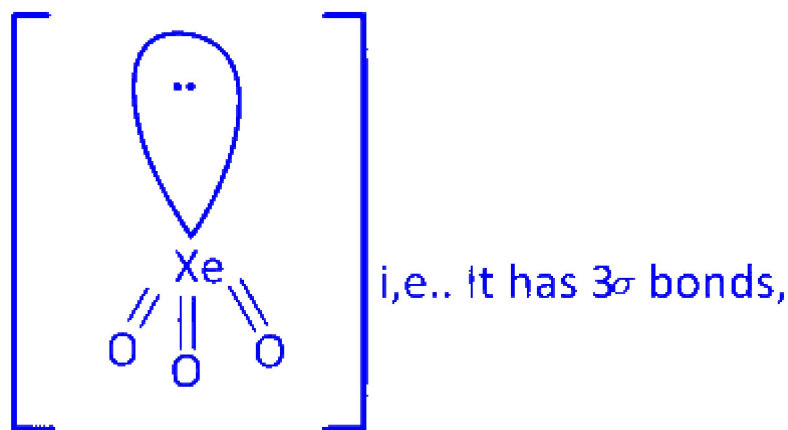
Answer: A

Solution:



Thus, statements II and IV are incorrect while statement I is correct. Also; from the structure of compound Z i.e., XeO₃ it is clear that statement III is also correct





3π -bonds and 1 lone pair of electrons.

Question24

TableMatch the following.

	List-I (Molecule/ion)	List-II (Shape)
(A)	SnCl_2	I. Trigonal planar
(B)	NH_3	II. Linear
(C)	I_3	III. Angular
(D)	SO_3	IV. Trigonal pyramidal

The correct answer is

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Options:

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

Answer: D

Solution:

	Molecule/ Ion	Bond pair	Lone pair	Shape
(A)	SnCl_2	2	1	III. Angular
(B)	NH_3	3	1	IV. Trigonal pyramidal
(C)	I_3	2	3	II. Linear
(D)	SO_2	3	0	I. Trigonal planar
