

Chemical Bonding and Molecular Structure

Question1

Among the following, the molecules /ions having same bond order are

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Options:

A. CO and O_2^{2-}

B. O_2^- and CO

C. O_2^{2-} and B_2

D. CO and N_2^+

Answer: C

Solution:

The molecules/ions that have the same bond order are:

Explanation

For O_2^{2-} (18 electrons):

Electron Configuration: $KK \sigma(2s)^2 \sigma^*(2s)^2 \sigma(2p_z)^2 \pi(2p_x)^2 \pi^*(2p_y)^2 \pi^*(2p_x)^2 \pi^*(2p_y)^2$

Bond Order (B.O.) calculation:

$$\text{B.O.} = \frac{\text{Number of bonding electrons} - \text{Number of antibonding electrons}}{2} = \frac{8-6}{2} = 1$$

For B_2 (10 electrons):

Electron Configuration: $KK \sigma(2s)^2 \sigma^*(2s)^2 \pi(2p_x)^1 \pi(2p_y)^1$

Bond Order (B.O.) calculation:

$$\text{B.O.} = \frac{\text{Number of bonding electrons} - \text{Number of antibonding electrons}}{2} = \frac{4-2}{2} = 1$$

Thus, O_2^{2-} and B_2 both have a bond order of 1, indicating they have identical bond orders.

Question2

Which of the following has maximum dipole moment?

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Options:

A. NCl_3

B. NBr_3

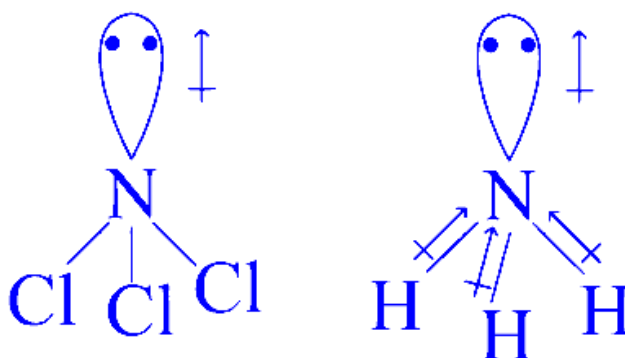
C. NH_3

D. NI_3

Answer: C

Solution:

Electronegativity difference between N(3.0) and Cl(3.0) is zero and hence, N – Cl bonds are non-polar. As a result, the overall dipole moment of NCl_3 molecule and its direction is just the dipole moment of the lone pair of electrons.



On the other hand, N – Br(3.0 – 2.8), N – I(3.0 – 2.5) and N – H(3.0 – 2.1) are polar and hence, contribute towards the overall dipole moment of the respective molecules. Since the EN difference is highest in case of N – H bonds, therefore, NH_3 has the highest dipole moment.

Question3

H-bonding is maximum in

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Options:

- A. ethanol
- B. methoxy methane
- C. chloro ethane
- D. N, N-diethyl amino ethane

Answer: A

Solution:

Hydrogen bonding is maximum in ethanol. This bonding is observed when H atom is attached to more electronegative atoms like N, F or O atom.

In ethanol, the hydrogen atom is attached directly to the electronegative element. Hence, hydrogen bonding occurs while in other given compound its not takes place.

Question4

The structure of XeOF_4 is

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Options:

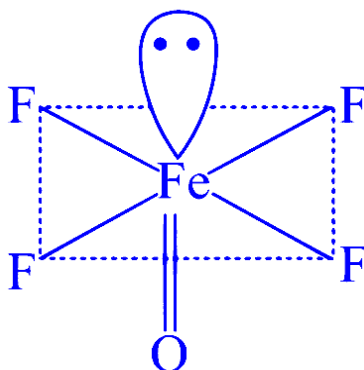
- A. square pyramidal
- B. pentagonal bipyramidal
- C. octahedron

D. square planar

Answer: A

Solution:

XeOF_4 has square pyramidal structure. In XeOF_4 , Xe is sp^3d^2 -hybridised and has 5 bond-pairs and 1 lone-pair of electrons.



Question5

PH_3 has much lower boiling point than NH_3 because :

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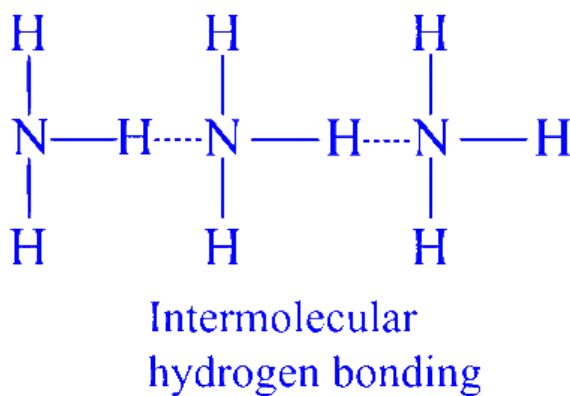
Options:

- A. PH_3 contains covalent bonds whereas NH_3 contains ionic bonds.
- B. NH_3 forms hydrogen bond
- C. PH_3 has smaller molecular weight
- D. NH_3 undergoes umbrella inversion

Answer: B

Solution:

Boiling point of ammonia (NH_3) is much higher than phosphine (PH_3). It is due to extensive inter molecular hydrogen bonding found in ammonia.



Question6

ortho-silicate ion is

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Options:

- A. SiO_2^{2-}
- B. SiO_4^{4-}
- C. $\text{Si}_2\text{O}_4^{6-}$
- D. SiO_3^-

Answer: B

Solution:

The ortho-silicate ion or group have SiO_4^{4-} formula. It has tetrahedral shape, with one silicon atom surrounded by four oxygen atoms. In the ion, each oxygen carries a unit negative charge. The Si – O bond is 162 pm long.

Question7

Which of the following option is correct regarding OF and F_2 ?

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Options:

- A. OF is paramagnetic while F_2 is diamagnetic.
- B. OF is more stable towards dissociation into atoms than F_2 .
- C. Both (a) and (b) are correct.
- D. None of the above is correct.

Answer: C

Solution:

Species	Electrons	Bond order	Unpaired electron	
OF	17	1.5	1	Paramagnetic
F_2	18	1.0	0	Diamagnetic

There is one unpaired electron in (O – F), hence it is paramagnetic. Thus, statement (a) is correct. Bond order of OF > F_2 Thus, bond energy of O – F > F – F. Thus, statement (b) is correct.

Question8

Match the species given in column I with the shape given in column II and assign the correct code.

	Column I (Species)		Column II (Shape)
A.	SF_4	(I)	Tetrahedral
B.	$HClO_2$	(II)	Pyramidal
C.	BrO_3^-	(III)	See-saw shaped
D.	NH_4^+	(IV)	Angular

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Options:

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

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

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

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

Answer: C

Solution:

Species	Shape	Structure
A. SF_4	See-saw shaped	
B. HClO_2	Angular	
C. BrO_3	Pyramidal	
D. NH_4	Tetrahedral	

Thus, the correct order is

$A \rightarrow \text{III}, B \rightarrow \text{IV}, C \rightarrow \text{II}, D \rightarrow \text{I}.$

Question9

Among the given species the isostructural pairs is

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Options:

- A. NF_3 and BF_3
- B. BF_4^- and NH_4^+
- C. BCl_3 and BrCl_3
- D. NH_3 and NO_3^-

Answer: B

Solution:

Isostructural species are those which have the same shape and hybridisation.

$\text{NF}_3 \Rightarrow 3 \text{ bond pairs} + 1 \text{ lone pair} = \text{pyramidal shape}$

$\text{BF}_3 \Rightarrow 3 \text{ bond pairs} + 0 \text{ lone pair} = \text{trigonal shape}$

$\text{BF}_4^- \Rightarrow 4 \text{ bond pairs} + 0 \text{ lone pair} = \text{tetrahedral shape}$

$\text{NH}_4^+ \Rightarrow 4 \text{ bond pairs} + 0 \text{ lone pair} = \text{tetrahedral shape}$

$\text{BCl}_3 \Rightarrow 3 \text{ bond pairs} + 0 \text{ lone pair} = \text{trigonal planar shape}$

$\text{BrCl}_3 \Rightarrow 3 \text{ bond pairs} + 2 \text{ lone pair} = \text{T-shaped}$

$\text{NH}_3 \Rightarrow 3 \text{ bond pairs} + 1 \text{ lone pair} = \text{pyramidal shape}$

$\text{NO}_3^- \Rightarrow 3 \text{ bond pairs} + 0 \text{ lone pair} = \text{trigonal planar shape}$

Question10

Which of the following statements is correct?

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Options:

- A. sp^3 -hybrid orbitals have equal s and p character
- B. The bond angle decreases with the decrease of s character of a hybridized orbital
- C. Resonance decreases the stability of a molecule
- D. Resonance is due to delocalization of sigma electrons

Answer: B

Solution:

The bond angle decreases with the decrease of s -character of hybridized orbital.

Hybridization	sp^3	sp^2	sp
Bond angle	$109^\circ 28'$	120°	180°
