CHEMISTRY

BOOKS - NCERT CHEMISTRY (ENGLISH)

CHEMICAL BONDING AND MOLECULAR STRUCTURE

Multiple Choice Question

1. Isostructrual species are those which have the same shape and hybridisation. Among the given identify the isostructural pairs.

A. NH_3 and BF_3

B. BF_4^- and NH_4^+

C. BCl_3 and $BrCl_3$

D. NH_3 and NO_3^-

Answer: A

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2. Polarity in a molecule and hence the dipole moment depends primarily on electronegativity of the constituent atoms and shape of a molecule. Which of the following has the highest dipole moment?

A. CO_2

B. HI

C. H_2O

D. SO_2

Answer: C

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3. The hybridization of atomic orbitals of nitrogen is NO_2^+, NO_3^-, and NH_4^+ respectively are

A. sp, sp^3 and sp^2

B. sp, sp^2 and sp^3

C. sp^2, sp and sp^3

D. sp^2, sp^3 and sp

Answer: B

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4. Hydrogen bonds are formed in many compounds e.g. H_2O, HF, NH_3. The boiling point of such compounds depends to a extent on the strength of hydrogen bond and the number of hydrogen bonds. The correct decreasing order of the boiling points above compounds is

A. $HF > H_2O > NH_3$

B. $H_2O > HF > NH_3$

C. $NH_3 > HF > H_2O$

D. $NH_3 > H_2O > HF$

Answer: B

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5. In PO_4^{3-} ion the formal charge on the oxygen atom of P-O bond is

A. $+1$

B. -1

C. -0.75

D. $+0.75$

Answer: C

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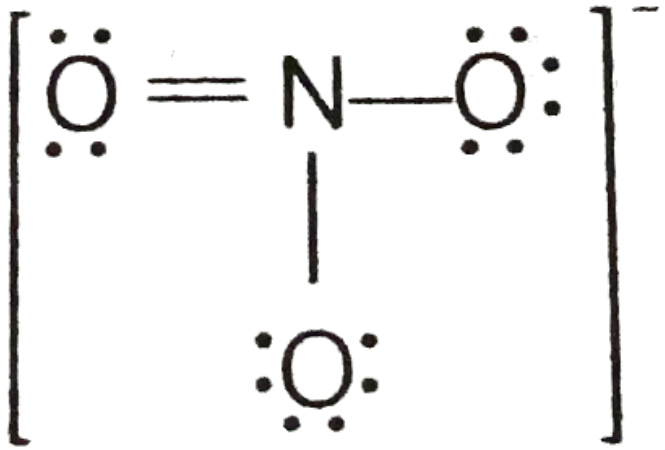
6. In NO_3^- ion, the number of bond pairs and lone pairs of electrons on nitrogen atom are

Thinking process

To solve this sequence we must know the structure of NO_3^- ion i.e,



Then, cound the bond pairs and lone pairs of electron on nitrogen.

A. $2, 2$

B. $3, 1$

C. $1, 3$

D. $4, 0$

Answer: D

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7. Which of the following species has tetrahedral geometry?

A. BH_4^-

B. NH_2^-

C. CO_3^{2-}

D. H_3O^+

Answer: A

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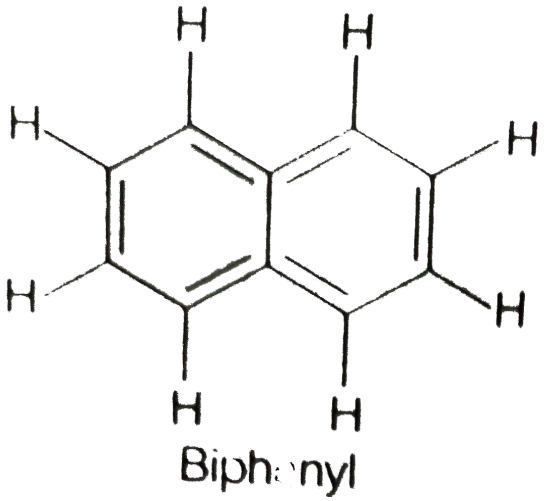
8. Number of π bonds and σ bonds in the following structure is



Biphenyl

A. 6,19

B. 4,20

C. 5,19

D. 5,20

Answer: C

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9. Which molecule/ion out of the following does not contain unpaired electrons?

A. N_2^+

B. O_2

C. O_2^{2-}

D. B_2

Answer: C

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10. In which of the following molecule/ion all the bonds are not equal?

A. XeF_4

B. BF_4^-

C. C_2H_4

D. SiF_4

Answer: B

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11. In which of the following substances will hydrogen bond be strongest?

A. HCl

B. H_2O

C. HI

D. H_2S

Answer: D

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12. If the electron configuration of an element is $1s^2, 2s^2, 2p^6, 3s^2, 3p^2, 3d^2, 4s^2$, the four electrons involved in chemical bond formation will be

A. $3p^6$

B. $3p^6, 4s^2$

C. $3p^6, 3d^2$

D. $3d^2, 4s^2$

Answer: D

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13. Which of the following angle correponds to sp^2 hybridisation?

A. 90°

B. 120°

C. 180°

D. 109°

Answer: B

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14. The electronic configuration ofhte elements. A, B and C are given below. Answer the question from 14 to 17 on the basis of these configuration.

$A \quad 1s^2 \quad 2s^2 \quad 2p^6$

$B \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^3$

$C \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^5$

Stable form of A may be represented by the formula.

A. A

B. A_2

C. A_3

D. A_4

Answer: A

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$A \quad 1s^2 \quad 2s^2 \quad 2p^6$

$B \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^3$

$C \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^5$

Stable form of C may be represented by the formula

A. C

B. C_2

C. C_3

D. C_4

Answer: B

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16. The electronic configuration ofhte elements. A, B and C are given below. Answer the question from 14 to 17 on the basis of these

configuration.

$A \quad 1s^2 \quad 2s^2 \quad 2p^6$

$B \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^3$

$C \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^5$

The molecular formula of the compound formed from B and C will be

A. BC

B. B_2C

C. BC_2

D. BC_3

Answer: D

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17. The electronic configuration ofhte elements. A, B and C are given below. Answer the question from 14 to 17 on the basis of these configuration.

$A \quad 1s^2 \quad 2s^2 \quad 2p^6$

$B \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^3$ `

$C \quad 1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^5$

The bond between B and C will be

A. ionic

B. covalent

C. hydrogen

D. coordinate

Answer: B

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18. Which of the following orderof energies of molecular orbitals of N_2 is correct?

A. $(\pi 2p_y < (\pi 2p_z) < (\pi 2p_x) = (\pi 2p_y)$

B. $(\pi 2p_y) > (\pi 2p_z) > (\pi 2p_x) = (\pi 2p_y)$

C. $(\pi 2p_y) < (\pi 2p_z) < (\pi 2p_x) = (\pi 2p_y)$

D. $\left(\pi 2p_y\right) > \left(\pi 2p_z\right) < \left(\pi 2p_x\right) = \left(\pi 2p_y\right)$

Answer: A

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19. Which of the following statement is not correct from the view point of molecular orbital theory?

A. Be_2 is not a stable molecule.

B. He_2 is not stable but He_2^+ is expected to exist.

C. Bond strength of N_2 is maximum amongst the homonuclear diatomic molecules belonging to the second period.

D. The order of energies of molecule orbitals in N_2 molecule is

$$\sigma 2s < \sigma^\star 2s < \sigma 2p_z < \pi 2p_x = \pi 2p_y < \pi^\star 2p_x = \pi^\star 2p_y < \sigma^\star 2p_z$$

Answer: D

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20. Which of the following options represents the correct bond order?

Thinking process

To calcualte bond order, write the molecular orbital configuration of particular species and afterwards using the formula.

Bond order $=\frac{1}{2}$ [Number of bonding (N_6) - Number of anti-bonding electrons (N_a)]

A. $O_2^- > O_2 > O_2^+$

B. $O_2^- < O_2 < O_2^+$

C. $O_2^- > O_2 < O_2^+$

D. $O_2^- < O_2 > O_2^+$

Answer: B

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21. The electronic configuration of the outer most shell of the most electronegative element is :

A. $2s^2 2p^5$

B. $3s^2 3p^5$

C. $4s^2 4p^5$

D. $5s^2 5p^5$

Answer: A

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22. Amongst the following elements whose electronic configuration are given below, the one having the highest enthalpy is

A. $[Ne]3s^2 3p^1$

B. $[Ne]3s^2 3p^3$

C. $[Ne]3s^{-2} 3p^2$

D. $[Ar]3d^{10}4s^24p^3$

Answer: B

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23. Which of the following have identical bond order?

A. CN^-

B. NO^+

C. O_2^-

D. O_2^{2-}

Answer: A::B

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24. Which of the following attain the linear structure ?

A. $BeCl_2$

B. NCO^+

C. NO_2

D. CS_2

Answer: A::D

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25. CO is isoelectronic with

A. NO^+

B. N_2

C. $SnCl_2$

D. NO_2^-

Answer: A::B

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26. Which of the following species have the same shape?

A. CO_2

B. $\mathbb{C}l_4$

C. O_3

D. NO_2^-

Answer: C::D

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27. Which of the following statements are correct about CO_3^{2-} ?

A. The hybridisation of central atom in sp^3

B. Its resonance structure has one C-O single bond and two C=O double bonds

C. The average formal charge on each oxygen atom is 0.67 units

D. All $C - O$ bond lengths are equal.

Answer: C::D

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28. Diamagnetic species are those which contain no unapired electrons. Which among the following are diagmagnetic?

A. N_2

B. N_2^{2-}

C. F_2^+

D. O_2^-

Answer: A::D

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29. Species having same bond order are

A. N_2

B. N_2^-

C. F_2^+

D. O_2^-

Answer: C::D

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30. Which of the following statements are not correct?

A. NaCl being an ioninc compound is a good conductor of electricity in the solid state

B. In canonical structure there is a difference in the arrangement of atoms.

C. Hybrid orbitals form stronger bonds than pure orbitals.

D. VSEPR theory can explain the square planar geometry of XeF_4

Answer: A::B

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Short Answer Types Questions

1. Interpret the non-linear shape of H_2S molecule and non-planar shape of PCl_3 using valence shell electron pair repulsion (VSEPR) theory.

(Atomic number : $H = 1, P = 15, S = 16, Cl = 17$)

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2. Using molelcular orbital theory, compare the bond energy and magnetic character of O_2^+ and O_2^- species.

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3. Explain the shape of BrF_5.

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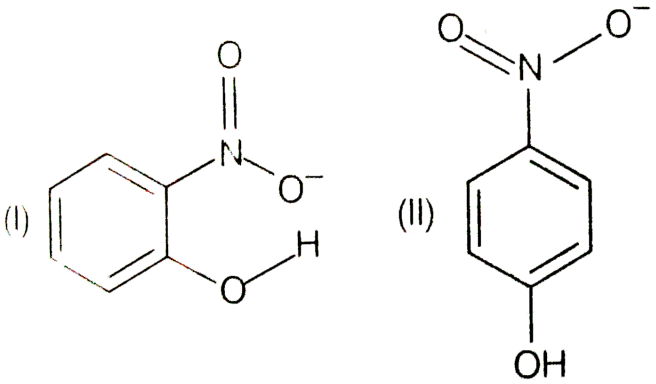
4. Structures of molecules of two compounds are given below.



a) Which of the two compounds will have intermolecular hydrogen bonding and which compound is expected to show intramolecular hydrogen bonding?

b) The melting point of compound depends on, among other things, the extent of hydrogen bonding. On this basis explain which of the above two compounds will show higher melting point?

c) Solubility of compounds in water depends on powers to form hydrogen

bonds with water. Which of the above compounds will form hydrogen bond with easily and be more stable in it?

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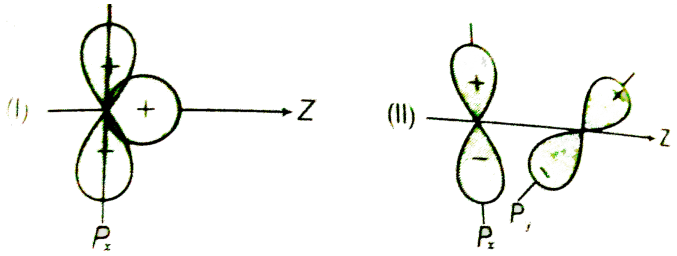
5. Why does type of overlap given in the following figure not result in bond formation?



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6. Explain why PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal ?

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7. In both water and dimethyl ether $\left(CH_3 - \ddot{\underset{\cdot\cdot}{O}} - CH_3\right)$, oxygen atoms is central atom, and has the same hybridisation, yet they have different bond angles. Which one has greater bond angle? Give reason.

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8. Write Lewis structure of the following compounds and show format charge on each atom.

HNO_3, NO_2, H_2SO_4

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9. The energy of $\sigma 2p_z$, molecular orbital is greater than $\pi 2p_x$ and $\pi 2p_y$ molecular orbitals in nitrogen molecule. Write the complete sequence of energy levels in the increasing order of energy in the molecule. Compare the relative stability and the magnetic behaviour of the following species.

$N_2, N_2^+, N_2^-, N_2^{2+}$

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10. Give the change in bond order in the following ionisation process?

i. $O_2 \rightarrow O_2^{\oplus} + e^-$, ii. $N_2 \rightarrow N_2^{\oplus} + e^-$

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11. Give reason for the following.

a) Covalent bonds are directional bonds while ionic bonds are non-directional.

b) Wate molecules has bent whereas carbon dioxide molecule is linear.

c) Ethyne molecule is linear.

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12. What is an ionic bond? With two suitable exmaples the difference between an ionic and a covalent bond?

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13. Arrange the following bonds in order of increasing ionic character giving reason.

N-H, F-H, C-H and O-H

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14. Explain why CO_3^{2-} ion cannot be represented by a single Lewis structure. How can it be best represented?

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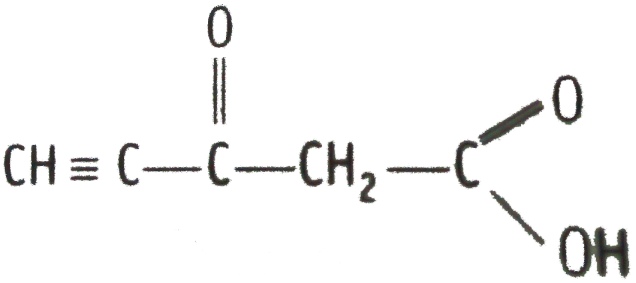
15. Predict the hybridisation of each carbon in the molecule of organic compound given below. Also indicate the total number of sigma and pi-

bonds in this molecule.



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16. Group the following as linear and non-linear molecules :

$H_2O, HOCl, BeCl_2, Cl_2O$

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17. Elements X,Y and Z have 4,5 and 7 valence electrons respectively, (i) Write the molecular formula of the compounds formed by these elements individually with hydrogen (ii) which of these compounds will have the highest dipolw moment ?

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18. Draw the resonatin structure of

(i) Ozone molecule (ii) Nitrate ion

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19. Presict the shapes of the following molecules on the basis of hybridisation.

BCl_3, CH_4, CO_2, NH_3

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20. All the C-O bonds in carbonate in $\left(CO_3^{2-}\right)$ are equal in length. Explain.

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21. what is meant by the term average bond enthalpy? Why is there difference in bond enthalpy of O-H bond in ethanol (C_2H_5OH) and water?

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Matching The Columns

1. Match the species in Column I with the type of hybrid orbitals in Column II.

Column I		Column II	
A.	SF_4	1.	sp^3d^2
B.	IF_5	2.	d^2sp^3
C.	NO_2^+	3.	sp^3d
D.	NH_4^+	4.	sp^3
		5.	sp

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2. Match the species in Column I with the geometry/shape in Column II.

	Column I		Column II
A.	H_3O^+	1.	Linear
B.	$HC \equiv CH$	2.	Angular
C.	ClO_2^-	3.	Tetrahedral
D.	NH_4^+	4.	Trigonal bipyramidal
		5.	Pyramidal

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3. Match the species in Column I with the bond order in Column II.

	Column I		Column II
A.	NO	1.	1.5
B.	CO	2.	2.0
C.	O_2^-	3.	2.5
D.	O_2	4.	3.0

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4. Match the items given in column i with example given in Column II

	Column I		Column II
A.	Hydrogen bond	1.	C
B.	Resonance	2.	LiF
C.	Ionic solid	3.	H_2
D.	Covalent solid	4.	HF
		5.	O_3

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5. Match the shape of molecules in Column I with the type of hybridisation in Column II.

	Column I		Column II
A.	Tetrahedral	1.	sp^2
B.	Trigonal	2.	sp
C.	Linear	3.	sp^3

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Assertions And Reasons

1. Assertion (A): Sodium chloride formed by the action of chlorine gas on sodium metal is a stable compound.

Reason: (R) This is because sodium and chloride ions acquire octet in sodium chloride formation.

A. A and R both are correct and R is the correct explanation of A

B. A and R both are correct, but R is not the correct explanation of A

C. A is true, but R is false

D. A and R both are false.

Answer:

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2. Assertion (A): Though the central atom of both NH_3 and H_2O molecules are sp^3 hybridised, yet H-N-H bond angle is greater thant that of H-O-H.

Reason(R): This is because nitrogen atom has one lone pair and oxygen atom has two lone pairs.

A. A and R both are correct and R is the correct explanation of A

B. A and R both are correct, but R is not the correct explanation of A

C. A is true, but R is false

D. A and R both are false.

Answer: a

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3. Assertion (A): Among the two O-H bonds in H_2O molecule, the energy required to break the first O-H bond and the other O-H bond is the same.

Reason (R) This is because the electronic environment around oxygen is the same even after brekage of one O-H bond.

A. A and R both are correct and R is the correct explanation of A

B. A and R both are correct, but R is not the correct explanation of A

C. A is true, but R is false

D. A and R both are false.

Answer: d

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Long Answer Type Questions

1. a) Discuss the significance/applications of dipole moment.

b) Represent diagrammatically the bond moments and the resultant dipole moment in CO_2, NF_3 and $CHCl_3$

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2. Use the molecular orbital energy level diagram to show that N_2 would be expected to have a triple bond. F_2, a single bond and Ne_2 , no bond.

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3. Briefly describe the valence bond theory of covalent bond formation by taking an example of hydrogen. How can you interpret energy changes taking place in the formation of dihydrogen?

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4. Describe hybridisation in the case of PCl_5 and SF_6 The axial bonds are longer as compared to equatorial bonds in PCl_5 whereas in SF_6 both axial bonds and equatorial bonds and have the same bond length. Explain.

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5. Discuss the concept of hybridisation. What are its different types in a carbon atom?

b) What is the type of hybridisation of carbon atoms marked with star?

(i) $\overset{*}{C}H_2 = CH - \overset{*}{\overset{O}{\overset{||}{C}}} - O - H$ (ii) $CH_3 - \overset{*}{C}H_2 - OH$

(iii) $CH_3 - CH_2 - \overset{O}{\overset{||}{C^*}} - H$ (iv) $\overset{*}{C}H_3 - CH = CH - CH_3$

(v) $CH_3 - \overset{*}{C} \equiv CH$

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6. Comprehension given below is followed by some multiple choice question, Each question has one correct options. Choose the correct option.

Molecular orbitals are formed by the overlap of atomic orbitals. Two atomic orbitals combine to form two molecular orbitals called bonding molecular orbital (BMO) and anti-bonding molecular orbital (ABMO). Energy of anti-bonding orbital is raised above the parent atomic orbitals that have combined and hte energy of the bonding orbital is lowered than the parent atomic orbitals.

energies of various molecular orbitals for elements hydrogen to nitrogen increase in the order

$\sigma 1s < \sigma^{\star} 1s < \sigma^{\star} 2s < \left((\pi 2p_x) = (\pi 2p_y)\right) < \sigma 2p_z < \left(\pi^{\star} 2p_x = \pi^{\star} 2p_y\right) <$

and For oxygen and fluorine order of enregy of molecules orbitals is given below.

$\sigma 1s < \sigma^{\star} 1s < \sigma 2s < \sigma^{\star} 2s < \sigma p_z < \left(\pi 2p_x \approx \pi 2p_y\right) < (\pi^{\star} 2p_x \approx \pi^{\star} 2py)$

Different atomic orbitalsof one atom combine with those atoms orbitals of the second atom which have comparable energies and proper orientation.

Further, if the overlapping is head on, the molecular orbital is called sigma, σ andif the overlap is lateral, the molecular orbital is called pi, π. The molecular orbitals are filled with electrons according to the same rules as followed for filling of atomic orbitals.

However, the order for filling is not the same for all molecules or their ions. Bond order is one of the most important parameters to compare the strength of bonds.

65) Which of the following statements is correct?

A. In the formation of dioxygen from oxygen atoms 10 molecular orbitals will be formed.

B. All the molecular orbitals in the dioxygen will be completely filled

C. Total number of bonding molecular orbitals will not be same as totla number of anti-bonding orbitals in dioxygen.

D. Number of filled bonding orbitals will be same as number of filled anti-bonding orbitals.

Answer: a

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66) Which of the following moleculart orbitals has maximum number of nodal planes?

A. $\sigma^{\star}1s$

B. $\sigma^{\star}2p_z$

C. $\pi 2p_x$

D. $\pi^{\star}2p_y$

Answer: d

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67) Which of the following pair is expected to have the same bonod order?

A. O_2, N_2

B. O_2^+, N_2^-

C. O_2^-, N_2^+

D. O_2^-, N_2^-

Answer: b

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In which of the following molecules, $\sigma 2p_z$ molecular orbital is filled after $\pi 2p_x$ and $\pi 2p_y$ molecular orbitals?

A. O_2

B. Ne_2

C. N_2

D. F_2

Answer: c

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