KD EDUCATION ACADEMY [9582701166] Street no. 21 A-1 Bengali colony sant nagar burari

Time : 6 Hour | STD 11 Science Chemistry | Total Marks : 220

kd 90+ chemical bonding and molecular structure

* **Choose The Right Answer From The Given Options.[1 Marks Each]** **[62]**

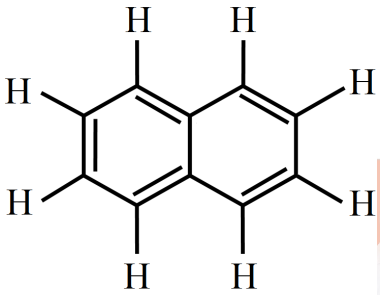
1. Kossel and Lewis approach was based on the:

(A) Reactivity of elements.
(B) Inertness of noble gases.
(C) Reactivity of metals.
(D) Inertness of non-metals.

Ans. :

b. Inertness of noble gases.

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



Naphthalene

(A) 6, 19
(B) 4, 20
(C) 5, 19
(D) 5, 20

Ans. :

c. 5, 19

3. The decreasing order of the repulsive interaction of electron pairs is (Here, lp = lone pair, bp = bond pair):

(A) lp-lp > lp-bp > bp-bp.
(B) lp-bp > lp-lp > bp-bp.
(C) lp-lp > bp-bp > lp-bp.
(D) bp-bp > lp-lp > lp-bp.

Ans. :

a. lp-lp > lp-bp > bp-bp.

Explanation:

According to VSEPR theory, the repulsive interaction of electron pairs decrease in the order.

Lone pair (lp) - lone pair (lp) > lone pair (lp) - bond pair (bp) > bond pair (bp) – bond pair (bp).

4. The product of the magnitude of the charge and the distance between the centres of positive and negative charge is called:

(A) Charge ratio.
(B) Dipole moment.
(C) Current flow.
(D) Magnetic moment.

Ans. :

b. Dipole moment.

Explanation:

As a result of polarisation, the molecule possesses the dipole moment which can be defined as the product of magnitude of the charge and the distance between the centres of positive and negative charge.

5. In an octahedral structure, the pair of d-orbitals involved in d^2sp^3 hybridisation is:

(A) $d_{x^2-y^2}, d_{xz}$ (B) d_{z^2}, d_{xy} (C) d_{xy}, d_{y^2} (D) $d_{x^2-y^2}, d_{z^2}$

Ans. :

d. $d_{x^2-y^2}, d_{z^2}$

Explanation:

∵ These are similar to 's' and 'p' orbitals.

6. CO is isoelectronic with:

(A) NO^+ (B) N_2 (C) $SnCl_2$ (D) NO2

Ans. :

a. NO^+

b. N_2

Explanation:

Number of electrons in CO =14

Number of electrons in NO^+ = 14

Number of electrons in N_2 = 14

Number of electrons in $SnCl_2$ = 84

Number of electrons in NO^-_2 = 24

7. The correct order of a dipole moment is:

(A) $CH_4<NF_3<NH_3<H_2O$ (B) $NF<CH_4<NH_3<H_2O$

(C) $NH_3<NF_3<CH_4<H_2O$ (D) $H_2O<NH_3<NF_3<CH_4$

Ans. :

a. $CH_4<NF_3<NH_3<H_2O$

Explanation:

The correct order of dipole moment is $CH_4<NF_3<NH_3<H_2O$.

Methane is zero dipole moment as it is tetrahedral molecule in which C−H bond dipoles cancel each other.

In NF_3, the bond dipole of the lone pair and the resultant dipole of three N−F bonds are in opposite direction wheres in ammonia, they are in same direction.

Hence, the dipole moment of NF_3 is smaller than that of methane.

The dipole moment of water is greater than the dipole moment of ammonia as oxygen is more electronegative than nitrogen.

8. The charge in coulombs on N^{3-} ion is:

(A) $4.80 \times 10^{-19}C$ (B) $1.60 \times 10^{-19}C$

(C) $-3C$ (D) $1.8 \times 10^{-24}C$

Ans. :

a. 4.80×10^{-19C}

Explanation:

Charge on one electron = $1.6 \times 10^{-19}C$

N^{3-} has -3 charge on it.

Charge on three electron = $3 \times 1.6 \times 10^{-19}C = 4.8 \times 10^{-19}C$

9. The number of lone pairs of electron on Xe in $XeOF_4$ is:

(A) 1 (B) 2 (C) 3 (D) 4

Ans. :

a. 1

Explanation:

The number of lone pairs of electron on Xe in $XeOF_4$ is 1. Xe in $XeOF_4$ has sp^3d^2-hybridization having one lone pair on Xe-atom and is square pyramidal in shape.

10. Which of the following is an electron deficient molecule?

(A) C_2H_6 (B) B_2H_6 (C) SiH_4 (D) PH_3

Ans. :

c. SiH_4

Explanation:

$\because$ Octet of Boron is not complete.

11. Which is the correct order of decreasing reactivity of metals?

(A) K>Na>Cu>Au (B) Na>Au>Cu>K

(C) Cu>Na>K>Au (D) Au>Cu>Na>K

Ans. :

a. K>Na>Cu>Au

Explanation:

Asbestos: was used for fireproof suits due to its high resistance to fire and heat.

Now a days, use of asbestos is banned in many countries because inhalation of asbestos fibres can cause a number of serious illness, including cancer.

Nomex: is a fire resistant nylon. Fire proof suits are made of nomex.

Kermel: is another fibre used as heat and flame protecting clothing.

12. The structure which represents the molecular structure more accurately is called:

(A) Resonance hybrid. (B) Canonical structure.

(C) Resonating structure. (D) None of these.

Ans. :

a. Resonance hybrid.

13. Which is not characteristic of π - bond?

(A) π - bond is formed when a sigma bond already formed.

(B) π - bond are formed from hybrid orbitals.

(C) π - bond may be formed by the overlapping of p-orbitals.

(D) π - bond results from lateral overlap of atomic orbitals.

Ans. :

b. π - bond are formed from hybrid orbitals.

Explanation:

π - bonds are formed from unhybridized orbitals.

Thus in ethylene, unhybridized 2p orbital of one C atom overlaps with unhybridized 2p orbital of second C atom to form π - bond.

14. Valence bond theory of Pauling and Slater accounts for the following characteristic of covalent bond:

(A) Directional
(B) Ionic
(C) Strength
(D) Hybrid

Ans. :

a. Directional

Explanation:

Valence bond theory was proposed by Heitler and London to explain the shapes of covalent molecules, their bond angles and bond lengths.

It was extended by Pauling and Slater to explain the directional nature of covalent bonds.

15. Shape of the molecules is decided by:

(A) σ-bond
(B) π-bond
(C) Both σ and π bonds
(D) Neither σ nor π bond

Ans. :

a. σ-bond

Explanation:

The reason that σ bonds (and lone pairs) determine the geometry is that they form the basic skeleton of the molecule, σ bonds are formed by head-on overlap of atomic orbitals, meaning that they are oriented a long the imaginery axis connecting two atomic nuclei, and hence concentrate electron density in the region directly between the nuclei, π bonds, on the other hand, are essentially orthogonal to the σ bond skeleton, and are substantially weaker.

Moreover, π bonds do not exist in isolation, meaning any π bond between two given atoms is always formed secondarily to the σ bond between said atoms.

As such, π bonds do not alter the basic idealized geometry of a molecule as dictated by σ bonding.

16. How many lone pair of electrons are present on the central atom of CH_4, NH_3, PCl_3 and PCl_5 molecules?

(A) 0, 1, 1, 0
(B) 0, 1, 1, 1
(C) 0, 0, 1, 1
(D) 0, 0, 0, 1

Ans. :

a. 0, 1, 1, 0

Explanation:

Methane (CH_4) does not have lone pair of electrons.

Ammonia(NH_3) has one lone pair of electron on nitrogen atom.

PCl_3 has one lone pair of electron on phosphorous atom.

PCl_5 does not have lone pair of electrons.

17. Ionic bonds will be formed more easily between elements with comparatively:

(A) Low ionisation enthalpy and high electron affinity.

(B) High ionisation enthalpy and high electron affinity.

(C) Low ionisation enthalpy and low electron affinity.

(D) High ionisation enthalpy and low electron affinity.

Ans. :

a. Low ionisation enthalpy and high electron affinity.

Explanation:

Lonic bonds will be formed more easily between elements with comparatively low ionisation enthalpies and high negative value of electron gain enthalpy.

18. Which of the following molecules does not have a lone pair of electrons?

(A) HCl (B) CO_2 (C) CH_4 (D) NH_3

Ans. :

c. CH_4

Explanation:

CH_4 does not has a lone pair because every electron in valence shell of carbon atoms is shared with Hydrogen atoms.

19. Which of the following molecule does not show hydrogen bonding?

(A) HF (B) H_2O (C) NH_3 (D) H_2S

Ans. :

d. H_2S

Explanation:

H_2S does not show hydrogen bonding also, that's why it exists as a gas.

20. A sigma bond is formed by the overlapping of:

(A) s − s orbital alone

(B) s and p orbital alone.

(C) s − s, s − p or p − p orbital along internuclear axis.

(D) p − p orbital along the sides.

Ans. :

c. s − s, s − p or p − p orbital along internuclear axis.

Explanation:

A sigma bond is formed by the overlapping of s − s, s − p or p − p orbital along inter-nuclear axis. On the other hand, the lateral overlap of p − p orbitals gives a pi bond.

21. Which of the following isoelectronic and isostructural:

(A) CO^{2-}, NO_3^{0-} (B) ClO_3^-, CO_3^{2-}

(C) SO_3^{2-}, NO_3^- (D) ClO_3^-, SO_3^{2-}

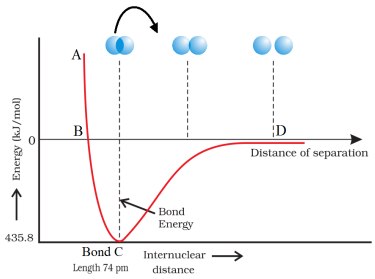
Ans. :

a. CO^{2-}, NO_3^{0-}

Explanation:

CO_3^{2-} has 6 + 24 + 2 = 32 electrons, NO_3^- has 7 + 24 + 1 = 32 electron. Both are triangle planar.

22.



The above potential energy curve is given for the formation of H_2 molecule as a function of internuclear distance of H-atoms. At what point in the curve H, is found in the most stable state?

(A) A (B) B (C) C (D) D

Ans. :

c. C

Explanation:

At C point in the curve, H_2 is found in the most stable state due to minimum energy, as the energy gets released when bond is formed between two hydrogen atoms.

23. The total number of electrons involved in the formation of CH_4 molecule are:

(A) 6 (B) 2 (C) 4 (D) 8

Ans. :

d. 8

Explanation:

Methane molecule is formed of 4 covalent bonds and each bond is formed of two electrons each.

So 4 × 2 = 8 electrons are present in methane molecule.

24. The species which has bond angle 120°

(A) ClF_3 (B) NCl_3 (C) BCl_3 (D) PH_3

Ans. :

c. BCl_3

Explanation:

It has trigonal planar shape with bond angle 120°.

25. Which of the following molecules has a triple bond?

(A) CH_4 (B) C_2H_4 (C) C_2H_2 (D) O_3

Ans. :

c. C_2H_2

26. The number and types of bonds in calcium carbide and:

(A) $1\sigma, 1\pi$ (B) $2\sigma, 1\pi$ (C) $2\sigma, 2\pi$ (D) $1\sigma, 2\pi$

Ans. :

d. $1\sigma, 2\pi$

Explanation:

$Ca^{2+}(C \equiv C)^{2-}$ has $1\sigma, 2\pi$ bonds.

27. In which of the following molecules, is the covalent bond most polar?

(A) HI (B) HBr (C) HCl

(D) H_2

Ans. :

c. HCl

Explanation:

HCl is most polar due to the high electronegativity of Cl.

28. According to Pauling, the atomic orbitals combine to form new set of equivalent atomic orbitals known as:

(A) Molecular orbitals. (B) Hybrid orbitals.

(C) Pure orbitals. (D) None of these.

Ans. :

b. Hybrid orbitals.

Explanation:

According to Pauling the atomic orbitals combine to form new set of equivalent orbitals known as hybrid orbitals. Unlike pure orbitals, the hybrid orbitals are used in bond formation.

29. Which of the following is correct?

(A) Bond order, $\propto \frac{1}{\text{bond length}} \propto \frac{1}{\text{bond enthalpy}} \propto \text{stability}$

(B) Stability, $\propto \frac{1}{\text{bond order}} \propto \frac{1}{\text{bond length}} \propto \frac{1}{\text{bond enthalpy}}$

(C) $\text{Stability} \propto \text{bond order} \propto \text{bond length} \propto \text{bond enthlpy}$

(D) $\text{Stability} \propto \text{bond order} \propto \text{bond enthalpy} \propto \frac{1}{\text{bond lenth}}$

Ans. :

d. $\text{Stability} \propto \text{bond order} \propto \text{bond enthalpy} \propto \frac{1}{\text{bond lenth}}$

Explanation:

A general correlation useful for understanding the stabilities of molecules is that, with increase in bond order, bond enthalpy increases and bond length decreases. Stability increases with increase in bond order and bond enthalpy.

Therefore, $\text{Stability} \propto \text{bond order} \propto \text{bond enthalpy}$. Stability increases with decrease in bond length. Therefore,

$\text{Stability} \propto \frac{1}{\text{bond length}}$

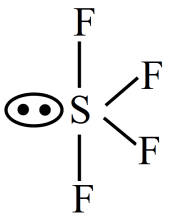
30. The shape of SF_4 molecule is:

(A) Trigonal bi-pyramidal. (B) Square planar.

(C) See-saw. (D) Bent.

Ans. :

c. See-saw.



see-saw

31. Sigma bond is more stronger than π—bond because of:

(A) Large extent of overlapping in $\pi-$bond.

(B) Small extent of overlapping in $\sigma-$bond.

(C) Small extent of overlapping in $\pi-$bond.

(D) Both (a) and (b).

Ans. :

c. Small extent of overlapping in $\pi-$bond.

32. Which one of the following molecular geometries (i.e. shapes) is not possible for the sp^3d^2 hybridization?

(A) Capped octahedral

(B) Octahedral

(C) Square planar

(D) Square pyramidal

Ans. :

a. Capped octahedral

Explanation:

 Which one of the following molecular geometries (i.e. shapes) is not possible for the sp^3d^2 hybridization?

33. Hydrogen bond formation takes place between the hydrogen atom and an atom having high_____.

(A) Electronaffinity

(B) Electronegativity

(C) Ionization potential

(D) Atomic size

Ans. :

b. Electronegativity

Explanation:

A hydrogen bond is the electrostatic attraction between polar molecules that occurs when a hydrogen atom bound to a highly electronegative atom such as Nitrogen,oxygen or fluorine experiences attraction to some other nearby highly electronegative atom.

34. Which of the following compounds shows the presence of intramolecular H-bond?

(A) H_2O_2

(B) HCN

(C) Cellulose

(D) Conc. Acetic acid.

Ans. :

c. Cellulose.

Explanation:

Cellulose has intramolecular H-bonding.

35. Which theory can be best understood by considering the formation of the chlorine molecule, Cl_2?

(A) Lewis theory.

(B) Langmuir theory.

(C) Lewis-Langmuir theory.

(D) Kossel-Lewis theory.

Ans. :

c. Lewis-Langmuir theory.

36. The shape of ClF_3 molecule is:

(A) T-shape.

(B) Trigonal planar.

(C) Bent shape.

(D) None of these.

Ans. :

a. T-shape.

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

(A) CO_2 (B) CCl_4 (C) O_3 (D) $NO^-{}_2$

Ans. :

c. O_3

d. $NO^-{}_2$

Explanation:

CO_2 → Linear, $CC1_4$ → Tetrahedral, O_3 → Angular (V-shaped), $NO^-{}_2$ → Angular (V-shaped)

38. The types of hybrid orbitals of nitrogen in NO_2, NO_3 and NH_4 respectively are expected to be:

(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^3

Ans. :

b. sp, sp^2 and sp^3

Explanation:

The number of orbitals involved in hybridization can be determined by the application of formula:

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

where H = number of orbitals involved in hybridization.

V = valence electrons of central atom.

M = number of monovalent atoms linked with central atom.

C = charge on the cation.

A = charge on the anion.

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

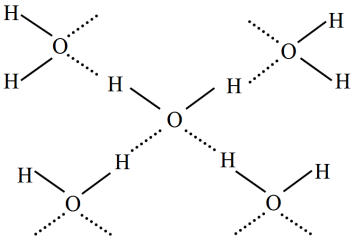
(A) HCl (B) H_2O (C) HI (D) H_2S

Ans. :

b. H_2O

Explanation:

HCl, HI and H_2S do not from H-bonds. Only H_2O forms hydrogen bonds. One H_2O molecule forms four H-bonds.



40. N_2 molecule contains _____ o and _____ π^- bonds.

(A) One, four (B) Three, two (C) One, two (D) None

Ans. :

c. One, two

Explanation:

Sigma bond always between S-S and Px-Px overlap. While pi bond is formed between Py-Py and Pz-Pz overlap.

So according to above diagram it is clear that there two pi bonds and one sigma bond in N_2.

41. In which of the following compounds, H-bonding is strongest in the liquid phase?

(A) HF (B) CH_4 (C) HI (D) PH_3

Ans. :

a. HF

Explanation:

As fluorine has small size and high electronegativity compared to others, it forms stronger H-bonds.

42. Which of the following molecules all bonds not equal?

(A) PCl_5 (B) SF_6 (C) BF_3 (D) AIF_3

Ans. :

a. PCl_5

Explantion:

∵ Three bonds are in horizontal plane at 120°, two are in vertical plane 90°, axial bonds are longer and weaker than equatorial bond.

43. VSEPR theory helps in predicting the shape of:

(A) Ionic molecules. (B) Covalent molecules.

(C) Noble gases. (D) All of these.

Ans. :

b. Covalent molecules.

Explanation:

VSEPR provides a simple procedure to predict the shapes of covalent molecules.

44. Decreasing order of stability:

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

(B) $O_2^- > O_2^{2-} > O_3^+ > O_2$

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

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

Ans. :

c. $O_2^+ > O_2 > O_2^- > O_2^{2-}$

Explanation:

Greater the bond order, more will be stability.

45. Sidgwick and Powell proposed the VSEPR theory which was further developed and refined by:

(A) Johann Dobereiner. (B) Werner Heisenberg.

(C) Nyholm and Gillespie. (D) Neils Bohr.

Ans. :

c. Nyholm and Gillespie.

Explanation:

Nyholym and Gillespie further developed and refined the VSEPR theory.

46. $H-O-H$ bond angle in water is:

(A) 104.5° (B) 109.5° (C) 105.5° (D) 108.5°

Ans. :

a. 104.5°

47. In a triple bond, there is sharing of:

(A) 3 electrons (B) 4 electrons

(C) 6 electrons (D) None of these

Ans. :

c. 6 electrons

Explanation:

A triple bond is formed by sharing of 6 electrons.

48. Why do the deviations occur from idealized shape of H_2O and NH_3 molecules?

(A) Same hybridisation. (B) Different hybridisation.

(C) Repulsive effect. (D) None of these.

Ans. :

c. Repulsive effect.

Explanation:

Greater repulsion between lone pairs of electrons as compared to the lone pair-bond pair and bond pair-bond pair repulsions. These repulsive effects result in deviations from idealised shapes and alterations in bond angles in the molecules.

49. The boiling point of a substance increases with increase in:

(A) Intermolecular hydrogen bonding. (B) Intramolecular hydrogen bonding.

(C) Molecular mass. (D) Both (a) and (c).

Ans. :

d. Both (a) and (c).

50. In the following questions two or more options may be correct:

Which of the following attain the linear structure:

(A) $BeCl_2$ (B) NCO^+ (C) NO_2 (D) CS_2

Ans. :

a. $BeCl_2$

d. CS_2

Explanation:

$BeCl_2$ and CS_2 have linear structure due to 'sp' hydration.

51. Amongst the following elements, whose electronic configurations are given below, the one having the highest ionization enthalpy is:

(A) $[Ne]3s^23p^1$ (B) $[Ne]3s^23p^3$

(C) $[Ne]3s^23p^2$ (D) $[Ar]3d^{10}4s^24p^3$

Ans. :

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

Explanation:

Have exactly half filled p-orbitals but (b) is smaller in size than Hence, (b) has highest ionization enthalpy.

52. The number of electron bond pairs involved in the formation of hydrogen cyanide molecule are:

(A) Two (B) Eight (C) Three (D) Four

Ans. :

d. Four

Explanation:

HCN contains 4 bonds (1C − H single bond and 1 triple bond between C and N). Thus, total bond pairs are 4.

53. Which of the following molecules represents resonance?

(A) O_3 (B) CO_3^{2-} (C) CO_2 (D) All of these.

Ans. :

d. All of these.

54. In which of the following pairs, the two species are isostructural:

(A) BrO_3^- and XeO_3

(B) SF_4 and XeF_4

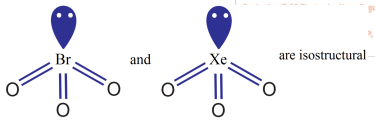
(C) SO_3^{2-} and NO_3^-

(D) BF_3 and NF_3

Ans. :

a. BrO_3^- and XeO_3

Explanation:



55. Canonical forms:

(A) Have real existence.

(B) Have no real existence.

(C) Are present in equilibrium.

(D) Exist in one form for certain fraction of time and to other in remaining time.

Ans. :

b. Have no real existence.

Explanation:

The canonical forms have no real existence.

56. 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 total number of anti bonding orbitals in dioxygen.

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

Ans. :

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

Explantion:

$O_2 = (8 + 8) = 16.$

$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma s^2 < \sigma 2s$

57. The correct order of dipole moment is:

(A) $CH_4 < NF_3 < NH_3 < H_2O$ (B) $NF_3 < CH_4 < NH_3 < H_2O$

(C) $CH_4 < NH_3 < NF_3 < H_2O$ (D) $< H_2O < NH_3 < NF_3 < CH_4$

Ans. :

a. $CH_4 < NF_3 < NH_3 < H_2O$

Explanation:

Greater the polarity, more will be dipole moment. In < NF_3 nitrogen is less electronegative then 'F' so dipole moment decrease as dipole are towards fluorine.

58. Lewis postulated that atoms achieve the stable octet when they are linked by:

(A) Ionic bonds. (B) Covalent bonds.

(C) Coordinate bonds. (D) Chemical bonds.

Ans. :

d. Chemical bonds.

Explanation:

The atoms can achieve the stable octet when they are linked by chemical bonds. It was postulated by Lewis.

59. Which of the following species has four lone pairs of electrons in its outer shell?

(A) I (B) O^- (C) Cl^- (D) He

Ans. :

a. Cl^-

Explanation:

Consider the electronic configuration of each of these options:

I - $[Kr]4d^{10}5s^25p^5$ → 3 lone pairs.

O^- - $1s^22s^22p^5$ → 3 lone pairs.

Cl^- - $1s^22s^22p^63s^23p^6$ → 4 lone pairs.

He - $1s^2$ → 1 lone pair.

60. Diagonal hybridisation is the another name of:

(A) sp^3- hybridization. (B) sp^2- hybridisation.

(C) sp-hybridisation. (D) All of the above.

Ans. :

c. sp-hybridisation.

Explanation:

The sp-hybridisation is also called diagonal hybridisation.

61. Which of the following molecule has net dipole moment zero?

(A) HF (B) H_2O (C) BF_3 (D) $CHCl_3$

Ans. :

c. BF_3

62. Which of the following angle corresponds to sp2 hybridisation?

(A) 90° (B) 120° (C) 180° (D) 109°

Ans. :

b. 120°

Explanation:

sp^2 hybridisation gives three sp^2 hybrid orbitals which are planar triangular forming an angle of 120° with each other.

The electronic configurations of three elements A, B and C are given below.

*** a statement of Assertion (A) is followed by a statement of Reason (R). [2]**

Choose the correct option.

63. **Note:** In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

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.

i. A and R both are correct, and R is the correct explanation of A.
ii. A and R both are correct, but R is not the correct explanation of A.
iii. A is true but R is false.
iv. A and R both are false.

Ans. :

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

Explanation:

Sodium chloride (Na^+Cl^-) is stable ionic compound because both Na^+ and Cl^- ions have complete octate in outermost shell.

64. Direction in the following Questions, the Assertion and Reason have been put forward. Read the statements carefully and choose the correct alternative from the following:

a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Both Assertion and Reason are false.

Assertion: Ionic compounds usually have high melting and boiling points.

Reason: A large amount of energy is needed to overcome the strong interionic electrostatic attractive forces.

Ans. :

a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

* **Answer The Following Questions In One Sentence.[1 Marks Each]** **[16]**

65. Discuss the shape of the following molecules using the VSEPR model:
$BeCl_2$

Ans. :

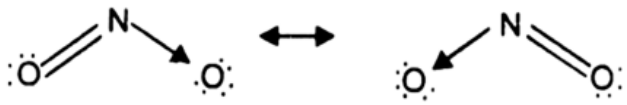
$BeCl_2 = Cl: Be: Cl.$

the central atom has only two bond pairs and thre is no lone pair, i.e, it is of the type AB_2. Hence,shape is linear.

66. Write the resonance structures for
NO_2.

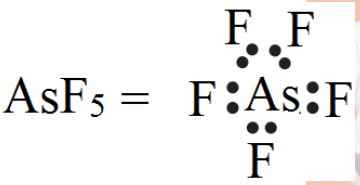
Ans. : The resonance structures are:

NO_2



67. Discuss the shape of the following molecules using the VSEPR model:
AsF_5

Ans. :

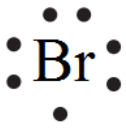


Bond pairs = 5, lone pairs = 0, i.e., it is of the type AB_5. Hence, shpe is trigonal bipyramidal.

68. Write Lewis dot symbols for atoms of the following elements:
Br.

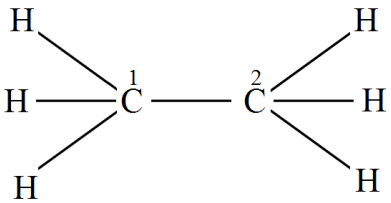
Ans. :

Br: There are seven valence electrons in bromine. Hence, the Lewis dot structure is:



69. Which hybrid orbitals are used by carbon atoms in the following molecules?
CH_3COOH

Ans. :



C_1 is sp^3 hybridized and C_2 is sp^2 hybridized.

70. Out of H_2O and H_2S, which is more polar?

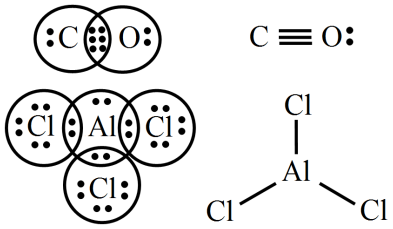
Ans. : H_2O is more polar than H_2S as oxygen is more electronegative than sulphur due to smaller size.

71. Out of σ and $\pi-$bonds, which one is stronger and why?

Ans. : $\sigma-$bond is stronger. This is because $\sigma-$bond is formed by head-on overlapping of atomic orbitals and therefore, the overlapping is large. $\pi-$bond is formed by sideway overlapping which is small.

72. Write electron dot structures of CO and $AlCl_3$.

Ans. :



$C \equiv O:$

73. What is the magnetic character of the anion of KO_2?

Ans. : Anion of KO_2 is O_2^- (superoxide ion) which has one unpaired electron and hence is paramagnetic.

74. Arrange the given bonds in increasing order of polarity:

$P-H, H-O, N-H, H-F$

Ans. : $P-H < N-H < H-O < H-F$

Because P < N < O < F is increasing order of electronegativity. Greater the difference in electronegativity, more will be polarity.

75. Why NF_3 is pyramidal but BF_3 is triangular planar?

Ans. : In NF_3, N is surrounded by three F atoms and a lone pair thus, have lp-bp repulsion along with bp-bp repulsion.

Thus, its shape is pyramidal.

In BF_3, B is surrounded by only three F atoms, i.e. have no lone pairs, so only repulsion present in it is bp-bp.

Thus, its shape is triangular planar.

76. How many nodal planes are present in $\pi(2px)$ and $\pi^*(2px)$ molecular orbitals?

Ans. : One and two respectively.

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

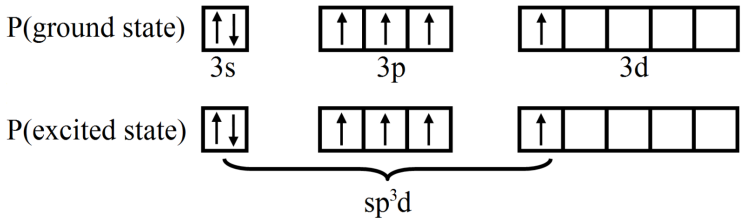
$NH_3,\ BF_3,\ BF_4^-,\ NH_4^+,\ BCl_3,\ BrCl_3,\ NH_3,\ NO_3^-$

Ans. : BF_4^- and Nh_4^+ both are sp^3 hybridized and tetrahedral shape.

78. Explain why PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal.

Ans. :

PCl_5 The ground state and the excited state outer electronic configurations of phosphorus (Z = 15) are represented below:



79. NH_3 and NH_4^+ have what covalencies?

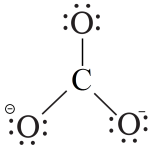
Ans. : NH_3 has covalency 3 because it forms 3 covalent bonds whereas in NH_4^+ 'N' has covalency 4 because it forms 4 covalent bodns.

80. Which of the following does not show resonance and why?

$CO_3^{2-}, BO_3^-, SO_4^{2-}$

Ans. :

BO_3^- because it does not have π-bond whereas others have $\pi-$bonds.



*** Given Section consists of questions of 2 marks each.** **[48]**

81. Write Lewis symbols for the following atoms and ions:

Al and Al^{3+}

Ans. :

Al and Al^{3+}

The number of valence electrons in aluminium is 3.

The Lewis dot symbol of aluminium (Al) is:

The tripositive charge on a species infers that it has donated its three electrons. Hence, the Lewis dot symbol is. $[Al]^{3+}$

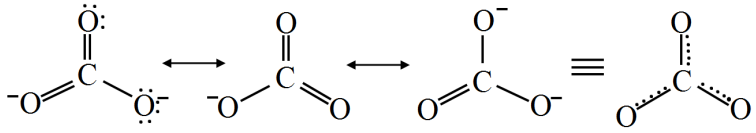
82. All the $C-O$ bonds in carbonate ion $\left(CO_3^{2-}\right)$ are equal in length. Explain.

Ans. :

To explain the reason of equal in length of $C-O$ bonds, it should keep in mind about the resonance. As a result of resonance, the bond length in a molecule become equal.

Carbonate ion $\left(CO_3^{2-}\right) = 3$ bond pair + 1 lone pair.

⇒ Trigonal planar

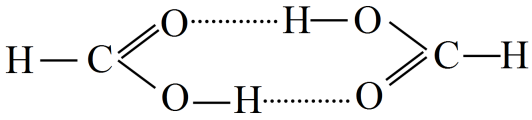


Due to resonance all $C-O$ bond length are equal.

83. Why does formic acid exist as dimer? What is its one consequence?

Ans. :

Formic acid exists as dimer because of hydrogen bonding.



Because of hydrogen bonding, it pretends larger size as well as molecular mass.

84. Why are dipole moments of $CO_2, BF_3, CCl_4, PF_5, SF_6$ are zero?

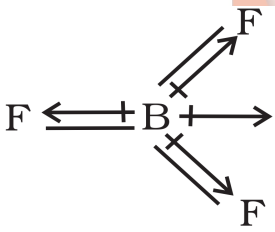
Ans. : They have symmetrical shape, individual bond moments or dipoles get cancelled, therefore, net dipole moment is zero.

85. Account for the following:

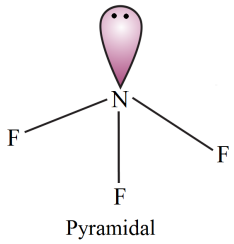
i. BF, molecule has a zero dipole moment although $B-F$ bonds are polar.
ii. The structure of NH_3 molecule is pyramidal.

Ans. :

i. Although $B-F$ bonds are polar but net dipole moment of BF_3 molecule is zero because of the symmetry of the molecule, individual dipole moments cancel out as shown below.



ii. NH_3 is pyramidal due to the presence of lone pair of electrons on nitrogen and 3 bonded pair of electrons.



Pyramidal

86. i. KHF, exists but $KHCl_2$, $KHBr_2$ do not, why?
ii. Out HF, H_2O, HCl, CCl_4 which is not liquid and why?

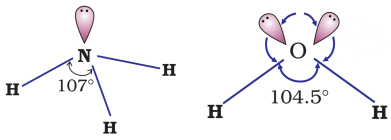
Ans. :

i. KF-HF, KF can form H-bonds with HF whereas KCl cannot form H-bond with HCl and KBr cannot form H-bond with HBr.
ii. HCl is not liquid because it is not associated with inter molecular H-bonding H_2O and HF are liquids due to inter molecular H-bonding.

CCl_4 is non-polar covalent compound with high molecular weight, therefore, liquid.

87. Bond angle in NH_3 is more than in H_2O. Justify.

Ans. : Both NH_3 and H_2O are sp^3 hybridised but there is only one lone pair present on N in NH_3 and two lone pairs on O of H_2O. Since lone pair-lone pair repulsion is greater than lone pair-bond pair and bond pair-bond pair repulsions, two lone pairs on oxygen push the bond pairs more closer than one lone pair on nitrogen. This leads to smaller bond angle in H_2O than in NH_3.



88. What is the total number of electrons in NO_3^-?

Ans. : NO, has 7 + 24 + 1 = 32 electrons

∵ 'N' has atomic number 7, therefore 7 electrons, O has 8 electrons, 30 atoms will have 24 electrons. NO_3^- ions is formed by gaining one electron.

89. What is hybrid state of central atom in the following?

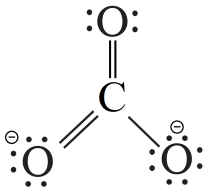
$NO_3^-, BF_4^-, PF_5, IF_5$ and CO_2

Ans. : N in NO_3^- is sp^2 hybridised, B in BF_4^- is sp^3 hybridised, Pin PF_5 is sp^3d hybridised, I in IF_5 is sp^3d^2 hybridised, C in CO_2 is sp hybridised.

90. What is the state of hybridisation of carbon in CO_3^{2-} ion?

Ans. :

sp^2 because 'C' is linked with one double bond and two single bonds.



91. Write resonating structures of O_3.

Ans. :

Resonating Structures of Ozone:

92. Arrange the following in order of decreasing bond angles.

i. $CH_4, NH_3, H_2O, BF_3, C_2H_2$

ii. NH_3, NH_2, NH_4^+

Ans. :

i. $C_2H_2(180^\circ) > CH_4(109^\circ 28') > BF_3(120^\circ) > NH_3(107^\circ) > H_2O > (104.5^\circ)$

ii. $NH_4^+ > NH_3 > NH_2^-$

This is because all of them involve sp^3 hybridisation. The number of lone pair of electrons present on N-atom are 0, 1 and 2 respectively. Greater the number of lone pairs, greater is the repulsion and lesser is the bond angle.

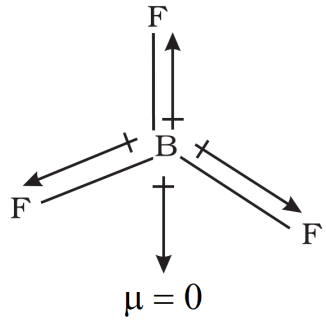
93. Give correct reason for the following:

i. BF_3 has a zero dipole moment although the $B - F$ bonds are polar.

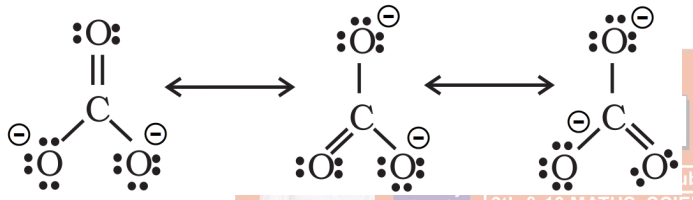
ii. All carbon to oxygen bonds in CO_3^{2-} are equivalent.

Ans. :

i. It is due to planar structure, individual dipoles get canceled.



ii. It is due to resonance, all $C - O$ bonds are equivalent.



94. Explain why HF is less viscous than H_2O.

Ans. : There is greater intermolecular hydrogen bonding in H_2O than that in HF as each H_2O molecule forms four H-bonds with other water molecules, whereas HF forms only two H-bonds with other HF molecules. Greater the intermolecular H-bonding, greater is the viscosity.

Hence, HF is less viscous than H_2O.

95. On the basis of VSEPR theory, predict the shapes of the following molecules and ions:

i. PH_3

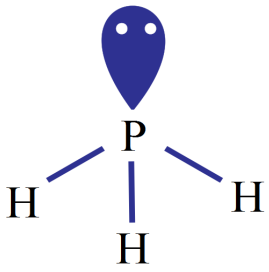
ii. NH_3

iii. NH_2^-

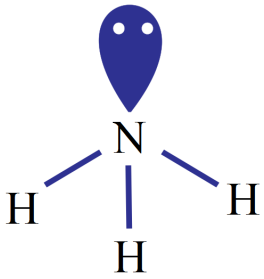
iv. H_3O^+

Ans. :

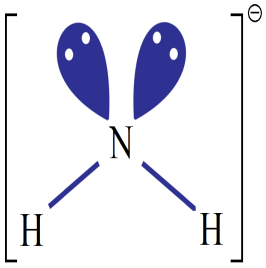
i. PH_3 has 3 bond pairs, one lone pair, it has pyramidal shape.



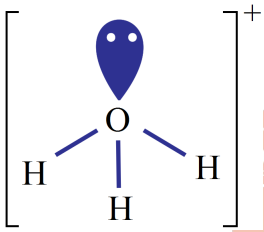
ii. NH_3 has 3 bond pairs and one lone pair, it has pyramidal shape.



ii. NH_2^- has 2 bond pairs and 2 lone pairs, therefore, it has V-shape or bent molecule.



iii. H_3O^+ has 3 bond pairs and one lone pair, therefore, it is pyramidal.



96. Give shapes of:

a. NH_4^+,

b. CO_3^{2-},

c. BeF_3^-,

d. SO_4^{2-}

Ans. :

a. NH_4^+, is tetrahedral,

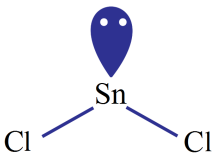
b. CO_3^{2-}, is trigonal planar,

c. BeF_3^-, is trigonal planar,

d. SO_4^{2-} is tetrahedral.

97. Why is $BeCl_2$ linear whereas $SnCl_2$ angular molecule?

Ans. : $BeCl_2$ is linear due to sp hybridisation and 2 boned pair (bp) of electrons and no lone pair (lp). In $SnCl_2$, there is sp hybridisation with a lone pair of electron, it is bent molecule.



(2 bp, 1 *l*p)

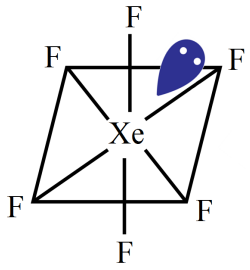
98. Draw the shape of:

i. $XeOF_5$

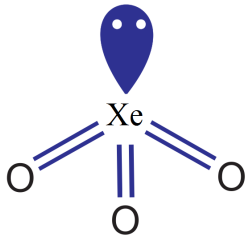
ii. XeO_3

Ans. :

i.



ii.



99. Aluminium forms the ion Al^{3+}, but not Al^{4+} why?

Ans. : Aluminium $\left([Ne]^{3s^2}3p'\right.$ can achien the electronic configuration of the nearest noble gas (Ne) by losing only three electrons. : $Al^{3+} = 1s^2 2s^2 2p^6$. Aluminium with not form the Al^{4+} ion because an extremely high amount of energy would be required to remove an electron from the stable noble gas configuration.

100. Explain the shapes of the following on the basis of VSEPR theory:

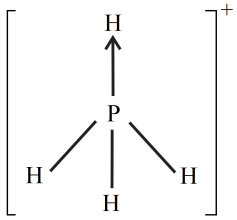
a. $BeCl_2$
b. PH_4^+
c. PF_5
d. SF_6

Ans. :

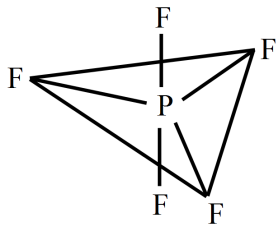
i. $BeCl_2$ has 2 bond pairs of electrons, therefore, it has linear shape.

$Cl - Be - Cl$

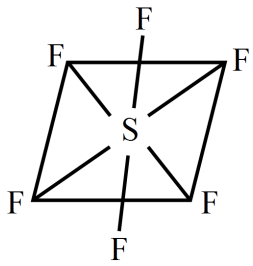
ii. PH_4^+ has 4 bond pairs of electrons, it is tetrahedral.



iii. PF_5 has 5 bond pairs of electrons, it is trigonal bipyamidal.



iv. SF_6 has 6 bond pairs of electrons, therefore, it has octahedral shape.



101. i. Which of the following are isostructural species. Give their structures.

$NO_2^+, BCl_3, CO_2, BeCl_2$

ii. Which has most electronegativity of carbon? Why?

$CH_3 - CH_3, CH = CH_2, HC \equiv CH$

Ans. :

i. NO_2^+, CO_2, $BeCl_2$ also isostructural as these are linear.

BCl_3 has trigonal planar structure.

ii.

a. has most electronegative 'C' because it is sp hybridised (50% 's' character) than sp^2 hybridised 'C' in $CH_2 = CH_2$, sp^2 (33% 's' character) and sp^3 (25% s-character) in $CH_3 - CH_3$.

Greater the s-character, more electronegativity.

$\therefore$'s' orbital is closer to nucleus.

102. N_2 molecule has a greater bond dissociation energy than N_2^+ ion whereas O_2 molecule has a lower bond dissociation energy than O_2^+ ion. Explain in terms of molecular orbital theory.

Ans. : $N_2(14) : (\sigma ls)^2(\sigma * ls)^2(\sigma 2S)^2(\sigma * 2s)^2(\pi 2p_x^2 = \pi 2p_x^2)(\sigma 2p_z)^2;$

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

$N_2^+(13) : (\sigma ls)^2(\sigma * ls)^2(\sigma 2s)^2(\pi 2p_x^2 = \pi 2p_x^2)(\sigma 2p_z)^1$

$B.O. = \frac{1}{2}(9 - 4) = \frac{5}{2}$

Since N_2 has higher bond order than N_2^+, therefore N_2 has higher bond dissociation energy than N_2^+.

$O_2(16) : (\sigma ls)^2(\sigma * ls)^2(\sigma 2s)^2(\sigma * 2s)^2(\sigma 2p_z)^2(\pi 2p_x = \pi 2p_y^2)(\pi * 2p_x^1 = \pi * 2p_y^1)$

$B.O. = \frac{1}{2}(10 - 6) = \frac{4}{2} = 2$

$O_2^+(15) : (\sigma ls)^2(\sigma * ls)^2(\sigma 2s)^2(\sigma * 2s)^2(\sigma 2p_z)^2(\pi 2p_x^2 = \pi p_y^2(\pi * 2p_x^1)$

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

O_2^+ has higher bond order than O_2, therefore, it has high bond dissociation energy than O_2.

103. AlF_3 is a high melting solid whereas SiF_4 is a gas. Explain.

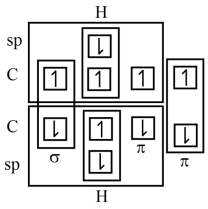
Ans. : AlF_3 is an ionic compound and there is strong force of attraction between Al^{3+} and F^- ions. Whereas SiF_4 is a covalent compound formed by sharing of electrons.

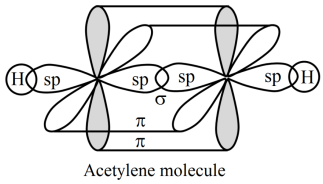
104. Define hybridisation. Explain the structure of C_2H_2 with orbital diagram.

Ans. :

Hybridisation is process of intermixing of atomic orbitals of slightly different energies which give rise to hybridised orbitals having exactly equal energy, identical shape and more stability.

In $\mathrm{H-C\equiv C-H}$ each 'C' is 'sp' hybridised, therefore, it has linear shape.





Acetylene molecule

*** Given Section consists of questions of 3 marks each.** **[39]**

105. Use molecular orbital theory to explain why the Be_2 molecule does not exist.

Ans. : The electronic configuration of Beryllium is $1s^2 2s^2$

The molecular orbital electronic configuration for Be_2 molecule can be written as:

$\sigma_{1s}^2 \ \sigma_{1s}^{*2} \ \sigma_{2s}^2 \ \sigma_{2s}^{*2}$

Hence, the bond order for Be_2 is $\frac{1}{2}(\mathrm{N_b - N_a})$.

Where

N_b = Number of electrons in bonding orbitals

N_a = Number of electrons in anti-bonding orbitals

$\therefore$ Bond order of $Be_2 = \frac{1}{2}(4-4) = 0$

A negative or zero bond order means that the molecule is unstable.

Hence, Be_2 molecule does not exist.

106. i. Explain, why Be_2 molecule does not exist by using molecular orbital theory.

ii. Describe the state of hybridization in PCl_5 Why are the axial bonds longer as compared to equatorial bonds?

Ans. :

i. Electronic configuration of Be = $1s^2\ 2s^2$

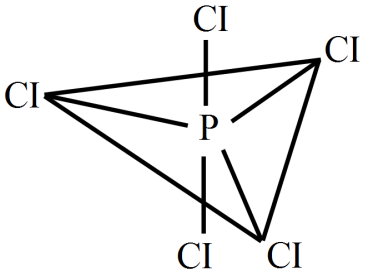
M.O. configuration of $\mathrm{Be_2} = (\sigma ls)^2(\sigma * ls)^2(\sigma 2s)^2(\sigma * 2s)$

Bond order of $\mathrm{Be_2} = \frac{1}{2}(4-4) = 0$

Since bond of $\mathrm{Be_2} = \frac{1}{2}(4-4) = 0$

ii. $\mathrm{P(15) = ls^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3}$

$\therefore$ Hydridization in PCl_5 is sp^3d



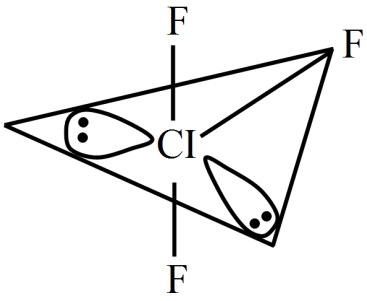
Axial bonds experience more electronic repulsion from three equatorial bond pairs and equatorial bonds experience repulsion from only two axial bond pairs hence axial bonds are longer as compared to equatorial bonds.

107. Give the shapes of following covalent molecules using VSEPR theory:

i. ClF_3
ii. XeF_4
iii. AsF_5

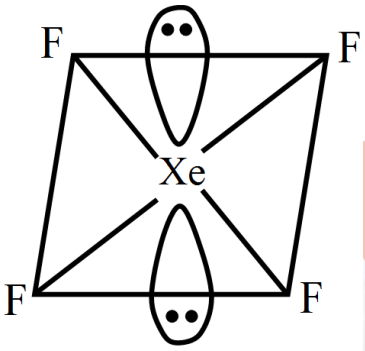
Ans. :

i.



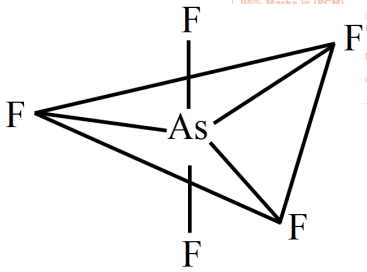
T-shaped

ii.



Square planar

iii.



Trigonal bipyramidal

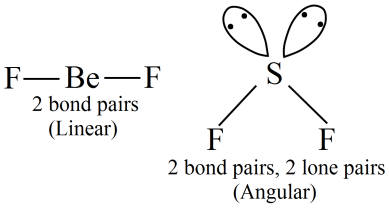
108. What is meant by hydrogen bond? What is bond energy of hydrogen bond? Why is HF, H_2O are liquids whereas HCl, HBr, HI and H_2S are gases?

Ans. : The force of attraction between hydrogen atom attached to nitrogen, oxygen or fluorine and other electronegative atom having lone pair is called H-bond. The energy of H-bond is of the order of 4 to 40 kJ mol^{-1}. HF molecules are associated with intermolecular H-bonding where HCl, HBr, HI are not associated with H-bonding.

Water molecules are associated with intermolecular H-bonding that is why water is liquid whereas H_2S is gas because H_2S molecules are not associated with intermolecular H-bonding.

109. BeF_2 molecule is linear while SF_2 is angular through both are triatomic?

Ans. : In BeF_2, Be is the central atom and is surrounded by 2 bond pairs only therefore, the molecule is linear. On the other hand, in SF_2, the central atom S is surrounded by 2 bond pairs and 2 lone pairs. Since at is surrounded by 4 electron pairs, the geometry is expected to be tetrahedral with two position occupied by lone pairs.



110. Which of the compounds in pair of compounds has higher dipole moment?

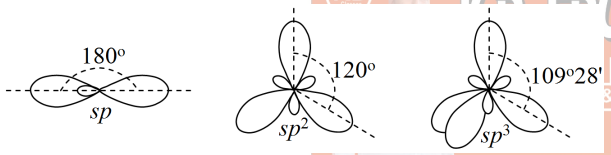
i. BCl_3 and BF_3
ii. SO_2 and SO_3
iii. H_2O and H_2S

Ans. :

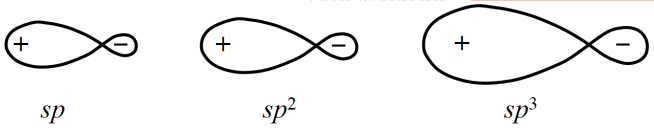
i. Both BCl_3 and BF_3 has zero dipole moment.
ii. SO_2 has higher dipole moment than SO_3.
iii. H_2O has higher dipole moment than H_2S.

111. Draw the shape of the following hybrid orbitals sp, sp^2 and sp^3.

Ans. :

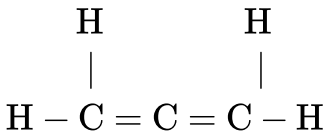


All the hybrid orbitals have same shape. However, their sizes are in the order : sp < sp^2 < sp^3.



112. Indicate the number of σ and π bonds in the molecule $CH_2 = C = CH_2$.

Ans. :



Number of σ bonds = 6, Number of π bonds = 2

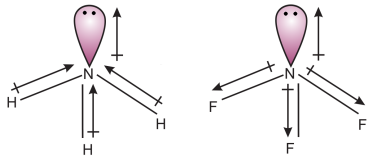
Reason: All single bonds are σ bonds. Each double bond has 1σ and 1π bond.

113. i. NH_3 has more dipole moment than NF_3 although $N - F$ bond is more polar than $N - H$ bond, why?
ii. H_2O is liquid while H_2S is gas, why?

Ans. :

i. In NH_3, 'N' is more electronegative than 'H', dipoles are toward lone pair dipole moment increases.

In NF_3, 'F' is more electronegative dipoles are away from lone pair, $\therefore$ dipole moment decrease.



ii. H_2O molecules are associated with inter molecular H-bond where as H_2S in not.

114. Draw the molecular structures of:

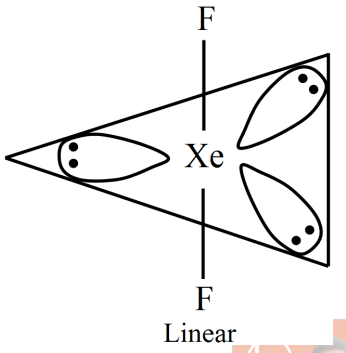
i. XeF_2,

ii. $XeOF_2$

iii. $XeOF_4$

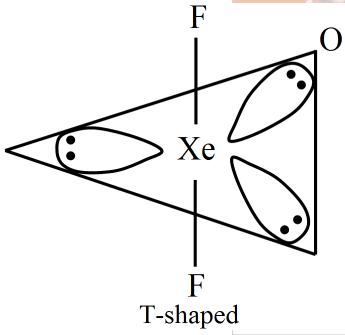
Ans. :

i.



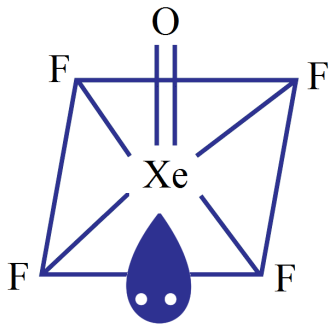
Linear

ii.



T-shaped

iii.



115. i. Deduce the structures of:

a. BrF_5

b. PF_5 on the basis of VSEPR theory.

ii. Which out of NH_3 and NF_3 has higher dipole moment and why?

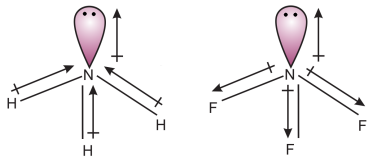
Ans. :

i.

a. In BrF_5, there are 5 bonded pairs of electrons and one lone pair of electrons, therefore, it is square pyramidal.

b. In PF_5, there are 5 bonded pairs of electrons due to which it is trigonal bipyramidal.

ii.

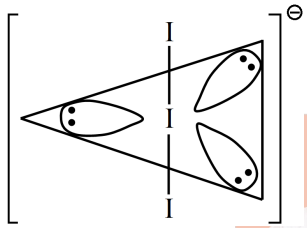


In NH_3, dipoles are being added and they are towards lone pair of electrons therefore its dipole moment is higher than NF_3 in which dipoles are away from lone pair of electrons.

116. i. Explain the shape of I_3^- ion.
ii. Why is KO_2 paramagnetic?

Ans. :

i. 'I' atom has 7 valence electrons. It forms one covalence bond with another iodine atom and coordinate bond with lion in which empty orbital accepts a lone pair. The central atom has 2 bonded pair and 3 lone pair it is linear.



ii. KO_2 is paramagnetic because O_2^- has one unpaired electron.

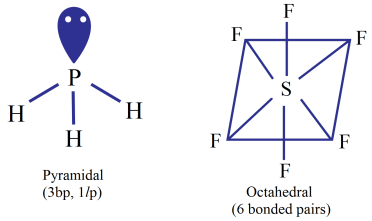
$$O_2^-(17) = \sigma 1^2\ \sigma * 1s^2\ \sigma 2s^2\ \sigma * 2s^2\ \sigma 2p_z^2\ \pi 2p_x^2\ \pi 2p_y^2\ \pi * 2p_x^2\ \pi * 2p_s^1$$

117. i. What is the state of hybridisation of nitrogen in NH_4^+ ion?
ii. Draw the shape of PH_3 and SF_6 according to VSEPR theory.
iii. Which hybrid orbitals are used by carbon atoms in $CH_3 - CHO$?

Ans. :

i. In NH3, 'N" is more electronegative than 'H'.

∴ dipoles are toward lone pair dipole moment increase. In NH_3, 'F' is more electronegative ∴ depoles are away from lone pair, dipole moment decrease.



ii. H_2O molecules are associated with inter molecular H-bond where as H_2S in not.

* Case study based questions [8]

118. Read the passage given below and answer the following questions from (i) to (v).
When covalent bond is formed betweentwo similar atoms, for example in H_2,O_2, Cl_2,N_2Or F_2, the shared pair of electrons is equally Attracted by the two atoms. As a result electronPair is situated exactly between the twoIdentical nuclei. The bond so formed is calledNonpolar covalent bond. As a result of polarisation, the moleculePossesses the dipole moment which can be defined as the productOf the

magnitude of the charge and theDistance between the centres of positive andNegative charge. It is usually designated by aGreek letter ‘μ’. Mathematically, it is expressedAs follows :Dipole moment (μ) = charge (Q) × distance ofSeparationDipole moment is usually expressed inDebye units (D). The conversion factor is1 D = 3.33564×10^{-30} C mWhere C is coulomb and m is meter. Just as all the covalent bonds haveSome partial ionic character, the ionicBonds also have partial covalentCharacter. The partial covalent character of ionic bonds was discussed by Fajans in terms of the following rules:

- The smaller the size of the cation and theLarger the size of the anion, the greater theCovalent character of an ionic bond.
- The greater the charge on the cation, theGreater the covalent character of the ionic bond.
- For cations of the same size and charge,The one, with electronic configuration(n-1)d^0ns^0, typical of transition metals, isMore polarising than the one with a nobleGas configuration, ns2 np6, typical of alkali and alkaline earth metal cations.

Sidgwick and Powell in 1940, proposed a simple theoryBased on the repulsive interactions of theElectron pairs in the valence shell of the atoms.It was further developed and redefined byNyholm and Gillespie (1957).The main postulates of VSEPR theory areAs follows:

- The shape of a molecule depends uponThe number of valence shell electron pairs(bonded or nonbonded) around the centralAtom.
- Pairs of electrons in the valence shell repelone another since their electron clouds arenegatively charged.
- These pairs of electrons tend to occupySuch positions in space that minimiseRepulsion and thus maximise distanceBetween them.
- The valence shell is taken as a sphere withThe electron pairs localising on theSpherical surface at maximum distanceFrom one another.
- A multiple bond is treated as if it is a singleElectron pair and the two or three electronPairs of a multiple bond are treated as aSingle super pair.
- Where two or more resonance structuresCan represent a molecule, the VSEPRModel is applicable to any such structure.

The arrangement of electron pairs and the atoms around the central atom can be : linear,Trigonal planar, tetrahedral, trigonal-Bipyramidal and octahedral. Valence bond theory was introduced byHeitler and London (1927) and developedFurther by Pauling and others. A discussionOf the valence bond theory is based on the knowledge of atomic orbitals, electronicConfigurations of elements.partialmerging of atomic orbitals is called overlappingof atomic orbitals which results in the pairingof electrons. The extent of overlap decides thestrength of a covalent bond. according toorbital overlap concept, the formation of acovalent bond between two atoms results bypairing of electrons present in the valence shellhaving opposite spins. When orbitals of two atoms come close to formbond, their overlap may be positive, negativeor zero depending upon the sign anddirection of orientation of amplitude of orbitalwave function in space. Positive andnegative sign on boundary surface diagramsin the show the sign (phase) of orbitalwave function and are not related to charge.Orbitals forming bond should have same sign(phase) and orientation in space. This is calledpositive overlap. The criterion

of overlap, as the main factorfor the formation of covalent bonds appliesuniformly to the homonuclear/heteronucleardiatomic molecules and polyatomic molecules.

i. Dipole moment is usually expressed in....
   a. Debye
   b. Centimeter
   c. Columbs
   d. Ergs

ii. 1D = ...
   a. 33564×10^{-28}Cm
   b. 3.3564×10^{-30}Cm
   c. 33564×10^{-32}Cm
   d. 33564×10^{-34}Cm

iii. Valence bond theory was introduced by ....
   a. Pauling and lewis
   b. Nyholm and Gillespie
   c. Heitler and London
   d. Sidgwick and Powell

iv. Pair is situated exactly between the two Identical nuclei the bond so formed is called .... covalent bond.
   a. Unipolar
   b. Bipolar
   c. Polar
   d. Nonpolar

v. Pairs of electrons in the valence shell ... one another since their electron clouds are negatively charged.
   a. Attract
   b. Repel
   c. Both a) & b)
   d. None if above

Ans. :

i. (a) Debye
ii. (b) 3.3564×10^{-30}Cm
iii. (d) Sidgwick and Powell
iv. (d) Nonpolar
v. (b) Repel

119. Read the passage given below and answer the following questions from (i) to (v).

The covalent bond may be classified into twotypes depending upon the types ofoverlapping:(i) Sigma(σ) bond, and (ii) pi(π) bond

1. Sigma(σ) bond: This type of covalent bondis formed by the end to end (head-on)overlap of bonding orbitals along theinternuclear axis. This is called as headon overlap or axial overlap. This can beformed by any one of the following typesof combinations of atomic orbitals.

   s-s overlapping: In this case, there isoverlap of two half filled s-orbitals alongthe internuclear axis.

   s-p overlapping: This type of overlapoccurs between half filled s-orbitals of oneatom and half filled p-orbitals of anotheratom.

   p–p overlapping: This type of overlaptakes place between half filled p-orbitalsof the two approaching atoms.

2. pi(π) bond: In the formation of π bondthe atomic orbitals overlap in such a waythat their axes remain parallel to each otherand perpendicular to the

internuclear axis.The orbitals formed due to sidewiseoverlapping consists of two saucer type charged clouds above and below the planeof the participating atoms.

Basically the strength of a bond depends uponthe extent of overlapping. In case of sigma bond,the overlapping of orbitals takes place to alarger extent. Hence, it is stronger as comparedto the pi bond where the extent of overlappingoccurs to a smaller extent. Further, it isimportant to note that in the formation ofmultiple bonds between two atoms of amolecule, pi bond(s) is formed in addition to asigma bond. In order to explain the characteristicgeometrical shapes of polyatomic moleculeslike CH_4,NH_3 and H_2O etc., Pauling introducedthe concept of hybridisation. According to himthe atomic orbitals combine to form new set ofequivalent orbitals known as hybrid orbitals.Unlike pure orbitals, the hybrid orbitals areused in bond formation. The phenomenon isknown as hybridisation which can be definedas the process of intermixing of the orbitals ofslightly different energies so as to redistributetheir energies, resulting in the formation of newset of orbitals of equivalent energies and shape.For example when one 2s and three 2p-orbitalsof carbon hybridise, there is the formation offour new sp^3 hybrid orbitals. Salient features of hybridisation: The mainfeatures of hybridisation are as under:

1. The number of hybrid orbitals is equal tothe number of the atomic orbitals that gethybridised.
2. The hybridised orbitals are alwaysequivalent in energy and shape.
3. The hybrid orbitals are more effective informing stable bonds than the pure atomicorbitals.
4. These hybrid orbitals are directed in spacein some preferred direction to haveminimum repulsion between electronpairs and thus a stable arrangement.Therefore, the type of hybridisationindicates the geometry of the molecules. Important conditions for hybridisation
5. The orbitals present in the valence shell of the atom are hybridised.
6. The orbitals undergoing hybridisation should have almost equal energy.
7. Promotion of electron is not essential condition prior to hybridisation.
8. It is not necessary that only half filled orbitals participate in hybridisation.

some cases, even filled orbitals of valence shell take part in hybridisation.

There are various types of hybridisationinvolving s, p and d orbitals. The differenttypes of hybridisation are as under:

1. sp hybridisation: This type ofhybridisation involves the mixing of one s andone p orbital resulting in the formation of twoequivalent sp hybrid orbitals. The suitableorbitals for sp hybridisation are s and pz, ifthe hybrid orbitals are to lie along the z-axis. Example of molecule having sphybridisation$BeCl_2$: The ground state electronicconfiguration of Be is $1s^2 2s^2$. In the exited stateone of the 2s-electrons is promoted to vacant 2p orbital to account for its bivalency.One 2s and one 2p-orbital gets hybridised toform two sp hybridised orbitals.
2. sp2 hybridisation : In this hybridisationthere is involvement of one s and twop-orbitals in order to form three equivalent sp2hybridised orbitals. For example, in BCl3molecule, the ground state electronicconfiguration of central boron atom is$1s^2 2s^2 2p^1$. In the excited state, one of the 2selectrons is promoted to vacant 2p orbital as a result boron has three unpaired electrons.These three orbitals (one 2s and two 2p)hybridise to form three sp2 hybrid orbitals.
3. sp^3 hybridisation: This type ofhybridisation can be explained by taking theexample of CH_4 molecule in which there ismixing of one s-orbital and three p-orbitals ofthe valence shell to form four sp^3 hybrid orbitalof equivalent

energies and shape. There is 25%s-character and 75% p-character in each sp^3hybrid orbital. The four sp^3 hybrid orbitals soformed are directed towards the four cornersof the tetrahedron. The angle between sp^3hybrid orbital is 109.5°.

i. ....ntroduced the concept of hybridisation.
   a. Pauling
   b. Lewis
   c. Nyholm
   d. Gillespie

ii. Which of the following is an example of sp3 hybridization?
   a. BeCl2
   b. Ch4
   c. BCl3
   d. C2H4

iii. The angle between sp3 hybrid orbital is ....
   a. 5°
   b. 9°
   c. 109.5°
   d. 120°

iv. A sigma bond is formed by the overlapping of ...
   a. s−s,
   b. s−p
   c. p−p
   d. All the above

v. When one 2s and three 2p-orbitals of carbon hybridise, there is the formation of four new ... hybrid orbitals.
   a. sp3
   b. sp2
   c. sp
   d. None of above

Ans. :

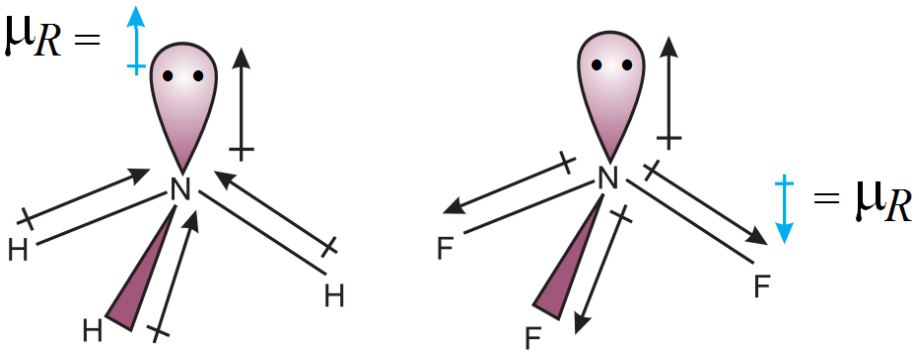
i. (a) Pauling
ii. (b) CH4
iii. (c) 109.5°
iv. (d) All the above
v. (a) sp3

*** Given Section consists of questions of 5 marks each. [45]**

120. Which out of NH_3 and NF_3 has higher dipole moment and why?

Ans. :

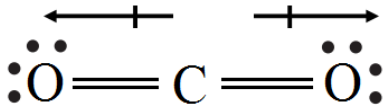
Both the molecules NH_3 and NF_3 have pyramidal shape with a lone pair of electron on nitrogen atom. Although fluorine is more electronegative than nitrogen, the resultant dipole moment of NH_3 (4.90×10^{-30} C m) is greater than that of NF_3 (0.8 x 103 the orbital dipole due to lone pair is in the same direction as the resultant dipole moment of the N—H bonds whereas in NF_3 the orbital dipole is in the direction opposite to the resultant dipole moment of the three N—F bonds. The orbital dipole because of lone pair decreases the effect of the resultant N—F bond moment which results in low dipole moment of NF_3 as represented below:



121. Although both CO_2 and H_2O are triatomic molecules, the shape of H_2O molecule is bent while that of CO_2 is linear. Explain this on the basis of dipole moment.

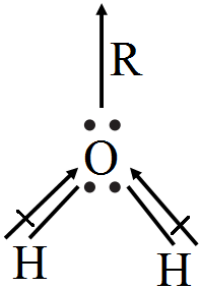
Ans. :

According to experimental results, the dipole moment of carbon dioxide is zero. This is possible only if the molecule is linear so that the dipole moments of C–O bonds are equal and opposite to nullify each other.



Resultant $\mu = 0$ D

H_2O, on the other hand, has a dipole moment value of 1.84 D (though it is a triatomic molecule as CO_2). The value of the dipole moment suggests that the structure of H_2O molecule is bent where the dipole moment of O–H bonds are unequal.



122. Explain the formation of H_2 molecule on the basis of valence bond theory.

Ans. :

Let us assume that two hydrogen atoms (A and B) with nuclei (N_A and N_B) and electrons (e_A and e_B) are taken to undergo a reaction to form a hydrogen molecule.

When A and B are at a large distance, there is no interaction between them. As they begin to approach each other, the attractive and repulsive forces start operating.

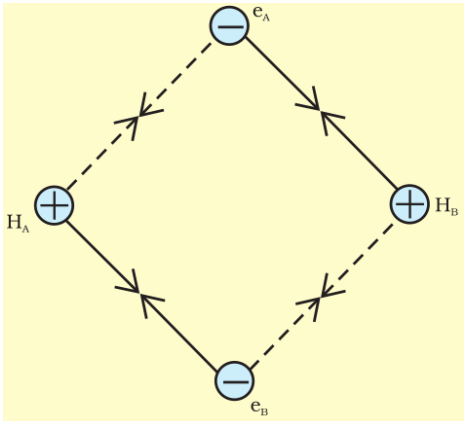
Attractive force arises between:

a. Nucleus of one atom and its own electron i.e., $N_A - e_A$ and $N_B - e_B$.
b. Nucleus of one atom and electron of another atom i.e., $N_A - e_B$ and $N_B - e_A$.

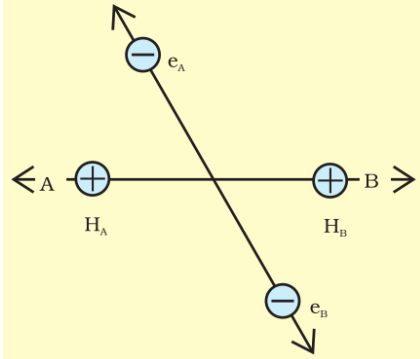
Repulsive force arises between:

a. Electrons of two atoms i.e., $e_A - e_B$.
b. Nuclei of two atoms i.e., $N_A - N_B$.

The force of attraction brings the two atoms together, whereas the force of repulsion tends to push them apart.



Attractive Forces



Repulsive Forces

The magnitude of the attractive forces is more than that of the repulsive forces. Hence, the two atoms approach each other. As a result, the potential energy decreases. Finally, a state is reached when the attractive forces balance the repulsive forces and the system acquires minimum energy. This leads to the formation of a dihydrogen molecule.

123. Define octet rule. Write its significance and limitations.

Ans. : Octet rule: Atoms of elements combine with each other in order to complete their respective octets so as to acquire the stable gas configuration.

Significance: It helps to explain why different atoms combine with each other to form ionic compounds or covalent compounds.

Limitations of Octet rule:

- According to Octet rule, atoms take part in chemical combination to achieve the configuration of nearest noble gas elements. However, some of noble gas elements like Xenon have formed compounds with fluorine and oxygen. For example: XeF_2, XeF_4 etc.

  Therefore, validity of the octet rule has been challenged.
- This theory does not account for shape of molecules.

124. Write the favourable factors for the formation of ionic bond.

Ans. : The following factors facilitate the formation of an ionic bond between a metal and a non-metal:

1. **Ionization energy:** Lesser the ionization energy, greater is the ease of formation of a cation.
2. **Electron affinity:** High electron affinity favours formation of an anion.

3. **Lattice Energy:** It is defined as the amount of energy released when cations and anions are brought close to each other from infinity to their respective equilibrium sites in the crystal lattice to form one mole of the ionic compound. The higher the magnitude of the lattice energy, the greater is the tendency of the formation of an ionic bond.

125. Define hydrogen bond. Is it weaker or stronger than the van der Waals forces?

Ans. :

A hydrogen bond is defined as an attractive force acting between the hydrogen attached to an electronegative atom of one molecule and an electronegative atom of a different molecule (may be of the same kind).

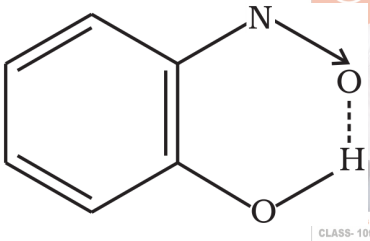
Due to a difference between electronegativities, the bond pair between hydrogen and the electronegative atom gets drifted far away from the hydrogen atom. As a result, a hydrogen atom becomes electropositive with respect to the other atom and acquires a positive charge. a positive charge.

$$4^{\delta} - X^{\delta-} \ldots\ldots H^{\delta+} - X^{\delta-} \ldots\ldots H^{\delta+} - X^{\delta}$$

The magnitude of H-bonding is maximum in the solid state and minimum in the gaseous state.

There are two types of H-bonds:

i. Intermolecular H-bond e.g., HF, H_2O etc.
ii. Intramolecular H-bond e.g., o-nitrophenol.



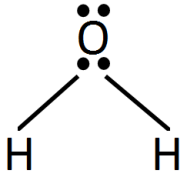
iii. Hydrogen bonds are stronger than Van der Walls forces since hydrogen bonds are regarded as an extreme form of dipole-dipole interaction.

126. Give reasons for the following:

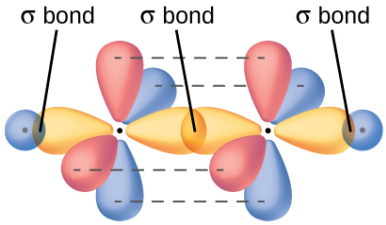
a. Covalent bonds are directional bonds while ionic bonds are non- directional.
b. Water molecule has bent structure whereas carbon dioxide molecule is linear.
c. Ethyne molecule is linear.

Ans. :

a. Since the covalent bond depends on the overlapping of orbitals between different orbitals, the geometry of the molecule is different. The orientation of overlap is different. The orientation of overlap is the factor responsible for their directional nature.
b. Due to presence of two lone pairs of electrons on oxygen atom in HiO the repulsion between is more. CO_2 undergoes sp hybridization resulting in linear shape (O = C = O) while H_2O undergoes sp^3 hybridisation resulting in distorted tetrahedral or bent structure.



c. In ethyne molecule carbon undergoes sp hybridization with two unhybridised orbitals. One sp hybrid orbital of one carbon atom overlaps axially with sp hybrid orbital of the other carbon atom to form C – C sigma bond while the other hybridized orbital of each carbon atom overlaps axially with S orbitals of hydrogen atoms forming. Unhybridised orbitals form n-bonds.



127. i. Why is HF liquid but HCl, HBr, HI are gases?

ii. Why is o-nitrophenol steam volatile whereas p-nitrophenol is not steam volatile?

a. Arrange the following in decreasing order of their bond angle: H_2O, NH_3, H_2S

b. Sketch the bond moments and resultant dipole moment of the following molecule:

H_2O, NH_3, NF_3 and PCl_5

c. Draw shape of the following molecules on the basis of VSEPR theory:

XeF_4 and SF_4. (At. No. of Xe = 54, At. No. of S = 16)

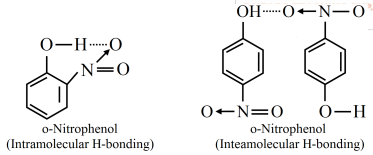
Ans. :

i. H-bond is the force of attraction between hydrogen and electronegative atoms like F, N, O, e.g., HF is liquid because HF molecules are associated with intermolecular H-bonding whereas HCl, HBr, HI do not have H-bonds.

ii. o-Nitrophenol has intramolecular H-bonding whereas p-nitrophenol has intermolecular H-bonding.

o-Nitrophenol is steam volatile due to weaker intramolecular H-bonding.

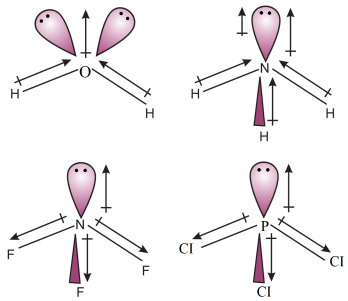
p-Nitrophenol is not steam volatile due to stronger intermolecular H-bonding.



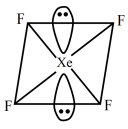
iii.

a. $NH_3 > H_2O > H_2S$

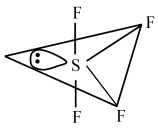
b.



b.



Square planar



See-saw shape

128. Arrange in properties:

i. HF, HCl, HBr, HI [Thermal stability]
ii. LiF, LiCl, LiBr, LiI [Ionic character]
iii. PH_3, PCl_3, PF_3, [Covalent character]
iv. H_2O, NH_3, H_2S, HF [Polarity]
v. $BeCl_2$, BCl_3, CCl_4, PCl_3, [Bond angle]

Ans. :

i. HI < HBr < $H - Cl$ < HF because bond length decreases, bond dissociation energy increases
ii. LiI < LiBr < LiCl < LiF because electronegativity of halogen increases, polarity increases.
iii. $PF_3 < PCl_3 < PH_3$ because electronegativity of F > Cl > H
∴ covalent character increases.
iv. $H_2S < NH_3 < H_2O <$ HF electronegativity of S < N < O < F
v. $PCl_3 < CCl_4 < BCl_3 < BeCl_2$
100° 107.5° 120° 180°

[Bond angle depends upon shape of molecules]

----- Do the best you can until you know better. Then when you know better, do better. -----