I PUC QUESTION BANK

Chapter: 4

Chemical bonding

1 Mark Questions

1) Who were the first to propose a theory on chemical bonding using electrons?

2) What is a chemical bond?

3) Write Lewis dot symbols for atoms of the following elements

Mg, Na, B, O, N, and Br.

4) Draw the Lewis structures for the following molecules and ions.

H_2, O_2, CO_2, C_2H_4, C_2H_2, HNO_3, CO

5) In the periodic table, the group of highly electronegative elements is _____.

6) In the periodic table, the group of highly electropositive elements is _____.

7) Write the general electronic configuration of noble gases.

8) What type of bond is present in NaCl?

9) Which force holds oppositely charged ions together in an ionic bond?

10) Name a cation that contains cation having two non metallic elements in an ionic compound.

11) How does resonance stabilize a molecule?

12) Give the mathematical expression for dipole moment.

13) Expand VSEPR

14) What is the basis of VSEPR theory?

15) Arrange the repulsive interaction between electron pairs (lp-bp, bp-bp, and lp-lp) in increasing order.

16) What is lone pair of electrons?

17) What is bonded pair of electrons?

18) Among bonded pair of electron and lone pair of electron, which occupy more space in a molecule?

19) How many lone pairs of electrons are present in a molecule of ammonia?

20) How many lone pairs of electrons are present in a molecule of water?

21) How many lone pairs of electrons are present in a molecule of ClF_3?

22) How many lone pairs of electrons are present in a molecule of SF_4?

23) What is hybridization?

24) Write the shape and bond angle of sp hybrid orbitals?

25) Give an example of a molecule having sp hybridization?

26) What is the percentage of s character in sp hybridization?

27) What is the shape and bond angle of sp^2 hybrid orbitals?

28) What is the percentage of s character in sp^3 hybridizations?

29) Give an example for sp^2 and sp^3 hybrid molecules

30) Write the shape and bond angle of sp^3 hybridized orbitals.

31) Write the shape, hybridization and bond angle of a) NH_3 and, b) H_2O

32) How many σ and π bonds are there in a) ethylene b) ethyne?

33) What is the type of hybridization found in PCl_5?

34) What is the shape and hybridization of SF_6?

35) Write the number of axial and equatorial bonds in PCl_5

36) Give example of a molecule showing dsp^2 hybridization.

37) Write the shape of Br F_5 molecule.

38) Arrange the following orbitals in the increasing order of s- character.sp, sp^2, sp3

39) Define hydrogen bond.

40) How is the magnitude of hydrogen bonding in different states of matter?

41) Is the force between two nuclei of hydrogen atoms attractive or repulsive?

42) Which of the force (i.e. attractive or repulsive) is stronger?

43) What is bond enthalpy?

44) The electrons present in valence shells should have ___spins in order to be paired up.

45) Will a bond be stronger when there is more overlap or less overlap of atomic orbitals?

46) Hydrogen molecule is formed due to overlap of ____ orbitals.

47) What is tetrahedral bond angle?

48) What are the types of overlap depending on the sign (phase) of orbital wave function?

49) If the wave functions of participating atomic orbitals are same phase, the overlap is called _____.

50) The energy required for changing the electronic configuration from ground to exited state is provided from where?

51) What is the angle between any two p orbitals?

52) What are the two types of covalent bonds?

53) What is a pi bond?

54) What is the shape of the electron cloud in a pi bond?

55) Can a pi bond exist without a sigma bond?

56) Is there greater overlap in sigma or pi bonds?

57) Define hydrogen bond.

2 Marks

1) Which type of elements is likely to form anions and give the reason for the same?

2) Which factor favours formation of cation? Explain.

3) Among KCl and NaCl, which is more stable? Give reason.

4) Under what conditions the concept of resonance is applied?

5) The dipole moment in BF_3 is zero. Explain

6) The net dipole of NH_3 is greater than that of NF_3. Why?

7) Write the resonance structures of CO_3^{2-} and CO_2.

8) List the outcome of repulsive interaction between electron pairs in a molecule.

9) Account for the shape of the following molecules based on VSEPR theory

i) Water molecule.

ii) SO_2 molecule

iii) Ammonia molecule

iv) SF_4 molecule.

10) What are the causes of formation of hydrogen bond?

11) What are the conditions for hydrogen bonding?

12) Draw the shapes of following hybrid orbitals.

sp, sp^2,sp^3

13) Considering X- axis as the internuclear axis, which out of the following will not form sigma bond? Why?

1s and 2s b) 1s and 2px c) 2py and 2py d) 1s and 2s

14) Draw the shapes of H_2O and C_2H_4 molecule

15) Describe the change in the hybridization of the Al atom in the following reaction.

$$AlCl_3 + Cl^- \rightarrow AlCl^{4-}$$

16) Is there any change in hybridization of B and N as a result of the reaction?

$$BF_3 + NH_3 \rightarrow BF_3.NH_3$$

17) What are the various forces that arise between the two atoms of hydrogen as they approach each other?

18) Give the ground and exited configuration of carbon for the formation of methane molecule.

19) What is a sigma bond? Mention types.

20) Explain the LCAO method for the formation of molecular orbitals from the atomic orbitals.

21) Distinguish between atomic orbital and molecular orbital.

22) Distinguish between bonding molecular orbital and anti-bonding molecular orbital.

23) Define bond order and give the relationship between bond order and bond length

24) What are the causes of formation of hydrogen bond?

25) What are the conditions for formation of hydrogen bonds?

3 Mark questions

1) Explain the conditions for the combination of atomic orbitals to form molecular orbitals.

2) Write the assumptions of the molecular orbital theory.

3) Explain the diamagnetic behaviour of Hydrogen molecule on the basis of molecular orbital theory.

4) Show the non-existence of helium molecule based on molecular orbital theory.

5) Explain the formation of Lithium molecule on the basis of molecular orbital.

6) Show that oxygen molecule is paramagnetic based on molecular orbital theory.

7) Write the molecular orbital electronic configuration for carbon molecule and comment on its magnetic property

8) Define octet rule. Write its significance and limitations.

9) Explain why crystal structure of NaCl is stable in spite of having sum of electron gain energy and ionization enthalpy as positive. Substantiate with an example

10) Why it is required to take average bond enthalpy in case of polyatomic molecules? Explain with example.

11) Among O_2 and N_2 which is more stable and why?

12) The net dipole moment of NH_3 is greater than that of NF_3. Why?

13) State the postulates of VSEPR theory

14) Indicate the geometry in the following compounds and give one example for each.

i) AB_2

ii) AB_3

iii) AB_4

iv) AB_5

v) AB_6

15) What are the types of hydrogen bonds?

16) What are the salient features of hybridization?

17) With the help of potential energy diagram explain how bonding between two hydrogen atoms takes place.

18) Explain the shape of methane molecule through valence bond theory.

19) Explain the formation of $BeCl_2$ using hybridization.

20) Explain the sp^2 hybridization with the example of BCl_3.

21) Explain the shape of NH_3 molecule using hybridization.

22) Explain the formation of SF_6 using sp^3d^2 hybridization.

1mark Answers:

1). Ans**:** Kossel and Lewis

2). Ans: The attractive force which holds various constituents (atoms or ions etc) together in different chemical species is called a chemical bond

3). **Ans**:

$_{12}Mg=1s^2 2s^2 2p^6 3s^2$

$_{11}Na= 1s^2 2s^2 2p^6 3s^1$

$_{5}B=1s^2 2s^2 2p^1$

$_{8}O = 1s^2 2s^2 2p^6$

$_{7}N =1s^2 2s^2 2p^3$

$_{35}Br =1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

4). **Ans:** Refer to pages 99 and 100

5) **Ans:** Halogens

6) **Ans:** Alkali metals

7) **Ans:** The general electronic configuration of noble gases is ns^2np^6

8) **Ans:** Electrovalent bond

9) **Ans:** Electrostatic force or coulombic force.

10) **Ans:** $\mathbf{NH_4^+}$ in NH_4Cl

11) **Ans: Resonance** stabilizes the molecule as the energy of the resonance hybrid is less than the energy of any single canonical structure.

12) **Ans:** $\mu=Q\times\Upsilon$

Dipole moment=charge×distance

13) **Ans:** Valence shell electron pair repulsion

14) **Ans:** Based on repulsive interactions between valence electron pairs in a molecule.

15) **Ans:** Bond pair-bond pair < bond pair-lone pair < lone pair-lone pair.

16) **Ans:** The localized pair of valence electrons over the central atom of a molecule which do not take part in covalent bond formation

. 17) **Ans:** The pair of electron shared between two atoms in a molecule.

18) **Ans:** Lone pair.

19) **Ans:** One lone pair.

20) **Ans:** Two lone pair.

21) **Ans:** Two lone pair.

22) **Ans:** One lone pair

23) **Ans:** The process of intermixing of atomic orbitals of different energies to get same number of new orbitals of equivalent energies is called hybridization

24) **Ans:** Linear shape, bond angle-180^0

25) **Ans:** $BeCl_2$

26) **Ans:** 50%

27) **Ans:** Shape-trigonal planar, bond angle-120^0

28) **Ans:** 25 %

29) **Ans:** BCl_3 - sp^2

CH_4 – sp^3

30) **Ans:** Shape: regular tetrahedron

Bond angle: $109^0\ 28'$

31) **Ans:** a) NH_3
Shape: Pyramidal
Hybridization: sp^3
Bond angle: 107^o

b) H_2O
Shape: V shape or angular shape
Hybridization: sp^3
Bond angle: 104.5^o

32) **Ans:** Ethylene σ bond = 5, π bond = 1
Ethyne σ bond = 3, π bond = 2

33) **Ans:** sp^3d hybridization

34) **Ans:** Shape – Octahedral
Hybridization – sp^3d^2

35) **Ans:** Axial bond – 2
Equatorial bond -3

36) **Ans:** $[PtCl_4]^{2-}$

37) **Ans:** Square pyramidal

38) **Ans:** $Sp^3<sp^2<sp$

39) **Ans:** Hydrogen bond is defined as the attractive force which binds hydrogen atom of one molecule with the electronegative atom (F, O or N) of another molecule.

40) **Ans:** It is maximum in solid state and minimum in the gaseous state.

41) **Ans:** Repulsive

42) **Ans:** Attractive

43) **Ans:** The energy released when a bond is formed between two atoms is called bond enthalpy.

44) **Ans:** Opposite

45) **Ans:** More overlap

46) **Ans:** 1s

47) **Ans:** $109^0 28'$

48) **Ans:** Positive, negative, zero

49) **Ans:** Positive

50) **Ans:** When atomic orbitals overlap there is release in energy, this energy is used to change the electronic configuration

51) **Ans:** 90^0

52) **Ans:** Sigma and pi

53) **Ans:** It is a type of covalent bond formed due to overlap of atomic orbitals side ways.

54) **Ans:** A pi electron cloud consists of two saucer shaped clouds above and below the plane of participating atoms.

55) **Ans:** No

56) **Ans:** Sigma bonds.

57) **Ans:** Hydrogen bond is defined as the attractive force which binds hydrogen atom of one molecule with the electronegative atom (F, O or N) of same molecule or another molecule.

2 Marks answers

1) **Ans**: Non-metallic elements have high electron gain enthalpy to form anions which is produced in the process

$Cl\ (g) + e^{-1} \rightarrow Cl^-_{(g)}$ $\Delta H = 348.7 kJmol^{-1}$

2) **Ans**: Metallic elements have low ionization energy which facilitates the easy release of electrons from the metal and formation of cation is

$Na \rightarrow Na^+ + e^-$

3) **Ans**: NaCl is more stable than KCl.
Lattice energy of NaCl (788KJ/mol) greater than lattice energy of KCl (718KJ/mol) because smaller ionic radius of Na^+ (95pm) when compared to K^+ (133pm).

4)**Ans**: According to the concept of resonance, whenever a single Lewis structure cannot describe a molecule accurately, a number of structures with similar energy, positions of nuclei, bonding and nonbonding pairs of electrons are taken as the canonical structures and the hybrid describes the molecule accurately.

5) **Ans:** In BF_3 $\mu = 0$, although the B-F bonds are oriented at an angle of $120^0$to one another. This is because the bond moments give a net sum of zero as the resultant of any two is equal and opposite of third.

6)**Ans:** In case of NH_3 the 0rbital dipole due to lone pair of electron on nitrogen atom , is in the same direction as the resultant dipole moment of N-H bonds, where as in NF_3, it is in the direction opposite to resultant dipole moment of 3 N-F bonds. The orbital dipole decreases the effect of the resultant N-F bond moments which reduces dipole moment of NF_3.

7) **Ans**: For the resonance structures of CO_3^{2-} and CO_2 refer to page no 106(Part-1)

8) **Ans:** a) Deviation in the shape of the molecule
b) Alterations in the bond angle in the molecule.

9) **Ans:** i) Water molecule belongs to type of AB_2E_2
The shape of water molecule should have been tetrahedral if there were all bond pair. But because of the presence of two lone pair, the shape is distorted tetrahedral or angular. The reason is lp-lp repulsion is more than bp-bp repulsion. Thus the angle is reduced to 104.5^0 from 109.5^0.
Refer to page no 112 for structure.

ii) SO_2 molecule
SO_2 molecule belongs to AB_2E
The shape of SO_2 molecule should have been triangular planar but it is found to be bent or V-shaped .This is due to the fact that lp-bp repulsion is much more than bp-bp repulsion. So the angle is reduced to 119.5^0 from 120^0.

iii) Ammonia molecule
Ammonia molecule belong to AB_3E type

The shape of NH_3 molecule should have been tetrahedral if all the electrons were bond pair. But because of the presence of one lp,ther is lp-bp repulsion which is more than bp-bp repulsion and the angle is reduced from 107^0 to 104.5^0.

iv) SF_4 molecule.

SF_4 molecule belongs to AB_4E type.

The shape of SF_4 molecule is distorted tetrahedron or a folded square or a see- saw in which the lp is in an equatorial position where there are only two lp-bp repulsions. This arrangement is more stable than the arrangement where the lp is present at axial position where there are three lp-bp repulsions at 90^0.

10) **Ans:** When there is formation of covalent bond between hydrogen and electronegative elements, the electrons of the covalent bond are shifted towards more electronegative atom as of which the positively charged hydrogen forms a bond with the other electronegative atom .

11) **Ans:** a) Hydrogen atom should be bonded to highly electronegative atoms such as fluorine, oxygen or nitrogen.

b) Size of the electronegative atoms should be small.

12) **Ans:** sp – Refer to page 117,fig 4.10

sp^2 – Refer to page 117, fig 4.11

sp^3 – Refer to page 118, fig 4.12

13) **Ans:** $2p_y$ and $2p_y$ will not form a sigma bond because taking x- axis as the internuclear axis, there will be lateral overlapping between 2py orbitals forming a pi bond.

14) **Ans:** For H_2O refer page 118, fig 4.14 and for C_2H_4 refer page 119, Fig 4.15

15) **Ans:** Electronic configuration of Al = $1s^2 2s^2 2p^6 3s^2 3p^2$

Exited state configuration is $1s^2 2s^2 2p^6 3s^1 3px^1 3py^1$

Hence hybridization is sp^2

In $AlCl^{4-}$ empty 3pz orbital is also involved so the hybridization is sp^3 and shape is tetrahedral.

16) **Ans:** In BF_3, B atom is sp^2 hybridized. In NH_3, N atom is sp^3 hybridized. After the reaction hybridization changes from sp^2 to sp^3.

17) **Ans:** a) Attractive force between nucleus and its own electron.

b) Attractive force between nucleus and electron of other atom

c) Repulsive force between the two nuclei

d) Repulsive force between two electrons.

18) **Ans:** Ground state [He] $2s^2 2p^2$

Excited state [He] $2s^1 2px^1 2py^1 2pz^1$

19) **Ans:** This type of covalent bond is formed by the head on overlap of atomic orbitals along the internuclear axis. The sigma bonds result from the following types of overlap

a) s-s b) s-p c) p-p

20) **Ans:** The molecular orbitals are formed by the linear combination of wave functions of the participating atomic orbitals. They may combine either by addition or by

subtraction. Let ψ_A and ψ_B represent the wave functions of the two combining atomic orbitals A and B taking part in chemical combination.

21) **Ans:** Atomic orbitals

1. Atomic orbitals are monocentric.

2. Atomic orbitals have simple shapes like spherical or dumb-bell.

Molecular orbitals

1. Molecular orbitals are polycentric.

2. Molecular orbitals have complex shapes.

22) **Ans:** Bonding molecular orbitals

1. Formed by symmetric combination of atomic orbitals.

2. Has more electron density between the nuclei.

Antibonding molecular orbitals.

1. Formed by asymmetric combination of atomic orbitals.

2. Has less electron density between the nuclei.

23) **Ans:** It is half of the difference between the number of electrons present in bonding molecular orbitals and the number of electrons present in the antibonding molecular orbitals.

Bond order=Number of electrons in B.M.O-Number of electrons in A.B.M.O/2

24) **Ans:** When there is formation of covalent bond between hydrogen and electronegative elements, the electrons of the covalent bond are shifted towards more electronegative atom which makes the hydrogen atom positive and it forms the hydrogen bond with other electronegative atom.

25) **Ans:** The conditions are

a) Hydrogen atom should be bonded to a highly electronegative atom such as F, O or N

b) Size of the electronegative atoms should be small.

3 Mark answers

1) **Ans**: The conditions for the combination of atomic orbitals to form molecular orbitals are
1. The combining atomic orbitals must have same or nearly the same energy.

2. The combining atomic orbitals must have the same symmetry about the molecular axis.
3. The combining atomic orbitals must overlap to the maximum extent.

2) **Ans:** The assumptions of the molecular orbital theory are

1. The molecular orbital is the region in space comprising the nuclei of the combining atoms around which there is maximum probability of finding electron density.
2. The number of molecular orbitals formed is equal to the number of atomic orbitals taking part in the combination.
3. When two atomic orbitals combine according to L.C.A.O. principle, they form two molecular orbitals i.e. bonding and antibonding.
4. The bonding molecular orbital has lower energy (more stability) as compared to antibonding molecular orbital.

3) **Ans:** It is formed by the combination of the two hydrogen atoms.
Each hydrogen atom has one electron in 1s orbital.
Hence there are two electrons in Hydrogen molecule.
The molecular orbital configuration is $\sigma\ 1s^2$
The bond order is calculated as follows

Bond order = $N_b - N_a/2$
= 2-0/2
=1

Hydrogen molecule is diamagnetic since there is no unpaired electron.

4) **Ans:** It is formed by the combination of the two helium atoms.
Each helium atom has two electrons in 1s orbital.
Hence there are four electrons in Helium molecule.
The molecular orbital configuration is $\sigma\ 1s^2, \sigma\ *1s^2$
The bond order is calculated as follows

Bond order = $N_b - N_a/2$
=2-2/2
=0

Helium molecule is unstable and does not exist.

5) **Ans:** It is formed by the combination of the two Lithium atoms.
Each Lithium atom has three electrons and its electronic configuration is $1s^2\ 2s^1$
Hence there are two electrons in Hydrogen molecule.
The molecular orbital configuration is $\sigma\ 1s^2\ \sigma\ *1s^2\ \sigma\ 2s^2$

The bond order is calculated as follows

Bond order = $N_b - N_a/2$
= 4-2/2
=1

Lithium molecule is diamagnetic since there is no unpaired electron.

6) **Ans:** It is formed by the combination of the two oxygen atoms.
Each oxygen atom has eight electrons and its electronic configuration is $1s^2, 2s^2, 2p_x^2, 2p_y^1, 2p_z^1$.
Hence there are 16 electrons in oxygen molecule.
The molecular orbital configuration is
$\sigma 1s^2, \sigma *1s^2, \sigma 2s^2, \sigma *2s^2, \sigma 2pz^2, \pi 2px^2 = \pi 2py^2, \pi *2px^1 = \pi *2py^1$

The bond order is calculated as follows

Bond order = $N_b - N_a/2$
$= 10-6/2$
$= 2$

Oxygen molecule is paramagnetic since there are unpaired electrons.

7) **Ans:** It is formed by the combination of the two carbon atoms.
Each carbon atom has six electrons and its electronic configuration is
$1s^2, 2s^2, 2p_x^1, 2p_y^1$.
Hence there are 12 electrons in carbon molecule.
The molecular orbital configuration is
$\sigma 1s^2 \sigma *1s^2 \sigma 2s^2 \sigma *2s^2 \pi 2px^2 = \pi 2py^2$

The bond order is calculated as follows

Bond order = $N_b - N_a/2$
$= 8-4/2$
$= 2$

Carbon molecule is diamagnetic since there no unpaired electrons.

8) **Ans:** Octet rule: Atoms can combine either by transfer of valence electrons from one atom to another (gaining or losing) or by sharing of electron in order to acquire stable gas configuration.
Significance: It helps to explain why different atoms combine with each other to form ionic compounds or covalent compounds.
Limitations:
1) 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.
2) The theory does not account for shape of molecule.

9) **Ans:** It is because energy released during the formation of crystal lattice (lattice energy) is greater than the sum of electron gain enthalpy and ionization enthalpy.
Example: In NaCl
Ionization enthalpy
$Na\,(g) \rightarrow Na^+ + e^{-1}$ $\Delta H_I = 495.8 kJmol^{-1}$
Electron gain enthalpy
$Cl\,(g) + e^{-1} \rightarrow Cl^-_{(g)}$ $\Delta H_E = 348.7 kJmol^{-1}$

Therefore $Na(g) + Cl(g) \rightarrow Na^+ + Cl^-$ $\Delta H = 147.1 kJmol^{-1}$

This is compensated by the lattice energy of NaCl

$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$ $\Delta H = -788\ kJmol^{-1}$

Thus stability of ionic compound is due to enthalpy of lattice formation not just by octet ionic species in gaseous state.

10) **Ans:** In polyatomic molecules the enthalpy required to break the same bond in different chemical environment are different.

Example: $H_2O(g) \rightarrow H(g) + OH(g)$ $\Delta H_1 = 502\ kJmol^{-1}$

$OH_{(g)} \rightarrow H_{(g)} + O_{(g)}$ $\Delta H_2 = 427\ kJmol^{-1}$

Average bond enthalpy is $502+427/2 = 464.5\ Kjmol^{-1}$

11) **Ans**:

	Bond order	bond length	bond dissociation enthalpy
$N_2 \rightarrow N \equiv N$	3	110nm	945 $kJmol^{-1}$
$O_2 \rightarrow O=O$	2	121nm	498 $kJmol^{-1}$

Greater the bond order, bond enthalpy (energy required to break the bond) increases, bond length decreases. Hence stability of the molecule increases. Thus N_2 is more stable than O_2.

12) **Ans:** In case of NH_3 the orbital dipole due to lone pair of electrons on N atom , is in the same direction as the resultant dipole moment of N-H bonds, whereas in NF_3 it is in the direction opposite to resultant dipole moment of three N-F bonds. The orbital dipole decreases the effect of the resultant N-F bond moments which reduces μ of NF_3.

13) **Ans:** a) The shape of the molecule depends upon the number of valence shell electron pairs (bonded or non bonded) around the central atom.

b) Pairs of electrons in the valence shell repel one another since their electron clouds are negatively charged.

c) These pairs of electrons tend to occupy such positions in space that minimize repulsion and thus maximize distance between them.

d) The valence shell is taken as a sphere with the electron pairs localizing on the spherical surface at maximum distance from one another.

e) A multiple bond is treated as if it is a single electron pair and the two or three electron pairs of a multiple bond are treated as a single super pair.

f) Where two or more resonance structure can represent a molecule, the VSEPR model is applicable to any such structure.

14) **Ans:** a) AB_2

Linear geometry, Ex: $BeCl_2$

b) AB_3

Trigonal planar geometry, Ex: BF_3

c) AB_4

Tetrahedral geometry, Ex: CH_4

d) AB_5

Trigonal bipyramidal geometry, Ex: PCl_5

e) AB_6

Octahedral geometry, Ex: SF_6.

15) **Ans:** There are two types of hydrogen bonds

Intermolecular hydrogen bond: It is formed between two different molecules of the same or different molecules of the same or different compounds.

Example: HF, H2O, Alcohols

Intramolecular hydrogen bond: It is formed when hydrogen atom is in between the two highly electronegative atoms present within the same molecule.

Example: O-nitrophenol.

16) **Ans:** a) The number of hybrid orbitals is equal to the number of atomic orbitals undergoing hybridization.

b) The hybridized orbitals are always equivalent in energy and shape

c) Hybrid orbitals are more effective in forming stable bonds than pure atomic orbitals

d) Type of hybridization indicates the geometry of the molecule

e) The orbitals in the valence shell of atom are hybridized

f) The orbitals undergoing hybridization should have comparable energy.

g) Not only half filled orbitals but filled orbitals also take part in hybridization

17) **Ans:** When two atoms approach each other, a number of attractive and repulsive forces operate. Experimentally it has been found that attractive forces have greater magnitude and hence the atoms come closer together. A point is reached here net attractive force balances net repulsive force and potential energy reaches a minimum. At this stage the atoms are said to be bonded. Refer fig 4.8, pg: 114

18).**Ans:** In the formation of methane molecule the unpaired electrons in each of the orbital s of carbon pair up with electron in 1s of hydrogen, resulting in formation of 4 C-H bonds. As the angle between p-orbitals is 90^0 the H-C-H bond angle should also be 90^0 and as 1s orbital is spherical the overlap can occur in any direction and direction of fourth C-H bond cannot be ascertained but CH_4 has a tetrahedral structure hence simple atomic overlap cannot explain the tetrahedral shape of methane.

19) **Ans:** The ground state electronic configuration of Be is $1s^2 2s^2$. In the exited state one of the 2s-electrons is promoted to vacant 2p orbital to account for its bivalency. One 2s and one 2p orbitals get hybridized to form two sp hybridized orbitals. These two sp hybrid orbitals are oriented in opposite direction forming an angle of 180^o. Each of the sp hybridized orbital overlaps with the 2p- orbital of chlorine axially and form two Be-Cl sigma bonds. Ref Pg 117 , Fig 4.10 (b).

20).**Ans:** In BCl_3 molecule, the ground state electronic configuration of central boron atom is $1s^2 2s^2 2p^1$. In the exited state, one of the 2s electrons is promoted to vacant 2p orbital as a result boron has three unpaired electrons. These 3 orbitals (one 2s and two 2p) hybridized to form three sp^2 hybrid orbitals. The three hybrid orbitals so formed are oriented in a trigonal planar arrangement and overlap with 2p orbitals of chlorine to form three B – Cl bonds. Therefore, in BCl_3, the geometry is trigonal planar with Cl-B-Cl bond angle of 120^0. Ref pg 117, Fig 4.11.

21) **Ans:** In ammonia, the valence shell electronic configuration of N in the ground state is $2s^2 2p_x^1 2p_y^1 2p_z^1$ having three unpaired electrons in the sp^3 hybrid orbitals and a lone pair of electrons is present in the fourth one. These 3 hybrid orbitals overlap with 1s

orbitals of hydrogen atoms to form 3 N-H sigma bonds. Force of repulsion between a lone pair and a bond pair is more than the force of repulsion between two bond pairs of electrons. The molecules thus get distorted and the bond angle is reduced to 107^0 from 109.5^0. The geometry of such a molecule will be pyramidal and can be explained with sp^3 hybridization. Ref Pg 118, Fig 4.13.

22).**Ans:** In SF_6 the central sulphur atom has the ground state outer electronic configuration of $3s^2 3p^4$. In the exited state the available 6 orbitals i.e., 1s, 3p and 2d are singly occupied by electrons. These orbitals hybridise to form 6 new sp^3d^2 hybrid orbitals, which are projected towards the 6 corners of a regular octahedron in SF_6. These 6 sp^3d^2 hybrid orbitals overlap with singly occupied orbitals of Fluorine atoms to form 6 S-F sigma bonds. Thus it has regular octahedron shape. Ref pg121, Fig 4.18