VBT & VSEPR Theory.

Teaching Task

Q1) Ans:- D.

Solution:-

→ XeF_2 ⟶ 3 lone pairs.

→ XeF_4 ⟶ 2 lone pairs.

→ XeF_6 ⟶ 1 lone pair.

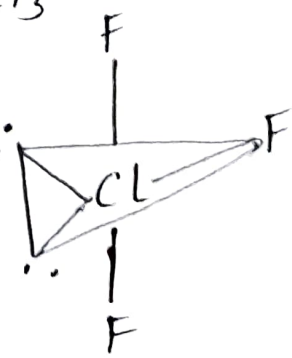
Q2) Ans:- A

Solution:- The bond angle of H_2O is $104°30'$ [$< 109.5°$ Expected]

→ The expected bond angle of F_2O is $< 109.5°$ but observed angle is $103°$ because of 'F' high Electronegativity

Q3) Ans:- C

Solution:- The molecular geometry of ClF_3 is said to be T-shaped. ClF_3 acquires such a shape because 2 lone pairs take up equatorial positions as they require more space & greater repulsion. They are arranged in trigonal bipyramidal shape with 3 bonds & 2 lone pairs.



Q4) Ans:- B

Solution:- Tetrahedral, see-saw, and trigonal bipyramidal are the forms of PCl_4^+, PCl_4^- & $AsCl_5$ respectively.

Q5) Ans:- B.

Solution:-

→ There are 12 F-S-F 90° bond angles.

→ S in SF_6 has an expanded octet. The sulphur have 12 electrons in SF_6.

Q6) Ans:- A

Solution:- The central iodine atom undergoes sp^3d hybridization and has 3 lone pairs of electrons and 2 bond pair of electrons.

Thus, I_3^- has trigonal bipyramidal geometry & linear shape.

Q7) Ans:- D.

Solution:-

→ SF_4 is square pyramid due to one lone pair of S.

→ CF_4 has tetrahedral geometry.

→ XeF_4 has square planar structure with 2 lone pairs of Xe.

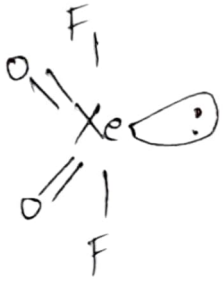
Q8) Ans:- C

Solution:

A) $XeOF_4$

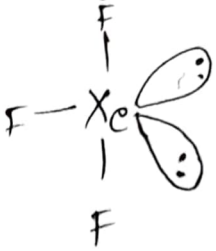
lone pair → 1

B) XeO_2F_2



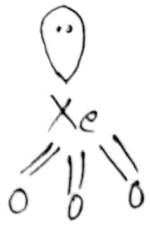
Lone pair - 1.

C) XeF_3^-



Lone pairs → 2.

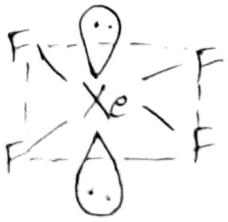
D) XeO_3



Q9) Ans:- C.

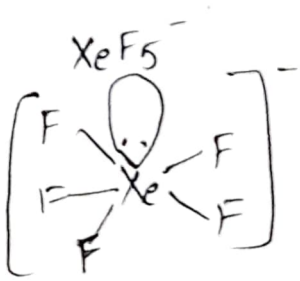
Solution:

XeF_4.

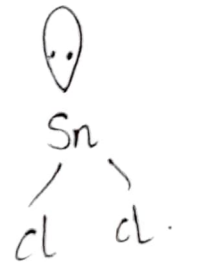


Square planar.

XeF_5^-



Pentagonal planar.

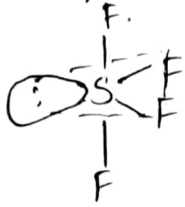


(angular)

Q10) Ans:- B.

Solution:-

A) XeF_4 → 4 bond pairs & 2 lone pairs.

B) SF_4 →  → 4 bond pairs & 1 lone pair.

C) XeF_3^- → 3 bond pairs & 2 lone pairs.

D) XeO_3 → 6 bond pairs & 1 lone pair.

Multiple Correct Answer Type

Q11) Ans:- A,D

Solution:-

A) $XeOF_2$ → Trigonal bipyramidal.

B) ICl_4^- → Square planar.

C) $[SbF_5]^{2-}$ → Square pyramidal.

D) NH_2^- → Bent shape.

Q12) Ans:- A,B,D.

Solution:-

A) BrF_6^+ → Octahedral.

B) $SnCl_5^-$ → Trigonal bipyramidal.

D) IF_4^+ → See-saw.

Q13) Ans:- C.

Solution:- pi bonds are weaker than sigma bonds.
→ π bonds are formed by sidewise overlap of 2 parallel p orbitals.

Comprehension Type

Q14) Ans:- A.

Solution:- The potential energy of a system decreases during bond formation. In the formation of bond force of attraction are more than force of repulsion, during that time it losses energy.

Q15) Ans:- C.

Solution:- According to valence bond theory (VBT), the 2 electrons in a hydrogen molecule (H_2) have opposite spins (↑↓).

Q16) Ans:- A.

Solution:- The covalent bond formed blw 2 hydrogen atoms is represented by s-s.

1S 1S s-s overlap.

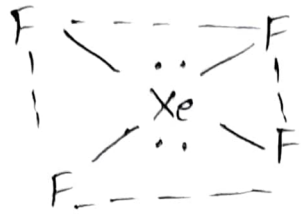
H H H_2.

Q17) Ans:- D

Solution:- AB_4E_2 → 4 bond pairs, 2 lone pairs.

XeF_4 → 4 bond pairs, 2 lone pairs.

Hybridisation → sp^3d^2.



Q18) Ans:- D.

Solution:-

A) CH_4 → 109°28'.

B). NH_3 → 107° 48'.

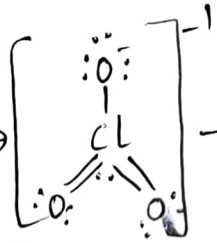
C) H_2O → 104°27'.

D) BeF_2 → 180°. (Maximum bond angle).

Integer Type

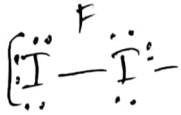
Q19) Ans:- 3.

Solution:-

ClO_3^- →  → 5 bond pairs, 1 lone pair.

XeF_4 →  → 4 bond pairs, 2 lone pairs

SF_4 →  → 4 bond pairs, 1 lone pair.

I_3^- →  → 2 bond pairs, 3 lone pairs.

Q20) Ans:- 3.

Solution:- SO_3^{2-}, ClO_3^- and AsO_3^{3-} are non-planar (pyramidal geometry)

NO_3^-, CO_3^{2-}, BO_3^{3-} are trigonal planar.

Q21) Ans:- 3.

Solution:- No. of lone pairs on S in SF_4 → 1.

No. of lone pair on C in CF_4 → 0.

No. of lone pairs on Xe in XeF_4 → 2.

Total lone pairs = 1+0+2 = 3.

Matrix Matching

Q22) Ans:- A) P B) S C) r D) q.

Solution:-

A) NO_2^+ ⟶ P) 180° (linear).

B) NO_2^- ⟶ S) 115°.

C) NO_2 ⟶ r) 134

D) NO_3^- ⟶ q) 120°.

Learner's Task

Conceptual Understanding Questions

Q1) Ans:- B.

Solution:- The formation of π bond shorten the distance blw two atoms.

Q2) Ans:- D.

Solution:- In the formation of a covalent bond blw 2 atoms results by pairing of electrons present in the valence shell having opposite spins

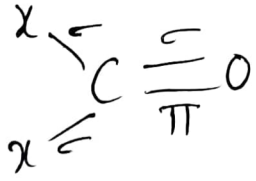
C ⇅ C

Q3) Ans:- C

Solution:- The order of bond energy of subshells in the 2nd orbit is s-s < s-p < p-p.

Q4) Ans:- D.

Solution:-



3- Sigma bonds, 1- π bond.

Q5) Ans:- B.

Solution:- σ bond involves axial overlap, it is directional, it has cylindrical symmetry, hybridised orbitals also involved in σ bond formation

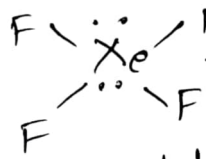
(Q6). Ans:- B.

Solution:- σ bonds are stronger than π bonds because, in 'σ' bonds axial overlapping done. where as in π bonds side wise overlapping.

(Q7) Ans:- C.

Solution:- When 2 atoms with the same spin of electrons approach each other for bonding, orbital overlap will not occur & bonding will not occur because the electrons with samespin violate the Pauli-Exclusion principle & Hund's rule.

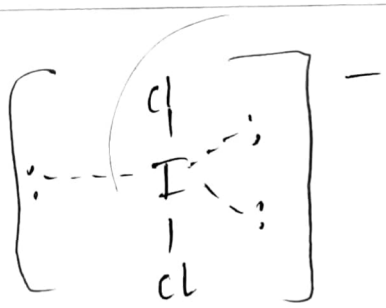
(Q8) Ans:- C.

Solution:- $XeF_4 \longrightarrow$  → Square planar.

The shape of XeF_4 is not dissorted due to presence lone pairs above & below the Xe-the bond pairs are in the equatorial position.

(Q9) Ans:- A.

Solution:-



ICl_2^- has a linear shape with 3 lone pairs of electrons in an equatorial position of trigonal bipyramidal. Thus it has symmetrical repulsions

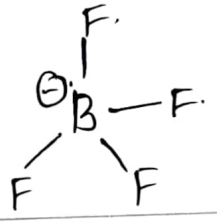
Q10) Ans:- B.

Solution:- The shape of NH_3 is similar to CH_3^- because both have a pyramidal shape. This is because the nitrogen atom in NH_3 & the carbon atom in CH_3^- both have sp^3 hybrization and one lone pair of electrons each.

JEE Main Level Questions

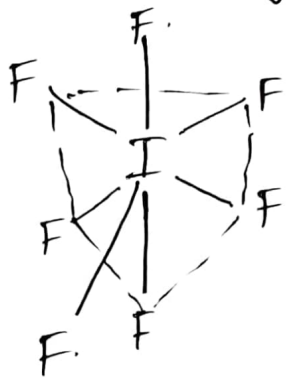
Q1) Ans:- C.

Solution:- BF_4^- has a regular tetrahedral structure.



Q2) Ans:- C

Solution:- IF_7 → Pentagonal bipyramidal shape with bond angle 72°, 90° & 180° (sp^3d^3 hybridisation)



Q3) Ans:- C.

Solution:-

A) CO_3^{2-} & NO_3^- are iso structural → Trigonal shape & bond angle of 120°

B) PCl_4^+ & $SiCl_4$ are both tetrahedral in shape, bond angle 109°, So they are isostructural.

C) PF_5 has trigonal bipyramidal shape.
BrF_5 has square pyramidal shape.

D). AlF_6^{3-} and SF_6 both are octahedral.

Q4) Ans:- A.

Solution:- A 'π' bond is weaker than '←' bond.

→ Double bond is stronger than single bond.

→ Ionic bond is stronger than covalent bond.

Q5) Ans:- B.

Solution:- Covalent bond formed blw electrons are having anti parallel spins.

a) ↑ + ↓ → possible.

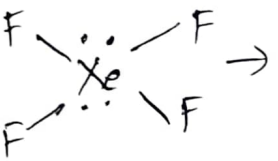
b) ↑ + ↑ → same spin not possible.

c) ↑ + ↑ → Not possible.

d) ↑ + ↑ → Not possible.

Q6). Ans:- C.

Solution:-



→ 4 bond pairs & 2 lone pairs.

Q7) Ans:- C.

Solution:- XY_2

- bonds = 2, lone pair = 1

sp^2 hybridization.

→ Trigonal planar.

Q8) Ans:- D.

Solution:- BF_3, BCl_3, BBr_3

In all these molecules, central atom has sp^2 hybridization, so all have bond angle of 120°C. But due to presence of lone pair on NF_3 & NH_3 they shows lower angle.

Q9) Ans:- B.

Solution:- If an atom has lone pairs & bonded electron pairs, the greater lone pair - lone pair repulsions will cause decrease in bond angle.

B-B < B-L < L-L.

NH_2^- has 2 bond pairs & 2 lone pairs.

NH_3 → 3 bond pairs & 1 lone pair.

NH_4^+ → 4 bond pairs.

NH_4^+ has no lone pairs. So its bond angle is high.

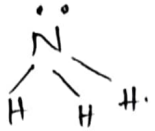
$NH_4^+ > NH_3 > NH_2^-$

Q10) Ans:- B.

Solution:-

1) NH_3 →

Hybridisation = sp^3 → Bond angle 107°48'.



Trigonal pyramidal.

2) H_2S → $\frac{6+2}{2} = \frac{8}{2} = 4$ → sp^3 → Tetrahedral.

Bond angle = 90°.

3) H_2O → sp^3 → 104°27'.

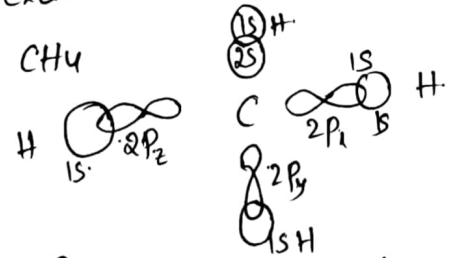
4) CH_4 → sp^3 → 109°28'.

Advanced Level Questions

Q11) Ans:- A, B, D

Solution:- $C = 1s^2 2s^2 2p^2$

Excited state : $2s^1 2p^3$



If 'C' doesnot under go hybridisation

A) The 3 p-orbitals are perpendicular, so the 3 C-H bonds formed by 2p-1s are perpendicular

B) One C-H bond will weaker than remaining 3 bonds

C) The shape of molecule may not be tetrahedral.

D) The angle of C-H bond formed by s-s overlapping will be uncertain w.r.to the other three bonds.

Q12) Ans:- A, C.

Solution:- CO_2 is isostructual with $HgCl_2$ & C_2H_2.

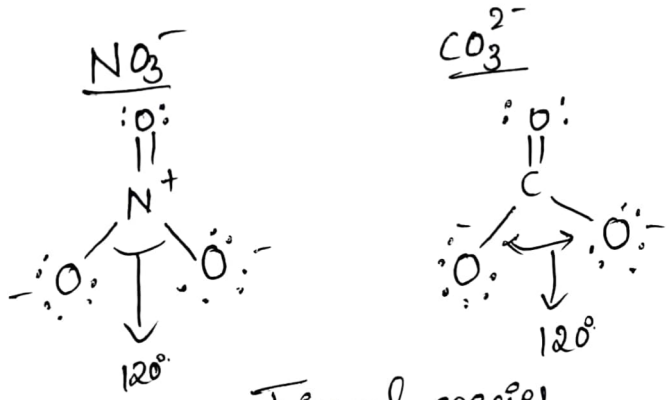
→ O=C=O → Linear, 180°; no lone pairs

→ Cl—Hg—Cl → Linear, 180°; no lone pairs

→ H—C≡C—H → linear, 180°, no lone pairs.

Q13) Ans:- B.

Solution:- NO_3^- and CO_3^{2-} ion both are trigonal planar because repulsions blw oxygen atom is same blw all atoms of oxygen. So they are equally distributed.



Trigonal species.

→ Both same no. of lone pairs i.e, zero

Q14) Ans:- A

Solution:- Bond formation is a exothermic process, meaning releases energy. To get stability atoms lose energy while forming bond.

$$\text{Stablity} \propto \frac{1}{\text{Energy}} \quad (\because \text{Energy released})$$

Q15) Ans:- C

Solution:-

A) H_2 → S-S overlapping.

B) HCl → S-P overlapping.

C) Cl_2 → P-P overlapping.

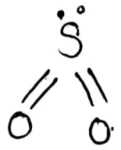
D) NH_3 → S-P over lapping.

Q16) Ans:- B.

Solution:- SO_2 has 2 bond pairs & 1 lone pair.

So it is AB_2E type molecule, bent shape,

sp^2 hybridisation.



Q17) Ans:- B.

Solution:- H_2O → 

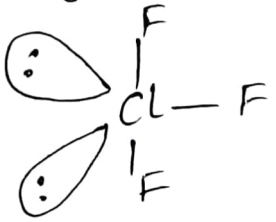
Lone pairs → 2 Bond pairs → 2.

Ratio of lone pairs & Bond pairs = 2 : 2

= 1 : 1

Q18) Ans:- A.

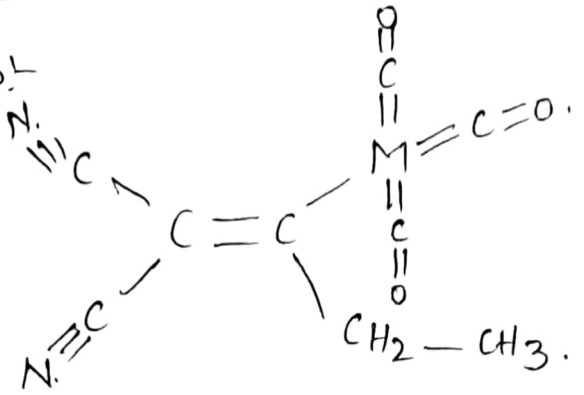
Solution:- ClF_3 → T shape.



Integer Type

(Q19) Ans:- 5

Solution:-



— bonds → 19.

π bonds → 11.

Total → 30 = 5 × 6

= 6x = 6 × 5

x = 5

(Q20) Ans:- 5

Solution:- The molecule ML_x is planar with 7 pairs of electrons around M in the valence shell. There will be 5 bond pairs of electrons & 2 lone pairs. The electron geometry will be pentagonal bipyramidal & molecular geometry will be planar.

5 Bond pairs of electrons will be in one plane & 2 lone pairs of electrons will be opposite to each other, one above the plane & other below the plane. This will minimize the electronic repulsion.

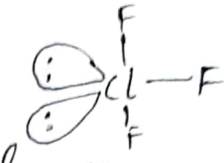
Hence the value of x = 5

Matrix Matching

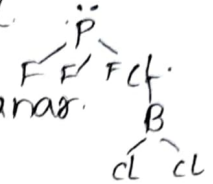
Q21) Ans: A) q B) r C) p D) s

Solution:

A) ClF_3 → q) T-shaped.



B) PF_3 → r) Pyramidal



C) BF_3 → p) Trigonal planar.

D) SF_6 → s) Octahedral.