Exercise-1

Marked questions are recommended for Revision.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Octet rule, Lewis dot structures

A-1. Draw the Lewis structures of the following molecules and ions.
PH_3, H_2S, BeF_2, $SiCl_4$, HCOOH, H_2SO_4, O_2^{2-}, F_2O, C_3^{4-}, S_3^{2-}, NOCl, $SOBr_2$, SO_2Cl_2

A-2. With the help of Lewis dot structure find the number of total covalent bonds formed in the following species.
(i) CO_3^{2-}, (ii) CCl_4, (iii) NF_3

A-3. Indicate what is wrong with each of the following Lewis structures? Replace each with a more acceptable structure.

(a)  (b) (c) (d)

A-4. In how many of the following species, the central atoms have two lone pairs of electrons ?

(i) XeF_4	(ii) XeF_5^-	(iii) F_2SeO_2	(iv) XeF_3^+	(v) $XeOF_4$
(vi) $ClOF_3$	(vii) ICl_4^-	(viii) SCl_2	(ix) OSF_4	

Section (B) : Formal charge & limitations of octet rule

B-1. How many compounds violate octet rule ?

(i) CO_2	(ii) PCl_5	(iii) SiF_4	(iv) BrF_5
(v) IF_7	(vi) PCl_3	(vii) H_2SO_4	(viii) BF_3

B-2. Write the reason for the violation of octet rule by various molecules?
BCl_3, XeF_2, NO, IF_7, NO_2, ClF_3, ClO_2

Section (C) : Resonance and Bond order Calculation

C-1. Write down the resonance structure(s) for :
(i) SO_4^{2-} (ii) CH_3COO^- (iii) HCO_3^- (iv) NO_3^- (v) PO_4^{3-}
Also calculate average bond order of M–O bond in these compounds.
Where M is central atom (And M–O bonds considered are the one which involve delocalization)

C-2. How many types of N–O bondlengths are present in (a) HNO_3 (b) NO_3^- ?

C-3. Explain the following :
C–O bond lengths in formic acid are 1.23 Å & 1.36 Å and both the C–O bond lengths in sodium formate have same value 1.27 Å.

C-4. Compare bond length of S–O bond in SO_3^{2-} and HSO_3^-.

Section (D) : VBT, Overlapping of orbitals

D-1. Find number of sigma bonds and pi bonds in $CH_2=C=C=CH_2$.

D-2. Draw the type of overlaps between

(a) s and p_x	(b) p_x and p_x	(c) p_y and p_y	(d) p_z and p_z
(e) s and d_{z^2}	(f) s and $d_{x^2-y^2}$	(g) s and d_{yz}	(h) p_z and d_{z^2}
(i) p_z and d_{xy}	(j) p_x and d_{xy}	(k) p_x and d_{z^2}	(l) p_x and $d_{x^2-y^2}$
(m) $d_{x^2-y^2}$ and $d_{x^2-y^2}$	(n) d_{xy} and d_{xy}	(o) d_{xy} and d_{yz}	

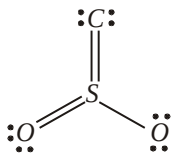
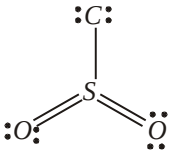
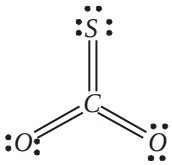
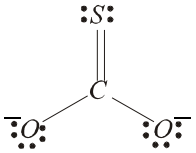
if internuclear axis is z-axis. Identify them as σ, π, δ bond wherever bond is formed.

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Octet rule, Lewis dot structures

A-1. Among the following which property is commonly exhibited by a covalent molecule
(A) High solubility in water (B) High electrical conductance
(C) Low boiling point (D) High melting point

A-2. The possible structure of monothiocarbonate ion is :

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

A-3. Which one is the electron deficient compound :
(A) ICl (B) NH_3 (C) BCl_3 (D) PCl_3

Section (B) : Formal charge & limitations of octet rule

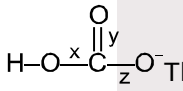
B-1. The octet rule is not obeyed in :
(A) CO_2 (B) BCl_3 (C) PCl_5 (D) (B) and (C) both

B-2. Pick out among the following species isoelectronic with CO_2.
(A) N_3^- (B) $(CNO)^-$ (C) $(NCN)^{2-}$ (D) All of these

B-3. To which of the following species is the octet rule applicable ?
(A) BrF_5 (B) SF_6 (C) IF_7 (D) CO_2

Section (C) : Resonance and Bond order Calculation

C-1. The average charge on each O atom and average bond order of I–O bond in IO_6^{5-} is :
(A) –1 and 1.67 (B) – 5/6 and 1.67 (C) –5/6 and 1.33 (D) –5/6 and 1.167

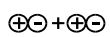
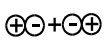
C-2.  The relation between x, y and z in bicarbonate ion with respect to bond length is -
(A) x > y > z (B) x > z > y (C) z = y > x (D) x > y = z

C-3. Average bond order of C–C bond in C_6H_6 is
(A) 1 (B) 2 (C) 1.5 (D) 1.33

C-4. Among the species, which has the weakest carbon- oxygen bond :
(A) CO_2 (B) CH_3COO^- (C) CO (D) CO_3^{2-}

Section (D) : VBT, Overlapping of orbitals

D-1. Which of the following overlaps is **<u>incorrect</u>** [assuming z-axis to be the internuclear axis] ?
(a) $2p_y + 2p_y \rightarrow \pi 2p_y$ (b) $2p_z + 2p_z \rightarrow \sigma 2p_z$ (c) $2p_x + 2p_x \rightarrow \pi 2p_x$ (d) $1s + 2p_y \rightarrow \pi(1s-2p_y)$
(A) 'a' & 'b' (B) 'b' & 'd' (C) only 'd' (D) None of these

D-2. Effective overlapping will be shown by :
(A)  (B)  (C)  (D) All the above

D-3. Indicate the wrong statement according to Valence bond theory :
(A) A sigma bond is stronger then π-bond
(B) p-orbitals always have only sidewise overlapping
(C) s-orbitals never form π-bonds
(D) There can be only one sigma bond between two atoms

D-4. C_3^{4-} has :
(A) two σ and two π-bond (B) three σ and one π-bond
(C) two σ and one π-bond (D) two σ and three π-bond

D-5. Which of the following is not correct____
(A) A sigma bond is weaker than π-bond
(B) A sigma bond is stronger than π-bond
(C) A double bond is stronger than a single bond
(D) A double bond is shorter than a single bond

PART - III : MATCH THE COLUMN

1. Match the column

	Column-I		**Column-II**
	Molecule/ion		**Number of σ bonds**
(A)	C_2^{-2}	(p)	5
(B)	C_2H_2	(q)	1
(C)	CH_3OH	(r)	3
(D)	HNO_3	(s)	4

Exercise-2

Marked questions are recommended for Revision.

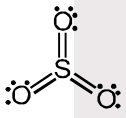
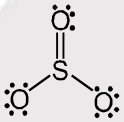
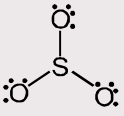
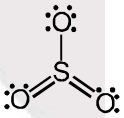
PART - I : ONLY ONE OPTION CORRECT TYPE

1. In NO_3^- ion, The number of bond pair and lone pair of electrons present on Nitrozen atom are :
(A) 2,2 (B) 3,1 (C) 1,3 (D) 4,0

2. How many bonded electron pairs are present in IF_7 molecule?
(A) 6 (B) 7 (C) 5 (D) None of these

3. Which of the following is the electron deficient molecule?
(A) C_2H_6 (B) SiH_4 (C) PH_3 (D) $BeCl_2$ (g)

4. Which is not an exception to the octet rule?
(A) BF_3 (B) $SnCl_4$ (C) XeF_6 (D) ClO_3

5. Which of the following structure is the most preferred structure for SO_3 ?
(A)  (B)  (C)  (D) 

6. For hydrazoic acid, which of the following resonating structure will be least stable?
$H - N = N^+ = N^- \longleftrightarrow H - N^+ - N^+ = N^{2-} \longleftrightarrow H - N^- - N^+ \equiv N$
(I) (II) (III)
(A) I (B) II (C) III (D) Both (I) and (III)

7. What is correct order of bond order of Cl–O bond.
(A) $ClO_4^- > ClO_3^- > ClO_2^- > ClO^-$ (B) $ClO^- < ClO_2^- > ClO_3^- < ClO_4^-$
(C) $ClO_3^- < ClO_2^- < ClO_4^- < ClO^-$ (D) $ClO_2^- < ClP_3^- < ClO_4^- < ClO^-$

8. Which of the following statements is not correct for sigma and pi bond formed between two carbon atoms?
(A) Free rotation of atoms about a sigma - bond is allowed but not in case of a pi-bond
(B) Sigma -bond determines the direction between carbon atoms but a pi-bond has no primary effect in this regard
(C) Sigma-bond is stronger than a pi-bond
(D) Bond energies of sigma- and pi-bonds are of the order of 264 kJ/mol and 347 kJ/mol. respectively.

9. Number and type of bonds between two carbon atoms in CaC_2 are :
(A) one sigma (σ) and one pi (π) bond (B) one σ and two π bonds
(C) one σ and one and a half π bond (D) one σ bond

10. The number of σ and π bonds in dicyanogen $(CN)_2$ are :
(A) $2\sigma + 3\pi$ (B) $3\sigma + 2\pi$ (C) $3\sigma + 4\pi$ (D) $4\sigma + 3\pi$

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. In OF_2 number of bond pairs of electrons are :

2. How many of the following molecules the central atom is surrounded by atleast 10 electrons.
(i) ClO_2 (ii) NO_3^- (iii) O_3 (iv) PCl_5
(v) SO_3 (vi) SO_4^{2-} (vii) CO_2 (viii) N_3^-
(ix) I_3^-

3. Number of molecule or ions having lone pairs ≥ 2 for central atom are :
(i) $HClO_4$ (ii) $HClO_3$ (iii) $HClO_2$ (iv) H_2O
(v) NH_2^{-1} (vi) ClF_3 (vii) XeF_2 (viii) XeF_4
(ix) XeF_6 (x) I_3^{-1} (xi) N_3^{-1} (xii) O_3
(xiii) ICl_4^- (xiv) ICl_2^+ (xv) XeO_3 (xvi) XeF_5^{-1}

4. Total no. of resonating structure in CO_3^{2-} are :

5. Compound SO_3 has x bond pairs and y lone pairs. Calculate value of x + y.

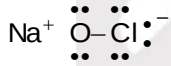
6. Find the number of molecule having two lone pairs on central atom.
(i) I_3^+ (ii) XeF_2 (iii) XeF_4 (iv) H_2O
(v) NH_2^- (vi) H_2S (vii) H_2SO_4 (viii) NF_3

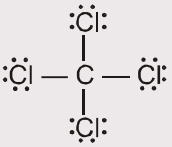
7. Consider y-axis as internuclear axis, how many of following will lead to π bond formation :
(i) $p_y - p_y$ (ii) $p_x - p_x$ (iii) $p_z - p_z$ (iv) $d_{xy} - d_{xy}$
(v) $d_{yz} - d_{yz}$ (vi) $p_x - d_{xy}$ (vii) $d_{xy} - p_z$ (viii) $d_{xz} - d_{xz}$

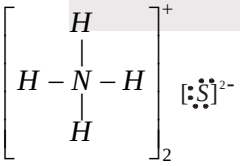
PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

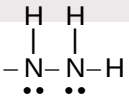
1. Find the correct statements regarding SO_4^{-2}.
(A) Bond order of S–O bond is 1.5 (B) Bond order of S–O bond is 2.5
(C) It violates Octet Rule. (D) All S–O bonds are equivalent.

2. Which of the following Lewis diagram is/are incorrect ?

(A) 

(B) 

(C) 

(D) 

3. Which are the exceptions of the lewis octet rule.
(A) NO_3^- and N_2O (B) BeH_2 and NO
(C) KrF_2 and ClF_3 (D) All of these

4. Which species have same bond order ?
(A) CO_3^{-2} (B) NO_3^- (C) NO_2 (D) NO

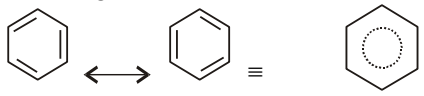
PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

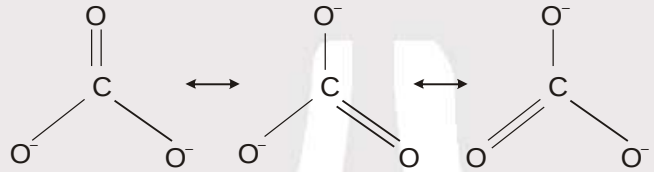
Definition: Resonance may be defined as the phenomenon in which two or more structures involving in identical position of atom, can be written for a particular compound.

Resonance hybrid: It is the actual structure of all different possible structures that can be written for the molecule without violating the rules of covalence maxima for the atoms.



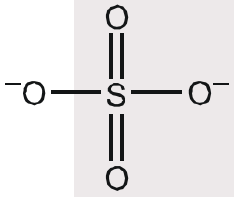
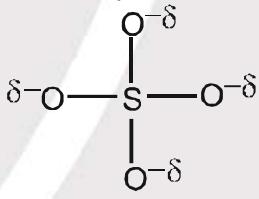
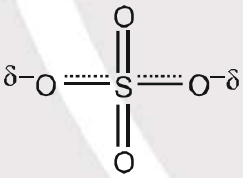
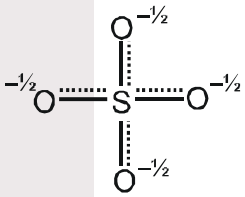
Resonance hybrid

- Bond order = $\frac{\text{Total No. of bonds formed between two atoms in all structures}}{\text{Total No. of resonating structures}}$

e.g.,  Bond order = $\frac{2+1+1}{3} = 1.33$

- Resonance energy = Actual bond energy – Energy of most stable resonating structure.
- Stability of molecule α resonance energy.
- More is the number of covalent bonds in molecule more will be its resonance energy.
- Resonance energy α number of resonating structures.

1. Which is the resonance hybride of sulphate ion :

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

2. The correct order of increasing C–O bond length of CO, CO_3^{2-}, CO_2 is :

(A) $CO_3^{2-} < CO_2 < CO$ (B) $CO_2 < CO_3^{2-} < CO$ (C) $CO < CO_3^{2-} < CO_2$ (D) $CO < CO_2 < CO_3^{2-}$

Comprehension # 2

Answer Q.3, Q.4 and Q.5 by appropriately matching the information given in the three columns of the following table.

Observe the three columns in which column-1 represents ions, column-2 represents number of equal contributing resonating structure while column-3 represents bond order.

Column-1		Column-2		Column-3	
(I)	SO_4^{-2}	(i)	4	(P)	1.66
(II)	CO_3^{-2}	(ii)	6	(Q)	1.25
(III)	NO_2^-	(iii)	3	(R)	1.33
(IV)	PO_4^{-3}	(iv)	2	(S)	1.5

3. Which of the following combinations is correct for a hypervalent ion?

(A) (I) (ii) (R) (B) (II) (i) (R) (C) (IV) (i) (Q) (D) (III) (iv) (S)

4. In which of the following combinations, octet is not violated?

(A) (IV) (i) (Q) (B) (II) (iii) (R) (C) (II) (i) (R) (D) (III) (iii) (P)

5. In which of the following combinations, the sum of oxidation state of central atom and number of π-bonds is maximum?

(A) (I) (ii) (S) (B) (II) (iii) (R) (C) (IV) (i) (Q) (D) (III) (iv) (R)

Exercise-3

*** Marked Questions may have more than one correct options.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. Molecular shapes of SF_4, CF_4 and XeF_4 are respectively : **[JEE–2000(S), 1/135]**
(A) the same with 2, 0 and 1 lone pair of electrons respectively.
(B) the same with 1, 1 and 1 lone pair of electrons respectively.
(C) different with 0, 1 and 2 lone pair of electrons respectively.
(D) different with 1, 0 and 2 lone pair of electrons respectively.

2. The number of lone pair(s) of electrons in $XeOF_4$ is : **[JEE–2004(S), 3/144]**
(A) 3 (B) 2 (C) 1 (D) 4

3. In which of the following the maximum number of lone pairs is present on the central atom ? **[JEE–2005(S), 3/144]**
(A) $[ClO_3]^-$ (B) XeF_4 (C) SF_4 (D) I_3^-

4.* The compound(s) with TWO lone pairs of electrons on the central atom is(are). **[JEE(Advanced) 2016, 4/124]**
(A) BrF_5 (B) ClF_3 (C) XeF_4 (D) SF_4

5. The sum of the number of lone pairs of electrons on each central atom in the following species is $[TeBr_6]^{2-}$, $[BrF_2]^+$, SNF_3, and $[XeF_3]^-$
(Atomic numbers: N = 7, F = 9, S = 16, Br = 35, Te = 52, Xe = 54) **[JEE Advanced 2017, 3/122]**

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) OFFLINE PROBLEMS

1. The number of lone pairs on Xe in XeF_2, XeF_4 and XeF_6 respectively are : **[AIEEE-2002, 3/225]**
(1) 3, 2, 1 (2) 2, 4, 6 (3) 1, 2, 3 (4) 6, 4, 2

2. In the anion $HCOO^-$ the two C–O bonds are found to be of equal length. What is the reason for it ?
(1) Electronic orbits of carbon atom are hybridised. **[AIEEE-2003, 3/225]**
(2) The C=O bond is weaker than the C–O bond.
(3) The anion $HCOO^-$ has two resonating structures.
(4) The anion is obtained by removal of a proton from the acid molecule.

3. Which of the following has maximum number of lone pairs associated with Xe ? **[AIEEE-2011, 4/120]**
(1) XeF_4 (2) XeF_6 (3) XeF_2 (4) XeO_3

4. Which of the following exists as covalent crystals in the solid state ? **[AIEEE-2013, 4/120]**
(1) Iodine (2) Silicon (3) Sulphur (4) Phosphorus

5. The correct statement for the molecule, CsI_3, is : **[JEE(Main)-2014, 4/120]**
(1) it is a covalent molecule. (2) it contains Cs^+ and I_3^-
(3) it contains Cs^{3+} and I^- ions. (4) it contains Cs^+, I^- and lattice I_2 molecule.

6. Total number of lone pair of electrons in I_3^- ion is : **[JEE(Main)-2018, 4/120]**
(1) 9 (2) 12 (3) 3 (4) 6

JEE(MAIN) ONLINE PROBLEMS

1. The number and type of bonds in C_2^{2-} ion in CaC_2 are : **[JEE(Main) 2014 Online (09-04-14), 4/120]**
(1) One σ-bond and one π-bond (2) One σ-bond and two π-bonds
(3) Two σ-bonds and two π-bonds (4) Two σ-bonds and one π-bonds

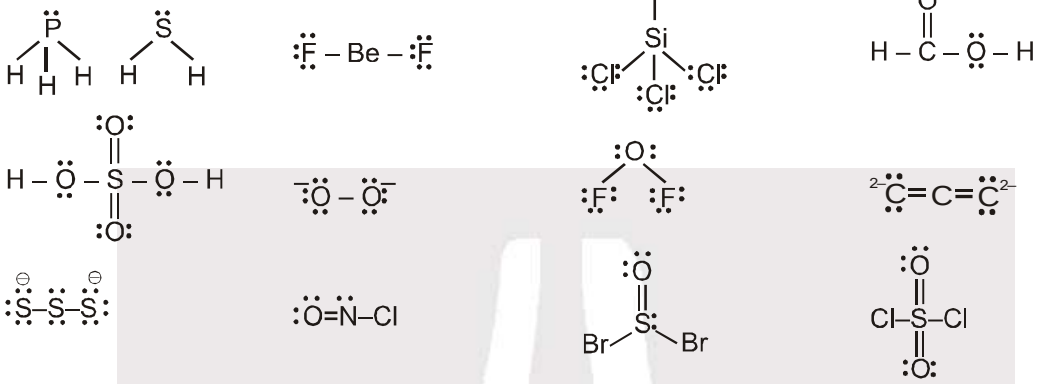
2. $H-\overset{(I)}{N}\cdots\overset{(II)}{N}\cdots N$ **[JEE(Main) 2018 Online (15-04-18), 4/120]**
In hydrogen azide (above) the bond orders of bonds (I) and (II) are :

	(I)	(II)		(I)	(II)		(I)	(II)		(I)	(II)
(1)	< 2	> 2	(2)	> 2	> 2	(3)	> 2	< 2	(4)	< 2	< 2

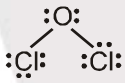
Answers

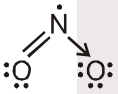
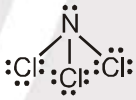
EXERCISE - 1

PART - I

A-1. 

A-2. (i) 4 (ii) 4 (iii) 3

A-3. (a) (b) Covalent compound 

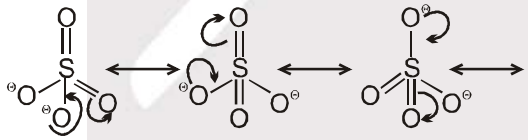
(c)  (d) 

A-4. 5 (i, ii, iv, vii, viii)

B-1. 5 (ii, iv, v, vii, viii)

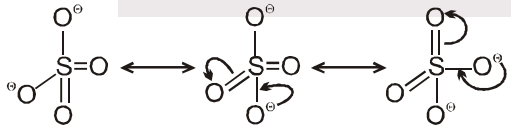
B-2.

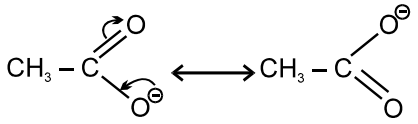
BCl_3	Electron deficient molecule	;	XeF_2	Super octet molecule
NO	Odd electron	;	IF_7	Super octet molecule
NO_2	Odd electron	;	ClF_3	Super octet molecule
ClO_2	Odd electron			

C-1. (i) 

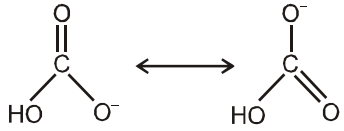
Bond order = $\frac{2+1+1+2}{4}$ = 1.5

$(SO_4^{\oplus})$

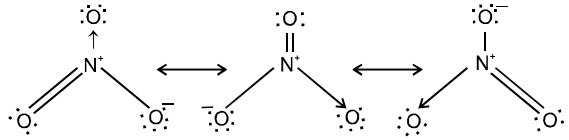


(ii) 

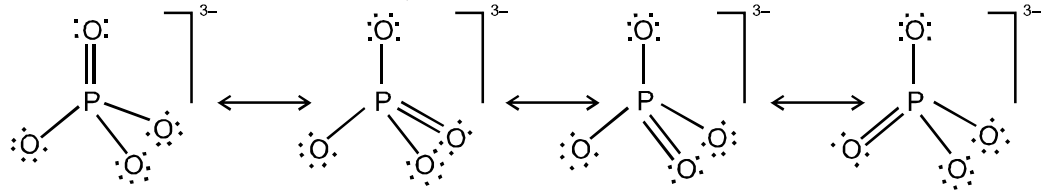
Bond order = $1 + \frac{1}{2}$ = 1.5

(iii) 

Bond order = $1 + \frac{1}{2}$ = 1.5

(iv) 

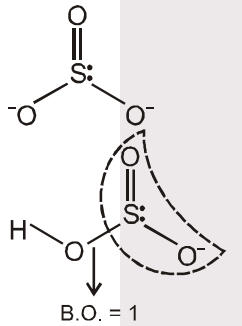
Bond order = $1 + \frac{1}{3} = 1.33$

(v) 

Bond order = $1 + \frac{1}{4} = 1.25$

C-2. (a) 2 (b) 1

C-3. Sodium formate exists as $HCOO^- Na^+$

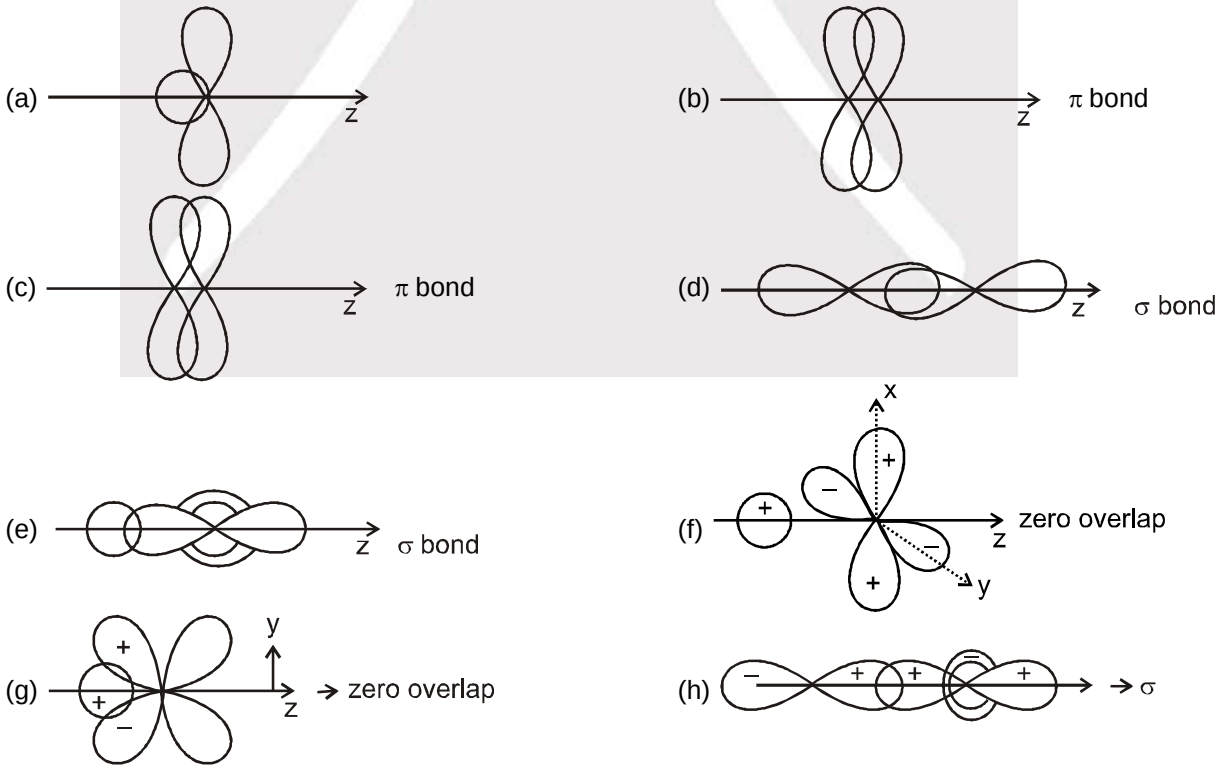
C-4. 

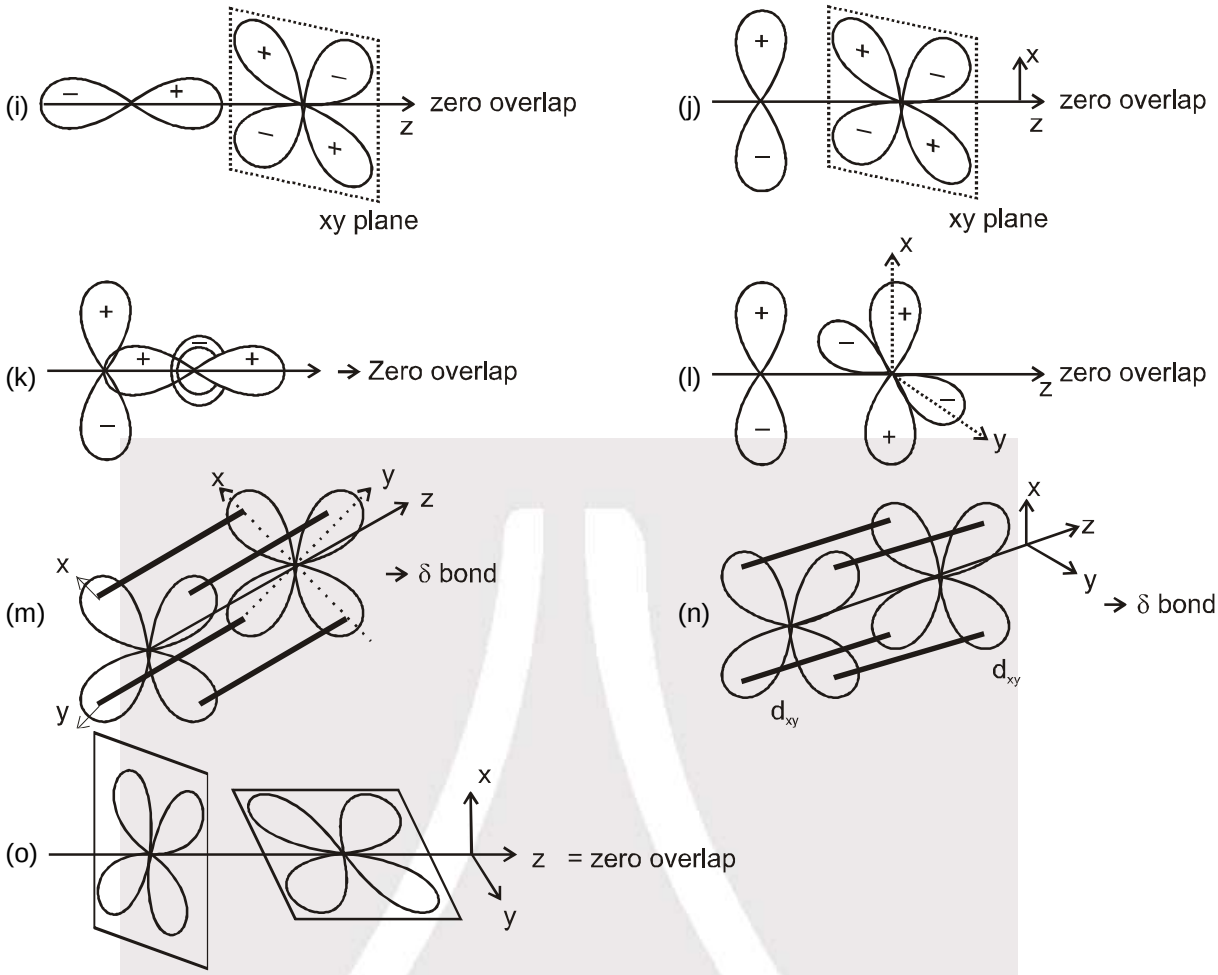
$\rightarrow$ average B.O. = $1\frac{1}{3}$

$\rightarrow$ average B.O. = $1\frac{1}{2}$

Hence one bond in HSO_3^- is longer than S–O bond in SO_3^{2-}. But other two S–O bond in HSO_3^- are shorter bonds.

D-1. Number of sigma bonds is 7 & number of pi bonds is 3.

D-2. 



PART - II

A-1.	(C)	**A-2.**	(D)	**A-3.**	(C)	**B-1.**	(D)	**B-2.**	(D)
B-3.	(D)	**C-1.**	(D)	**C-2.**	(D)	**C-3.**	(C)	**C-4.**	(D)
D-1.	(C)	**D-2.**	(C)	**D-3.**	(B)	**D-4.**	(A)	**D-5.**	(A)

PART - III

1. (A) → q, (B) → r, (C) → p, (D) → s

EXERCISE - 2

PART - I

1.	(D)	**2.**	(B)	**3.**	(D)	**4.**	(B)	**5.**	(A)
6.	(B)	**7.**	(A)	**8.**	(D)	**9.**	(B)	**10.**	(C)

PART - II

1.	2	**2.**	5 (i, iv, v, vi, ix)	**3.**	10 (iii, iv, v, vi, vii, viii, x, xiii, xiv, xvi)
4.	3	**5.**	12 (x = 6, y = 6)	**6.**	5 (i, iii, iv, v, vi)
7.	5 (ii, iii, iv, v, vi)				

PART - III

1. (ACD) **2.** (AC) **3.** (BC) **4.** (AB)

PART - IV

1. (D) **2.** (D) **3.** (C) **4.** (B) **5.** (A)

EXERCISE - 3

PART - I

1. (D) **2.** (C) **3.** (D) **4.*** (BC) **5.** 6

PART - II

JEE(MAIN) OFFLINE PROBLEMS

1. (1) **2.** (3) **3.** (3) **4.** (2) **5.** (2)

6. (1)

JEE(MAIN) ONLINE PROBLEMS

1. (2) **2.** (1)