Single Choice

1. In which of the following metal carbonyls the C – O bond order is lowest?

(A) $[V(CO)_6]^-$ (B) $[Mn(CO)_6]^+$ (C) $[Cr(CO)_6]$ (D*) $[Ti(CO)_6]^{2-}$

1. निम्न में से किस] /ाातु कार्बोनिल में C – O का बंध क्रम न्यूनतम है ?

(A) $[V(CO)_6]^-$ (B) $[Mn(CO)_6]^+$ (C) $[Cr(CO)_6]$ (D) $[Ti(CO)_6]^{2-}$

Ans. (D)

Solution

As electron density on central atom increases, synergic bonding increases. This means metal carbon bond strength or bond order increases As a result, carbon oxygen bond strength or bond order decreases.

$[V(CO)_6]^{\ominus}$ → charge on metal ion ⇒ −1.

$[Mn(CO)_6]^+$ → —— " —— ⇒ +1.

$[Cr(CO)_6]^+$ → —— n —— ⇒ 0

$[Ti(CO)_6]^{-2}$ → —— " —— ⇒ −2.

Clearly, $[Ti(CO)_6]^{-2}$ has maximum electron density on central atom. Hence Metal carbon bond order is maximum and carbon oxygen (C−O) bond order is minimum

Ans (D)

2. Arrange the following compound according to d_{C-C} order.

(I) C_2F_4 **(II)** C_2H_4 **(III)** $[PtCl_3(C_2H_4)]^-$

(A) I > II > III (B*) III > II > I (C) II > I > III (D) II > III > I

2. निम्न ;ौगिकों को d_{C-C} क्रम के अनुसार व्यवस्थित कीजिए।

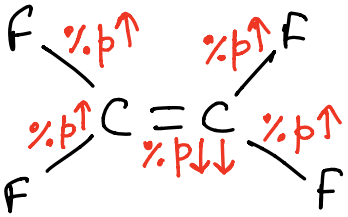
(I) C_2F_4 **(II)** C_2H_4 **(III)** $[PtCl_3(C_2H_4)]^-$

(A) I > II > III (B) III > II > I (C) II > I > III (D) II > III > I

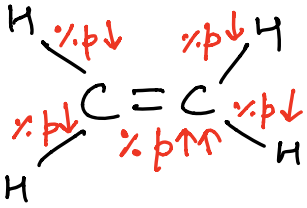
Ans. (B)

Solution

In C_2F_4 & C_2H_4



(I)

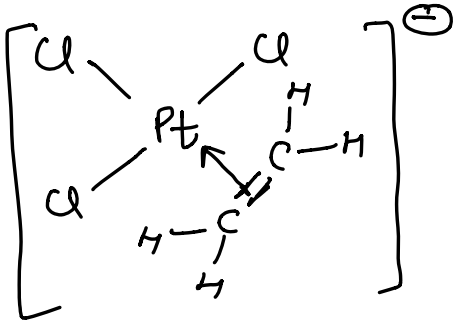


(II)

(F being more EN element increases %p character in its orbital whereas H being less EN decrease %p in its orbital).

As a result %p decreases in >C=C< in C_2F_4 & increases in case of C_2H_4.

$$(d_{C-C})_{C_2F_4} < (d_{C-C})_{C_2H_4}$$



some of pi electron density of C_2H_4 is shared with Pt resulting in Bond order less than 2 in C–C of C_2H_4.

Hence $(d_{C-C})_{III} > (d_{C-C})_{II} > (d_{C-C})_{I}$.

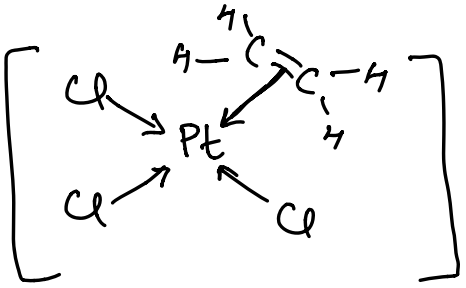
3. **Statement-1 :** In Zeise's salt C – C bond order regarding ethylene molecule is less than two. **[3]**
Statement-2 : Ethylene accepts electron pair from filled d-orbital of Pt^{2+} into its vacant bonding M.O.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C*) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

3. **कथन-1** : "जीसस लवण" (Zeise's salt) में] ,थिलीन अणु के संदर्भ में C – C बंध क्रम 2 से कम है। **[3]**
कथन-2 : एथिलीन Pt^{2+} के भरे हु, d-कक्षक से] अपने रिक्त बंधी आण्विक कक्षक में] इलेक्ट्रॉन ;ुग्म ग्रहण करता है।
(A) कथन-1 सत; है] कथन-2 सत; है ; कथन-2] कथन-1 का सही स्पष्टीकरण है।
(B) कथन-1 सत; है] कथन-2 सत; है ; कथन-2] कथन-1 का सही स्पष्टीकरण नहीं है।
(C) कथन - 1 सत; है परन्तु कथन - 2 असत; है।
(D) कथन - 1 असत; है परन्तु कथन - 2 सत; है।

Ans. (C)

Solution

Zeise's salt → $K[PtCl_3(C_2H_4)]$



C_2H_4 is involved in synergic bonding with Pt and it accepts electron density from Pt in its AntiBonding molecular orbital thereby decreasing bond order.

Hence 2nd statement is incorrect.

4. Which of the following complex has highest M–C bond order ?

(A) $[Mn(CO)_6]^+$ (B) $[V(CO)_6]^-$ (C) $[Cr(CO)_6]$ (D) $[Ti(CO)_6]^{2-}$

4. निम्न में से कौन से संकुल में M–C बंध क्रम अधिकतम है ?

(A) $[Mn(CO)_6]^+$ (B) $[V(CO)_6]^-$ (C) $[Cr(CO)_6]$ (D) $[Ti(CO)_6]^{2-}$

4. Ans. (D)

Solution (Similar to Question 1)

If electron density on central atom increases, Metal-carbon Bond order increases.

Hence Highest M-C Bond order will be in $[Ti(CO)_6]^{-2}$ since central atom has (-2) charge.

5. Which has largest C-O bond length in the given following complexes -

(A)$Ni(CO)_4$ (B) $[Fe(CO)_4]^{2-}$

(C)$[Co(CO)_4]^-$ (D) $[Cu(CO)_4]^+$

5. दिये गये निम्न संकुलों में से किसमें] C-O बन्ध लम्बाई अधिकतम है&

(A)$Ni(CO)_4$ (B) $[Fe(CO)_4]^{2-}$

(C)$[Co(CO)_4]^-$ (D) $[Cu(CO)_4]^+$

5. **Ans. (B)**

Solution

Again a similar question like Q_1 & Q_4.

As electron density on central atom increases, synergic bonding increases. This means metal carbon bond strength or bond order increases As a result, carbon oxygen bond strength or bond order decreases and bond length increases.

$[Fe(CO)_4]^{-2}$ has maximum electron density (-2) on central atom, hence M-C Bond length will be minimum & C-O Bond length will be maximum

6. Select the incorrect statement about metal carbonyl complex compounds :

(A)Metal carbon bond in metal carbonyls possess both σ and π character

(B) Due to synergic bonding metal carbon bond becomes weak

(C) Due to synergic bonding carbon oxygen bond strength decreases

(D) In metal carbonyls extent of synergic bonding will increase with increase in negative charge on central metal ion

6. धातु कार्बोनिल संकुल ;ौगिकों के सन्दर्भ में गलत कथन चुनि,:

(A)धातु कार्बोनिलो में] /ातु कार्बन बंध में σ तथा π दोनों लक्षण उपस्थित होते हैं

(B)सिनर्जिक बंधन के कारण] /ातु कार्बन बंध दुर्बल हो जाता है

(C)सिनर्जिक बंधन के कारण] कार्बन ऑक्सीजन बंध की सामर्थ्य !ाट जाती है

(D)धातु कार्बोनिलों में केन्द्री; /ातु आयन पर ऋणावेश में वृद्धि के साथ सिनर्जिक बंधन की मात्रा ब< जायेगी

6. Ans. (B)

Solution

(A) Metal & carbon in Metal carbonyls are involved in synergic bonding in which ligand donates e^- cloud to metal (σ) and metal then shares its electron cloud back with the ligand (π). Correct

(B) If synergic Bonding is more, Metal carbon Bond strength increases. Incorrect

(C) If synergic bonding is more, Metal carbon Bond strength increase & carbon oxygen bond strength decrease. Correct

(D) If electron density on central atom increases, synergic bonding increases

More than one may be correct :

7. Which of the following statement is /are **CORRECT**.
   (A) According to Werner's co-ordination theory secondary valencies of central metal ion is fixed
   (B) C_2H_4 and NO act as non-classical ligand.
   (C) The bond order of O_2 is 2 and it is colourless gas and paramagnetic in nature
   (D) CH_2=CH–CH_2^- acts as only classical ligand

7. निम्न में से कौन सा कथन **सत्;** है?
   (A) वर्नर के उपसहसंयोजन सिद्धान्त के अनुसार केन्द्री; /ातु आयन की द्वितीयक संयोजकताऐं निश्चित होती हैं
   (B) C_2H_4 तथा NO, नॉन-क्लासिकल लिगेण्ड के :प में कार्य करते हैं
   (C) O_2 का बंध क्रम 2 है तथा ;ह रंगहीन गैस है तथा अनुचुम्बकी; प्रकृति की है
   (D) CH_2=CH–CH_2^- केवल क्लासिकल लिगेण्ड के :प में कार्य करता है

7. **Ans. (A,B,C)**

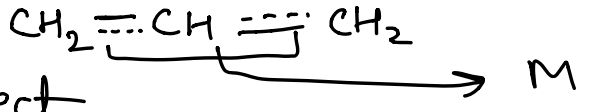
Solution

(A) According to Werner's Theory, primary valency may change but secondary valencies are fixed. Correct

(B) Both C_2H_4 & NO can show synergic bonding & hence are non-classical ligands Correct

(C) According to Molecular Orbital theory, O_2 is paramagnetic & is colorless in gaseous form. It is Blue in liquid state Correct.

(D) $CH_2 = CH - CH_2^{\ominus} \longrightarrow M$ (classical)



(non classical)

incorrect

8. Which of the following chemical species can act as non-classical ligand(s)
(A) CO (B) C_2H_4 (C) NO^+ (D) PR_3

8. Ans. (A, B, C, D)

Solution

Ligands CO, C_2H_4, NO^+ accept electron density from central metal in their antibonding molecular orbital. Hence are non classical ligands.

PR_3 accepts electron density from central atom in its vacant 'd' orbital of P. Hence it is also non classical ligand.

Match the list :

9.

List-I **[Species]**	**List-II** **[Stretching frequency of CO (cm^{-1})]**
(P) CO	(1) 2143
(Q) $Cr(CO)_6$	(2) 2000
(R) $[V(CO)_6]^-$	(3) 1860
(S) $[Mn(CO)_6]^+$	(4) 2090

Code :

	P	**Q**	**R**	**S**
(A)	1	2	3	4
(B)	2	1	3	4
(C)	3	1	2	4
(D)	4	1	3	2

9.. Ans. (A)

Solution stretching frequency or vibrational frequency refers to vibrations per second of the Bond. If the Bond is strong, the stretching frequency increases. (for eg. in a guitar, a vibration is generated if the strings are tight)

If synergic Bonding is strong (more e^- density on central metal) then metal carbon bond is strong & C-O bond is weak.

(P) will have max. strength of C-O Bond since it is not involved in any bonding. Hence max. stretching frequency.

In Q, R, S order of CO Bond strength

S > Q > R

min. synergic Bonding

max. synergic Bonding

Integer :

10. Find the number of ligands which behave predominantly as π-donor ligand (as well as non-classical ligand)

C_2H_4, C_6H_6, NO^+, NO, CO, NH_3, NH_2^-, H_2O, OH^-

10. निम्न में से ;से लिगेण्डों की सं[;ा बताईये जो प्रमुखता से π-दाता लिगेण्ड (के साथ-साथ नॉन-क्लासिकल लिगेण्ड) के रूप में व्यवहार करते है

C_2H_4, C_6H_6, NO^+, NO, CO, NH_3, NH_2^-, H_2O, OH^-

10. Ans. (2)

Solution

All π donor ligands are non classical ligands.

C_2H_4 & C_6H_6 are only π donor ligands.

NO^+, NO, CO ⟶ σ donor, π- acceptor (non classical)

NH_3, $NH_2^{\ominus}$, H_2O, OH^- ⟶ Classical ligands