BYJU'S EXAM PREP

Important Questions on Cages and Metal Clusters

Important Questions on Cages and Metal Clusters

1. Calculate the no. of skeletal electron pairs in $[Pd_5(CN)_{12}]^{2-}$?
   A. 6 B. 7
   C. 8 D. 9

2. Determine the geometry of the complex $[Rh_6N(CO)_{17}]^{3+}$.
   A. Trigonal Prism B. Trigonal Bipyramidal
   C. Square pyramidal D. Pentagonal bipyramidal

3. Determine the geometry of the complex $[Os_5C(CO)_{15}]$.
   A. Trigonal Prism B. Trigonal Bipyramidal
   C. Square pyramidal D. Pentagonal bipyramidal

4. $Os_6(CO)_{18}$ has a monocapped TBP structure. On addition of 2 electrons, the structure changes to:
   A. Trigonal Prism B. Octahedron
   C. Square pyramidal D. Pentagonal bipyramidal

5. Calculate the Bonding molecular orbital of the following cage structure $[Fe_4(CO)_{12}C]^{2-}$.
   A. 35 B. 32
   C. 44 D. 31

6. Determine type of cluster of compound $[Os_6C(CO)_{17}]$.
   A. Arachno B. Nido
   C. hypo D. Closo

7. Determine type of cluster of compound $[Os_6C(CO)_{17}\{P(OMe)_3\}_3]$.
   A. Arachno B. Nido
   C. hypo D. Closo

8. Determine type of cluster of compound $[Ru_5N(CO)_{14}]^-$.
   A. Arachno B. Nido
   C. hypo D. Closo

9. Determine type of cluster of compound $[Ni_5(CO)_{12}]^{2-}$.
   A. Arachno B. Nido
   C. hypo D. Closo

10. Calculate the M-M- Bond present in $[(Fe_3(CO)_{12}]$.
    A. 3 B. 0
    C. 2 D. 1

Answer Key

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

Solutions

Solution 1.

Determination of structure for Skeletal Electron Pair:

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step III →Calculate skeletal electron Pair (S) as:

S = (TVE - n x 12)/2

Electronic configuration of Pt = $4d^{10}4s^0$

Pd is a 10 e^- contributor whereas CN is a 2e^- contributor in nature method.

TVE = 5 ×10 + 12 × 2 +2 = 76

S = (76 – 12 × 5)/2

= (76 – 60)/2

Skeletal electron pair = 8

Solution 2.

Determination of structure for Geometry: -

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step II → Compare with table of geometries.

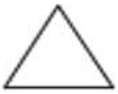
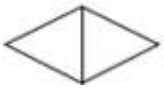
Electronic configuration of Rh = $4d^8 5s^1$

Hence electronic configuration by Ru = 9 e^-

TVE = (9 × 6) + 5 + (17 × 2) -3

= 54 + 5 + 34 -3

= 90

Cluster framework	Diagrammatic representation of the cage	Valence electron count
Triangle		48
Tetrahedron		60
Butterfly, or planar raft of four atoms	 	62
Square		64
Trigonal bipyramid		72
Square-based pyramid		74
Octahedron		86
Trigonal prism	 	90

Solution 3.

Determination of structure for Geometry: -

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step II → Compare with table of geometries.

$[Os_5C(CO)_{15}]$

Electronic configuration of Os = $5d^6 6s^2$

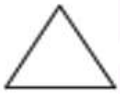
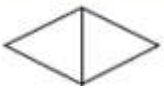
Hence, electronic configuration by Os= 8 e^-

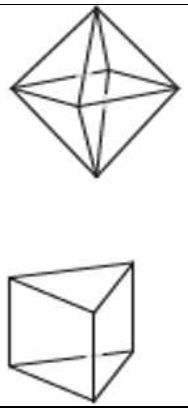
TVE = (8 × 5) + 4 + (15 × 2)

= 40 + 4 + 30

= 74

Compare TVE with table as:

Cluster framework	**Diagrammatic representation of the cage**	**Valence electron count**
Triangle		48
Tetrahedron		60
Butterfly, or planar raft of four atoms	 	62
Square		64
Trigonal bipyramid		72
Square-based pyramid		74
Octahedron		86
Trigonal prism		90

It is square Pyramidal.

Solution 4.

Determination of structure for Geometry: -

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step II → Compare with table of geometries.

We know that $Os_6(CO)_{18}$ has a monocapped TBP structure.

Calculate total valence electrons as:

Electronic configuration of Os = $5d^6 6s^2$

Hence, electronic configuration by Os= 8 e^-

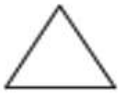
TVE = (8 ×6) +(18 × 2)

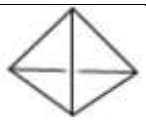
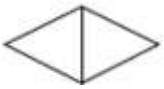
= 48 + 36

= 84

On adding 2 electrons, the total valence electron becomes 86.

Compare TVE with table as:

Cluster framework	**Diagrammatic representation of the cage**	**Valence electron count**
Triangles		48
Tetrahedron		60

Butterfly, or planar raft of four atoms		62
Square	 	64
Trigonal bipyramid		72
Square-based pyramid		74
Octahedron		86
Trigonal prism	 	90

It is an octahedron in shape.

Solution 5.
Determination of Bonding molecular orbital: -
Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step III →Calculate Bonding molecular orbital

BMO = (TVE)/2

Calculate T.V.E as:

C = 4 e^- Contribution because it is encapsulated atom

Os = $3d^6 4s^2$ = 8 e^- contribution

= 4+(8 x 4) + (12 x 2) +2

= 62 e^-

BMO = Total valence electron /2

=62/2

= 31

Solution 6.

Determination of structure for HNCC: -

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step III →Calculate Skeletal electron Pair (S)

S = (TVE - n x 12)/2

n = Number of metals in the given cluster.

Step IV

The structure is arranged according to the wade rule, if skeletal electron pair is,

S=n -1 Super closo

S=n Hyper closo

S=n +1 Closo

S=n+2 Nido

S=n +3 Arach no

S=n +4 Hypho

Calculate T.V.E as:

C = 4 e^- Contribution because it is encapsulated atom

Os = $3d^6 4s^2$ = 8 e^- contribution

= 4+(8 x 6) + (17 x 2)

= 86 e^-

Skeletal Electron pair = (TVE – 12xN)/2

= (86 – 12×6)/2

= 7

S = n+1 hence, it is an example of Closo

Solution 7.

Determination of structure for HNCC: -

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step III →Calculate Skeletal electron Pair (S)

S = (TVE - n x 12)/2

n = Number of metals in the given cluster.

Step IV

The structure is arranged according to the wade rule, If skeletal electron pair is,

S=n -1 Super closo

S=n Hyper closo

S=n +1 Closo

S=n+2 Nido

S=n +3 Arachno

S=n +4 Hypho

Ligand	Electronic configuration
Co	2
$P(OMe)_3$	2

Calculate T.V.E of $[Os_6C(CO)_{17}\{P(OMe)_3\}_3]$ as:

C = 4 e^- Contribution because it is encapsulated atom

Os = $5d^6 6s^2$ = 8 e^- contribution

= 4+(8 x 6) + (17 x 2) + (2 x 3)

= 92

Skeletal Electron pair = (TVE – 12xN)/2

= (92 – 12×6)/2

= 10

10 = 6+4

S = n+4 hence, it is an example of Hypho

Solution 8.

Determination of structure for HNCC: -

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step III →Calculate Skeletal electron Pair (S)

S = (TVE - n x 12)/2

n = Number of metals in the given cluster.

Step IV

The structure is arranged according to the wade rule, if skeletal electron pair is,

S=n -1 Super closo

S=n Hyper closo

S=n +1 Closo

S=n+2 Nido

S=n +3 Arach no

S=n +4 Hypho

Ligand	Electronic configuration
Co	2

Calculate T.V.E of $[Ru_5N(CO)_{14}]^-$ as:

N = 5 e^- Contribution because it is encapsulated atom

Ru = $4d^75s^1$ = 8 e^- contribution

= 5+(8 x 5) + (14 x 2) + 1

= 74

Skeletal Electron pair = (TVE – 12xN)/2

= (74 – 12× 5)/2

S = 7

7 = 6+1

S = n+1 hence, it is an example of Closo

Solution 9.

Determination of structure for HNCC: -

Step I → Calculate TVE (Total Valence e- count.)

Step II → Add the value of the valence electron of interstitial atoms.

E.g., H → 1 e-

H_2 → 2 e-

Carbon family → 4 e-

Nitrogen family → 5 e-

Step III →Calculate Skeletal electron Pair (S)

S = (TVE - n x 12)/2

n = Number of metals in the given cluster.

Step IV

The structure is arranged according to the wade rule, if skeletal electron pair is,

S=n -1 Super closo

S=n Hyper closo

S=n +1 Closo

S=n+2 Nido

S=n +3 Arach no

S=n +4 Hypho

Ligand	Electronic configuration
Co	2

Calculating T.V.E of $[Ni_5(CO)_{12}]^{2-}$

Ni= $3d^8 5s^2$ = 10 e^- contribution

= (10 x 5) + (12 x 2) + 2

= 76

Skeletal Electron pair = (TVE – 12xN)/2

= (76 – 12×5)/2

S = 8

8 = 5+3

S = n+3 hence, it is an example of arachno

Solution 10.

Ligand Electronic configuration

CO 2

Fe = $3d^6 5s^2$ → 8 e^- contributor

T.V.E = 12 X 2 + 3 X 8

= 24 + 24

= 48

Total M-M Bond = (18 X n – T.V.E)/2

= (54 – 48)/2 = 3

No. M-M Bond present in compound = 3

BYJU'S EXAM PREP

CSIR NET Chemical Science 2022

A Foundation Course

Complete Prep of Chemical Science for June 2022 Aspirants

Why take this course?

- 450+ Hrs Live Classes & Doubt Sessions for complete conceptual clarity
- 3000+ Practice Questions covering all levels of difficulty
- 20+ Unit Wise Study Modules & Mind Maps
- 50+ Full Mock Tests, Chapter Wise Mock Tests, PYQs Mock Tests