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BCT A 004

Complex compound

1 What is complex compound? How does it differ from a double salt?

Those compounds which retain their identities even when dissolved in water or any other solvent and their properties are completely different from those of the constituents are called complex compound.

Double salt	Complex compound
a They contain two salt in equimolar amount	a. They may or may not be in equimolar amount
b. The exist in solid state.	b. Exist in solid as well as liquid
c They form simple ion and compound ion in solution state	c. They form complex ion only while in solution state.
d They have no dative bond.	d. They have dative bond.
e.g. Mohr's salt ($FeSO_4(NH_4)_2SO_4.6H_2O$)	e.g. $[Cu(NH_3)_4]SO_4$ Tetraaminecopper (II) sulphate

2. Explain how werner's theory is used to explain the bonding in coordination compound.

The postulates of Werner's Theory are:-

Metal exhibit two types of valencies

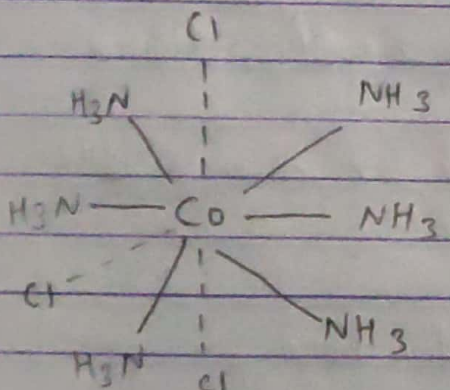
a Primary valency (Principal valency)
b Secondary valency (Auxiliary valency)

• Primary valency is satisfied by negative ions or positive ions whereas secondary valency is satisfied by negative or neutral or by both

Structure of $CoCl_3 \cdot 6NH_3$

$[Co(NH_3)_6]Cl_3 \longrightarrow [Co(NH_3)_6]^{+3} + 3Cl^-$

$3Cl^- + 3AgNO_3 \longrightarrow 3AgCl\downarrow + 3NO_3^-$



• Gives a conducting solution
• $3Cl^-$ are satisfied by primary valency while $6NH_3$ are satisfied by secondary valency.

• Primary valency are represented by dotted lines. Secondary valency are represented by solid lines.

3. Differentiate between primary valency and secondary valency on the basis of werner's theory

- On the basis of werner's theory

Primary Valency	Secondary Valency
•) This valency is satisfied by positive or negative ions	•) This valency is satisfied by negative or neutral or both molecules
•) It is non directional in nature	•) It is directional in nature.

4. Write the IUPAC name of the following complex and calculate EAN value. Predict the stability of complex.

a. $Li[AlH_4]$

Nobel gases
Kr = 36
Xe = 54
Rn = 86

Lithium tetrahydridoaluminate (III)

Here,
atomic number of Al (z) = 13
oxidation number of Al (x) = +3
number of ligands (n) = 4
no of electrons donated by a ligand (y) = 2
Now,
EAN = (z - x) + ny
= (13 - 3) + 4 × 2
= 18 which is equal to Ar
So, it is stable.

b. $[Cu(SO_4)(NH_3)_4]NO_3$

- Tetraammine sulphato copper (III) nitrate

Here
atomic number of Cu (z) = 29
oxidation state of Cu = +3 (x)
no. of ligands (n) = 5
no of electrons donated by a ligand (y) = 2
So
EAN = (z - x) + ny
= (29 - 3) + 2 × 5
= 36 which is equal to Kr so it is stable

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c. $K_3[Co(CN)_5NO]$

= Potassium pentacyanonitrosyl cobaltate (II)

Here,

Atomic number of cobalt (z) = 27

oxidation number of cobalt (x) = 2

no. of ligands (n) = 6

no. of electrons donated by a ligand (y) = 2

So

EAN = $(z-x) + ny$

$= (27-2) + 6\times2$

= 37 which is not equal to any noble gas. so it is unstable

d. $[Cr(H_2O)_5Cl]Cl_2$

= Penta aqua chloro chromium (III) chloride

Here,

Atomic number of Cr (z) = 24

oxidation number of Cr (x) = 3

no of ligands (n) = 6 (Both H_2O & Cl are monodentate)

no of electrons donated by one ligand (y) = 2

So

EAN = $(z-x) + ny$

$= (24-3) + 2\times6$

= 33 which is not equal to any nobel gas

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e. $[Ni(CN)_4]^{-2}$

= Tetracyano nickelate (II) ion

Here,
Atomic number of Ni (z) = 28
Oxidation number of Ni (x) = 2
no. of ligands (n) = 4
no of electrons donated by one ligand (y) = 2
Now,
$EAN = (z-x) + ny$
$= (28-2) + 4 \times 2$
$= 34$ which is not equal to any nobel gas.
So it is unstable.

f. $[Cr(en)_3]Cl_3$

= Tris (ethylenediamine) chromium (III) chloride

Here,
Atomic number of Cr (z) = 24
oxidation number of Cr (x) = 3
no of ligands (n) = 3
no of electrons donated by one ligand (y) = 4
So
$EAN = (z-x) + ny$
$= (24-3) + 3 \times 4$
$= 33$ which is not equal to any ideal gas
so it is unstable

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q. $[Fe(CN)_6]^{-3}$

Hexa cyano ferrate (III) ion

Here,

Atomic number of Fe (Z) = 26
Oxidation number of Fe (x) = 3
no. of ligands (n) = 6
no. of electrons donated by a ligand (y) = 2
Now,

$EAN = (Z - x) + ny$
$= (26 - 3) + 2 \times 6$
$= 35$ which is not equal to any nobel gas
so it is unstable

5. Explain the formation of $[Ni(CO)_4]^0$ complex on the basis of VBT

Here, Formation of $[Ni(CO)_4]^0$
central metal atom = Ni
Oxidation state of Ni = 0
Coordination number (CO) = 4

So, It may have sp^3 or dsp^2 hybridization. Now using VBT

	3d	4s	4p	
Ni atom	↑↓ ↑↓ ↑↓ ↑ ↑	↑↓	_ _ _	
Ni - 0	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	_	_ _ _	(Back-pairing due to CO)
	3d	sp^3		
$[Ni(CO)_4]$	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	xx xx xx xx		

Here, sp^3 hybridization leads to tetrahedral geometry and n = 0 so, it is diamagnetic

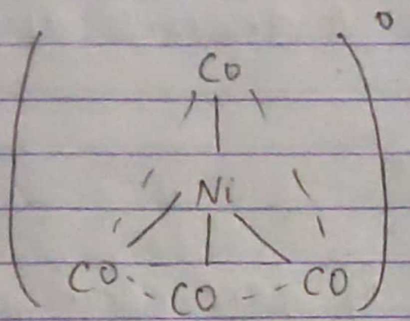


fig: Tetrahedral geometry of $[Ni(CO)_4]^0$

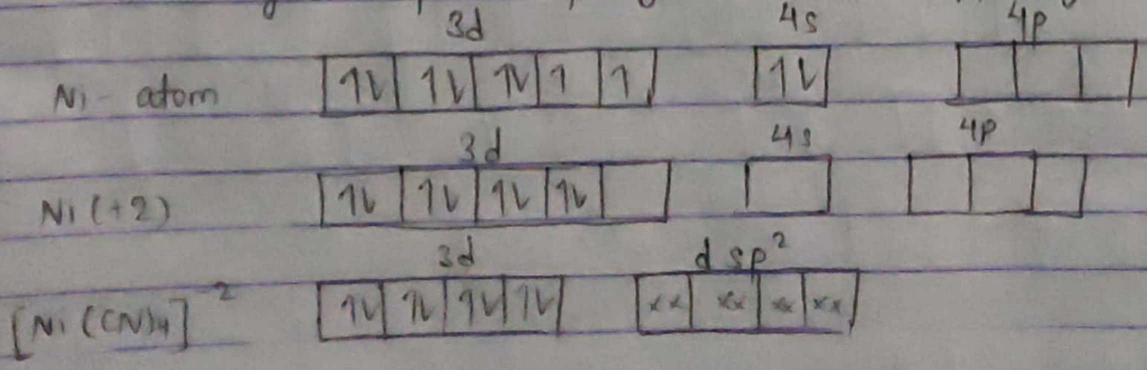
6. What do you mean by square planar complex? Explain the formation of $[Ni(CN)_4]^{2-}$ on the basis of VBT.

= Those complex compounds which undergo dsp^2 hybridization and are formed by strong field ligand are square planar complex

Formation of $[Ni(CN)_4]^{-2}$

Central metal atom = Ni
Oxidation State of Ni = +2
Coordination number (CN) = 4

Here, It may be sp^3 or dsp^2 hybridized. Now applying VBT



Here, $(CN)^-$ is a strong field ligand. So, back pairing of electron takes place and one d orbital is vacant which leads to dsp^2 hybridization. Thus it has square planar geometry. As there is no unpaired electron (i.e. n=0) it is diamagnetic.

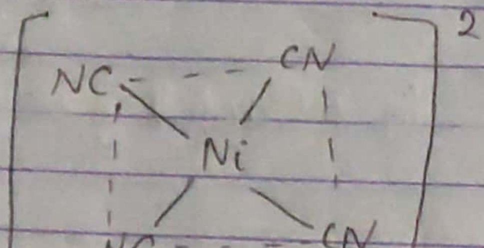


fig: Square-planar geometry of $[Ni(CN)_4]^{2-}$

7. Explain the formation of $[Ni(NH_3)_6]^{2+}$ and $[Cr(NO_3)_6]^{3-}$ on the basis off VBT. Predict the geometry and magnetic property also

= Formation of $[Ni(NH_3)_6]^{2+}$

Central metal atom = Ni
Oxidation state of Ni = +2
Coordination number (NH_3) = 6

So, it may be sp^3d^2 or d^2sp^3 hybridized. Using VBT

	3d	4s	4p	4d
Ni - atom	↑↓ ↑↓ ↑↓ ↑ ↑	↑↓	_ _ _	_ _ _ _ _
Ni (+2)	↑↓ ↑↓ ↑↓ ↑ ↑	_	_ _ _	_ _ _ _ _
$[Ni(NH_3)_6]^{2+}$	↑↓ ↑↓ ↑↓ ↑ ↑	sp^3d^2: xx xx xx xx xx xx		

Here, although (NH_3) is a strong field ligand, the two outer orbitals of 3d remain half filled as back-pairing would lead to one vacant spot which is not possible. So, d orbital has no vacant space which leads to sp^3d^2 hybridization and formation of octahedral geometry. As there are two unpaired electrons, it is paramagnetic in nature

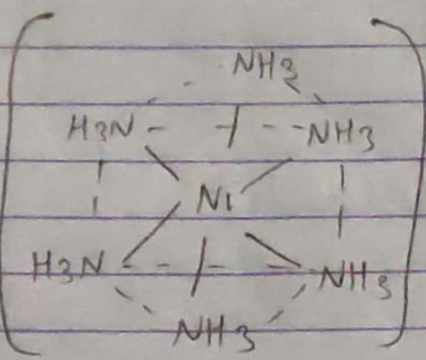


fig: Octahedral geometry of $[Ni(NH_3)_6]^{2+}$

Formation of $[Cr(NO_3)_6]^{-3}$

Central metal atom = Cr
Oxidation state of Cr = +3
Coordination number (NO_3) = 6

So, it may be sp^3d^2 hybridized or d^2sp^3 hybridized. Using VBT

	3d	4s	4p	4d
Cr - atom	1 | 1 | 1 | 1 | 1	1	| |	| | | |
Cr (+3)	1 | 1 | 1 | |		| |	| | | |

	3d	d^2sp^3
$[Cr(NO_3)_6]^{-3}$	1 | 1 | 1	xx | xx | xx | xx | xx | xx

Here, although $(NO_3)^-$ is a strong field ligand, backpairing does not take place as two d orbital are vacant. So, it undergoes d^2sp^3 hybridization resulting in octahedral geometry. As there are 3 unpaired electrons, it is paramagnetic in nature

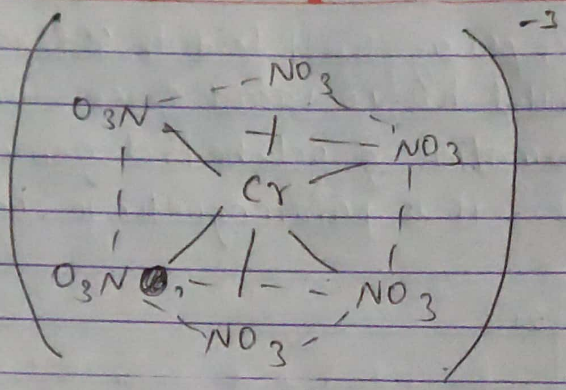


fig: Octahedral geometry of $[Cr(NO_3)_6]^{-3}$

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