Programme: Bachelor of Science (T. Y. B. Sc.)
Subject: Chemistry
Paper Code: CHC 109
Paper Title: Inorganic Chemistry - Section A
Unit: 2 - Spectra and Magnetic Properties
Module Name: Effect of Crystal Field Splitting on Properties of Octahedral Complexes: Magnetic
Module No: 15
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Hello students, welcome to this session in Inorganic Chemistry.

The title of the unit is Spectra and magnetic properties, and the module name is Effect of Crystal Field splitting on the properties of octahedral complexes: Magnetic.

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The outline of the study: magnetic behavior. Magnitude of crystal field splitting in an octahedral complex.
Nature and strength of ligands and magnetic moment.
At the end of this module, students will be able to describe the magnetic properties of complexes.Explain the magnitude of crystal field splitting, Understand the strength of ligands and learn to calculate the spin magnetic moment.

Magnetic properties of octahedral complexes.

Crystal Field splitting can successfully explain the magnetic properties of complexes. Accordingly, crystal field splitting can explain the following the magnetic behavior of a complex.

That is, if a complex is diamagnetic or paramagnetic,and determination of magnetic moment of a complex. The magnetic properties are then established from the magnitude of crystal field splitting in an octahedral complex.

Magnetic behavior of substances show two types of behavior,: diamagnetic and paramagnetic.

Diamagnetic substances do not have any unpaired electrons in their orbitals.They are repelled by the magnetic field and do not have a permanent magnetic dipole moment .For example, water, wood, glass,organic compounds and some metals like pure gold, copper, zinc etc.

Paramagnetic substances have unpaired electrons. They are attracted by magnetic field and have a magnetic dipole moment. Greater the number of unpaired electrons, greater is its magnetic moment.
Examples copper oxide, iron oxide, magnetite, hexa aquo cobalt chloride etc.

In Crystal Field splitting the D orbitals of the central metal atom split into two energy levels in presence of ligands, the low energy t2g orbitals and the higher energy eg orbitals.

The energy difference between t2g and eg levels is termed as magnitude of crystal field splitting and represented as delta O.
The magnitude of crystal field splitting then depends upon the strength of ligands which causes either smaller or larger d- orbital splitting.
The Crystal field diagram showing magnitude of crystal field splitting which is the distance between the low

energy t2g orbital and the higher energy eg orbital. The magnitude of delta O and the distribution of electrons in the orbitals is then dependent or influenced by the strength of ligand.
Accordingly, Delta O will be either maximum or minimum.

Nature and strength of ligands: weak field ligands cause small degree of D orbital splitting. Delta O is minimum and this forms high spin complex. Strong field feelings cause large degree of D orbital splitting.

Delta O is maximum and this will form Low spin complex depending upon their field strength, the ligands are arranged in the order of their increasing splitting power. This arrangement of ligands is called as spectrochemical series which is given below.

The week field ligands are placed to the extreme left of the series and ligands from iodine to water.

The strong field ligands are placed at the extreme right of the series, and include ligands from carbon monoxide to thiocyanate,

High spin and low spin complexes: weak field ligands cause small D orbital splitting.

Delta O is minimum and this will favor the formation of high spin complexes in which t2g orbitals are first singly filled followed by filling of the upper eg orbitals and then pairing of electrons begins in the lower t2g orbitals.

Strong field ligands cause large D orbital splitting, Delta O is maximum. This favors the formation of low spin complexes in which t2g orbitals are completely filled first before any electron occupies in the upper EG orbitals.

In this slide we shall see a crystal field splitting and electron distribution in a d6 system in presence of weak and strong ligands. When it is a weak field ligand delta O is minimum and a high spin complex is formed.
Here electrons enter the upper energy orbital singly before pairing begins in the lower t2g orbitals.
Therefore the number of unpaired electrons is 4 and the system is highly paramagnetic when it is a strong field, ligand delta oh is maximum and it forms a low spin complex.

Here electrons pair up in the t2g orbitals before entering the eg orbitals. Thus number of unpaired electrons
is equal to zero and the substance is diamagnetic.

Therefore here we see the magnetic properties of a system changes in presence of a weak field or strong field ligand which will either form a paramagnetic substance or diamagnetic behavior of the substance.

Strong field ligand and weak field ligand thus determine the magnitude of crystal field splitting and the electron distribution in the t2g and eg orbitals. Once electrons are filled in the t2g and eg orbitals the magnetic behavior of a complex can be explained based on the number of unpaired electrons.
Magnetic moment:
Crystal field splitting is thus useful in determining the number of unpaired electrons in high spin and low spin complexes from the number of unpaired electrons. Magnetic moment can be calculated.

Magnetic moment is defined as the magnetic strength of a substance and its tendency to align in the direction of magnetic field.

Spin magnetic moment of a complex is calculated by using spin only formula which considers only the spin
motion of the central metal atom which is caused due to spin of unpaired electrons. The formula is Ms is equal to Square root n plus two Bohr Magneton, where Ms is a spin magnetic moment and n is the number of unpaired electrons. The orbital movement is not considered for complexes as orbital motion of the electrons is quenched or hindered by the ligands. We shall now see the magnetic properties of a few complexes.

Hexacyano ferrate is diamagnetic with no unpaired electrons.

Hexa fluoro iron three and Hexa aquo Iron three are strongly paramagnetic. Hence I know Iron three is weakly paramagnetic with one unpaired electron and hexa aquo cobalt two is paramagnetic with three unpaired electrons. We shall now see the explanation for this complexes.

Example one: hexa cyano ferrate where iron is in plus two state. Its atomic number is 26 and it is a D6 system. Here cyanide is a strong field ligand. Delta O is maximum. Therefore it forms a low spin complex and the electron distribution is t2g6 eg0.

Therefore the number of unpaired electrons is Zero and the system is diamagnetic.
Its magnetic moment is equal to 0.
Hexafluoro iron and Hexa aquo iron . Here iron is in plus three state its atomic number 26, and it is a D5 system. In this complex, fluorine and water are both weakfield ligands and therefore delta O is minimum and they will form high spin complexes.The electron distribution will be t2g3 eg2. Therefore the number of unpaired electrons is 5 and the systems are highly paramagnetic.
The Ms (mu s) value is 5.91 Bohr magneton.

Example 3: hexa cyano ferrate 3 . Here Fe is in plus three state. its atomic number 26 and it is a D6 system and this complex Cyanide is a strong field ligand. Delta O is maximum and it will form a low spin complex.
The electron distribution will be to t2g5 eg0. Therefore the system has one unpaired electron and it is weakly paramagnetic. Its magnetic moment is calculated and it is 1.73 bohr magneton.

Example 4; hexa aquo Chromium 3 plus. Here Chromium is in plus three state. Its atomic number is 24 and it is a D3 system. Here water is a weak field ligand. Delta O is minimum, therefore it forms a high spin complex and the electron configuration will be t2g3 eg0. Therefore, the number of unpaired electrons is 3 and the system is paramagnetic. Bohr magneton.

Example five : Hexa aquo Cobalt 2 plus. here cobalt is in plus 2 state. Its atomic number is 27 and it is a D7 system. In this complex, water is a weak field ligand delta O is minimum, therefore it forms a high spin complex. And its electronic configuration is t2g5 eg2.

Thus the number of unpaired electrons is 3 and the system is paramagnetic. Its magnetic moment is calculated to be 3.87 bohr magneton.
For many ions of the transition series, particularly for the first half of the series, spin magnetic moment values for high spin complexes agrees well with the experimental values.
Thus, Crystal Field splitting can successfully explain the magnetic properties of complexes.
The references for the topic are given here,
Thank you.