Coordination Chemistry
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Lecture - 30
Magnetic properties

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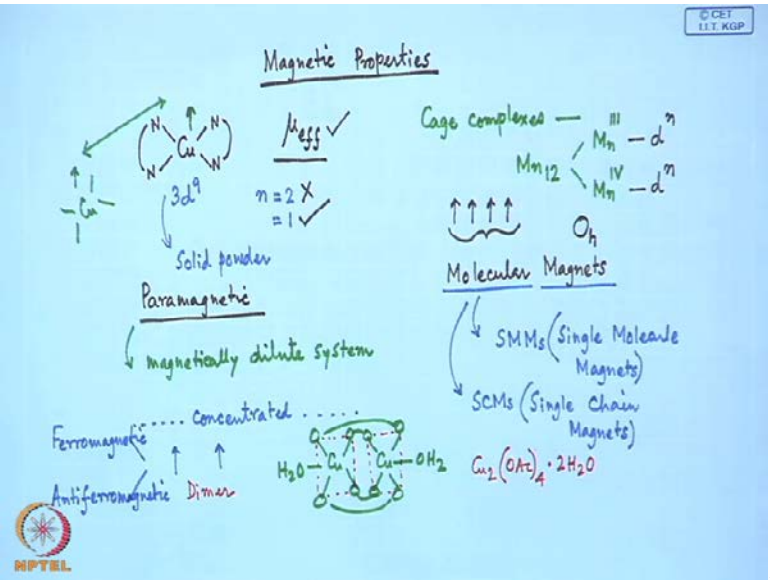

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Good evening everybody. Today we will see after the brief introduction about the magnetic chemistry, how the magnetic properties can help the corresponding course in chemistry in which we try to find the magnetic properties of silver metal complex. So, if we have a very simple copper compound which is in the impartment of some elegant and if we try to find out both vertically as well as experimentally the corresponding mu effective values, so how we can determine these mu effective value for simple mono nuclear paramagnetic compound because this area is now, has become very complex 1 after the introduction of so many plaster or cage like complex.

So, when we see the cage complexes where large number of midlines are there such as the most well studied example is a compound containing 12 manganese ions and not only 12 manganese ions, part of the manganese iron are present in 2 different oxidation states like manganese 3 and manganese 4 as a result we can have some good idea depending upon the corresponding de-electron configurations, that means the d n value the number of unpaired electron presents in manganese 3 and manganese 4 and they when placed in a typical coordinating environment whether the typical coordinating environment which is the most faithful 1. Here is the octahedral 1 in that particular case the total number of unpaired electrons present in different manganese centered and how 1 particular manganese entered is interacting with the other manganese center..

That which give rights to typical area where we can consider a magnetic properties can be untilled for identifying these cage or cluster like assemblies. Here we see that this particular thing that we have the molecule, so, we can consider them as molecular magnets. These molecular magnets are very interesting and very exciting area nowadays. To know these molecular magnets because these give like to 2 or 3 different branches when a particular single molecules can function as a magnets with some characteristic and interesting property we can call it as single molecule magnet. So, this s m. M is nothing but, single molecule magnet and also we can have s c m magnets which are single chain magnets. So, these are, whether some complex area are vacant, so we can store data were the molecule have some other interesting behavior and properties because these are the most in matching area. Nowadays we can understand the magnetic properties of big molecules having large ground states being valued that means large number of unpaired electrons are present within the molecules but, before going to talk all these thing lets us have what happened when we have a single unpaired electrons in a metal complex like a copper 2 complex of 2 bidented enntonant ligands..

Since we all know that this is a 3 d 9 system and whatever coordination environment, coordination geometry we can put around the copper iron in a ford coordinative system, like it can be either header geometry or an a square penal geometry. We basically get corresponding magnetic movement what we can measure in a solid state if we can get this compound as a solid powdered 1. So, using the solid powdered compound, so, we can determine the corresponding magnetic movement where we did can get the corresponding paramagnetic, where there this paramagnetic is any equal to 2 any equal to 1 or any equal to something else that we can find out. That means the number of unpaired electrons, so, we can determine nicely through the measurement of these new effective values. So, it cannot be n equal to 2 it will be n is equals 1 so, for n is equal to 1 system or we can have single unpaired electrons we can determine the corresponding paramagnetic behavior of the system..

So, we get a compound which is paramagnetic in nature and it is also magnetically dilute system. So, what is that so magnetically dilute system means we have individual centers which are well separated, means if we have the second center over here having again 1 unpaired electron 1 the second centered we see that these 2 unpaired electrons will not interact. They are at quite large distance even if we determine the corresponding the solid state structure and with in that solid state structure. If we get the pistil packing and we find the corresponding distance between these 2 copper centers we find they are very large distance. So, they cannot show any kind of interaction that means what we can know that these 2 unpaired electrons if they are close enough they can interrupt with each other and some time they can say at such as 2 magnetic orbital's that magnetic orbital's of this copper center can interact with the magnetic orbital's of the second copper center and as a result we can have 2 or 3 different type of larger magnetic interaction. So, when we have a typical paramagnetic center in magnetically dilute system while individual paramagnetic metals are well separated by the elegant system we get the exact halos of the theatrically predicted as well as experimentally predicted magnetic moment values related to the number of unpaired electrons presents..

But when we have a magnetically concentrated 1, so, if we have a magnetically concentrated system then we see that we can have 2 individual centers what we know that we can have for simple copper acetates. So, incase of copper acetates which is basically a die mart and this is basically connected like these 4 acetates group are attaching like this, and the individual copper centers are in square pyramidal geometry. So, this the corresponding square pyramidal geometry and so we find the individual magnetic half bridals on copper center is interacting with the second 1. So, this is CO2 o a c wholes 4 dote 2 H2O is the basic structure of simple copper acetate salt which is basically dineric 1. So, we get a dine mar. In that dine mar these 2 unpaired spins can definitely interact with each other and that interaction can also play major role in experimentally determining the corresponding magnetic moment to the system and when there are interacting in such a manner, then the over all magnetic moment can be increased. We get a ferro magnetic interaction and if the interaction demonstrates the total magnetic moment of the system we get some anti ferro magnetic interaction. The interaction can task the ferro magnetic or anti ferro magnetic in nature, so, these things how we can determine all these things that is basically depends on the different energy level

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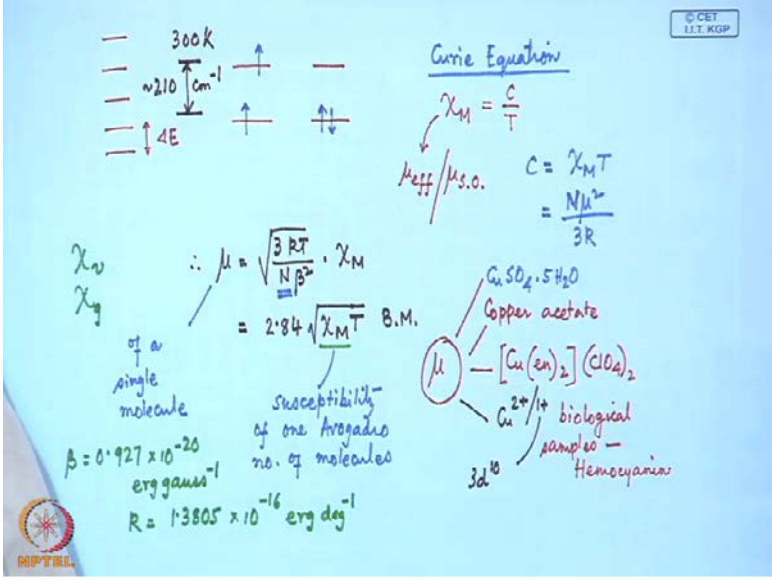

So, the different energy levels for this system, so, if we can have several energy level for a particular structure of these electron distribution and if they are separated by some energy values delta e and will find the if we can have 2 such levels so we can have 2 option for these unpaired electrons on the 2 copper centered.

So, in 1 case or ferro magnetic interactions we can have the 2 unpaired electrons in 2 different orbital’s and these delta e value is small so that we can push the second electron to the other level but, when this particular value is large we basically get the paring of this 2 electron for the first 1 can be considered as a ferro magnetic interaction and this can be considered as anti ferro magnetic interaction. So, depending upon the temperature utilized for the measurement that means if we can go for variable temperature magnetic susceptibility or magnetic moment measurement we can see that how we can populate the different energy levels because depending upon the available thermal energy we can have some comparison of these energy level for the distributions of different unpaired electrons in to the system..

So, from the very basic Curie equation what we have seen the Curie equation give us the corresponding dependence of the susceptibility tan the emulate susceptibility chi n. It is possible anal to 1 by t or is equal to c by t while c is the Curie constant to that we can see over last class that this particular tan emulate susceptibility is very much elated to corresponding mule effective value or the mu spin only value. If we are considering only the spin magnetic or spin annular moment mentor for the corresponding value for the spin only magnetic moments. So, if we get the particular value of this c by t and this c can be equated 2 therefore, chi m t and this and this relationship also gives us corresponding value for n mu square by 3 k were k is the corresponding both men constant and this basically gives as this particular relationship also gives us therefore, the mu values which nothing but, total of 3 k t by n beta square beta is calling tons of the corresponding values in the bore magnetron. Which will basically fit try to find out entire constant if we put that gives us magnitude of 2 point 84 into chi m t that much board magnetism..

We can find out, so, this very simple technique where we can use as the corresponding mullets susceptibility value and if we multiplied with the temperature and this square beta of these when multiplied by 2 point 84 the constant value we can get the corresponding mu value. So, over problem for determining these magnetic moment is that where therefore, a particular system like copper compound any simple copper salts and copper sulphate enta hydrate and the 1 last which we have seen which is copper acetate. So, if we can have these 2 compounds in over hand we want to measure the corresponding mu values for them to experimentally, we can determine the corresponding magnetic moment of these compound and also if we get the corresponding coordination compound or coordination complex like these it has several rather components like diamagnetic parts which are coming from ( ). So, we should have some diamagnetic correction also for these measurements that will see afterwards. So, for these things we can calculate all the corresponding mu value for all this compounds and that difficulty us that corresponding magnetic property for this salts the copper dissolves or the corresponding copper compound. If even u can determine these mu value for copper iron that 2 plus or say 1 plus because 1 plus will diamagnetic which has 3 d 10 electronic configuration which is diamagnetic, so, copper 2 plaza or copper 1 plaza which is present in biological samples also that will discuss afterwards in detail that when we study little bit of out the metal complex is some biological system. So, these are such as the hemocyanine..

In hemocyanine types of molecules we can have the copper center and that copper center and each some para magnetic area that we can determine very easily. So, whatever these mu value we can determine is that of this any single molecules. So, it is the magnetic moment of a single molecule and since we have utilized the corresponding in valued ever got pro number into explanation. So, these susceptibility terms what we are using for this equation is nothing but, the corresponding susceptibility of 1 ever got the number of molecules so this is the corresponding susceptibility term for 1 Avogadro number of molecules. That’s why we consider it as a corresponding mu susceptibility town. Similarly we can have the corresponding valium susceptibility. It is known us chi v and when we considered for the pram susceptibility we can considered as pram susceptibility values.

So, we have the typical constant that means the corresponding both magnetism the beta haulm and the beta is equal to nothing but, we can have SI unit and non SI unit. In this particular case beta is equal to point 927 into 10 to bar minus twenty erg gauges and we can have also the both men constant value k is equal to corresponding board men constant which is 1 point 3805 into 10 power minus 16 erg deg. If we put these values will get some interesting information related to the corresponding magnetic moments the mu susceptibility and these distribution because when ever we get this delta e value, we, at the same time, we should have some basic idea about the corresponding width for the thermal energy what is the order level of thermal energy at a particular temperature. So, if the temperature is in the range of 300 Kelvin we get about 80 value equal to about 210 centimeter. Also these particular width basically we can control the population of these different levels by these.

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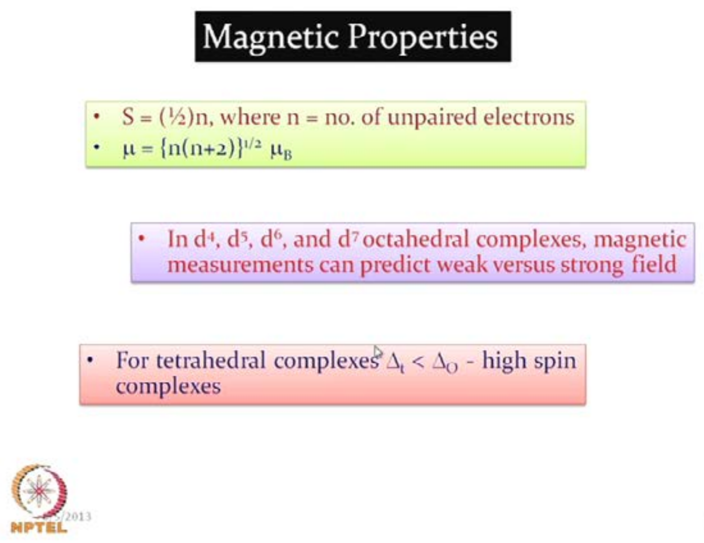

Magnetic Properties

- S = (½)n, where n = no. of unpaired electrons
- $\mu = \{n(n+2)\}^{1/2}\ \mu_B$

- In d^4, d^5, d^6, and d^7 octahedral complexes, magnetic measurements can predict weak versus strong field

- For tetrahedral complexes $\Delta_t < \Delta_O$ - high spin complexes

Unpaired electrons so we just has all these in formation for this magnetic properties and we basically utilized the number of unpaired electrons n is equal to number of unpaired electron by determined the corresponding mu effective or the mu spin only value because this n is added to related with the total spin value for the system. So, for simple coordination cage compound coordination plaster compound we see these values are very high. Similarly these a value will also be found in case of lanthanide were we have 7 a for bridals and 7 a for bridals can accommodate 14 electrons. So, the number of unpaired electrons present in all these lanthanide or the lanthanide bearing corresponding metal complex having high s value for that is why for making these plaster compound for the cage compound immediate choice for the midlines could be the corresponding lanthanide.

If we try to have high ground state pin value that means large spin molecules so, we have a n value which can be utilized for the determine the mule. So, if we have d 4 d 5 d 6 and d 7 electronic configuration in octahedral complexes then the magnetic measurement can predict weak versus strong field for the corresponding available cris sulphate. So, this is the direct application of the corresponding crystal field theory. The crystal field theory is giving us 2 different forum, that is, weak field forum and the strong field forum and for d 4 d 5 d 6 and d 7 so far we have been able to calculate out the corresponding system stimulization energies for these electronic configuration because they can have the depending upon the number of electron in t to g and e g level, we can have the corresponding c f s e value different that we have seen. Also, when we have applied the c f s e value for ingratiate for hydrogen energy for spin structure and so many cases and now if we have the strong field and weak field case then the distribution of total number of electrons from the p I on that means is cobalt 2. We have a 3 d 7 electron configuration then in octahedral field we can have 2 different dispositions.

That means we have the corresponding configuration for occupying c in the t 2 g and the e g level and we have different number of unpaired electrons. So, simply by measuring the magnetic moments we can determine the corresponding complex as the width field complex or the strong field complex. Similarly in case of several r n compound we have seen that there is a spin state equilibrium and that in state equilibrium is also very much temperature dependent. So, as at a particular temperature will see that a system can go from a low spin phase to a high spin phase as we increase the temperature and then we can identify that a very spin state equilibrium and at different temperature we can have different magnetic moments. So, that also can be determined if we simply measure the magnetic moments of these compounds.

So, in different number of unpaired electrons from 1 state to the other but, in case of tetrahedral complexes where delta tetrahedral is less than delta octahedral we only get high spin complexes. So, for a typical distribution of these unpaired electrons in the different levels, so, will find only the high spin configuration for delta t which is very much lesser than ion is 4 ninth of the delta octahedron and accordingly we can have the corresponding number of unpaired electrons and we determined theoretically as well as experimentally the corresponding magnetic moments of the compound such as when we have the the cobalt which is bound to some ligand like thiocyanate ligand we gave the corresponding tetra cyanate cobalt 2 compound and we get the corresponding magnetic moments exactly matching with the number of unpaired electrons which will be available for 3 d 7 electron configuration e tetra hedral.

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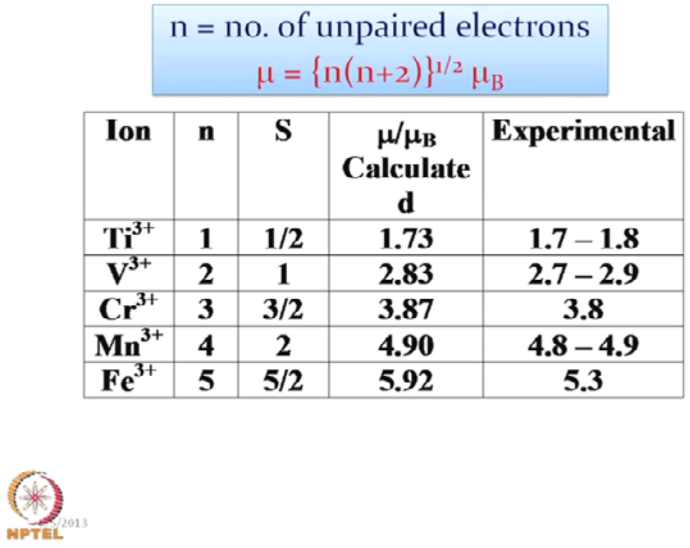

n = no. of unpaired electrons

$\mu = \{n(n+2)\}^{1/2} \mu_B$

Ion	n	S	μ/μ_B Calculated	Experimental
Ti^{3+}	1	1/2	1.73	1.7 – 1.8
V^{3+}	2	1	2.83	2.7 – 2.9
Cr^{3+}	3	3/2	3.87	3.8
Mn^{3+}	4	2	4.90	4.8 – 4.9
Fe^{3+}	5	5/2	5.92	5.3

Environment which is high spin obviously. So, we just go for this equation for determining the corresponding electrons in the different system, so, if we can see that how we calculate out these number of electrons whether we have 1 unpaired electron 2 unpaired electron up to 5 unpaired electron and if we put these values on this equation n value equal to 1 or n value equal to 5 we get the corresponding new value in new b. New b is nothing but, the board magnesium and we can calculate out is this is the calculated values of the corresponding magnetic moments is 1 point 7 3 2 point 8 3 2 up to 5 point 9 2 and when you determined these values experimentally will find that in case of titanium in trivalent state that means titanium 3 class the corresponding magnetic moments is very much is equal to that of the theoretically predicted value that means whatever we are determined as the experimental magnetic moments which is equal or close to equal to corresponding theoretically predicted spin only value. So, these spin only value are very much matching with that of the calculator or the experimental values for these magnetic moments. So, we do not have any orbital contribution because we have seen that when in unpaired electrons present in system such as in metal complexes will see that in has its own spinning motion around its own access as well as it has his orbital motion.

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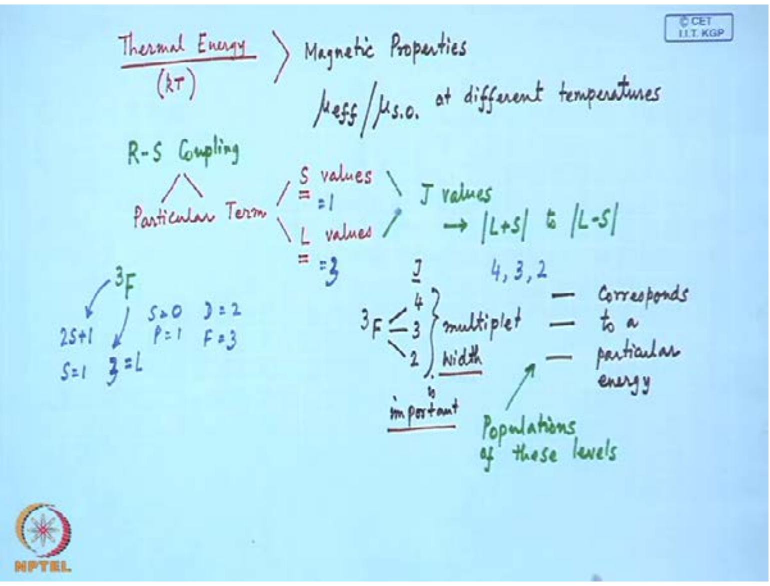

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So, both this 2 motion can generate the corresponding moments, so, we can have spin analog momentum as well as orbital analog momentum values and as there is that we can have a spin moment as well as orbital moments worth the total magnetic moment of the system. Similarly for 2 unpaired for 3 unpaired electrons system and 4 unpaired electronic systems we can have a magnetic moment which is very much close to delta power spin only value.

So this spin only value can be very much use full when we have a particular arrangement for the first annicent rich irons because whatever we are talking that we have the available thermal energy. So, we have the corresponding available thermal energy in terms of the k 2 values and these thermal energy is basically can control the corresponding magnetic properties of the metal complexes. So, these can basically control the magnetic properties and we can determine the mu effective or new spin only what we are thinking of which are the main contributors of magnetic moments at different temperatures. So, this we can determined at different temperatures an when we use all we see that the corresponding number of unpaired electrons which are available they are basically couple in a fashion which are already discussed the corresponding russell saunders coupling scheme.

So, these r s coupling can be operative there and a particular term we can have so, a particular term we get and which has typical s value and n values and so this is due to the corresponding number of unpaired electrons and this is due to the corresponding orbital motion, orbital analog momentum value which can contribute to the corresponding magnetic moments. So, when these things are happening so far a particular s value and particularly l value which is contributing for spin magnetic moment or orbital magnetic moments. So, we can have through these 2 l and s values we can have their corresponding coupling scheme which we can consider as the corresponding j values. So, the different energy levels what we can have is due to the presence of different j values. So, from the same l and s values for due to the different types of interaction for these j values these j values can arrange forms l plus s 2 l minus s so if we have a ground steed palm of 3 f for 3 f we know now what are the values is he corresponding spin multiplicity which is 2 s plus 1.

Therefore here s is equal to 1 for a spin multiplied value of 3 and the a value also we known as tan the corresponding l value is equal to s p d f that mean 0 1 2. So, this l value equal to 2 so 2 is equal to l so these combination that means now we get these s value and the n value so this combination this s is equal to 1 and l value equal to 2. So, this l plus s that means we can have the corresponding values of this s p d f, so, this is 3 s is equal to 0 p is equal to 1 d is equal to 2 and f is equal to 3 this will be 3 so 3 and 1 so, we can have the total value from l plus s 12 minus s that means 4 3 2. So, these are the corresponding values for these j so we have fore this 3 f ground state term we are having 3 levels with j values these are the j values 4 3 and 2 so we have a level which is 3 f 4 and 3 f 3 and 3 f 2 and these 3 levels when they belong to these 3 f town and when there is no such platy we considered this us a multiplet.

So, this is a corresponding multiplet and each of this states that is means if we are j value is equal to 4 j value is equal to 3 and j value is equal to 2. So, each of these states corresponds to a particular energy so, these corresponds to a particular energy value so, now if we see that depending upon the available k t value if we have the different levels so we can now think of the corresponding population of these levels. So, population of these levels are therefore, important so population of these levels basically give us some idea that weather our magnetic moments will due to the entire population of the ground state or the exited state or the second exited state. So, this particular case they multiplied width is important so we just see how is multiplet width can control the corresponding the magnetic moments and what particular formula can use to determine s multiplets width. So, there will be 3 different such cases that we can have these variation first 1 is where we have the width is large compare to k t.

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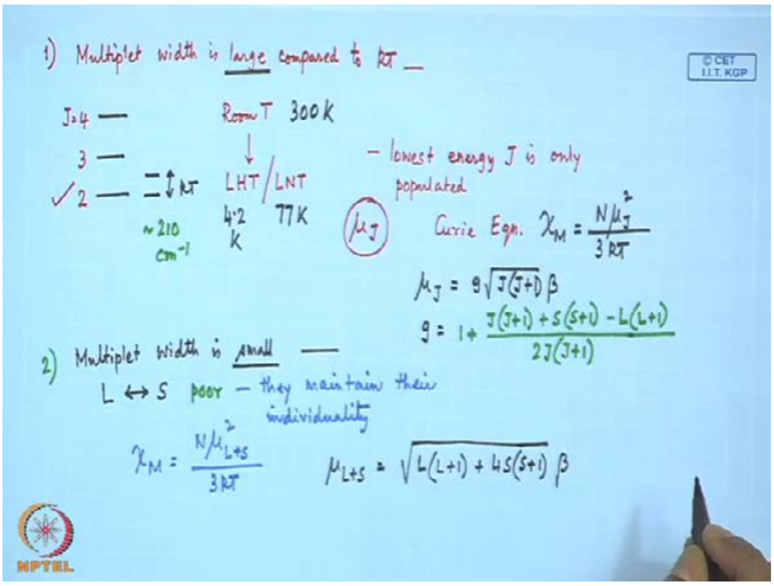

1) Multiplet width is large compared to kT –

- lowest energy J is only populated

Curie Eqn. $\chi_M = \frac{N\mu_J^2}{3kT}$

$\mu_J = g\sqrt{J(J+1)}\,\beta$

$g = 1 + \frac{J(J+1) + S(S+1) - L(L+1)}{2J(J+1)}$

2) Multiplet width is small —

$L \leftrightarrow S$ poor – they maintain their individuality

$\chi_M = \frac{N\mu_{L+S}^2}{3kT}$ $\mu_{L+S} = \sqrt{L(L+1) + 4S(S+1)}\,\beta$

So, when the multiplet width is large, it is large compare to k t. So, if we have a multiplet width is large compare to k t we see that we have the different j levels such us j is equal to 4 j is equal to 3 and j is equal to 2. So, this multiplet t g is large that means this (separation is large and the magnitude of these k t is small so the thermal energy available say we are measuring the corresponding magnetic moments from room temperature down to say liquid helium temperature or liquid nitrogen temperature. So, this liquid nitrogen temperature and liquid helium temperature that use full for determining these magnetic moments at low temperature.

So, this liquid helium temperature is around 4 point 2 kelvin and this 77 kelvin and down from 300 kelvin which is the room temperature magnitude for the corresponding available temperature in Kelvin scale and your k t value is close to 210 centimeter inverse. So, this multiplet width for this different j value which is j is equal to 4 or j is equal to 3 or j is equal to 2 is large..

So, what happens that is whatever number of unpaired electrons available over there is they will entirely populate the corresponding down level or the lowest energy j levels. So, in this particular case what we see that the corresponding state that the lowest energy g is only populated so this lowest energy j if this is the lowest energy so lowest energy j is only populated and j is now a good quantum number instead of l and a. So, the entire magnetic moment can be controlled by the corresponding mu j value so we can find out the corresponding magnetic moment in terms of the mu value and now the Curie equation now the curie equation will take the form terms of the corresponding mu j which will be the chi n equal to n mule j square divided by 3 k t or mu j is equal to g into g into g plus 1 into beta were g is the chi magnetic ratio.

This ratio has some relationship with this corresponding quantum numbers and the multiplied for the magnetic moment is 1 plus j into j plus 1 plus s into s plus 1 minus l into l plus 1 divided by 12 j into j plus 1. So, for situations like these when we have these multiplied 2 j is last when compare to k t..

We can basically use the corresponding equation which belongs to the j value and we have to have the corresponding term which cannot be utilized for e determining the corresponding l and s values. So, we have to use the corresponding j value to determine the corresponding magnetic moments so that will see how the first time sins serious elements or lanthanides can deviate from these calculation if we can theoretically predict the corresponding values related to these magnetic moments so the second case which is that of opposite to this particular situation that means while the multiple 2 j is small the previous 1 is large compare to k t. Now the multiplet width is small compare to k t. So, when it is small so the coupling between l and s so, in the previous case coupling between l and s is strong so, we have the j which is in good quantum number but, now the coupling between l and s are the orbital moment and the spin moment is poor and as a result these 2 individual term maintain their individuality.

So, they basically maintain there individuality and we now get this chi m value compared to this 1 has in v l plus s square divided by 3 k t instead of j mu j we have mu l plus s so in this particular situation we can find out the total values related to me l plus s. So, we can compare the magnetic moments theoretically whether we are getting a magnetic moments using the mu j plus n or mu l plus s equation or mu s equation that means theoretically prediction they ask whether our magnetic moment experimentally determine the magnetic moment, we can follow a mu j equation or mu l plus s equation or mu s equation only because the mu s equation is only valid for mu spin only magnetic moments values that Is available for the first I n series element.

So, this basically gives us the corresponding equations in the form of curie equation. So, what we have now mu l plus s like that of mu j were we can utilized instead of using j as the good quantum number we can use l us the useful quantum number also multiplied into 4 s into s plus 1. What we can have for the spinal equations into beta so these are the theme we can have the multiplied width which is small and the third case. The third case is little bit complicated were we have these 2 levels.

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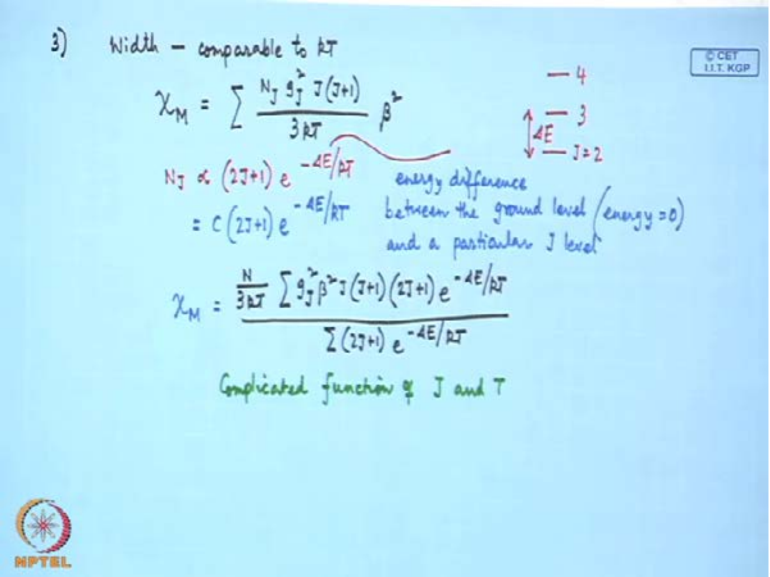

3) Width – comparable to kT

$$\chi_M = \sum \frac{N_J g_J^2 J(J+1)}{3kT} \beta^2$$

$$N_J \propto (2J+1) e^{-\Delta E/kT}$$

$$= c(2J+1) e^{-\Delta E/kT}$$

energy difference between the ground level (energy = 0) and a particular J level

$$\chi_M = \frac{\frac{N}{3kT} \sum g_J^2 \beta^2 J(J+1)(2J+1) e^{-\Delta E/kT}}{\sum (2J+1) e^{-\Delta E/kT}}$$

Complicated function of J and T

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That means the available thermal energy for the typical k t value and the corresponding width they are comparable. So, when the width the multiplied width is comparable to k t we get a situation where we see that the individual things that the individual ions, how they are in populated for the different levels. For that we can have the summation over the difference j level that means the population of the different j levels with those g j values for those levels in g j square into j into j plus 1 divided by 3 k t into beta square. This is the form of the corresponding new Curie equation for a situation where the multiplet 2 g is comparable to k t..

So, this n g values are proportional to the corresponding multiply related to the j value and exposal c l minus delta e by d t and that is the corresponding energy that what we are talking about for e these different levels. So, if we have j is equal to 2 and j is equal to 3 and j is equal to 4 values and the energy gap between these 2 level it is are delta e, then this delta e term can come over here which is nothing but, the energy difference between the ground level where we are considering the energy as 0 and a particular j level that means j value is equal to 3 or j value is equal to 4. That’s been the first exited level and this is the second exited level. So, if we get this and if we bring proportionality constant c, so, it will be c into twice j plus 1 into exposal l minus delta e by k t and as a result chi m equation ill take the form which is the all being corresponding delta e tta and also which is equal to n by c k t and sum over g j square beta square g into g plus 1 into this term twice j plus 1 e to the power minus delta e by k t divided by these level that means twice j plus 1 e to the power minus delta e by k t. So, what we get now that the mu susceptibility now can have all these terms that means it can have the values of this j the g j values and the corresponding energy town.

Therefore, it is a complicated function of j and t that means the most difficult and most complex situation will arise when our multiplet through this only comfortable to k t that means, we cannot ignore the corresponding term related to the relative distribution of all these levels. In 1 case it is only the ground state populated, in other case this higher levels are also populated. We are considering both the l and s values got from the width is comparable only then only we have to bring the corresponding energy gap between these levels and how these levels are populated so these basically gives us some ideas that, if we can determine the corresponding susceptibility term width respective temperature, then only we can have some good idea about the relative population of these level. So, as it is that if we just apply the different term for these different values.

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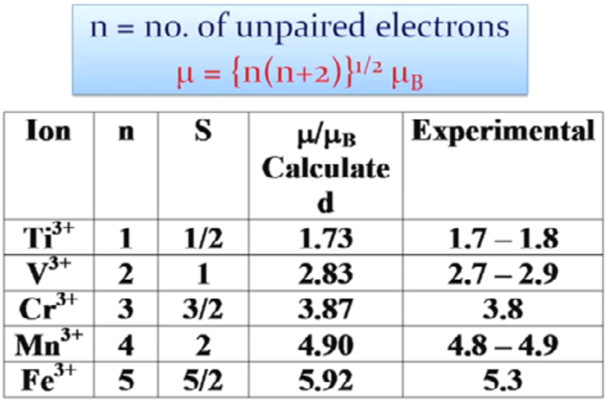

n = no. of unpaired electrons

$\mu = \{n(n+2)\}^{1/2} \mu_B$

Ion	n	S	μ/μ_B Calculated	Experimental
Ti^{3+}	1	1/2	1.73	1.7 – 1.8
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What we have seen therefore, titanium, vanadium, chromium, manganese, up to copper 2 plus and we can calculated out in terms of the corresponding values with respect to the s value

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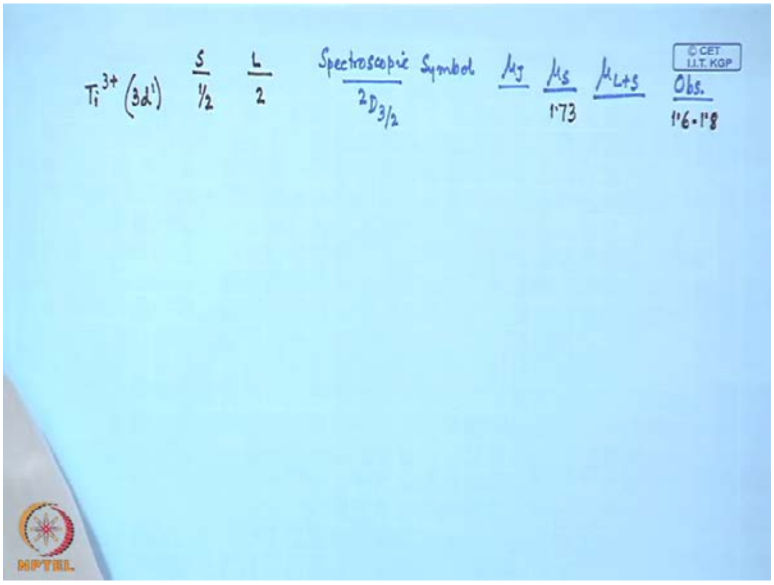

	S	L	Spectroscopic Symbol	μ_J	μ_S	μ_{L+S}	Obs.
Ti^{3+} $(3d^1)$	1/2	2	$^2D_{3/2}$		1·73		1·6-1·8

Now if we just simply take the example us the corresponding s not only the s value but, also the l value. So, if we just consider the corresponding l value at the same time so if we have the titanium 3 plus it is 3 d 1 case and that 3 d 1 case basically give us some information and that we can have the corresponding s value and the corresponding l value. So, we have it is half and l value is equal to 2 for the d electron and the spectroscopic symbol.

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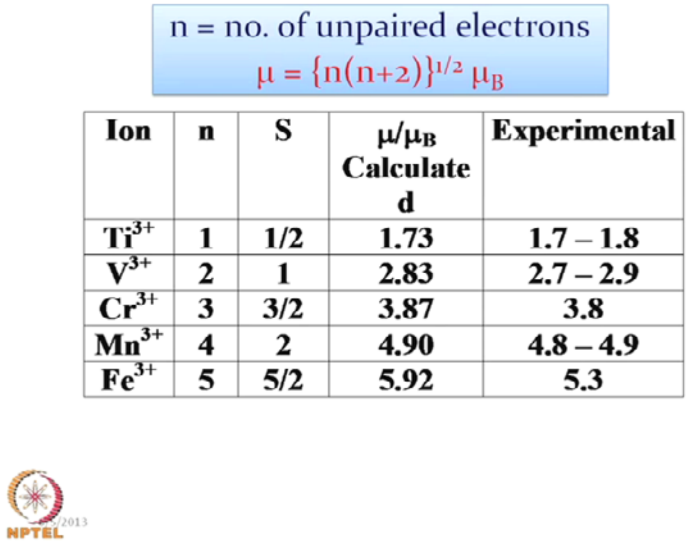

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Ion	n	S	μ/μ_B Calculated	Experimental
Ti^{3+}	**1**	**1/2**	**1.73**	**1.7 – 1.8**
V^{3+}	**2**	**1**	**2.83**	**2.7 – 2.9**
Cr^{3+}	**3**	**3/2**	**3.87**	**3.8**
Mn^{3+}	**4**	**2**	**4.90**	**4.8 – 4.9**
Fe^{3+}	**5**	**5/2**	**5.92**	**5.3**

Symbol for e this will be 2 d 3 by 2. So, for e this basically we can utilize the corresponding mu j equation corresponding mu s equation and mu l plus s equation theoretically we can utilize these we get the corresponding different values and finally, the observe value of the magnetic moments. So, in a resistible, what we are seeing there we are basically looking at the corresponding p a namely value which is 1 point 73 and the observed value are also ranging from 1 point 6 to 1 point 8.

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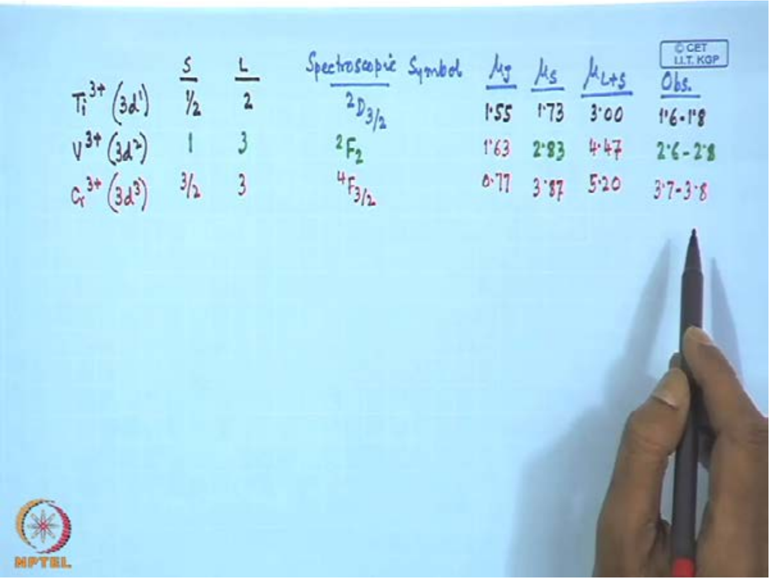

	S	L	Spectroscopic Symbol	μ_J	μ_S	μ_{L+S}	Obs.
Ti^{3+} $(3d^1)$	$1/2$	2	$^2D_{3/2}$	1·55	1·73	3·00	1·6-1·8
V^{3+} $(3d^2)$	1	3	$^2F_2$	1·63	2·83	4·47	2·6-2·8
Cr^{3+} $(3d^3)$	$3/2$	3	$^4F_{3/2}$	0·77	3·87	5·20	3·7-3·8

So, this is the thing that subscribe we can have the corresponding value which is n is the number of unpaired electrons is equal to half and mu value is equal to 1 point 73. So, this is nicely looking nice for these corresponding values but, if we calculate out the corresponding mu g also it will be less it is 1 point 55 and it will be 3 point 00 formal l plus s. So, basically what we are fixing over here, that we have a small value for these magnetic moments when we considered the mu j equation that the mu j is the good content number if we considered there is no orbital contribution then mu s is the good equation to determine the corresponding magnetic moment equal to 1 point 7 3, and in fat experimental determine values are close to these values but, if we considered that orbital contribution is, they are the l values are also contributing towards the magnetic moment then the upper limit of these magnetic moment is equal 3. That means if orbital contribution is there our total magnetic moment can go beyond the spin only value and it can reach up to a magnitude of 3 point 00.

Similarly, in case of vanadium 3 plus which is 3 d 2 electron configuration s value equal to 1. L value equal to 3, the term is twice f 2 and as we have seen in our previous table that mu spin only value is equal to 2 point 8 3 and the experimental values are also ranging from 2 point 6 to 2 point 8 but, when we bring the other 2 values theoretically calculated as using j us the quantum number and l and s both us the 2 quantum numbers contributing towards the magnetic moments. It I’ll be 1 point 63 which is in the lower range, but, in the higher range it is 4 point 4 7. Similarly, 4 chromium 3 plus we can have

3 d 3 situation were s value is equal to 3 by 2 and s value is equal to 3 and we have 4 3 by 2 and spin only values. We have spin, it is 3 point 8 7 and experimental value are 3 point 7 to 3 point 8 which is matching with the spin only value, but, if we think of the corresponding mu equation is very less it point 77 only and upper limit for l plus s is 5 point 2 0. So, when we continue and when we fill up the entire terry in our next class, will find that there will be some values were the mu spin only is not the exact value, that it can have a value close to mu l plus s. That means it can have a corresponding orbital contribution towards the magnetic moments.

Thank you very much.