

Concepts of Chemistry for Engineering
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Lecture – 35
Problem Solving Approach

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Magnetism				
Ion	Config	OAM ?	μ_{so}	
Ti(III)	d1	yes	1.73	1.6
V(IV)	d1	yes	1.73	1.7
V(III)	d2	yes	2.83	2.7
Cr(IV)	d2	yes	2.83	2.8
V(II)	d3	no	3.88	3.7
Cr(III)	d3	no	3.88	3.7
Mn(IV)	d3	no	3.88	3.7
Cr(II)	d4 h s	no	4.90	4.7
Cr(II)	d4 l s	yes	2.83	3.0
Mn(III)	d4 h s	no	4.90	4.7
Mn(III)	d4 l s	yes	2.83	3.0
Mn(II)	d5 h s	no	5.92	5.7
Mn(II)	d5 l s	yes	1.73	1.8
Fe(III)	d5 h s	no	5.92	5.7
Fe(III)	d5 l s	yes	1.73	2.0
Fe(II)	d6 h s	yes	4.90	5.0
Co(II)	d7 h s	yes	3.88	4.0

Orbital
Contributions in
Octahedral
Complexes

So, so far today I think magnetism wise, we did not discuss too much, we have introduced the topic magnetism where the origin of the magnetism coming or magnetic moment coming into the molecule. It is the molecule unpaired electron that is responsible, number of unpaired electrons should technically give you the clear cut idea, what is the magnetic moment going to be, there is some more to it.

Of course, in reality, we know that it is orbital angular momentum and the spin only values that should give you, that should combine, but you do not need to combine because it is somewhat restricted, still somewhat allowed, that is where, when it is allowed, then you have a better value or the higher value for magnetic moment.

And when that spin only plus orbital angular momentum is coming into picture, that is what we have introduced, but we will be discussing from here on in the next class. Now, we will, we have two more topic, one is, this magnetism; the next one, will be (0)(1:17), two classes, we should be able to finish.

Student: (0)(1:25)

Lecturer: Yeah, oh, yes, that is a good question. Sure. If I am getting, I think in the beginning, I did not get your point at the end what I get is you have to think that total ensemble like if of

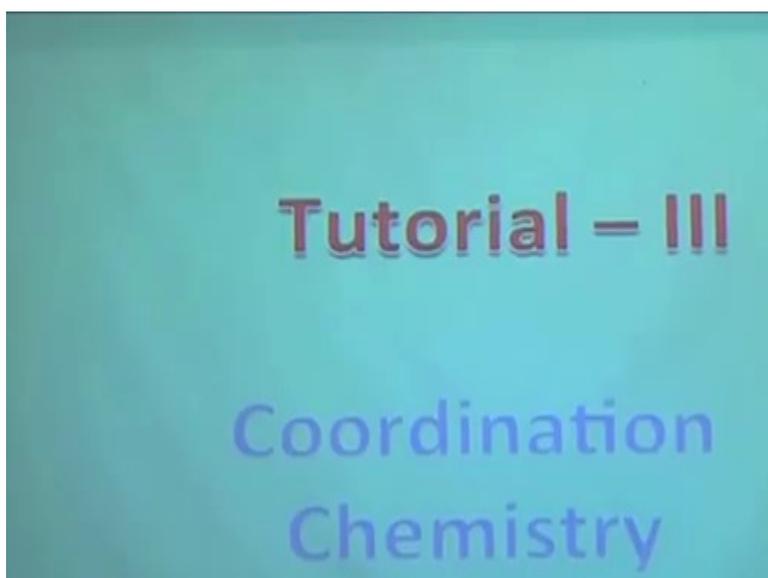
course, if a molecule, one molecule had some magnetic moment, another molecule associated with it has another magnetic moment you have to basically assemble.

Yes, at that end at the very last, at the end, we will see it is not the individual magnetic behaviour will matter, it is the total collective molecule whatever molecule you are associated with, if it is only one type of molecule, one centre, then that is of no problem. But the moment you have let us say clusters, one thing is attached via another thing, through another thing, then things are more complicated. So that is what, that is where I would like to take you to at the end of the magnetism.

So, there they can two magnet can communicate through a mediator, one spin up, another spin up, is it going to be magnetic moment going to be addition of these two? Can, can they talk with each other and reverse, inverse? Let us say this is up in between these two magnet there is something which is communicating between the two, can that communicator influence the total magnetic behaviour?

So there, there is magnetic communication that is actually the basis for more fun in this area. We will not discuss a lot of cases maybe one or two cases we will discuss and then leave. So, I think is that the type of queries you are having or maybe I have taken you to a different direction, some something related, initially I could not hear you, but at the end, I think I heard you correctly.

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Now, hopefully, the next part will not be that long another 20 minutes or so, or 30 minutes maximum. Depends on how you, how you, see the third tutorial which is on coordination compounds. You have the printout, the question?

Students: No.

Lecturer: No problem, I have that question here. Tutorial, if you want to go, I have no problem but I think it is important, I will try to get it done very quickly. Tutorial questions were uploaded in the module and nowadays all of you are having smartphone. So, if you have Wi Fi connection you could have downloaded earlier, do not come to my office to download it.

Just take it, one of you should have been able to download it. If you are really dying, I, you could have asked me I could have sent you or give you a printout. Anyway, that does not matter too much, it is in there. If you like I can give you the printout the next time, who is going to pay for it. We can, we can give it, IIT can pay for it. Of course, you are paying IIT, no problem.

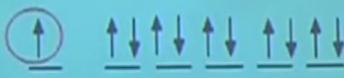
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Q01. Crystalline AgO is diamagnetic. Explain.

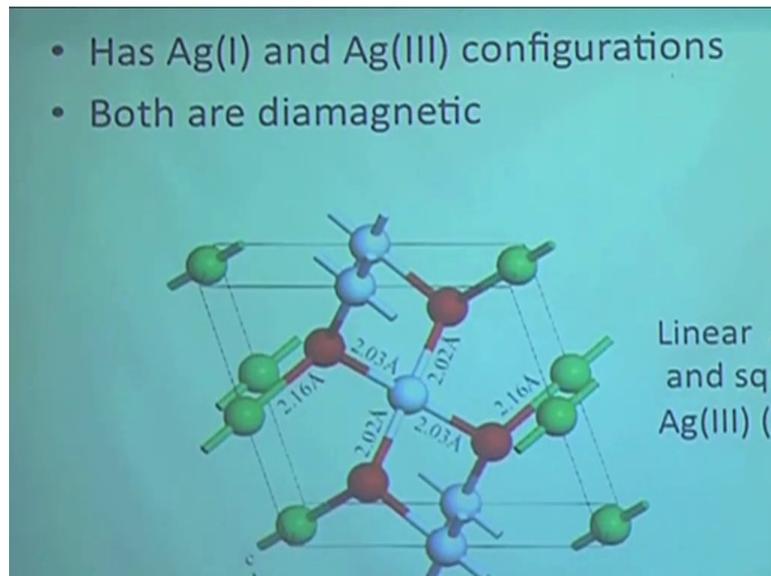
- AgO

As per formula, oxidation state is +2

Electronic configuration should be
Ag: [Kr] 4d¹⁰ 5s¹
Ag(II): [Kr] 4d⁹



• Mixture of Ag₂O and Ag₂O₃



So, first question. crystalline silver oxide is diamagnetic. Explain. Question number one. So sometimes you have to be a little bit cautious, some, some not all of the questions either in the exam or in tutorial are going to be straightforward. There is something more into it. So, silver oxide you just calculate, you figure out what is the silver oxidation state. Do it plus 2, what is the electronic configuration?

Students: (0)(5:48)

Lecturer: Okay. Time up. Silver oxidation state is plus 2, so it is a d9 electronic configuration, d9 electronic configuration means one unpaired electron. So, it should be paramagnetic. Diamagnetic means two spin right, pair or at least pair spin. How it is? This is where I was saying it is a trick question. So, it see, it is a mixture of, sorry. Yeah, that is what it is. So, that is where it is a trick question. So, it is a mixture of Ag₂O and Ag₂O₃.

Now, you have to look back at each of them. Let me, let me try to discuss you have to look back each of them silver plus, silver plus, 1 plus and silver 3 plus. 1 minus is usually not possible.

You want to, no, no, do not worry, I will give you, I will upload since I have made the slide I will upload, no need to, if you bothered you few are bothered to take the picture and take it, it is a public domain thing why, why should I not upload it? No need to, just think a little bit silver 1 please, if you want to get it done quickly, either you answer quickly or I give you the answer and go, I will upload the slide.

Now, silver one is going to be d10 configuration, that is diamagnetic This is silver 1, two of the silver 1, one is oxide, another over here this is silver 3 plus, oxide is always minus 2, 6

minus so it has to be silver 3 plus, silver 3 plus means what one d8 configuration, so d8 configuration can be, can be diamagnetic. D8 going to be square planar.

Student: () (8:09)

Lecturer: Because silver is in high oxidation state. It is a, so this is where sometimes the problem comes either the high oxidation state so, it is the combination of both the ligands should be strong field or metals should be high oxidation state or the combination of higher oxidation state and strong field ligand, then you are going to get that.

Student: () (8:41)

Lecturer: Sorry. Oxidation state? Ag2O plus 1, silver is in plus 1, oxide, oxide all oxide water, are all oxide metal any oxide you see is minus 2. Water if you split? H plus H plus oxide 2 minus. Now that is fine. So, there the geometry as you can see over here silver is linear and silver 3 which are in grey in here it is going to be square planar, square planar, oxide, oxide, oxide, oxide, silver is in the middle.

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• Q02. Work out the hybridization and geometry for the following complexes using the valence bond approach.

(a) $\text{Ni}(\text{CO})_4$; (b) $[\text{Ni}(\text{CN})_4]^{2-}$; (c) $[\text{CoCl}_4]^{2-}$; (d) OsO_4 ; (e) VOCl_3 ; (f) $[\text{Pt}(\text{NH}_3)_4]^{2+}$; (g) $[\text{Ag}(\text{NH}_3)_2]^+$; (h) $[\text{Pt}(\text{PPh}_3)_4]$; (i) $(\text{Cr}_2\text{O}_7)^{2-}$

$\text{Ni}(\text{CO})_4$

Ni atom: 3d $\uparrow\uparrow\uparrow\uparrow$ 4s \uparrow 4p $\uparrow\uparrow\uparrow$; Ni in $[\text{Ni}(\text{CO})_4]$: 3d $\uparrow\uparrow\uparrow\uparrow$ 4s \uparrow 4p $\uparrow\uparrow\uparrow$

sp^3 hybridization

$\text{Ni}(\text{CO})_4$ has a tetrahedral structure and is diamagnetic (no unpaired electrons).

$[\text{Ni}(\text{CN})_4]^{2-}$

$[\text{Ni}(\text{CN})_4]^{2-}$ orbital diagram: 3d $\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow$ 4s \uparrow 4p $\uparrow\uparrow\uparrow$

Now that is you know that in some, some question which is directly, I think these questions are something we have given earlier also, same questions for the tutorial. Now, work out the hybridization and geometry for the following complexes using the valence bond approach. First one is?

Student: () (9:50)

Lecturer: The second one is?

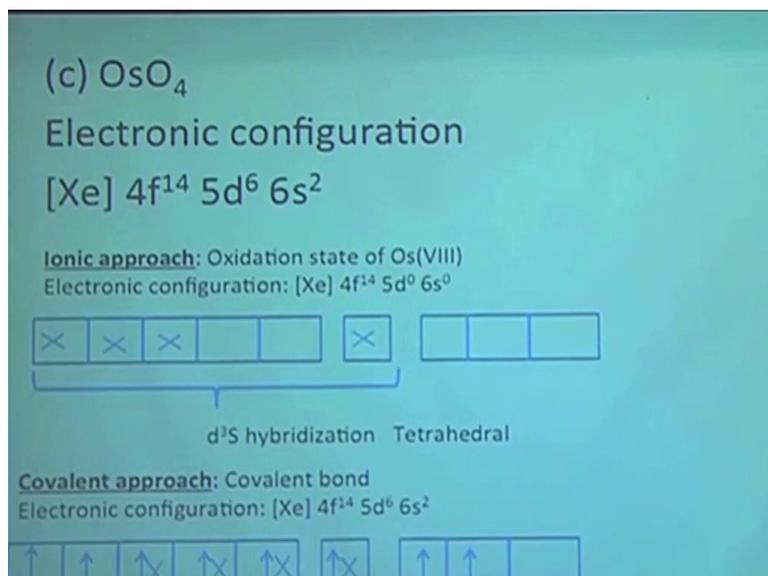
Student: (0)(9:55)

Lecturer: Why is that?

Student: (0)(9:57)

Lecturer: Fantastic. So, nickel is in zero oxidation state and then therefore you, I think this is may not be visible, four of them Sp, Sp³ hybridization, four of the, four of the ligand Sp³ hybridization it is going to be tetrahedra, nickel tetra cyanide it is going to be strong field ligand and thereby the pairing will occur by valence bond approach, we are going to discuss it by valence bond approach and you know that pairing will occur, the electron, the hybridization will be then dsp², that is going to be the square planar. Of course, you can explain it better by crystal field theory, but that is okay.

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$\text{Ni}(\text{CO})_4$	$\text{Ni}(0)$	d^{10}	sp^3	Td
$[\text{Ni}(\text{CN})_4]^{2-}$	$\text{Ni}(II)$	d^8	dsp^2	sq
$(\text{CoCl}_4)^{2-}$	$\text{Co}(II)$	d^7	sp^3	Td
OsO_4	$\text{Os}(VIII)$	d^0	d^3s	Td
VOCl_3	$\text{V}(V)$	d^0	d^3s	Td
$[\text{Pt}(\text{NH}_3)_4]^{2+}$	$\text{Pt}(II)$	d^8	dsp^2	sq
$[\text{Ag}(\text{NH}_3)_2]^+$	$\text{Ag}(I)$	d^{10}	sp	lin
$[\text{Pt}(\text{PPh}_3)_4]$	$\text{Pt}(0)$	d^{10}	sp^3	Td
$(\text{Cr}_2\text{O}_7)^{2-}$	$\text{Cr}(VI)$	d^0	d^3s	Td

All right. Now I think I will skip this, this is the summary, what is given here. Yes that, that is where over here OsO_4 electronic configuration is going to be $4f14 5d6 6s2$. This is what is a little bit difficult over here to do it via VVT. Anyway, if you do it by ionic approach osmium 7 plus it is going to be $4f14$, osmium, sorry osmium is going to be 8 plus, 6 plus 2, 8.

So, $4f14$, total it is going to be d^3s hybridization and it is going to be tetrahedral, we do not call it d^4 or anything, it is going to be d^3s , three of d and one of s , d^3s that is going to be tetrahedral by covalent approach similarly you can look at and you can tell that it is going to be d^3s as well, it is a little bit on a borderline explanation it is, it is see these are, these are little bit older approach VVT approach. So, the explanation is going to be a little bit skewed at some point, but this is okay, you can kind of make sense for both of them.

Now, this is most of them are clear cut tetrahedral square planar, tetrahedral square planar, linear, tetrahedral, tetrahedral. Linear is the silver ammonium where another molecule will be coordinating, anyway this is, you should be able to find out by whatever you have done earlier, tetrahedral (12:44) should not be a problem, square planar on the one where you have the stronger ligand if it is a d^8 configuration, that is where the square planar comes into picture.

But the real reason that valence bond theory wise explanation was simply given, it is a strong field ligand and thereby it should be paired up and so that is what you have learned in the valence bond approach. But by crystal field approach, we have shown how things are going in terms of electron distribution, how orbitals are splitted and thereby why we are saying that d^8 is going to be the square planar one.

(Refer Slide Time: 13:28)

Q03. While the most stable chloride of Zr is $ZrCl_4$ that of Pd is $PdCl_2$. Why?

- The third and high I.E. of the d-block metal increases with increasing atomic number. Owing to the large Z_{eff} making it more energetically unfavourable to attain oxidation state above +2.
- Further the d-orbitals become more contracted towards the end of the series and so are more effective in stabilising higher oxidation states.

Now, while the most stable chloride of zirconium is zirconium tetra chloride that of palladium is palladium chloride $PdCl_2$. Yes, it is also called relativistic effect. What is that, anyone wants to answer?

Student: () (13:52)

Lecturer: Sorry? No, it is, it is more of a d orbital, see what we have seen so far, it is, there are, let me tell you, there are, these are palladium is going to be down the periodic table so you have already seen these Z effective because, because the orbital the higher orbital whichever getting involved, they are not neutralising the positive charge effectively.

So, as we were discussing in the very early class, first class or so Z effective is going to be very, very strong. The moment Z effective is going to be strong, they will be pulling out, pulling in those d orbitals, which are going to participate into the plus 4 oxidation state, up to plus 2 is okay, but plus 4 another two electron release, although technically possible, since Z effective is very high, it is going to not allow those electron, last two electrons to get oxidised to palladium something like plus 4 relatively speaking.

So, those due to the high Z effective, you are not going to participate very strongly or those plus 4 oxidation state achieving becomes difficult, this is what it is called relativistic theory or relativistic effect or so, called inert pair effect, as you go down in the periodic table, the participation of the electrons becomes less and less and if from first floor to second floor if you go there, you do not see much effect, as you go down below further it becomes more prominent.

So, therefore, although higher oxidation state is technically feasible, but practically it becomes difficult to access those removing those electrons, last third electron, fourth electron becomes extremely difficult because Z effective is higher, this is going to pull in very tightly. These are becoming more of a core like, the electrons become more of a core, I mean, why it is difficult, it is become part of the core, so much attracted it does not want to leave those or the atom is not going to leave those.

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Q04. When high pressure is applied, what type of electronic configuration is favoured for a d^5 transition metal complex (Octahedral, weak field ligand)?

Low spin; because it leads to low electron density between the metal and the ligand (i.e., along the bond axis).

d^5 : HS

d^5 : L

Next question, question number four, when high pressure is applied, what type of electronic configuration is favoured for a d^5 transition? When high pressure is applied, what type of electronic configuration is favoured for a d^5 transition metal complex? It is, you are going to put high pressure, you are going to take out the electron from the let us say d_{z^2} orbital which is shown in there and thereby, you are going to kind of paired off the electron.

So, because it leads to low electron density between the metal and the ligand that is along the bond axis you are going to end up pairing. So, you will get the low spin complex, not clear? When high pressure is applied, I will tell you it is not clear to me as well. Let me see, what type of electronic configuration is favoured for a d^5 transition metal complex?

So, d^5 you are going to have two configuration, $t_{2g}^3 e_g^2$ and another configuration is going to be $t_{2g}^5 e_g^0$. Now, I think it is, it is you are going to apply more field means you are going to split between the t_{2g} and e_g , e_g level. If you are pulling out you are going to separate out the t_{2g} versus e_g . Still not clear?

I am getting more confused. I will bring it back, leave it. I think pulling some base, it is clear that you pull out then you decrease the electron density along the axis. Tej, can you explain? Low electron density between the metal and the ligand that is along the bond axis. What exactly is happening?

Student: (0)(18:58)

Lecturer: Repulsion between what?

Student: Ligand and metal.

Lecturer: Ligand and metal.

Student: (0)(19:14)

Lecturer: Okay, okay. So, when you are compressing, wait, wait, wait, wait, I am not clear here, when you are compressing between these two, then?

Student: (0)(19:31)

Lecturer: Repulsion forced to be much more, yeah.

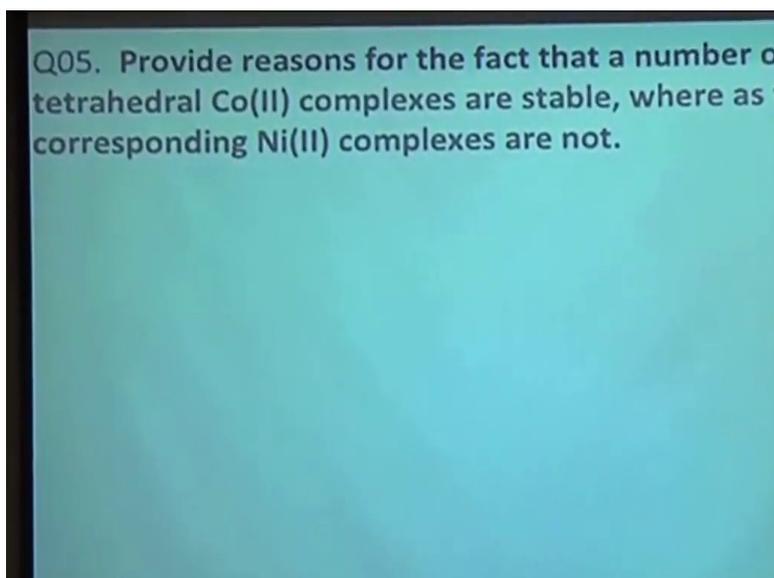
Student: (0)(19:39)

Lecturer: Okay, fine. I think it is still not clear unless I am 100 percent clear, I am not, okay, fine, it is, it is interesting. Yeah.

Student: (0)(19:52)

Lecturer: I think you are saying exactly what he is trying to say. But explaining the explaining becomes a little bit difficult. Let me, let me digest it a little bit better, I will come back.

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Now provide reasons for the fact that a number of tetrahedral cobalt 2 complex are stable, whereas the corresponding nickel 2 complexes are not, anyone? Provide reasons for the fact that a number of tetrahedral cobalt 2 plus complexes are stable and whereas, corresponding nickel 2 complexes are not. Nickel 2 is what?

Students: d8.

Lecturer: d8, d8 tetrahedral square planar more or tetrahedral versus octahedral even if you are considering and cobalt 2 plus tetrahedral and octahedral you are considering, what you see, that is what you have to see.

(Refer Slide Time: 20:52)

Q05. Provide reasons for the fact that a number of tetrahedral Co(II) complexes are stable, whereas corresponding Ni(II) complexes are not.

The CFSE of d^7 tetrahedral complex is greater than that of d^8 tetrahedral complex.
Similarly, the CFSE of d^8 octahedral complex is greater than that of the d^7 octahedral complex.

Octahedral Vs Tetrahedral

Table 19.2 Ligand-field stabilization energies

d^n	Example	Octahedral	Tetrahedral
d^0		0	0
d^1	Ti^{3+}	1	0.4
d^2	V^{3+}	2	0.8
d^3	Cr^{3+}, V^{2+}	3	1.2
Strong-field			
d^4	Cr^{2+}, Mn^{3+}	2	1.6
d^5	Mn^{2+}, Fe^{3+}	1	2.0
d^6	Fe^{2+}, Co^{2+}	0	2.4

So, d7 tetrahedral CFSE and d7 octahedral CFSE. So, what you see overall is d7 tetrahedral complex is greater CFSE is greater than the d8 tetrahedral complex. Calculate that d7 CFSE for tetrahedral field, what is the d7 CFSE? Minus $2\Delta_{tet}$ d7 CFSE tetrahedral, d7 yeah tetrahedral is high spin always high spin minus $12, 12 \Delta_{tet}$. What is for d8? Minus, minus $8, 12$ and 4 over there, minus $8, 12$ which one is more stable, d7 is more stable. So, d7 is going to be cobalt 2 plus d7 is going to be tetrahedral. You.

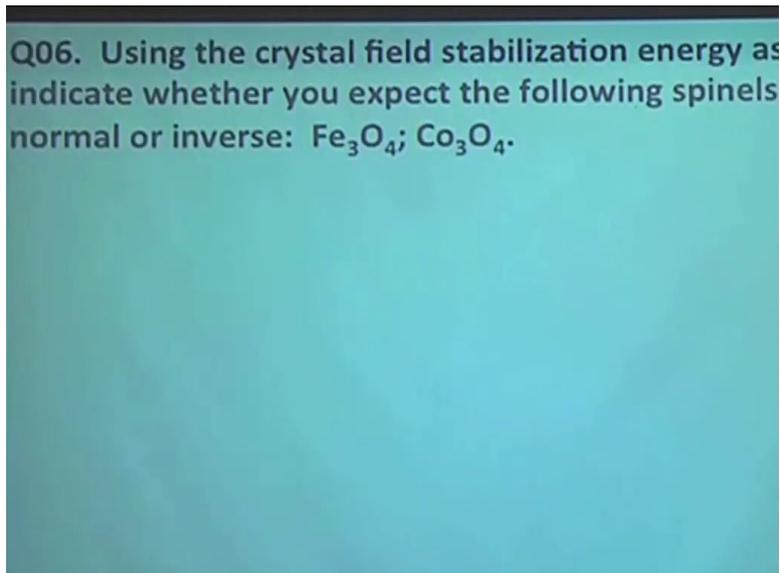
No, no, I am asking you to compare tetrahedral versus tetrahedral, tetrahedral for d7, tetrahedral for d8, octahedral for d7, octahedron for d8. You see the answer is within that, so CFSE of d8 octahedral, d8 octahedral will be just, just do the octahedral, simple octahedral. So, it is going to be minus 1.2 or $12 \Delta_{oct}$ or Δ_{oct} and what is for d, d7? Minus, no, no, minus 0.8 or $8\Delta_{tet}$, d7.

Calculate that is what I was saying maximum cases calculate the CFSE of both the geometry d7, what is the geometry, d8 what is the geometry, what is the splitting, a sorry, what is the stabilization energy? This you should be able to do it in your dream. Now, the statements here is correct CFSE for d7 is more for tetrahedral case, you have find out and CFSE for d8 octahedral is more. CFSE of d8 octahedral complex is greater than d7 octahedral, you calculate, you will find.

So, for these d8 it is going to be minus $12 \Delta_{oct}$ or minus $1.2 \Delta_{oct}$. For d7 it is going to be minus $8\Delta_{tet}$ or $0.8 \Delta_{oct}$, or Δ_{oct} . The fact is here so, the answer is correct. The experimental fact is also given over here which you can corroborate.

Provide reasons for the fact that a number of tetrahedral cobalt 2 complexes are stable whereas corresponding nickel 2 complexes are not, that is the answer. Of course, this is clearly shows that cobalt 2 plus preferred tetrahedral, nickel 2 plus are not preferring tetrahedral. I am not saying what it is. So, answer is okay.

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Now using the crystal fields stabilization energy as criteria indicate, whether you expect the following spinels to be normal or inverse. Now calculate, calculate and figure it out, another 10 minutes you should be done, calculate quickly. See, this is what I was really trying to tell you that you should be able to calculate the CFSE really quick, write down, calculate.

CFSE for Fe³⁺, what we have asked you to for normal and inverse spinel, you do not have to worry about tetrahedral you just think about octahedral, Fe³⁺ plus and Fe²⁺ plus octahedral and it is going to be high spin, high spin octahedral case you just calculate. Should I calculate? No, I can calculate Fe³⁺ plus is d⁵ system, high spin d⁵ system is 0, d_{2g}³ is e_{2g}², so there is 0 CFSE.

High spin iron 2 plus that is d⁶, d⁶ means high spin t_{2g}⁴ e_g². Fe²⁺ plus having minus 4dq as a stabilisation energy, Fe³⁺ plus having zero stabilization energy. So, higher oxidation state is having less stabilisation, lower oxidation state is having higher stabilisation, you are going to get an inverse spinel, I guess I was discussing in the class as well.

(Refer Slide Time: 26:57)

Q06. Using the crystal field stabilization energy and indicate whether you expect the following spinels normal or inverse: Fe_3O_4 ; Co_3O_4 .

Spinel by definition, the 3+ ion has to go to the O_h site leaving the

Fe_3O_4 is composed of Fe(II) Td and Fe(III) O_h ions with d^6 and d^5 respectively. Since d^5 has no CFSE, it is more advantageous to be in Td environment than in O_h . In other words, by placing d^6 ions in O_h there is more gain in CFSE than keeping this in Td environment.

Here the Fe_3O_4 structure is inverse spinel.

Co_3O_4 has a similar structure with d^7 and d^6 configurations for Co^{2+} and Co^{3+} respectively. Co^{3+} d^6 ion is low spin because (a) high charge

Now Co_3O_4 is a little tricky case because Co^{3+} is low spin, high charge and iron cobalt d^6 iron is low spin because high charge even with, with ligand. This is a tricky case. Co^{2+} plus has a similar structure with d^7 and d^6 configuration. This is going to be a normal spinel, d^7 , d^7 is what, d^7 is what? Co^{2+} plus is d^7 , iron cobalt d^7 in Co_2 plus.

If you Co^{2+} plus with oxide it is not going to be the low spin, it is going to be the high spin Co^{2+} plus lower oxidation state oxide is not that of a great ligand, so it is going to be the high spin, Co^{2+} plus high spin d^7 so it is going to be minus $8dq$. How about Co^{3+} plus, Co^{3+} plus it is going to be d^6 , d^6 it is going to be minus $4dq$, if it is high spin, $3 t_{2g}^4 e_g^2$, $t_{2g}^4 e_g^2$ if it is high spin d^6 .

Now, the problem is that is minus $4dq$ technically speaking, it should be inverse spinel, higher oxidation state is having lower stability compared to the lower oxidation state. But Co^{3+} plus this is an exception you have to kind of remember but we will try in the exam, we will try to give not such example. Co^{3+} plus being high oxidation state and even with lower oxygen, lower I will even weaker field ligand such as oxide, we still are going to get the normal spinel.

(Refer Slide Time: 30:00)

Q07. By showing the details, determine the CFSE for the following complexes
(a) $[\text{FeCl}_4]^{2-}$; (b) $\text{W}(\text{CO})_6$.

$e^3 t_2^3$ $\text{CFSE} = -0.6 \Delta_t$

$t_{2g}^6 e_g^0$

Next, few more questions left, by showing the details determine the CFSE for the following complex. These are the very simple questions. CFSE for Fe²⁺, Fe²⁺ is d⁶. Cl is a weak field ligand, iron is 2+, low oxidation state. So, it is going to be the high spin d⁶, high spin t_{2g}⁴ e_g², t_{2g}³ e_g² cancels out, minus 4dq. All of you got it or should I wait a little bit? Okay, 30 seconds.

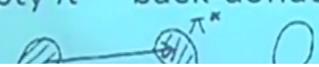
The titanium, titanium is going to be sorry, not tungsten. My bad, tungsten, tungsten is going to be, carbonyl is going to be strong field ligand, almost the strongest you can get out there. So, it is going to give you low spin for Co, t_{2g}⁶ e_g⁰.

Yeah, yeah, it is usually we, when we count, we just count for d, until these, like d⁶, that is why we are counting because you, that was the atomic orbital, you have to take into the atomic orbital into the more of a complex orbital or molecular orbital. We never so far, we never talk about d_{2s}, atomic orbital wise it is correct d⁴, s₂d⁴ but in reality, when you are doing anything with the hybridization or anything with specially with the complexation, you have to say it is. it is a mixing; orbital mixing is happening. Yeah, you have to say it is a d⁶. So t_{2g}⁶ e_g⁰.

(Refer Slide Time: 31:36)

Q08. Explain what is meant by the term “synergic bonding”?

In the synergic bonding the σ -donation of from the ligand to the metal is reinforced by back-donation from the metal to the ligand. In a valence bond model it may be represented as $M \cdot CO^+$ and $M=C=O$. The filled CO orbital to empty M σ -donation. Filled orbital to empty π^* - back-donation.



Now explain what is meant by the terms synergic bonding, this is the textbook question. synergic bonding, I think you have studied for your exam before. It is the, it is the pi bonding between the, between the ligand sorry, sigma bonding between the ligand, these ligand orbital and the metal orbital and pi back bonding between the metal orbital and the antibonding orbital of the carbon monoxide.

It is written in the way I think you have studied before synergic bonding is the ligand donates metal gives back, so it is I am teaching that is what I was trying to say you, you tomorrow you will give me money. That is the synergic bonding. Once you become trillionaire I am sure some of you billionaire or whatever.

(Refer Slide Time: 32:15)

Q09. The Cr^{2+} ion in CrF_2 is surrounded by six fluoride ions. Of these, four are at a distance of 2.00 Å while the other two are at a distance of 2.13 Å from the metal ion center. Explain this observation.

CrF_2 : Cr^{2+} is surrounded by 6 fluoride ions in an octahedral environment.

Cr^{2+} is d^4 high spin; $t_{2g}^3 e_g^1$.

The unsymmetrical distribution of electrons in e_g orbitals leads to the observed distortion.

Now the chromium 2 plus ion in CrF_2 is surrounded by six fluoride ions, chromium 2 plus. This is, this is a clear cut def, I mean statement is given it is CrF_2 we are saying but it is surrounded by six ligands, it is surrounded by six fluoride of these four are at a distance of 2 Armstrong, four are shorter and the other two are at a distance of 2.43 Armstrong. Explain this observation.

So, chromium 2 plus is surrounded by six fluoride ions in an octahedral environment. It is surrounded by six fluoride ion, chromium 2 plus is what, d4 scandium, titanium, vanadium, chromium d4S2. So, 2 plus is going to be d4. Now it is going to be $t_{2g}^3 e_g^1$. So, the unsymmetrical distribution of electrons in eg orbital that is what we were trying to show, eg orbital whenever you are having unsymmetrical feeling then there is a possibility of further splitting of the eg orbital, eg orbital can be splitted.

These observations suggest that eg electrons in d_{z^2} orbital because the two or two of them are longer, four, four are shorter, two are longer, a little bit longer. Two longer means that direct sense it is getting stabilised. The ligands are getting longer, that means ligands are not coming close.

I think now I can explain a little bit that question anyway, ligands are farther and therefore z, it is going to be z out, slightly z out and you are going to get dz square orbital stabilised, ligand are far at the z direction, therefore d_{z^2} orbital is going to be stabilised, slightly lower in energy and that electron since it is stabilised electron is going to go there. Because you, it wants to achieve the stabilised state. Move on, that is it.