

~~(31)~~ **Today**

32 Section 10.1 Experimental Data Used in when Describing Bonding in Coordination Compound

Section 10.2 Crystal Field Theory

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Section 10.2 Crystal Field Theory 33

Section 10.3 Ligand Field Theory

~~(33)~~ **Second Class from Today**

33 Section 10.3 Ligand Field Theory

Section 10.5 The Jan-Teller Effect

Section 10.6 Four and Six-Coordinate Preferences

**Third Class from Today** ~~(34)~~

Section 10.6 Four and Six-Coordinate Preferences 34

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Complete mini-project 3 by 12/15

# What Do We Do when We Study Bonding in Metal Complexes

## Formation Constants and Thermodynamic Quantities



information about how strongly the ligands are bonded to the metal

## Magnetic Susceptibility

information about the electronic structure number of unpaired  $e^-$ 's

## Electronic Spectra

energy levels of the orbitals

# Thermodynamic Data and Formation Constants

## Section 10.1.1

		K		
		Cu <sup>2+</sup>	Ag <sup>+</sup>	
$[M(H_2O)_6]^{Z+}(aq) + NH_3(aq)$	$\rightleftharpoons$	$[M(NH_3)(H_2O)_5]^{Z+}(aq) + H_2O(l)$	17,000	2,000
$[M(H_2O)_6]^{Z+}(aq) + F^-(aq)$	$\rightleftharpoons$	$[M(F)(H_2O)_5]^{(Z-1)+}(aq) + H_2O(l)$	8	<u>0.68</u>
$[M(H_2O)_6]^{Z+}(aq) + Cl^-(aq)$	$\rightleftharpoons$	$[M(Cl)(H_2O)_5]^{(Z-1)+}(aq) + H_2O(l)$	1.2	1,200
$[M(H_2O)_6]^{Z+}(aq) + Br^-(aq)$	$\rightleftharpoons$	$[M(Br)(H_2O)_5]^{(Z-1)+}(aq) + H_2O(l)$	<u>0.9</u>	<u>20,000</u>

Cu  
↓

For Cu Z = 2, for Ag Z = 1

$$K = \frac{[Cu(NH_3)(H_2O)_5]^{2+}}{[Cu(H_2O)_6]^{2+} [NH_3]}$$

strongly bonded to metal  
products favored

reactants favored

hard Lewis acid

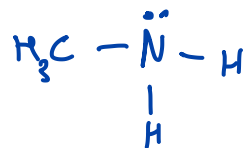
Cu<sup>2+</sup> bonds more strongly with F<sup>-</sup> ← hard Lewis base

Ag<sup>+</sup> bonds more strongly with Br<sup>-</sup>

↑  
larger softer

↑  
larger softer

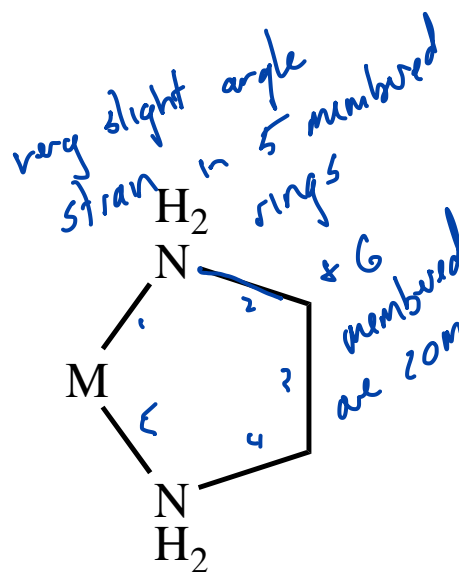
Thermodynamic Data and the Chelate Effect



Section 10.1.1

$$\Delta G^\circ = -RT \ln K$$

		$\Delta H^\circ$ (kJ/mol)	$\Delta S^\circ$ (K kJ/mol)	$K$	
$[\text{Cd}(\text{H}_2\text{O})_6]^{2+}(\text{aq}) + 4 \text{CH}_3\text{NH}_2(\text{aq})$	$\rightleftharpoons$	$[\text{Cd}(\text{NH}_2\text{CH}_3)_4(\text{H}_2\text{O})_2]^{2+}(\text{aq}) + 4 \text{H}_2\text{O}(\text{l})$	-57.3	-67.3	$3.3 \times 10^6$
$[\text{Cd}(\text{H}_2\text{O})_6]^{2+}(\text{aq}) + 2 \text{en}(\text{aq})$	$\rightleftharpoons$	$[\text{Cd}(\text{en})_2(\text{H}_2\text{O})_2]^{2+}(\text{aq}) + 4 \text{H}_2\text{O}(\text{l})$	-56.5	14.1	$4.0 \times 10^{10}$



We can determine  $\Delta G^\circ$  from  $K \dots$

$$\Delta G = \Delta H - T\Delta S$$

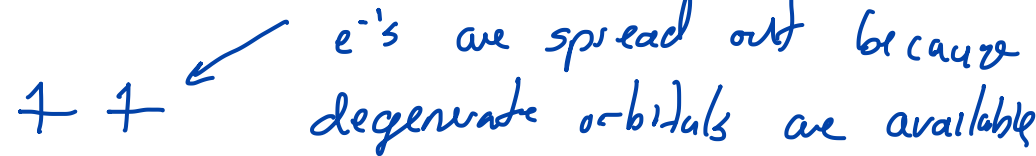
can find  $\Delta S$  based on experimentally determined  $\Delta G$  &  $\Delta H$

got this from  $K$

use calorimetry to determine the change in enthalpy

- $S$  entropy - a measure of order/randomness -  $\Delta S > 0$  increase in entropy is favorable
- $H$  enthalpy - a measure of bond energy -  $\Delta H < 0$  releases  $E$  to universe
- $G$  Gibbs free energy - related to  $\Delta S_{\text{universe}}$  -  $\Delta G < 0$  release  $E$  to universe

Hunds rule says that e<sup>-</sup>'s will singly occupy degenerate orbitals before pairing

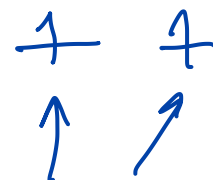


Diamagnetic compounds are slightly repelled by magnetic fields

Paramagnetic compounds are attracted to magnetic fields



e<sup>-</sup>'s cannot line up with magnetic field



"spinning" charges

these little magnets can align with an applied magnetic field ... and attracted to magnets