

# Advanced Inorganic Chemistry

## Exam 3 Topics and Suggested Problems

### Chapter 9

- naming coordination compounds (mostly covered on quiz)
- isomers: cis/trans, mer/fac.
- common geometries for each coordination number (3-7)
- types of compounds which tend to have low or high coordination numbers

### Chapter 10

- crystal field/ligand field theory: octahedral/tetrahedral splitting, relative magnitudes, CFSE/LFSE
- MO - crystal field theory relationship
- determining the number of valence d electrons in a metal ion
- high spin complexes, low spin complexes, spin-only magnetic momenta
- ligands as  $\pi$  donors/acceptors
- weak/strong field ligands
- angular overlap method: predicting d orbital splitting from the aom chart
- $\pi$  acceptors, backbonding

### Chapter 11

- Term symbols, ground state terms
- Tanabe-Sugano diagrams
- Electronic spectra - calculating  $\Delta_o$ ,  $B$

### Chapter 12

- labile and inert complexes: definitions, general rules
- substitution mechanisms (+ likely ones for octahedral, square planar)
- trans effect (order for  $\text{CN}^-$ ,  $\text{CO}$ ,  $\text{Cl}^-$ ,  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ )
- labilization of COs
- inner and outer sphere mechanisms

### Chapter 13

- 18 electron rule, counting electrons, M-M bonding
- carbonyls, bonding modes, backbonding (IR implications)
- ligands with  $\pi$  systems ( $\text{Cp}$ ,  $\text{C}_2\text{H}_4$ , allyl, benzene)

### Sample Questions

1. Name the following compounds:

- (a)  $\text{Co}(\text{H}_2\text{O})_6]^{3+}$   
 (b)  $\text{PtCl}_2(\text{NH}_3)_2$
- Draw the structure of the octahedral species mer-tricarbonyltrichlorocobalt(III)
  - Name and describe or draw the 2 common geometries for coordination compounds with coordination number 6.
  - Coordination compounds typically have coordination numbers of 4-6, whereas higher and lower coordination numbers are less common. What types of  $\text{ML}_x$  species have low coordination numbers?
  - Tetrahedral complexes are more likely to be high spin. Why?
  - On the left, sketch a d orbital splitting diagram for an octahedral complex. On the right, sketch another d orbital splitting diagram, showing what would happen to the d orbitals if a  $\pi$  donor ligand like  $\text{Cl}^-$  were present.
  - Calculate the spin only magnetic moment for the following species. Consider both high/low spin if needed.
    - $\text{Co}(\text{NH}_3)_6]^{2+}$
    - $\text{PtCl}_4]^{2-}$
    - $\text{Mn}(\text{acac})_3$  (acac is a bidentate ligand with a formal charge of -1)
  - Ligands like  $\text{CN}^-$  and CO are referred to as strong field ligands, why?
  - Draw a d orbital splitting diagram for an  $\text{ML}_4$  square pyramidal species using AOM. You may assume that this looks like an octahedral complex with 1 ligand removed. Label all the d orbitals and indicate the bonding properties of each (i.e. nonbonding, M-L bonding, M-L antibonding, etc).
  - Calculate the LFSE for a high spin and low spin  $d^4$  tetrahedral complex. If  $\Delta_o = 18,000 \text{ cm}^{-1}$  for an octahedral complex with the same metal and ligands, and the pairing energy for this metal is  $10,000 \text{ cm}^{-1}$ , is the tetrahedral complex likely to be high spin or low spin? Explain your reasoning.
  - Predict the relative lengths of the C=O bond in  $\text{M}(\text{CO})\text{L}_5$ ,  $\text{trans-M}(\text{CO})_2\text{L}_4$  and  $[\text{M}(\text{CO})\text{L}_5]^+$  where L is a  $\sigma$  donor only and the metal is the same in each case ( $\text{M}^o$  is  $d^6$ ).
  - Which of the following octahedral high spin complexes should be Jahn-Teller distorted, state what kind of distortion it should be, and whether it would be large or small. Explain your reasoning.
    - $[\text{MoF}_6]$
    - $[\text{Co}(\text{OH}_2)_6]^{2+}$
    - $[\text{Mn}(\text{NH}_3)_6]^{2+}$
    - $[\text{ZrCl}_6]^{2-}$
  - Ligand substitution reactions: draw the product formed from  $[\text{Pt}(\text{H}_2\text{O})_4]^{2+}$  after double substitution with  $\text{Cl}^-$ . Explain your reasoning.
  - Octahedral complexes do not generally undergo substitution reactions via the associative mechanism. Why? Explain.
  - Describe the difference between the outer and inner sphere mechanisms.
  - Counting electrons (try: M&T 13.1, 13.2, 13.6)
  - M-M bonding (try: M&T 13.4, 13.7a,c,e)
  - Draw the structures of the following carbonyl complexes:
    - $(\eta^5\text{-Cp})\text{Mo}(\text{CO})_3$
    - di- $\mu$ -carbonylbis(tricarbonylcobalt)(0)
    - $[(\eta^5\text{-Cp})_3\text{Ni}_3(\mu_3\text{-CO})_2]^+$