

# Chem 151A, Inorganic Chemistry

Spring 2015

## Problem Set #3

DUE: MONDAY JUNE 1, 2015, 9:30 am

Chem 151A Mail Slot in PSB Mail Room (Next to PSB 238)

- 20 marks 1. Construct an MO diagram for  $[\text{Co}(\text{CN})_6]^{3-}$ . Include the proper MO labels, AO to MO connections, electron filling,  $\Delta_{\text{Oct}}$  and LFSE. For each energy level, sketch one MO (i.e. the  $a_{1g}$ , one of the three  $t_{1u}$  MOs, etc.).
- 15 marks 2. Determine the free atom term symbol(s) for a  $d^1$  metal (ignore jj coupling).
- 15 marks 3. Using the Tanabe-Sugano diagrams on page A-38, find the values (in units of  $\text{cm}^{-1}$ ) of  $D_q$  (or  $\Delta_{\text{Oct}}$ ) and  $B$  for  $[\text{Cr}(\text{CN})_6]^{3-}$ , which has UV-Vis absorption bands at 264nm (CT), 310nm ( $\nu_1$ ) and 378nm ( $\nu_2$ ). All transitions are spin allowed.
- 10 marks 4. For  $d^5$ , write all possible *spin-allowed* transitions, including the ground state and excited state molecular term symbols involved and approximate E/B values for: (i)  $\Delta_{\text{Oct}}/B = 15$ ; (ii)  $\Delta_{\text{Oct}}/B = 35$ .
- 10 marks 5. The frequency of the symmetrical M-O stretching vibration of the octahedral aqua ions  $[\text{M}(\text{OH}_2)_6]^{2+}$  increases along the series  $\text{Ca}^{2+} < \text{Mn}^{2+} < \text{Ni}^{2+}$ . How does this trend relate to acidity?
- 10 marks 6. Mn(VI) is not stable and undergoes redox. Name this phenomenon and sketch a suitable Frost diagram. Specify whether  $E^\circ$  and  $\Delta G^\circ$  for the redox are positive, zero or negative.
- 10 marks 7. Give at least four reasons why square planar substitution reactions are associative.
- 10 marks 8. Account for the color, or lack thereof, for the following pairs of molecules:  
(a)  $\text{Cu}(\text{NH}_3)_4^+$  is colorless,  $\text{Cu}(\text{NH}_3)_4^{2+}$  is intense blue  
(b)  $\text{Co}(\text{H}_2\text{O})_6^{2+}$  is pale pink,  $\text{CoCl}_4^{2-}$  is deep blue  
(c)  $\text{Au}(\text{CN})_4^-$  and  $\text{Co}(\text{CN})_6^{3-}$  both form colorless crystals

Total: 100 marks