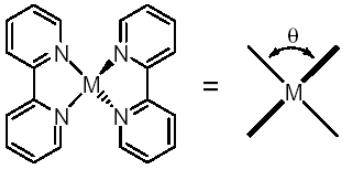
## 2003 2nd semester Final
## Advanced Inorgnanic Chemistry 2
(Open Book Test)

1. (50 pts) What are the point groups of the following molecules? Write down all the existing symmetry elements of each molecule. (Consult character tables)

(a) Θ = 90° (b) Θ = 70°




(c) $H_2O$ (d) cyclohexane (chair form) (e) cisplatin

2. (30 pts) What are the nomenclatures or chemical formula of the followings?

(a) *trans*-$[Cu(H_2O)_2(en)_2]^{2+}$
(b) *fac*-$[IrCl_3(PMe_3)_3]$
(c) *trans*-$[Ni(CN)_4(H_2O)_2]^{2-}$
(d) *trans*-dichlorobis(ethylenediamine)cobalt(III) chloride
(e) *fac*-tricarbonyl-tris(trifluorophosphine)molybdenum(0)
(f) tetraamminechromium(III)-μ-oxo-μ-methoxo-bis(ethylenediamine)cobalt(III) chloride

3. (105pts) $[PtCl_4]^{2-}$ is diamagnetic while $[NiCl_4]^{2-}$ is paramagnetic.
(a) (10 pts) What are the geometrical structures of the above two complex ions?
(b) (20 pts) Explain why the magnetic properties differ between two compounds using VBT (Valence Bond Theory)?
(c) (20 pts) Explain why the magnetic properties differ between two compounds using CFT (Crystal Field Theory)?
(d) (10 pts) What is the point group of each compound?
(e) (5 pts) How many do vibrational modes exist for the compounds?
(f) (40 pts) There are four M-Cl stretching vibrations. What are the symmetry types of the stretching vibrations for each compound? Distinguish Raman-, IR-active modes. (Hint, Draw four M→Cl arrows and think about that.)

4. (50 pts) Equilibrium constants for the reactions between ethylenediamine (en) and $Co^{2+}$, $Ni^{2+}$, $Cu^{2+}$ are listed in the table below. (M=Co, Ni, Cu)
$[M(OH_2)_6]^{2+}$ + en ⇄ $[M(en)(OH_2)_4]^{2+}$ + $2H_2O$ $K_1$
$[M(en)(OH_2)_4]^{2+}$ + en ⇄ $[M(en)_2(OH_2)_2]^{2+}$ + $2H_2O$ $K_2$
$[M(en)_2(OH_2)_2]^{2+}$ + en ⇄ $[M(en)_3]^{2+}$ + $2H_2O$ $K_3$

| ion | $\log K_1$ | $\log K_2$ | $\log K_3$ |
|---|---|---|---|
| $Co^{2+}$ | 5.89 | 4.83 | 3.10 |
| $Ni^{2+}$ | 7.52 | 6.28 | 4.26 |
| $Cu^{2+}$ | 10.55 | 9.05 | -1.0 |

(a) (10 pts) Explain why $K_1>K_2>K_3$ for $Co^{2+}$ and $Ni^{2+}$.
(b) (20 pts) Explain why $K(Co^{2+})<K(Ni^{2+})<K(Cu^{2+})$ for $K_1$ and $K_2$.
(c) (20 pts) Explain why $K_3(Cu^{2+})<K_3(Co^{2+})<K_3(Ni^{2+})$.

5. (30 pts) The spectrum of d1 $Ti^{3+}(aq)$ is attributed to a single electronic transition $t_{2g}\rightarrow e_g$. The band shown in Fig7.10 is not symmetrical and suggests that more than one state is involved. Suggest how to explain this observation using the Jahn-Teller theorem.

6. (85 pts) Identify the ground state terms with the spin multiplicity for the following transition metal ions.

| | | Free Ions | Octahedral Complexes | | Tetrahedral Complexes |
|---|---|---|---|---|---|
| | $Cu^{2+}$ | $^2D$ | $^2E_g$ | | $^2T_2$ |
| (a) | $V^{3+}$ | | | | |
| (b) | $Cr^{3+}$ | | | | |
| (c) | $Mn^{2+}$ | | high-spin | low-spin | |
| | | | | | |
| (d) | $Fe^{2+}$ | | | | |
| (e) | $Ni^{2+}$ | | | | |

7. (30 pts) Explain why $[FeF_6]^{3-}$ is colorless whereas $[CoF_6]^{3-}$ is colored but exhibits only a single band in visible.

8. (30 ts) Use Tababe-Sugano diagram to predict the ground state and the number of observable transitions for each of the following molecules.

(a) $[Cr(H_2O)_6]^{+3}$ (Octahedral structure)
(b) $[Fe(CN)_6]^{4-}$ (Octahedral structure, strong-field complex)
(c) $[NiCl_4]^{2-}$ (Tetrahedral structure)

9. (30 pts) Consider the molecular orbital diagram for a tetrahedral complex and relevant d orbital configuration. Show that the purple color of $MnO_4^-$ ions cannot arise from a ligand-field transition (d-d transition).

10. (Bonus 60 pts) Essay: Write good thing, bad thing, ugly thing, suggestion, to be improved, thing you want to learn in inorganic chemistry lecture,.....anything about this lecture. Write at least **12 lines** (Korean, 5 points/line, at least 40 characters/line, max point 60) or **6 lines** (English, 10 points/line, at least 50 characters/line, max point 60). Of course, you can write as much as you want. Just maximum point is 60.

*** Exam score and term grade will be posted in my web site within a week.** Check the site frequently.
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