1. On the basis of inductive effect, the Lewis acidity of the boron halides is expected to be $BF_3 > BCl_3 > BBr_3$. Experimentally, the opposite is observed. Explain these apparent anomaly (5%).

2. Complete the following equations: (8%)

(a) $2\ CrO_4^{2-} + 2\ H_3O^+ \longrightarrow$

(b) $(H_3Si)_2O + BF_3 \longrightarrow$

(c) $B_4H_{10} + 2\ (CH_3)_3N \longrightarrow$

(d) ***closo***-$C_2B_9H_{11} + 2\ e^- \longrightarrow$

3. Explain the following: (12%)

(a) Borazines undergo addition reactions much more easily than does benzene.

(b) The optical absorption bands of lanthanide compounds are much narrower than those of transition complexes.

(c) Trisilylamine, $(H_3Si)_3N$, is a very weak base.

(d) Si_2H_6 is more chemically reactive than does C_2H_6.

4. Use the Valence Bond theory to predict the structure of NO_2, NO_2^+, and NO_2^- (including the assignment of lone-paired electrons) (6%).

5. The melting point of following compounds shown as below:

KBr, 730°C; CsF, 684°C; $CaBr_2$, 765°C; BaF_2, 1280°C

Explain the trend of changing (4%).

6. Predict the trend of IR stretching frequency of C=O in the following compounds and explain: (4%)

(a) cyclobutanone (b) cyclopentanone (c) cyclohexanone

7. Give the ground-state term symbol of Cr^{3+}, Mg, and C with consideration of the spin-orbit coupling effect (6%).

8. Use Slater's rule and Clementi & Raimondi Equation to evaluate the effective nuclear charge (Z^*) for a 2S-electron of Br atom, respectively. Explain the difference between the two values of Z^* (5%).

[Clementi & Raimondi Equation of shielding factor:

$S_{2s} = 1.7208 + 0.3601\ (N_{2s} - 1 + N_{2p}) + 0.2062\ (N_{3s,p,d} + N_{4s,p})$]

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9. Tell the difference between lability and instability of a compound (3%).

10. Give possible structures of $[Pt(NH_3)_2(py)_2Cl_2]^{2+}$ (3%).

11. From the view points of Valence Bond Theory and Molecular Orbital Theory, what would make CO a very strong ligand? (8%)

12. Using the following data, illustrate what kind of relationship exists between the acid-base strength and hardness (or softness) (5%).

F^-	$+ H^+$ <------>	HF	$K_{eq} = 10^{2.85}$
Cl^-	$+ H^+$ <------>	HCl	$K_{eq} = 10^{-7}$
S^{2-}	$+ H^+$ <------>	HS^-	$K_{eq} = 10^{14.2}$
F^-	$+ CH_3Hg^+$ <------>	CH_3HgF	$K_{eq} = 10^{1.5}$
Cl^-	$+ CH_3Hg^+$ <------>	CH_3HgCl	$K_{eq} = 10^{5.25}$
S^{2-}	$+ CH_3Hg^+$ <------>	CH_3HgS^-	$K_{eq} = 10^{21.2}$

13. The ground state for a d^1 species is ^2D. What states will ^2D be split into if a d^1 species is under the influence of a tetrahedral field? What electronic configurations will correspond to each split state? How many microstates does each split state contain? (6%)

14. Draw structures for (a) π-allylmolybdenum (b) $Os_3(CO)_{10}(\mu_2\text{-}CH_2)(\mu_2\text{-}CO)$ (c) Metalacyclobutane (6%).

15. Explain the following questions:

(a) β-Elimination cannot happen for $Cr(CHMe_2)_4$ although this compound has β-hydrogen atoms (3%).

(b) The reaction between $(\eta^5\text{-}C_5Me_5)_2Zr(Me)_2$ and CO does not give the expected product, $(\eta^5\text{-}C_5Me_5)_2Zr(Me)(\eta^1\text{-acyl})$ but $(\eta^5\text{-}C_5Me_5)_2Zr(Me)(\eta^2\text{-acyl})$ (3%).

(c) $W(CO)(PhC_2Ph)_3$ is an eighteen-electron compound although each diphenylacetylene can donate four electrons to the tungsten atom (2%).

(d) $L_2TiCl_3(CH_2CH_3)$ (L is a phosphorus ligand) contains an agostic ethyl group; this group is stable with respect to β-elimination (3%).

16. Give the electron counts for the following compounds: (8%)

(a) WMe_6 (b) $Co(\eta^5\text{-}C_5H_5)_2$ (c) $Mn(CO)_5$ (d) $Cr(NO)_4$.