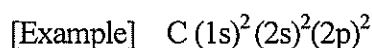


Inorganic Chemistry I

I – a Answer the following questions.

(1) Write down the ground state electronic configuration for each atom or ion listed below [(i) ~ (iii)] according to the example.



- (i) F^-
- (ii) P
- (iii) Mn

(2) Which element has the highest first ionization energy in each list [(i) and (ii)]? Also, which element has the lowest first ionization energy in each list [(i) and (ii)]?

- (i) He, Ne, Ar, Kr, Xe
- (ii) Ni, Cu, Zn, Ga, Ge

(3) Consider the structures of the following molecules and ion, (i) ~ (v), based on the valence-shell electron pair repulsion (VSEPR) model, and draw the structures with showing spatial arrangement of each atom clearly. In case that the central atom has lone-pair electrons, show the direction of each lone pair in the structures.

- (i) BF_3
- (ii) NF_3
- (iii) BF_4^-
- (iv) SF_4
- (v) ClF_5

(4) The Lewis acidity of BF_3 is smaller than that of BCl_3 . Explain the reason.

I – b Answer the following questions regarding N_2 and CO molecules.

(1) Draw the molecular orbital energy level diagram from the atomic orbital energy level for N_2 , and add electrons in the diagram. Use “↑” and “↓” to represent electrons in the diagram.

(2) Similarly to the case of N_2 , draw the molecular orbital energy level diagram for CO. Also, explain the difference in the molecular orbital energy level between N_2 and CO.

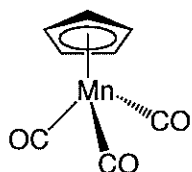
(3) When CO is molecularly adsorbed onto metal, the coordination with metal occurs at the carbon side. Explain the reason.

(4) The dipole moment of CO is very small. Explain the reason.

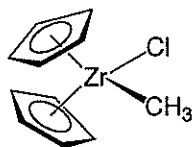
Inorganic Chemistry II

II – a Answer the questions for the following complexes [(i) ~ (v)]. Each metal complex is a monomer. In the complex (ii), Ph represents phenyl group.

- (i) $\text{Ni}(\text{CO})_4$
- (ii) $\text{PtCl}_2(\text{PPh}_3)_2$
- (iii) $\text{CoCl}_3(\text{NH}_3)_3$
- (iv)



- (v)



(1) Answer the number of valence electrons by using the electron counting methods which are used in the 18-electron rule. Show the method you used for the valence electron count for each complex.

(2) Answer the oxidation state of the metal center and the number of *d*-electrons for each complex.

(3) Draw all of the possible stereoisomers for the complexes [(ii) and (iii)]. The rotational isomers are not considered.

II – b Answer the questions for the following iron complexes [(i) and (ii)].

- (i) $[\text{Fe}(\text{CN})_6]^{4-}$
- (ii) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$

(1) Draw the *d*-orbital energy level diagram for each complex [(i) and (ii)], and label each *d*-orbital (d_{xy} , d_{yz} , d_{zx} , d_{z^2} , $d_{x^2-y^2}$). Be sure to add electrons in the diagram. Use “↑” and “↓” to represent electrons in the diagram. Then, explain briefly the magnetic property of each iron complex.

(2) Calculate the ligand-field stabilization energy (LFSE) in terms of Δ_0 (ligand-field splitting parameter) for each iron complex [(i) and (ii)]. The pairing energy is not considered.

II – c Answer the following questions.

(1) Infrared (IR) spectroscopy provides information on C-O bond strength of carbon monoxide (CO) ligands in metal carbonyls. The C-O stretching frequencies of free CO and $\text{Cr}(\text{CO})_6$ are observed at 2143 cm^{-1} and 2000 cm^{-1} , respectively. Explain briefly why the C-O stretching frequency of $\text{Cr}(\text{CO})_6$ is observed at lower wavenumber than that of free CO.

(2) Explain briefly how the C-O stretching frequencies of $[\text{Mn}(\text{CO})_6]^+$ and $[\text{V}(\text{CO})_6]^-$ are observed when compared to the C-O stretching frequency of $\text{Cr}(\text{CO})_6$.