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.

[Example] C $(1s)^2(2s)^2(2p)^2$

(i) Be

(ii) S^{2-}

(iii) Fe

(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) H, He, Si, Ar, K

(ii) Li, C, N, O, Na

(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) PF_5

(ii) BrF_5

(iii) ClO_4^-

(iv) BCl_3

(v) ClF_3

(4) CO_2 is considered to be isoelectronic with $[N_3]^-$. Give two other species that are also isoelectronic with CO_2.

(5) There are three common definitions used to describe acids and bases, Arrhenius, Brønsted-Lowry, and Lewis acids and bases. Give an explanation of each definition to show the differences among them briefly.

I－b　Answer the following questions regarding B_2 and O_2 molecules.

（1）Draw the molecular orbital energy level diagram for O_2, and add electrons in the diagram. Use " ↑ " and " ↓ " to represent electrons in the diagram.

（2）The ground state of B_2 is triplet. Draw the molecular orbital energy level diagram for B_2, and add electrons in the diagram. Use " ↑ " and " ↓ " to represent electrons in the diagram.

（3）Which molecule has a shorter distance between two atoms, B_2 or O_2? Also, explain the reason briefly.

Inorganic Chemistry II

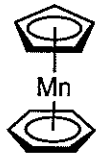
II − a Answer the questions for the following complexes [(i) ~ (v)]. Each metal complex is a monomer. Here, Ph = phenyl, ^{t}Bu = *tert*-butyl.

(i) $[CoCl_2(NH_3)_4]Cl$

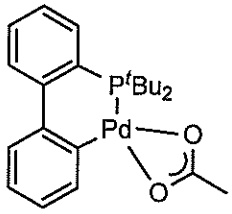
(ii) $PtCl_2(PPh_3)(\eta^2\text{-}C_2H_2)$

(iii) $IrH(CO)_2(PPh_3)_2$

(iv)



(v)



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

（2） 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.

II − b Answer the following questions.

（1） Draw all of the possible stereoisomers for the following complexes [(i) ~ (iii)]. The rotational isomers are not considered. Each metal complex is a monomer.

(i) $PtBr_2(PPh_3)_2$

(ii) $[CrF_2(NH_3)_4]^+$

(iii) $Co(CN)_3(NH_3)_3$

（2） Determine the point group for the following complexes [(i) ~ (iii)]. Each metal complex is a monomer.

(i) $Cr(CO)_6$

(ii) $Fe(CO)_5$

(iii) $[Ni(CN)_4]^{2-}$

Ⅱ－c　Answer the following questions.

（1）Draw the *d*-orbital energy level diagram for the following complexes [(i) ~ (iii)], 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. ($\sqrt{2}$ = 1.41, $\sqrt{3}$ = 1.73, $\sqrt{5}$ = 2.24, $\sqrt{7}$ = 2.65)

(i)　$[Co(NH_3)_6]^{3+}$ (octahedral, diamagnetic)

(ii)　$[PtCl_4]^{2-}$ (square planar)

(iii)　$[Fe(OH_2)_6]^{3+}$ (octahedral, the magnetic moment is 5.9 μ_B)

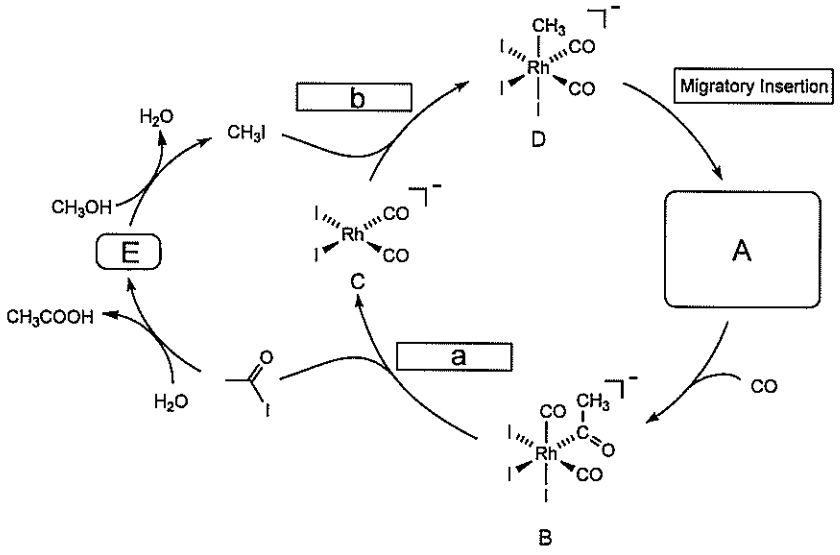
（2）Calculate the ligand-field stabilization energy (LFSE) in terms of Δ_o (ligand-field splitting parameter) for the following octahedral complexes [(i) ~ (iii)]. The pairing energy is not considered.

(i)　d^9 complex

(ii)　low-spin d^6 complex

(iii)　high-spin d^5 complex

Ⅱ－d　A catalytic cycle for the formation of acetic acid with a rhodium-based catalyst (Monsanto process) is shown below.



（1）Fill in the blanks with the general names of the reaction processes [(a) and (b), (boxes adjacent to the arrows)] and the structures of the intermediates [(A) and (E)].

（2）Give the oxidation state of the metal center and the number of *d*-electrons for the intermediates [(B), (C) and (D)].