Inorganic Chemistry I

I－a Answer the following questions regarding boron compounds.

（1） The atomic numbers of the boron family elements are 5, 13, 31, 49, and 81. Write down chemical symbol and ground state electronic configuration for each atom according to the example.

[Example] $_{14}Si\ (1s)^2(2s)^2(2p)^6(3s)^2(3p)^2$ or $_{14}Si\ [_{10}Ne](3s)^2(3p)^2$

（2） Draw the structures of BF_3 and BF_4^-, with showing spatial arrangement of each atom clearly. Also, answer the point group for each molecule or ion.

（3） Draw the structure of the product obtained from the reaction of BF_3 with trimethylamine, $N(CH_3)_3$, with showing spatial arrangements around B and N atoms clearly. Also, which describes the role of BF_3 in the reaction, Brønsted acid, Brønsted base, Lewis acid, or Lewis base?

（4） Draw the structure of diborane (B_2H_6), which is a dimer of borane (BH_3), with showing spatial arrangement of each atom clearly. Also, answer which point group diborane belongs to.

（5） Hydrides of boron form a variety of cluster compounds by a characteristic bonding. Explain the reason briefly.

I－b Answer the following questions regarding crystal lattices.

（1） There are two types for close-packed structures: the cubic close-packed structure and the hexagonal close-packed structure. Explain the difference by drawing these two structures.

（2） In the NaCl-type structure, the anions can be regarded to be in a cubic close-packed arrangement and the cations to be located at holes among the close-packed anions. Answer the coordination number of cation in the NaCl-type structure.

（3） Some crystal lattices have 4-fold or 6-fold rotational symmetry. On the other hand, no crystal lattice has 5-fold rotational symmetry. Explain the reason briefly.

Inorganic Chemistry II

II — a Answer the questions on the following metal complexes (i) ~ (v). Each metal complex is a monomer. Here, Ph = phenyl.

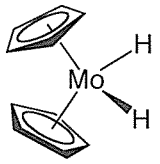
(i) $Co(CN)_3(NH_3)_3$

(ii) $PtCl_2(NH_3)_2$

(iii) $V(CO)_6$

(iv) $RuCl(CO)H(PPh_3)_3$

(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 metal complexes (i) and (ii).

（4） Explain the magnetic property and reactivity of the metal complex (iii) briefly.

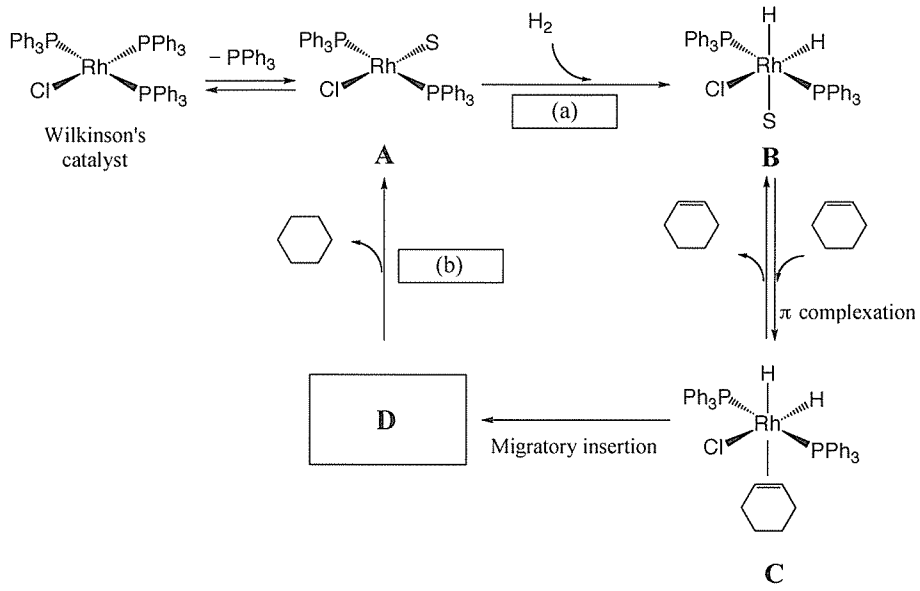
II — b Answer the following questions on color of metal complexes.

（1） Draw the *d*-orbital energy level diagram for the following cobalt complexes (i) $[Co(H_2O)_6]^{2+}$ and (ii) $[CoCl_4]^{2-}$, and label each *d* orbital (d_{xy}, d_{yz}, d_{zx}, d_{z^2}, and $d_{x^2-y^2}$). Be sure to add electrons in the diagram by using "↑" and "↓" to represent electrons. Then, explain the difference in color between these cobalt complexes briefly.

（2） The nickel complexes (iii)$[Ni(H_2O)_6]^{2+}$ and (iv)$[Ni(NH_3)_6]^{2+}$ have different colors. Explain the reason for this difference briefly.

（3） Explain briefly the reason why permanganate ($[MnO_4]^-$) in an aqueous solution has deep purple color.

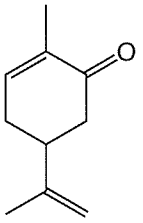
II － c　A catalytic cycle for the hydrogenation of cyclohexene with Wilkinson's catalyst is shown below. Answer the following questions. Here, S = solvent and Ph = phenyl.



（1）Fill in the blanks with the general names of the reaction processes (a) and (b). Then, draw the structure of the intermediate (**D**) that satisfies the 18-electron rule.

（2）Give the oxidation state of the metal center and the number of *d* electrons for the intermediates (**A**) and (**C**).

（3）Draw the structure of the product when the compound shown below (carvone) is hydrogenated with Wilkinson's catalyst. The stereoisomers are not necessarily considered.



Carvone