Inorganic Chemistry I

I－a

（1）Explain briefly the following terms related to electronic configuration.

(i) Hund's rule
(ii) Spin orbit coupling

（2）Show the ground state electron configurations of the following (i)-(iv) atoms and ions according to the example.

[Ex.] B : $[He](2s)^2(2p)^2$

(i) S (ii) Ti (iii) Cr (iv) Cu (v) Cu^{2+}

（3）Show the electron arrangements of the ground states of oxygen molecule O_2, superoxide ion O_2^- and peroxide ion O_2^{2-} according to the example (the inner shells are omitted). Also list all those that show paramagnetism.

[Ex.] N_2 : $(2\sigma_g)^2(2\sigma_u)^2(1\pi_u)^4(3\sigma_g)^2$

I－b

（1） Explain the following terms regarding acids and bases.

(i) Brønsted acid and Brønsted base
(ii) Lewis acid and Lewis base

（2） Of the following combinations, which is the stronger acid? State the reason you chose it.

(i) $[Fe(OH_2)_6]^{3+}$ and $[Fe(OH_2)_6]^{2+}$
(ii) $[Al(OH_2)_6]^{3+}$ and $[Ga(OH_2)_6]^{3+}$
(iii) $HClO_3$ and $HClO_4$

（3） What is the Lewis acid and Lewis base in the following reactions?

(i) $FeCl_3 + Cl^- \rightarrow FeCl_4^-$
(ii) $KH + H_2O \rightarrow KOH + H_2$

（4） $(H_3Si)_2O$ is a weaker Lewis base than $(H_3C)_2O$. Explain the reason.

（5） Classify the five metals of Cd, Rb, Pb, Sr, and Pd into two groups; likely to be present in aluminosilicate minerals and likely to be present in sulfide. Explain briefly the reason.

Inorganic Chemistry II

II－a Answer the following questions concerning metal complexes (i)~(v). Here bpy and Ph indicate 2,2'-bipyridine and phenyl group, respectively.

(i) $Ni(CO)_4$
(ii) $Fe(CO)_2(PPh_3)_3$
(iii) $Mo(\eta^6\text{-}C_6H_6)_2$
(iv) $Pt(bpy)Cl_2$
(v) $Ru(\eta^5\text{-}C_5H_5)(PPh_3)_2CH_3$

（1）Answer the formal oxidation number and the number of d electrons of metal in each complex.

（2）Answer the number of valence electrons of metal in each complex based on the eighteen-electron rule, and show how you have counted the valence electrons.

II－b $[Co(OH_2)_2(NH_3)_4]^{3+}$ with an octahedral coordination geometry can form two steric isomers. Show the chemical structures and the point groups of the two isomers. Ignore the hydrogen atoms when you consider the point groups.

II－c Answer the following questions concerning iron complexes (vi)~(viii). Here py indicates pyridine.

(vi) $[Fe(CN)_6]^{4-}$, octahedral coordination geometry, low spin state
(vii) $[Fe(py)_6]^{2+}$, octahedral coordination geometry, high spin state
(viii) $[FeCl_4]^{2-}$, tetrahedral coordination geometry, high spin state

（1）Illustrate the energy level diagram of d orbitals of each complex based on the crystal field theory. Assign all the orbitals (d_{xy}, d_{yz}, d_{xz}, $d_{x^2-y^2}$, d_{z^2}) and show electrons on the orbitals as ↑ or ↓.

（2）Explain why the crystal field splitting patterns of d orbitals in (vii) and (viii) are different.

（3）Explain why the spin states of (vi) and (vii) are different, from the viewpoints of ligand field splitting parameter and spin-pairing energy.