Inorganic Chemistry I

I − a Answer the atom for each ground state electronic configuration, (i)~(iv), as listed below.

(i) $(1s)^2(2s)^2(2p)^5$

(ii) $(1s)^2(2s)^2(2p)^6(3s)^2(3p)^3$

(iii) $(1s)^2(2s)^2(2p)^6(3s)^2(3p)^6$

(iv) $(1s)^2(2s)^2(2p)^6(3s)^2(3p)^6(3d)^6(4s)^2$

I − b Answer the following questions regarding the valence-shell electron pair repulsion (VSEPR) model.

(1) Draw the structures with showing spatial arrangement of following molecules, (i)~(v). In case that the central atom has lone-pair electrons, show the direction of each pair in the structures.

(i) BI_3

(ii) H_2O

(iii) NH_3

(iv) IF_5

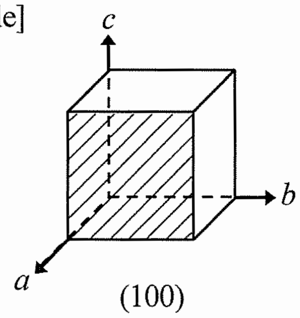
(v) SCl_4

(2) Arrange the above molecules, (i)~(iii), in decreasing order of bond angle. Also, explain the reason.

I − c Answer the following questions.

(1) According to the following example, draw the lattice planes of miller indices (111), (110), (121), and (113) in the cubic-type lattice.

[example]



(100)

(2) An X-ray diffraction measurement for cubic CsCl was carried out using CuKα-X-ray (wavelength: $\lambda = 0.154$ nm), and as a result, a diffraction peak reflected from (110) plane was observed at $2\theta = 30.6°$. Calculate the lattice constant of CsCl. In an orthogonal coordinate system, the following equation (1) holds between the lattice spacing d, lattice constants (a b c), and the miller index (h k l). Here, $\sin(15.3°) = 0.264$, and $\sqrt{2} = 1.41$.

$$\frac{1}{d^2} = \frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2} \qquad \text{equation (1)}$$

Inorganic Chemistry II

II－a Answer the following questions regarding transition-metal carbonyl complexes.

(1) Answer the number of CO ligands (n) for each complex, (i)~(v), listed below. Here, all the complexes satisfy the 18-electron rule.

(i) $[Ni(CO)_n]$

(ii) $[Fe(CO)_n]$

(iii) $[Mn_2(CO)_n]$

(iv) $[Co(\eta^5\text{-}C_5H_5)(CO)_n]$

(v) $(C_6H_5)_4P[V(CO)_n]$

(2) Describe the change in C-O bond lengths before and after the formation of coordination bonds between CO ligands and metal ions. Also, explain the reason.

II－b Answer the questions for the following metal complexes, (i) and (ii).

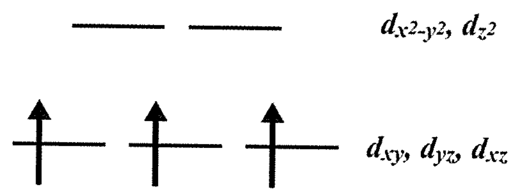
(i) $[Ni(CN)_4]^{2-}$

(ii) $[Cu(H_2O)_6]^{2+}$

(1) Draw the structure with showing spatial arrangement for each complex. In case that bond lengths are not equivalent, show the differences clearly in the structures.

(2) Draw the d-orbital energy level diagram for each complex according to the example shown below.

[example]



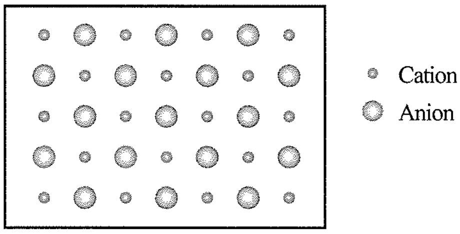
d-orbital energy level diagram for $[Cr(NH_3)_6]^{3+}$

(3) Calculate the spin-only magnetic moment in Bohr magnetron unit for each complex. If necessary, following values can be used ($\sqrt{2} = 1.41$, $\sqrt{3} = 1.73$, $\sqrt{5} = 2.24$, $\sqrt{7} = 2.65$).

II－ｃ Answer the following questions regarding ionic crystals.

（1） According to the schematic diagram of a perfect crystal, draw a Schottky defect and a Frenkel defect and explain them briefly.

[example]



Perfect crystal

（2） A solid solution is a crystalline phase that can have a variable composition and is basically classified as either substitutional or interstitial solid solutions. Explain the difference between substitutional and interstitial solid solutions.

（3） Yttria-stabilized zirconia (YSZ) used as solid electrolytes for solid state oxide fuel cells is a solid solution of zirconium oxide (ZrO_2) and yttrium oxide (Y_2O_3) with the cubic fluorite-type structure. Describe the chemical formula of YSZ. Here, oxygen vacancies are introduced into the lattice by the substitution of partial Zr with Y and the charge neutrality is maintained.

II－ｄ Answer the following questions.

（1） Draw the band structures of metals, semiconductors, and insulators, respectively, and explain the differences among their electric conductivities. The following terms must be used for explanation: valence band, conduction band.

（2） Explain the difference between n-type and p-type semiconductors.

（3） Answer whether boron-doped silicon single crystals are either n-type or p-type semiconductors. Also, explain the reason.