

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

一、選擇題：(30分，每題3分)

- Which of the following compound has the point group of C_{3v} ?
(A) CO_3^{2-} (B) SO_3^{2-} (C) $\text{B}(\text{OH})_3$ (D) AlF_3
- Which of the following species has "square planar" geometry?
(A) SF_4 (B) SiF_4 (C) KrF_4 (D) TeF_4
- What is the point group of $\text{Ni}(\text{cyclobutadiene})_2$ (staggered)?
(A) D_{2h} (B) D_{2d} (C) D_{4h} (D) D_{4d}
- Which of the following has the highest ionization energy?
(A) O (B) O_2 (C) O_2^- (D) O_2^+
- The structure of manganese fluoride can be described as a simple cubic array of manganese ions with fluoride ions at the center of each edge of the cubic unit cell. What is the charge of the manganese ions in this compound?
(A) $+3/2$ (B) $+2$ (C) $+3$ (D) $+6$
- Which of the following will act as a Lewis acid?
(A) BF_3 (B) H_2O (C) H_3O^+ (D) NH_4^+
- Which is the close-packing scheme of a face-centered cubic structure?
(A) ABABC... (B) ABCABC... (C) ABABAB... (D) ABBAAB...
- Which of the following complex ion has the largest d -orbital splitting energy?
(A) $[\text{Co}(\text{NH}_3)_6]^{3+}$ (B) $[\text{Co}(\text{CN})_6]^{3-}$ (C) $[\text{CoCl}_6]^{3-}$ (D) $[\text{CoCl}_4]^{2-}$
- Which of the following complex is not subject to Jahn-Teller distortion?
(A) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (B) $[\text{CoCl}_6]^{4-}$ (C) $[\text{Fe}(\text{CN})_6]^{3-}$ (D) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$
- Which NMR spectroscopy is used to distinguish between the *cis* and *trans* isomers of $[\text{W}(\text{CO})_4(\text{PMe}_3)_2]$?
(A) ^{31}P NMR (B) ^{13}C NMR (C) ^{183}W NMR (D) none of these

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二、簡答題：(70 分)

- (a) What is the lanthanide contraction? (5%)

(b) How does the lanthanide contraction affect the properties of the $4d$ and $5d$ transition metals? (5%)
- (a) Compounds of copper(II) are generally colored, but compounds of copper(I) are not. Explain. (5%)

(b) Would you expect compounds of Sc^{3+} to be colored? Explain. (5%)
- The radius of tungsten is 137 pm and the density is 19.3 g/cm^3 . Does elemental tungsten have a face-centered cubic structure or a body-centered cubic structure? Explain. (5%)
- For a simple cubic array, solve for the volume of an interior sphere (cubic hole) in terms of the radius (r) of a sphere in the array. (5%)
- What is wrong about the following statements concerning each complex ion and the d -orbital splitting diagrams? Explain your answer.

(a) CoCl_4^{2-} is an example of a strong-field case having two unpaired electrons. (5%)

(b) Because CN^- is a weak-field ligand, $\text{Co}(\text{CN})_6^{3-}$ will be a low-spin case having four unpaired electrons. (5%)
- Why $\text{Mo}(\text{PMe}_3)_5\text{H}_2$ is a dihydride, but $\text{Mo}(\text{CO})_3(\text{PR}_3)_2(\text{H}_2)$ contains the dihydrogen ligand (Me=methyl, R=isopropyl)? Explain. (5%)
- Why CO_2 is a linear molecule, but SiO_2 (silica) is bent? Explain. (5%)
- AlF_3 is insoluble in liquid HF but dissolves if NaF is present. When BF_3 is added to the solution, AlF_3 precipitates. Explain. (5%)
- Determine the point group of a body-centered tetragonal structure. (5%)
- Although thousands of examples of carbonyl complexes are known, the chemistry of the fluoroborylene (BF) ligand is still in its infancy.

(a) Prepare a molecular orbital energy level diagram of BF, showing how the atomic orbitals of B and F interact. (5%)

(b) On the basis of your answer to part (a), would you expect BF to be a stronger or weaker π -acceptor ligand than CO? Explain (5%)