1. The ion NO^- can react with H^+ to form a bond. Which structure is more likely, HON or HNO? You need to show the molecular orbitals of NO^- to explain your reasoning. (2%)
2. Give Lewis dot structures and sketch the shapes of the following: (a) $SeCl_4$, (b) IF_7, (c) N_3^-, (d) $SeOCl_4$ (Se is central), (e) XeO_2F_2, (f) $ClOF_4^-$, (g) ClO_3^-, (h) carbon suboxide C_3O_2 (16%)
3. Determine the point groups for (a) B_2H_6, (b) cyclohexane (chair form), (c) $[Cr(C_2O_4)_3]^{3-}$, (d) Ni(cyclobutadiene)$_2$ (staggered), (e) allene ($H_2C=C=CH_2$), (f) IOF_3, (g) SF_4, (h) S_8 (puckered ring), (i) ethane (staggered form), (j) N_2H_4 (gauche conformation). (20%)
4. Choose (a) The least soluble halide in water: LiF, LiCl, LiBr, or LiI. (b) Which one has the largest solubility: $MgSO_4$, $CaSO_4$, $SrSO_4$, $BaSO_4$. (c) Stronger hydrogen bond: $[OH_3\cdots OH_2]^+$ or $OH_2\cdots OH_2$. (d) The strongest acid in aqueous solution: $HMnO_4$, H_3AsO_4, H_2SO_3 or H_2SO_4. (e) Stronger gas-phase basicity: triphenylamine or triphenylphosphine. (f) The strongest Lewis acidity: BF_3, BCl_3, BBr_3, or BI_3. (g) The strongest Brønsted-Lowry basicity with hydrogen ion: pyridine, 2-methylpyridine, 2,6-dimethylpyridine, or 2-t-butylpyridine. (h) Longer N-S bond: Me_3N-SO_3 or H_3N-SO_3. (i) Both GaAs and GaN are used in LEDs. Which one is expected to emit lower energy? (j) A series of ZnSe quantum dots were prepared and the photoluminescence emission spectra were recorded. Were the lowest energy emission bands produced by the smallest or largest quantum dots? (10%)
5. Describe the structures of CsCl, ZnS (wurtzite), and CaF_2. (6%)

注意：背面有試題

6. The structure of high-temperature superconductor $YBa_2Cu_3O_7$ consists of square-pyramidal and square-planar Cu-O units. Assign the oxidation state of the Cu atom in each unit. (2%)

7. Name these coordination complexes in English:

   (a) $Cr(NH_3)_3Cl_3$, (b) $Pt(en)Cl_2$, (c) $[Pt(ox)_2]^{2-}$, (d) $[Cr(H_2O)_5Br]^{2+}$, (e) $[Fe(OH)_4]^-$ (10%)

8. Determine the ground terms for low spin d^4, high-spin and low-spin d^6 configurations in O_h symmetry? (4%)

9. Explain why the electronic spectra of $[Ti(H_2O)_6]^+$ and $[Fe(H_2O)_6]^{2+}$ show two closely overlapping absorption bands rather than a single band. (2%)

10. The d^2 ions CrO_4^{4-}, MnO_4^{3-}, FeO_4^{2-}, and RuO_4^{2-} have been reported.

   (a) Which of these has the largest value of Δ_t? Which has the smallest? (2%)

   (b) Of the first three, which one has the shortest metal-oxygen bond distance? (2%)

   (c) The charge-transfer transitions for the first three complexes occur at 43,000, 33,000, and 21,000 cm^{-1}, respectively. Are these more likely to be ligand-to-metal or metal-to-ligand charge-transfer transitions? (2%)

11. Predict the products of these reactions. (10%)

   $[PtCl_4]^{2-} + NO_2^- \rightarrow$ (a),　　(a) + $NH_3 \rightarrow$ (b)

   $[PtCl_3NH_3]^- + NO_2^- \rightarrow$ (c),　　(c) + $NO_2^- \rightarrow$ (d)

   $[PtCl(NH_3)_3]^+ + NO_2^- \rightarrow$ (e),　　(e) + $NO_2^- \rightarrow$ (f)

   $[PtCl_4]^{2-} + I^- \rightarrow$ (g),　　(g) + $I^- \rightarrow$ (h)

   $[PtI_4]^{2-} + Cl^- \rightarrow$ (i),　　(i) + $Cl^- \rightarrow$ (j)

注意：背面有試題

12. Is the reaction $[Co(NH_3)_6]^{3+} + [Cr(H_2O)_6]^{2+}$ likely to proceed by an inner-sphere or outer-sphere mechanism? (2%)

13. On the basis of the 18-electron rule, determine the expected charge on the following: (5%)

(a) $[Ni(CO)_3(NO)]^z$ (contains linear M-N-O)

(b) $[Ru(CO)_4(GeMe_3)]^z$

(c) $[(\eta^3\text{-}C_3H_5)V(CNCH_3)_5]^z$

(d) $[(\eta^5\text{-}C_5H_5)Fe(CO)_3]^z$

(e) $[(\eta^5\text{-}C_5H_5)_3Ni_3(\mu_3\text{-}CO)_2]^z$

14. The ^1H NMR spectrum of $(C_5H_5)_2Fe(CO)_2$ shows two peaks of equal area at room temperature but has four resonances of relative intensity 5:2:2:1 at low temperature. Explain. (5%)