1. Short questions to answer
   a. Please give the molecular formulas of nitrous acid, phosphoric acid, and perchloric acid. (3 pts)
   b. What are the possible oxidation states of Fe, Ni, and Zn? (3 pts)
   c. Please give the correct nomenclature of the complex molecule, $K_3Fe(CN)_6$. (4 pts)
   d. What is Heisenberg's uncertainty principle? (4pts)
   e. For atomic quantum number n (principal quantum number)= 3, what are the possible values for ℓ (azimuthal quantum number) and m_ℓ (magnetic quantum number)? (4 pts)
   f. Please balance the electrochemical equation: $H^+ + Cr_2O_7^{2-} + H_2SO_3 \rightarrow SO_4^{2-} + Cr^{3+} + H_2O$ (4pts)
   g. Please briefly explain London force (dispersion force). Which of the following molecules: CH_4, H_2, $C_{10}H_8$ (napthalene), has the strongest London force? (4pts)
   h. If we want to make an n-type semiconductor, what are the needed elements? (4pts)
   i. Which of the following compounds (CH_2Cl_2, $CH_3CHBrCl$, cis-$[Co(en)_4Cl_2]^+$, trans-$[Co(en)_4Cl_2]^+$) have optical isomers? (2 pts)
   j. Please explain the difference between the high-spin case and the low-spin case for coordination compounds in terms of ligand field splitting. (3 pts)

2. Please use VSEPR (Valence Shell Electron Pair Repulsion) model to predict the hybridization of the central atom in the following molecules and the shape of these molecules. Please also determine the formal charge of each atom in these molecules (10 pts)
   a. NO_2^-　　b. SO_4^{2-}

3. At 1 atm, the enthalpy (ΔH_{vap}) of vaporization of H_2O: ΔH_{vap}=43.54 kJ·Mol^{-1} at 298 K, ΔH_{vap}=40.68 kJ·Mol^{-1} at 373 K, $\bar{C}_p$ (heat capacity per mole under constant pressure) of $H_2O_{(l)}$ is 75.3 J·K^{-1}·Mol^{-1}

   a. What is the $\bar{C}_p$ of $H_2O_{(g)}$? (5 pts)

   b. What is the change of entropy (ΔS) of $H_2O_{(g)} \leftrightarrow H_2O_{(l)}$ at 373K? (5 pts)

4. Please draw the phase diagram of water (pressure vs. temperature) and explain this diagram as detailed as you can. (5 pts)

注意：背面有試題

5. Polymer chemistry and biochemistry
   a. What are linkages that form proteins and polysaccharides, respectively? Please also draw the structure for each linkage. (4 pts)
   b. What is the bonding that forms the secondary structures of proteins? What are the two types of the secondary structure? What is the difference between these two types? (3 pts)
   c. What are the monomers that form DNA? (3 pts)

6. There is a reaction: $2NO + O_2 \rightarrow 2NO_2$. The mechanism is as follows: $2NO \leftrightarrow N_2O_2$ (Rate Constant: $k_1 \rightarrow$ forward, $k_{-1} \leftarrow$ reverse), $N_2O_2 + O_2 \rightarrow 2NO_2$ (Rate Constant: k_2). If the first step is a fast equilibrium and the second step is a slow reaction, please use

   Steady State Approximation to show that: $Rate = \left(\dfrac{k_1 k_2}{k_{-1}} \right)[NO]^2[O_2]$. (10pts)

7. Please give the English names (IUPAC) of the following compounds.
   a. $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ (5pt)
   b. $CH_3CH=CHCH_2CH_3$ (the CH_3 and C_2H_5 chains are on the same side relative to the double bond) (5pt)

8. Please draw the structures of the following compounds.
   a. 4-tert-Butylheptane (4 pts)
   b. *ortho*-Dimethylbenzene (4 pts)
   c. Acetaldehyde (2 pts)