所別：化學學系碩士班 科目：綜合化學

1. Quick questions
   a. Please write down the electronic configuration for Cu atom (Z= 29). (2 pts)
   b. Which of the following molecules (N_2^-, F_2, C_2, CN) are paramagnetic? (2 pts)
   c. Please explain the difference between homogeneous catalysis and heterogeneous catalysis. (2pts)
   d. Please briefly explain what Arrhenius equation is. (2 pts)
   e. What is the relation between half-life time ($t_{1/2}$) and rate constant (k) in a first order reaction? (2 pts)
   f. Please briefly explain what London force (dispersion force) is. And, which of the following moles: CO, O_2, C_6H_6 (benzene), has the strongest London force. (2 pts)
   g. Please explain why CO_2 is a linear molecule, but SiO_2 (silica) is bent. (2 pts)
   h. Please explain reverse osmosis (RO) and give an example of its application. (2 pts)

2. Please draw the Lewis structure and determine the formal charge for each atom in the following molecules. Please also use VSEPR (Valence Shell Electron Pair Repulsion) model to predict the hybridization of the central atom in these molecules and the shape of each molecule. (16 pts)
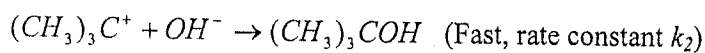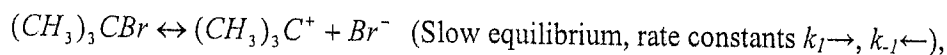   a. SO_2　　　b. SO_4^{2-}　　　c. N_2O　　　d. I_3^-

3. If we completely dissolve 200g $AgNO_{3(s)}$ in the left cell with 500 ml water of a galvanic cell setup at 298K, and we put 20g $AgCl_{(s)}$ in the right cell with 500 ml water. Both anode and cathode are made of $Ag_{(s)}$. ($Ag^+ + e^- \rightarrow Ag$, ε°= +0.80V, $K_{sp}(AgCl) = 1.6 \times 10^{-10}$, Atomic weight: Ag= 107.87, N= 14, O= 16, H= 1, Cl= 35.45)(log2= 0.301, log3= 0.477, log5= 0.699, log7= 0.845)
   a. What is the voltage of this galvanic cell at 298K? (2 pts)
   b. Now, what is the new voltage at 298K if we add 500 ml of 2M $HCl_{(aq)}$ into the left cell? (4 pts)
   c. Now, instead of adding to the left cell, we add this 500ml of 2M $HCl_{(aq)}$ into the right cell. What is the new voltage at 350K? (4 pts)

4. In organic chemistry, S_N1 (first order nucleophilic substitution) is an important reaction type.

   For example: $(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$ The mechanism consists of two steps:

   $(CH_3)_3CBr \leftrightarrow (CH_3)_3C^+ + Br^-$ (Slow equilibrium, rate constants $k_1\rightarrow$, $k_{-1}\leftarrow$),

   $(CH_3)_3C^+ + OH^- \rightarrow (CH_3)_3COH$ (Fast, rate constant k_2)

   Please show that this reaction is effectively a first order reaction. (8pts) (Hint: Steady State Approximation)
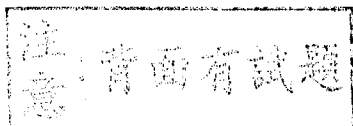
5. (A). Ethylene could be polymerized by $(C_5Me_5)_2ZrMe_2 + B(C_6F_5)_3$. Write a catalytic cycle including the real active catalyst, reactant, product, for this polymerization. (8 pts)

(B). Why $C(C_6H_5)_3 B(C_6F_5)_4$ could also activate $(C_5Me_5)_2ZrMe_2$? Write this activation reaction and the catalytic cycle. (8 pts)

(C). Which cocatalyst might perform the highest polymerization activity:

C1. $B(C_6F_5)_3$　　C2. $B(o\text{-}C_6F_5C_6F_4)_3$　　C3. $C(C_6H_5)_3 B(C_6F_5)_4$, (2 pts)

Brief your reason. (2 pts)

6. A. Remarkable progress in the development organic thin film field-effect transistors (OTFTs) have been achieved over the past 10 years. Give three advantages of OTFTs comparing to those conventional Si-based. (3 pts)

B. Organic compounds such as pentacene $(C_{22}H_{14})$ has been reported as the best candidate for OTFTs so far, which could be synthesized from this following reaction.

B1. What is the structure of pentacene? (1 pt)

B2. What is the structure of **B** (2 pts)

B3. Write the mechanism for the reaction of **A** to **B** (4 pts)
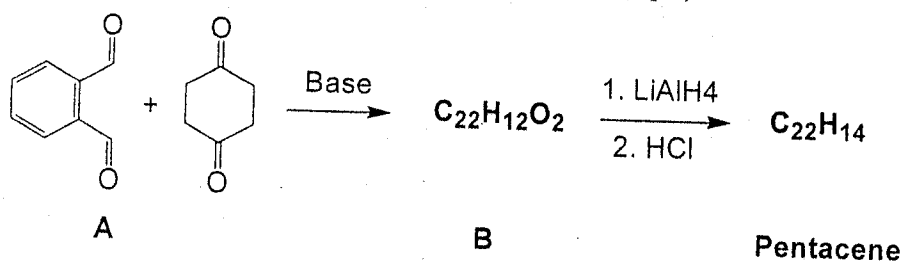
7. (A) Draw the structure of the dipeptide formed from the condensation reaction between leucine and phenylalanine. (4 pts)

(B). Tertiary structure of a protein could be stabilized by various types of interactions, give three of them. (3 pts)

(C) Draw the structure of Nylon and it's two composing monomers. (3 pts)

8. (A) Calculate the pH of a 1.0 M solution of NaH_2PO_4. (5 pts)

$(H_3PO_4, k_{a1} = 1.0 \times 10^{-3}, k_{a2} = 1 \times 10^{-9}, k_{a3} = 1 \times 10^{-13})$

(B) A monoprotic weak acid was synthesized and 10.0 mmol of it was dissolved in 100.0 mL of water and titrates with 0.0500 M NaOH. After 100 mL of NaOH has been added, the pH is 10.0. What is the K_a value for the acid? (3 pts)

(C) How did the indicator (HIn) works? Using the following reaction equation to explain how it change color. HIn (aq) $\leftrightarrow$ H$^+$ (aq) + In$^-$ (aq) (2 pts)