1. Consider the following gas-phase equilibrium reaction: \( \text{N}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}(g) \); \( K_c = 4.10 \times 10^{-4} \) at 2000°C. If 1.0 mol of NO is introduced into a 1.0 L container at 2000°C, what is the concentration of NO when equilibrium is reached? 5 分

2. Consider the equilibrium: \( A(s) \rightleftharpoons B(g) + C(g); \Delta H_{	ext{rxn}}^\circ > 0 \) 8 分
   Predict and explain how or whether the following actions would affect this equilibrium.
   a. adding more solid \( A \)
   b. lowering the temperature
   c. increasing the pressure on the system by reducing its volume
   d. adding helium gas to increase the total pressure

3. For what signs of \( \Delta H \) and \( \Delta S \) will a process be spontaneous at high temperatures but not at low temperatures? 6 分
   a. be spontaneous at high temperatures but not at low temperatures?
   b. not be spontaneous at any temperatures?

4. A chemical reaction has \( \Delta G^\circ = 10.0 \text{ kJ} \) and \( \Delta S^\circ = 50.0 \text{ J/K} \) 8 分
   a. Calculate \( \Delta H^\circ \) for this reaction at 25°C.
   b. Could this reaction ever be spontaneous? Explain your answer.

5. A galvanic cell is constructed using the two hypothetical half-reactions
   \[ \begin{align*}
   A + \sigma^- & \rightarrow B & E^\circ = +1.50 \text{V} \\
   C + 2e^- & \rightarrow D & E^\circ = -0.50 \text{V}
   \end{align*} \] 3 分
   a. Write down the balanced equation representing the cell reaction.
   b. Calculate the standard potential of this cell, \( E^\circ_{\text{cell}} \).
   c. Calculate \( \Delta G^\circ \) for the cell reaction.

6. The vapor pressure of 1-butene is 1.268 atm at 273.15 K and its heat of vaporization is 22.9 kJ/mol. What is the normal boiling point of 1-butene? (ln 1.268 = 0.237) 6 分

7. You are required to determine the energy of activation (\( E_a \)) of a reaction. Briefly describe the experimental measurements you would make and how you would obtain the activation energy from a suitable linear plot of the experimental data. 8 分

8. The decomposition of dinitrogen pentaoxide has an activation energy of 102 kJ/mol and \( \Delta H_{	ext{rxn}}^\circ = +55 \text{ kJ/mol} \). What is the activation energy for the reverse reaction? 5 分

9. The reaction \( \text{CH}_3\text{NC}(g) \rightarrow \text{CH}_3\text{CN}(g) \) is first-order with respect to methyl isocyanide, \( \text{CH}_3\text{NC} \). If it takes 10.3 minutes for exactly one quarter of the initial amount of methyl isocyanide to react, what is the rate constant in units of \( \text{min}^{-1} \)? \( \text{ln} 2 = 0.693 \) 6 分

10. The concentration of iodine in sea water is 60. parts per billion by mass. If one assumes that the iodine exists in the form of iodide anions, what is the molarity of iodide in sea water? (The density of sea water is 1.025 g/mL.) 5 分

11. 1.00 L of an aqueous solution contains 1.52 g of a compound used in antifreeze. If the osmotic pressure of this solution at 20.0°C is 448 torr, calculate the molar mass of the antifreeze compound. 6 分

12. A 2.50-L flask contains a mixture of methane (\( \text{CH}_4 \)) and propane (\( \text{C}_3\text{H}_8 \)) at a pressure of 1.45 atm and 20°C. When this gas mixture is then burned in excess oxygen, 8.60 g of carbon dioxide is formed. (The other product is water.) What is the mole fraction of methane in the original gas mixture? 8 分
13. Give the number of lone pairs around the central atom and the molecular geometry of
   a. IF₅
   b. PCl₅

14. Calculate the mass of excess reagent remaining at the end of the reaction in which 90.0 g of SO₂ are mixed with 100.0 g of O₂.
   \[ 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3 \]

15. The first step in the Ostwald process for producing nitric acid is
   \[ 4\text{NH}_3(g) + 5\text{O}_2(g) \rightarrow 4\text{NO}(g) + 6\text{H}_2\text{O}(g) \]

If the reaction of 150.0 g of ammonia with 150.0 g of oxygen gas yields 87.0 g of nitric oxide (NO), what is the percent yield of this reaction?