甲. 化工熱力學部份 (50%)

(14%) 1. If the molar density of a binary mixture at different mole fractions is given by the empirical expression

$$\rho = a_0 + a_1 x_1 + a_2 x_1^2 \quad \text{where } a_0, a_1 \text{ and } a_2 \text{ are constants.}$$

Find the corresponding partial molar volumes, $\overline{V}_1$ and $\overline{V}_2$, in terms of a_0, a_1, a_2 and x_1.

(14%) 2. Estimate the value of f/f^{sat} for liquid water at 150 °C and 15,000 kPa, where f^{sat} is the fugacity of saturated liquid at 150 °C and 476 kPa. The volume of saturated liquid water at 150 °C is 1.019 cm^3/g.
[Hint: G = VdP – SdT, G = Γ(T) + RTln$f$, and the volume of liquid water is fairly constant.] R = 8.314 (Pa m^3)/(mol K).

(14%) 3. A 50-kg block of iron casting at 500 K is thrown into a large lake that is at a temperature of 285 K. The iron block eventually reaches thermal equilibrium with the lake water. Assuming an average specific heat of 0.45 kJ/(kg K) for the iron, determine

(a) the entropy change of the iron block,

(b) the entropy change of the lake water, and

(c) the entropy generated during the process.

(8%) 4. Derive the Clapeyron and the Clausius/Clapeyron equations for two-phase systems.

(背面仍有題目,請繼續作答)

乙、反應工程 (50%)

1. How many steady states are possible for A → B，r = k in an adiabatic CSTR if the reaction is exothermic ? endothermic? Please explain your answer in detail. **(14%)**

   A general energy balance for a CSTR is
   $F_{A0}X\Delta H_R = F_{A0}C_{P0}(T-T_0) + UA(T-T_a)$

   ΔH_R : heat of reaction
   T_0 : feed temperature
   T_a : ambient temperature
   U : heat transfer coefficient from the reactor to the ambient
   A : heat transfer area

2. Consider the reactions

   A → B $\quad r_1 = k_1C_A$
   B → C $\quad r_2 = k_2C_B$
   A → D $\quad r_3 = k_3C_A^2$
   with B the desired product.

   Should one use a PFR or CSTR and is there an optimum residence time to obtain (a) maximum C_B or

   (b) maximum selectivity，S，where $S = \dfrac{C_B}{C_{A0} - C_A}$?

   Please explain your answer in detail. **(18%)**

3. The reaction $H_2 + 1/2\ O_2 \rightarrow H_2O$ has a rate-limiting step $H_{(ads)} + O_{(ads)} \rightarrow OH_{(ads)}$ and the rate of the reaction is $r = K_R\theta_H\theta_O$

   Derive a reaction rate expression $r(P_{H2},P_{O2})$ for this reaction assuming Langmuir-Hinshelwood kinetics with competitive adsorption. **(18%)**