1. Consider the following electrochemical cell:

$$Zn(s)\,|\,Zn^{2+}(aq) \quad Cu^{2+}(aq)\,|\,Cu(s)$$

What are (a) the standard electromotive force (4%), (b) the equilibrium constant for the cell reaction (4%), and (c) the equilibrium constant expression (4%)?
$\Delta_f G^\circ[Zn^{2+}(ao)] = -147.06$ kJ/mol, $\Delta_f G^\circ[Cu^{2+}(ao)] = 65.49$ kJ/mol.

2. Consider the series of first order irreversible reactions

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

The initial concentration of A is $[A]_0$. Neither B nor C is present initially.
(a) Derive the expressions for the variations of [A], [B] and [C] with time. (5%)
(b) At what time does the concentration of B reach a maximum? (5%)

3. Describe the following terms briefly
(a) Langmuir adsorption isotherm and its assumptions (3%)
(b) Debye-Hückel theory (3%)
(c) relaxation time (3%)
(d) microscopic reversibility (3%)
(e) principle of detailed balance (3%)

4. Show that the Joule-Thomson coefficient μ can be written as

$$\mu = -\frac{1}{C_p}\left(\frac{\partial H}{\partial P}\right)_T \quad (8\%)$$

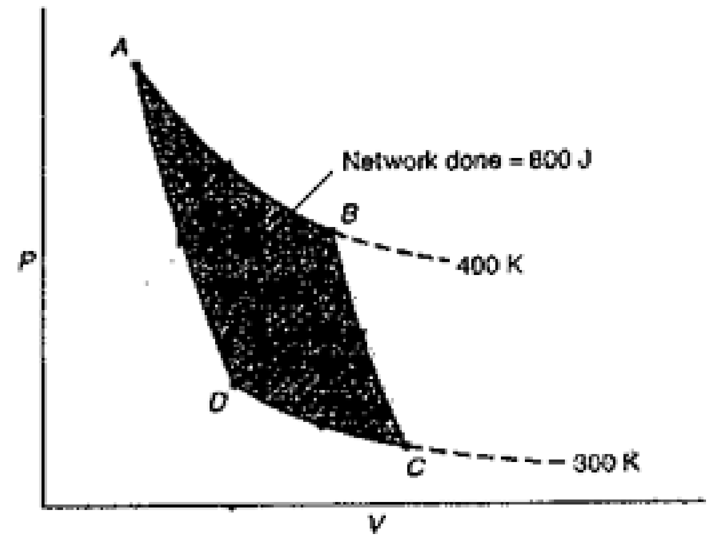
For a van der Waals gas, show that μ can be written as

$$\mu = \frac{2a/RT - b}{C_p} \quad (8\%)$$

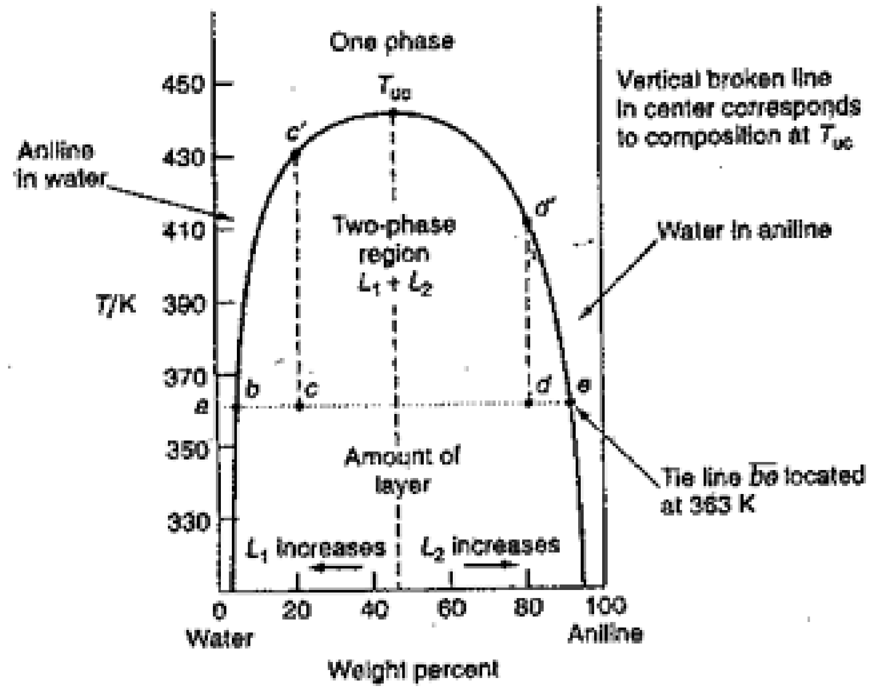
Then calculate ΔH for the isothermal compression of 1.00 mol of the gas at 300 K from 1 bar to 100 bar. (4%)

5. The following diagram represents a reversible Carnot cycle for an ideal gas:
a. What is the thermodynamic efficiency of the engine? (3%)
b. How much heat is absorbed at 400 K? (3%)
c. How much heat is rejected at 300 K? (3%)
d. What is the entropy and Gibbs energy change in the process A→B? (3%)
e. What is the entropy change in the entire cycle? (3%)
f. In order for the engine to perform 2 kJ of work, how much heat must be absorbed? (3%)

(背面仍有題目,請繼續作答)



6. Calculate the ratio of the mass of the water-rich layer to that of the aniline-rich layer, for the points of c and d in the following diagram, respectively, at 363 K. Where weight percent of aniline are 8%, 20%, 80%, and 90% for b, c, d, and e, respectively. (10%)



7. a. For an ideal gas undergoing reversible adiabatic process, show that

$PV^{\gamma} = constant$, where $\gamma = C_P/C_V$ (7%)

b. Derive the following equations: (8%)

(1) $C_P = -T\left(\frac{\partial^2 G}{\partial T^2}\right)$ (2) $\left(\frac{\partial C_P}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$

Some constants:
R = 8.314 J/mol-K
F = 96485 Coulomb/mol