科目：材料熱力學
考試時間：100 分鐘

系所：化學工程及材料工程學系
（乙組）
本科原始成績：100 分

是否使用計算機：是

1. One mole of an ideal gas at 25°C and 1 atm undergoes the following reversibly conducted cycle:

   a. An isothermal expansion to 0.5 atm, followed by
   b. an isobaric expansion to 100°C, followed by
   c. an isothermal compression to 1 atm, followed by
   d. an isobaric compression to 25°C.

   The system then undergoes the following reversibly cyclic process.
   a. An isobaric expansion to 100°C, followed by
   b. a decrease in pressure at constant volume to the pressure P atm, followed by
   c. an isobaric compression at P atm to 24.5liters, followed by
   d. a decrease in pressure at constant volume to 1 atm.

   Calculate the value of P which makes the work done on the gas during the first cycle equal to the work done by the gas during the second cycle. (Please write done how much the work done by the gas during each process of the cycles) (15%)

2. A reversible heat engine, operating in a cycle, withdraws heat from a high-temperature reservoir (the temperature of which consequently decreases), performs work w, and rejects heat into a low-temperature reservoir (the temperature of which consequently increases). The two reservoirs are, initially, at the temperatures T_1 and T_2 and have constant heat capacities C_1 and C_2 respectively. Calculate the final temperature of the system and the maximum amount of work which can be obtained from the engine. (10%)

3. At the normal boiling temperature of iron, $T_b = 3330K$, the rate of change of the vapor pressure of liquid iron with temperature is 3.72×10^{-3}atm/K. Calculate the molar latent heat of boiling of iron at 3330K. (10%)

4. Demonstrate the law of corresponding states by writing the van der Waals equation in terms of the reduced variables. Calculate the compressibility factor for a van der Waals gas at its critical point. Calculate the value of $(\partial U / \partial V)_T$ for a van der Waals gas. (15 %)

5. When one mole of argon gas is bubbled through a large volume of an Fe-Mn melt of $X_{Mn} = 0.5$ at 1863 K evaporation of Mn into the Ar causes the mass of the melt to decrease by 1.50 g. The gas leaves the melt at a pressure of 1 atm. Calculate the activity coefficient of Mn in the liquid alloy. (10%) ($\ln p^o_{Mn(l)}$ (atm) $= -\dfrac{33440}{T} - 3.02 \ln T + 37.68$, 1 mole of Mn = 54.94 g)

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6. n moles of an ideal gas A and (1-n) moles of an ideal gas B, each at 1 atm pressure, are mixed at total constant pressure. What ratio of A to B in the mixture maximizes the decrease in the Gibbs free energy of the system? If the decrease in the Gibbs free energy is ΔG^M, to what value must the pressure be increased in order to increase the Gibbs free energy of the gas mixture by $1/2\,\Delta G^M$? (10%)

7. How much heat is evolved when 1 mole of SO_2 and 1/2 mole of O_2, each at 1 atm pressure, react to form the equilibrium SO_3-SO_2-O_2 mixture at 1000 K and 1 atm pressure? (10%) (for formation of 1 mole of SO_3, ΔG^o_{1000K} = -5,230 J, ΔH^o_{1000K} = -94,600 J)

8. An Fe-Mn solid solution containing X_{Mn} = 0.001 is in equilibrium with an FeO-MnO solid solution and an oxygen-containing gaseous atmosphere at 1000 K. How many degrees of freedom does the equilibrium have? What is the composition of the equilibrium oxide solution, and what is the partial pressure of oxygen in the gas phase? Assume that both solid solutions are Raoultian in their behavior. (10%) (Mn + ½ O_2 = MnO, ΔG^o_{1000K} = -312,580 J; Fe + ½ O_2 = FeO, ΔG^o_{1000K} = -199,350 J)

9. Please write down your answers to the following questions.
   a. ΔS and ΔH, in terms of the temperature coefficient of the EMF (4%)
   b. Explain the meaning of the Pourbaix diagram (3%)
   c. Explain the application of the Ellingham diagram (3%)

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ln298 = 5.697, ln3 = 1.099, ln7 = 1.946, ln10 = 2.303
$e^{-3.01}$ = 0.049 , $e^{-7.56}$ = 5.2×10⁻⁴, $e^{37.59}$ = 2.12×10¹⁶, $e^{23.98}$ = 2.59×10¹⁰
$e^{0.629}$ = 1.876 , $e^{-8.56}$ = 1.9×10⁻⁴ , $e^{-20.89}$ = 8.4×10⁻¹⁰, $e^{-11.94}$ = 6.47×10⁻⁶