國立臺灣科技大學 108 學年度碩士班招生試題
系所組別：材料科學與工程系碩士班丙組
科　　目：熱力學

(總分為 100 分)

1 The vapor pressures of the substance are given as follows.

$$\ln P(atm) = -\frac{16000}{T} - 0.8\ln T + 20$$

$$\ln P(atm) = -\frac{15000}{T} - 1.3\ln T + 22$$

(a) (5%) Which equation is for the solid substance? Which equation is for the liquid substance?

(b) (5%) What is the temperature of the normal boiling point? (Hint: The value is between 1000 K – 1200 K)

(c) (5%) What is the temperature of the triple point? (Hint: The value is between 600 K – 800 K)

(d) (5%) What is the enthalpy of vaporization of the normal boiling point?

(e) (5%) What is the enthalpy of fusion of the triple point?

(f) (5%) What is the difference of the heat capacity between the liquid and the solid?

2 A binary A-B solution is a regular solution which obeys the below equation:

$$G^{XS} = 16000X_AX_B$$

(a) (5%) Calculate the critical temperature.

(b) (5%) Determine ΔH^M at 700 K and $X_A = 0.1$.

(c) (5%) Determine ΔS^M at 700 K and $X_A = 0.1$.

(d) (5%) Determine the spinodal compositions at 700 K.

G^{XS}: The excess molar Gibbs free energy of the solution

ΔH^M: The change in molar enthalpy caused by the mixing process

ΔS^M: The change in molar entropy caused by the mixing process

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3. Compute the change of internal energy in joules (J) when 10 liters of argon gas at 300 K and 2 atm is expanded to 30 liters with the final pressure equal to 0.5 atm. Assume the heat capacity at constant volume is (3/2)R for monatomic gas. **(10%)**

4. If $\beta_T = (-1/V)(\partial V/\partial P)_T$ and $\beta_S = (-1/V)(\partial V/\partial P)_S$, please prove $\beta_T/\beta_S = c_p/c_v$.

c_p: Heat capacity at constant pressure

c_v: Heat capacity at constant volume **(10%)**

5. For heat engine operating in a Carnot cycle, the engine undergoes the following sequential processes:

(a) Reversible isothermal expansion from V_A to V_B. **(2%)**

(b) Reversible adiabatic expansion process from V_B to V_C. **(2%)**

(c) Reversible isothermal compression process from V_C to V_D. **(2%)**

(d) Reversible adiabatic compression process from V_D to V_A. **(2%)**

Obtain expressions for the change in entropy of the engine for each process. Assume one mole of an ideal monatomic gas.

(e) Prove $V_B/V_A = V_C/V_D$. **(2%)**

6. (a) Show that

$$\left(\frac{\partial H}{\partial S}\right)_V = T\left(1 + \frac{V\alpha}{c_v\beta_T}\right) \quad \textbf{(5\%)}$$

(b) Show that

$$\left(\frac{\partial\left(\frac{\Delta G}{T}\right)}{\partial T}\right)_P = -\frac{\Delta H}{T^2} \quad \textbf{(5\%)}$$

7. Determine the isothermal compressibility (in atm^{-1}) of aluminum given the following data:

Assume that at 27°C, aluminum has the following properties:

constant pressure heat capacity, c_p = 24.3 J/mole·K

constant volume heat capacity, c_v = 23.1 J/mole·K

thermal expansion coefficient, $\alpha = 7.0\times10^{-5}\ K^{-1}$

density, $\rho = 2.7\ g/cm^3$

atomic weight of aluminum is 27. **(10%)**