國立臺灣科技大學 110 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. Determine which of the following properties of a thermodynamic system are extensive properties and which are intensive.
   (1) The potential energy of a system in a gravitational field. **(2%)**
   (2) Molar density. **(2%)**
   (3) Entropy. **(2%)**
   (4) Thermal conductivity. **(2%)**
   (5) Heat capacity. **(2%)**

2. Consider a model in which the available energy levels are linearly spaced along the energy axis

$$\epsilon_n = \left(n + \frac{1}{2}\right)\epsilon_0 \quad (n = 0, 1, 2, \ldots, 9)$$

   where ϵ_n is the energy of the n level and ϵ_0 is a constant.
   The system contains ten particles. Consider three macrostates:

   State I　{0, 0, 1, 2, 4, 2, 1, 0, 0, 0}
   State II　{0, 1, 1, 2, 2, 2, 1, 1, 0, 0}
   State III　{1, 1, 1, 1, 1, 1, 1, 1, 1, 1}

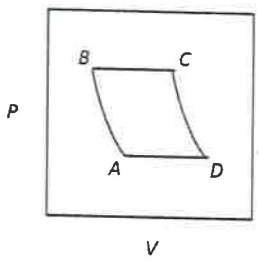
   (1) Which macrostate has the highest energy? **(5%)**
   (2) Which macrostate is more likely to be observed? **(5%)**

3. From

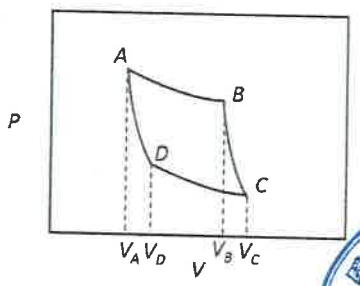
$$A = -nk_BT \ln Z$$

   Where *A*, *n*, k_B, *T*, and *Z* are Helmholtz free energy, total number of particles, Boltzmann's constant, temperature, and partition function, respectively. Please derive
   (1) Entropy in terms of *Z* **(5%)**
   (2) Internal energy in terms of *Z*. **(5%)**

4. The cycle shown in the figure consists of two isotherms (AB and CD) and two isobars (BC and DA). Use the TdS equations to draw the T-S diagram for this cycle. **(10%)**



5. For the Carnot cycle processes shown below
   (1) Obtain expressions for the change in entropy of the engine for each process and the total change in entropy of the engine. **(5%)**
   (2) Draw an entropy versus temperature diagram. **(5%)**



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(總分為 100 分)

6. Two metals, 1 mole of M and 2 moles of N, form the ideal solid and liquid solutions. Some thermodynamic properties of M and N are given in the below table. Calculate the following questions.

	$C_{P(s)}$ $(J\ mol^{-1}\ K^{-1})$	$C_{P(l)}$ $(J\ mol^{-1}\ K^{-1})$	T_m (K)	ΔH_m $(kJ\ mol^{-1})$
M	25.0	30.0	1400	12.0
N	26.0	31.0	1300	11.0

$C_{P(s)}$: Specific heat capacity of solid

$C_{P(l)}$: Specific heat capacity of liquid

T_m: Melting temperature

ΔH_m: Specific latent heat of fusion

(1) What is the total entropy change of M-N mixing liquid solution at 1350 K? **(5%)**

(2) What is the total free energy change of M-N mixing liquid solution at 1350 K? **(5%)**

(3) What is the total enthalpy change of M-N mixing liquid solution at 1350 K? **(5%)**

(4) The solid M at 1350 K is dissolved in the liquid N at 1350 K, forming the M-N mixing liquid solution. Calculate the total entropy change and the total enthalpy change in the whole process. **(10%)**

7. Two metals, A and B, form the regular solution at 500 K. The activity of B is 0.283 when the molar fraction of B is 0.40.

(1) Calculate the activity of A in the solution. **(5%)**

(2) Calculate the activity of A in the solution when the solution temperature is at 700 K. **(5%)**

8. The regular solution of A-B at 1100 K is followed by: $G^{xs} = 20000 X_A X_B$

G^{xs}: Excess free energy

X_A: Molar fraction of A

X_B: Molar fraction of B

(1) Calculate the critical temperature. **(5%)**

(2) Determine the positions of the spinodal compositions. (5%)

(3) Determine the practical activity, a_A, at $X_A = 0.1$, at 1100 K. (5%)