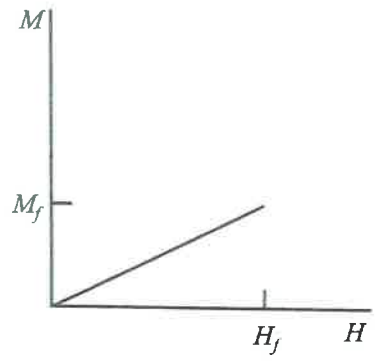
國立臺灣科技大學 111 學年度碩士班招生試題

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；所有試題務必於答案卷內頁依序作答，否則不予計分)

1. (10%) A magnetic field H is applied to a material with a positive susceptibility. Assume the field (H) and the magnetization (M) are parallel, μ_0 is the permittivity of vacuum, V is the volume of the material, and that the M vs. H plot is linear (as shown in the figure below).



   (1) Determine the work done when H varies from zero to $H = H_f$ and M varies from zero to $M = M_f$. (5%)

   (2) Sketch the area on a M-H plot that corresponds to the work done on the material. (5%)

2. (10%) A weak magnetic field is applied to a system of up and down spins. The up spins have a slightly lower energy state than down spins. This is because the up spins are favored by the weak magnetic field. Thus, the up spin energy level ($\varepsilon^{\uparrow}$) is lower than the down spin energy level ($\varepsilon^{\downarrow}$).

   (1) Determine the partition function for this system using $\varepsilon^{\uparrow}$, $\varepsilon^{\downarrow}$, Boltzmann constant (k), and temperature (T). (5%)

   (2) Determine the ratio ($n^{\uparrow}/n^{\downarrow}$) of numbers of particles with up spin ($n^{\uparrow}$) and down spin ($n^{\downarrow}$) for very high temperatures and very low temperatures. (5%)

3. (10%) Draw the following figures.

   (1) Draw a figure to show the variations of internal energy (U), entropy (S), and Helmholtz free energy (A) with the number of atoms in the vapor phase of a closed solid-vapor system at constant temperature and constant volume. (5%)

   (2) Draw a figure to show the influence of temperature (suppose $T_1 < T_2$) on the equilibrium number of atoms in the vapor phase of a closed solid-vapor system at constant volume. The Helmholtz free energy (A) curves for T_1 and T_2 should be clearly indicated. (5%)

4. (10%) Draw a figure to show entropy of mixing (ΔS^M) vs. molar fraction of B crystal in A crystal (X_B) with no preference for any type of bonds. Indicate the position for the maximum entropy of mixing in the figure.

5. (10%) Draw a pressure-volume (P-V) diagram showing Carnot cycles operating between T_1 and T_2, T_1 and T_3, and T_2 and T_3 ($T_1 > T_2 > T_3$). Indicate the isothermal and adiabatic parts in the diagram.

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6. (20%) The saturated vapor pressure of liquid zinc is:

$$\ln P(atm) = -\frac{15246}{T} - 1.255 \ln T + 21.79$$

(1) Get the normal boiling point of zinc. (Hint: the answer is between 1000 K and 1200 K) (10%)

(2) Get the enthalpy of vaporization at the normal boiling point of zinc. (10%)

7. (20%) Some thermodynamic properties of graphite and diamond are listed in the below table.

	ΔH^0_{298} $(J\ mol^{-1})$	S^0_{298} $(J\ mol^{-1}\ K^{-1})$	ρ $(g\ cm^{-3})$	C_P $(J\ mol^{-1}\ K^{-1})$
Graphite	0	5.73	2.22	8.53
Diamond	1900	2.43	3.515	6.115

(1) What is the minimum pressure to convert graphite into diamond if the initial condition of graphite is at 1 atm and 298 K? $R = 8.314\ J\ K^{-1}\ mol^{-1} = 0.082\ L\ atm\ K^{-1} mol^{-1}$ (10%)

(2) If the temperature is at 3000 K, what is the minimum pressure to convert graphite into diamond if the initial condition of graphite is at 1 atm and 298 K? (Hint: $\int \ln x\, dx = x \ln x - x$) (10%)

8. (10%) The regular solution of A-B at 900 K is followed by: $G^{xs} = 18000 X_A X_B$ and G^{xs}: Excess free energy.

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

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