國立臺灣科技大學109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. (20%)

(1) If n particles are distributed among the energy levels such that n_0 are on level ε_0, n_1 on level ε_1, n_2 on level ε_1,..., and n_r on level ε_r, the highest level of occupancy. Starting from the number of arrangements within a given distribution, Ω, derive the Boltzmann distribution for the number of particles among various energy levels (n_i) in terms of total number of particles (n), arbitrary constant (β), energy levels (ε_i), and the partition function. **(10%)**

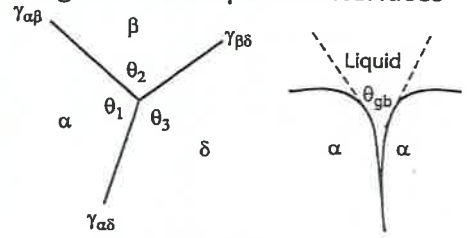
(2) Draw a ε_i vs. n_i diagram and show the influence of temperature on the most probable distribution of particles among energy levels in a closed system of constant volume. **(5%)**

(3) One mole of a FeX alloy of 50 at% X has its Fe and X atoms randomly arranged on a body centered cubic lattice. The spins on the Fe atoms are also randomly arranged. The X atoms do not have spins. Calculate the sum of configurational and spin entropies of the alloy. **(5%)**

2. (10%)

Three phases, α, β, and δ meet as shown in the figure below, forming three interphase interfaces (α/β, α/δ, and β/δ). It can be shown that

$$\frac{\gamma_{\alpha/\beta}}{\sin\theta_3} = \frac{\gamma_{\alpha/\delta}}{\sin\theta_2} = \frac{\gamma_{\beta/\delta}}{\sin\theta_1}$$



Using this equation, determine the ratio of the grain boundary energy ($\gamma_{\alpha/\alpha}$) to $\cos(\theta_{gb}/2)$ in terms of the interface energy ($\gamma_{\alpha/L}$). **(10%)**

3. **(20%)**

(1) Draw a pressure vs. volume diagram of a Carnot cycle and indicate the steps that are isothermal and adiabatic, respectively. **(10%)**

(2) A reversible 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 temperatures T_1 and T_2 and have constant heat capacities C_1 and C_2, respectively. Calculate the maximum amount of work which can be obtained from the engine in terms of C_1, C_2, T_1, and T_2. **(10%)**

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4. (30%) Some thermodynamic properties of gold and silver are given in the below table:

	$c_{P(s)}$ $(J\ mol^{-1}\ K^{-1})$	$c_{P(l)}$ $(J\ mol^{-1}\ K^{-1})$	T_m (K)	ΔH_m $(kJ\ mol^{-1})$	S^0_{298} $(J\ mol^{-1}\ K^{-1})$
Au	24.7	29.5	1338	12.5	47.4
Ag	25.7	30.2	1234	11.3	42.6

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

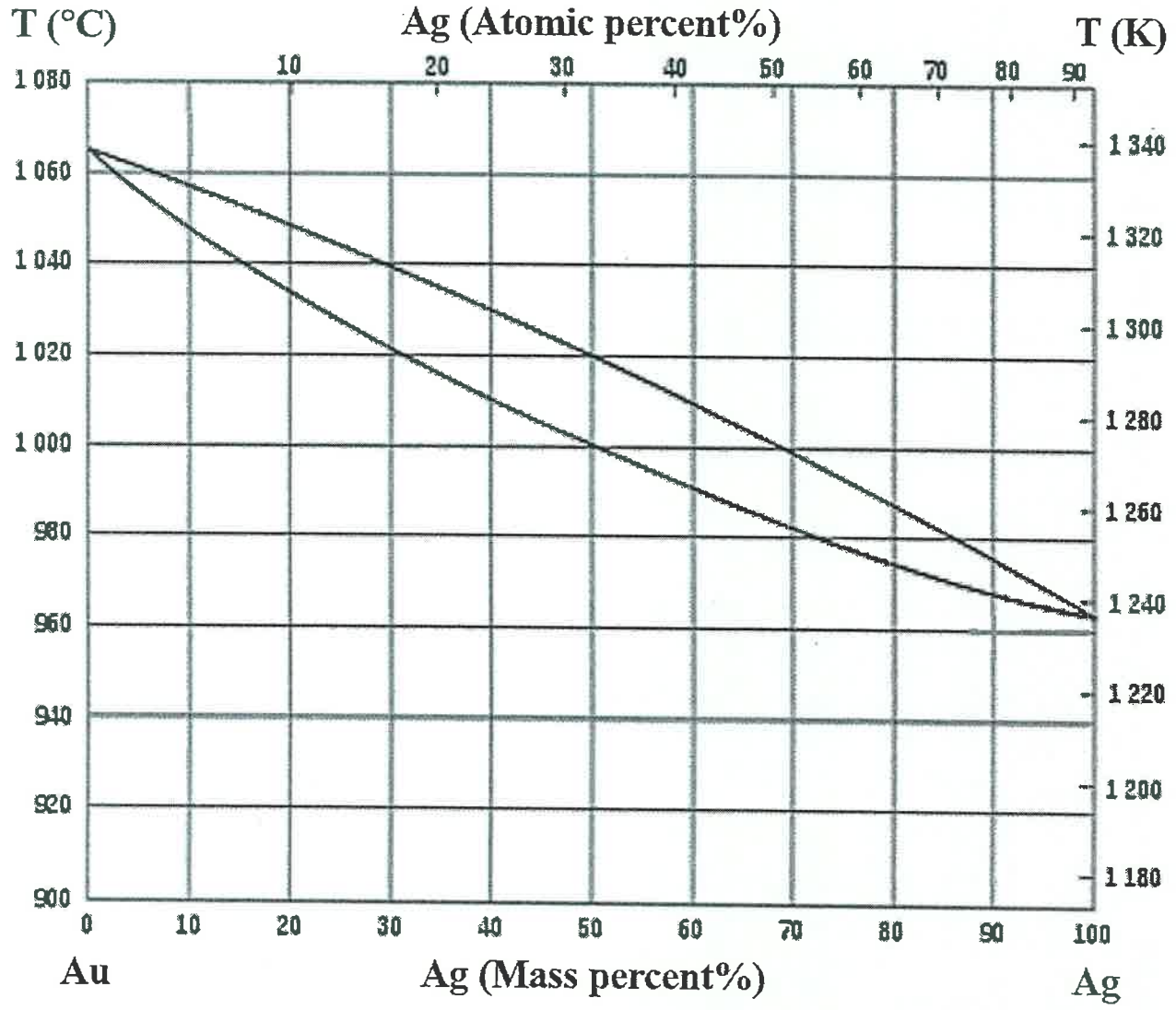
$c_{P(l)}$: Specific heat capacity of liquid

T_m: Melting temperature

ΔH_m: Specific latent heat of fusion

S^0_{298}: Specific entropy at 298 K

The gold-silver (Au-Ag) alloy contains 1 mole of gold and 1 mole of silver, which this alloy is set in the crucible and then introduced into the tube furnace. The phase diagram of Au-Ag is given in the below diagram. Assume that all solutions are ideal and the heat capacities of all substances are independent on temperature. The initial temperature is 298 K.



(1) Calculate the total enthalpy change and the total entropy change of the alloy when the furnace temperature is raised from 298 K to 1248 K. **(10%)**

(2) Calculate the total enthalpy change and the total entropy change of the alloy when the furnace

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temperature is raised from 298 K to 1268 K. **(10%)**

(3) Calculate the total enthalpy change and the total entropy change of the alloy when the furnace temperature is raised from 298 K to 1288 K. **(10%)**

5. (20%) The A-B solution is mixed at 700 K, which the activity coefficient of A is followed by:

$$\ln \gamma_A = 1.5X_B^2 - 0.5X_B^3$$

where γ_A, γ_B, a_A, a_B, X_A, and X_B are the activity coefficient of A, the activity coefficient of B, the activity of A, the activity of B, the molar fraction of A, and the molar fraction of B, respectively.

(1) Is the A-B solution a positive deviation solution or a negative deviation solution? **(5%)**

(2) Calculate γ_A and a_A at $X_A = 0.5$. **(5%)**

(3) Derive the expression of $\ln \gamma_B$ based on the composition of X_A. **(10%)**