注意：考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

國立清華大學 109 學年度碩士班考試入學試題

系所班組別：工程與系統科學系
甲組

科目代碼：3002

考試科目：材料熱力學

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 作答中如有發現試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 109 學年度碩士班考試入學試題

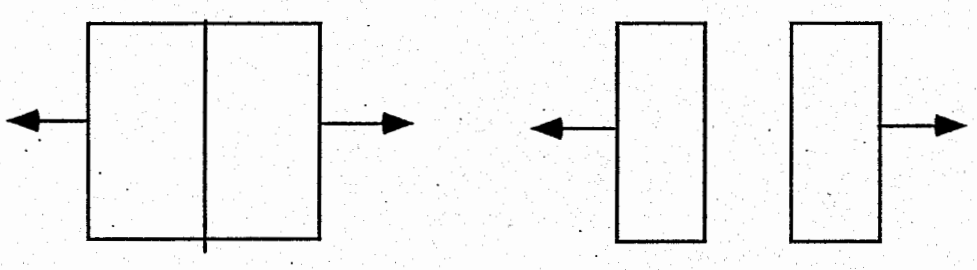
系所班組別：工程與系統科學系碩士班 甲組(0526)

考試科目（代碼）：材料熱力學 (3002)

1. The work performed in creating surfaces can be added to the work flows in the First Law of Thermodynamics. If σ is defined as the surface energy per unit area, the work performed when creating new surface is σdA, where A is the surface area of the system. Separatium (Sp) has a surface energy (solid-gas) which over the temperature range of interest increases with temperature as B + C ln(T) with C and B positive constants. A single crystal of Sp is reversibly pulled apart as show in the figure below. The crystal is insulated so that there is no heat flow to the environment.

   (a) Calculate the change in entropy of the system (per unit new surface area) as the crystal is isothermally and reversibly pulled apart. Answer can be in terms of constants B, C, and Temperature. (8%)

   (b) What happens to the temperature of the system if the crystal is pulled apart adiabatically (but reversibly). Assume that there is no plastic deformation in the system while it is being pulled apart. (7%)



2. Some researchers have considered to use phase transitions in a material as a way of rapidly absorbing mechanical energy (work). The idea is that under high enough pressure a substantial amount of work is done on a system when it transforms to a phase with smaller volume. Some recent results on *Absorbium*, a previously unknown element, indicate that it might be desirable for such applications. At atmospheric pressure *Absorbium* undergoes an allotropic reversible phase transition from the α to the β form at $T_0 = 350K$. (The low temperature phase is α). The β form has a lower molar volume. Clearly state any assumptions you make.

(a) Argue that for temperatures below $T_0 = 350K$ the α phase can be transformed to β by the application of pressure. How do you know? (7%)

(b) Find the amount of work absorbed by the α to β transition when it is induced by pressure at T = 300K. (8%)

(c) In some cases (e.g. when the transition is completed very quickly) it is more realistic to think of the transition as occurring adiabatically (isentropically). What is the work absorbed from the environment when the transition is induced by pressure at 300 K, but occurs adiabatically. Assume that only reversible processes take place in the material (e.g. no plastic deformation or defect creation). Both phases may be considered incompressible (though there is a volume change when the system transforms from α to β. (8%)

Assume that only reversible processes take place in the material (e.g. no plastic deformation or defect creation). Both phases may be considered incompressible (though there is a volume change when the system transforms from α to β.

DATA: for the transition from α to β at 350K: $\Delta H = 1$ kJ/mol; $\Delta V = 1$ cc/mol

Clearly state any assumptions you make

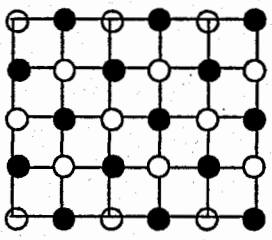
3. Below is given a description (in some case with figure) of the macroscopic state of an A-B alloy that mixes on square lattice. In each case you are asked for

(1) the total configurational entropy is as function of 2N, the number of lattice sites

(2) the entropy per lattice site in the thermodynamic limit (i.e. as 2N goes to infinity).

Note that there are 2N lattice sites. So in the perfectly ordered alloy the number of A is N and the number of B atoms is N.

(a) A perfectly ordered system with composition AB, as shown below. (8%)



S_{tot} = _____ $S_{tot}/2N$ = _____

(b) Same system as in (a) but with 1% of the A atoms replaced by B atoms. (8%)

4. For a binary A-B alloy, the free energy of mixing for the regular solution model is (expressed per mole):

$$\Delta G_{mix} = Z\omega X_A X_B + RT\left(X_A \ln X_A + X_B \ln X_B\right)$$

where

$$\omega = w_{AB} - \frac{1}{2}\left(w_{AA} + w_{BB}\right)$$

and Z = the coordination number of each atom in the crystal.
Assume ω=630 J/mole and Z = 8.

(a) Calculate expression for the
(i) enthalpy of mixing, (4%)
(ii) entropy of mixing, (4%)
(iii) the chemical potentials of A and B, (10%)
(iv) the activities of A and B. (10%)

(b) Plot $\triangle G_{mix}$ at different temperatures at 200K, 250K, 300K and 350K. (10%)

(c) Use the answer in (b) to sketch a phase diagram for this A-B alloy in this temperature range (200K to 400K). (8%)