國立中山大學114學年度
碩士班考試入學招生考試試題

科目名稱：材料科學導論【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】

—作答注意事項—

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。
- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

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※本科目依簡章規定「不可以」使用計算機(混合題)

第一部分：單選題，每題5分，答錯無倒扣

1. Which one of the following descriptions is **not** correct? (5 points)
   (A) An optical fiber consists of three main components: the core, cladding, and coating. To confine light within the core, the cladding must have a slightly higher refractive index than the core.
   (B) The beam from a semiconductor laser results from the recombination of excited electrons in the conduction band with holes in the valance band.
   (C) Luminescence is a phenomenon that materials are capable of absorbing energy and then reemitting visible light.
   (D) Luminescence is classified according to the magnitude of the delay time between absorption and reemission events. If reemission occurs for times much less than one second, the phenomenon is termed fluorescence.

2. A material that is transparent in its single-crystal form can become translucent or even opaque due to internal scattering caused by many factors. Which one of the following reasons does **not** course the material becoming translucent/opaque? (5 points)
   (A) The material being in a polycrystalline form,
   (B) The material contains vacancies in an equilibrium concentration,
   (C) The presence of fine pores in the material,
   (D) The presence of fine second-phase particles in the material.

3. Two of the most important interactions between electromagnetic radiation and atoms, ions and/or electrons are electronic polarization and electron excitation (energy transitions). Which one of the following descriptions is **not** correct? (5 points)
   (A) Two consequences of electronic polarization are absorption and refraction of light.
   (B) Electromagnetic radiation may be absorbed by causing the excitation of electron from one energy state to a higher state.
   (C) When light passes from one transparent medium to another having a different index of refraction, some of it is reflected at the interface.
   (D) Metals appear opaque as a result of the absorption and then reemission of light radiation within a surface layer of more than 1 μm thick.

4. Which one of the following descriptions is **not** correct? (5 points)
   (A) Domain wall energy is the excess energy in the domain wall as a result of the gradual orientations of the neighboring spin magnetic moments of atoms through the wall region.
   (B) Magnetostatic energy is the potential energy stored in an external magnetic field.
   (C) Magnetostrictive energy is the potential energy stored in the crystal due to magnetization.
   (D) Exchange interaction energy is a kind of Coulombic energy between two neighboring electronics and positive metal ions that depends on the relative spin orientations of the electrons as a consequence of the Pauli Exclusion Principle.

5. Magnetic susceptibility χ_m of a materials is defined by $\mathbf{M} = \chi_m \mathbf{H}$, where **M** is the magnetization and **H** is the magnetizing field. Which one of the following descriptions is **not** correct? (5 points)
   (A) The silicon crystal is diamagnetic with $\chi_m \sim -5 \times 10^{-6}$.
   (B) The magnesium crystal is paramagnetic with $\chi_m \sim 1 \times 10^{-5}$.
   (C) The α-chromium crystal is antiferromagnetic $\chi_m \sim -4 \times 10^{-6}$.
   (D) The alpha-iron crystal is ferromagnetic with $\chi_m \sim 6 \times 10^{3}$.

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6. Which one of the following descriptions is correct? (5 points)
   (A) Polymeric materials typically exhibit thermal expansion coefficients lower than those of ceramics.
   (B) For solid materials, heat is transported by free electrons and by phonons.
   (C) Above the Debye temperature, the heat capacity (C_v) becomes nearly temperature-independent and approaches a value of approximately 2R, where R is the gas constant.
   (D) The change in length of a steel bar is 12 cm when it is cooled from 625 °C to 25 °C, if it is 20 m in length at 600 °C (assuming that the linear thermal expansion coefficient of the steel is $2x10^{-5}$).

7. With regard to atomic point defects in ceramics, which one of the following descriptions is **not** correct? (5 points)
   (A) Interstitials and vacancies for each anion and cation are possible.
   (B) If electroneutrality is to be reserved, one Na^+ interstitial or a Cl^- vacancy has to be formed in NaCl when a Ca^{2+} substitutes for an Na^+ ion.
   (C) The defect involves a cation-vacancy and a cation-interstitial pair is called a Frankel defect.
   (D) A small portion of iron ions in $Fe_{1-x}O$ (x~0.05) are trivalent.

8. Upon consideration of the Yb_2O_3 and SiO_2 phase diagram in Fig. 1, which one of the following compositions will probably be the most desirable refractory? (5 points)
   (A) 10 mol% Yb_2O_3-90 mol% SiO_2, (B) 30 mol% Yb_2O_3-70 mol% SiO_2, (C) 70 mol% Yb_2O_3-30 mol% SiO_2, (D) 90 mol% Yb_2O_3-10 mol% SiO_2.

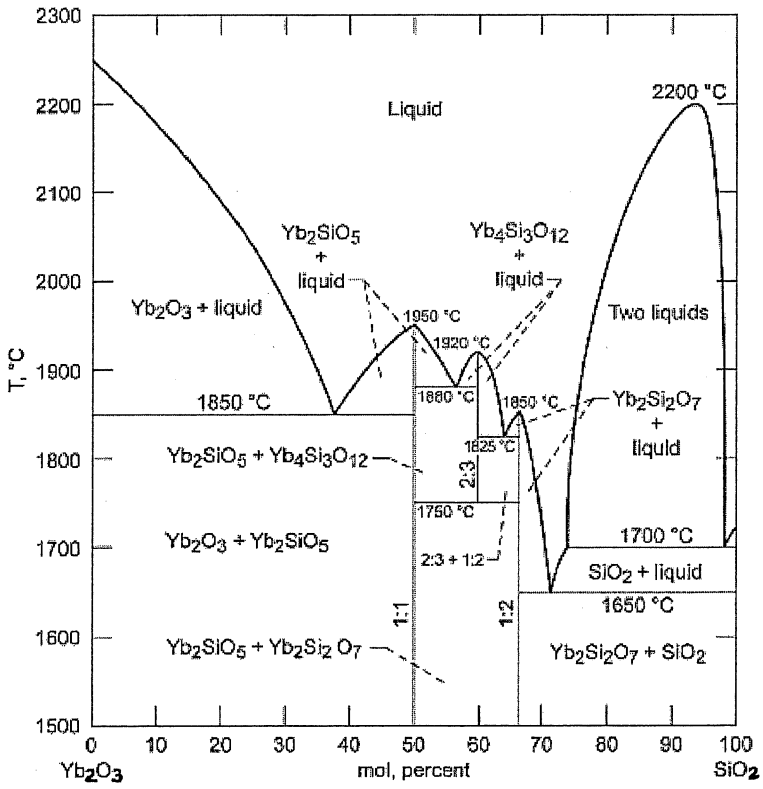

Figure 1 Yb_2O_3-SiO_2 phase diagram.

第二部分：問答計算題，答錯無倒扣

9. List the name (in English) and the unit cell geometries for the seven crystal systems. (7 points)

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10. Determine the Miller indices for the direction and plane shown in the unit cell in Fig. 2. (8 points)

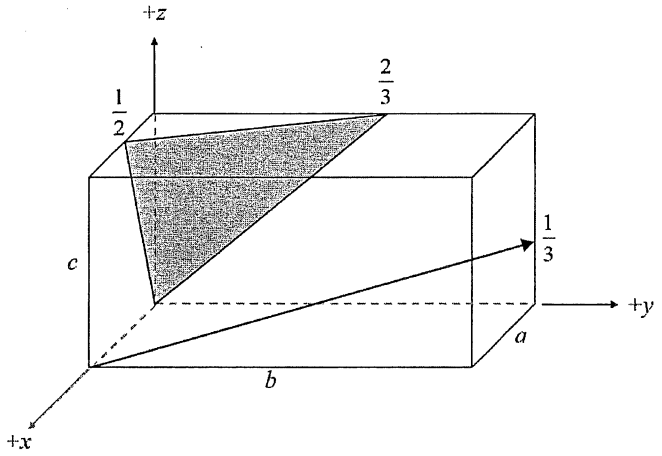

Figure 2

11. The potential energy E per ion pair in a crystal as a function of interionic separation r can be written as the sum of an attractive potential energy and a repulsive potential energy,

$$E(r) = -\frac{A}{r} + \frac{B}{r^n}$$

where A, B, and n are constants. Derive the equilibrium interionic separation r_0 and bulk modulus K in terms of A, B, and n. (8 points)

12. If hydrogen gas leaks at a constant rate of 6×10^{-11} kg/m^{2}s from a steel tank with a thickness of 2 mm containing high-pressure hydrogen (100 MPa), estimate the rate of change of hydrogen concentration over time, $(\frac{\partial C}{\partial t})$, at the inner surface of the tank, and explain your answer. (6 points)

13. Figure 3 shows a scanning electron micrograph of a steel sample in which a triple junction of three grain boundaries, GB_{12}, GB_{13}, and GB_{23}, can be observed. Estimate the ratios of the three grain boundary energies, γ_{12}, γ_{13}, and γ_{23}, and explain your answer. (6 points)

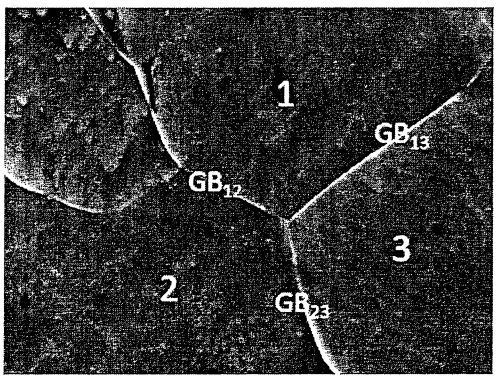

Figure 3 Scanning electron micrograph of a steel sample.

14. A tensile stress of 560 MPa is applied along the longitudinal direction of a cylindrical tungsten rod having an unloaded length of 1000 mm and an unloaded diameter of 10 mm. Determine the length and diameter of the rod upon loading. (Note: the elastic modulus, shear modulus, Poisson's ratio and yield stress are 400 GPa, 160 GPa, 0.28 and 750 MPa, respectively.) (8 points)

15. Determine the moving direction of the dislocation in each of the following cases (see Fig. 4). (8 points)

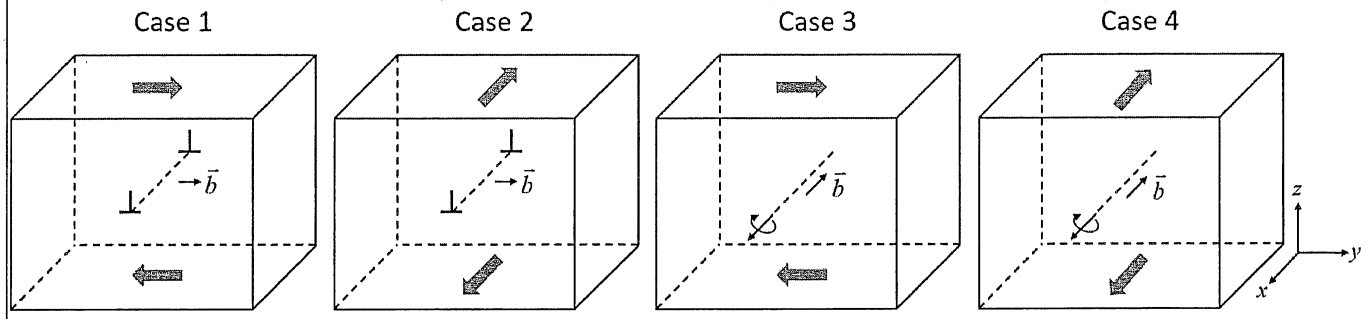

Figure 4 Schematic drawing of dislocations in crystals with shear stresses applied.

16. Using the schematic A-B phase diagram, specify the nature of the final microstructure (in term of microconstituents present and their relative location) of three small specimens with composition of C_1, C_2 and C_3, respectively, that have been subject to the following heat treatment: holding at T_1 long enough to have achieved a homogenous liquid state followed by a slow cooling (~100 °C/h) from T_1 to T_6 and a final quenching from T_6 to room temperature. You may also give a schematic drawing of the microstructure of each specimen. (9 points)

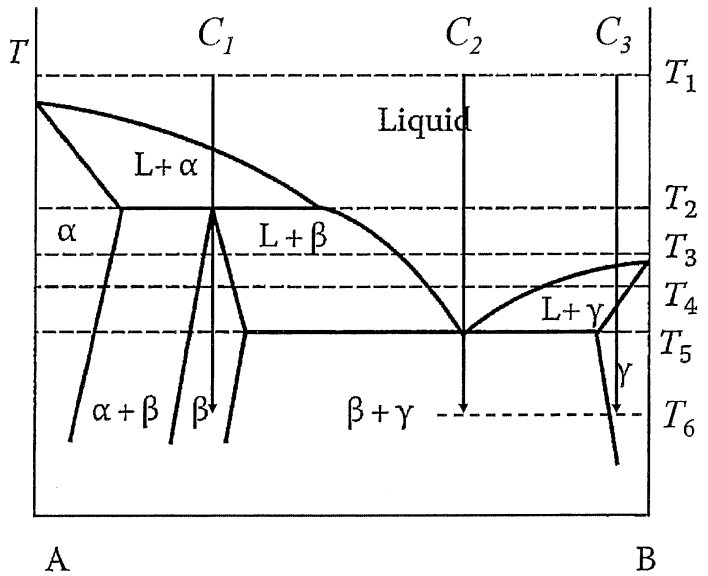

Figure 5 Schematic binary diagram of A and B

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