115MM02

# 國立臺北科技大學 115 學年度碩士班招生考試

## 系所組別：3300 材料科學與工程研究所

## 第二節　材料科學與工程導論　試題



**注意事項：**

1. 本試題第一部分計算與問答，共 4 題，共 50 分；第二部分選擇題，共 10 題，每題 3 分；第三部分選擇題，共 10 題，每題 2 分。總分共計 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

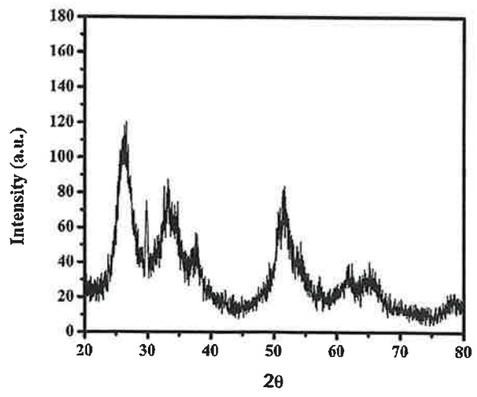
**Part 1.Answer the following questions (50%)**

**1.** Consider the gas carburizing of a gear of a low-carbon steel at 927 °C. Given the carbon content at the surface is 0.9%, the steel has a nominal carbon content of 0.2%, and $D = 1.28 \times 10^{-11}\ m^2/s$.

A. Calculate the time necessary to increase the carbon content to 0.4% at 0.5 mm below the surface. (6%)

B. Calculate the carbon content at 0.5 mm below the surface after 5 hours carburization. (6%)

**2.** Given the diffraction pattern of an as-synthesized alloy, roughly sketch diffraction patterns in different time stages with different heating temperature, respectively. State the major differences by the FWHM of diffraction peaks and the signal-to-noise ratio. Note that $T_m$ is the melting temperature of the alloy. (18%, each for 2%)




| Temperature | Time stage | | |
|---|---|---|---|
| | A few seconds | A few minutes | A few hours |
| 1.2 $T_m$ | A | B | C |
| 0.6 $T_m$ | D | E | F |
| 0.2 $T_m$ | G | H | I |

**3.** For the following pairs, specify the differences between them.

A. Primitive cell vs. conventional cell (2%)

B. Crystal system vs. lattice system (2%)

**4.** Both α-Fe and V crystallize in the body-centered cubic (BCC) structure, with similar but not identical lattice parameters. When combined at an equiatomic composition, they may form either an intermetallic compound or a solid solution. In both cases, atoms occupy the lattice sites at (0, 0, 0) and (0.5, 0.5, 0.5) within the cubic unit cell.

A. Sketch the unit cells of the intermetallic compound and the solid solution of FeV, respectively. (4%)

B. Derive X-ray diffraction (XRD) selection rules for the two structures described above, and indicate the key differences in their diffraction patterns with explanations. (6%)

C. Which of the two phases is thermodynamically stable at high temperature? Explain your reasoning. (3%)

D. "*The intermetallic compound formed between α-Fe and V can be nonstoichiometric, exhibiting a relatively wide composition range in the phase diagram.*"
Is this statement correct? Justify your answer. (3%)

**Part 2.Selection questions (30%, each for 3%)**

**5.** Which is the most probable driving force of the diffusion?

(a) Internal strain
(b) Brownian motion
(c) Concentration gradient
(d) Activation energy
(e) None of them

注意：背面尚有試題

**6.** Which of the following statements is not related to the diffusionless transformation?
(a) Twinning
(b) Martensite transformation
(c) Spinodal decomposition
(d) Strain-induced transformation
(e) None of them

**7.** Which of the following statements is incorrect?
(a) The peritectic reaction involves the transformation of a liquid and one solid phase into a different solid phase upon cooling
(b) The eutectic reaction involves simultaneous solidification of two phases from a liquid.
(c) The peritectoid reaction involves the transformation of two solid phases into a different solid phase upon cooling.
(d) The eutectoid reaction involves the simultaneous transformation of one solid phase into two different solid phases.
(e) None of them

**8.** Which of the following statements about GP zone could be caused?
(a) Casting
(b) Heat treatment
(c) Rolling
(d) Twinning
(e) None of them

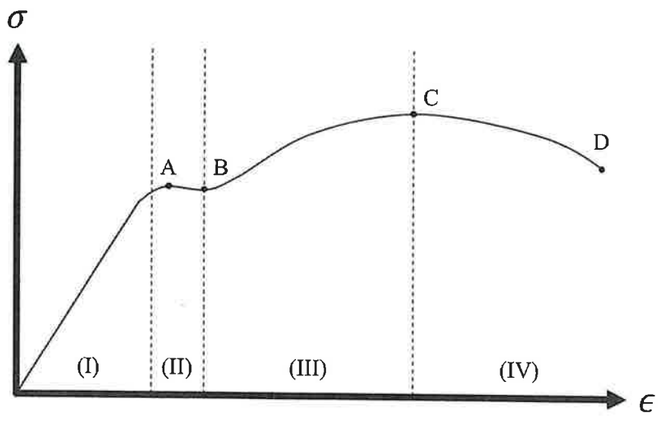
**9.** Which of the followings might not be composed of different specie?
(a) Solid solution
(b) Twinning
(c) Intermetallic compound
(d) Amalgam
(e) None of them

**10.** Which of the following statements about the mechanisms of material failure is incorrect?
(a) Overload: the sudden failure of a material due to applied stress exceeding its strength limit.
(b) Creep: the slow deformation of a material under constant stress over a long period of time, especially at high temperature
(c) Corrosion: the deterioration of a material due to chemical or electrochemical reactions with its environment
(d) Fatigue: a material fails after repeated or cyclic loading, when the applied stress exceeds its strength limit.
(e) None of them

**11.** Regarding the fracture behavior of the ceramic described, which statement is correct?
(a) Fine grains promote extensive dislocation motion, leading to plastic deformation prior to fracture.
(b) Ionic or covalent bonding enables large tensile ductility before crack initiation.
(c) Porosity improves fracture toughness by reducing local stress concentration.
(d) At high temperatures, fracture in ceramics is dominated by ductile mechanisms rather than brittle cracking.
(e) Cracks tend to initiate at microstructural defects such as pores or inclusions rather than at dislocation pile-ups.

**12.** The polymer might be semicrystalline, containing crystalline domains embedded within an amorphous matrix. The fraction of crystalline regions is influenced by processing conditions such as cooling rate and molecular weight. Regarding the semicrystalline regions, which statement is incorrect?
(a) Increasing crystallinity generally increases modulus and strength.
(b) Crystalline regions lower the polymer's melting temperature.
(c) Semicrystalline polymers have higher chemical resistance than amorphous polymers.
(d) Crystallinity affects viscoelastic response above $T_g$.
(e) None of them.

Given a stress-strain curve, answer question 13 & 14.




**13.** Which of the following statements is incorrect?
(a) This stress-strain curve is measured from a "high-carbon steel".
(b) "Lüders band" can be observed in the region II.
(c) "Strain hardening" can be observed in the region III.
(d) "Necking" can be observed in the region IV.
(e) None of them

**14.** Which description is correct?
(a) A: "Proportional Limit"
C: "Upper Yield point"
(b) B: "Ultimate strength point"
D: "Fracture point"
(c) B: "Lower yield point"
C: "Upper yield point"
(d) A: "Upper yield point"
C: "Ultimate strength point"
(e) None of them

**Part 3.Fill the blanks (20%, each for 2%)**

**15.** A _____ assumes ideal entropy of mixing but a nonzero enthalpy of mixing arising from differences in atomic interaction energies.

**16.** In ionic ceramics, a _____ involves the formation of paired cation and anion vacancies, whereas a _____ consists of a cation displaced from its lattice site to an interstitial site.

**17.** _____ from high temperature can produce non-equilibrium microstructures.

**18.** The _____ describes the relationship between the transverse voltage, current, magnetic field, and carrier density in a conductor.

**19.** The _____ measures a material's ability to resist crack propagation.

**20.** The _____ characterizes the magnitude and direction of lattice displacement in a dislocation.

**21.** The _____ determines the thermodynamic stability of phases at constant temperature and pressure, while the _____ determines the thermodynamic stability of phases at constant entropy and volume.

**22.** A _____ consists of two or more chemically distinct polymer blocks covalently bonded together and can self-assemble into lamellar, cylindrical, or spherical domains with tunable properties.