113MM02

# 國立臺北科技大學 113 學年度碩士班招生考試

## 系所組別：3301 材料科學與工程研究所

## 第二節　材料科學與工程導論　試題（選考）



**注意事項**：

1.本試題第一部分計算及問答，共 5 題，每題 10 分；第二部分選擇題，共 10 題，每題 3 分；第三部分填空，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. Answering the following questions. (50%)**

**1.** In figure 1, determine the indices for the planes (P1, P2) and directions (D1, D2). Use both 3-axis and 4-axis system for D1 and D2. (10%)

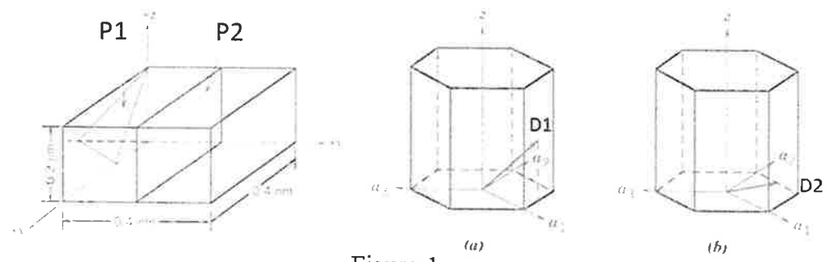


Figure 1

**2.** $CH_3NH_3SnI_3$ is a material with perovskite structure ($ABX_3$) where $CH_3NH_3^+$ represents an ionized organic molecule. The degradation or decomposition of $CH_3NH_3SnI_3$ occurs due to oxidation of $Sn^{2+}$ to $Sn^{4+}$.

**(a)** if degradation occurs, what crystalline defect (or defects) would be expected to form in order to maintain charge neutrality? (5%)

**(b)** how many defects would be created for each $Sn^{4+}$ ion? (5%)

**3.** For the nucleation process of solidifying from liquid, free energy changes as a function of nucleus radius. Sketch this free energy plot accordingly,

**(a)** at two different temperatures T1 and T2, where T1>T2. (5%)

**(b)** for homogeneous and heterogeneous nucleation process. (5%)

**4.** Using the isothermal transformation diagram for an iron–carbon alloy of eutectoid composition in figure 2, specify the nature of the final microstructure (in terms of microconstituents present and approximate percentages of each) of a small specimen that has been subjected to the following time–temperature treatments. In each case assume that the specimen begins at 760°C and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

**(a)** Cool rapidly to 600°C, hold for 6 s, then quench to room temperature. (2%)

**(b)** Rapidly cool to 670°C, hold for 50 s, rapidly cool to 300°C, hold for 600 s, then quench to room temperature. (2%)

**(c)** Reheat the specimen in part (b) to 700°C for 20 h. (2%)

**(d)** Rapidly cool to 500°C, hold for 50 s, rapidly cool to 350°C, hold for $10^2$ s, then quench to room temperature. (2%)

**(e)** Rapidly cool to 450°C, hold for 10 s, rapidly cool to 165°, then hold for this temperature. (2%)

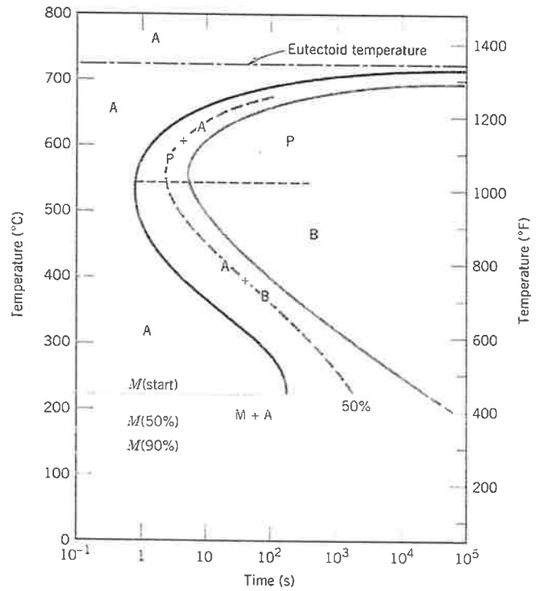


Figure 2

Table 1.

| z | erf(z) |
|---|---|
| 0.65 | 0.6420 |
| 0.70 | 0.6778 |
| 0.75 | 0.7112 |
| 0.80 | 0.7421 |

Table 2.

| Diffusing Species | Host Metal | $D_0$(m²/s) | $Q_d$(J/mol) |
|---|---|---|---|
| Interstitial Diffusion | | | |
| C[b] | Fe (α or BCC)[a] | $1.1\times10^{-6}$ | 87400 |
| C[c] | Fe (γ or FCC)[a] | $2.3\times10^{-5}$ | 148000 |
| N[b] | Fe (α or BCC)[a] | $5.0\times10^{-7}$ | 77000 |
| N[c] | Fe (γ or FCC)[a] | $9.1\times10^{-5}$ | 168000 |

**5.** From table 1 and 2, determine the parameters necessary to achieve a carbon concentration of 0.4 wt% at a position 3 mm into an iron-carbon alloy that initially contains 0.13 wt% C. The surface concentration is to be maintained at 1 wt% C, and the treatment is to be conducted at 1200°C. Given $\frac{C(x.t)-C_0}{C_s-C_0}$ = 1-erf $(\frac{x}{2\sqrt{Dt}})$, $D = D_0\exp(-\frac{Q}{RT})$, R is gas constant 8.314 J / mol·K.

**(a)** What is the iron lattice structure in this process? (5%)

**(b)** determine carburization time to achieve required condition. (5%)

注意：背面尚有試題

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

**6.** Choose the correct statement.

a. carbon atoms in unsaturated hydrocarbons are singly bonded to other atoms.

b. free radical polymerization can be accomplished by using saturated hydrocarbon molecules.

c. polymer size is determined by measuring the polymer chain length.

d. bond breaking is not required to obtain different polymer conformations.

**7.** Choose the correct statement.

a. Energy of electrons in an atom is continuously distributed, and electron tend to occupy from the lowest energy state.

b. atomic bonding forms when attractive energy and repulse energy cancel each other.

c. atoms with large different electronegativity values tend to form ionic bonding.

d. electron position in an atom can be precisely determined.

**8.** Choose the wrong statement

a. shear stress is the driving force for the slip to occur of edge dislocations.

b. materials with more slip systems are more easily to be deformed.

c. dislocation motion in metals is relatively easy because metallic bonding is non-directional.

d. plastic deformation is easier in a perfect single crystal.

**9.** Which is the valid slip systems for FCC, BCC structure of metal?

a. FCC {100}<110> ; BCC {321}<111>;

b. FCC {111}<110> ; BCC {211}<111>;

c. FCC {111}<110> ; BCC {111}<110>;

d. FCC {111}<111> ; BCC {211}<111>;

e. FCC {110}<111> ; BCC {110}<111>

**10.** A single crystal of hypothetical metal that has FCC crystal structure and is oriented such that a tensile stress is applied along a [112] direction. If slip occurs on a (111) plane and in a [011] direction, and the critical resolved shear stress is 4.18 MPa, calculate the magnitude of the applied tensile stress necessary to initiate yielding.

a. 0 MPa;

b. 2.95 MPa;

c. 3.41 MPa;

d. 5.12 MPa;

e. 5.91 MPa

**11.** Choose wrong statements. (multiple selection)

a. magnetic moment of materials arises from both electron orbital motion and the spin of electrons.

b. complete filled electron shell has large spin moment.

c. antiferromagnetic materials have incomplete cancellation of spin moments.

d. paramagnetic materials have permanent atomic dipoles.

e. diamagnetic and paramagnetic materials are non-magnetic.

f. ferromagnetism is permanent magnetization.

g. Materials with positive magnetic susceptibility is considered magnetic.

**12.** Select the properties with the same temperature dependence from the following. (multiple selections)

a. vacancy concentration;

b. diffusion coefficient;

c. critical radius for nucleation;

d. intrinsic carrier concentration;

e. steady-state creep rate;

f. number of stable nuclei.

**13.** Silicon has an energy bandgap of 1.12 eV; which one in the following statements could be absorbed by Si? (multiple selections)

a. photons with the energy of 1 eV;

b. photons with the energy of 1.5 eV;

c. Light with a wavelength of 532 nm;

d. Light with a wavelength of 1 μm.

**14.** Choose the wrong statement about semiconductors. (multiple selections)

a. Hall effect determines the majority carrier type, concentration, and mobility.

b. The energy corresponding to the highest filled state at 300K is Fermi energy.

c. A p-n junction diode turns on at forward bias and turns off at reverse bias.

d. Recombination of electrons from the conduction band to the valence band always results in photon generation.

e. At high temperature, extrinsic carrier concentration dominates.

**15.** Choose the wrong statement. (multiple selections)

a. creep occurs due to a lengthy period of stress fluctuations.

b. the maximum stress for fatigue must be higher than the static yield or tensile strength.

c. steady-steady creep rate and creep rupture lifetime increases with reducing stress level.

d. for most metals, creep occurs at $T > 0.4\ T_m$

**Part 3. Fill the blanks. (20%)**

**16.** Martensite is produced by rapidly quenching austenite to a sufficiently low temperature to prevent carbon _____. (2%)

**17.** Si has _____ band structure where electron changes its momentum when transit form valence band to conduction band. (2%)

**18.** Metals can be strengthened by reducing grain size, _____ and _____. (each for 1%)

**19.** Solid solution strengthening results from _____ interactions between impurity atoms and dislocations. (2%)

**20.** Metallic corrosion is typically electrochemical, involving both _____reactions. (2%)

**21.** _____ is a kind of material failure due to the stress fluctuation with time. And _____ is a kind of material failure at elevated temperatures and constant stress. (each for 1%)

**22.** When light interact with materials, small angle deflection of transmitted light is termed as _____; large angle deflection (larger than $90^{o}$) is termed as _____. (each for 1%)

**23.** _____ dislocation motion is perpendicular to the applied shear stress direction. (2%)

**24.** During the thermal annealing process, _____ significantly reduce the dislocation density. (2%)

**25.** For non-equilibrium cooling, the transformation of materials is shifted to a lower temperature than indicated by the phase diagram. This phenomenon is termed _____. (2%)