# 國立中山大學八十九學年度碩博士班招生考試試題

科　目：材料所甲組（材料科學）



**Please answer any 8 of the following 12 questions.**

1. A binary eutectic system consists of element A and B. At the eutectic temperature, the liquid phase is in equilibrium with two solid phases, $\alpha$ and $\beta$, where $\alpha$ is A-rich and $\beta$ is B-rich. Show the free energy-composition diagram of this binary alloy system at the eutectic temperature. (12.5%)

2. Copper has a face-centered cubic (fcc) structure. At low homologous temperatures ($T/T_m < 0.5$), it deforms mainly by dislocation slip. List the 12 slip systems in copper. (12.5%)

3. A binary alloy of elements A and B has a composition $c_o$, where $c_o$ is the atomic fraction of B in this alloy. It is known that at temperature $T_a$, two phases, $\alpha$ and $\beta$, coexist in this alloy system and the equilibrium compositions for $\alpha$ and $\beta$ are $c_1$ and $c_2$, respectively. After solution treatment, the alloy is aged at $T_a$ and $\beta$ precipitates in the $\alpha$ matrix. Show with diagram how the composition will change in the vicinity of an $\alpha/\beta$ interface during the precipitation process if it is diffusion controlled. Indicate all relevant compositions on your sketch. (12.5%)

4. We have a unknown crystal, which is believed to have a body-centered cubic (bcc) structure. The crystal is examined by x-ray diffraction, and several Bragg diffraction peaks are observed. It is known that for bcc structure, the Bragg diffraction occurs when h + k + l = even number, where h, k, and l are Miller indices to characterize crystal plane. What will be the ratio of the interplanar spacings corresponding to the first three diffraction peaks, if the crystal has a bcc structure? (12.5%)

5. For a cold-worked aluminum alloy, it takes 100 hours to fully recrystallize the structure at 270 °C and only 10 hours at 200 °C.
(a) Calculate the activation energy for the recrystallization process in the aluminum alloy? (b) At what temperature would complete recrystallization occur within 2 hours? (12.5%)

6. Please use free energy - composition diagram to describe the conditions of spinodal decomposition. (12.5%)

7. (a) What is the thermodynamic driving force ($\Delta p$) for the sintering of ceramic powder in the solid state, (b) calculate $\Delta p$ for $\alpha$-$Al_2O_3$ powder of an average particle size $\approx 1\ \mu m$ and the solid-to-vapour surface energy $\gamma_{sv} \approx 0.1\ J{\cdot}m^{-2}$. (12.5%)

8. Adopt Kröger-Vink notations and write the defect reaction equations for MgO-doped $Al_2O_3$, assuming (a) Schottky and (b) Frenkel intrinsic defects in pure (undoped) $Al_2O_3$. (12.5%)

9. Describe the crystal structure of $\alpha$-$Al_2O_3$ using a schematic illustration with crystallographic orientations. Hint: starting from anion packing. (10%)

10. Silica is the term used in ceramics for silicon dioxide ($SiO_2$). There is at least five polymorphic modifications of crystalline silica. (a) Name them, and (b) explain why "quartz glass" is a misnomer. (12.5%)

11. Calculate the theoretical density ($\rho_{TD}$) for pure (undoped) $BaTiO_3$ at 150°C. Lattice parameters, for cubic: a ≈ 0.4010 nm, and for tetragonal: a ≈ 0.3994 nm and c ≈ 0.4038 nm and atomic weights: Ba = 137.3, Ti = 204.4 , and O = 16.0. (12.5%)

12. Differentiate between the yield stress ($\sigma_Y$) and the critical resolved shear stress ($\tau_C$) for a hexagonal crystal. (12.5%)

# 國立中山大學八十九學年度碩博士班招生考試試題

科　目：材料所乙組（高分子科學）　

Please note that (1) *this examination has three subject areas each has three problems*, and (2) *partial credits will be given only to incomplete answer relevant to the solution of the problem.*

*A. Polymer Synthesis*

A1. Molecular weight of polymers from condensation polymerization is governed by several experimental variables. List the possible experimental methods in order to prepare high molecular-weight polymer from polycondensation reaction. (10 pts.)

A2. List three characteristic features of "living polymerization". (10 pts.)

A3. Give the possible explanations for the following observations.

(1) Polycondensation of α,ω-amino acids ($HCOO-(CH_2)_n-NH_2$) is not a practical way to obtain nylon 4 and 5. (5 pt.)

(2) 1,2-Dialkylolefins can not be polymerized by radical process. (5 pt.)

(3) Generally, polyureas (-HN-C(=O)-NH-R-) possess higher melting temperatures than polyurethanes (-O-C(=O)-NH-R-). (5 pt.)

*B. Polymer Processing* (note: please be sure to define all the symbols used)

B1. Explain the physical meaning of the constitutive equation from the viewpoint of polymer melt rheology. Give one empirical constitutive equation for each of the following polymer melt:

(1) a Newtonian fluid (usually non-polymeric)
(2) a non-Newtonian fluid
(3) a linear viscoelastic fluid
(4) a non-linear viscoelastic fluid (15 pts.)

B2. Starting from the equation of motion (first of all, write this equation in one-dimensional and three-dimensional forms), list and discuss all the possible compression methods appropriate for polymer processing. (10 pts.)

B3. Starting from the equation of energy (first of all, write this equation in one-dimensional and three-dimensional forms), list and discuss all the possible melting methods appropriate for polymer processing. (10 pts.)

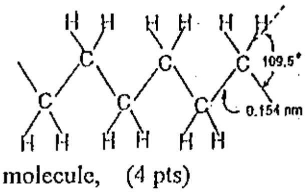
*C. Physical Properties*

C1. A polyethylene has a *glass transition temperature* of −25°C and a *melting temperature* of 130°C.

(1) Differential scanning calorimeter (DSC) can measure thermal properties of polymers showing enthalpy response (ΔH) as a function of scanning temperature (T). Please sketch (描繪) the DSC responses (i.e. ΔH versus T) of the polyethylene (a) upon *heating* from −80 °C to 140 °C, and (b) followed by *cooling* from 140 °C to room-temperature. (5 pts.)

(2) The microstructure of the polyethylene can be studied using X-ray diffraction. Please also sketch and explain qualitatively that the X-ray scattering intensity as a function of scattering angle (θ). (5 pts.)

C2. A linear polyethylene with a molar mass of 140,000 g/mol has a typical C–C bond length of 0.154 nm and a backbone angle of 109.5° as shown below. By neglecting chain end effects, please calculate the *end-to-end distance*




(1) of the *fully-extended* polyethylene molecule, (4 pts)
(2) if the polyethylene molecule is a *random coil*. (6 pts)

C3. Atactic polystyrene dissolved in cyclohexane has a *theta* (Θ) *temperature* of 36°C. Please

(1) give the definition of *theta* (Θ) *temperature* (3 pts)
(2) describe the change in *molecular dimension* as the solution temperature is less than 36°C. (3 pts)
(3) describe the relationship between *molecular weight* and *end-to-end distance* of the polystyrene molecule after cyclohexane is *completely removed*. (4 pts.)