

國立中山大學九十三年學年度博士班招生考試試題

科目：材料科學【材料所甲組】

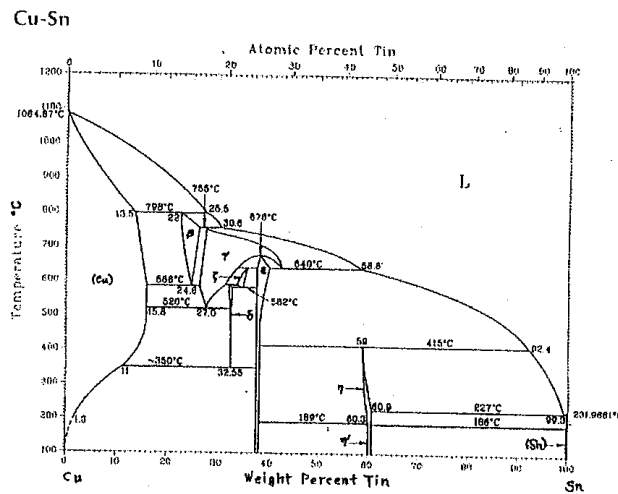
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- Consider the cracking of gaseous NH_3 according to the reaction,

$$2\text{NH}_3(\text{g}) = \text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$$

$$\Delta G^\circ = 87030 - 25.8 T \cdot \ln(T) - 31.7 \cdot T \text{ joules}$$
 Calculate the equilibrium gas composition at 1 atm and 400 C. (13%)

- Please list and describe three phase equilibrium types in Cu-Sn phase diagram.
 According the phase diagram, what will be the interface microstructure when Sn plated on copper and holding at 120 C. (20%)

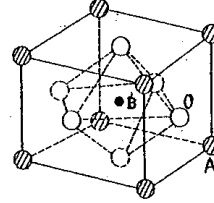


- NiAl crystal has a B2 structure, where Ni atom occupies 0, 0, 0 position, and Al atom occupies 0.5, 0.5, 0.5 position. Prove that {100} diffraction of NiAl in both X-ray and electron diffraction can occur. (10%)
- What defect(s) in crystals will have the symmetry of the building in the picture shown below? (10%)



- Explain the following terms: (a) ductile fracture, (b) fatigue, (c) creep, and (d) segregation, and (e) Shockley partial. (10%)

6. For a perovskite structure of the formula $A_2B^+O_3^{2-}$ as shown in the figure, (a) list the number of the nearest neighbors of A, B and O atoms with respect to the A atom. (b) Do the same for O atom. (8%)



7. For a face-centered cubic crystal, calculate the spacings of (a) (100), (b) (110) and (c) (111) planes with real atoms by drawing the proper figures. (8%)
8. A drop of solid phase A lies on the surface of a solid phase B and reaches equilibrium, a contact angle θ is measured. Now if a drop of solid phase B lies on the surface of a solid phase A and reaches equilibrium, a contact angle θ' is measured.
 (a) Derive a relationship of θ and θ' in terms of γ_A and γ_B .
 (b) If $\gamma_B \gg \gamma_A = \gamma_{AB}$, calculate θ and θ' . (12%)
9. The solid phase transformation from α to β is accomplished by homogeneous nucleation and growth. The nucleus has been observed to be cubic in shape. Let $\gamma_{\alpha\beta}$ be the interfacial energy per unit area and $\Delta G_{\alpha\beta}$ be the free energy of transformation per unit volume of the nucleus. Determine the edge length and activation energy of nucleation of the critical nucleus. (9%)

國立中山大學九十三年學年度博士班招生考試試題

科目：高分子科學【材料所乙組】

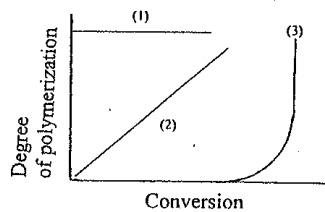
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Please note that (1) this examination has three subject areas which each has three problems, and (2) partial credits will be given only to incomplete answer relevant to the solution of the problem.

A. Polymerization Reaction and Mechanism (30%)

Condensation, addition and living polymerizations have their individual characters, which constitute the abundant sources for the preparation of polymers. Appropriate polymerization method is crucial for each individual monomers and one monomer may yield polymers of different physical properties dependent on the polymerization pathways applied. Therefore, to understand the polymerization characteristic is particularly important in polymerization reactions:

- A1. Molecular weight is usually characterized by degree of polymerization. Suppose that a polystyrene (PSt) prepared from addition polymerization has a number-average molecular weight (M_n) of 104,000. What is the degree of polymerization of this PSt? (5 pts.)
- A2. Degree of polymerization can be used to estimate how well the polymerization proceeds. Suppose degree of polymerizations during different polymerization pathways were determined and characterized as the diagram shown below:



Indicate curves (1), (2) and (3) as condensation, addition or living polymerization. (5 pts.) Why? (10 pts.)

- A3. Condensation polymerization between ethylene glycol (EG, HOCH₂CH₂OH) and terephthalic acid (TPA, HOOC-C₆H₄-COOH) can yield poly(ethylene terephthalate) (PET), however, in industrial process, PET was prepared by transesterification reaction from a single monomer, bis(2-hydroxyethyl)terephthalate (BHT, HOCH₂CH₂OOC-C₆H₄-COOCH₂CH₂OH).
- What is the advantage for the industrial BHT process as compared to condensation between EG and TPA in the aspect of polymer's molecular weight. (5 pts.)
 - Generally, there is small-molecule side product produced in condensation polymerization. What is the side products in (a) reaction between EG and TPA, and (b) transesterification of BHT. (5 pts.)

B. Polymer Processing (35%)

- B1. Describe the instrument and the operational principles of the *cone and plate viscometer*. Describe further how, without any mathematical equations, can the shear viscosity, the primary normal stress difference, and the secondary normal stress difference be obtained from this type of rheometer? Additional credits will be given if equations are provided. (15 pts.)

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科目：高分子科學【材料所乙組】

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- B2. Describe the machine and the operational principles of a typical die-forming process. This type of polymer processing often results in a phenomenon called *die swell*. Explain what the die swell is. Analyze factors causing the die swell. Provide methods to minimize the die swell. (15 pts.)
- B3. Make a comparison among the *injection molding*, *transfer molding*, and *compression molding* from the viewpoint of the requirements of the polymer, the mold design, and the characteristics of the molded products. (5 pts.)
- C. Physical Properties (35%)
- C1. A polyethylene has a *glass transition temperature* of -25°C and a *melting temperature* of 130°C .
- Differential scanning calorimeter (DSC) can measure thermal properties of polymers showing enthalpy response (ΔH) as a function of scanning temperature (T). Please sketch 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.)
 - The polyethylene microstructure can be studied using X-ray diffraction. Please sketch and explain qualitatively the X-ray scattering intensity as a function of scattering angle (2θ). (5 pts.)
- C2. Atactic polystyrene dissolved in cyclohexane has a *theta* (Θ) *temperature* of 36°C . Please
- give the definition of *theta* (Θ) *temperature* of a polymer solution; (4 pts.)
 - describe the relationship between *end-to-end distance* and *molecular weight* of the polystyrene molecule after cyclohexane is *completely removed*. (8 pts.)
- C3. In modern science, polymers assume an important role in the frontier materials.
- Conjugated polymers have been recognized to acquire excellent electrical conductivity and opto-electrical response. Please describe briefly the necessary conditions for conjugated polymers to become electrical conductors within 40 percent to that of copper. (5 pts.)
 - Nano*-particles, such as C_{60} , carbon *nanotube*, and montmorillonite, can be mixed with polymers for enhanced mechanical, thermal, or electrical properties. By considering only mechanical properties, please discuss (1) the importance in achieving dispersion of the *nano*-particles; and (2) the difference in mechanical reinforcement efficiency in using same weight percentage of C_{60} and carbon *nanotube*. (8 pts.)

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