甲組試題

(1) The face-centered cubic lattice has a nonprimitive unit cell. Show, in a drawing, whether or not the lattice axes can be reassigned to give a primitive unit cell.
Note: a nonprimitive unit cell means that there is more than one atom in the unit cell. **(20 points)**

(2) It is quite often to find that, when the direction of plastic deformation is reversed, the strength just after the reversion is lower than the strength just before the reversion. Explain the possible reasons for this. **(15 points)**

(3) What are the free energy terms in the total free energy change (ΔG) for liquid-solid phase transformation **(5 points)** and solid-solid phase transformation **(5 points)**? Explain activation energy and critical nucleus size in terms of these energy terms for both type transformations **(10 points)**.

(4) Graphite has a lower density and higher entropy than the polymorph diamond at given temperature and pressure condition.
Draw schematically the graphite/diamond phase boundary in the temperature-pressure phase diagram **(5 points)**.
Explain why overpressure and transition metals help synthesize diamonds from graphite-like materials in the diamond stability field. **(10 points)**

(5) Compare the properties of 1-mm-thick single-crystal slices of intrinsic silicon (Si) and high purity aluminum (Al) at temperatures near 300 K. Indicate your answer by writing Al, Si, *same* (when the properties are the same within ± 20%) or *neither*. **(18 points)**
(a) The resistivity changes strongly with temperature.
(b) Transparent to infrared radiation.
(c) Has a carrier mobility greater than 100 $cm^2/V\text{-}sec$.
(d) Has a carrier concentration greater than $10^{21}/cm^3$.
(e) Has a atomic concentration of 5 to $6x10^{22}/cm^3$.
(f) Has a density of 10 g/cm^3.

(6) (a) Explain why a dislocation must terminate on itself or on a surface; (b) Give two examples to show how the dislocations affect the material properties. **(12 points)**

Please note that there are three parts of this examination. Be sure to define or describe the symbols not in the problem statement, but in your answers.

A. Polymer Reactions and Mechanism (35%)

A1. Feasibility of addition polymerization is generally determined by the entropy (ΔS) and enthalpy (ΔH) change during polymerization. In other words, free energy change (ΔG) during polymerization decides the possibility of polymerization. This comment is especially true for addition polymerization.
(i) Is ΔS a favorable or unfavorable factor for the transformation of monomer to polymer? [3%] Why? [5 %]
(ii) Diethyl maleate (*cis*-EtOOC-HC=CH-COOEt) is a 1,2-disubstituted monomer and possesses interesting properties. It can not be homopolymerized but can be co-polymerized with other vinyl monomer like styrene via a radical process. Give a reasonable explanation for this interesting observation. [10 %]

A2.

(i) Condensation and addition polymerizations have different relationship between molecular weight variation and polymerization conversion. Describe it. [10%]
(ii) Comment on the major difference between radical and ionic polymerizations in the aspects of reaction solvent effect. [7%]

B. Polymer Physics (35%)

B1. How to construct a master curve from the stress relaxation data (modulus versus time over a temperature range)? Describe the principles and the procedure in detail. [10%]

B2. Describe the effect of molecular weight, copolymerization, crystallinity, and pressure on T_g. Discuss the dependence of T_g on chemical structure: *e.g.*, aliphatic side groups, and tacticity. [10%]

B3. Discuss the phenomenon of chain folding in polymer crystals including evidence in support of chain folding and the conditions under which it occurs. [6%]

B4. Describe any one experiment and calculation that can be used to measure the intrinsic viscosity, $[\eta]$. What kind of information does one obtain from $[\eta]$? [9%]

C. Polymer Processing (30%)

C1. One of the important properties of polymeric materials is the *viscoelasticity*. Explain what the *viscoelasticity* is. [5%]

C2. In order to describe theoretically the *viscoelastic property* of polymers, give one linear constitutive equation and describe the disadvantages and advantages of the model. [5%]

C3. In order to describe theoretically the *viscoelastic property* of polymers, give one non-linear constitutive equation and describe the disadvantages and advantages of the model. [5%]

C4. Describe the effects of this *viscoelasticity* on the final properties of polymers made by a typical die-forming process. Explain each effect. [5%]

C5. Describe the effects of this *viscoelasticity* on the final properties of polymers made by a typical molding process. Explain each effect. [5%]

C6. In general, what kinds of *constitutive equations* are needed (as many as you can think of) in order to describe theoretically a typical polymer processing? Write the exact mathematical form for each equation. [5%]