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Your Name Goes On This Line

E106 Final Examination
12, 13, or 16 December 2005
Exam Time: 3 hours.

In this examination you may use the class texts and *any notes* that you have taken in class or made in preparation for the exam. You may also use your homework and quizzes, and my homework solutions. There are two sections to the exam. The first section consists of six short problems, each worth 16 points. They are designed to be answered quickly, without a great deal of derivation or calculation. The second section consists of three problems each worth 35 or 34 points. The total possible for the exam is 200 points. Within each section, the problems are of equal weight but *not* of equal difficulty. There is partial credit. Please write neatly and ***on one side*** of your paper only. You may work on your problems in any order, but please assemble your completed exam with the problems in the correct order and in the correct section. For safety, you may want to write your name on every page.

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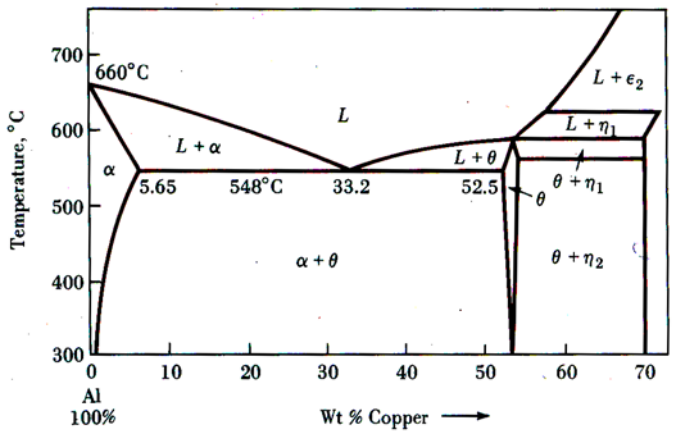
Section I – Skills Questions (16 Points Each)

1. Indium antimonide is a III-V semiconductor which has the zinc blende structure. The density of InSb is $5.76\ \text{g/cm}^3$, the atomic weight of indium is $114.818\ \text{g/g-atom}$, the atomic weight of antimony is $121.76\ \text{g/g-atom}$, and the ionic radius of antimony in InSb is $0.138\ \text{nm}$. What is the ionic radius of indium in InSb?

2. A carbon flux of $7.31\times10^{-6}\ \text{kg/(m}^2\text{s)}$ is passing through a $10\ \mu\text{m}$ thick sample of austenite. The carbon concentrations on the two sides of the sample are $15\ \text{kg/m}^3$ and $18.75\ \text{kg/m}^3$ respectively. The pre-exponential for diffusion of carbon through austenite is $2.3\times10^{-5}\ \text{m}^2\text{/s}$ and the activation energy is $148\ \text{kJ/mol}$. At what temperature is this process taking place?

3. 36.8% of test samples of alumina are able to survive a stress of 300 MPa. The test samples have a volume of $2.50\ \text{cm}^3$. 50% of production samples of volume $35.0\ \text{cm}^3$ are able to survive a stress of 226 MPa. What is the Weibull modulus for this type of alumina?

4. A sample of 15 wt% copper and 85 wt% aluminum is slowly cooled from 700°C to 547°C. For the final condition at 547°C state what phases are present and their relative amounts.



5. Do problem 15.8 part (a) on page 664 of *Callister* in American Engineering units (psi).

6. A semi-infinite sample of dewadinum had an initial temperature of 22°C, and after being exposed to a surface temperature of 106°C for 20.7 minutes, has a temperature of 46.2°C at a depth of 81.0 mm. What is the thermal diffusivity of dewadinum? The heat capacity of dewadinum is $678\ \text{J/(kg K)}$ and its density is $6660\ \text{kg/m}^3$. What is the thermal conductivity of dewadinum?

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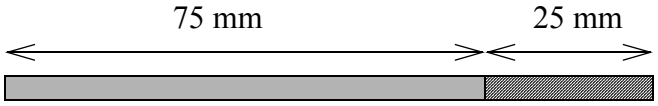
Section II – Long Question (34 or 35 Points Each)

1. A 25 mm long by 5 mm diameter cylinder of AZ31B magnesium (properties in Appendix B of *Callister*) is reaction bonded to a co-axial 75 mm long by 5 mm diameter cylinder of 2024 aluminum (properties in Appendix B of *Callister*). The resultant 100 mm-long cylinder is then placed in a temperature-controlled tensile test apparatus at $25°C$ and given a tensile pre-load of $2598\ \text{N}$. The system is then heated or cooled until the load cell indicates no load on the cylinder.
   a. What is the length of the pre-loaded cylinder before the temperature is varied?
   b. At what temperature does the load cell indicate no load?



2. Intermediate modulus carbon fibers (data in Appendix B of *Callister* under FIBER MATERIALS) are $200\ \mu\text{m}$ in diameter and chopped to a length of $11.25\ \text{mm}$. The fibers are mixed in with an epoxy resin and hardener ($V_f = 0.65$) and extruded through a $15\ \text{mm}$ by $2.50\ \text{mm}$ rectangular opening. The extrusion process aligns the fibers in the direction of extrusion. After the composite has fully polymerized and set, a $60\ \text{mm}$-long section is given a three-point load test. At what load does the beam fail? The fiber-matrix bond strength and the matrix stress at fiber failure may both be taken as the lowest tensile strength of epoxy in Appendix B of *Callister*.

3. Kitchen ovenware often has to go straight from the oven to the freezer, which has a tendency to shatter ceramic or glass baking pans. With the objective being to avoid breaking when going from oven to freezer or vice versa, rank the following four materials from best to worst: borosilicate glass (Pyrex), soda-lime glass, glass ceramic (Pyroceram), and hot-pressed silicon nitride. Why are baking pans made from the best one of these materials not available to consumers?