Ph.D. Qualifying Examination

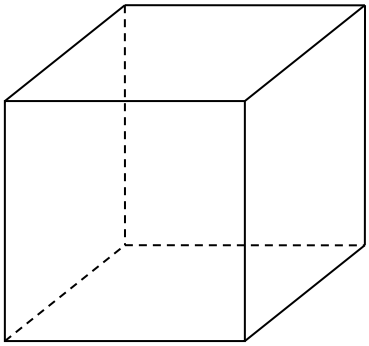
Materials Science

Spring 2016

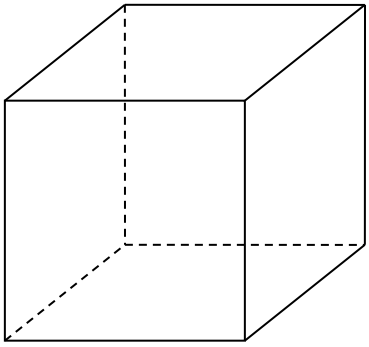
Logistics Notes:

- Time allowed: 2 hours.
- Problems count 25 points each (total=100 points).
- Exam is closed-book and closed-notes
- State your assumptions, methods, and procedures. Show your work on these exam sheets. (Add additional sheets, if needed.)
- Calculators are allowed.
- Laptops, tablets and cell phones are not allowed.

1. (a) Lithium fluorite (LiF) has the so-called "rock salt" crystal structure, which may be thought of as two interpenetrating FCC lattice, one composed of the cations, the other of anions. Draw the atomic arrangement in a single *unit cell* shown below, using "O" for F and "•" for Li. Also, what type of the atomic bond does this LiF possess?



(b) Silicon carbide (SiC) has the so-called "zinc blende" crystal structure, in which one type of atom forms an FCC-like structure while the other occupying certain interior tetrahedral positions. Draw the atomic arrangement in a single *unit cell* shown below, using "O" for Si and "•" for C. Also, what type of the atomic bond does this SiC possess?

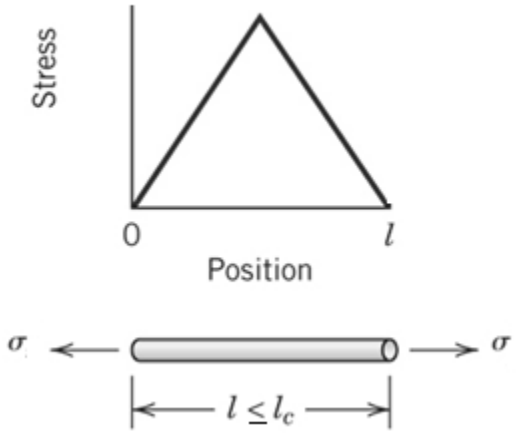


2. For composite materials reinforced with short fibers, there is a critical fiber length l_c above which effective strengthening can be achieved. The general formula for this critical fiber length is

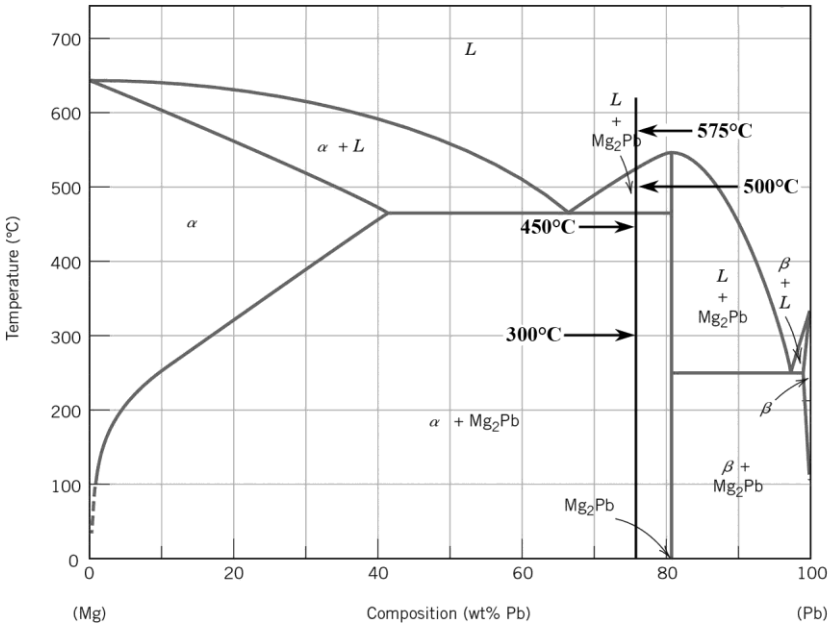
$$l_c = \frac{\sigma_f^* d}{2\tau_c}$$

where σ_f^* is the ultimate tensile strength of fiber, d is fiber diameter, and τ_c is the fiber-matrix bond strength (or the shear yield strength of the matrix, whichever is smaller).

Derive this equation. (Show your assumptions and derivation step by step. Even if you are not able to arrive at exactly the same final form, you may still receive credits based on your logic.)



3. For a 76 wt% Pb–24 wt% Mg alloy, make schematic sketches of the microstructure that would be observed for conditions of very slow cooling at the following temperatures: 575°C (1070°F), 500°C (930°F), 450°C (840°F), and 300°C (570°F). Label all phases and indicate their approximate compositions.



4. Draw 3 stress-strain curves on the same plot for a typical metal, ceramic, and polymer, respectively. Comment on the toughness of each material category.