3.091 OCW Scholar

Self-Assessment Exam
Amorphous Materials

Solution Key

Write your answers on these pages.

State your assumptions and show calculations that support your conclusions.

RESOURCES PERMITTED: PERIODIC TABLE OF THE ELEMENTS, TABLE OF CONSTANTS, AN AID SHEET (ONE PAGE 8½" × 11"), AND A CALCULATOR.

NO BOOKS OR OTHER NOTES ALLOWED.

Exam 3, Problem #2

(a) For a given alloy composition, explain why the yield strength of the amorphous form (metallic glass) is greater than that of the crystalline form.

In metals, plastic deformation occurs by slip. This involves closest-packed planes moving relative to one another along closest-packed directions. In metallic glasses, owing to the lack of long-range order, there are no slip systems operative. Hence, the threshold for slip is higher in metallic glasses than in crystals of the same composition

Exam 3, Problem #6

(a) Classify each of the constituents of a glass with the composition 15% K_2O – 70% B_2O_3 – 15% SiO_2 as (1) a network former, (2) a network modifier, or (3) an intermediate, and explain the role each constituent plays in giving the glass its set of properties.

K_2O: modifier. It breaks up the borate network, thereby lowering the viscosity of the melt and lowering the processing temperature.

B_2O_3: former. It forms the network of the glass thanks to the covalent oxygen linkages that connect the borons.

SiO_2: intermediate. It forms covalent bonds with oxygen linkages, but with a different coordination number from that of the borate network. The result is high disorder, poorer packing, and greater thermal shock resistance.

(b) The glass described in part (a) is to be surface strengthened by ion exchange. To this end, two identical specimens approximately the shape of credit cards are soaked for the same length of time at 850°C: one specimen in NaCl; and one specimen in KCl. How do you expect the yield strength of each specimen to change? Explain.

1. NaCl

Soaking in NaCl will lower the yield strength. Thanks to the concentration gradient in cations, K^+ will leach out of the glass and Na^+ will infuse the void spaces created by the loss of K^+. But Na^+ is a smaller ion, so the glass will develop a tensile stress at its surface. This will weaken the glass.

2. KCl

Soaking in KCl will have no effect on the yield strength. Thanks to the fact that there is no concentration gradient in cations, there will be no change in the composition of the glass.

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