

Name: _____

Amorphous Materials
Exam I
90 min Exam

Problem 1 (25 Points) _____

Problem 2 (25 Points) _____

Problem 3 (25 Points) _____

Problem 4 (25 Points) _____

Total (100 Points) _____

Happy exam! And may the odds be ever in your favor.

Problem 1 Appetizers

Please briefly justify your choice using ONE sentence.

- 1) All metastable solids are amorphous.

- 2) Laboratory glasses always have a smaller density than their supercooled liquid counterparts due to the presence of free volume.

- 3) Laboratory glasses always have higher enthalpy compared to their supercooled liquid counterparts. As a result, isothermal crystallization of glass is an exothermic reaction.

- 4) A stretched exponential relaxation kinetics suggests that multiple microscopic relaxation mechanisms co-exist.

5) A research paper proposes to mold tunable infrared optical lenses out of the commercial phase change memory alloy $\text{Ge}_2\text{Sb}_2\text{Te}_5$. When the lens piece is heat treated to switch between the crystalline/amorphous states, its optical property is reversibly adjusted. Do you think the approach is technically sound?

There is a problem here...

The typical crystallization time for commercial GST alloys is in the order of 100 ns, and therefore there is no way to control the phase composition in a bulk optical element.

Problem 2 Soup

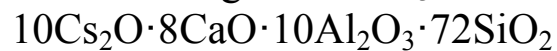
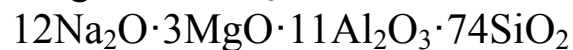
1) [Part A] Briefly explain why glasses prepared using different processing routes exhibit different macroscopic properties.

[Part B] Consider a glass thin film deposited via vacuum vapor deposition and a bulk glass sample of identical chemical composition prepared using air quench. Both samples are amorphous. Which one do you expect to have larger molar enthalpy at standard conditions (15 °C and 1 atm)?

2) Briefly explain the key difference(s) between viscoelasticity and viscosity.

Problem 3 Main course

You have been hired as a research group leader by a start-up company Gninroc Inc.. The company focuses on developing new display glasses for Orange Inc., a leading manufacturer of smart phones. After some preliminary research, your team has recommended the following candidate compositions for the company's next-generation chemically toughened glass product (all are given in atomic/molar fractions):



- i) Among the four compositions, which one would you pick to move on to the next stage of R&D? Why?
- ii) Use your own words, briefly explain the strengthening mechanism.
- iii) If you want to batch 1 kg of the glass composition you selected for lab testing, specify the amount (in gram) of raw materials needed for the synthesis. You can pick raw materials from the following list:

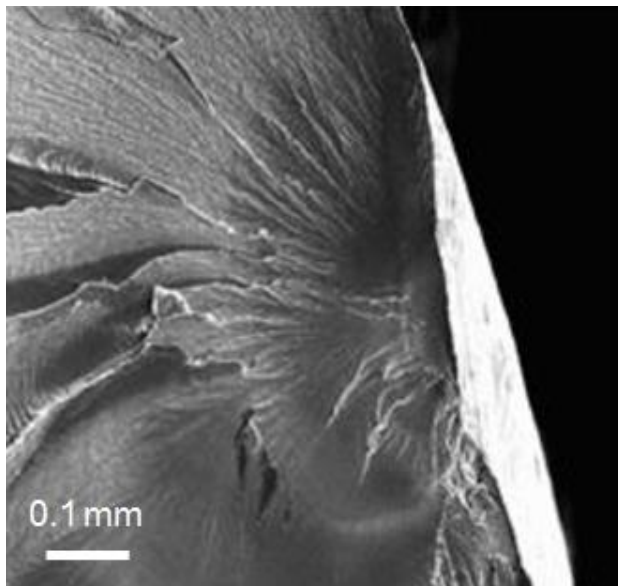
Sand [SiO₂], soda [Na₂CO₃], limestone [CaCO₃], albite [Na₂O·Al₂O₃·6SiO₂], feldspar [K₂O·Al₂O₃·6SiO₂], potassium carbonate [K₂CO₃], cesium nitrate [CsNO₃], lead metal [Pb], barringtonite [MgCO₃·2H₂O].

Problem 4 Dessert

Gnipro has developed a number of glass products under your leadership with overwhelming market success. Impressed by your technical prowess and leadership skills, Orange Inc. has appointed you as their corporate research VP heading their R&D efforts on bulk metallic glass (BMG) smart phone cases. The cases will be made of the BMG composition Vitreloy-1 ($\text{Zr}_{41.2}\text{Be}_{22.5}\text{Ti}_{13.8}\text{Cu}_{12.5}\text{Ni}_{10}$).

i) Your engineering team has proposed manufacturing the cases using compressive molding at a viscosity value of $10^{7.6}$ Poise. Determine the molding temperature and processing time window before crystallization occurs.

ii) After a few test molding runs, your team reports that fracture toughness of the molded case falls well below expectation. The following figure shows an exemplary fracture surface. What do you think is the likely cause of the material's subpar performance?



MIT OpenCourseWare
<http://ocw.mit.edu>

3.071 Amorphous Materials
Fall 2015

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.