Department of

MATERIALS SCIENCE AND ENGINEERING

Doctoral Written Exam

Day 1

Core Areas:

MATERIALS PHYSICS AND CHEMISTRY
ADVANCED MECHANICAL BEHAVIOR

Thursday, January 25, 2007

Department of Materials Science and Engineering

DOCTORAL WRITTEN EXAM – Day 1
January 25, 2007

Your exam packet for day I contains a total of six (6) questions from two (2) core areas, MATERIALS PHYSICS AND CHEMISTRY and ADVANCED MECHANICAL BEHAVIOR, plus 10 answer sheets. Each question is on a separate page. A copy of the Table of Constants is included for your reference. **You must submit 2 questions from each core area for grading**. You will have 4 hours to complete the questions. You can obtain extra answer sheets from the proctor, if needed. Please use the following procedure:

Write a four (4) digit code of your choice, and your name on the 3 X 5 card provided. Use this code in place of your name to identify all answer sheets you submit for both days of the exam. Renee will keep the code information, sealed in an envelope, until after the exams are graded.

For each answer, use the question sheet as the first page of your answer. If additional pages are required, use the blank answer sheets provided. At the end of the examination, staple each question sheet and corresponding answer sheets for each question separately, put this instruction sheet on top of the questions you are turning in, and place them in one side of your exam folder. Place all other exam pages in the other side of your folder, and return everything to the proctor, or Renee if you finish before 12:30 P.M.

Please be sure to complete the information required on each page.

GOOD LUCK!

CODE NUMBER _____

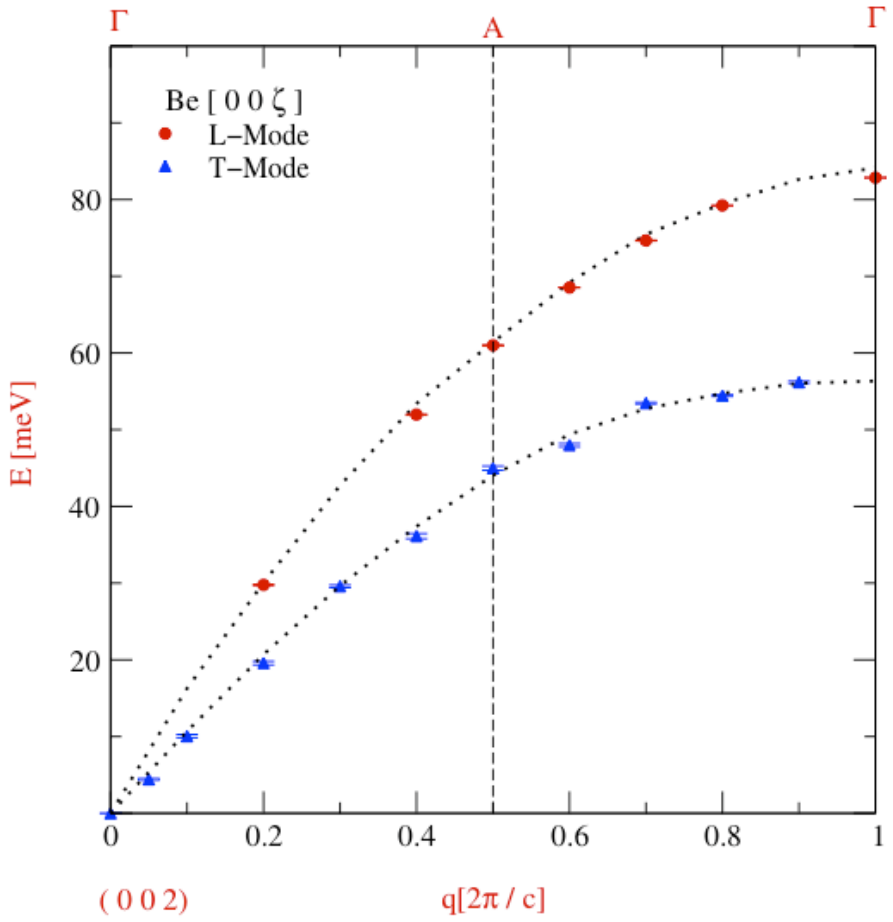
CHECK THE 4 QUESTIONS YOU WISH TO HAVE GRADED.

MATERIALS PHYSICS AND CHEMISTRY:	ADVANCED MECHANICAL BEHAVIOR:
1. ____	4.____
2. ____	5.____
3. ____	6.____

Day 1 – MATERIALS PHYSICS AND CHEMISTRY **CODE #_____**

1.

The following curves show the room temperature phonon dispersion curves for a single crystal of beryllium in the [001] direction in both the longitudinal (L) and transverse (T) modes. The lattice parameter for beryllium in this direction is c=0.358 nm.



a) What phonon mode (T or L) is the fastest?

b) What are the velocities of these two modes in the low-frequency limit?

c) Describe an experiment or set of experiments that could be used to measure these phonon dispersion curves.

d) If the modulus of this sample was 50 GPa, and the density 4 gm/cm^3, what would be the expected velocity of sound?

e) If an acoustical phonon were propagating in the [001] direction, what would be its energy at the wavevector k. The magnitude of k is 10% of that corresponding to the zone boundary.

f) What would be the energy of this same phonon at k=0?

g) What is the Debye temperature for this solid?

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2.

a) Consider isotactic polystyrene, which is a crystallizable polymer. Plot the specific volume vs. temperature for the range 0-573K for both amorphous and crystalline polystyrene.

Data:

Volume coefficient of expansion a	$= 2 \times 10^{-4}$/°C T < Tg
	$= 6 \times 10^{-4}$/°C T > Tg
glass phase density at T = 300K, r_g	= 1.05 g/cc
crystalline density at T = 300K, r_c	= 1.12 g/cc
T_g	= 100°C
T_m	= 250°C

b) Under what conditions will the following polymers crystallize?

i. polystyrene

ii. polypropylene

iii. polyethylene

iv. polyvinylchloride $[-(CH_2CHCl)_n-]$

v. If all of the above polymers had the same molecular weight, which would you predict to have the highest melting temperature? The highest T_g?

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3.

Wavefunction Normalization and Uncertainty Principle2

A particle has the wave function $\Psi(x) = A(e^{ix} - e^{-ix})$ in the region $-\pi < x < \pi$ and zero elsewhere.

a) Sketch the Wavefunction

b) Normalize the wavefunction, and determine the value of A

c) Determine the probability of finding the particle between x=0 and $\pi/8$

d) Determine $\langle x \rangle$, $\langle x^2 \rangle$, and $\Delta x = [\langle x^2 \rangle - \langle x \rangle^2]^{1/2}$

e) Determine the uncertainty in momentum, Δp

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4.

The stress-strain curve in tension for a ductile metal is given by $\sigma = \sigma_0[1 - \exp(-A\varepsilon)]$.

a) Find the true strain at the onset of necking.

b) Calculate the tensile strength.

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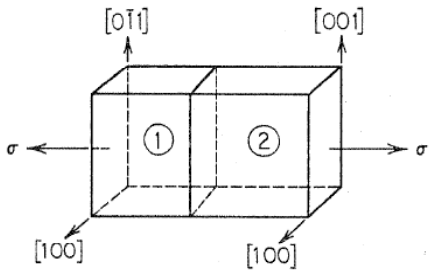
5.

A bicrystal with a simple cubic crystal structure is oriented as shown below. Which crystal will slip first if the slip systems is {100} <100>?



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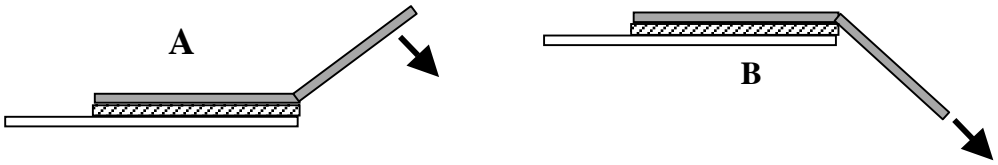
6.

a) Describe in 50 words or less, how ductility as measured by reduction of area is affected by microstructure.

b) Describe in 50 words or less, how the toughness of thin sheets that fail by necking depends on thickness.

c) Sometimes the elongation in a tension test is increased by increasing the strain rates and sometimes the elongation in a tension test is decreased by increasing the strain rates. Explain

d) Of the following two adhesive joint arrangements (adhesively joined to sheet metal), which is likely to be the more durable, or are they likely to be equally durable?



Explain the basis for your answer.