Name: Solution

Midterm 3

December 12, 2013

Instructions: Answer all questions on the examination sheets. (use backs if needed). If there is a fact or equation you cannot recall, ask and I will write it on the board for everyone. Eg…what is Avagadro’s number? $6.023 	imes 10^{23}$; what is that phase rule equation? $F=C-P+1.\text{(const p)}$

There are four essay questions, as well as 5 T/F and 5 fill-in-the-blank. You have 80 minutes, the full class time + 5 minutes. Exam over at 10:55+5 = 11:00 AM

Calculators Allowed but No Books & No Reference Sheet. Time: 80 minutes.

\[
\begin{array}{c}
G-D \text{ Prob. #1} \\
RH\text{+PQ} \text{ Prob. #2} \\
\text{LH} \text{ Prob. #3} \\
\text{SP} \text{ Prob. #4} \\
\text{SP} \text{ Prob. #5} \\
\text{SP} \text{ Bonus} \\
\text{Total} \\
\end{array}
\]
ME 280 Midterm 3

1. (25 pts) Make a sketch of the TTT curve for a typical heat treatable eutectoid steel characterized by the 5% and 95% transformation lines. Be sure to indicate temperatures for the start and finish of the shear transformations. Include a dotted line that represents 50% completion of the diffusion controlled portions of the transformation. Put typical numerical values on the axes for times and temperatures. Write three short paragraphs to describe:

A-How to change $R_c$50 Bainite into coarse Pearlite
B-How to change fine pearlite into $R_c$ 52 Martensite
C-How to create a maximally soft structure (for machining) comprised of spherical particles of Fe₃C

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A. Start by Austenitizing the Bainite to a phase at ~50 degrees above 727°C. Then Cool slowly by moving to a 700°C Furnace and waiting 1 hr. (Time ~500 sec = 8 min 30 sec)

B. Again, Austenitize at ~780°C to 850°C. Then quench in water or oil as shown, missing the Nitobe or TTT. You could hold above MS in Martensite or not depending on size or part. Then Cool to Finish shear transformation. Show is OK because diffusion processes or too slow to happen, but this makes $R_c$ 60-65 Martensite. To lower hardness to $R_c$ 52, we select in Tempering over 70 ~300°C (or thereabouts) to soften it via Tempering which lowers Saffler.

C. Start with Martensite or Bainite—a structure with 60% or

Stained away and heat for long time (10-20 hrs) just below 727°C (say 700°C) to allow $Fe_3C$ to respond to surface sympathy. The $Fe_3C$ forms a spherical particle—called Ferrodite. This is soft since it has retained carbon as the dominant phase.
2. (25 pts) You have identified two polymer systems you want to combine into a copolymer. Both of these systems have monomers that contain double bonds between carbon atoms, one with a single large benzene ring as the side group and one with a side group that contains only hydrogen. To prepare for the copolymerization, you polymerize each system separately to a degree of polymerization of 100 as a practice. Write a paragraph that describes how to do this for the system containing the benzene ring. The procedure for doing the hydrogen only side group system is similar. NOW Write a separate paragraph that describes how to co-polymerize the system to create chains that have alternating regions of about 50 benzene ring rich monomer segments and 200 hydrogen only monomer segments. What could go wrong? Include a final paragraph that addresses concerns about why this process might not work for this system.

practice polymerization of poly styrene: start with monomer of \[ \text{H}_2\text{C}=\text{C}-\text{H} \]

Put in a flask with stirring bar and heat up to a temperature where polystyrene would be melted. (it is a thermoplastic) ADD a peroxide \[ \text{H}_2\text{O}_2 \] which splits to \( \text{HO}^+ \) with unpaired electron. This will open the double bonds of styrene monomer and create \[ \text{H}_2\text{C}-\text{C}-\text{OH} \] which is a free radical as well. This makes a chain react. By waiting (and measuring viscosity) we can tell how long the chains are. There will be a distribution in lengths \[ \text{L} \] when we get now the AVG value = 100 monomers, we terminate the addition polymerization by flowing with \( \text{H}_2\text{O}_2 \). The \( \text{HO}^+ \) combine with \( \text{H}_2\text{C}-\text{C}- \) to terminate the chain growth.

Co-polymer run both PS polymerization and PE \[ \text{H}_2\text{C}=-\text{CH}_2 \] by using \( \text{H}_2\text{O}_2 \) initiation, watching the degree of polymerization increase until

\[ \text{PS} \quad \text{PE} \]

Then mix the two systems together. We have to make sure we have enough monomers so that the new vinyl will initiate many monomers. At this point the chains will bond to each other, cut this will terminate the process as the PS + PEs active radicals join we will not get what we want. Because the initiation of addition will stop the polymerization too early and we cannot get the pieces to join up. We can only make
This question shows how to think about chain of thought. This will lead to new structures.

Chains That Maintain a PEP Mass, Not a PEP

So, it is not possible to achieve a 30/200 g/m² polymer sequence chain starting with adding an ester on one end and an amine group on the other.

If we know how to achieve an ester sequence chain starting with adding an amine on one end and an ester group on the other, we can join two molecules using condensation.
3 (25 pts) You want to go into business selling samples to universities for use in their materials science labs. You are making CHARPY bars and you want to offer them in 7 different grain sizes with a nominal chemistry equivalent to 1020 steel. You own the metallurgical processing to create the ½ inch x ½ inch barstock by rolling the as received 3" x 3" barstock. Write an essay that describes how to roll the steel down and how to heat treat it during the rolling to the final dimensions to produce both a small grain size and a large grain size. HINT: if you only deform the steel a small amount, it will not have much stored energy so the nucleation of new grains will create only a few nuclei.

During the rolling, each time we anneal (soften) the steel, it grows new grains. If we do this at high temperature, the grains generally come out larger because of grain growth. We can emphasize this by using small strain rolling passes that promote fewer nuclei.

For ordinary manufacture of barstock, we target a specific grain size, usually as small as possible for the steel. Here we allow the steel to have a larger grain size on purpose.

By adjusting the degree of strain in the rolling passes and the temperature where we pass it, we can control the final grain size to achieve our objective.
4 (15 pts) Write ONE PARAGRAPH essay that how a junction diode that combines a P type and N type semiconductor works. Include two circuit diagrams showing the charge carriers for both forward and reverse bias situations.

The two types of semiconductors have different charge carriers, electrons & holes. In Forward Bias, these recombine to complete circuit allowing current flow. Light, often resulting from the recombination, holes are from as electrons leave P type. In Reverse Bias, charges start to move but there is no source of carriers at junction so current soon stops. The Diode does not conduct in the direction.

Such devices act as check valves to electric current and are very useful for electronic circuits.
5. (10 pts (1. points each))

Answer the following short answer questions with T or F.

a. T If two polymers dissolve in the same solvent they will probably dissolve in each other.

b. T We need to be at very high temperature to allow grain growth to proceed at a rapid rate.

c. F Etching a sample sanded to 600 grit lets up observed the grain boundaries.

d. F The FERMI level for a semiconductor is always just at the top of the valence band.

e. T Dielectrics are fundamentally not able to conduct electricity yet their molecules interact with electric fields.

Fill in the blank or complete the phrase with one or more words to make a true statement.

a. A method of determining the heat treatment response of an alloy is the JOMINY test that exposes the END of the sample to FLOWING WATER OR WATER STREAM.

b. The damage created during abrasive polishing is limited to $\frac{3}{a}$ (a number) times the diameter of the abrasive, even for soft samples. Hard samples are less easily damaged and the damage depth is usually $\frac{1}{b}$ (a number) times the abrasive size (or less such as $\frac{1}{5}$).

c. Martensite is acicular, comprised of zones that SHEAR to change FCC austentite to BCT structure.

d. Peak aged, over aged, and underaged refer to PRECIPITATION HARDENING CONDITIONS.

e. A polymer blend is when two polymers are mechanically mixed (NO CO-POLYMERS).

BONUS: worth 5 points Circle one:

- [ ] I have completed the online course survey for ME280.
- [ ] 87% completed at time of this exam.
- [ ] I have not completed the online course survey but plan to before the final.
- [ ] I never fill out those surveys because they are anonymous.