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MSE 2001
Fall 2011
Midterm Exam #3
November 14, 2011

I have neither received nor given help in taking this exam.

Signature: _____

Definitions - Fill in the blanks with letters corresponding to the words that best match the definitions given. 3 points each.

A 1. A reaction in which a liquid transforms to two soild phases on cooling.
A. Eutectic; B. Eutectoid; C. Peritectic; D. Peritectoid; E. Monotectic

C 2. A reaction in which a liquid and a solid transform to a different solid on cooling:
A. Eutectic; B. Eutectoid; C. Peritectic; D. Peritectoid; E. Monotectic

E 3. A reaction in which a liquid transforms to a solid and different liquid on cooling:
A. Eutectic; B. Eutectoid; C. Peritectic; D. Peritectoid; E. Monotectic

A 4. The proeutectoid phase in a hypoeutectoid Fe - C steel.
A. Ferrite; B. Pearlite; C. Cementite; D. Spheroidite

C 5. A line on a phase diagram separating a single solid phase region from a solid + liquid phase region.
A. Solvus; B. Liquidus; C. Solidus; D. Tie line

E 6. A metastable, BCT phase (constituent of carbon steels) that forms from austenite.
A. Bainite; B. Pearlite; C. Ferrite; D. Cementite; E. Martensite

B 7. The process which produces grains of non-uniform composition due to non-equilibrium cooling.
A. Congruent cooling; B. Coring; C. Athermal transformation; D. Displacive transformation; E. None of the above

C 8. A type of boundary between crystalline grains across which the atomic bonding is completely disrupted.
A. Coherent; B. Semi-coherent; C. Incoherent

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A 9. A phase or phase combination that occurs in a characteristic configuration in an alloy's microstructure.
A. Constituent; B. Component; C. Line compound; D. Invariant phase

D 10. The relative ability of a ferrous alloy to form martensite when quenched from austenite.
A. Quenchability; B. Embrittlement; C. Sintering potential; D. Hardenability

Circle the correct underlined word or words in each statement. Three points per question.

11. Larger undercoolings typically produce finer / coarser microstructures than those formed at smaller undercoolings.

12. Homogeneous / heterogeneous nucleation is more common.

13. Pearlite / Bainite forms from austenite at lower undercoolings.

14. Increasing C content in Fe-C steels increases / decreases the alloy's martensite start temperature.

15. Precipitation hardened alloys are susceptible to overaging / decomposition.

16. Rapidly quenching austenite can form spheroidite / martensite.

17. The relative amounts of two coexisting phases may be determined with the Gibbs phase rule / lever rule.

18. Ferrite / cementite is the strengthening phase of carbon steels.

19. Phase transformations are driven by an increase / decrease in the Gibb's free energy.

20. Nucleation and growth are typically a maximum at small / intermediate / large undercoolings.

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Short answer - Provide answers to the questions posed. 5 points per question.

21. Write the reaction that occurs during congruent melting.

$\alpha \rightarrow L$

22. Describe the phase composition and morphology of spheroidite (what phases are present and what is their shape/distribution?).

- Ferrite & cementite
- cementite particles of approximate spherical shape in a ferrite matrix

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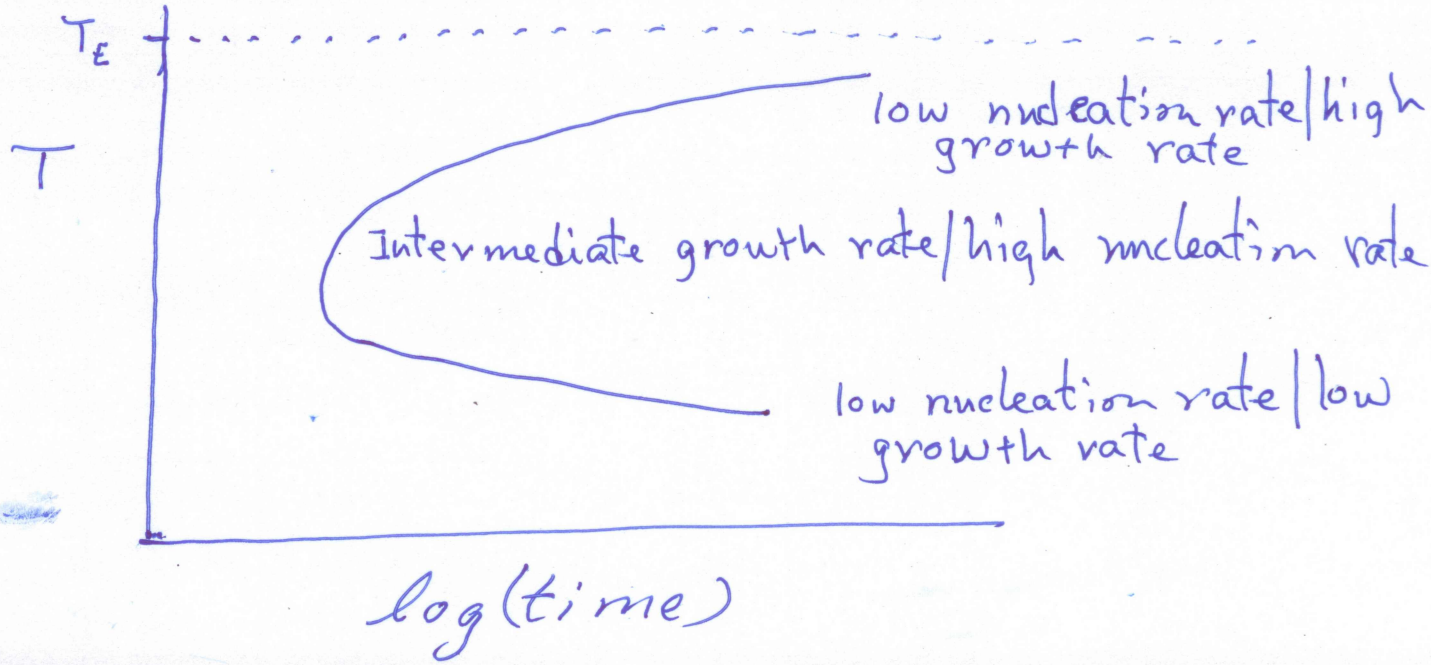
23. Sketch an isothermal transformation diagram (T-T-T diagram) and briefly describe why it has the shape it does.



24. Briefly describe the strengthening mechanism in precipitation hardened alloys including the effects of overaging.

Small precipitates that are either coherent or semicoherent with the matrix create strain fields that impede dislocation motion within the matrix, thus, strengthening the material.

Overaging produces larger precipitates, which lose their coherence/semicoherence with the matrix. This decreases the strain fields around the precipitates and lessens their ability to impede dislocation motion - weakening the material.

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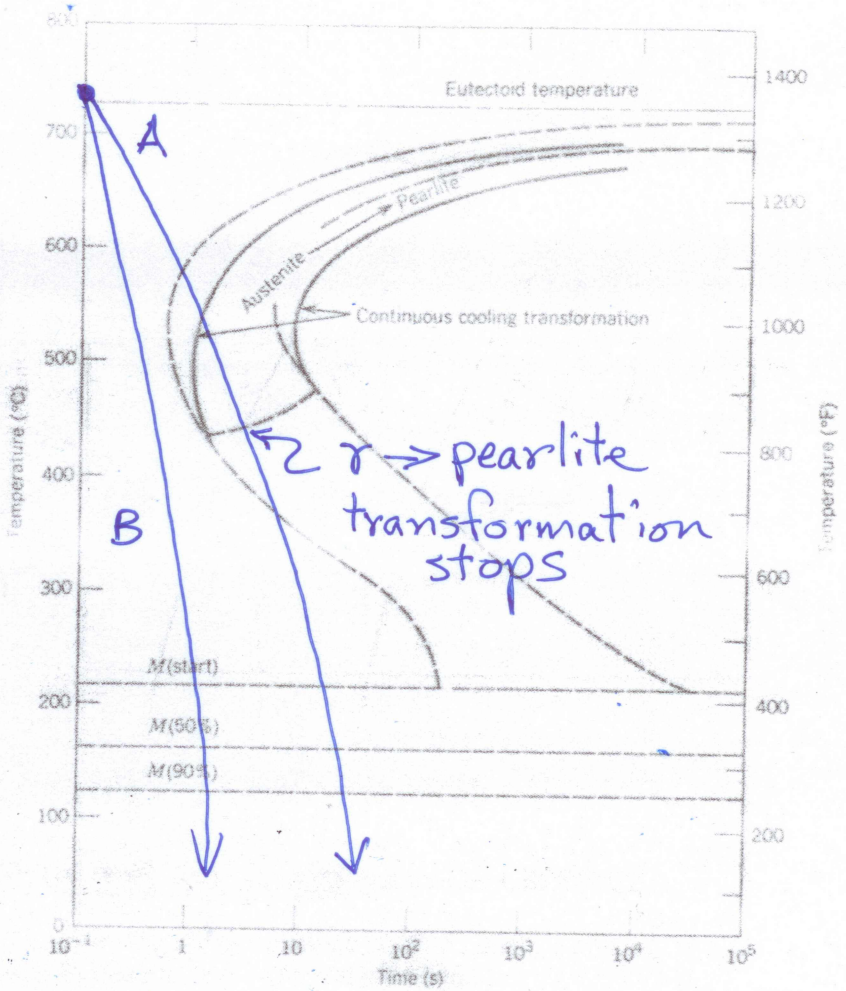
Problems -

25. 10 Points

Shown below is the continuous cooling transformation diagram of a eutectoid steel. **Sketch and label** cooling curves A and B as described below:

Cooling Curve A: A cooling curve for austenite (stable above 727°C) that produces microstructure of ~50% pearlite and ~50% martensite.

Cooling Curve B: A cooling curve for austenite (stable above 727°C) that produces a microstructure of 100% martensite.



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26. 10 points

a) Determine the fraction of proeutectic α in a Mg 50 wt% Pb alloy at equilibrium just below the upper eutectic temperature after equilibrium cooling from above the liquidus.

Fraction proeutectic α = 0.63

$\frac{67-50}{67-40}$

b) What is the maximum solubility of Pb in Mg?

Max. Solubility Pb in Mg = 40 wt.%