

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY EXAMINATIONS
2004 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS
DECEMBER 2004

ME 232 – PROPERTIES OF ENGINEERING MATERIALS I

Time Allowed: Three hours

Closed Book

Answer: Five questions with three from Section A and two from Section B

Hand in Sections A and B separately

All questions carry equal marks

SECTION A – Answer at three questions, INCLUDING Question 2, from this section.

Q1.

- (a) Define Polymerisation and briefly describe the two main types of the polymerisation process. **[08 marks]**
- (b) What is the function of plasticisers, and what chemical property of a polymer becomes important for it to blend properly with a plasticiser? **[06 marks]**
- (c) Explain how temperature and degree of cure can affect the viscosity of a thermosetting polymer. **[06 marks]**

Q2. – This Question is Compulsory.

- (a) You are the Chief Engineer at the University of Zambia Mechanical Engineering Workshop. You have been given a task by one of the engineering companies in Lusaka to manufacture a large screwdriver. The heat treatment process should be such that the external source of heat should be used only once to develop a fine pearlitic structure in the shank and a tempered martensitic structure at the tip. Design the heat treatment process for the screwdriver. **[08 marks]**
- (b) Using the IT curve shown in Fig.Q2, on page 3, for an AISI 1045 steel, describe the microstructure (phases present and relative amounts) at the conclusion of each step described below.

AISI 1045 steel contains 0.45 wt% C.

- (i) Normalizing anneal at 900 °C for 1 hour:
- (ii) Part (i) followed by rapid cooling to 400 °C:
- (iii) Part (ii) followed by holding at 400 °C for 10 seconds:
- (iv) Part (iii) followed by rapid quench to room temperature:
- (v) Part (iv) followed by reheat to 400 °C for two hours:
- (vi) Normalize at 900 °C for 2 hours, cool to 550 °C and hold for 10⁵ seconds.

[12 marks]

Q3.

- (a) Show that in a tensile test $\epsilon_t = \ln(1 + \epsilon)$ and $\sigma_t = \sigma(1 + \epsilon)$. What are the practical limitations of these relationships? **[08 marks]**
- (b) During the tensile test experiment you did in the ME-232 class you used a metal that obeys the flow curve (true stress-strain curve). The tensile strength of the specimen was found to be 340 MPa. Reaching the maximum load required an elongation of 30 %.
- (i) Calculate the stress K
- (ii) Calculate the strain-hardening coefficient, n . **[08 marks]**
- (iii) Sketch the strain as a function of time for a sample with significant **ANELASTICITY** that is loaded and unloaded within the elastic region. **[04 marks]**

Q4.

- (a) Define Pig Iron and name the components, which make up a charge to a blast furnace. **[05 marks]**
- (b) What are the basic steps in roasting with regards steel production **[04 marks]**
- (c) Name the major components of a blast furnace and briefly describe the functions of each component. **[08 marks]**
- (d) Name the three functions of coke in iron and steel production. **[03 marks]**

SECTION B – Answer two questions, INCLUDING Question 7, from this section**Q5.**

- (a) Sketch a unit cell of the face-centred cubic crystal system and show the positions of the (100) plane, (110) plane, and a (111) plane. **[04 marks]**
- (b) Sketch the atomic packing of each of the above planes in one unit cell, giving dimensions of the planes in terms of the lattice parameter a . **[06 marks]**
- (c) Show by calculation that the (111) plane in the fcc system possesses a greater density of atomic packing and a smaller interplanar spacing than either the (100) or (110) planes. **[10 marks]**

Q6.

Two metals, A and B , show partial solubility in each other. Metal A , of melting point $1,000\text{ }^\circ\text{C}$, can dissolve 30% of metal B at $500\text{ }^\circ\text{C}$ and 20% of metal B at $0\text{ }^\circ\text{C}$. Metal B , of melting point $800\text{ }^\circ\text{C}$, can dissolve 20% of metal A at $500\text{ }^\circ\text{C}$ and 10% of metal A at $0\text{ }^\circ\text{C}$. A eutectic, occurring at $500\text{ }^\circ\text{C}$, has a composition of 60% of metal B .

- (a) Draw to scale the fully labelled phase diagram of the system above. Assume all lines are straight. **[10 marks]**
- (b) For an alloy containing 50% of metal A , give the compositions of the phases present and their relative proportions at the following temperatures:
- (i) $550\text{ }^\circ\text{C}$ **[02 marks]**
- (ii) $500\text{ }^\circ\text{C}$ **[04 marks]**
- (iii) $200\text{ }^\circ\text{C}$ **[02 marks]**
- (c) Describe the room temperature microstructure of the alloy containing 15% of metal B after solidification by chill casting. **[02 marks]**

Q7. – This Question is Compulsory.

- (a) Draw to scale and fully label the steel section of the iron-carbon phase diagram. **[10 marks]**
- (b) With reference to the steel section of the iron-carbon phase diagram you have drawn, for two plain carbon steels, one containing 0.4% C and the other 1.0% C:
- (i) Calculate the amount of austenite in each of these steels at a temperature of 723 °C. **[02 marks]**
 - (ii) Calculate the amount of pearlite in each of these steels at a temperature of 25 °C. **[02 marks]**
 - (iii) Estimate the proportion of cementite existing at the grain boundaries as free cementite and the proportion present with ferrite in pearlite in the hypereutectoid steel at room temperature. **[04 marks]**
 - (iv) Suggest a typical application for each of the two types of steel in its fully hardened and tempered conditions, and justify your choice. **[02 marks]**

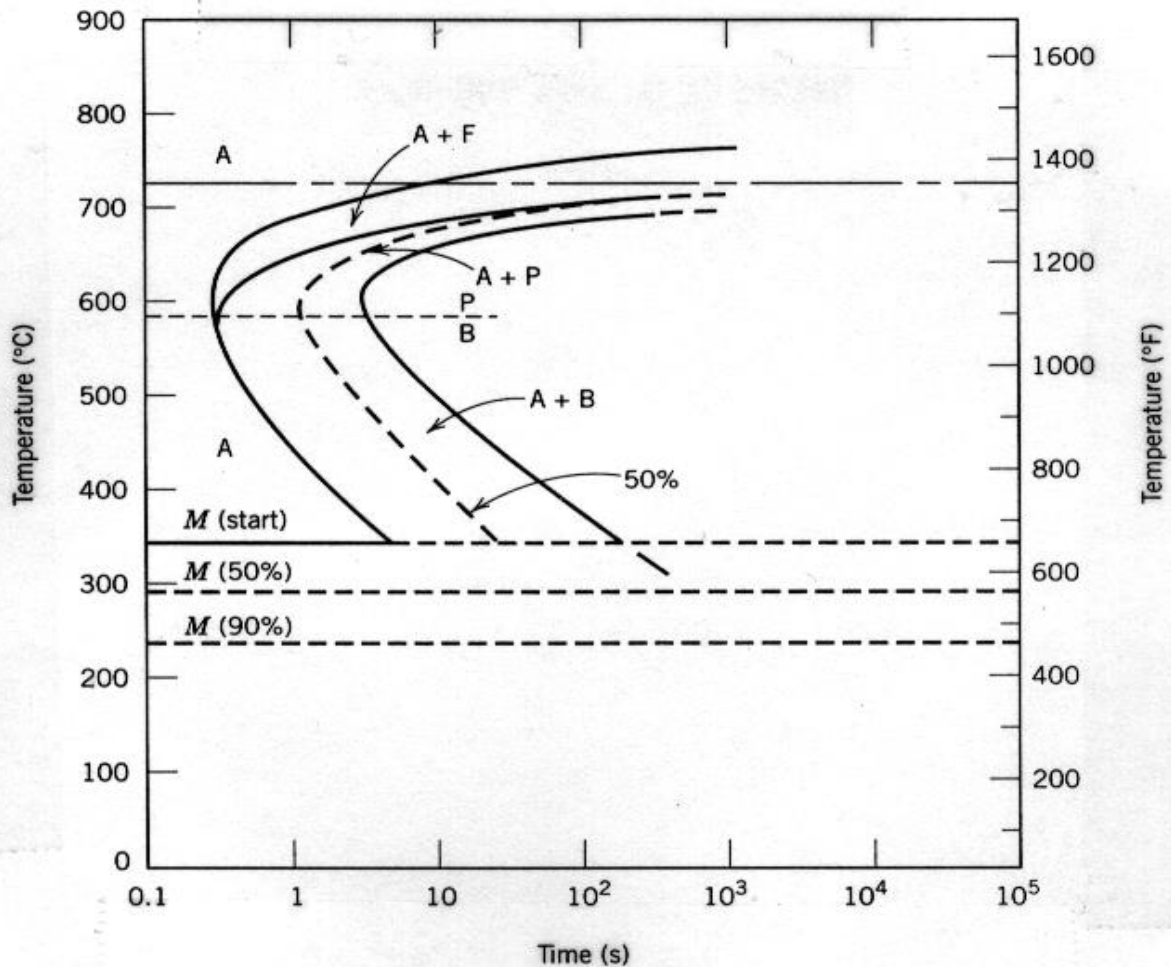


Figure Q2 – IT Curve

END OF EXAMINATION
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