THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION 2007/2008

MEX 4233 – MATERIALS ENGINEERING- PART B

DATE : 2nd MAY 2008
TIME : 1015 HRS. – 1230HRS.
DURATION : 2 HOURS & 15 MINUTES

048

ANSWER FIVE QUESTIONS ONLY. ALL QUESTIONS CARRY EQUAL MARKS.

1. (a) Define the following terms.

   (i) Space lattice
   (ii) Atomic Packing Factor
   (iii) Crystal structure

   (b) The lattice constant of FCC Nickel is 0.352nm. Determine the atomic radius of Nickel.

   (c) Sodium has a BCC crystal structure, an atomic radius of 0.192nm and an atomic weight of 63.5 g/mole. Calculate the true density of sodium in g/cm^3.
   Take the Avogadro's number as 6.023×10^{23} g/mole .

2. Using the isothermal transformation diagram given in Figure (2) for an iron-carbon alloy of eutectoid composition, answer the following questions. In each case assume that the temperature of the specimen begins at 760° C and that it has been held at this temperature long enough to achieve a complete and homogeneous austenite structure.

   (i) If the specimen was rapidly cooled down, at what temperature will martensite start to form and at what temperature can we expect to have 50% martensite?

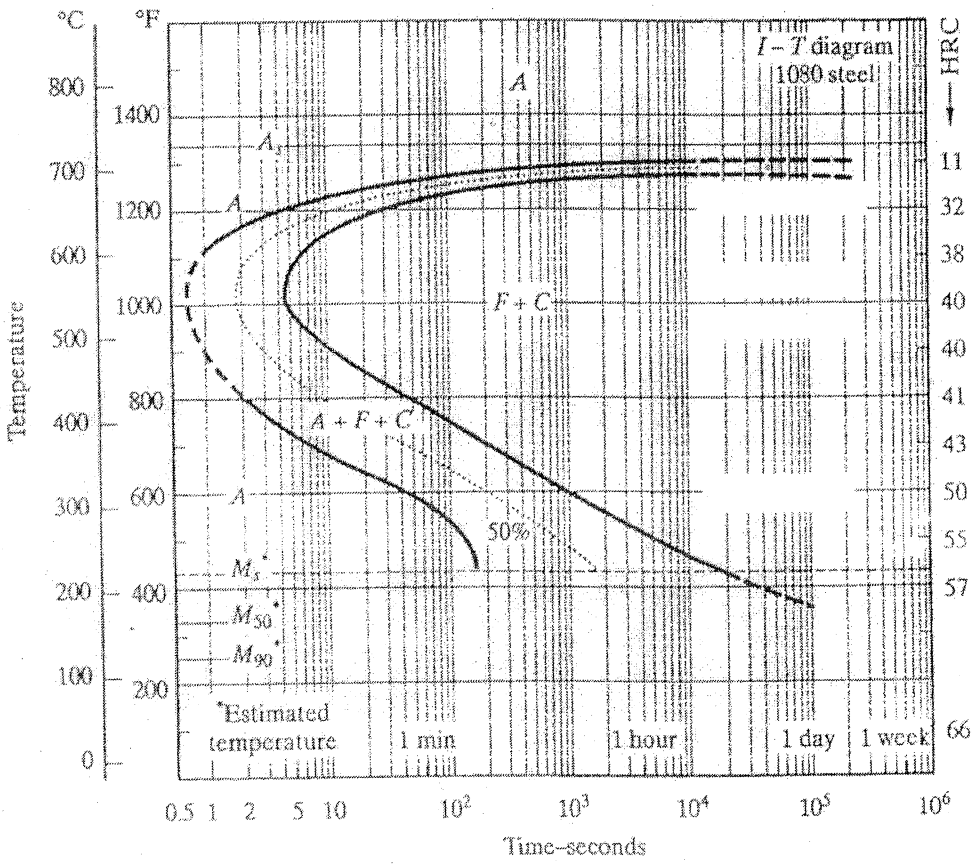
   (ii) What is the minimum cooling rate required to form 100% martensite?

   For (iii) to (v) specify the nature of the final microstructure (in terms of micro constituents present and approximate percentages of each) of a small specimen that has been subjected the time temperature treatments as given in the questions.

   (iii) Cool rapidly to 650°C, hold for 10 sec, and then quench to room temperature

   (iv) Rapidly cool to 425°C, hold for 10 sec, and then quench to room temperature

   (v) Rapidly cool to 650°C, hold for 10 sec, rapidly cool to 450°C, hold for 5 sec and then quench to room temperature in water.



TTT diagram of Eutectoid steel

Figure 2

3. (a) A plain carbon steel bar containing 1.2 wt% of carbon was heated to 1000°C and held for a long period, before being slowly cooled to below 650°C. Using Figure (3) answer the following.

(i) What are the equilibrium phase/phases at 800°C and its/their compositions?

(ii) At what temperature does the proeutectoid phase start to form?
What is the name of this proeutectoid phase and what is the composition of this phase?

(iii) At 700°C, determine the equilibrium phases, their compositions and the mass fraction of each phase. (Show your calculations clearly)

(iv) At 650°C, determine the mass fraction of pearlite and the proeutectoid phase.(show your calculations clearly)

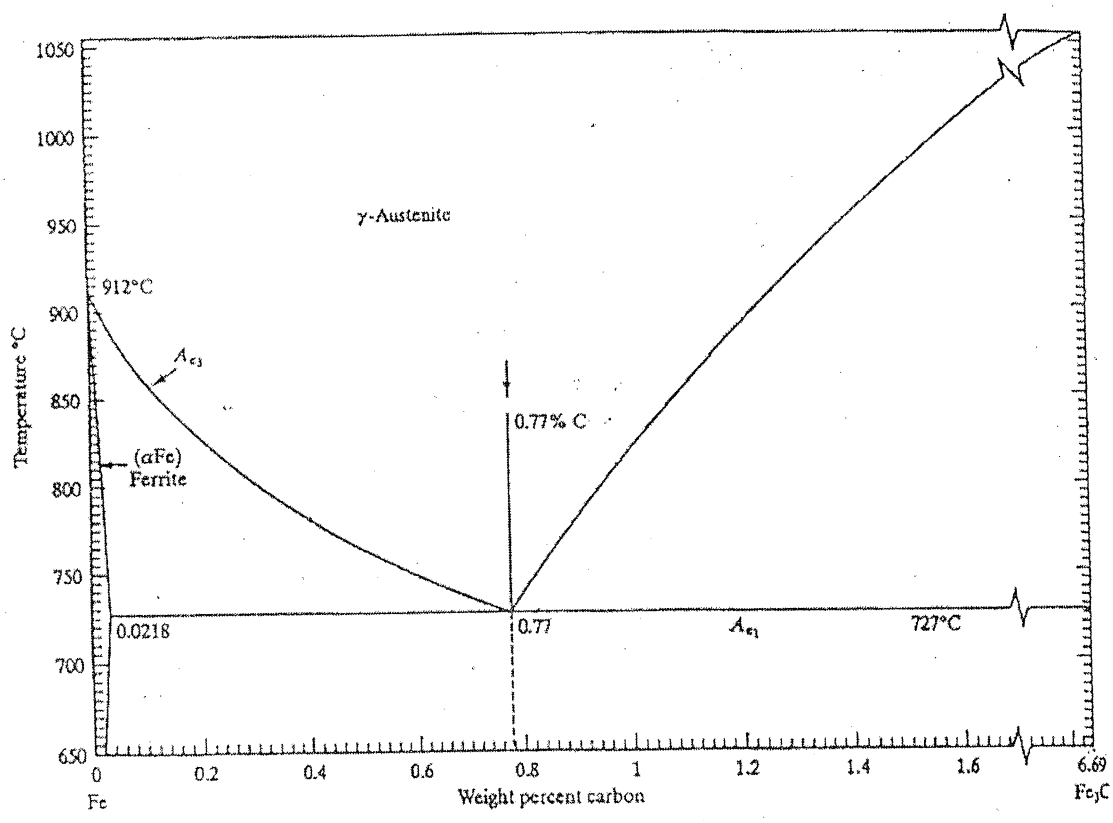


Figure 3

4. Discuss and analyze **two** of the following topics from an Engineering view points.

   (i) Pilling Bedworth ratio
   (ii) Inter atomic bonds present in materials
   (iii) Crystal Imperfections
   (iv) Three major polymer categories

5. (a) State the Fick's 1st & 2nd laws of Diffusion.

(b) A low carbon steel which initially contains 0.1% carbon is to be surface hardened by diffusing more carbon into its surface. Determine the length of time needed to obtain a concentration of carbon at 0.45% at a distance of 2mm below the surface at 1000° C if the carbon concentration at its surface remains constant at 1.2%,
$D_o = 0.23 \times 10^{-10}$ m^2/sec, Activation Energy $q_v = 137.7$kJ/mol and
$R = 8.314 \times 10^{-3}$ kJ/mole$^{\circ}$K. Use the Error function Table given below.

Z	erf Z
0.50	0.521
0.60	0.604
0.70	0.678
0.80	0.742
0.90	0.797

6. (a) Briefly explain, what Ductile-Brittle transition temperature is?

(b) The data given below are gathered from a series of Charpy impact tests on a tempered 4140 steel alloy.

Temperature (C°)	Impact Energy (J)
100	89.3
75	88.6
50	87.6
25	85.4
0	82.9
-25	78.9
-50	73.1
-65	66.0
-75	59.3
-85	47.9
-100	34.3
-125	29.3
-150	27
-175	25.0

(i) Plot the data as impact energy verses temperature. (Use a graph paper)

(ii) Determine a Ductile to Brittle transition temperature taking it as the temperature corresponding to the average of the maximum and minimum impact energies.

(iii) Determine a Ductile to Brittle transition temperature at which the impact energy is 70J.

7. A continuous and aligned glass reinforced composite consists of 40 vol. % of glass fibers having a modulus of elasticity of 69 GPa and 60 vol.% of polyester resin which when hardened, displays a modulus of 3.4GPa.

(a) Compute the modulus of elasticity of this composite in the longitudinal direction.

(b) If the cross-sectional area of a specimen is $250mm^2$ and a stress of 50 MPa is applied in the longitudinal direction, compute the magnitude of the load carried by each of the fiber and matrix phases.

(c) Determine the strain that is sustained by each phase of the above specimen when the stress in part (b) is applied.

(d) Assuming tensile strengths of 3.5 GPa 69 MPa respectively, for glass fibers and polyester resin, determine the longitudinal tensile strength of this fiber composite.

8. (a) Sketch and label a typical creep curve (strain vs time) for a hypothetical metal, and discuss the behaviour of the material during the three stages associated with the graph.

(b) Explain how the steady state creep rate can be determined from the graph.

(c) A shaft of 45mm diameter is to carry a load of 20 kN at a temperature of 220°C. The material's steady state creep rate follows the Norton equation given by

$$\frac{d\varepsilon}{dt} = C\sigma^n$$

Where $C = 4.5x10^{-14}$ and $n = 3.2$ (when strain is given in MPa and strain rate is in m/m/hr)

If the allowable strain is 0.25%, determine the useful life expectancy of the shaft.

9. (a) Briefly describe the most popular 18-8 stainless steel (18Cr-8 Ni)

(b) List down five Engineering applications of stainless steel.

(c) Explain the welding problem encountered when using stainless steel.

(d) What is cast iron? Compare and contrast gray cast iron and nodular cast iron.

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