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OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION 2009/2010

MEX 4233 – MATERIALS ENGINEERING
DATE : 13^{TH} MARCH 2010
TIME : 0930 HRS. – 1230 HRS.
DURATION : 3 HOURS

ANSWER 5 PARTS FROM SECTION A & FIVE QUESTIONS FROM SECTION B.

SECTION A

Select any **Five** Parts.

(a) What are the crystallographic imperfections generally found in materials?

(b) Use a cubic unit cell and illustrate the $(\bar{2}\ 1\ \bar{1})$ crystallographic plane and the $[\bar{2}\ 1\ \bar{1}]$ crystallographic direction.

(c) State Hund's rule on pairing of electrons in atoms.

(d) Differentiate between second phase strengthening and solute strengthening of materials.

(e) Explain the process of vulcanization of natural rubber.

(f) What is the difference between Engineering stress- strain and True stress –strain?

(g) Chromium at 20^0 C is BCC and has a lattice constant of 0.2885 nm. Calculate a value for the atomic radius of a chromium atom in centimeters.

(h) Define the terms Space lattice, Unit cell and Atomic Packing Factor.

(20 marks)

SECTION B

Select any **Five** questions. All questions carry equal marks.

1. (a) State Fick's 1^{st} and 2^{nd} law of Diffusion. **(5 marks)**

(b) During a carburizing experiment diffusivity of carbon at a temperature of 900^0 C was found to be 7.4×10^{-8} cm^2/sec. The depth of carburized layer after this treatment for 3.5 hrs was found to be same as that after the treatment at 1000^0C for 1.5 hrs. At the end of the latter treatment the surface of the specimen had a carbon content of 1.4%, whereas in the original sample it was 0.3 percent.

(i) Calculate the diffusion coefficient at 1000^0C. **(4 marks)**

(ii) Find the carburizing time to achieve a carbon content of 0.5% at a depth of 1.5mm at 1000^0C. The error function values are given in the table below. **(4 marks)**

(iii) Compute the activation energy for the process.
(Assume k (Boltzmann's constant) $= 8.6x10^{-5}$ ev k^{-1} **(3 marks)**

Values of error function

Z	erf Z
0.1	0.113
0.2	0.223
0.3	0.329
0.4	0.428
0.5	0.521
0.6	0.604
0.7	0.678
0.8	0.742
0.9	0.797
1.0	0.843

2. Using the isothermal transformation diagram in Figure 2 , for a 1.13 wt% C steel alloy determine the final microstructure of a small specimen that has been subjected to the following time-temperature treatments. In each case assume that the specimen begins at 920^0C and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

(a) Rapidly cool to 400^0C, hold for 500secs, then quench to room temperature. **(3 marks)**

(b) Rapidly cool to 650^0C , hold at this temperature for 10secs, rapidly cool to 450^0 C hold for 10 secs and then quenched to room temperature. **(4 marks)**

(c) Determine the requirements for heat treatment (time temperature paths) to produce the following microstructures.

(i) 100% coarse pearlite
(ii) 50% martensite and 50% austenite
(iii) 50% coarse pearlite, 25% bainite and 25% martensite **(9 marks)**

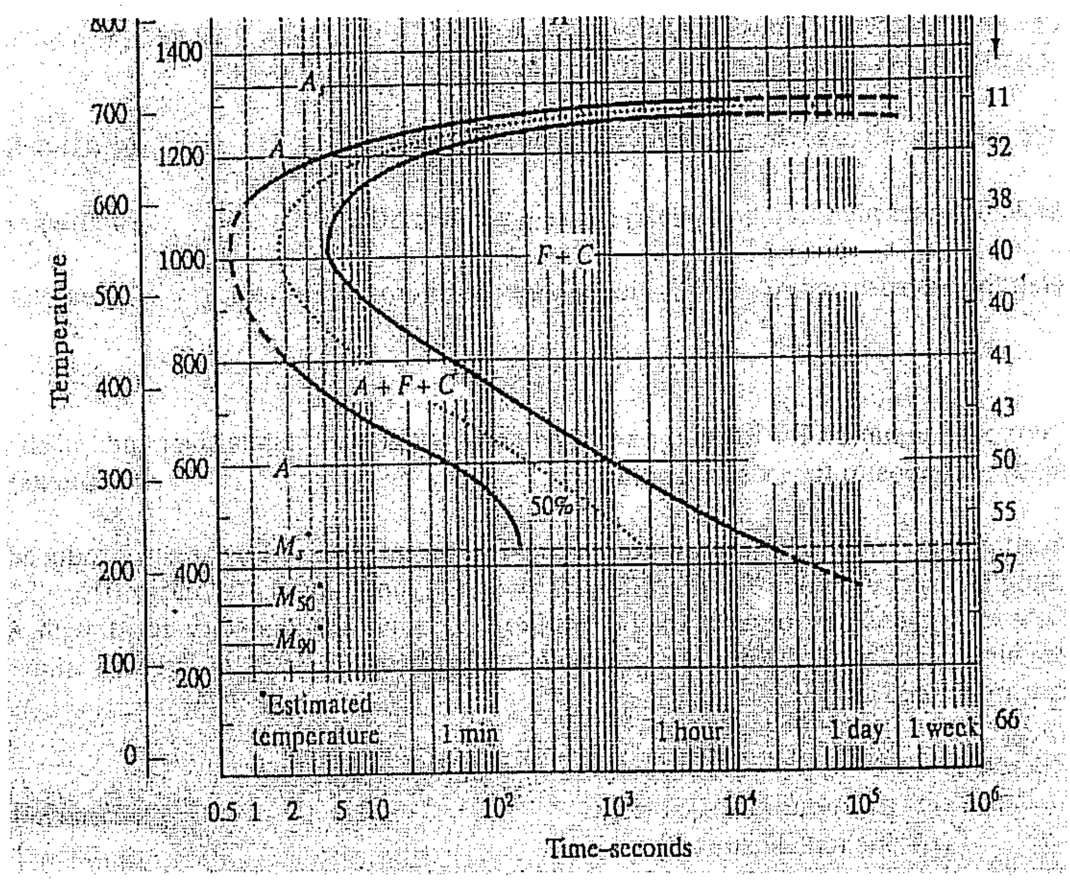

Figure 2

3. (a) Define the terms " phase" in a material and an "equilibrium phase diagram".

(b) **(4 marks)**

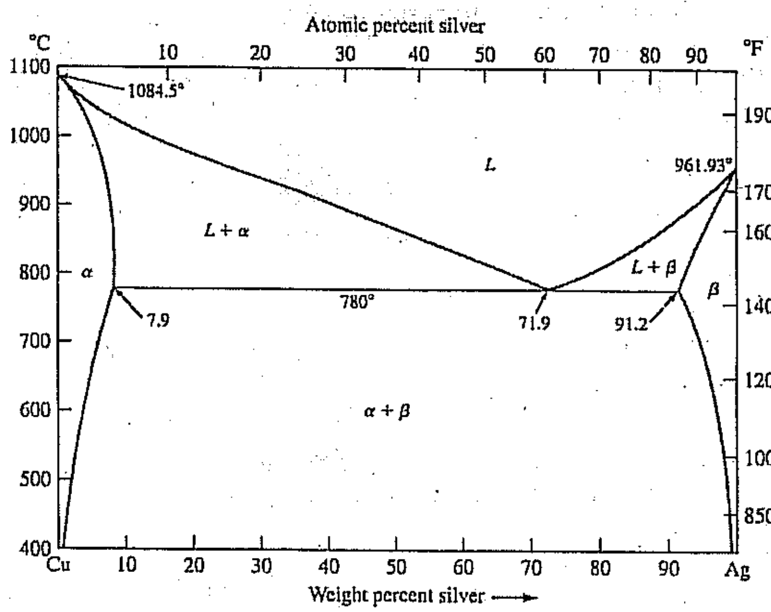

Figure 3

Shown in Figure 3 above is the Binary Eutectic Copper-Silver phase diagram. Consider an alloy containing 88 wt% Ag and 12 wt% Cu, and answer the following.

(i) Make phase analyses when cooling from 1000^0C to 500^0C. **(4 marks)**

(ii) Calculate the amount of liquid and β phase present at 800^0C. **(4 marks)**

(iii) Sketch the microstructure at 800^0C using circular microscopic field. **(4 marks)**

4. (a) Derive an equation for Elastic modulus of a lamellar continuous fiber and plastic matrix composite for isostrain condition. **(5 marks)**

(b) A composite made of continuous glass-fiber-reinforced–epoxy resin produced using 60% by volume of E-glass fibers, having a modulus of elasticity of $E_f = 72$ GPa and a tensile strength of 2400 MPa and a hardened epoxy resin with a modulus of $E_m = 3$ GPa and a tensile strength of 62 MPa is stressed under isostrain conditions.

Calculate,

(i) the modulus of elasticity **(4 marks)**
(ii) the tensile strength **(4 marks)**
(iii) the fraction of the load carried by the fiber **(3 marks)**

5. (a) Describe and differentiate crevice corrosion cracking and stress corrosion cracking. **(5 marks)**

(b) Explain the method of minimizing crevice corrosion. **(5 marks)**

(c) Explain the oxidation resistance of metals solely by considering the Pilling – Bedworth ratio. **(6 marks)**

6. (a) Explain, how you would strengthen a material using the grain boundary strengthening mechanism. **(5 marks)**

(b) Outline the relationship between the yield strength of a material and its grain size quoting the Hall-Petch equation. **(5 marks)**

(c) The average grain diameter for a brass material was measured as a function of time at 650^0C, and the results are as tabulated below.

Time(min)	Grain Diameter (mm)
30	3.9×10^{-2}
90	6.6×10^{-2}

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(i) What was the original grain diameter? **(3 marks)**

(ii) What grain diameter would you predict after 150 min at 650^0C? **(3 marks)**

7. (a) What is meant by "creep failure" of materials? **(3 marks)**

(b) Explain the term "steady state creep or the secondary creep" in creep failure of materials. **(3 marks)**

(c) The following creep data were taken on an Aluminium alloy at 400^0C and a constant stress of 25 MPa.

(i) Plot the data as strain vs time in a graph (use a graph paper) **(5 marks)**

(ii) Determine the steady state creep rate. **(5 marks)**

Note: The initial and instantaneous strain is not included.

Time (min)	Strain
0	0.000
2	0.025
4	0.043
6	0.065
8	0.078
10	0.092
12	0.109
14	0.120
16	0.135
18	0.153
20	0.172
22	0.193
24	0.218
26	0.255
28	0.307
30	0.368

8. (a) Discuss and analyze **three** of the following topics from an Engineering view point.

(i) Primary bonds in materials
(ii) Three major polymer categories
(iii) Types of cast iron
(iv) Ductile failure of materials
(v) Edge dislocation **(16 marks)**