GX650

OLLSCOIL NA hÉIREANN
The National University of Ireland

National University of Ireland, Galway

Hilary Examinations, 1998/99

Third Year Mechanical and Biomedical Engineering

METALS and METAL PROCESSING

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Attempt Three Questions
Time Allowed: 2 Hrs.

1(a) **(i)** Give a brief definition for each of the following terms :
— strength
— ductility
— hardness
— toughness **(4)**

(ii) Draw a fully labelled tensile stress strain plot for a ductile strain hardening metal up to failure point.
Define engineering stress and true stress and show curves for both on the plot.
Discuss the reason for the difference between the curves and determine the strain level at which there is more that a 5% difference in the two quantities. **(5)**

(iii) Briefly discuss the Rockwell hardness test with the aid of sketches. Discuss the relationship, if any, between hardness and tensile strength for metals. **(4)**

(b) **(i)** Discuss dislocations under the following headings with the aid of labelled sketches :
— dislocation motion
— edge, screw and mixed dislocations
— definition of burgers vector and relationship between dislocation line and burgers vector for edge and screw dislocations
— the Frank Read mechanism of dislocation multiplication
(12)

2(a) In the nitriding process for steel a nitrogen environment is used to set the surface nitrogen content at 1.0 wt%. If the initial nitrogen content is 0.01 wt % calculate how long it will take at 900°C for the nitrogen content to reach 0.1 wt % at a distance of 1 mm from the surface. Assume that the diffusivity of nitrogen in steel at 900°C is 1.2×10^{-10} m^2/s. For a semi-infinite slab the concentration at a distance x from the surface at a time t, c(x, t) is given by :

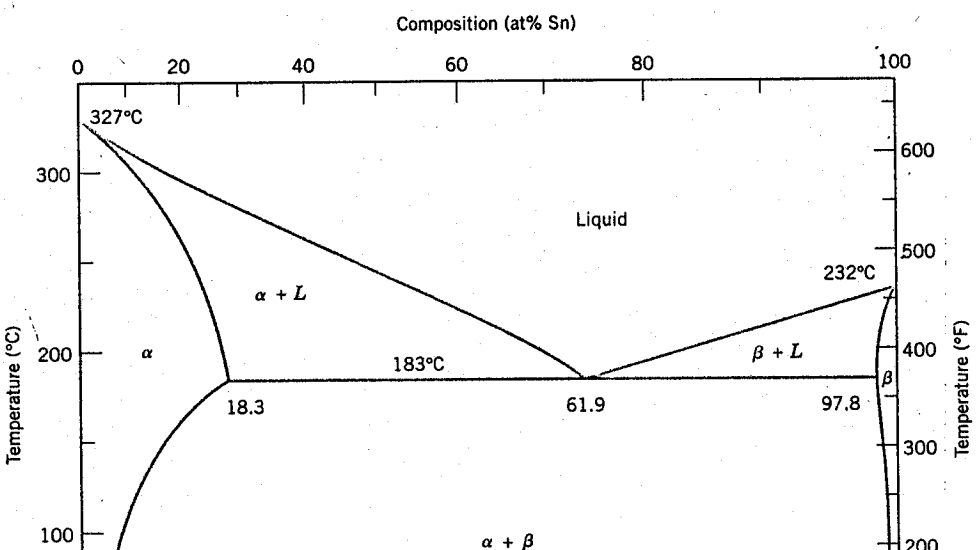
$$\frac{c(x,t)-c_0}{c_s-c_0} = 1 - \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$$

c_0 = bulk concentration
c_s = surface concentration
D = diffusivity

(11)

(b) **(i)** Figure 2 shows a phase diagram for solder, the Pb-Sn system. Calculate the amount in kg and composition of each phase present in 1 kg of a 60 wt% Pb – 40 wt% Sn alloy at 300°C, 200°C and 100°C. **(8)**

(ii) A solder batch is made by melting together 64g of a 40:60 Pb-Sn alloy with 53g of a 60:40 Pb-Sn alloy. Calculate the amount in kg of each phase present assuming it is slowly cooled to 25°C. **(6)**



For assistance, the Error Function is shown below :

z	erf (z)	z	erf (z)
0.00	0.0000	0.70	0.6778
0.01	0.0113	0.75	0.7112
0.02	0.0226	0.80	0.7421
0.03	0.0338	0.85	0.7707
0.04	0.0451	0.90	0.7969
0.05	0.0564	0.95	0.8209
0.10	0.1125	1.00	0.8427
0.15	0.1680	1.10	0.8802
0.20	0.2227	1.20	0.9103
0.25	0.2763	1.30	0.9340
0.30	0.3286	1.40	0.9523
0.35	0.3794	1.50	0.9661
0.40	0.4284	1.60	0.9763
0.45	0.4755	1.70	0.9838
0.50	0.5205	1.80	0.9891
0.55	0.5633	1.90	0.9928
0.60	0.6039	2.00	0.9953
0.65	0.6420		

Figure 2

3(a) Draw a clearly labelled Time Temperature Transformation (TTT) Diagram for 0.8 wt% C steel. Show both isothermal curves and modifications for continuous cooling. Explain the terminology used and briefly describe, with the aid of sketches, the different material structures corresponding the different parts of the diagram. **(8)**

(b) Based on the TTT diagram, discuss the hardening of cylindrical steel bars with reference to their diameters. Explain what is meant by the "Ruling Section". Name and describe, with the aid of sketches, a test that is used to assess the hardenability of steel. Illustrate the effects of changing the carbon content and introducing alloying elements on the TTT diagram and explain the implications for the hardening of steel. **(10)**

(c) Describe, with the aid of sketches, the four main non-equilibrium heat treatments for steel. **(7)**

4(a) Discuss the inclusion of alloying elements in steel under the following headings, giving examples of relevant elements in each case.

— increase in strength
— change in transition temperatures
— stabilisation of carbides
— grain growth
— displacement of eutectoid point
— corrosion resistance **(13)**

(b) Describe the following steel types on the basis of chemical composition (giving details of the effects of the main alloying elements present), typical heat treatment and typical applications :

— low alloy constructional steel
— high alloy constructional steel
— stainless steel **(12)**