NATIONAL UNIVERISTY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 4104 – MATERIALS SCIENCE I

BSc HONOURS PART IV: DECEMBER 2001 *DURATION: 3 HOURS*

ANSWER **ALL** QUESTIONS IN SECTION A AND ANY **THREE** QUESTIONS IN SECTION B. SECTION A CARRIES 40 MARKS WHILE EACH QUESTION IN SECTION B CARRIES 20 MARKS.

SECTION A

1 (a) Determine the repeat distance, linear density, and packing fraction for BCC Lithium which has a lattice parameter of 0.35089 nm in the [110] and [111] directions. [4]

Which of these directions is close packed? [1]

(b) Show that the packing factor for FCC unit cell is 0.75 [3]

(c) (i) Define the resolved shear stress. [2]

(ii) A force of 5000 N is applied in the [111] direction of Tin. What is the resolved force in the [110] direction? [3]

(d) Show that true strain is given by $\epsilon_t = \ln (A_o/A)$ [3]

(e) A test bar with a diameter of 12.83 mm and a 50mm gauge length is loaded elastically with 156 kN. Its diameter is 12.80 mm under load . Determine its bulk modulus and its shear modulus. [4]

(f) A component to operate for long periods at a constant high temperature is designed with an initial length of 150 mm with the maximum increase in length permitted being 2mm. What is the maximum value of the creep strain rate at the temperature which can be tolerated if the design life of 15000 hours is required? [3]

(g) The mean diagonal length of a Vickers diamond impression made on a sample of aluminium using a 2.5kg indenting load is 0.362mm. What is the hardness of aluminium? [3]

(h) A solder contains 60w/o tin and 40w/o lead. What is the atom percent for each element? [2]

(i) The melting point of lead is 237°C and that of tin is 232°C.They form a eutectic containing 62% tin at 182°C. The maximum solid solubility of tin in lead at this temperature is 19% of lead in tin is 3%. Assume the solubility of each at room temperature is 1 %.

(i) Draw the equilibrium diagram to scale on a piece of graph paper labelling all points, lines and phase spaces. [5]

(ii) Describe the cooling of a 70% tin alloy. [2]

(iii) Draw a cooling curve of the above alloy. [2]

(k) How could corrosion fatigue be distinguished from intergranular attack? [3]

SECTION B

2 (a) (i) Define and describe with examples, point defects and dislocations. [5]

(ii) How do defects affect the strength of materials? [3]

(iii) Which type of defects greatly affect the electrical conductivity of metals? [2]

(b) (i) Explain how the grain size affects the strength of an alloy at both low and high temperatures. [4]

(ii) Which type of grain structure is more suitable for creep resistant properties? Explain. [3]

(c) What is the significance of the c/a ratio of hexagonal close-packed metals? [3]

(a) Describe the carburisation process of steel. What is its effect on the surface of steel? With the aid of a sketch, show the carbon concentration profile. [6]

(b) A low carbon steel (0.20%) component is to be carburized at 950°C. Calculate the length of treatment needed to give a carbon content of 0.36% at a distance of 1mm below the surface . Assume the carbon content at the surface is 0.95% throughout the process. The diffusivity at 950°C is $1.74 \times 10^{11} m^2 s$. [5]

(c) Briefly describe the recovery, recrystallization and the grain growth processes in an annealing process. [9]

4 (a) Differentiate between hardness and toughness. [4]

(b) (i) Derive an expression for the Brinel hardness Number (BHN). [6]

(ii) Why should the load factor be constant for similar geometrical impressions? [3]

(c) (i) What is meant by the term proof stress? [2]

(ii) What is the necessity for determining proof stress and how is it determined? [5]

5. (a) (i) With the aid of a fully labeled diagram, describe the stages of creep and explain what happens at each stage. [10]

(ii) What information can be obtained from a creep curve? [2]

(b) Define the following terms

(i) endurance ratio

(ii) fatigue life

(iii) glass transition temperature.

(iv) Poisson's ratio. [8]

(a) Differentiate slip from the twinning mechanisms of plastic deformation. [6]

(b) Explain what the following designation means with respect to slip, [3]

<110>{111}

(c) On which slip planes and directions is slip most prevalent? [4]

(d) Describe the principles behind the following non-destructive testing methods:

(i) magnetic particle inspection [2]

(ii) radiographic method of inspection [2]

(iii) ultrasonic method of inspection. [3]

- END OF PAPER -

Table 1 - Table of the Error Function

z	erf(z)
0	0
0.025	0.0282
0.05	0.0564
0.10	0.1125
0.15	0.1680
0.20	0.2227
0.25	0.2763
0.30	0.3286
0.35	0.3794
0.40	0.4284
0.45	0.4755
0.50	0.5205
0.55	0.5633
0.60	0.6039
0.65	0.6420
0.70	0.6778
0.75	0.7112
0.80	0.7421
0.85	0.7707
0.90	0.7970
0.95	0.8209
1.00	0.8427
1.1	0.8802
1.2	0.9103
1.3	0.9340
1.4	0.9523
1.5	0.9661
1.6	0.9763
1.7	0.9838
1.8	0.9891
1.9	0.9928
2.0	0.9953
2.2	0.9981
2.4	0.9993
2.6	0.9998
2.8	0.9999