M. TECH. MAT. ENGG. & M. MET. ENGG. (I.M.) 1ST. SEM. EXAM. - 2017

Subject: DEFORMATION AND DAMAGE **Time: 3 hours** **Full Marks : 100**

Answer ANY FIVE (5) questions. All questions carry equal marks.

1 (a) (i) Write down the expression for generalized Hooke's law in terms of principal stresses and strains. (ii) Define: hydrostatic stress, deviatoric stress, triaxiliaty factor. 4+6

(b) The uniaxial yield stress of a material is 300 MPa. If for a triaxial stress field, the principal stresses $\sigma_2 = \sigma_3 = 150$ MPa, what should be the value of σ_1 to cause yielding? Compare the triaxiality factors for these two stress fields. 10

2 Answer ANY TWO (2) questions 2x10

(a) The following reaction between two Shockley partial dislocations in an fcc crystal has been given as an example of how a Lomer-Cottrell barrier can form (a_0 is the lattice parameter):

$$\frac{a_0}{6}[\bar{1}2\bar{1}] + \frac{a_0}{6}[1\bar{1}2] \rightarrow \frac{a_0}{6}[001]$$

(i) Identify the slip plane(s) of the partial dislocations. (ii) Show that the product dislocation lies along the vector $[0\bar{1}1]$. (iii) For the product dislocation, use the line vector and the Burger vector, to show that its possible glide plane is (100). Hence comment on its mobility.

(b) Explain the generation of dislocations by the operation of Frank-Read sources, clearly identifying the importance of the strength of the pinning points.

(c) With the help of suitable schematic diagram(s), explain the following terms in the context of thermally activated plastic deformation: thermal component of flow stress, athermal component of flow stress, activation area, activation energy.

(d) List the important considerations in developing high strength alloys for high temperature applications.

3 Consider constant nominal strain rate tensile tests at ambient temperature with specimens of cylindrical gage geometry.

(a) With the help of a schematic engineering stress-strain diagram, identify all the significant engineering strength and ductility parameters that are determined from such tests. 7

(b) Show that for a rate-insensitive material, the true strain at maximum load equals the strain exponent in the Hollomon work hardening equation. 7

(c) Two tension tests are carried out at identical nominal strain rate and with the same specimen gage length; the gage diameter of one specimen is 10 mm and that for the other specimen is 8 mm. Which of the significant engineering strength and ductility parameters would be different, and why? 6

4	(a)	Define Brinell, Vicker, Meyer, Knoop, and Rockwell hardness numbers.	10
	(b)	(i) What is "principle of geometric similitude" in the context of hardness testing ?	5+5
		(ii) Why Vicker hardness Number (VHN) is independent of the load applied except at very low loads?	
5	(a)	For impact testing of Charpy V-notch (CVN) specimens, in a schematic plot, show how the ductile to brittle transition (DBT) behaviour is reflected in the variations of energy absorbed and macroscopic fracture appearance, with temperature. Identify the significant points on this plot.	10
	(b)	Qualitatively explain the origin of the DBT behavior. Hence explain the roles of the notch and the high strain rate in this test.	10
6	(a)	Consider isothermal creep testing in a constant load creep testing unit. Draw a typical three stage creep curve, as would be obtained from such a test. Identify the different regimes and important engineering parameters on this curve.	8
	(b)	Briefly explain the terms: Monkmann-Grant ductility, Damage tolerance parameter (as proposed by Ashby and Dyson).	4
	(c)	What is the difference between Nabarro-Herring and Coble creep mechanisms ?	4
	(d)	Write a brief explanatory note on the role of grain boundary sliding in creep deformation and fracture.	4
7		Answer ANY TWO (2) of the following	2x10
	(a)	Draw a typical S-N curve for high cycle fatigue. Why some materials show endurance limit (fatigue limit) ? Why high cycle fatigue data show considerable statistical scatter ?	
	(b)	Briefly explain the following terms: cyclic hardening, cyclic softening, Bauschinger effect, cyclic stress-strain curve.	
	(c)	Draw a typical experimentally determined fatigue crack growth curve for a mechanically long crack. Identify the different regimes in this curve. Briefly indicate how the data can be used for mechanical design.	
8	(a)	Explain Griffith theory for crack initiation in a brittle material. Explain the conditions for unstable growth of a brittle crack.	4+4
	(b)	(i) Show that for valid plane strain K_{Ic} testing, the relevant specimen dimensions should be at least 15π times Irwin's estimate of the corresponding plastic zone size.	6+6
		(ii) K, J and crack tip opening displacement (CTOD) are three fracture toughness parameters. Clarify the regimes of their applicability.	