ME 301: Structure and Properties of Solids, Spring Semester 2009

Homework Assignment #7 - Midterm Review - 50 pts.
March 25, 2009

#1- A gear made of 1020 steel (0.20 wt % C) is to be gas-carburized at 927^0C (1700^0F). Calculate the carbon content at 0.04 inches below the surface of the gear after a 7-hour carburizing time. Assume the carbon content at the surface fo the gear is 1.15 wt %. Assume D for C in Fe at 927^0C is $1.28 \times 10^{-11}\ m^2/s$.

#2 - The diffusivity of copper atoms in the aluminum lattice is $7.50 \times 10^{-13} m^2/s$ at 600^0C and $2.50 \times 10^{-15} m^2/s$ at 400^0C. Calculate the activation energy for this case in this temperature range. [$R = 8.314 J/(mol \cdot K)$].

#3 - A specimen of magnesium having a circular cross-section with diameter of 12.7mm is deformed in tension and the load elongation data is tabulated below.

Load (N)	Elongation (mm)	Load (N)	Elongation (mm)
0	63.50	9870	64.14
1380	63.53	12850	65.41
2780	63.56	14100	66.68
5630	63.62	14340	67.95
7430	63.70	13830	69.22
8140	63.75	12500	70.49

Calculate and plot the engineering stress and strain in the sample.

Stress (MPa)	Strain (mm/mm)	Stress (MPa)	Strain (mm/mm)

From the stress-strain data that you calculated, determine:

- the modulus of elasticity of the steel,
- the 0.2% offset yield strength,
- the ultimate tensile strength, and
- the % elongation at fracture.

#4 - A stress of 75 MPa is applied in the [001]direction on an FCC single crystal. Calculate (a) the resolved shear stress acting on the (111)[$\bar{1}$01] slip system and (b) the resolved shear stress acting on the (111)[$\bar{1}$10] slip system.

#5 - When a cold-worked metal is heated into the temperature range where recrystallization takes place, how are the following affected: (a) internal residual stresses, (b) strength, (c) ductility, and (d) hardness.

#6 - Determine the critical crack length for a through crack in a thick plate of 7150-T651 aluminum alloy that is in uniaxial tension. For this alloy, $K_{Ic} = 25.5\ MPa\sqrt{m}$ and $\sigma_f = 400\ MPa$. Assume $Y = \sqrt{\pi}$.

#7 - Using the equation $K_{Ic} = \sigma_f\sqrt{\pi a}$, plot the fracture stress, MPa, for aluminum alloy 7075-T651 versus surface crack size a, mm, for values of a ranging from $0.2mm$ to $2.0mm$.

#8 - A large flat plate is subjected to constant-amplitude uniaxial cyclic tensile and compressive stresses of 120 and 35 MPa respectively. If before the testing the largest surface crack is 1.0 mm and the plain-strain fracture toughness of the plate is 35 $MPa\sqrt{m}$, estimate the fatigue life of the plate in cycles to failure. For the plate, $m = 3.5$ and $A = 5.0 \times 10^{-12}$ in MPA and meter units. Assume $Y = 1.3$.