Sum 2010 **Engineering Material**

Exam II - Version B

Thursday, July 29, 2010

Duration: 60 minutes
Closed Book Exam
Write clearly your derivations and answers on the question sheet

Name: rabba

ID#:

I [70 points]

1. A brass alloy of grain size 0.01 mm has yield strength of 150 MPa and it is 60 MPa when the grain size is 0.1 mm. Yield strength of this alloy at a grain size of 0.05 mm will be

(a) 99.25 MPa
(b) 89.75 MPa
(c) 77.25 MPa
(d) 65.5 MPa
(e) 62.25 MPa

2. After cold working a metal, which of the following are usually true when compared with the undeformed material

(a) the dislocation density increases
(b) the remaining ductility decreases
(c) the yield strength increases
(d) the tensile strength increases
(e) all of the above

3. As a result of recrystallization from a cold worked condition the material will have

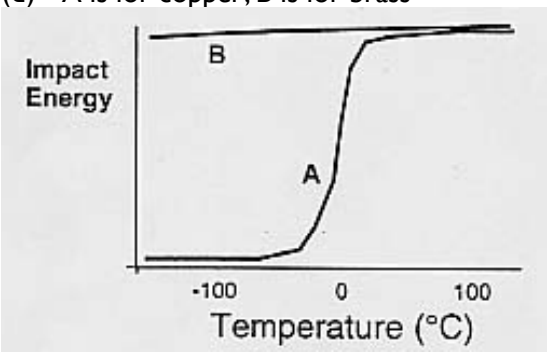
(a) smaller grain size
(b) lower dislocation density
(c) increased ductility
(d) lower yield strength
(e) all of the above

4. Consider a metal single crystal oriented such that the normal to the slip plane and the slip directions are at angles 43.1° and 47.9°, respectively, with the tensile axis. If the applied stress is 45 MPa, the resolved shear stress will be

(a) 20 MPa
(b) 2.2 MPa
(c) 22 MPa
(d) 44 MPa

5. Which of the following is true concerning the impact energy vs temperature curves shown below

(a) A is for aluminum; B is for low carbon steel
(b) A is for low carbon steell B is for aluminum
(c) A is for γ- iron (FCC); B is for α-iron (BCC)
(d) A is for copper; B is for brass



6. Dislocation motion can be impeded by

(a) other dislocations
(b) grain boundaries
(c) impurity atoms
(d) diffusion
(e) a,b and c

7. After cold working a metal, which of the following are usually true when compared with the undeformed material

(a) the dislocation density increases
(b) the remaining ductility decreases
(c) the yield stress increases
(d) the tensile strength increases
(e) all of the above

8. A bar with a cross sectional area of 8 mm^2 is cold worked by drawing, so that the final area is 4.8 mm^2. The %CW produced by the drawing is

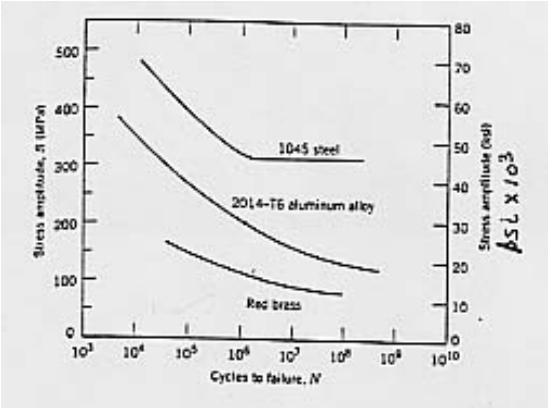
(a) 20
(b) 30
(c) 40
(d) 50

9. Dislocation motion in a glass

(a) increases as temperature increases
(b) is inhibited by grain boundaries
(c) is inhibited by solute species with large radii
(d) all of the above
(e) is nonexistent

10. A 0.5 diameter cylindrical rod fabricated from 2014-T6 aluminum is subjected to cyclic tension compression loading along its axis. If the maximum tensile and compressible loads are +6000 lbs and -6000 lbs respectively what is the expected fatigue life based on the S-N data given below (assume the mean stress for this data is equal to zero)

(a) 10^5 cycles
(a) 10^6 cycles
(a) 10^7 cycles
(a) 10^8 cycles



11. The yield stress of most metals increases with grain size d as

(a) $d^{0.5}$
(b) $d^{-0.5}$
(c) $d^{1.5}$
(d) $d^{-1.5}$

12. Intergranular fracture

(a) occurs when the crack propagates along the grain boundaries
(b) only occurs in ductile material
(c) require the presence of interstitial impurities
(d) occurs when the crack propagates through the grain interiors
(e) is responsible for sandy rather than rocky beaches

13. In tension the true stress is

(a) the same as engineering stress
(b) smaller than the engineering stress
(c) larger than the engineering stress
(d) always greater than the true strain
(e) better than false stress

14. The poisson's ratio

(a) increases with increasing cold work
(b) decreases with increasing cold work
(c) is unaffected by cold work
(d) increases with increasing grain size
(e) decreases with increasing grain size

15. Of the following statements identify the one that is false

(a) Hardness is an indicator of strength
(b) hard materials can scratch less hard materials
(c) Hardness may be measured using an indentor
(d) Hardness values may be converted to modulus values

16. Which of the following does not increase strength

a. cold working
b. heating
c. adding impurities
d. adding particles
e. decreasing grain size

17. Dislocations will strengthen a material by

a. necking
b. creep
c. tangling
d. separating

18. The yield stress in metals corresponds to

a. a permanent deformation of 0.02%
b. a permanent deformation of 0.2 %
c. a change of slope of the stress vs. strain curve
d. a stress which causes the metal to neck

19. The driving force for grain growth

(a) is elastic stress
(b) requires extensive dislocation slip
(c) is the removal of high densities of dislocations
(d) is the reduction in grain boundary area
(e) comes from porosity

20. Dislocation motion can be impeded by

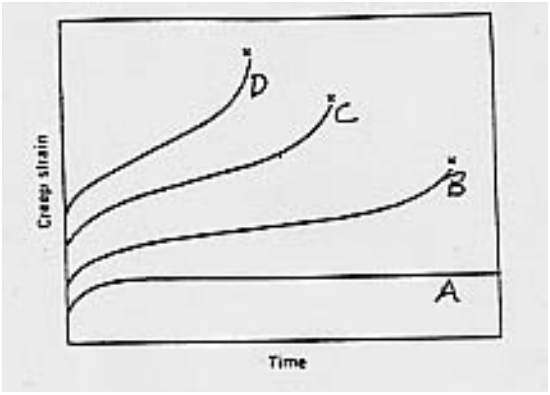
(a) other dislocations
(b) grain boundaries
(c) impurity atoms
(d) diffusion
(e) a, b and c.

21. For a given far field applied stress, the maximum stress near a crack will increase as

(a) the crack length increases
(b) the radius of curvature at the crack tip increases
(c) the fracture toughness increases
(d) all of the above

22. Below are creep strain versus time curves for various applied tensile stresses. If all of these tests were conducted at the same stress the curve corresponding to the highest temperature is

(a) A
(b) B
(c) C
(d) D



II [15 points]

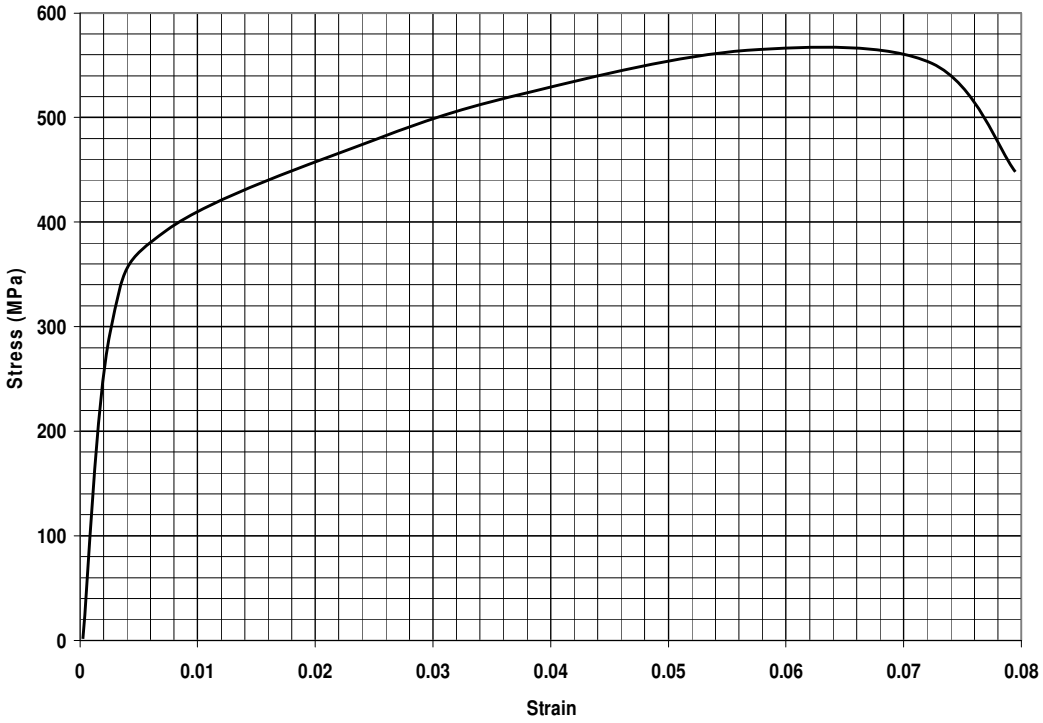
At approximately what temperature would a specimen of iron have 8 hours to produce the same diffusion as when held for 16 hours at:

(a) 1000°C?
(a) 900°C?

III [15 points]

The figure below shows a stress-strain curve for a typical ductile material.

(a) What is the Young's modulus of this material?
(b) What is its yield stress?
(c) Consider two specimens that are subjected to a stress of 200 MPa and 500 MPa respectively: what is the total strain observed for each specimen?
(d) What proportion of this deformation is retained after unloading?
(e) Sketch a typical stress-strain curve for a ceramic material.



Data and Formula

Avogadro's number: 6.023×10^{23} /mol

Gas Constant R: 8.31 J/mol•K, 1.987 cal/mol•K

Boltzmann's constant k: 1.38×10^{-23} J/atom • K, 8.62×10^{-5} eV/atom • K

$$\sigma_y = \sigma_0 + k_y d^{-1/2}$$

$$\sigma_m = \sigma_0 \left[1 + 2 \left(\frac{a}{\rho_t} \right)^{1/2} \right]$$

$$d^n - d_0^n = Kt$$

$$\%CW = \left(\frac{A_0 - A_d}{A_0} \right) \times 100$$

$$\tau_R = \sigma \cos\phi \cos\lambda$$

Table 5.1 Tabulation of Error Function Values

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

Table 5.2 A Tabulation of Diffusion Data

Diffusing Species	*Host Metal*	$D_0(m^2/s)$	*Activation Energy* Q_d *kJ/mol*	*Activation Energy* Q_d *eV/atom*	*Calculated Values* $T(°C)$	*Calculated Values* $D(m^2/s)$
Fe	α-Fe (BCC)	2.8×10^{-4}	251	2.60	500 900	3.0×10^{-21} 1.8×10^{-15}
Fe	γ-Fe (FCC)	5.0×10^{-5}	284	2.94	900 1100	1.1×10^{-17} 7.8×10^{-16}
C	α−Fe	6.2×10^{-7}	80	0.83	500 900	2.4×10^{-12} 1.7×10^{-10}
C	γ-Fe	2.3×10^{-5}	148	1.53	900 1100	5.9×10^{-12} 5.3×10^{-11}
Cu	Cu	7.8×10^{-5}	211	2.19	500	4.2×10^{-19}
Zn	Cu	2.4×10^{-5}	189	1.96	500	4.0×10^{-18}
Al	Al	2.3×10^{-4}	144	1.49	500	4.2×10^{-14}
Cu	Al	6.5×10^{-5}	136	1.41	500	4.1×10^{-14}
Mg	Al	1.2×10^{-4}	131	1.35	500	1.9×10^{-13}
Cu	Ni	2.7×10^{-5}	256	2.65	500	1.3×10^{-22}

Source: E. A. Brandes and G. B. Brook (Editors), *Smithells Metals Reference Book,* 7th edition, Butterworth-Heinemann, Oxford, 1992.