

Materials Science and Engineering Department
MSE 200-002, Exam #2, Spring 2009

ID number _____

First letter of your last name: _____

Name: _____

No notes, books, or information stored in calculator memories may be used. Cheating will be punished severely. All of your work must be written on these pages and turned in. Mark your answer on this paper first, and then copy onto the answer sheet at the end of the test. **Use #2 pencil to mark the answer sheet.**

Constants, equations, and other data are given on the last page of the exam.

Multiple choices (3 points each):

- ____ 1. Plastic deformation means that the sample
- A. returns to its original dimension when a reversed load is applied
 - B. permanently deformed after the load is removed
 - C. returns to its original dimension after the load is removed
- ____ 2. The equation $\sigma = E \epsilon$ can be used to describe
- A. plastic deformation
 - B. plastic and elastic deformation
 - C. elastic deformation
 - D. none of the above
- ____ 3. Ultimate tensile strength is defined as (during tensile testing)
- A. the stress at 0.2% plastic deformation
 - B. the stress at the point of the sample failure
 - C. the maximum stress a sample could sustain
 - D. none of the above
- ____ 4. A bcc single crystal is loaded along the $[112]$ direction with a stress of 100 MPa, the resolved shear stress in the $(312)[\bar{1}11]$ slip system is
- A. 23.2 MPa B. 35.6 MPa C. 41.1 MPa D. 68.9 MPa
- ____ 5. An fcc single crystal is loaded along the $[11\bar{1}]$ direction with a stress of 100 MPa, the resolved shear stress in the $(111)[\bar{1}10]$ slip system is
- A. 0 MPa B. 28.4 MPa C. 45.6 MPa D. 56.3 MPa

For the following two problems: A copper rod was deformed to a true strain of 10% under a true stress of 400 MPa.

- ____ 6. The engineering strain is
- A. 11% B. 9.5% C. 10% D. 10.5%
- ____ 7. The Engineering stress is (in MPa)
- A. 440 MPa B. 400 MPa C. 364 MPa D. 425 MPa

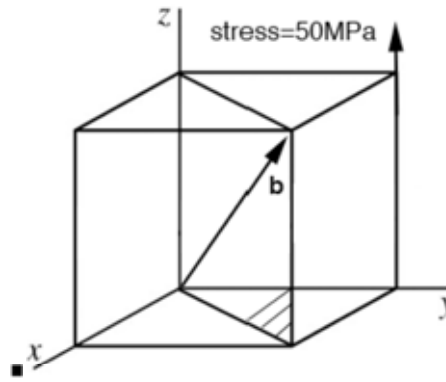
- ___ 8. Brittle fracture is characterized by
- large permanent deformation prior to failure
 - abrupt (catastrophic) failure with little or no warning.
 - blunting of crack tips
 - All of the above
- ___ 9. An fcc single crystal is loaded along the [010] direction with a stress of 100 MPa, the resolved shear stress in the $(11\bar{1})[112]$ slip system is
- 23.6 MPa
 - 33.8 MPa
 - 45.7 MPa
 - 63.4 MPa
- ___ 10. Work hardening is the result of
- increase in dislocation density upon deformation
 - absence of slip systems
 - presence of carbon atoms at the edge dislocations
 - increase in grain boundary

For the following four problems: 20 cm long rod with a diameter of 20 mm is loaded with a 5000 N weight. If the diameter is reduced to 18 mm, determine the following:

- ___ 11. The engineering strain is
- 10%
 - 10%
 - 11.1%
 - 23.5%
- ___ 12. The engineering stress is
- 15.9 MPa
 - 159 MPa
 - 19.7 MPa
 - 197 MPa
- ___ 13. The true strain is
- 21.1%
 - 10%
 - 11.1%
 - 10%
- ___ 14. The true stress is
- 15.9 MPa
 - 159 MPa
 - 19.7 MPa
 - 197 MPa
- ___ 15. The following are slip systems in a bcc metal
- $(111)[10\bar{1}]$, $(11\bar{1})[110]$, $(11\bar{1})[011]$, $(111)[01\bar{1}]$
 - $(111)[10\bar{1}]$, $(11\bar{1})[101]$, $(1\bar{1}1)[011]$, $(111)[01\bar{1}]$
 - $(011)[111]$, $(101)[11\bar{1}]$, $(1\bar{1}0)[111]$, $(110)[111]$
 - $(011)[11\bar{1}]$, $(101)[11\bar{1}]$, $(1\bar{1}0)[111]$, $(110)[\bar{1}11]$
- ___ 16. Engineering stress is the
- load (force) divided by the initial cross sectional area
 - load (force) divided by the true cross sectional area
 - change in length divided by the initial length
 - change in length divided by the true length

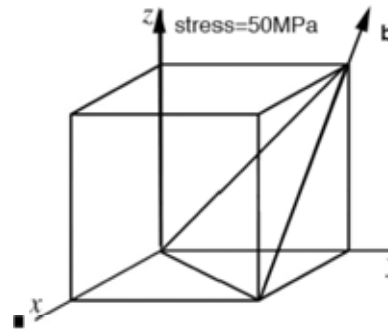
____ 17. In the following bcc crystal, the stress in the loading direction is 50 MPa, calculate the resolved shear stress in the indicated slip system

- A. 0 MPa
- B. 12.3 MPa
- C. 25.6 MPa
- D. 36.5 MPa



____ 18. In the following fcc crystal, the stress in the loading direction is 50 MPa, calculate the resolved shear stress in the indicated slip system

- A. 13.5 MPa
- B. 20.4 MPa
- C. 35.6 MPa
- D. 58.7 MPa

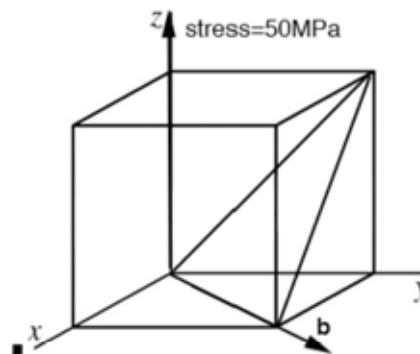


____ 19. The modulus of elasticity (Young's modulus)

- A. can be determined by the initial linear portion of the engineering stress-strain curve
- B. is another way to describe hardness
- C. is proportional to the total engineering strain to failure
- D. is the only material property not related to atomic bonding

____ 20. In the following fcc crystal, the stress in the loading direction is 50 MPa, calculate the resolved shear stress in the indicated slip system

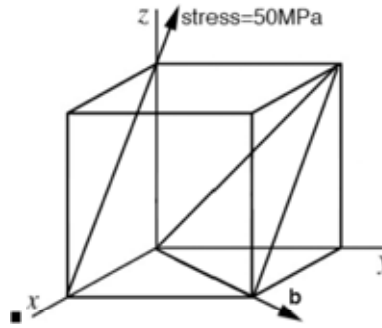
- A. 0 MPa
- B. 14.5 MPa
- C. 28.4 MPa
- D. 41.3 MPa



____ 21. The resolved shear stress in a slip system depends on:

- A. the orientation of the slip plane
- B. the orientation of the slip direction
- C. the magnitude of the applied stress
- D. all of the above

____ 22. In the following fcc crystal, the stress in the loading direction is 50 MPa, calculate the resolved shear stress in the indicated slip system



- A. 0 MPa
- B. 14.3 MPa
- C. 23.6 MPa
- D. 36.8 MPa

____ 23. Fatigue strength is

- A. the highest stress a materials can sustain to survive 10^6 cycles of loading
- B. load divided by sample cross-section area
- C. the maximum stress under tension
- D. the critical stress for a fatigue crack to propagate

For the following two Problems: An aluminum alloy has a plane strain fracture toughness of $24 \text{ MPa(m)}^{1/2}$. Assume $Y=1$.

____ 24. Calculate the longest allowable surface crack such that the alloy will withstand an applied stress of 400MPa.

- A. 1.146 m
- B. 1.146 mm
- C. 1.146 cm
- D. 0.0146 m

____ 25. How long could the crack be if it was internal?

- A. 1.146 cm
- B. 2.293 cm
- C. 2.293 mm
- D. 1.146 mm

____ 26. The creep strength at a given temperature is determined as the stress at a creep rate of 10^{-5} /h at the stage of

- A. primary creep
- B. secondary (steady state) creep
- C. tertiary creep

____ 27. A material with a high fracture toughness

- A. will fail in a brittle manner
- B. will fail at comparatively low stresses if small cracks are present
- C. will exhibit a relatively smooth fracture surface
- D. none of the above

____ 28 A fatiue test is made with a maximum stress of 200 MPa and a minimum stress of -40 MPa. The stress amplitude is

- A. 200 MPa
- B. 240 MPa
- C. 160 MPa
- D. 120 MPa

____ 29. The fracture toughness (K_{IC})

- A. decreases as the crack size increases

- B. increases as the applied stress increases
- C. neither of the above
- D. both of the above

___ 30. The three stages of creep are

- A. fast primary, slow secondary, and fast tertiary
- B. slow creep, steady-state creep, and fast creep
- C. slow primary, fast secondary, and fastest tertiary
- D. none of the above

For the following 5 problems: The following creep curves were obtained for copper at temperatures of 600° and 800°C.

___ 31. The steady state creep strain rate in units of (hour)⁻¹ in sample A is close to

- A. 0.9×10^{-6}
- B. 0.4×10^{-6}
- C. 1.2×10^{-6}

___ 32. Steady state creep strain rate in sample A compared to that in sample B is

- A. higher
- B. equal
- C. lower

___ 33. Steady state creep strain rate in sample B in units of (hour)⁻¹ is close to

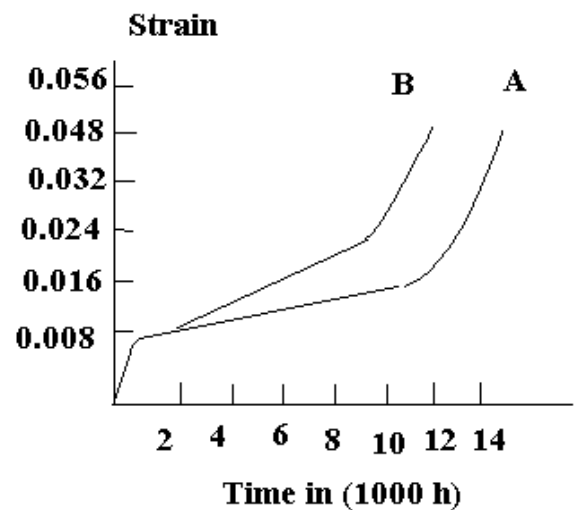
- A. 2.2×10^{-6}
- B. 0.2×10^{-6}
- C. 1.2×10^{-6}

___ 34. Total creep rupture life at 800°C is close to

- A. 11000 hr
- B. 15 000 hr
- C. 9000 hr

___ 35. Creep rate increases

- A. during the intermediate stage
- B. when the temperature is raised
- C. when the applied stress is decreased
- D. all of the above



Equation sheet

$$\epsilon = (l - l_0)/l_0, \quad \sigma = F/A_0, \quad \sigma = E \epsilon, \quad \tau = G\gamma$$

$$\epsilon_t = \ln \frac{l}{l_0}, \quad \sigma = F/A,$$

$$\tau_r = \sigma \cos \phi \cos \lambda$$

$$K_I = Y\sigma\sqrt{\pi a}, \quad K_{IC} = Y\sigma_f\sqrt{\pi a_c}$$

$$\sigma_m = \frac{\sigma_{\max} + \sigma_{\min}}{2}, \quad \sigma_a = \frac{\sigma_{\max} - \sigma_{\min}}{2}, \quad \sigma_r = \sigma_{\max} - \sigma_{\min}, \quad R = \frac{\sigma_{\min}}{\sigma_{\max}}$$

$$\frac{da}{dN} = A\Delta K^m, \quad P(\text{Larsen-Miller}) = T[\log t_r + 20] \quad (T: K; t: h)$$

Answer Key: 1B 2C 3C 4C 5A 6D 7C 8B 9A 10A 11D 12A 13A 14C 15D
16A 17A 18B 19A 20A 21D 22A 23A 24B 25C 26B 27A 28D 29C 30A
31A 32C 33A 34A 35B