

Materials Science
EXAM II

Dec. 12, 2013

I. Explain the following terms: (20%)

1. self-diffusion
2. carburization
3. necking
4. Young's modulus
5. fatigue
6. residual stresses
7. true stress strain curve
8. Tensile test
9. toughness
10. transgranular fracture

II. Short answer: (36%)

1. A 70% Cu–30% Zn brass sheet is 0.12 cm thick and is cold-rolled with a 20 percent reduction in thickness. What must be the final thickness of the sheet?
2. Draw a typical creep curve for a metal under constant load and at a relatively high temperature, and indicate on it all three stages of creep.
3. What manufacturing techniques make use of the cold-working process? (At least write down three manufacturing techniques)
4. Write the equation for Fick's first law of diffusion, and define each of the terms in SI units.
5. What are strengthening mechanisms of materials? (At least write down three mechanisms)
6. The Hall-Petch equation is

$$\sigma_y = \sigma_0 + \frac{k_y}{\sqrt{d}}$$

where σ_y is the yield stress, σ_0 is a materials constant for the starting stress for dislocation movement, k_y is the strengthening coefficient (a constant unique to each material), and d is the average grain diameter. What could you obtain from this equation?

7. Describe the characteristic microstructure features of ductile fracture.
8. Draw a typical Arrhenius plot of \log_{10} of the reaction rate versus reciprocal absolute temperature, and indicate the slope of the plot.
9. How is the ductility of a metal normally affected by cold working? Why?
10. Differentiate between transgranular and intergranular fractures.
11. How is self-diffusion of atoms in metals verified experimentally?
12. 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 $K_{IC} = 25.5 \text{ MPa } \sqrt{m}$ and $\sigma_f = 400 \text{ MPa}$. Assume $Y = \sqrt{\pi}$.

- III. (a) Is ceramic brittle or ductile? (1%)
(b) Strain hardening is normally not a consideration in ceramic materials. Explain why? (3%)

IV. 單選題 (Multiple choice, only one answer): (21%)

1. Which one of the following is not a mechanical property? (A) toughness (B) hardness (C) transmittance (透射率) (D) strength (E) stress (F) strain (G) ductility.
2. Which metal alloys may experience a ductile to brittle transition with decreasing temperature? (A) FCC (B) HCP (C) BCC (D) Simple Cubic.
3. The slope of stress-strain plot in the elastic region is called (A) toughness (B) modulus of elasticity (C) transmittance (D) strength (E) Poisson's ratio (F) Strain (G) ductility.
4. (A) Tension (B) Fatigue (C) Creep (D) Compression, of a metal refers to the slow, progressive plastic deformation of a metal subjected to a constant load or stress. It is the time dependent strain of a metal.

5. Which one of the following would not increase the resistance to steady state creep?
 (A) Decrease grain size (B) Decrease temperature (C) Decrease porosity in specimen (D) Decrease stress (E) none of above.

6. In a cold-worked metal, the recrystallized grain size is insensitive to which of the following parameters? (A) Purity of the metal (B) Initial grain size (C) Annealing temperature (D) Amount of deformation (E) none of above.

7. Atoms of one metal diffuse into another is termed (A) interdiffusion (B) self-diffusion (C) Frenkel diffusion (D) Schottky diffusion (E) none of above.

V. For an FCC unit cell, (a) how many atoms are there inside the unit cell (1%) (b) what is the coordination number for the atoms (1%) (c) what is the relationship between the length of the side a of the FCC unit cell and the radius of its atoms, (1%) (d) what are the principal slip planes and slip directions for FCC metals ? (3%) (e) how many slip systems for FCC metals ? (2%) ,
 (總共 8 分)

VI. The “Titanic”(鐵達尼號) was hit by floating iceberg and suddenly split in half and sank , please propose the possible reasons from the viewpoint of materials performance of steels for the ship. (5%)

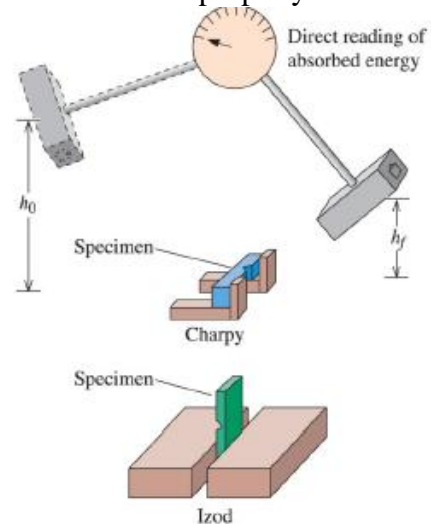
VII. (a) What is the driving force for steady-state diffusion? (2%)
 (b) What is the driving force for recovery? (2%)
 (c) What is the driving force for recrystallization? (2%)
 (d) What is the driving force for grain growth? (2%)

VIII. Watch the following figure:

(a) What is its name? (2%)

(b) Explain this method. (4%)

Hint: This is a method for testing material mechanical property.



IX. The actual fracture strength of metals is much less than their theoretical cohesive strength. Please state the reason and describe the mechanisms of strengthening in metals. (6%)

Hint: Cohesive strength is the theoretical stress that causes fracture in tensile test if material exhibits no plastic deformation.

X. (a) Draw true stress strain curve. (2%)
 (b) and engineering stress strain curve. (2%)
 (c) Compare true stress strain curve with engineering stress strain curve. (2%)

XI. Three turbine blades were made with three different microstructures: Equiaxed grain, columnar grain, single crystal. (a) Which one will have the best performance for jet engines? (b) Which one is the worst? (c) Explain why? (6%)