

Shiley School of Engineering, University of Portland
EGR 221 - Materials Science, Exam 2 (closed book, closed notes, NO calculator)
October 13, 2015, Dr. Ken Lulay

NAME: SOLUTION

1) {5 pts} Answer true (T) or false (F):

- A. Poisson's ratio is: $-\epsilon_{tr} / \epsilon_{ax}$, where ϵ_{tr} is the transvers strain and ϵ_{ax} is the axial strain. ☒ T ☐ F
- B. Diffusion rate is affected by the temperature. ☒ T ☐ F Generally
- C. In order for two different metals to be completely soluble in each other, they must have different crystal structures from each other. ☐ T ☒ F MUST HAVE SAME
- D. Toughness is defined as the amount of strain in a material before fracturing. ☐ T ☒ F Amount of Energy
- E. Diffusion rate (aka flux) is linearly proportional to the concentration gradient. ☒ T ☐ F

2) {15 pts} Fill in the blanks with the correct terminology:

$$F = -D \frac{\partial c}{\partial x}$$

- A. The material property that characterizes a material's ability to resist penetration of a sharp object, or in other words, ability to withstand local deformation by surface indentation is known as: hardness
- B. The equation, $E = \sigma / \epsilon$, is known as: Hooke's Law (Young's Mod, E, is a material property)
- C. A solid solution wherein relatively small solute atoms occupy the "open space" between the solvent atoms is referred to as: interstitial impurity or interstitial solid solution
- D. The equation for elongation (%EL) is: $\%EL = \left(\frac{l_{fract} - l_0}{l_0} \right) \times 100\%$
- E. The material property defined as the maximum stress on a stress-strain diagram is known as: tensile strength (or ultimate tensile strength)

3) {5 pts} Multiple Choice. Pick the single answer in each question that is most correct.

- A. In aluminum, self-diffusion:
- a) will result in change of the of composition in the aluminum.
 - ☒ b) atoms of aluminum will migrate through the aluminum.
 - c) will change the crystal structure of the aluminum.
 - d) self-diffusion cannot happen in aluminum.
- B. An alloy is a:
- a) pure metal
 - ☒ b) mixture of a metal and another element (metal or non-metal)
 - c) mixture of a metal and another metal only
 - d) mixture of a metal and non-metal only

4) {5 pts} Will carbon likely diffuse more quickly in iron at 915°C or at 910°C? Remember that iron is Face Centered Cubic (FCC) above 912°C and Body Centered Cubic (BCC) below 912°C. Briefly justify/explain your answer.

FCC is more tightly packed (greater APF); therefore has less "open space" than BCC. The open space in BCC allows for easier/faster diffusion.
 \therefore faster at 910°C than 915°C

5) {30 pts} A cylindrical bar is loaded in tension as shown. The original gage length of the bar is 2.0000 inches and the original diameter is 0.5050 inches. When a 15,000 pound load is applied the gage length becomes 2.0050 inches and the diameter becomes 0.5045 inches. Determine the following – assume the 15,000 pound load is applied for all questions. STATE ALL ASSUMPTIONS, SHOW EQUATIONS IN VARIABLE FORM FIRST, THEN INCLUDE APPROPRIATE NUMBERS. YOU DO NOT NEED TO CALCULATE THE ANSWERS.

a) What is the normal stress along the axis of the bar (σ_{axial})?

$$\sigma_{\text{axial}} = \frac{F}{A} \quad F = 15,000 \text{ lb}$$

$$A = \frac{\pi}{4} d_o^2 \quad d_o = 0.5050 \text{ in}$$

b) What is the strain along the axis of the bar (ϵ_{axial})?

$$\epsilon_{\text{axial}} = \frac{l - l_o}{l_o} = \frac{2.0050'' - 2.0000''}{2.0000''}$$

c) What is the stress perpendicular to the axis of the bar ($\sigma_{\text{transverse}}$)?

No force component perpendicular to the axis. $\therefore \sigma_{\text{transverse}} = 0$

d) What is the strain perpendicular to the axis of the bar ($\epsilon_{\text{transverse}}$)?

$$\epsilon_{\perp} = \frac{d - d_o}{d_o} = \frac{0.5045'' - 0.5050''}{0.5050''}$$

f) What is Young's modulus (aka modulus of elasticity) of the material? State assumptions.

Assuming the material is linear elastic up to the 15,000 lb load,
 $E = \frac{\sigma_{\text{axial}}}{\epsilon_{\text{axial}}} \quad \text{--- part (a)}$
 $\epsilon_{\text{axial}} \quad \text{--- part (b)}$

