

工程材料 題庫

Engineering Material

參考書籍：

Material Science and Engineering: An Introduction 8th edition

Author: William D. Callister, Jr. and David G. Rethwisch

Publisher : John Wiley & Sons, Inc

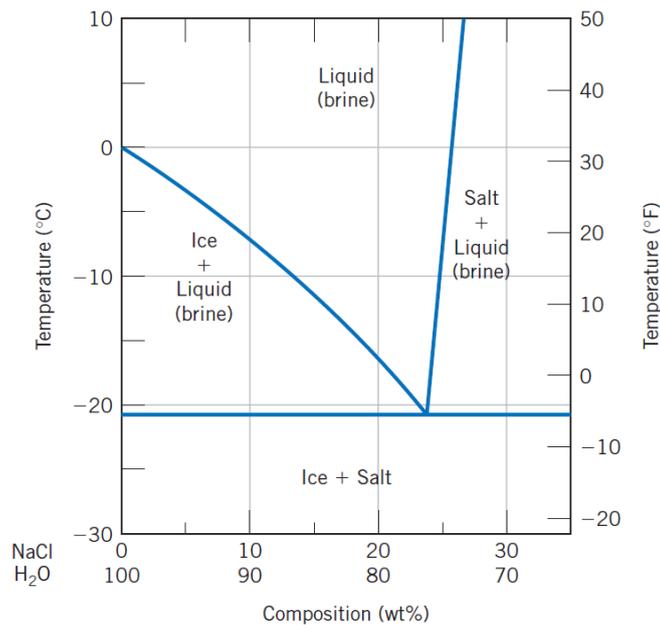
材料科學與工程導論 基礎篇 (第八版) 林景崎審閱 高立圖書出版

命題範圍：

Chapters: 3,6,8,9,10

Problem set #1

The following is a portion of the H₂O–NaCl phase diagram:



(a) Using this diagram, briefly explain how spreading salt on ice that is at a temperature below 0_C (32_F) can cause the ice to melt.

(b) At what temperature is salt no longer useful in causing ice to melt?

Problem set #2

Show for the body-centered cubic crystal structure that the unit cell edge length a and the atomic radius R are related through $a = 4R/\sqrt{3}$

For the HCP crystal structure, show that the ideal c/a ratio is 1.633.

Show that the atomic packing factor for BCC is 0.68.

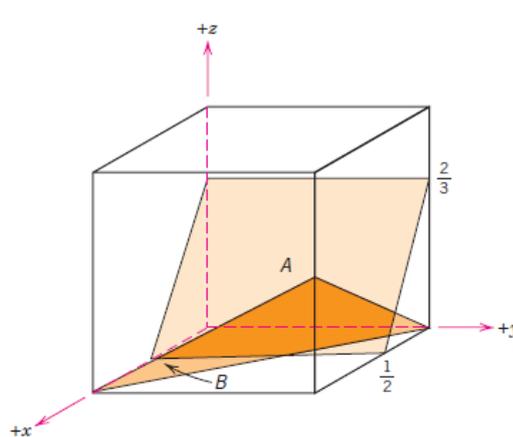
Problem set #3

Sketch a tetragonal unit cell, and within that cell indicate locations of the $1/2 \ 1 \ 1/2$ and $1/4 \ 1/2 \ 3/4$ point coordinates.

Within a cubic unit cell, sketch the following directions:

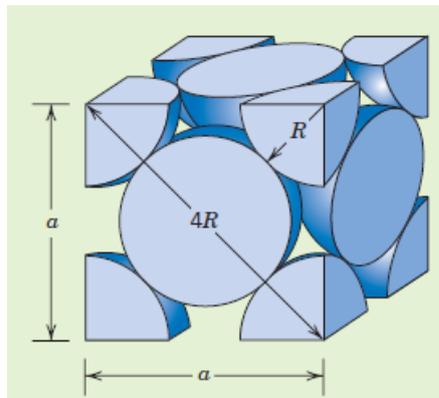
- | | |
|---------------------------|---------------------------|
| (a) $[\bar{1}10]$, | (e) $[\bar{1}\bar{1}1]$, |
| (b) $[\bar{1}\bar{2}1]$, | (f) $[\bar{1}22]$, |
| (c) $[0\bar{1}2]$, | (g) $[1\bar{2}\bar{3}]$, |
| (d) $[1\bar{3}3]$, | (h) $[\bar{1}03]$. |

Determine the Miller indices for the planes shown in the following unit cell:



Problem set #4

Calculate the volume of an FCC unit cell in terms of the atomic radius R .



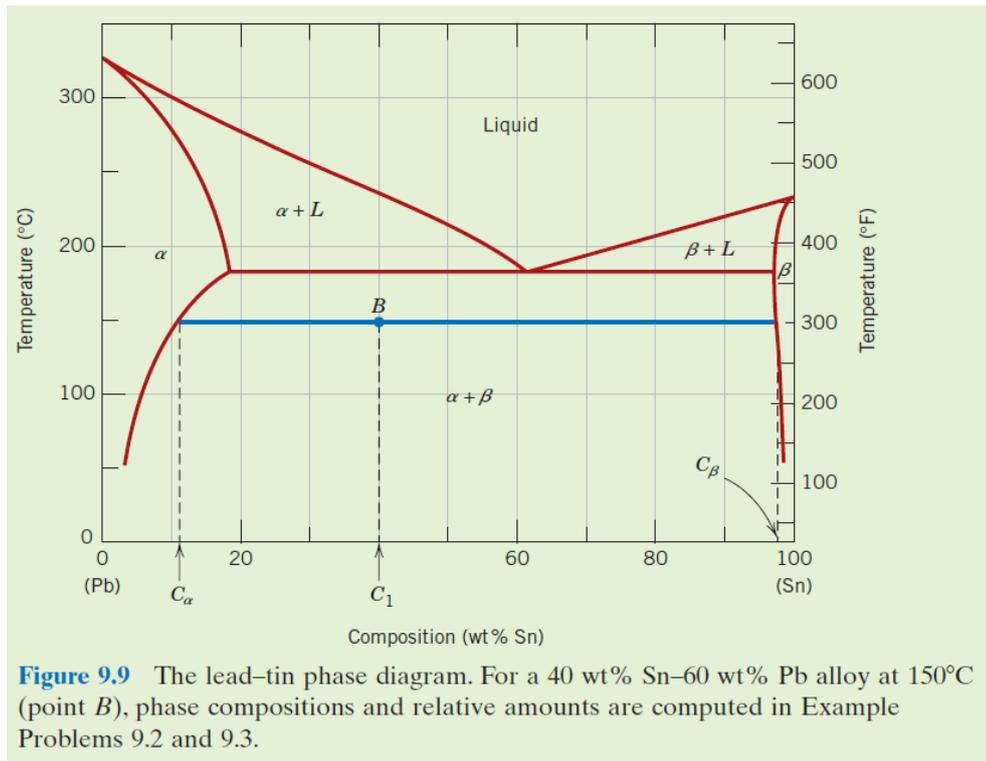
- (1) 請繪製 FCC[100]及[111]方向，
- (2) 請計算 FCC[100]的線密度。請計算 FCC[111]的線密度
- (3) 請繪製 FCC(100)面，請計算 FCC(100)的面密度

Problem set #5

A tensile stress is to be applied along the long axis of a cylindrical brass rod that has a diameter of 10 mm (0.4 in.). Determine the magnitude of the load required to produce a 2.5×10^{-3} mm (10^{-4} in.) change in diameter if the deformation is entirely elastic. The modulus of elasticity is 97 GPa (14×10^6 psi)

Problem set #6

For a 40 wt% Sn–60 wt% Pb alloy at 150°C (300°F), (a) what phase(s) is (are) present? (b) What is (are) the composition(s) of the phase(s)?



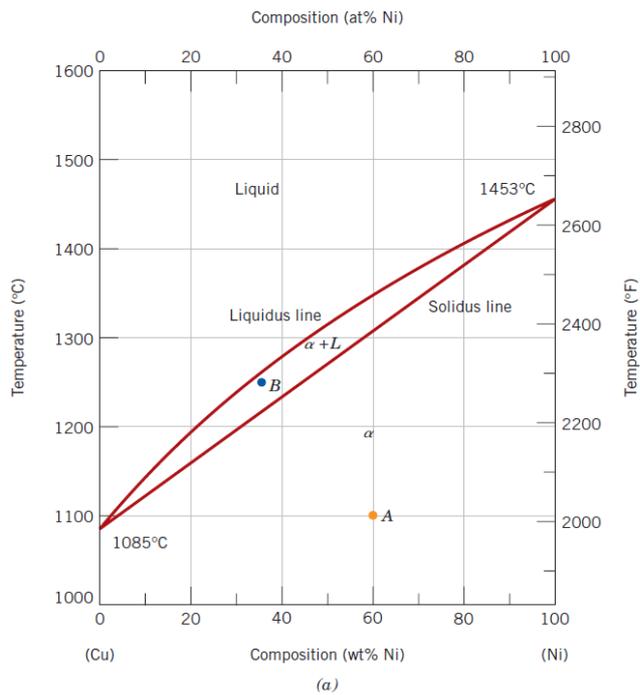
For the lead–tin alloy in Example above, calculate the relative amount of each phase present in terms of (a) mass fraction and (b) volume fraction. At 150°C take the densities of Pb and Sn to be 11.23 and 7.24 g/cm³, respectively

Problem set #7

A copper–nickel alloy of composition 70 wt% Ni–30 wt% Cu is slowly heated from a temperature of 1300°C (2370°F).

- At what temperature does the first liquid phase form?
- What is the composition of this liquid phase?
- At what temperature does complete melting of the alloy occur?
- What is the composition of the last solid remaining prior to complete melting?

Figure 9.3 (a) The copper–nickel phase diagram. (b) A portion of the copper–nickel phase diagram for which compositions and phase amounts are determined at point *B*. (Adapted from *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Editor, 1991. Reprinted by permission of ASM International, Materials Park, OH.)



Problem set #8

A 50 wt% Pb-50 wt% Mg alloy is slowly cooled from 700°C (1290°F) to 400°C (750°F).

- At what temperature does the first solid phase form?
- What is the composition of this solid phase?
- At what temperature does the liquid solidify?
- What is the composition of this last remaining liquid phase?

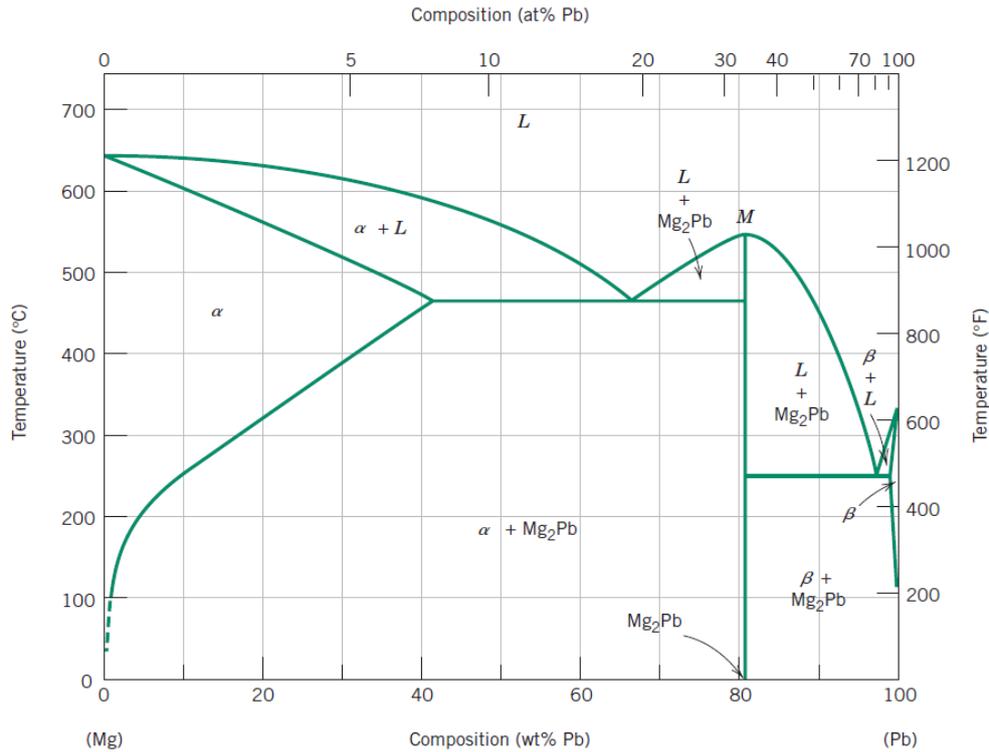


Figure 9.20 The magnesium–lead phase diagram. [Adapted from *Phase Diagrams of Binary Magnesium Alloys*, A. A. Nayeb-Hashemi and J. B. Clark (Editors), 1988. Reprinted by permission of ASM International, Materials Park, OH.]

Problem set #9

Using the isothermal transformation diagram for an iron–carbon alloy of eutectoid composition (Figure 10.22), specify the nature of the final microstructure (in terms of microconstituents present and approximate percentages of each) of a small specimen that has been subjected to the following time–temperature treatments. In each case assume that the specimen begins at 760°C (1400°F) and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

- Cool rapidly to 700°C (1290°F), hold for 10⁴ s, then quench to room temperature.
- Reheat the specimen in part (a) to 700°C (1290°F) for 20 h.
- Rapidly cool to 600°C (1110°F), hold for 4 s, rapidly cool to 450°C (840°F), hold for 10 s, then quench to room temperature.
- Cool rapidly to 400°C (750°F), hold for 2 s, then quench to room temperature.

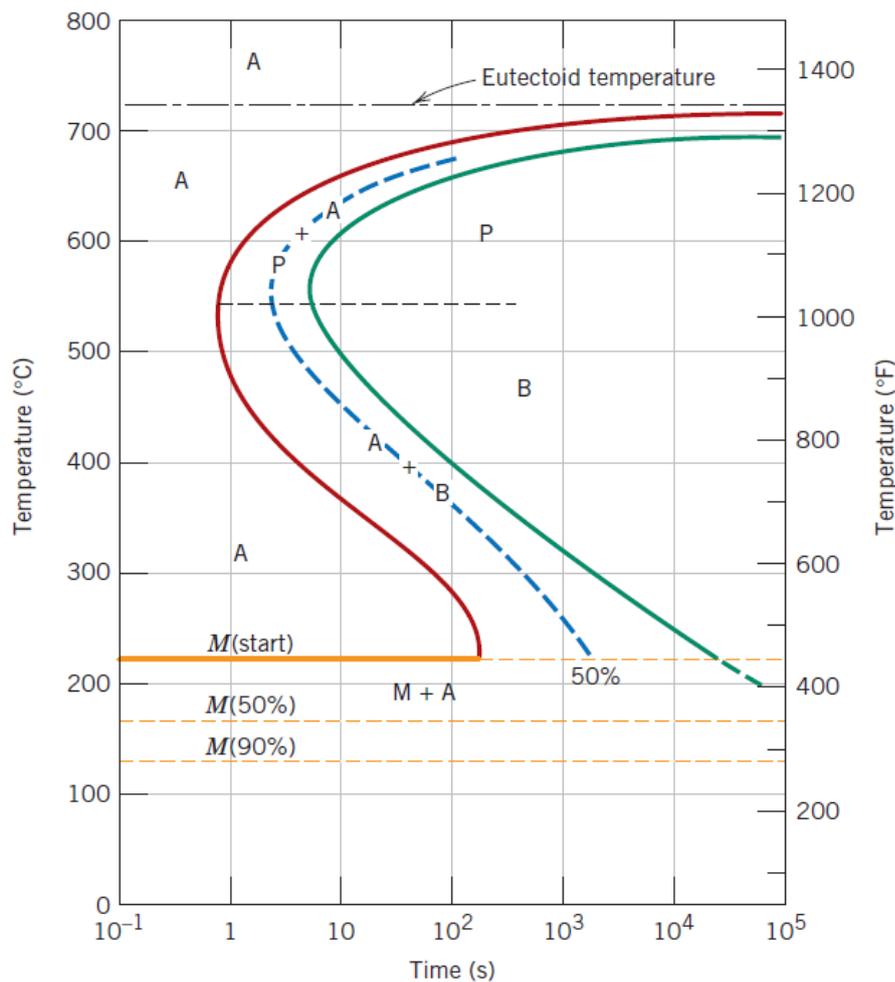


Figure 10.22 The complete isothermal transformation diagram for an iron–carbon alloy of eutectoid composition: A, austenite; B, bainite; M, martensite; P, pearlite.

Problem set #10

Using the isothermal transformation diagram for an iron–carbon alloy of eutectoid composition (above Figure), specify the nature of the final microstructure (in terms of microconstituents present and approximate percentages) of a small specimen that has been subjected to the following time–temperature treatments. In each case assume that the specimen begins at 760_C (1400_F) and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

- (a) Rapidly cool to 350_C (660_F), hold for 10^4 s, and quench to room temperature.
- (b) Rapidly cool to 250_C (480_F), hold for 100 s, and quench to room temperature.
- (c) Rapidly cool to 650_C (1200_F), hold for 20 s, rapidly cool to 400_C (750_F), hold for 10^3 s, and quench to room temperature.

Problem set #11

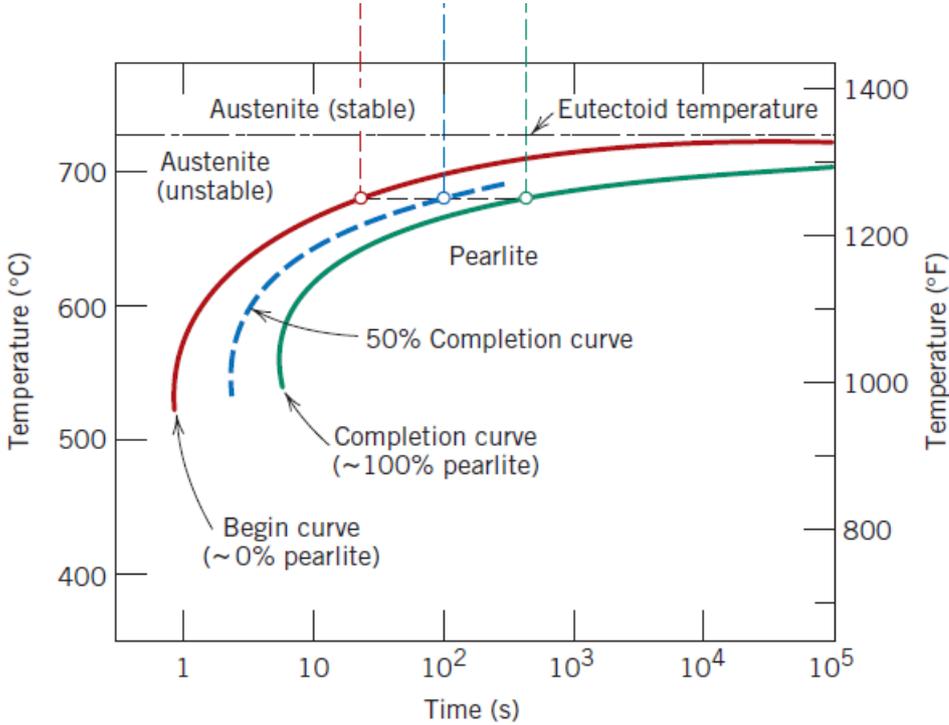
The fatigue data for a brass alloy are given as follows:

<i>Stress Amplitude (MPa)</i>	<i>Cycles to Failure</i>
310	2×10^5
223	1×10^6
191	3×10^6
168	1×10^7
153	3×10^7
143	1×10^8
134	3×10^8
127	1×10^9

- (a) Make an $S-N$ plot (stress amplitude versus logarithm cycles to failure) using these data.
- (b) Determine the fatigue strength at 5×10^5 cycles.
- (c) Determine the fatigue life for 200 MPa

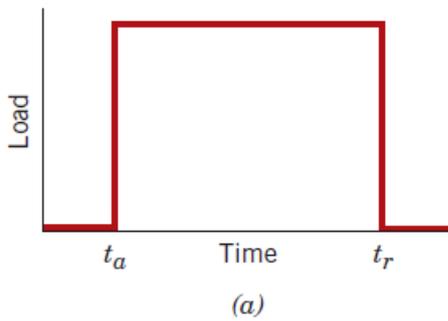
Problem set #12

How to make an ISOTHERMAL TRANSFORMATION DIAGRAMS (or sometimes as time–temperature–transformation (or T–T–T) plots.) from your experimental works?



Problem set #13

Load versus time, where load is applied instantaneously at time t_a and released at t_r . For the load–time cycle in (a),



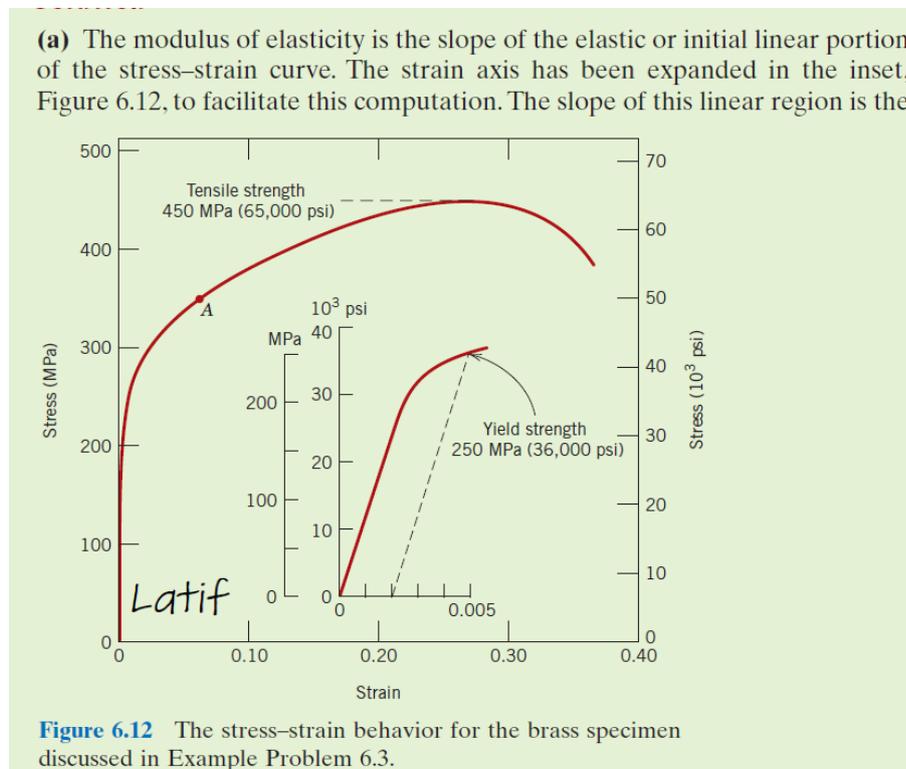
Please sketch the strain-versus time responses are for totally elastic (b), viscoelastic (c), and viscous (d) behaviors.

Please define glass transition temperature,

Problem set #14

From the tensile stress–strain behavior for the brass specimen shown in Figure below, determine the following:

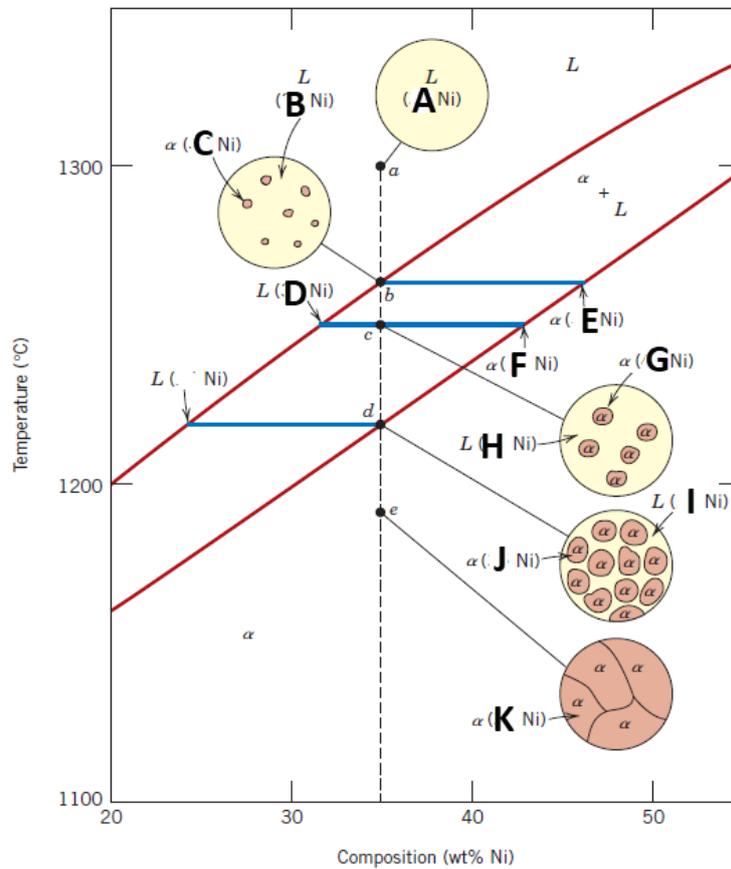
- (a) The modulus of elasticity
- (b) The yield strength at a strain offset of 0.002
- (c) The maximum load that can be sustained by a cylindrical specimen having an original diameter of 12.8 mm (0.505 in.)
- (d) The change in length of a specimen originally 250 mm (10 in.) long that is subjected to a tensile stress of 345 MPa (50,000 psi)



Problem set #15

Please explain cooling process from point a to e

Please fill ABCDEFGHIJK number



Problem set #16

Where is Eutectic phase (point)?

Why we buy Pb/Sn (61.9wt % Sn) alloy in the market ?

Use this diagram to explain "Lever rule" (expression for computation of total -phase mass fraction)

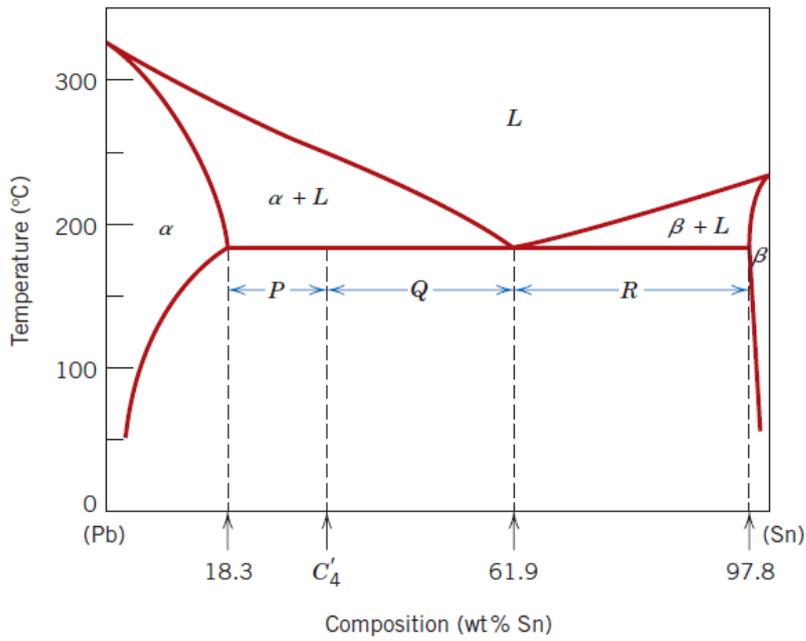
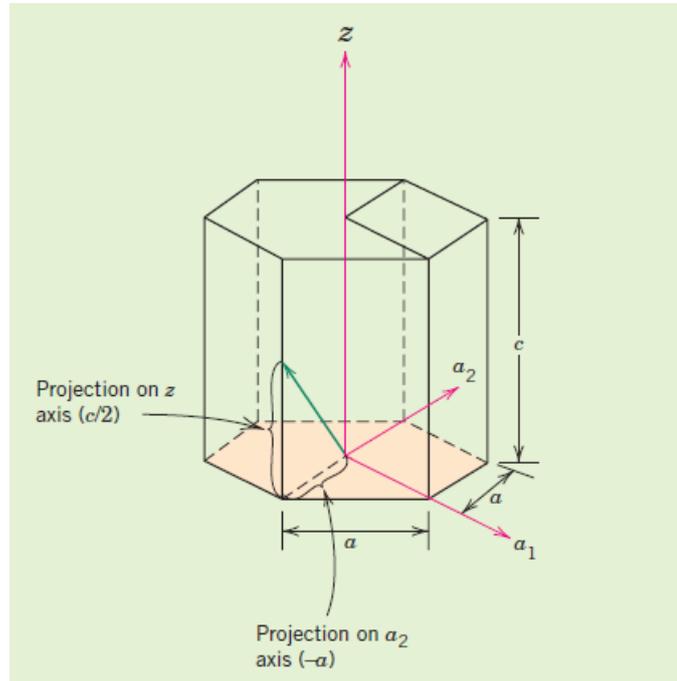


Figure 9.18 The lead-tin phase diagram used in computations for relative amounts of primary α and eutectic microconstituents for an alloy of composition C'_4 .

Problem set #17

Determine the directional indices (four-index system) for the direction shown in the accompanying figure.

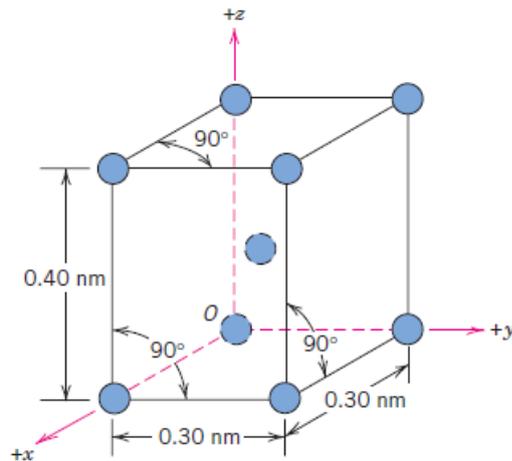


Problem set #18

The accompanying figure shows a unit cell for a hypothetical metal.

- (a) To which crystal system does this unit cell belong?
- (b) What would this crystal structure be called?

(c) Calculate the density of the material, given that its atomic weight is 141 g/mol.



Problem set #19

A tensile-testing apparatus is to be constructed that must withstand a maximum load of 220,000 N (50,000 lbf). The design calls for two cylindrical support posts, each of which is to support half of the maximum load. Furthermore, plain-carbon (1045) steel ground and polished shafting rounds are to be used; the minimum yield and tensile strengths of this alloy are 310 MPa (45,000 psi) and 565 MPa (82,000 psi), respectively. Specify a suitable diameter for these support posts.

Problem set #20

The progress of a phase transformation may be broken down into two distinct stages: **nucleation** and **growth**. Please explain Figure below.

