國立虎尾科技大學機械與機電工程研究所博士班資格考試試題

科目名稱：工程材料 2008/05

班級：_____ 學號：_____ 姓名：_____ 成績：

1. Define anisotropy. (10%)
2. What is strain hardening, and what effects does it have on metals? (10%)
3. What is a slip system, and what is its significance? (10%)
4. Distinguish between engineering stress and true stress. (10%)
5. Describe the differences between brittle and ductile fracture. (10%)
6. What factors lead to the corrosion of a metal? (10%)
7. Describe the features of a phase diagram. (10%)
8. What is the purpose of annealing? (10%)
9. How do stainless steels become stainless? (10%)
10. what are superalloys? Why are they so named? (10%)

國立虎尾科技大學　機械與機電工程研究所

97 學年度第 2 學期　博士班資格考 【工程材料】

1. 有關材料實驗：　20%
   (a) 何謂材料耐久限(Endurance Limit)？請畫出鋁材及低碳鋼之 S-N 曲線說明之。10%

   (b) 何謂彈性模數(Modulus of Elasticity)？如何由實驗取得該數據？　10%

2. 鋼由高溫的沃斯田鐵急冷可得到麻田散鐵組織，此變態過程有何特徵？　15%

3. 請以差排的運動解釋材料產生塑性變形的過程。　15%

4. 請列舉並說明 3 種材料強化的原理。　15%

5. 請從原子間結合機構解釋陶瓷材料爲何比金屬材料較硬脆且是電的不良導體？15%

6. 解釋以下的名詞：　20%
   (a) 活化能(Activation Energy)

   (b) 擴散(Diffusion)

   (c) sp^3 混成軌域(Hybrid Orbital)

   (d) 外質半導體(Extrinsic Semiconductor)

國立虎尾科技大學　機械與機電工程研究所

98 學年度第 1 學期　博士班資格考 【工程材料】

班級：_____學號：_____姓名：_____ 成績：_____

1. **Define the difference between elastic and plastic deformation in terms of the effect on the crystal lattice structure.**
2. **Define the recrystallization temperature for a metal.**
3. **Describe the difference between preferred orientation and mechanical fibering.**
4. **Describe the difference between brittle and ductile fracture.**
5. **Define residual stress.**
6. **List reasons why density is an important material property in manufacturing.**
7. **Describe the engineering significance of the existence of a eutectic point in phase diagrams.**
8. **What are superalloys? Why are they so named?**
9. **Distinguish between composites and alloys.**
10. **What are the carbon contents of low-carbon, medium-carbon, and high-carbon steels, respectively?**

國立虎尾科技大學 102 學年度第一學期博士班資格考試題

所別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 3 頁

科目：Engineering materials【close book examination】

注意事項：
（1）本試題共有 5 題，任選 5 題作答，每題 20 分，合計一百分。
（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。
（3）可使用計算機

1. Fe-Fe_3C phase diagram is shown in Figure 1, answer fellow questions according to this diagram.
   (a) 0.6wt%C hypoeutectoid plain-carbon steel is slowly cooled from austenite region to a temperature just slightly below 727°C; calculate the weigh percent (wt %) of proeutectoid ferrite and eutectoid ferrite present in the steel. (6%)
   (b) Plain-carbon steel is slowly cooled from austenite region to a temperature just slightly below 727°C; assume the amount of proeutectoid phase is equal to the amount of eutectoid phase, what is the carbon content of the steel? (6%)
   (c) 0.4wt%C hypoeutectoid plain-carbon steel and 1.2wt%C hypereutectoid plain-carbon steel were spheroidized treatment by spheroidizing, the result phases contain ferrite (matrix) and spheroidite(cementite); calculate respectively the weight percent (wt %) of ferrite and spheroidite for these steels. (6%)
   (d) Write the allotropic transformations which occur in the Fe-Fe_3C diagram. (2%)

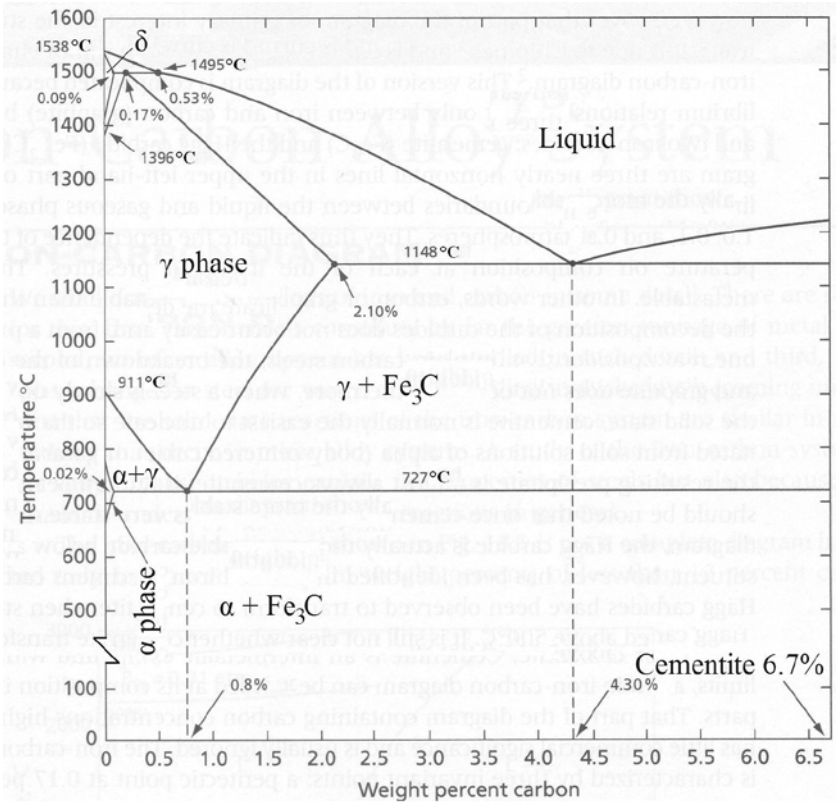


Figure 1

2. Aluminum-rich end of Al-Cu alloy equilibrium diagram is shown in Figure 2, Al-4(wt) %Cu wrought aluminum alloy was concerned in fellow questions.
   (a) How to carry out strengthening heat treatment for Al-4(wt) %Cu wrought aluminum alloy? Describe the heat treatment processes in detail. (8%)
   (b) Sketch aging hardening curves (relationship between hardness-aging time at constant temperature) and explain the effect of temperature on hardening curves. (6%)
   (c) Explain the precipitation sequences to match the hardening curve. (6%)

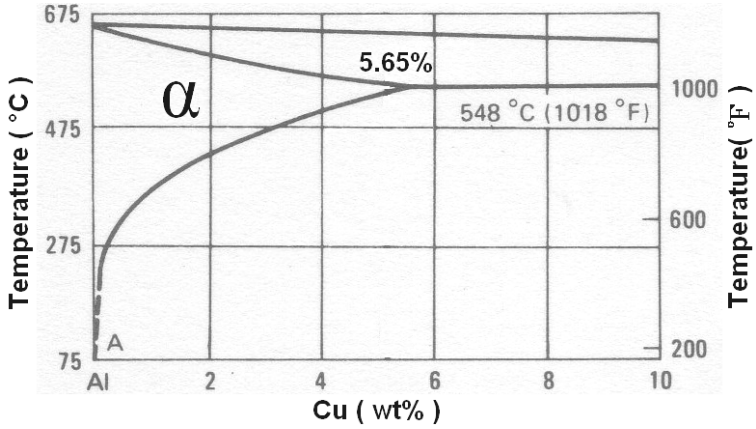


Figure 2

3. On the basis of compositional and structural differences, wrought stainless steels are divided into four main groups (types), answer fellow questions.
   (a) List the four main groups (types) of stainless steels; describe their principal characteristics and properties. (8%)
   (b) What is “intergranular corrosion” in austenitic stainless steel? How to prevent “intergranular corrosion”? (8%)
   (c) Why as-extruded austenitic stainless steel (e.g. AISI 304) seamless pipe is magnetic? (4%)

4. The result (strain-stress) curves of tensile test for four different materials are shown in Figure3 (a) (b) (c) (d); we know that four materials are plain-carbon steel, aluminum alloy, ductile cast iron and ceramics in tensile test, answer fellow questions.
   (a) To match the Figure 3 and material depending on curve profile, and explain your answer in detail. (8%)
   (b) Strain-stress curve has no distinct yielding point in Figure 3(c); describe how to decide the yielding stress? And strain-stress curve shows yielding phenomenon in Figure 3(d), explain this phenomenon. (6%)
   (c) Describe how to compare the toughness and also list the toughness rank from the result curves of tensile test for the above mentioned materials. (6%)

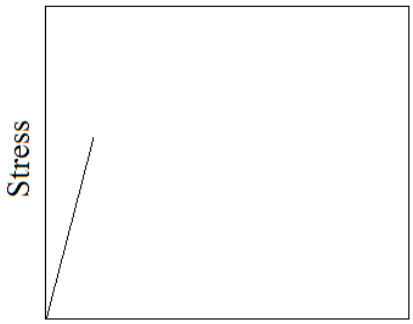


Figure 3(a)

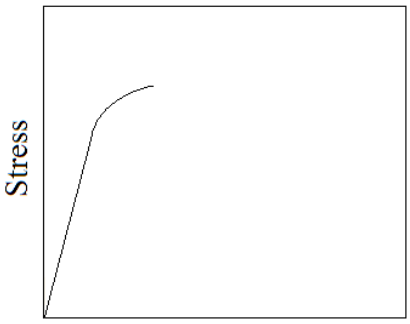


Figure 3(b)

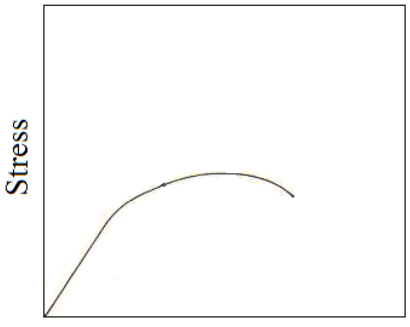


Figure 3(c)

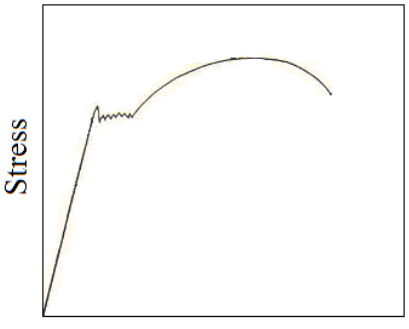


Figure 3(d)

5. Describe the strengthening methods and explain the strengthening mechanisms in engineering materials. (20%)

國立虎尾科技大學 103 學年度第一學期博士班資格考試題

所別：動力機械系機械與機電工程博士班　　第 1 頁　共 2 頁

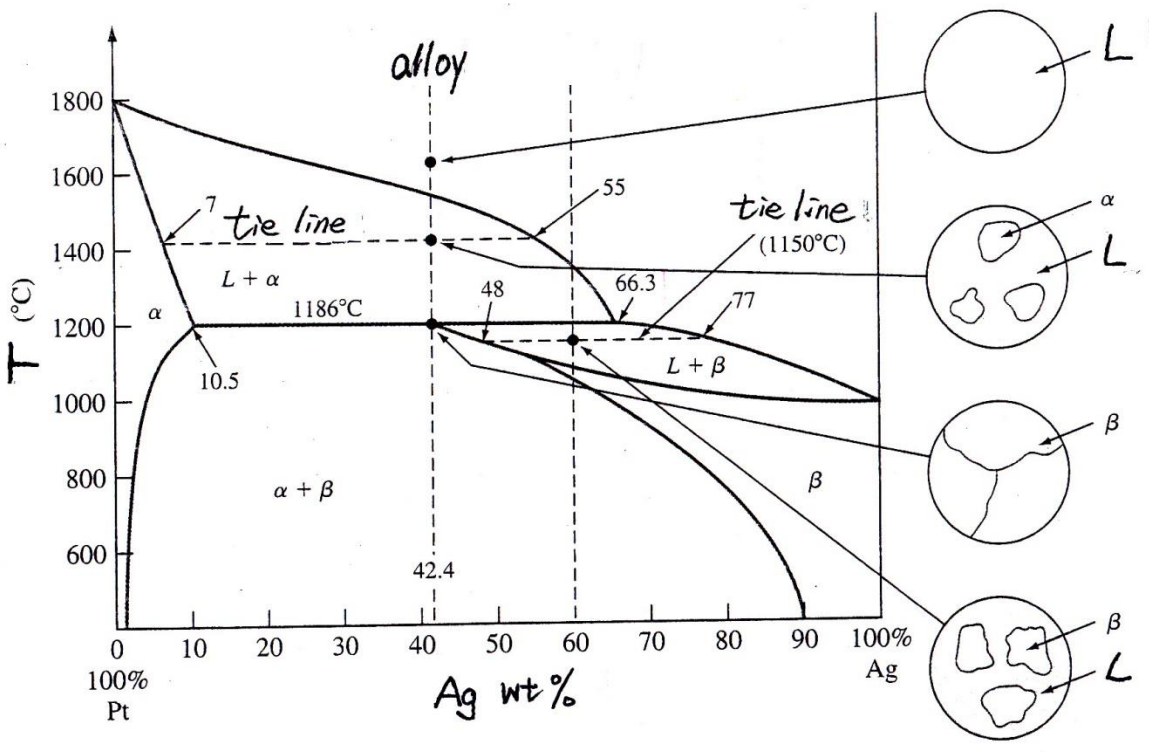
科目：工程材料

注意事項：
（1）本試題共有 4 題，每題 25 分，合計一百分。
（2）請依序作答於答案卷上並註明題號。
（3）可使用計算機，close book

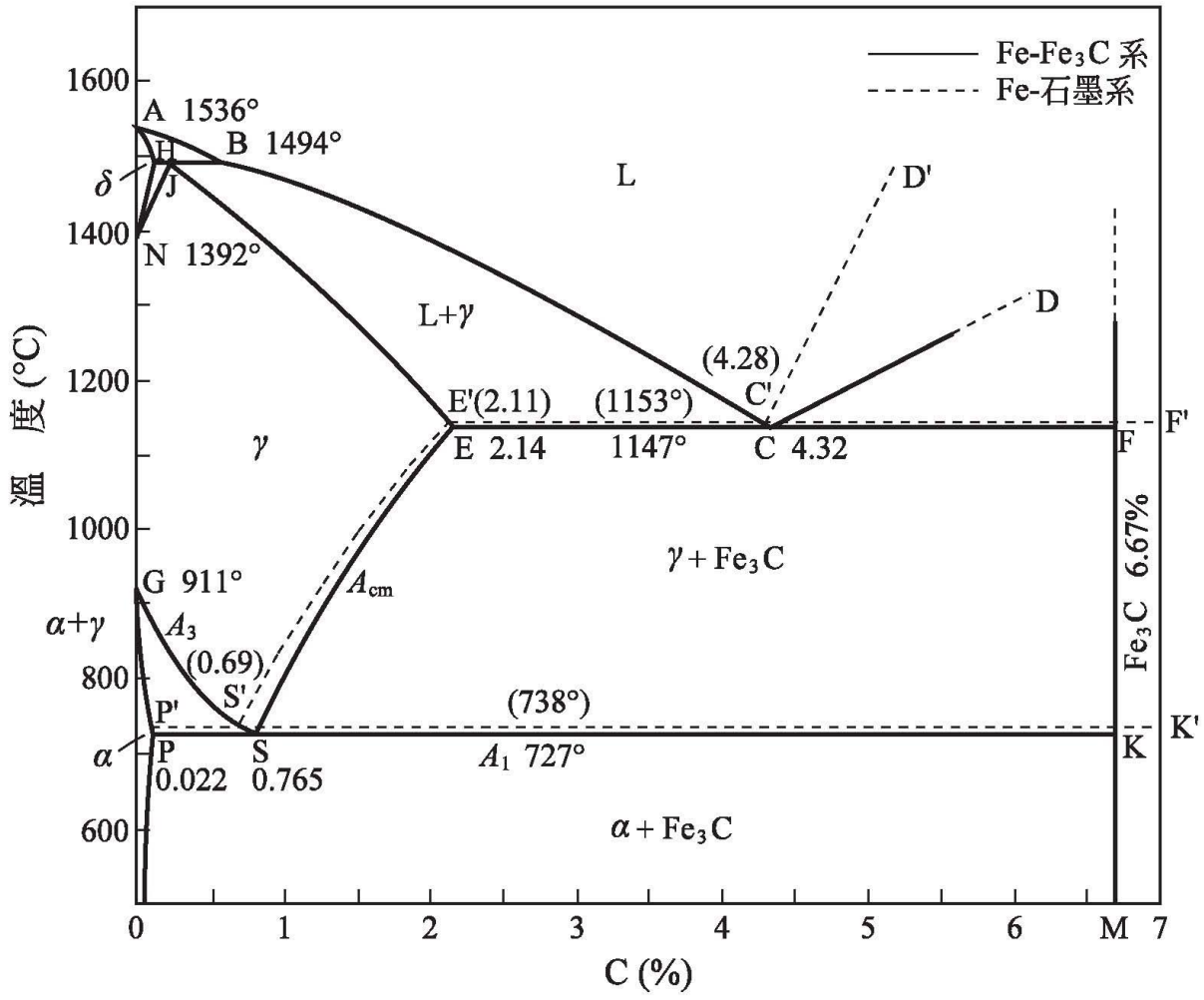
（1）If the copper atoms have a radius of 0.128 nm, determine the density in FCC and BCC structures. (Note: atomic mass of copper is 63.54 g/mol, Avogadro's number is 6.02×10^{23}). 25%

（2）To discuss the definitions of (a) Young's modulus; (b) Yield strength; (c) Tensile strength; (d) Toughness; (e) Brittle fracture in separate stress-strain diagram. 25%

（3）In the Pt-Ag (Platinum-Silver) equilibrium phase diagram, determine the component and ratio of phases in the following points. (a) 42.4 %Ag at 1400 ^{o}C; (b) 42.4 %Ag at 1186+ΔT ^{o}C. 25%



（4）In the Fe-Fe_3C equilibrium phase diagram, discuss the heat treatment for (a) full annealing; (b) normalizing; (c) quenching; (d) tempering. 25%



國立虎尾科技大學 104 學年度第一學期博士班資格考試題

所別：動力機械系機械與機電工程博士班　　

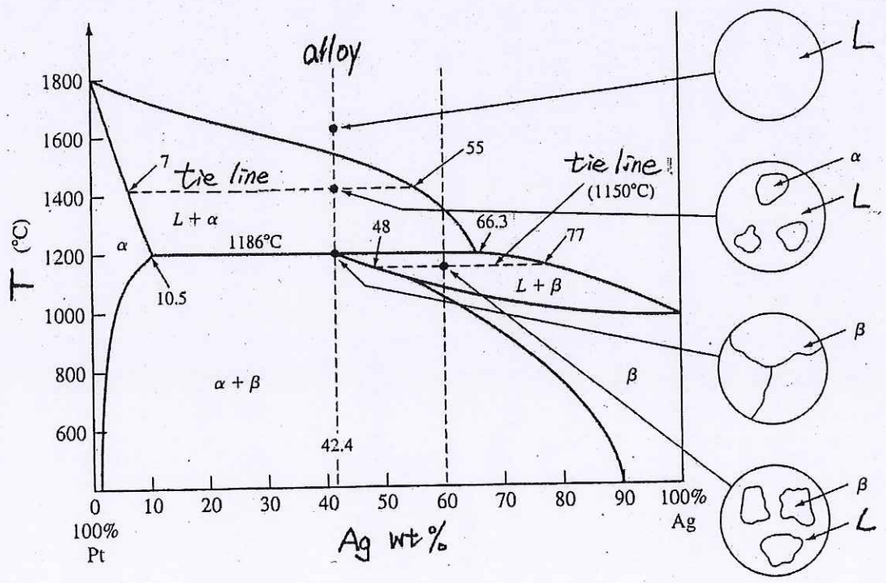
科目：工程材料

注意事項：
（1）本試題共有 4 題，每題 25 分，合計一百分。
（2）請依序作答於答案卷上並註明題號。
（3）可使用計算機，close book

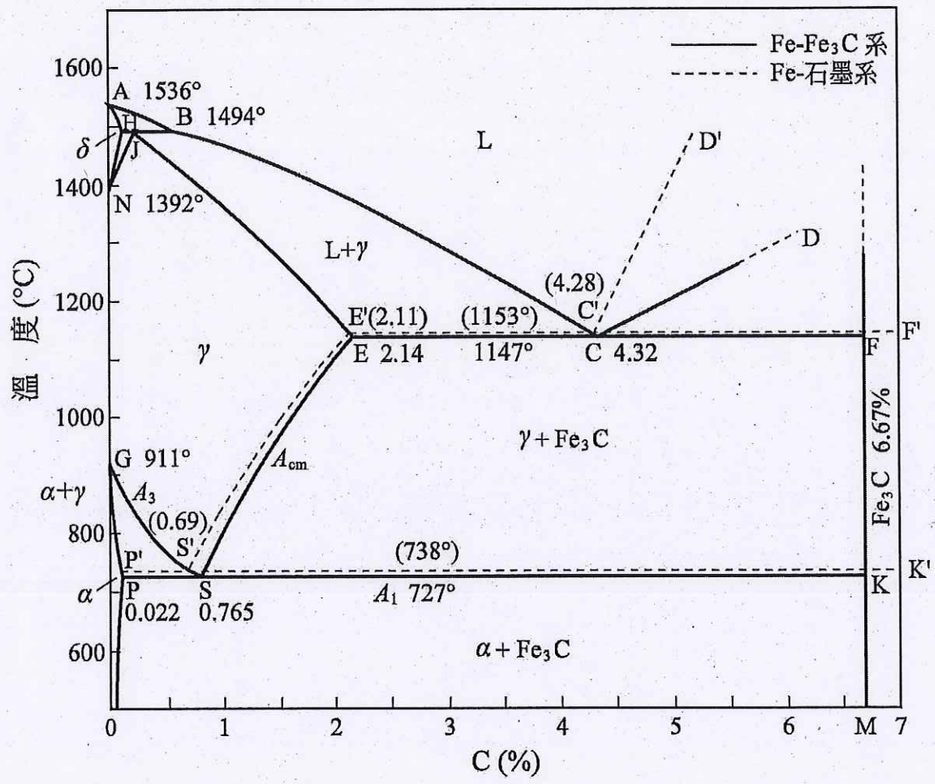
（1）If the copper atoms have a radius of 0.128 nm, determine the density in FCC and BCC structures. (Note: atomic mass of copper is 63.54 g/mol, Avogadro's number is 6.02×10^{23}). 25%

（2）To discuss the definitions of (a) Young's modulus; (b) Yield strength; (c) Tensile strength; (d) Toughness; (e) Brittle fracture in separate stress-strain diagram. 25%

（3）In the Pt-Ag (Platinum-Silver) equilibrium phase diagram, determine the component and ratio of phases in the following points. (a) 42.4 %Ag at 1400 °C. 25%



（4）In the Fe-Fe_3C equilibrium phase diagram, discuss the heat treatment for (a) full annealing; (b) normalizing; (c) quenching; (d) tempering. 25%



國立虎尾科技大學 106 學年度第一學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 1 頁

科目：工程材料

注意事項：
(1)本試題共有四題，每題二十五分，合計一百分。
(2)可使用計算機 close book

（1）Please define the meaning of the following items :

(a) Endurance Limit. (5%)

(b) Residual Stress. (5%)

(c) Brittle Fracture. (5%)

(d) Toughness.(5%)

(e) Work Hardening.(5%)

（2）(a) Explain the theory and design of C-60 Buckyball field-effect transistors (FETs). (15%)

(b) Describe the main structure of a single wall carbon nanotube (SWCNT). (10%)

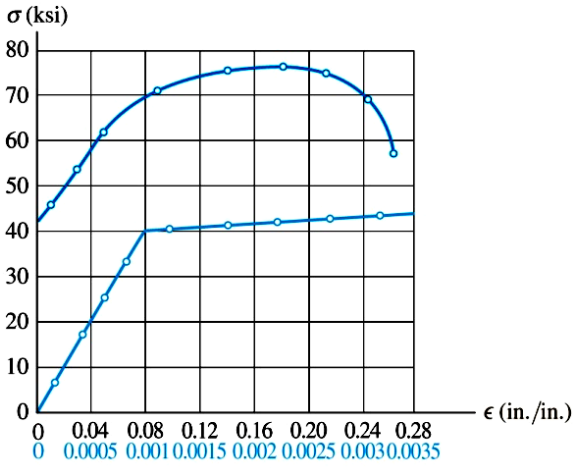
（3）A continuous and aligned glass fiber-reinforced composite consists of 40 vol% of glass fibers having a modulus of elasticity of 69 GPa and 60 vol% of a polyester resin that displays a modulus of 3.4 GPa .

(a) Compute the modulus of elasticity of this composite in the longitudinal direction. (5%)

(b) If the cross-sectional area is 250 mm^2 and a stress of 50 MPa is applied in this longitudinal direction, compute the magnitude of the load carried by each of the fiber and matrix phases. (10%)

(c) Determine the strain that is sustained by each phase when the stress in part (b) is applied. (10%)

（4）The stress-strain diagram for a steel alloy having an original diameter of 0.5 in. and a gauge length of 2 in. is given in the figure as shown.



(a) Determine the modulus of elasticity *E*. (5%)

(b) Determine the load P_y applying on the specimen that causes yielding. (5%)

(c) If the specimen is loaded until it is stressed to 70 ksi, determine the recovered elastic strain ε_{rec} after it is unloaded. (5%)

(d) If the specimen is loaded until it is stressed to 70 ksi, determine the amount of permanent increase in gauge length δ after it is unloaded. (10%)

國立虎尾科技大學 108 學年度第二學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 1 頁

科目：工程材料

注意事項：

（1）本試題共有 5 題，每題 20 分，合計一百分。

（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。

（3）可以使用工程計算機。

（4）close book.

1. Please explain the relationship between the crystallization size and degree of supercoiling after solidification of metal materials?

2. Please explain the relationship between cooling rate and transformation of carbon steel?

3. Explain the classifications and features of the semi-solid forming method of magnesium alloys?

4. When the iron atomic radius is 0.1263 nm, the crystal structure is FCC (The Face-centered Cubic Crystal Structure), and when the radius is 0.1241 nm, the crystal structure is BCC. Both the atomic weight is 55.847 g / mol.
   (1) When the crystal structure is FCC, what is the density of iron (g / cm^3)?
   (2) When the crystal structure is (crystal structure) BCC, what is the density of iron (g / cm^3)?

5. Titanium (Ti) has the HCP crystal structure, its lattice constant ratio c / a is 1.58, if the atomic radius of titanium is 0.1445nm; try to calculate: (1) the volume of a unit cell? (2) the density of unit cell?

國立虎尾科技大學 109 學年度第一學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 2 頁

科目：工程材料

注意事項：

（1）本試題共有 5 題，每題 20 分，合計一百分。

（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。

（3）可以使用工程計算機。

（4）close book.

1. Please explain and compare the ferrous metal and nonferrous metal?

2. Explain what transformations will occur during the heating of pure iron from room temperature to the melting point.

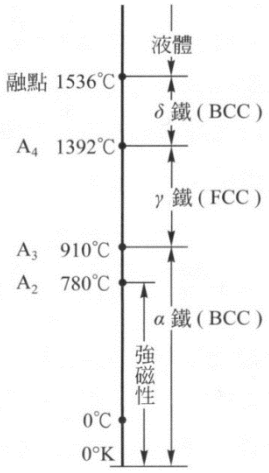


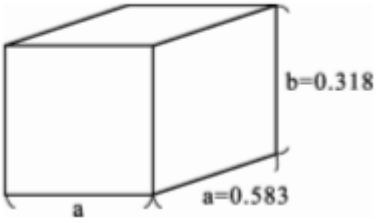
圖 9.2　純鐵之狀態圖

純鐵狀態圖

3. Please explain which alloying elements should be added to cast iron to have corrosion resistance?

4. Please compare and explain thermoplastic plastics and thermosetting plastics?

5. Sn has the cubic crystal structure, its lattice constant ratio a is 0.583 mm; b is 0.318 mm, if the atomic radius of Sn is 0.151 nm; density is 7.3 g / cm^3; atomic weight is 118.69 g / mol, try to calculate Atomic Packing Factor (APF)?



國立虎尾科技大學 109 學年度第 2 學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 1 頁

科目：工程材料

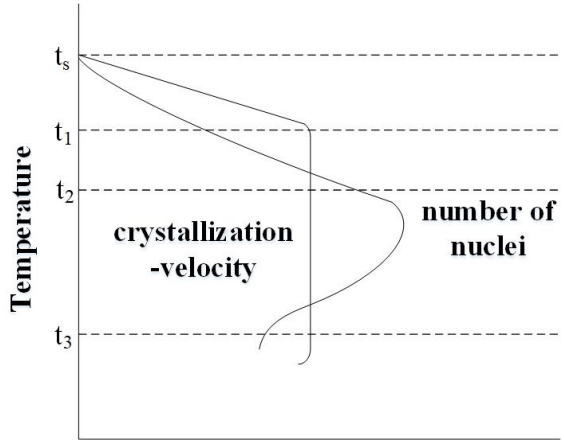
注意事項：

（1）本試題共有 5 題，每題 20 分，合計一百分。

（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。

（3）close book.

1. Please explain the relationship between the crystallization size and degree of supercoiling after solidification of metal materials?



2. Please explain which types of strengthening mechanisms are available for metal materials?

3. Please explain the process of martensite transformation of carbon steel and explain the Ms and Mf points?

4. Please explain the classification of magnesium alloys?

5. Please explain the classification of composite materials?

國立虎尾科技大學 110 學年度第一學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 1 頁

科目：工程材料

注意事項：

（1）本試題共有 5 題，每題 20 分，合計一百分。

（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。

（3）可使用工程計算機/close book.

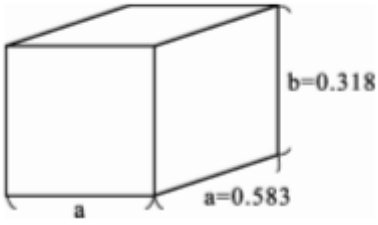
1. Please explain the features of intermetallic compound and what is the practical value in industry?

2. Explain what transformations will occur during the heating of pure iron from room temperature to the melting point.

3. Please explain the steel tempering and its scope and objective?

4. Please explain the necessary nature of heat resisting steel?

5. Sn has the cubic crystal structure, its lattice constant ratio a is 0.583 mm; b is 0.318 mm, if the atomic radius of Sn is 0.151 nm; density is 7.3 g / cm^3; atomic weight is 118.69 g / mol, try to calculate Atomic Packing Factor (APF)?



國立虎尾科技大學 110 學年度第二學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 1 頁

科目：工程材料

注意事項：

（1）本試題共有 5 題，每題 20 分，合計一百分。

（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。

（3）可使用工程計算機/close book.

1. The following flow curve parameters were obtained for a metal alloy in a tensile test: strength coefficient = 550 MPa and strain-hardening exponent = 0.25. The same metal is now tested in a compression test in which the starting height of the specimen = 50 mm and its diameter = 30 mm. Assuming that the cross section increases uniformly, determine the load required to compress the specimen to a height of (a) 45 mm and (b) 35 mm.

2. A polymer matrix composite consists of polyester reinforced with Kevlar-29 fibers. The volume fractions of polyester and Kevlar are 60% and 40%, respectively. The Kevlar fibers have a modulus of elasticity = 130 GPa in the longitudinal. The polyester matrix has a modulus of elasticity = 2500 MPa in both directions. Determine the modulus of elasticity for the composite in the (a) longitudinal direction and (b) transverse direction.

3. The metal rubidium has a BCC crystal structure. If the angle of diffraction for the (321) set of planes occurs at 27˚ (first-order reflection) when monochromatic x-radiation having a wavelength of o.071 nm is used, compute (a) the interplanar spacing for this set of planes, and (b) the atomic radius for the rubidium atom.

4. The density of totally crystalline polypropylene at room temperature is 0.946 g/cm^3. Also, at room temperature the unit cell for this material is monoclinic with lattice parameters

   a= 0.666nm, α= 90˚;

   b=2.078 nm, β= 99.62˚;

   c= 0.650 nm, γ= 90˚

   If the volume of a monoclinic unit cell. V_{mono} is a function of these lattice parameters as

   V_{mono}= abc sinβ

   determine the number of repeat units per unit cell.

5. Calculate the radius of an iridium atom, given that Ir has an FCC crystal structure, a density of 22.4 g/cm^3, and an atomic weight of 192.2 g/mol.

國立虎尾科技大學 111 學年度第 1 學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班

科目：工程材料 Engineering Material

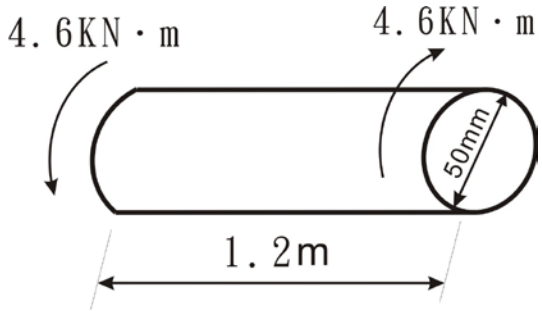
注意事項：
（1）本試題共有 9 題，合計一百分。
（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。
（3）可使用計算機 close book and use calculator

Problem Set # 1 (15%)

1. What do you need to prepare before you perform uniaxial testing experimental work? How to calculate Young's modulus and how to determine the unit after you have done the experiment?
2. A solid rod with length 1.2 meter and diameter 50mm. It was applied with a 4.6KNm torque on the end (as shown below). If the shear strength is 150MPa, please find the max allowable torque before yield.

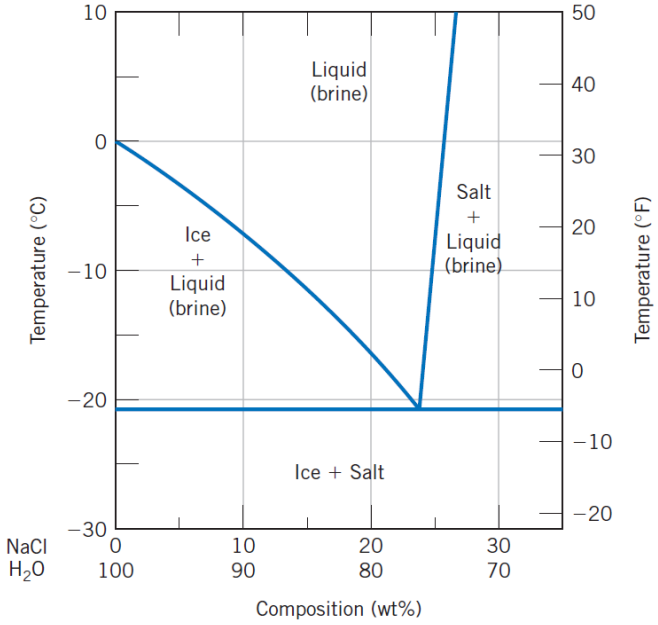
量測材料的楊氏係數（Young's modulus）是一項重要的工作，假設你手上有一片試片，實驗室中有一台拉伸實驗機，請問你在做拉伸實驗之前要先記錄試片甚麼特徵？在做完拉伸實驗後，假設你得到的是**彈性範圍**內的力量(kg)與位移(mm)，如何算出此試片的楊氏係數，其單位為何？

一長 1.2m，直徑 50mm 之實心圓軸，受到 4.6KNm 之扭矩，假設此圓軸抗剪強度是 150MPa，求降伏強度下最大扭矩



Problem Set # 2 (10%)

The following is a portion of the H_2O–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 # 3 (10%)

Show for the body-centered cubic crystal structure that the unit cell edge length a and the atomic radius R are related through a =4*R*/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 #4 (10%)

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:

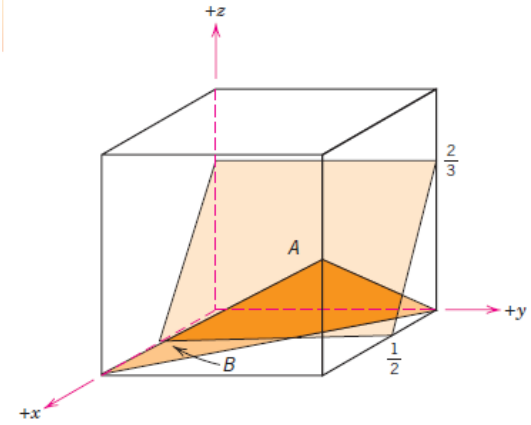
(a) $[\bar{1}10]$, *(e)* $[\bar{1}\bar{1}1]$,

(b) $[\bar{1}\bar{2}1]$, *(f)* $[\bar{1}22]$,

(c) $[0\bar{1}2]$, *(g)* $[1\bar{2}\bar{3}]$,

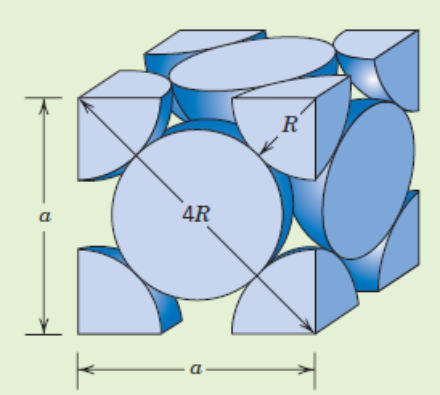
(d) $[1\bar{3}3]$, *(h)* $[\bar{1}03]$.

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



Problem set #5 (15%)

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，please show FCC[100] and [111] directions。

(2) 請計算 FCC[100]的線密度。請計算 FCC[111]的線密度。Please show FCC[100] and FCC[111] line density

(3) 請繪製 FCC(100)面，請計算 FCC(100)的面密度。Please show FCC(100) surface and calculate FCC(100) surface (area) density.

Problem set #6 (10%)

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 X10^{-3} mm (10^{-4} in.) change in diameter if the deformation is entirely elastic. The modulus of elasticity is 97 GPa (14 X10^{6} psi)

Problem set #7 (10%)

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

(a) At what temperature does the first liquid phase form?

(b) What is the composition of this liquid phase?

(c) At what temperature does complete melting of the alloy occur?

(d) What is the composition of the last solid remaining prior to complete melting?

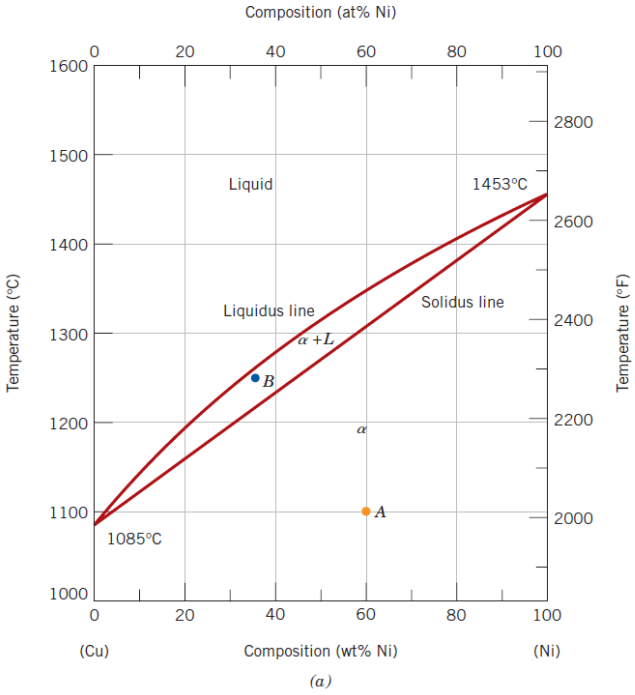


Figure 9.3 (*a*) The copper–nickel phase diagram. (*b*) A portion of the copper–nickel phase diagram for which compositions and phase amounts are determined at point *B*. (Adapted from *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Editor, 1991. Reprinted by permission of ASM International, Materials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

Problem set #8 (10%)

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.

(a) Cool rapidly to 700°C (1290°F), hold for 10^4 s, then quench to room temperature.

(b) *Reheat the specimen in part (a) to 700°C (1290°F) for 20 h.*

(c) *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.*

(d) *Cool rapidly to 400°C (750°F), hold for 2 s, then quench to room temperature.*

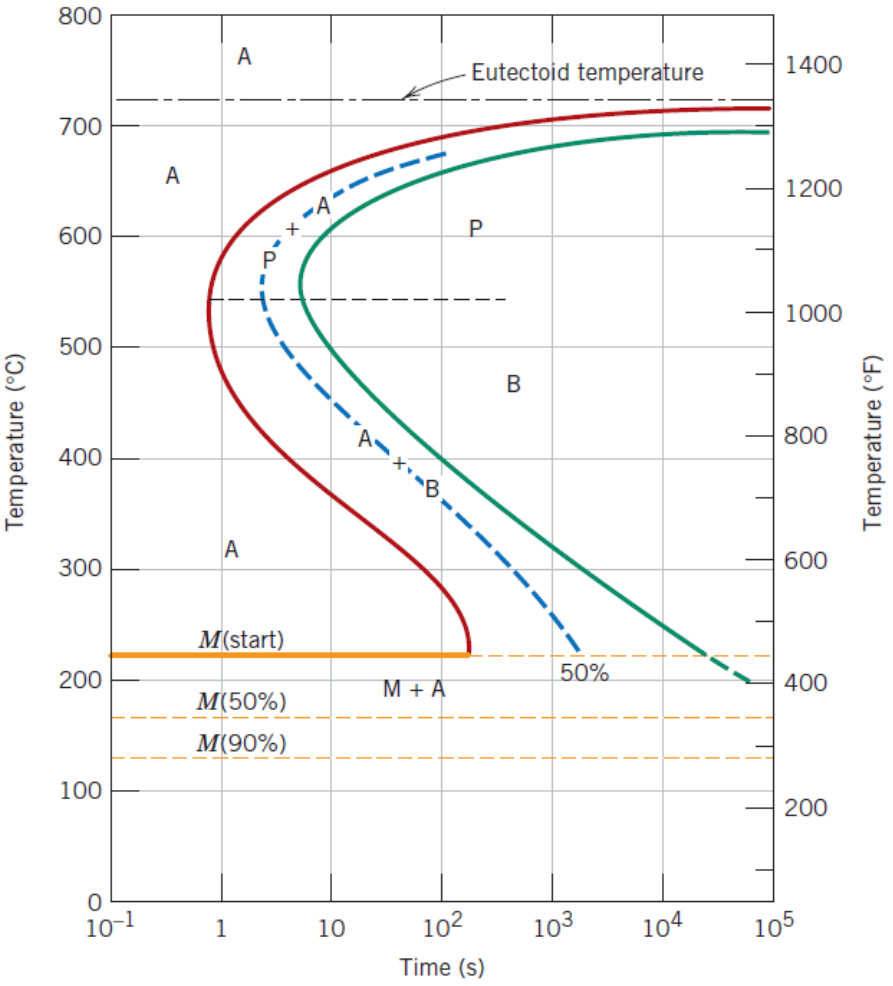


Figure 10.22 The complete isothermal transformation diagram for an iron–carbon alloy of eutectoid composition: A, austenite; B, bainite; M, martensite; P, pearlite.

Problem set #9 (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.

國立虎尾科技大學 111 學年度第 2 學期博士班資格考試題

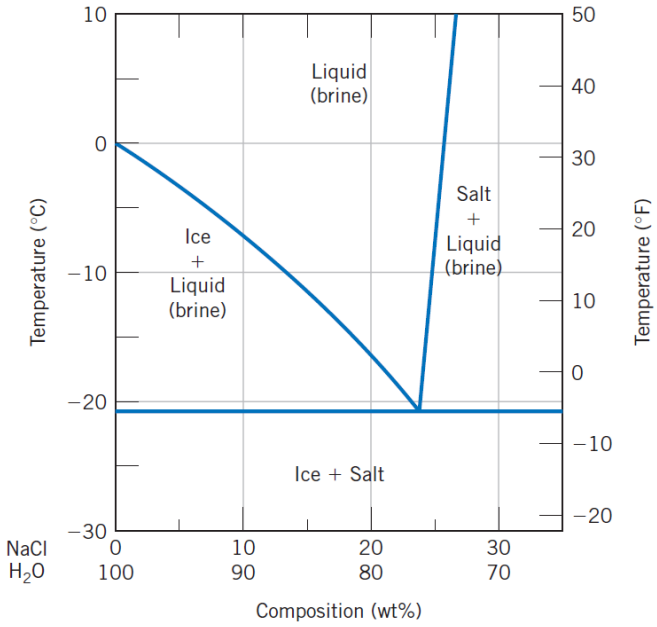
系別：動力機械工程系機械與機電工程博士班

科目：工程材料(Material Science and Engineering)

注意事項：
（1）本試題共有七題，合計 100 分。
（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。
（3）閉書考、可使用計算機
Close book and Engineering calculator is allowable.

Problem Set # 1 (20%)

The following is a portion of the H_2O–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) What is the ice/liquid ratio at -10C when 10% NaCl applied?

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

Problem Set # 2 (12%)

(a) Sketch within a cubic unit cell the following planes

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

(a) $(0\bar{1}\bar{1})$,

(b) $(11\bar{2})$,

(c) $(10\bar{2})$,

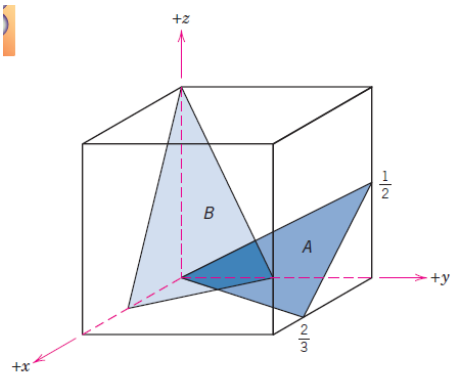
(d) $(1\bar{3}1)$,

(e) $(\bar{1}1\bar{1})$,

(f) $(1\bar{2}\bar{2})$,

(g) $(\bar{1}2\bar{3})$,

(h) $(0\bar{1}\bar{3})$



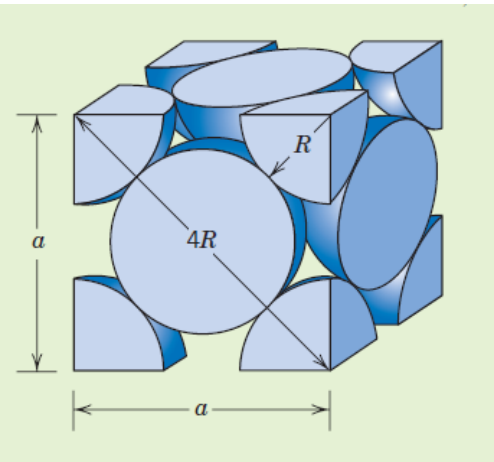
Problem Set # 3 (20%)

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

(b) Show that the atomic packing factor for the FCC crystal structure is 0.74.

(c) Show FCC[100]、[111] direction

(d) Show FCC[110]、 FCC[100] line density



Problem Set # 4 (10%)

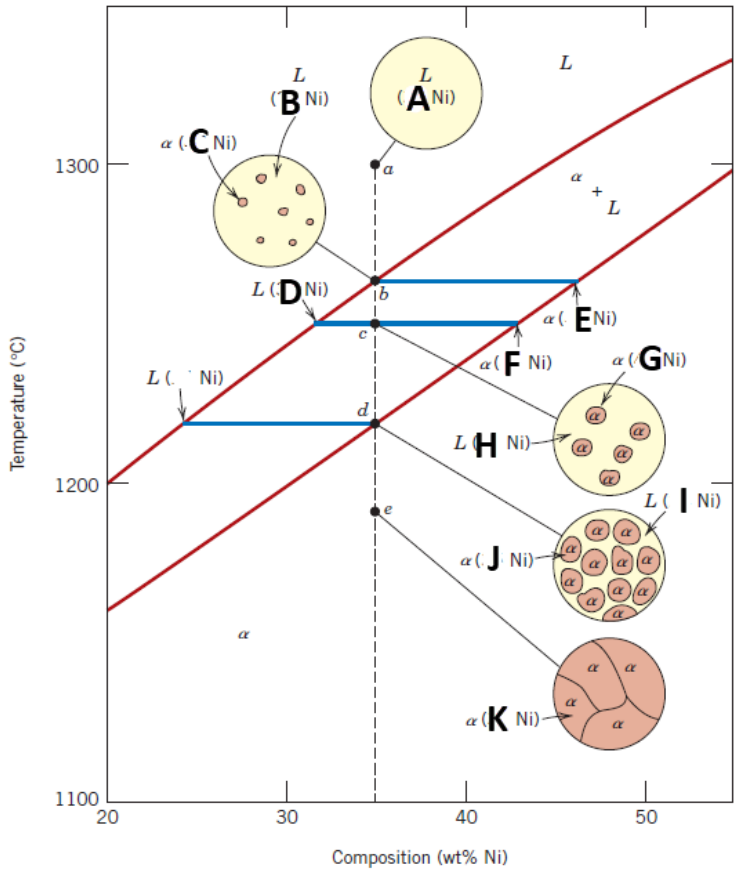
Below is the schematic representation of the development of microstructure during the equilibrium solidification of a 35 wt% Ni–65 wt% Cu alloy.

(a) Please explain cooling process from point a to e

(b) Please fill ABCDEFGHIJK number

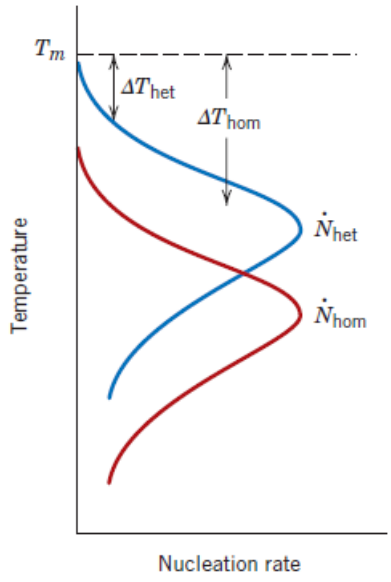
(c) What will happen to “non equilibrium cooling” in this figure? Please sketch.

(d) What is the percentage of two phases at Point E (using level rule) ?



Problem Set # 5 (10%)

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



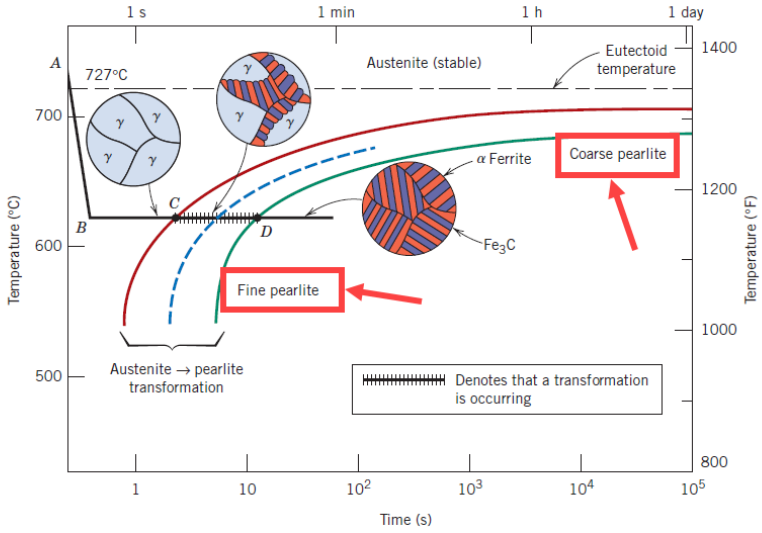


Figure 10.14 Isothermal transformation diagram for a eutectoid iron–carbon alloy, with superimposed isothermal heat treatment curve (*ABCD*). Microstructures before, during, and after the austenite-to-pearlite transformation are shown. [Adapted from H. Boyer

Problem Set # 6 (20%)

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 104 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 103 s, and quench to room temperature.

(d) what is the difference between time–temperature–transformation (or T–T–T) and continuous cooling transformation (CCT) diagrams? Make sketch to explain if needed.

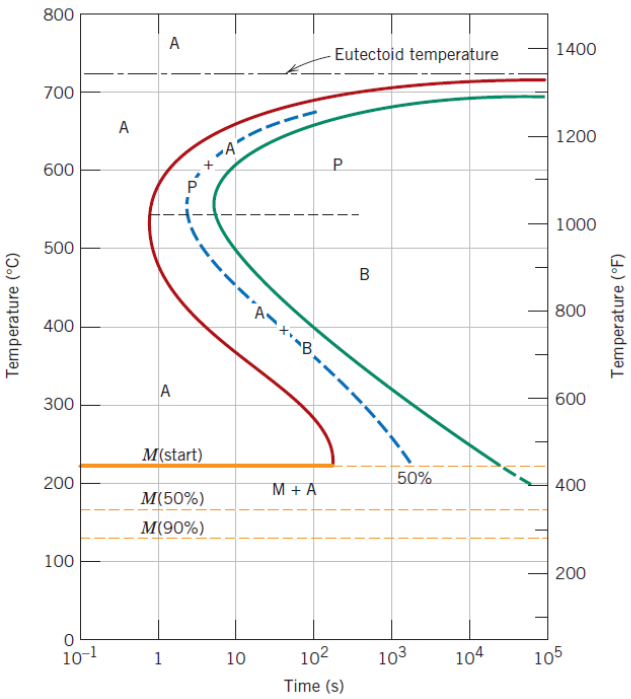


Figure 10.22 The complete isothermal transformation diagram for an iron–carbon alloy of eutectoid composition: A, austenite; B, bainite; M, martensite; P, pearlite.

Problem Set # 7 (8%)

Please sketch the iron–iron carbide phase diagram

Please outline the name of each phase on the diagram

國立虎尾科技大學 111 學年度第 2 學期博士班資格考試題

科目：○○○○○○

國立虎尾科技大學114學年度第2學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班

科目：工程材料 Engineering Material

注意事項：

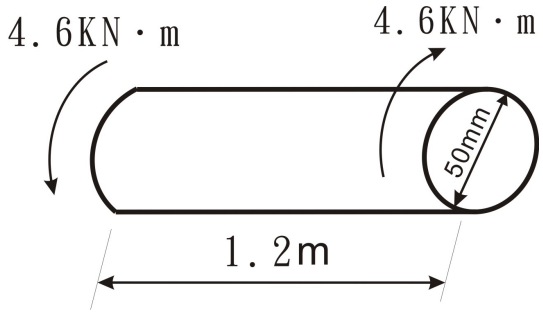
（1）本試題共有〇題，任選〇題作答，每題〇分，合計一百分。

（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。

（3）閉書考試、可使用計算機 close book and use calculator

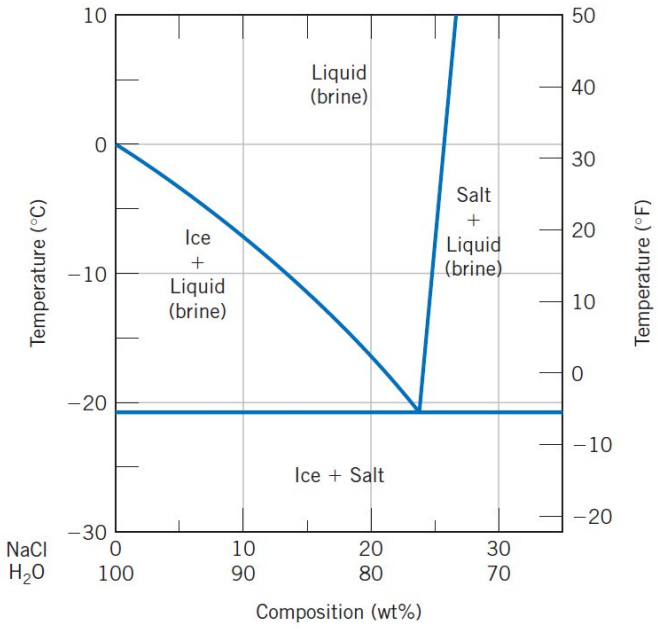
Problem Set # 1 (15%)

1. What do you need to prepare before you perform uniaxial testing experimental work? How to calculate Young's modulus and how to determine the unit after you have done the experiment?
2. A solid rod with length 1.2 meter and diameter 50mm. It was applied with a 4.6KNm torque on the end (as shown below). If the shear strength is 150MPa, please find the max allowable torque before yield.



Problem Set # 2 (10%)

The following is a portion of the H_2O–NaCl phase diagram:



(a) Using this diagram, briefly explain how spreading salt on ice that is at a temperature

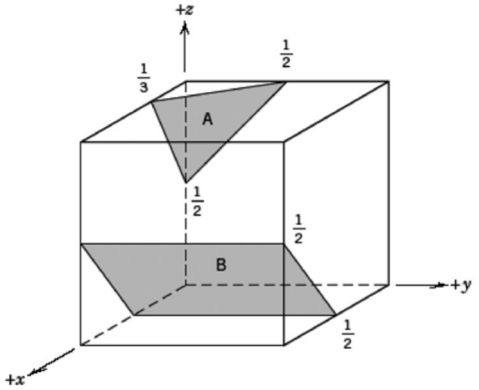
below 0_C (32_F) can cause the ice to melt.
(b) At what temperature is salt no longer useful in causing ice to melt?

Problem Set # 3 (10%)

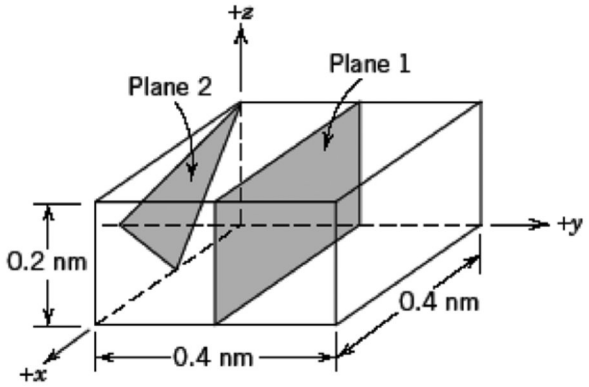
3.1 Show FCC [110] planar density (PD)
3.2 Show that the atomic packing factor for the FCC crystal structure is 0.74.
3.3 Calculate the volume of an FCC unit cell in terms of the atomic radius R.

Problem set #4 (20%)

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



4.2 What are the indices for the two planes drawn in the sketch below?



4.3 Sketch the atomic packing of (a) the (100) plane for the BCC crystal structure, and (b) the (201) plane for the FCC crystal structure
4.4 Within a cubic unit cell, sketch the following directions:

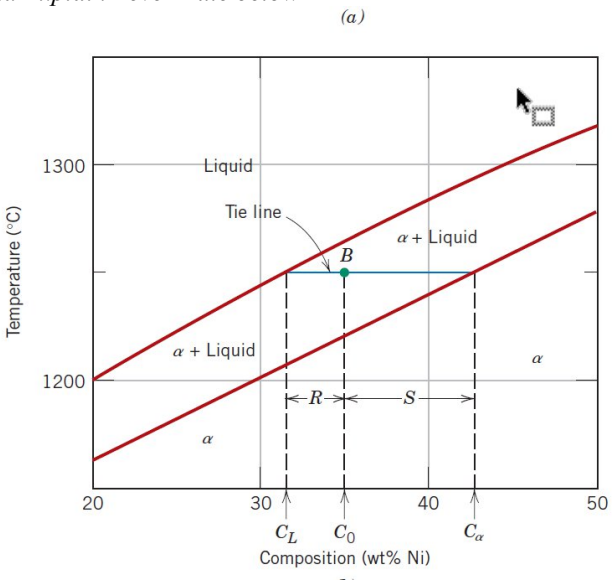
(a)	$[\bar{1}10]$,	*(e)*	$[\bar{1}\bar{1}1]$,
(b)	$[\bar{1}\bar{2}1]$,	*(f)*	$[\bar{1}22]$,
(c)	$[0\bar{1}2]$,	*(g)*	$[1\bar{2}\bar{3}]$,
(d)	$[1\bar{3}3]$,	*(h)*	$[\bar{1}03]$.

Problem set #5 (10%)

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 $X10^{-3}$ mm (10^{-4} in.) change in diameter if the
deformation is entirely elastic. The modulus of elasticity is 97 GPa (14 $X10^{6}$ psi)

Problem set #6 (10%)

Derive the lever rule below. And Explain Lever Rule below



Problem set #7 (15%)

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.

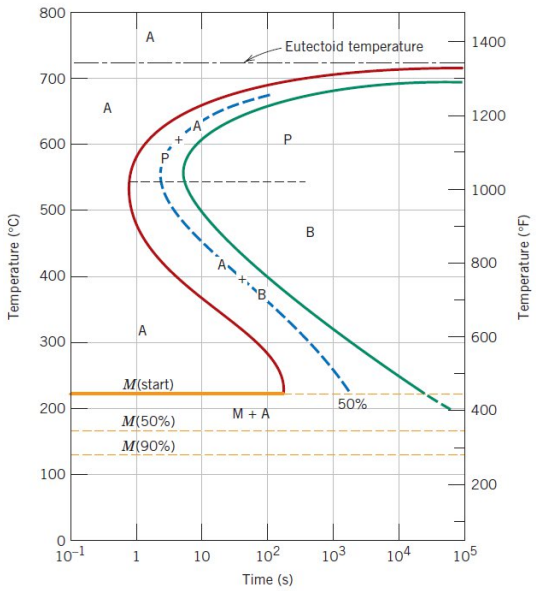


Figure 10.22 The complete isothermal transformation diagram for an iron–carbon alloy of eutectoid composition: A, austenite; B, bainite; M, martensite; P, pearlite.

Problem set #8 (10%)

1. what is the difference between Fig.10.22 (above) and Fig.10.26 (below)?
2. Explain the formation and mechanism between “Coarse pearlite” and “Fine pearlite” paths.

3. Any colling path to get “Coarse pearlite” and “Fine pearlite” using this figure? Why?

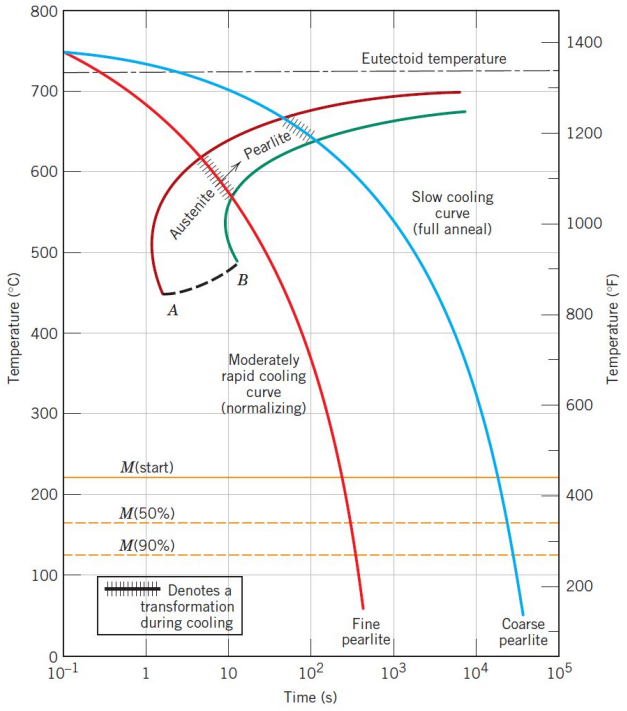


Figure 10.26 Moderately rapid and slow cooling curves superimposed on a continuous cooling transformation diagram for a eutectoid iron–carbon alloy.