

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX5204 Materials Engineering
Academic Year	: 2024/25
Date	: 27 th February 2026
Time	: 0930 hrs.-1230 hrs.
Duration	: 3 hours

General Instructions

1. This question paper consists of **Five (5)** questions in **Four (4)** pages.
2. Answer all **Five (5)** questions.
3. Answer for each question should commence from a new page.
4. Any missing data can be sensibly and reasonably assumed, but such assumptions are not acceptable unless they are justified and clearly stated.
5. This is a Closed Book Test (CBT).

Question 01

- a. i. Illustrate a typical fatigue fracture surface and indicate its important features. [3 marks]
ii. List 4 factors influencing fatigue of material and explain how each factor influence to the fatigue performance. [4 marks]
- b. i. Discuss creep resistant alloys, clearly explaining the concept of improving the creep resistance. [3 marks]
ii. Steady state creep data for a 50 mm long cylindrical specimen constructed from an S-590 alloy is shown in Figure Q1. If it is to be exposed to a tensile load of 70,000 N, what minimum diameter is required for it to experience an elongation of no more than 8.2 mm after an exposure for 1,500 h at 650°C? Assume that the sum of instantaneous and primary creep elongations is 0.6 mm. [10 marks]

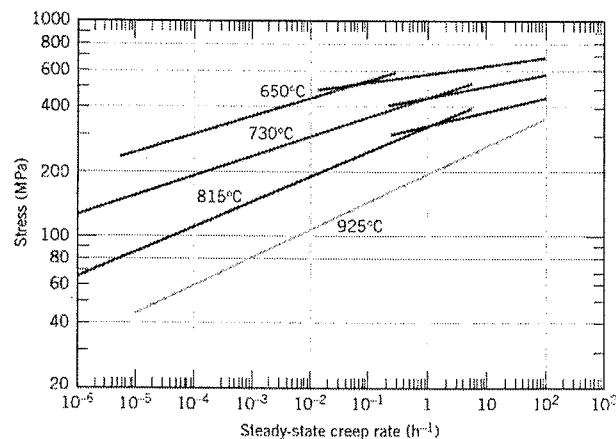


Figure Q1: Stress (logarithmic scale) versus steady-state creep rate (logarithmic scale) for an S-590 alloy at four temperatures.

Question 2

- Explain what invariant reactions are. [2 marks]
- Figure Q2 (a) is a portion of the $H_2O-NaCl$ phase diagram.
 - Referring to the phase diagram shown in Figure Q2(a), briefly explain how spreading salt on ice can cause the ice to melt. [2 marks]
 - As the ice cools below a certain temperature, salt is no longer useful in causing ice to melt. State the temperature below which salt is no longer cause ice to melt and explain why. [4 marks]

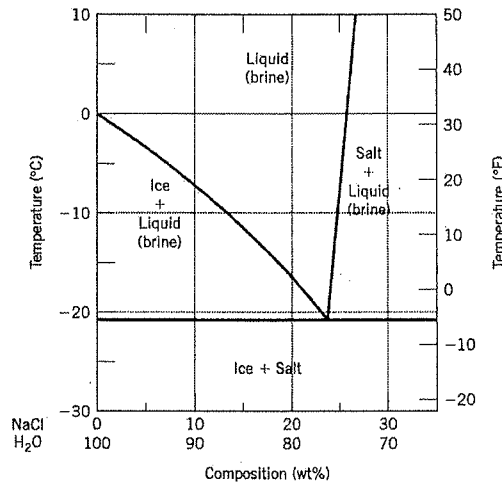


Figure Q2(a)- $H_2O-NaCl$ phase diagram.

- The iron-iron carbide phase diagram is shown in Figure Q2(b).
 - Name the phases corresponding to A, B, C, D, E, F, G and H. [3 marks]
 - Explain three important invariant reactions occur in the Iron carbon phase transformation.
Note: You must write the (1) name of the reaction, (2) write the reaction, (3) relevant temperature, and (4) Carbon %. [6 marks]
 - For a 99.65 wt.% Fe - 0.35 wt.% C alloy at a temperature just below the eutectoid, determine the fractions of total ferrite and cementite phases. [3 marks]

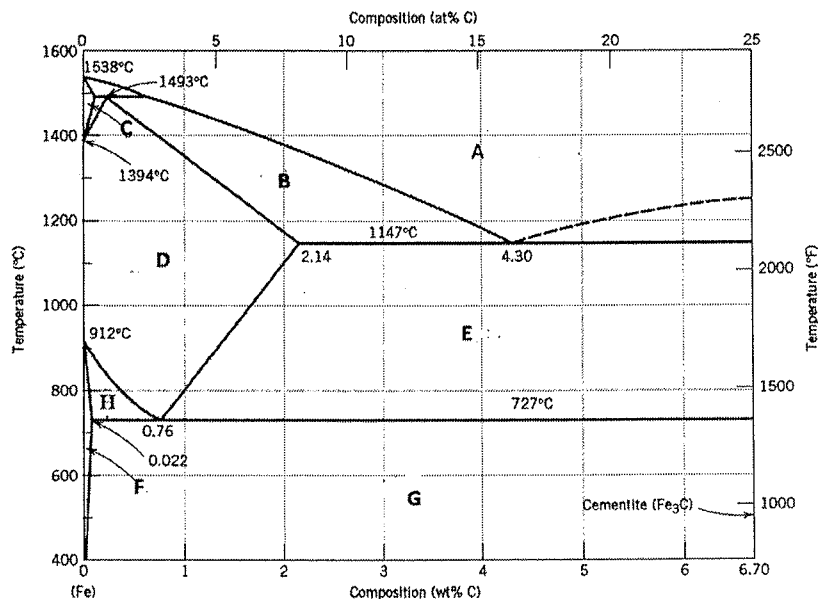


Figure Q2(b): The iron-iron carbide phase diagram.

An eutectoid steel (0.76 wt.%C) is subjected to various heat-treatment cycles. The Time–Temperature–Transformation (*TTT*) diagram for this steel is shown in Figure Q3.

- a. Briefly explain the purpose of a *TTT* diagram. [2 marks]
 - b. Explain the nature of the steel in the Austenite, Pearlite, Bainite, and Martensite regions. [4 marks]
 - c. A specimen is austenitized at 900°C and then rapidly cooled to 650°C and held isothermally for 100 s before quenching to room temperature.
 - i. Describe the sequence of phase transformations that occur. [3 marks]
 - ii. Name the final microstructure formed. [2 marks]
 - d. Another specimen is austenitized at 900°C and quenched directly to room temperature.
 - i. Explain why martensite forms during this process. [3 marks]
 - ii. State two important characteristics of martensite. [2 marks]
 - e. Using the *TTT* diagram, explain how cooling rates influence the mechanical properties of steel. Refer specifically to hardness and toughness. [4 marks]
- Note: Answer should consider; (1) Slow cooling (Furnace Cooling), (2) Moderate cooling (Air Cooling), (3) Faster cooling (Oil Quenching / Controlled Cooling), and (4) Very-rapid cooling (Water Quenching)*

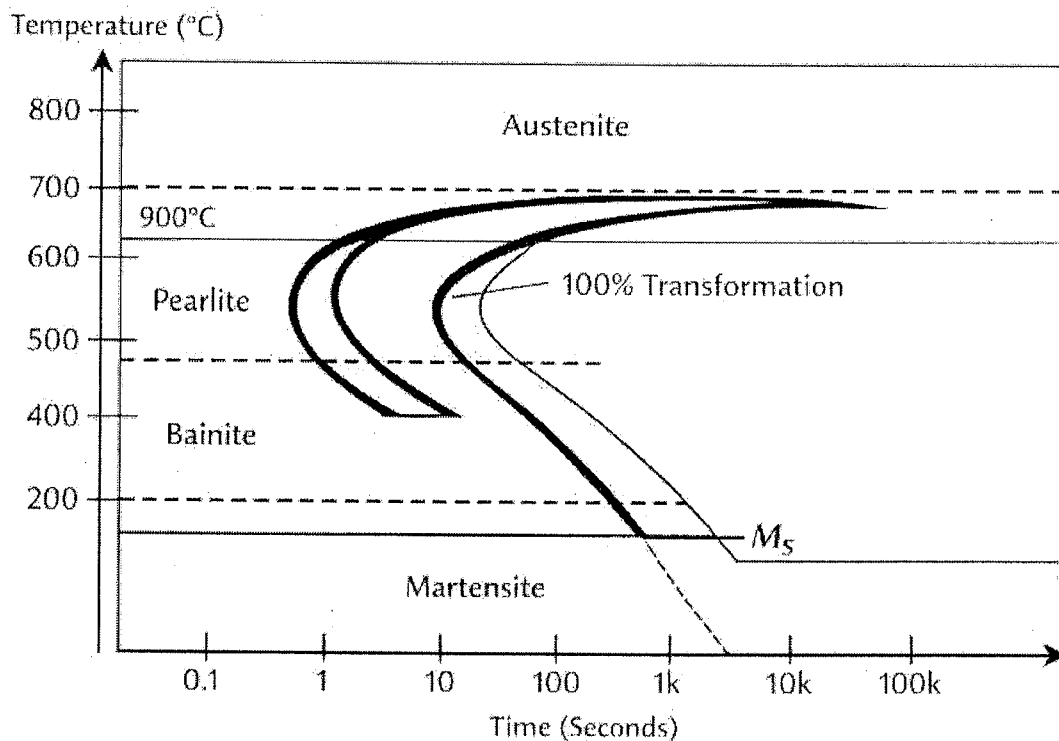


Figure Q3: *TTT* diagram for eutectoid steel (0.76 wt.% C)

Question 4

- a. By means of sketches, illustrate Corundum, Silicate and Olivine crystal structures of ceramics. [3 marks]
- b. i. Distinguish Traditional ceramics with High-performance ceramics. [3 marks]
- ii. List 3 advantages of High-performance ceramics over traditional ceramics. [3 marks]
- iii. List 3 limitations of High-performance ceramics. [3 marks]
- c. Write short notes on the following.
- i. Ceramic semiconductors. [4 marks]
- ii. Piezoelectric effect of ceramics. [4 marks]

Question 5

- a. Derive an equation for elastic modulus of a lamellar continuous fiber and matrix composite for isostrain conditions in terms of volume fractions of the composite and their modulus. [8 marks]
- b. A continuous and aligned carbon fiber-reinforced epoxy matrix composite is to be produced consisting of 64 vol.% carbon fiber and 36 vol.% epoxy matrix. Refer Table Q5 for mechanical characteristics of these two materials.

Table Q5: Mechanical characteristics

	Tensile modulus of elasticity (GPa)	Tensile strength (MPa)
Carbon fiber	372.6	2136
Epoxy matrix	3.65	63.5

Calculate,

- i. the tensile modulus of elasticity of the composite. [4 marks]
- ii. the tensile strength of the composite. [4 marks]
- iii. fraction of the load carried by carbon fiber. [4 marks]

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