Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2022/2023

| | | |
|---|---|---|
| COURSE NAME | : | MATERIAL ENGINEERING TECHNOLOGY |
| COURSE CODE | : | BNQ 20503 |
| PROGRAMME | : | BNN |
| EXAMINATION DATE | : | JULY/AUGUST 2023 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | 1. ANSWER **ALL** QUESTIONS |
| | | 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** |
| | | 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK |

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES ONLY

**Q1** (a) (i) Describe the importance of phase diagrams to a system with given temperature and composition.

(3 marks)

(ii) Express your understanding on solubility limit.

(4 marks)

(iii) Identify **THREE (3)** variables that determine the microstructure of an alloy.

(3 marks)

(b) **Figure Q1(b)** shows a portion of the titanium-copper phase diagram

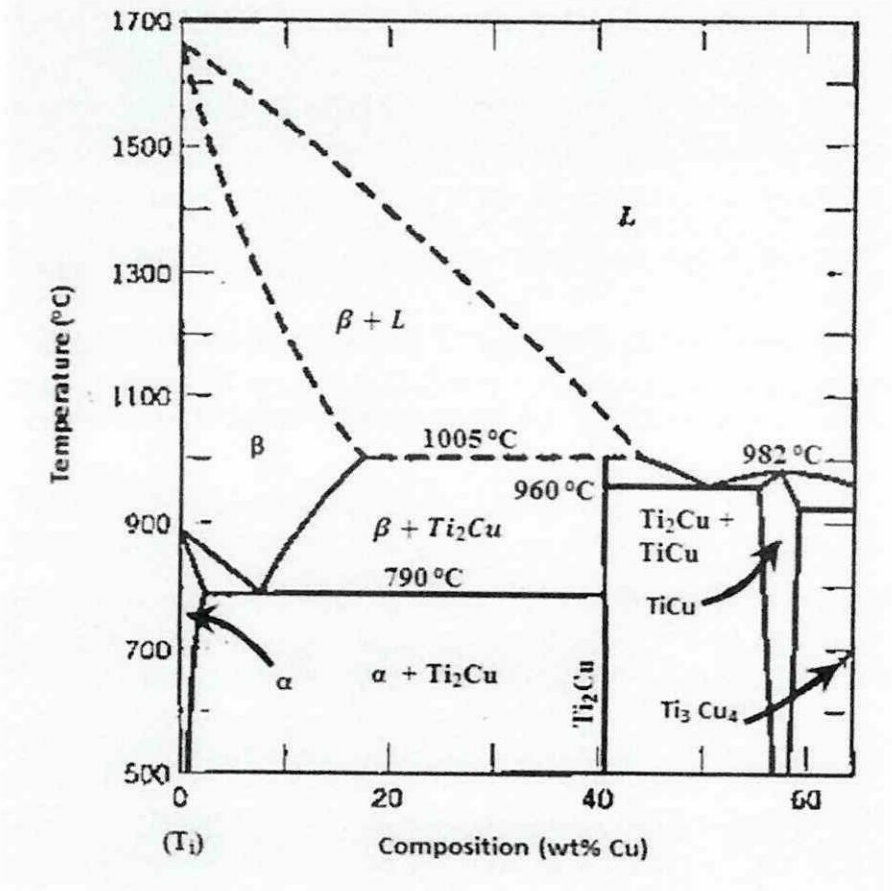


**Figure Q1(b): Titanium-Copper Phase Diagram**

(i) Determine all composition and temperature points at which eutectic, eutectoid, peritectic, and congruent phase transformations occur.

*Example answer:*
*Eutectic point: about XX wt% Cu – YY wt% Ti at Z °C (Z Kelvin)*

(4 marks)

(ii) For each point in **Q1(b)(i),** identify the equation of reaction upon cooling.

*Example answer: A → B + C*

(4 marks)

(c) **Figure Q1(c)** shows the iron-carbide phase diagram. Consider 2.5 kg of austenite containing 0.65 wt% C is cooled to below 725°C (998K).

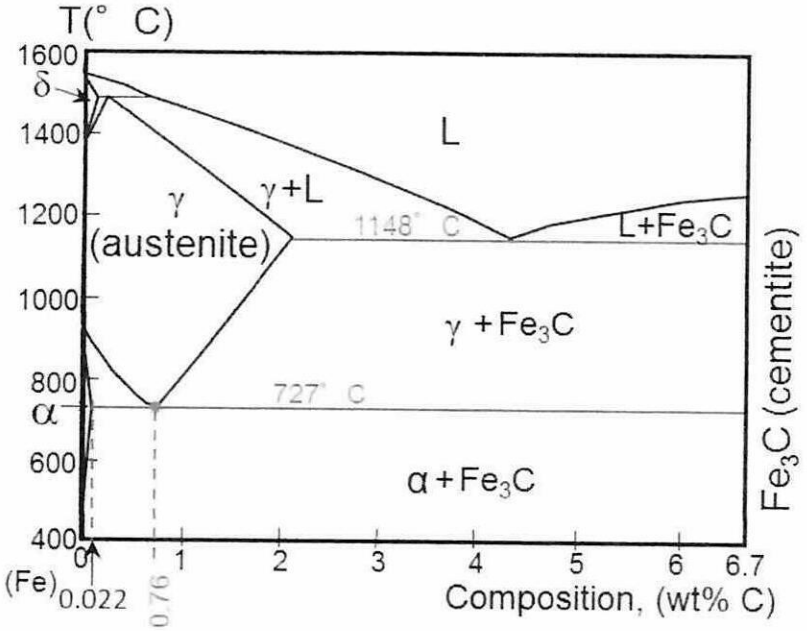


**Figure Q1 (c): Iron-Carbide Phase Diagram**

(i) Identify the proeutectoid phase

(1 mark)

(ii) Determine the quantity of total ferrite and cementite formed.

(3 marks)

(iii) Schematically sketch and label the resulting microstructure upon cooling.

(3 marks)

**Q2** (a) For a bronze alloy, the stress at which plastic deformation begins is 280 MPa, and the modulus of elasticity is 115 GPa.

(i) Determine the maximum load that may be applied to a specimen with a cross-sectional area of 325 $mm^2$ without plastic deformation.

(2 marks)

(ii) If the original specimen length is 120 mm, determine the maximum length to which it may be stretch without causing plastic deformation.

(2 marks)

(b) A cylindrical rod 380 mm long, having a diameter of 10.0 mm, is to be subjected to a tensile load. If the rod is to experience neither plastic deformation nor an elongation of more than 0.9 mm when the applied load is 24,500 N, which of the four metals or alloys shown in **Table Q2 (b)** are possible candidates? Justify your choice(s).

**Table Q2 (b)**

| Material | Modulus of Elasticity (GPa) | Yield Strength (MPa) | Tensile Strength (MPa) |
|---|---|---|---|
| **Aluminium alloy** | 70 | 255 | 420 |
| **Brass Alloy** | 100 | 345 | 420 |
| **Copper** | 110 | 250 | 290 |
| **Steel Alloy** | 207 | 450 | 550 |

(8 marks)

(c) Explain the term '*annealing*', '*quenching*' and '*tempering*'. In your explanation, includes the importance, purposes, and effects of each respective term in producing specific desirable metal alloy.

(9 marks)

(d) Briefly describe the phenomena of superheating and supercooling

(4 marks)

**Q3** (a) Corrosion of metals causes the spending of approximately 5% of an industrialized nation's income on prevention, maintenance, or replacement of products lost or contaminated as a result of corrosion reactions.

(i) Define the term '*corrosion*'.

(2 marks)

(ii) Discuss **FIVE (5)** forms of corrosion mechanisms. Give an example for each type.

(10 marks)

(iii) For each type of corrosion in **Q3 (a)(ii),** suggest **ONE (1)** best prevention method.

(5 marks)

(b) Tin cans are made of steel, the inside of which is coated with a thin layer of tin. The tin protects the steel from corrosion by food products in the same manner as zinc protects steel from atmospheric corrosion. Explain how this cathodic protection of tin cans is possible, given that tin is electrochemically less active than steel in the galvanic series. Support your answer with overall reaction and half-reactions that occur.

(8 marks)

**Q4** (a) Creep is normally undesirable phenomenon and is often the limiting factor in the lifetime of a part or components.

(i) Define the term '*creep*'.

(3 marks)

(ii) Explain the primary, secondary, and tertiary stages of creep.

(5 marks)

(b) A steel bar is subjected to a tensile stress of 200 MPa at a temperature of 550 °C for 100 hours. The initial length of the bar is 500 mm, and the final length is 505 mm. Calculate the creep rate of the steel.

(5 marks)

(c) Differentiate the terms '*minimum creep rate*' and '*rupture time*'.

(6 marks)

(d) Using the Larson–Miller data for the S-590 alloy shown in **Figure Q4 (d)**, predict the time to rupture for a component that is subjected to a stress of 140 MPa (20,000 psi) at 800 °C.

(6 marks)

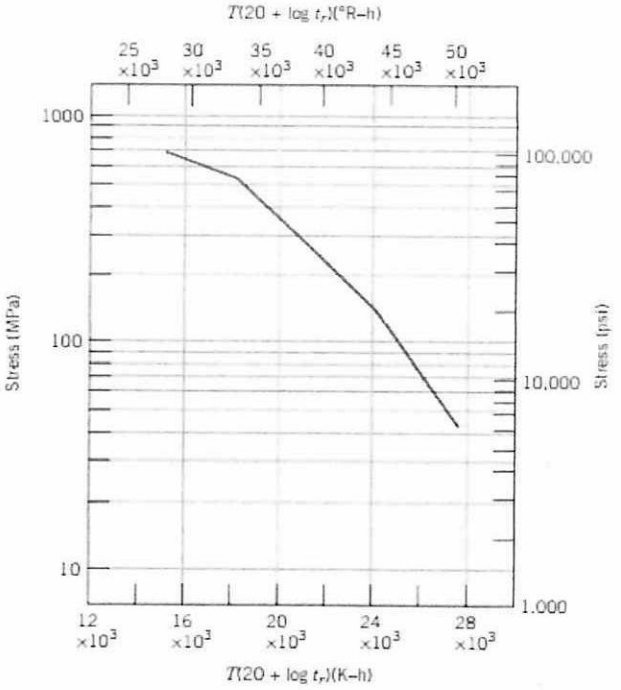


**Figure Q4 (d)**

**-END OF QUESTIONS-**