UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	ENGINEERING TECHNOLOGY MATERIALS
COURSE CODE	:	BDU 10603
PROGRAMME CODE	:	BDC
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **FOUR(4)** QUESTIONS FROM FIVE (5) QUESTIONS ONLY 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION

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

Q1 (a) Explain why mechanical engineers should be knowledgeable about the composition, properties and processing of materials.

(10 marks)

(b) Make a list of five (5) major components for aircraft. For each component, determine the class of materials used in its structure and justify your answer.

(10 marks)

(c) Nickle base superalloys are used in the structure of aircraft turbine engines. Describe major properties of this metal that make it suitable for this application.

(5 marks)

Q2 (a) Distinguish between crystal structure and crystal system in terms of its structure and atomic arrangement.

(3 marks)

(b) The cubic crystal plane intersects at the following position coordinates: (1, ¼, 0), (1, 1, ½), (¾, 0, ¼). Determine its Miller indices.

(5 marks)

(c) Differentiate the atomic packing factor between a body-centered cubic (BCC) and a face-centered cubic (FCC) crystal structure. Which structure exhibits a greater atomic packing factor and what is the reason for this? Explain briefly and include a numerical example for Gold that has both crystal structures. Given, Gold has an FCC crystal structure with a lattice constant of 4.08 Å and BCC crystal structure has a lattice constant of 4.16 Å.

(12 marks)

(d) Compare planar density at (110) plane for body centered cube structure and face centered cube structure (FCC) with respect to number of atoms intersected. Show appropriate sketches in your answer.

(5 marks)

Q3 (a) An FCC iron-carbon alloy initially containing 0.35% C is exposed to an oxygen-rich and virtually carbon-free atmosphere at 1400K(1127°C). Under these circumstances, the carbon diffuses from the alloy and reacts at the surface with the oxygen in the atmosphere; that is, the carbon concentration at the surface position is maintained essentially at 0wt%. Identify the position in which the carbon concentration will be 0.15wt% after 10 hours of treatment. The value of D at 1400K is 6.9×10^{-11} m/s. Please refer to **Table APPENDIX A.1**

(8 marks)

(b) (i) Describe and illustrate the Frenkel and Schottky imperfections that can be present in the metal lattice.

(3 marks)

(ii) Is it possible to have a Frenkel defect in covalent crystals?

(2 marks)

(c) Is non steady state diffusion process more sensitive to temperature or time? Explain using appropriate equations.

(6 marks)

(d) The diffusivity of silver atoms in solid silver metals is 1.0×10^{-17} m^2/s at 500°C and 7.0×10^{-13} m^2/s at 1000°C. Calculate the activation energy (joules per mole) for the diffusion of Ag in Ag in the temperature range 500°C to 1000°C.

(6 marks)

Q4 (a) As a researcher, you are interested in analyzing the stress-strain diagram. If the material tested is a ductile metal, construct the expected stress-strain diagram. Highlight the key strength points (yield, ultimate, and fracture strength) on the curve.

(5 marks)

(b) By refer to your constructed diagram in **Q4(a)**, schematically, show what happens if you load the specimen just below the yield point and then unload to zero. Will the specimen behave differently if you load it again? Explain.

(8 marks)

(c) Distinguish the mechanical testing of materials (hardness, impact, fatigue, and creep test) in terms of loading and purpose.

(12 marks)

Q5 **(a)** Consider the binary eutectic copper-silver phase diagram in **Fig. Q5.1**. Make phase analyses of an 88 wt % Ag–12 wt % Cu alloy at the following temperatures. In the phase analyses, include the phases present, the chemical composition, the amount of each phase and sketch the microstructure.

(i) 800°C

(8 marks)

(ii) 780°C -ΔT .

(8 marks)

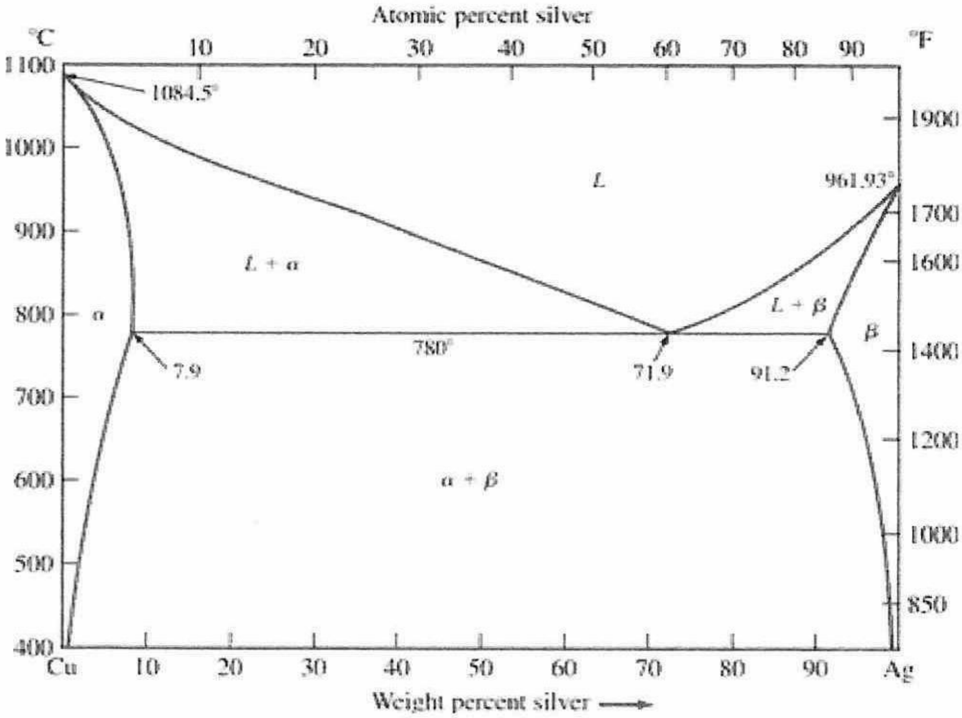

Figure Q5.1 Cu-Ag Phase Diagram

(b) Distinguish heat treatment of steel between full annealing and normalizing in terms of their heat treatment procedure and microstructure.

(5 marks)

(c) Compare the microstructure and heat treatment procedure for martensite and pearlite steel.

(4 marks)

- END OF QUESTIONS -

APPENDIX A

Table APPENDIX A.1 Tabulation of Error Function Values

z	erf(z)	z	erf(z)	z	erf(z)
0	0	0.55	0.5666	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999