GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND THE ENVIRONMENT

2ND SEMESTER EXAMINATION

COURSE : **ENGINEERING MATERIALS**

CODE : **EMR/EMI 1204**

DATE : **MAY/ JUNE**

DURATION : **3 HOURS**

EXAMINER : **MR P CHAMBOKO**

AUTHORISED MATERIALS : **CALCULATOR**

INSTRUCTIONS AND INFORMATION FOR THE CANDIDATES

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1. Attempt the whole of Section A and three questions from Section B.
2. Each question carries twenty **(20**) marks and there are seven **(7)** questions in total.
3. Start each question on a fresh page
4. Use good engineering language and clear presentation in your answers.
5. This paper comprises five **(**5**)** printed pages
6. Good luck!!

NB: DO NOT TURN OVER THE QUESTION PAPER OR COMMENCE WRITING UNTIL INSTRUCTED TO DO SO

SECTION A

Question 1

(a) Derive the relationships between unit cell edge length and atomic radius for face-centered cubic and body-centered cubic crystal structures. [8]

(b) Show that the atomic packing factor for the FCC crystal structure is 0.74. [5]

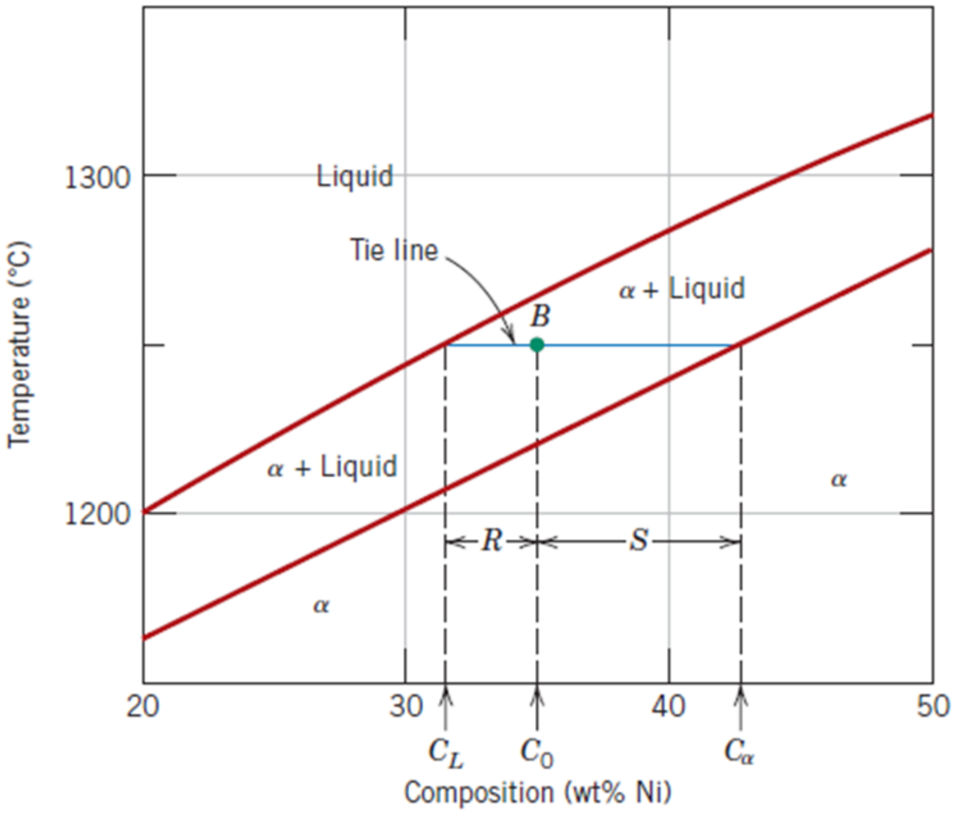
(c) Copper has an atomic radius of 0.128 nm, an FCC crystal structure, and an atomic weight of 63.5 g/mol. Compute its theoretical density and compare the answer with its measured density. [5]

(d) Define polymorphism. [2]

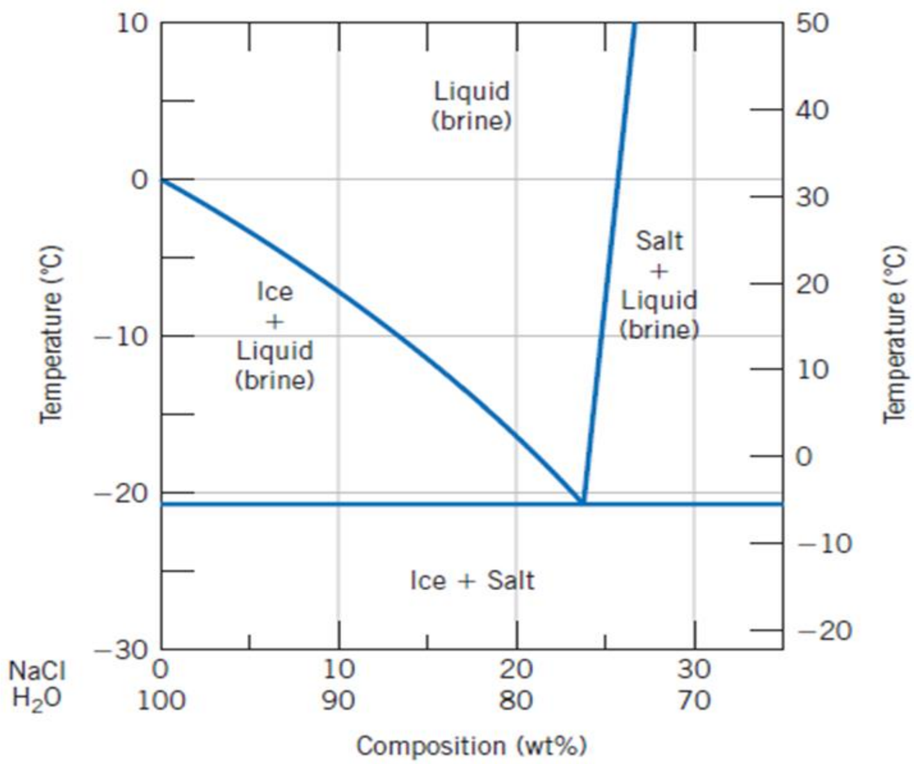
Question 2

(a) Draw a well-labeled diagram of the iron–iron carbide (Fe–Fe_3C) phase diagram and explain the phases in detail, showing the three-phase reactions i.e. eutectic, eutectoid, and peritectic. [10]

(b) Derive the lever rule with the copper–nickel phase diagram below. [5]



(c) Below is a portion of the H_2O–NaCl phase diagram:



Using this diagram, briefly explain how spreading salt on ice that is at a temperature below 0^oC (32^oF) can cause the ice to melt. [3]

(d) At what temperature is salt no longer useful in causing ice to melt? [2]

SECTION B

Question 3

(a) A crankshaft is made of forged steel. However, the crankshaft is simultaneously subjected to bending and torsion when revolving. Because of the way they work, is expected to have a hard casing and tough core. Describe, with the aid of diagrams where applicable, any heat treatment method/s that can be applied in order to meet this objective. [10]

(b) For the same chemical composition, the densities of forged and cast steel are different. Explain. [10]

Question 4

(a) What is a composite material? [3]

(b) What material can be used for automobile building and why? [5]

(c) How do fiber orientation and concentration influence the strength of fiber-reinforced composites? [12]

Question 5

(a) Explain two reasons interstitial diffusion proceeds faster than vacancy diffusion [4]

(b) What are the key differences between steady-state and non-steady-state diffusion? [6]

(c) A sheet of steel 2.5 mm thick has nitrogen atmospheres on both sides at 900^oC and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is 1.2×10^{-10} m^2/sand the diffusion flux is found to be 1.0×10^{-7} m^2/s. Also, it is known that the concentration of nitrogen in the steel at the high-pressure surface is 2 kg/m^3. How far into the sheet from this high-pressure side will the concentration be 0.5 kg/m^3? [10]

Question 6

(a) Explain why titanium alloys are finding increased application as biomedical implants. [5]

(b) What are the key differences between mild steel and stainless steel? [4]

(c) Discuss the advantages of ferrous metal alloys over their non-ferrous alloys. [6]

(d) Aluminium alloys are classified into cast and wrought alloys. Describe these classifications and state examples for each class. [5]

Question 7

(a) Define

  (i) Engineering stress [2]

  (ii) Engineering strain [2]

(b) With the aid of a diagram, explain the stress-strain curve of a ductile material [8]

(c) State Hooke's law, and note the conditions under which it is valid [3]

(d) A piece of copper originally 305 mm (12 in.) long is pulled in tension with a stress of 276 MPa (40,000 psi). If the deformation is entirely elastic, what will be the resultant elongation? Given the magnitude of the modulus of elasticity, E for copper is 110GPa (16 x10^6psi). [5]

END OF EXAMINATION