NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

DEPARTMENT OF CIVIL, MINING AND PROCESS ENGINEERING

QUALIFICATION: BACHELOR OF ENGINEERING IN METALLURGY	
QUALIFICATION CODE: 08BMET	LEVEL: 7
COURSE CODE: PDF711S	COURSE NAME: PHASE DIAGRAMS AND FORMING PROCESSES 314
SESSION: JUNE 2023	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 65

SECOND OPPORTUNITY QUESTION PAPER	
EXAMINER(S)	Mrs. Jaquiline Tatenda Kurasha
MODERATOR:	Professor Sofya Mitropolskaya

INSTRUCTIONS
1. Answer all questions. 2. Read all the questions carefully before answering. 3. Marks for each question are indicated at the end of each question. 4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.
2. Non-programmable calculator.

THIS QUESTION PAPER CONSISTS OF 4 PAGES (Including this front page)

Question 1 (20 Marks)

(a) Sketch the planes identified by the following miller indices.
  (i) (101) [2]
  (ii) (112) [2]
  (iii) (123) [2]

(b) Distinguish between the following:
  (i) a normal grain boundary and a twin boundary. [2]
  (ii) dislocation climb and dislocation annihilation. [2]

(c) Explain the effect of the following defects on the strength of a metal:
  (i) High angle grain boundary. [1]
  (ii) low angle grain boundary. [1]
  (ii) Substitutional defect. [1]

(d) The activation enthalpy for the formation of vacancies in copper is 83 700 J/mol, while the activation enthalpy for the formation of self-interstitial atoms in copper is 385 000 J/mol.
  (i) Calculate the equilibrium concentration of vacancies in copper at 1000 K. [3]
  (ii) Calculate the equilibrium concentration of interstitial atoms in copper at 1000 K. [3]
  (iii) Comment and explain your answers in (i) and (ii). [1]

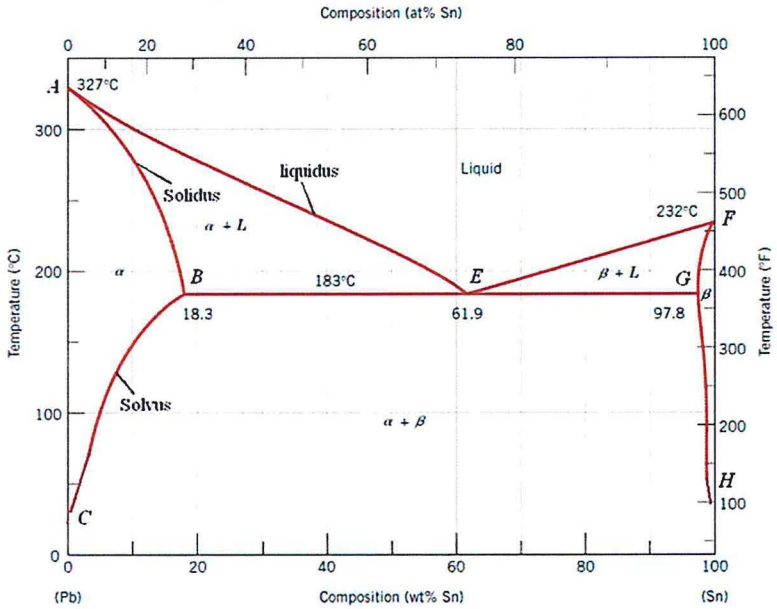
Question 2 (20 marks)

The diagram below shows the lead-tin phase diagram.

(a) Comment on the solubility of lead and tin within each other, and identify the terminal solid solution(s) and the intermediate phase(s). [3]

(b) Point E indicates an invariant point.
  (i) Identify the invariant point. [1]
  (ii) Calculate the phase fractions in the alloy at point E. [4]
  (iii) Sketch the microstructure of the alloy formed at point E. [2]
  (iv) What is the alloy formed point E commonly used for, and why? [1]

(c) Consider a Pb-20Sn alloy.
  (i) Sketch the cooling curve for the alloy given that the pouring temperature during casting is 300°C. [3]
  (ii) Calculate the phase fractions in the alloy at 100°C. [4]
  (iii) Sketch the microstructure of the alloy. [2]



Question 3 (15 Marks)

(a) Springback increases as yield strength increases. Explain. [2]

(b) A square hole 60mm on each side, or a circular hole 60mm in diameter, is to be punched into a 5mm thick annealed titanium-alloy Ti-6Al-4V sheet at room temperature. The UTS of the alloy is 1000 MPa. Evaluate which option is more economic, giving reasons for your choice. [3]

(c) Name and briefly describe the three main types of extrusion operations. [3]

(d) A billet 75 mm long and 35 mm in diameter is extruded at 600°C to a diameter of 20mm with an extrusion constant of 175MPa. Calculate

(i) the extrusion ratio. [2]

(ii) The extrusion force. [3]

(iii) Explain how you can ensure that all the material is extruded, i.e., minimal off-cut. [2]

Question 4 (10 Marks)

(a) Explain what is meant by the term weldability of a material? [2]

(b) Most components used for various applications are made of parts joined together. Give four reasons that support the rationale of joining parts instead of making one complete part. [2]

(c) Suggest a joining method generally used for the following scenarios, and give reasons for your choice.

(i) Calculator circuit board. [2]

(ii) Component that has to be opened regularly for inspection and servicing. [2]

(iii) Two sink basins, such that the joint is hardly noticeable and is strong. [2]

End of Question Paper.