MACHAKOS UNIVERSITY

University Examinations 2023/2024

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECRICAL AND ELECTRONIC ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 200: INTRODUCTION TO MATERIALS SCIENCE

DATE: **TIME:**

INSTRUCTIONS

1. ***This paper contains FIVE questions.***
2. ***Question ONE is compulsory and carries 30 marks.***
3. ***Four remaining questions carry 20 marks each.***
4. ***Attempt question ONE and any other TWO.***

QUESTION 1 (30 MARKS)

a) Define the following terms as used in materials science

(i) Unit cell **(1 Mark)**

(ii) Crystal lattice **(1 Mark)**

(iii) Dislocation **(1 Mark)**

(iv) Polymorphism **(1 Mark)**

(v) Solid solution **(1 Mark)**

b) Explain why the study of materials science is important **(2 Marks)**

c) Sketch the following planes and directions in separate unit cells

(i) Plane (423) **(1 Mark)**

(ii) Direction [112] which is equivalent to direction $[\frac{1}{2}\ \frac{1}{2}\ 1]$ **(1 Mark)**

(iii) Plane $(1\bar{1}0)$ **(1 Mark)**

d) Explain FOUR factors that cause imperfections in crystalline materials **(4 Marks)**

e) During a tensile test on a steel bar, the following were measured: $d_o = 6.2\ mm;\ L_o = 50\ mm;\ d_f = 4.8\ mm;\ L_f = 83\ mm; and\ P = 8.45\ kN\ and\ \Delta L = 0.092\ mm\ at\ the\ elastic\ limit; breaking\ force = 7.31\ kN$. Calculate:

(i) The value of Young's modulus **(3 Marks)**

(ii) Logarithmic strain at fracture **(1 Marks)**

(iii) True fracture stress **(1 Marks)**

f) Consider the alloy system with an intermetallic compound shown in Figure Q1(c). For 100 g of an alloy containing 95% of B, determine:

(i) The temperatures at which melting starts and ends **(1 Marks)**

(ii) The phases present, their chemical compositions, and their quantities at 520°C **(4 Marks)**

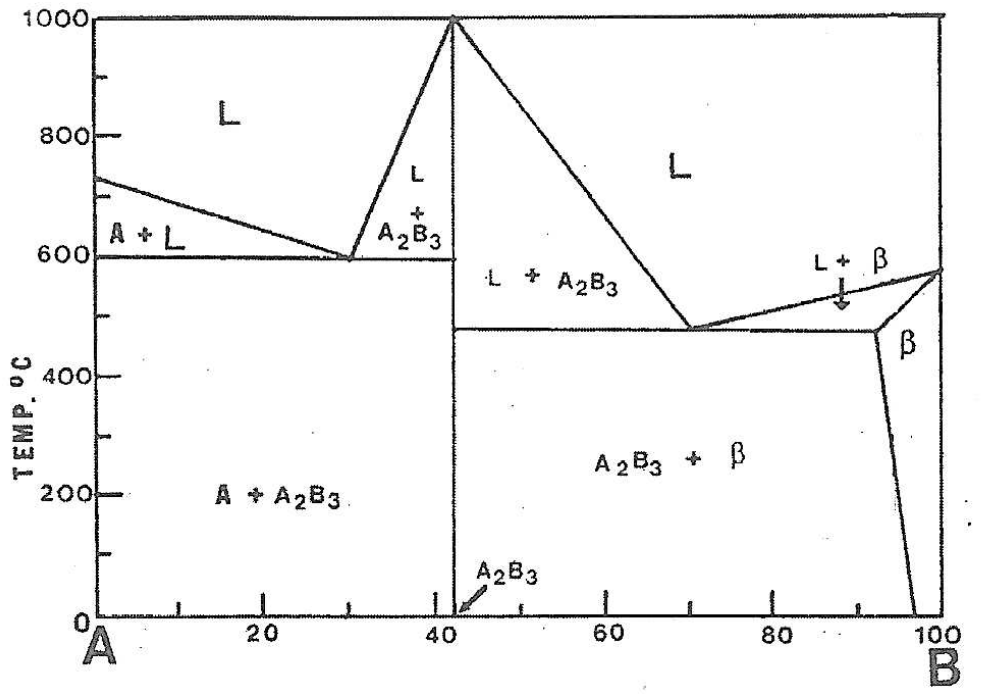

Figure Q1(c)

g) Show that the Vickers hardness number (VHN) is given by: $VHN = \frac{1.854P}{d^2}$ **(6 Marks)**

QUESTION TWO (20 MARKS)

a) Figure Q2(a) shows the unit cell of a hypothetical metal.

i) What is the crystal system of the metal and what would the crystal structure be called? **(2 Mark)**

ii) Calculate the atomic packing factor of the unit cell **(5 Marks)**

iii) Calculate the planar density in the plane $(\bar{1}01)$ **(3 Marks)**

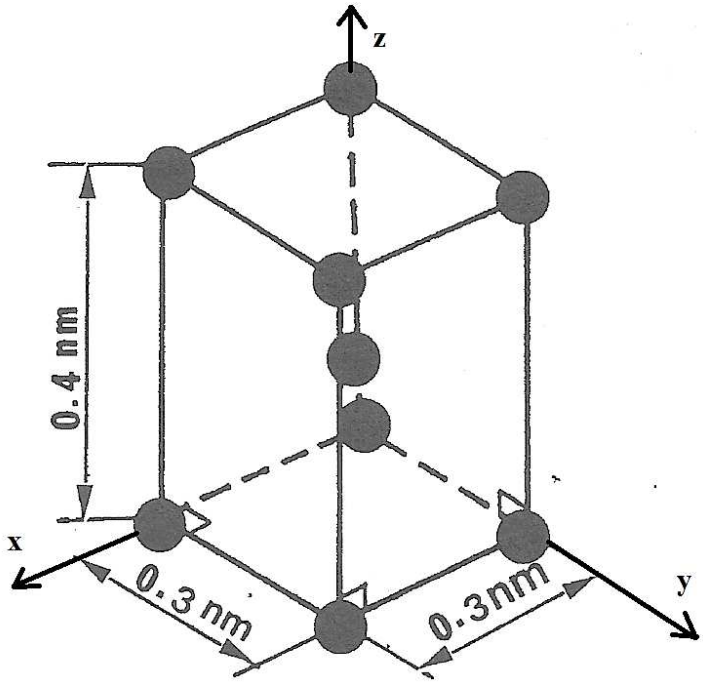

Figure Q2(a)

b)

i) With the aid of sketches, show how the magnitude and direction of a Burgers vector **b** of an edge dislocation can be determined **(4 Marks)**

ii) Explain TWO differences between an edge and a screw dislocation **(2 Marks)**

c) Discuss TWO planar defects that may occur in engineering materials **(4 Marks)**

QUESTION THREE (20 MARKS)

a) Differentiate between the following terms:

i) Engineering strain and true strain **(2 Marks)**

ii) Toughness and brittleness **(2 Marks)**

iii)

b)

i) Show that the Brinell hardness number is given by: $BHN = \frac{P}{\frac{\pi D}{2}\left[D-\sqrt{D^2-d^2}\right]}$ **(5 Marks)**

ii) Discuss FOUR differences between the Brinell and Vickers hardness scales **(4 Marks)**

c) During the tensile test of an aluminium specimen, the following results were recorded: $L_o = 70\ mm$; $d_0 = 14.0\ mm$.

Load (kN)	0	3	6	9	11	12.5	14	15
ΔL (mm)	0.0	0.0197	0.0395	0.0592	0.0724	0.096	0.125	0.185

i) Plot a stress-strain curve and determine the modulus of elasticity of the specimen **(4 Marks)**

ii) If the diameter under the 9 kN load was 13.997 mm, determine the materials Poisson's ratio **(3 Marks)**

QUESTION FOUR (20 MARKS)

a) Figure Q4(a) gives the atomic radii, crystal structure, the most common valency, and the electronegativities of some elements. Determine, giving reasons, which element is likely to:

i) Form a solid solution with nickel showing complete solubility in the solid state **(2 Marks)**

ii) Form a substitutional solid solution with nickel **(2 Marks)**

iii) Form an interstitial solid solution with nickel **(2 Marks)**

Element	Atomic radius [nm]	Common valence	Crystal structure	Electro negativity
Ni	0.1246	2+	FCC	1.8
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	1+	FCC	1.9
Al	0.1431	3+	FCC	1.5
Co	0.1253	2+	HCP	1.8
Cr	0.1249	3+	BCC	1.6
Fe	0.1241	2+	BCC	1.8
Pt	0.1387	2+	FCC	2.2
Zn	0.1332	2+	HCP	1.6

Figure Q4(a)

b) Explain FOUR differences between solid solutions and intermetallic compounds **(4 Marks)**

c)

i) Plot an equilibrium phase diagram of two metals A and B which are completely insoluble in the solid state **(1 Mark)**

ii) Describe the solidification of an alloy of metal A and B whose composition is to the left of the eutectic point **(7 Marks)**

d) Sketch and label the equilibrium diagram between two metals A and B given that: B has a higher melting point than A; A and B form an intermetallic compound in which both metals are soluble; and B is soluble in A but A is not soluble in B. **(2 Marks)**

QUESTION FIVE (20 MARKS)

a) Discuss THREE reasons why the ferrous alloys (steels and cast irons) are widely used engineering metals

(3 Marks)

b) Differentiate between thermoplastics, thermosets and elastomers **(3 Marks)**

c) Name and explain FOUR groups of ceramic materials **(4 Marks)**

d) List TWO uses of 2XXX (Al-Cu) Al alloys **(2 Marks)**

e) Explain FOUR important properties of aluminium **(4 Marks)**

f) Differentiate between brasses and bronzes **(2 Marks)**

g) What is a composite material**?** **(2 Marks)**