(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF TECHNOLOGY EDUCATION (CIVIL, MECHANICAL AND ELECTRICAL OPTIONS)

COURSE CODE: **TEC 104**

COURSE TITLE: **MATERIAL SCIENCE**

DATE: 26/04/2022   **TIME:** 3.00 – 5.00 PM

INSTRUCTIONS TO CANDIDATES
1. This paper consists of **FOUR** questions
2. Answer Question **ONE (Compulsory)** and any other **TWO** Questions
3. All symbols have their usual meaning

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of **5** Printed Pages. Please Turn Over

QUESTION ONE (COMPULSORY) [30 marks]

a) Explain briefly the difference between the following:
    i. A crystalline and an amorphous solid [2 Marks]
    ii. Vacancy point defect and substitutional solid solutions point defect [2 Marks]
    iii. Eutectic and eutectoid reaction [2 Marks]

b) Using sketches, derive the atomic packing factor (APF) for the following crystal structures:
    i) Simple cubic (SC), [1.5 Marks]
    ii) Body centered cubic (BCC) and [1.5 Marks]
    iii) Face centered cubic crystal structures [1.5 Marks]

c) Express the $[0\bar{2}1]$ direction into the Miller–Bravais index system for hexagonal crystals [2.5 Marks]

d) Why are hardness tests performed more frequently than any other mechanical test? [3 Marks]

e) A cylindrical brass rod that has a diameter of 10 mm is subjected to tensile stress axially. Determine the magnitude of the load required to produce a 2.5×10^{-3} mm change in diameter if the deformation is entirely elastic. Take E = 97 GPa and $v = 0.34$. [4 Marks]

f) Explain why electrochemical corrosion is generally limited to metals and does not typically occur in ceramics or polymers. [1 mark]

g) State **TWO** ways in which the ratio of water to cement affects the behavior of concrete [2 marks]

h) State and explain different types of polymers based on the structure. [3 marks]

i) Explain any **TWO** ways in which the electrical conductivity of metals can be controlled [2 Marks]

j) State two factors that affect the properties of a particle reinforced composite. [2 marks]

QUESTION TWO [20 marks]

a) With an aid of a sketch, describe how a coordinate bond is formed using a typical compound. [2 marks]

b) Describe the following types of intermediate/ inter-metallic compounds;
    i) Electron compounds [1.5 Marks]
    ii) Interstitial compounds [1.5 marks]

c) Explain what you understand by equilibrium/ phase diagram? What are the external controllable parameters considered in construction of the phase diagrams? Explain any TWO types of phase diagrams. [5 Marks]

d) A tensile test is carried out on a bar of mild steel of diameter 2 cm. The bar yields under a load of 80 kN. It reaches a maximum load of 150 kN, and breaks finally at a load of 70 kN. Calculate the:

     i.   the tensile stress at the yield point;   **[1.5 Marks]**

     ii.   the ultimate tensile stress;   **[1.5 Marks]**

     iii. the average stress at the breaking point (true stress), if the diameter of the fractured neck is 1 cm.   **[1.5 Marks]**

e) State four factors that affect the Charpy impact energy of a specimen.   **[2 Marks]**

f) Using a sketch, explain ductile-brittle transition phenomenon experienced in impact test   **[3.5 Marks]**

QUESTION THREE   **[20 marks]**

a) Explain factors that should be considered while selecting the material for engineering purposes.   **[3 Marks]**

b) Explain the term metal alloy and explain the reason for alloying a pure element.   **[2 Marks]**

c) Explain briefly the following defects:

     i.   Grain boundary   **[2 Marks]**

     ii.   Twin boundary   **[2 Marks]**

d) State the seven crystal systems based on the lattice parameters of a crystal structure   **[3.5 Marks]**

e) Consider the section of a (110) plane within an FCC unit cell represented in Figures 3e(a) and 3e(b). Calculate the planar density of that plane. Take R = 0.1241nm. (R is the radius of the atom)   **[4 Marks]**
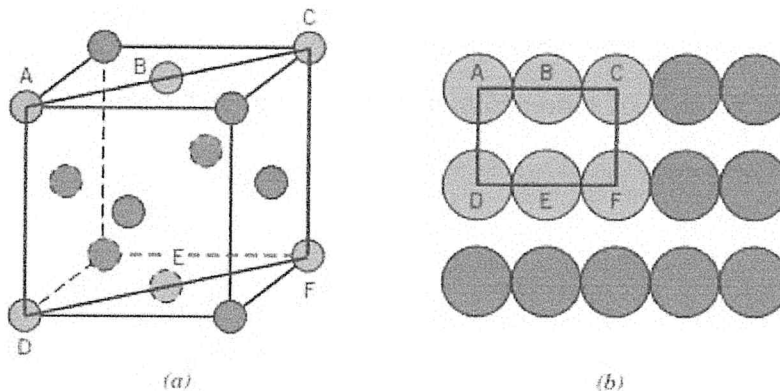

Figure 3e

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f) Show that the true strain (ε_T) and engineering strain (ε) are related by [3.5 Marks]

$$\varepsilon_T = ln(1 + \varepsilon)$$

QUESTION FOUR [20 marks]

a) 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. Take Avogadro's constant = 6.023×10^{23} atoms/g.mole [3 Marks]

b) What is an anisotropic material [1 Mark]

c) Coiled springs ought to be very strong and stiff. Silicon nitride (Si_3N_4) is a strong, stiff material. Would you select this material for a spring? Explain. [3 marks]

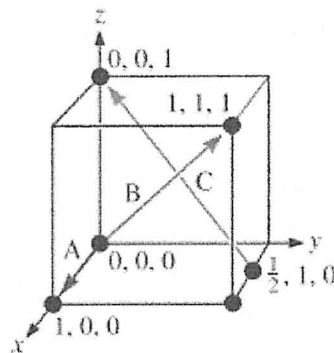d) Determine the Miller indices of directions A, B, and C in Figure 4d. [6 marks]

Figure 4d

e) A low carbon steel specimen is subjected to tensile stress in a tensile test until it failed. Sketch and label fully the expected tensile stress-strain graph of the tensile test subjected to the specimen noting some key regions, points and stresses. [4 marks]

f) State **THREE** effects of solid-solution strengthening on the properties of metals [3 marks]