FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENTS OF MINING AND METALLURGICAL ENGINEERING

ENGINEERING MATERIALS

EMR 1204

Final Examination Paper

August 2021

This examination paper consists of 4 pages

Time Allowed: **3 hours**

Total Marks: **100**

Examiner's Name: **Miss B. Ndlovu**

Instructions

1. Answer all questions in Section A and any 2 Questions from Section B.
2. Each question carries 25 marks.
3. Use of calculators is permissible.

Additional Requirements

Calculator
Periodic Table of Elements

Mark Allocation

Question 1-5	25 Marks
Part Questions	As shown in each part question.
Total Attainable	100

SECTION A: Answer all questions in this section.

QUESTION 1

a) List any six important properties of solid materials that are of paramount importance in the study of engineering materials. [3]

b) State and explain the three major factors that need to be considered by engineers upon selection of the right material(s), from the many thousands that are available, for a particular use. [6]

c) Understanding the interrelationships that exist between the structure, properties, processing, and performance of materials is key in engineering materials. Explain these interrelationships using a material of your choice as an example. [5]

d) Define the term "nanotechnology". [2]

e) Smart or intelligent materials are a group of new and state of the art materials now being developed that will have a significant influence on many of our technologies.

   i. Describe one major property of smart materials. [2]

   ii. State any three (3) types of materials that are commonly used for actuators in smart materials. [3]

   iii. Discuss the major applications of smart materials in metallurgical and mining engineering. [4]

QUESTION 2

a) Show that the atomic packing factor for the FCC crystal structure is 0.74. [4]

b) Calculate the volume of an FCC unit cell in terms of the atomic radius R. [4]

c) Copper has an atomic radius of 0.128 nm, an FCC crystal structure and a measured density of 8.94 g/cm^3. Compute its theoretical density and compare the answer with its measured density. [6]

d) Discuss the properties and characteristics of crystalline and non-crystalline silicone dioxide. [6]

e) Atomic bonding can be broadly classified as primary bonding and secondary bonding. State the types of bonds that fall under these two classes.

[5]

SECTION B: Answer any two questions in this section.

QUESTION 3

a) Distinguish between the following types of defects:

i. Vacancy and self-interstitial [5]

ii. Screw dislocation and edge dislocation [5]

N.B: You may use diagrams to explain your answers.

b) Determine the composition, in atom percent, of an alloy that consists of 97 wt. % aluminum and 3 wt. % copper.

[3]

c) Atomic radius, crystal structure, electronegativity, and the most common valences for several elements are tabulated in ***Table 1***. For those that are nonmetals, only atomic radii are indicated.

Table 1 (Extracted from Materials Science and Engineering by D. Callister)

Element	*Atomic Radius (nm)*	*Crystal Structure*	*Electro-negativity*	*Valence*
Ni	0.1246	FCC	1.8	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Pt	0.1387	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

Write down the elements you would expect to form the following with nickel:

i. A substitutional solid solution having complete solubility. [2]

ii. A substitutional solid solution of incomplete solubility. [2]

iii. An interstitial solid solution. [2]

d) Briefly explain the working principles of the following microscopic techniques:

i. Scanning Electron Microscopy [3]

ii. Transmission Electron Microscopy [3]

QUESTION 4

a) Define the term an-elasticity. [2]

b) Briefly explain the concept of plastic deformation from an atomic perspective. [3]

c) A piece of copper originally 305 mm long is pulled with a stress of 276 MPa. If the deformation is entirely elastic and the magnitude of E for copper is 110 GPa, calculate the resultant elongation. [3]

d) State the three major reasons why hardness tests are performed more frequently than any other mechanical tests. [3]

e) Safe stress (or working stress) is based on the yield strength of the material and is defined as the yield strength divided by a factor of safety, N.

i. State any three (3) important selection criteria for the value of N in engineering design problems. [3]

ii. Discuss the effects of choosing an inappropriate value of N. [2]

f) Briefly describe the following modes of failure in materials:

i. Fracture [3]

ii. Fatigue

[3]

iii. Creep [3]

QUESTION 5

a) Briefly discuss how the choice of a material(s) for a particular component may affect the profitability of a mining or metallurgical plant. [3]

b) In a few sentences, write down what you understand by the term green engineering. [3]

c) Draw a diagram showing the total materials cycle, and indicate the relevant issues that pertain to each stage of this cycle. [7]

d) Imagine you are a metallurgical engineer at a gold plant. Your company wants to install a Carbon in Pulp (CIP) process for the leaching of gold from its ore; and you are assigned to design the plant. The process utilizes a toxic and corrosive chemical namely *sodium cyanide.* Describe how you would carry out the materials selection process for the leach tanks of a capacity of your choice, clearly outlining the pros and cons associated with the chosen material and two (2) other alternatives. [12]

**********End of Question Paper**********