NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF COMMERCE

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

BACHELOR OF ENGINEERING (HONS) DEGREE INDUSTRIAL AND MANUFACTURING ENGINEERING

MATERIALS TECHNOLOGY I

TIE 2104

First Semester Main Examination Paper

December 2014

This examination paper consists of 3 pages

Time Allowed: 3 hours

Total Marks: 100

INSTRUCTIONS

1. Answer any five (5) questions
2. Each question carries 20 marks
3. This paper contains seven (7) questions

MARK ALLOCATION

QUESTION	MARKS
1.	**20**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
6	**20**
7	**20**
TOTAL	**100**

Question 1

(a) Discuss the general properties and applications of the following classes of engineering materials:

(i) Metals, [3]

(ii) Polymers, [3]

(iii) Ceramics, [3]

(iv) Composites, [3]

(v) Advanced materials. [3]

(b) What is the relationship between structure, processing and properties of engineering materials? [5]

Question 2

(a) Giving examples in each case, distinguish between an amorphous and a crystalline structure. [4]

(b) Prove that for a Hexagonal Close Packed structure (HCP), the atomic packing factor is 0.74 [12]

(c) What is the significance of Atomic Packing Factors (APFs) in determining properties of materials? [2]

(d) Define polymorphism. [2]

Question 3

(a) Describe a solid solution. [4]

(b) Clearly distinguish between interstitial and substitutional defects [6]

(c) State and explain two (2) situations where imperfections in material structures are desirable. [6]

(d) Calculate the fraction of atom sites that are vacant for copper at its melting temperature of 1084 ^{o}C. Assume an energy for vacancy formation of 0.90 eV/atom. [4]

Question 4

(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^{o}C and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is $1.2 \times 10^{-10} m^2/s$ and the diffusion flux is found to be $1.0 \times 10^{-7} m^2/s$. Also, it is known that the concentration of nitrogen in the steel 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 5

(a) Describe your understanding of the following terms as applied to material properties:

(i) Ductility, [2]

(ii) Flexural strength, [3]

(iii) Resilience, [3]

(iv) True stress, [3]

(v) True strain. [2]

(b) What is elasticity and how does it compare for metallic and polymeric materials? [4]

(c) Which material properties can be measured using the stress-strain curve? [3]

Question 6

(a) Fully describe and explain the following fracture mechanisms:

(i) Brittle fracture, [8]

(ii) Ductile fracture, [8]

(b) Suggest how fatigue failure can be minimised. [4]

Question 7

(a) Describe the ultrasonic testing technique and state its applications. [8]

(b) Compare and contrast the Vickers and Rockwell hardness tests. [10]

(c) State two (2) techniques that can be used for microstructural analysis. [2]

End of Examination