The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering
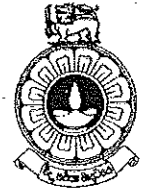
Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: **DMX3203 Introduction to Engineering Materials**
Academic Year	: 2019/20
Date	: 03rd October 2020
Time	: 0930 - 1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.

2. This question paper consists of **Two (2)** parts in **Seven (7)** pages.

3. Answer **All** questions in **Part A** and **Four(4)** questions from **Part B**.

6. This is a Closed Book Test(CBT).

7. Answers should be in clear handwriting.

8. Do not use Red colour pen.

SECTION A (ANSWER ALL QUESTIONS)

1. Name two natural polymers and two synthetic polymers. Give one application for each noting the characteristics which make the polymer suitable for that application.

   (04 marks)

2. Name two primary bonds and two secondary bonds that present between atoms. Give one example for each type of bond.   *(04 marks)*

3. Iron has a Body Centered Cubic (BCC) structure and an atomic radius of **0.126 nm.** Calculate the linear density of iron atoms in the [1 1 1] direction.   *(04 marks)*

4. Identify the given crystal structure in Figure A4, and find the number of atoms in the unit cell, coordination number and the a/R ratio of the given unit cell.
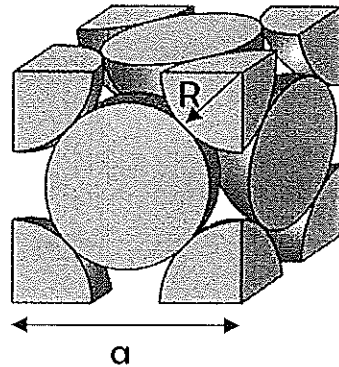
(04 marks)

Figure A4

5. Draw the following crystallographic plane and the direction in a cubic unit cell.
   (i) $(2\,2\,\bar{1})$ (ii) $[\bar{1}\,2\,1]$ *(04 marks)*

6. Name four types of imperfections in crystals and give one example for each type.

(04 marks)

7. Name the two main mechanisms of solid-state diffusion and state Fick's first and second laws of diffusion.   *(04 marks)*

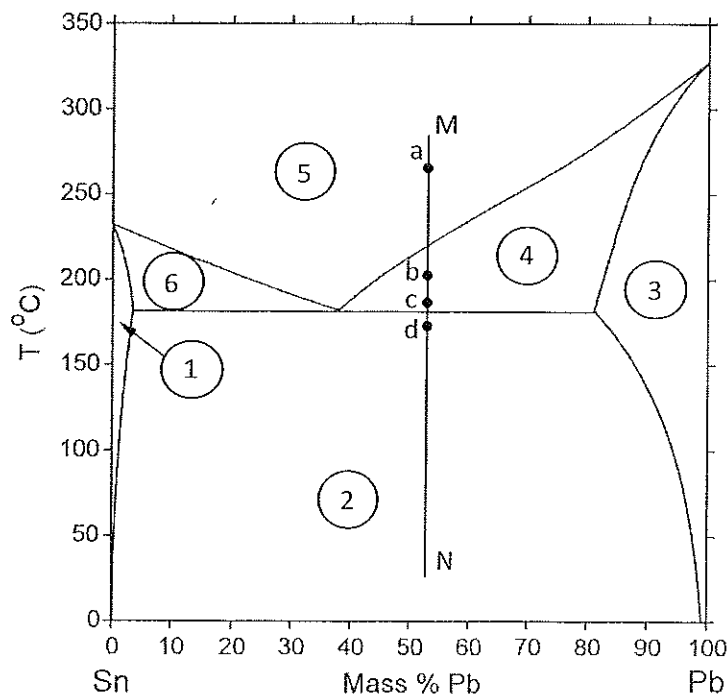8. Identify the regions **1 - 6** in the Pb-Sn phase diagram given in Figure A8.

(04 marks)

Figure A8

9. Referring Figure A8, sketch the developed microstructure at points **a, b, c** and **d** when a particular Pb-Sn alloy is cooled along line MN. *(04 marks)*

10. A circular rod with **5 cm** length made from Aluminum alloy has been subjected to uniaxial tensile load and its length at maximum load was **5.3 cm**. The load indicated in the machine was **35580 N** at maximum level and at fracture it was **33800 N**. The diameter at maximum load was **1.263 cm** and at the fracture it was **0.995 cm**. Length of the rod after fracture was **5.512 cm**. Find the following at the fracture,

    (i)   Engineering Stress
    (ii)   True Stress
    (iii) Engineering Strain
    (iv) True Strain. *(04 marks)*

(Part A 40 marks)

SECTION B (ANSWER FOUR QUESTIONS)

1. One of the important advancements in materials engineering is the development of nanomaterials. A nanomaterial is defined as the "material with any external dimension in the nanoscale or having internal structure or surface structure in the nanoscale". In recent years researchers have developed nanoparticles with magnetic properties.

    (a)   Briefly explain **Paramagnetism** and **Ferromagnetism** behaviors shown by materials under an external magnetic field. *(03 marks)*

    (b)   Briefly explain **Soft magnetic materials** and **Hard magnetic materials** *(03 marks)*

    (c)   Sketch the graph Magnetic Flux Density **(B)** vs Magnetic Field Strength **(H)** and describe "**Hysteresis Loop**". *(04 marks)*

    (d)   Discuss the importance of synthetic and natural nanomaterials with examples. *(05 marks)*

(15 marks)

2. Integrated circuits (IC) and solid state devices are being used in wide variety of applications from large scale industrial processes to domestic appliances. Inside an IC (refer Figure B2) there are semiconducter wafers with the semiconductor devices, conductors to pass electrical signals between semiconductor devices and in and out from IC and a pakaging material surrounding these delicate circuits.
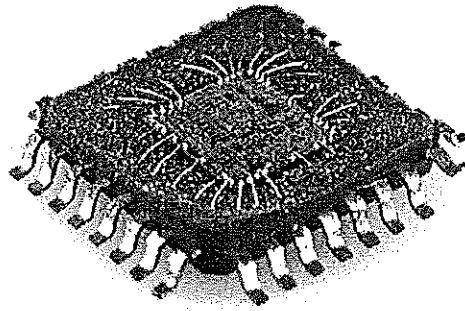
Figure B2

(a) What is semiconductivity? Name two semiconductor materials. *(02 marks)*

(b) Briefly explain "**Extrinsic Semiconductors**". *(03 marks)*

(c) Name the three energy bands which effects the electrical conductivity of a material and briefly describe one energy band. *(03 marks)*

(d) Sketch the band formation in an electical conductor and in a semiconductor. *(03 marks)*

(e) What are the important functions of IC pakaging material? While proposing a suitable pakaging material considering the functinality and ease of manufacturing, justify your answer. *(04 marks)*

(15 marks)

3. Reinforced concreate is an extensively used material in constrauction projects. The structural components were casted by embedding steel bars in concreate. With time the embeded steel bars start to corrode due to envoronmental conditions as shown in Figure B3. This corrosion is sevear in costal areas.
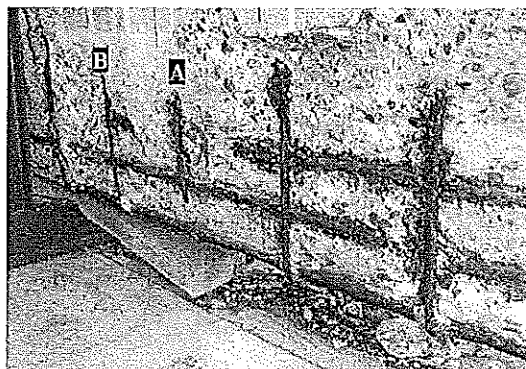

Figure B3

(a) Rusting of steel bars can be explained as a Galvanic cell corrosion with single electrode. Write the Anodic and Cathodic reactions for this cell. *(03 marks)*

(b) Write four other types of Corrosion in metallic materials and describe one of them. *(04 marks)*

(c) Name three different corrosion control methods and briefly describe. one of them. *(04 marks)*

(d) Briefly explain how the corrsion of steel reinforcment would effect the concreate structural component. *(04 marks)*

(15 marks)

4. About one million single-use plastic water bottles (refer Figure B3-a) are purchased around the world every minute. Use of single-use, pre-filled plastic water bottles have increased almost every single year for more than a decade. People tend to buy them becouse of convinent and hygene. These bottles are madeout from a plastic call polyethylene terephthalate (PET).
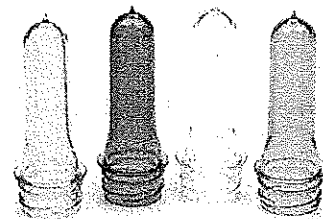

Figure B3-a   **Figure B3-b**

(a) Name the two groups of Plastics. Briefly describe the group which PET bottles are included. *(03 marks)*

(b) Production process of PET is called as **"condensation polymerization"**.
Briefly describe this process. *(04 marks)*

(c) PET bottles are manufactured as a two step process. First a Preform is made from PET polymer (refer Figure B3-b). Then this preform is formed into a bottle of required shape as shown in Figure B3-a. Identify and briefly describe the production processes used in these steps. *(04 marks)*

(d) Nowadays,due to environmental concerns reusable water bottles are promoted. Name three different materials that can be used to manufacture reusable water bottles with their advantages and disadvantages. *(04 marks)*

(15 marks)

5. (a) Explain why, liquid phase is transformed in to solid phase, when reachers below the melting point. *(03 marks)*

    (b) Describe the difference between **"Homogeneous"** and **"Heterogeneous"** nucleation. *(03 marks)*

    (c) Briefly explain the derivation of **"Critical Radius of Nucleation"** and why it is an important parameter in solidification process. *(04 marks)*

    (d) The cross sectional grain structure shown in Figure B4, was observed when an iron ingot is cast using a squre block shaped mold. Explain how this grain structure is formed when liquid iron is solidified. *(05 marks)*
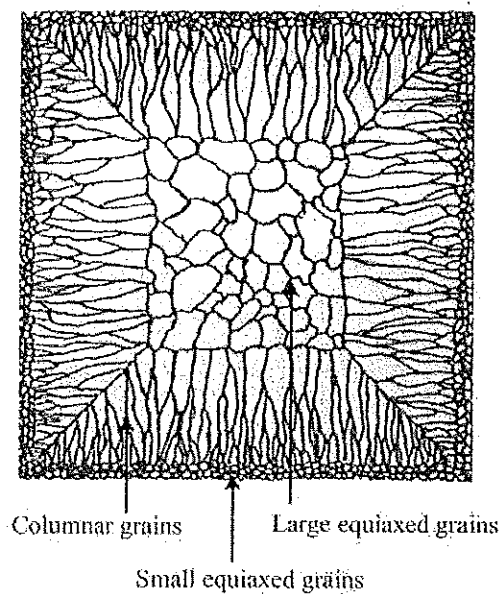

Columnar grains   Large equiaxed grains

Small equiaxed grains

Figure B4

(15 marks)

6. (a) What is a dislocation of a crystal? *(03 marks)*

    (b) Show with diagrams, an edge dislocation and a screw dislocation in crystal structure. *(04 marks)*

    (c) Briefly explain the **"Precepitation Hardening of Metals"** and how it is being done. *(04 marks)*

    (d) Describe two methods that can be use to strengthen polymers. *(04 marks)*

(15 marks)

7. Discuss and analyze the significance of any three of the following from an Engineering point of view.

    (a)   Fatigue failure occures in materials.   *(05 marks)*

    (b)   Invarient reactions in the Iron-Carbon diagram.   *(05 marks)*

    (c)   Mechanical properties of materials.   *(05 marks)*

    (d)   Metal fabrication processes.   *(05 marks)*

                                      (15 marks)