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	**: DMX4533 / MEX4233 Materials Engineering**
Academic Year	: 2019/20
Date	:17th 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 **Six (6)** pages.
3. Answer **Five (5)** questions from **Part A** and **Five(5)**questionsfrom **Part B**.
6. This is a Closed Book Test(CBT).
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.

SECTION A (ANSWER FIVE QUESTIONS)

1. Draw the following crystallographic plane and the direction in a cubic unit cell
   (i) $(3\,\bar{2}\bar{1})$ (ii) $[\bar{1}\,2\,0]$

2. List 4 important mechanical properties of materials and name the test that can be used to measure each of the properties.

3. Nickel has a Face Centered Cubic (**FCC**) structure and an atomic radius **0.163 nm.** Calculate the linear density of Nickel atoms in the [1 1 0]

4. List the types of Primary bonds and Secondary bonds present in materials. Give one example for each type.

5. What is the maximum tensile load that can be carried by a **15 mm** diameter bar of 1040 carbon steel without permanent deformation? The material has a Young's Modulus of **200 GPa** and Yield Strength of **415 MPa.**

6. Calculate a value for the density of **BCC** Chromium, from its lattice constant of **0.291 nm** and its atomic mass of **51.996 g/mol.**

7. Briefly explain how the work hardening occurs in material.

8. Define the terms Space Lattice, Unit Cell, Atomic Packing Factor and Coordination Number.

SECTION B(ANSWER FIVE QUESTIONS)

1. (a) Discuss the types of point imperfections found in materials.
   (b) Calculate the number of vacancies per cubic meter in gold at **900°C**. The energy for vacancy formation is **0.98 eV/atom**. The density and atomic weight for gold are **19.32 g/cm³** and **196.9 g/mol** respectively.
   Avogadro's number is $\mathbf{6.023 \times 10^{23} mol^{-1}}$
   Boltzmann constant is $\mathbf{8.62 \times 10^{-5} eV/K}$

2. Using the isothermal transformation diagram in **Figure Q2**, for a **1.13 wt%** Carbon steel alloy determine the final microstructure of a small specimen that has been subjected to the following time-temperature treatments. In each case assume that the specimen begins at **920°C** and that it has been held at this temperature long enough to have achieved a compleate and homogeneous austenitic structure.

   (a) Rapidly cool to **400°C**, hold for **500 s** and then quench to room temperature.

   (b) Rapidly cool to **650°C**, hold at this temperature for **10 s**, rapidly cool to **450°C** hold for **10 s** and then quenched to room temperature.

   (c) Determine the requiremets for heat treatment (time-temperature paths) to produce the following microstructures.

      (i) 100% coarse pearlite.
      (ii) 50% martensite and 50% austenite.

3. (a) With the aid of sketches, briefly explain complete solid solubility and partial solid slubility in alloys.

(b) A phase diagram of Magnesium-Lead is shown in **Figure Q3.**. Answer the following questions refering Figure Q3.

(i) Lable the phases in areas 1 - 6 and name the reaction which occurs at point E. **(Attached the phase diagram with your answer script)**

(ii) Consdering an alloy containing **Pb-75 wt%** and **Mg-25 wt%** state the phase changes that occur when cooling from **700°C** to **0°C**.

(iii) Calculate the amount of liquid and solid present at temperature **500°C** for the above alloy.

4. (a) List the types of Primary bonds and Secondory bonds present in materials. Explain two of them briefly with the aid of sketches

(b) State Hund's rule on pairing of electrons in atoms with an example.

(c) Write the electronic configuration of Cr^{2+} and Fe^{3+} irons. Atomic numbers of **Cr** and **Fe** are **24** and **26** respectively.

(d) Calculate the mass in grames of one atom of Aluminum. Atomic mass of Aluminum is **26.98 g/mol** and Acogadro's number is $\mathbf{6.023 \times 10^{23}}$ $\mathbf{mol^{-1}}$.

5. (a) State Fick's 1st and 2nd laws of Diffusion

(b) The diffusion coefficients of Carbon in Titanium were determined at the following temperatures.

Teperature (°C)	Diffusion Coefficient (m^2/s)
736	2×10^{-13}
782	5×10^{-13}
835	13×10^{-12}

Assuming that Arrhenius exponential relationship of $\boldsymbol{D = D_0 e^{(-Q/RT)}}$ is valid, find the followings.

(i) Constant $\mathbf{D_0}$ of the equations
(ii) Activation Energy **Q**
(iii) The diffusion coefficient at **500°C**

6. (a) Differentiate between thermoplastics and thermosetting plastics. Give two examples for each type of plastics.

   (b) Describe the Injection Moulding process used for forming thermoplastic products.

   (c) What are the advantages and disadvantages of this process over other processes used fot the fabrication of thermoplastic products.

7. (a) What is a dislocation of a crystal?

   (b) Show with diagrams, how the motion of an edge dislocation can lead to the plastic deformation of a crystal under an applied shear stress.

   (c) Show how dislocations can occur in,

      (i) Cold work hardening
      (ii) Solid solution hardening
      (iii) Precipitation and dispersion hardening

   (d) The lower yield point for an iron that has an average grain size of **50 μm** is **135 MPa**. At a grain size of **8 μm**, the yield point increases to **260 MPa**. At what grain size will the lower yield point be **205 MPa**?

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

   (a) Creep failure occures in materials

   (b) Invarient reactions in the Iron-Carbon diagram

   (c) Pilling-Bedworth ratio.

   (d) Mechanical properties of materials

   (e) Difference in cervice corrision and stress corrision cracking

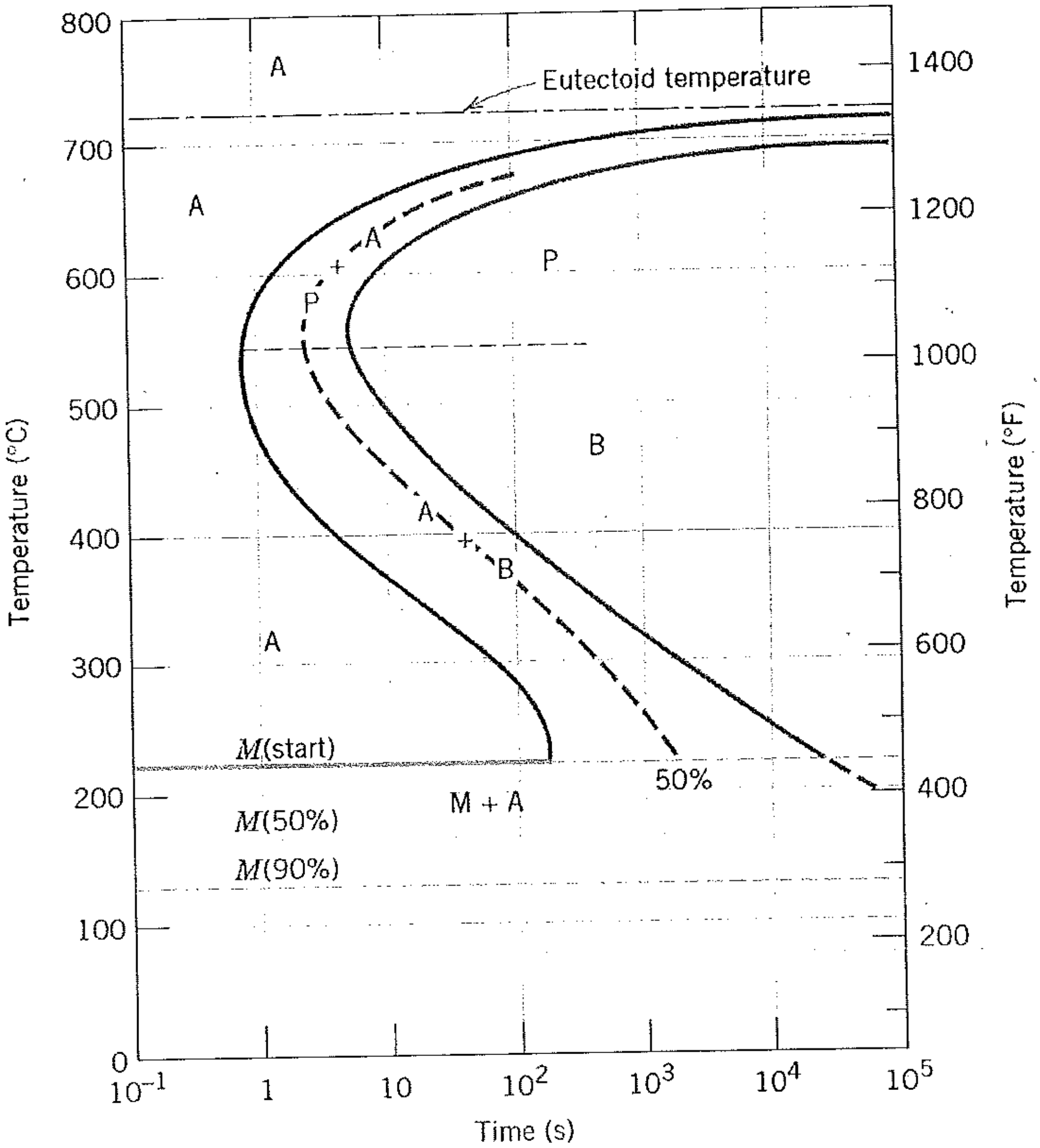

Figure Q2 : Isothermal transformation diagram of steel

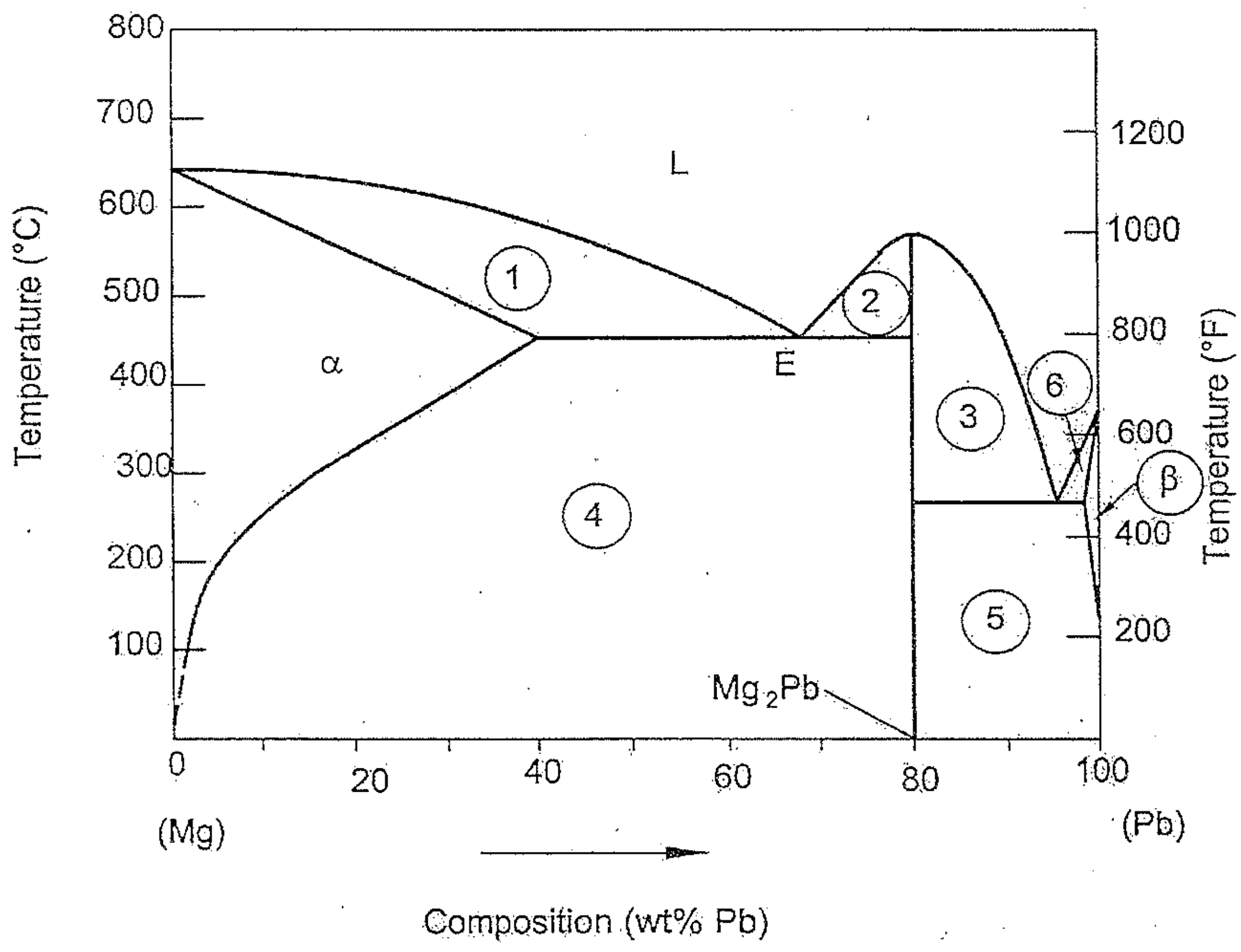

Figure Q3 : The Magnesium-Lead phase diagram

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