



Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX4533 - Materials Engineering
Academic Year	: 2020/ 21
Date	: 22 nd January 2022
Time	: 0930 - 1230 hrs
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Two (2)** parts.
3. Answer **Five (5)** questions from **Part A** and **Four (4)** questions from **Part B**.
4. Answer for each question should commence from a new page.
5. Relevant charts/ codes are provided.
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 5 QUESTIONS ONLY)

- (1) Draw the following crystallographic plane and the direction in a cubic unit cell (4 marks)
 - (i) $(3\bar{2}\bar{1})$
 - (ii) $[\bar{1}20]$
- (2) List 4 important mechanical properties of materials and name the test that can be used to measure each of the properties. (4 marks)
- (3) Nickel has a Face Centered Cubic (FCC) structure and an atomic radius **0.163 nm**. Calculate the linear density of copper atoms in the $[110]$ direction. (4 marks)
- (4) List the types of Primary bonds and Secondary bonds present in materials. Give one example for each type. (4 marks)

- (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**. (4 marks)
- (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**. (4 marks)
- (7) Briefly explain how the work hardening occurs in material. (4 marks)
- (8) Define the terms Space Lattice, Unit Cell, Atomic Packing Factor and Coordination Number. (4 marks)

SECTION - B (ANSWER 4 QUESTIONS ONLY)

QUESTION 01 (20 marks)

- (a) State the **four** factors that affect the solubility in formation of substitutional solid solutions. (4 marks)
- (b) The Fig. Q1 below shows the Hafnium-Vanadium phase diagram. Using the phase diagram answer the following.
- Label the phase/s in areas marked **1-8** in the phase diagram. (8 marks)
 - For an alloy containing **60 wt% Vanadium** and **40 wt% Hafnium**, describe the process of solidification from **2000°C**. (3 marks)
 - Calculate the amount of liquid and vanadium present at **1600°C** and at **60 wt% Vanadium**. (5 marks)

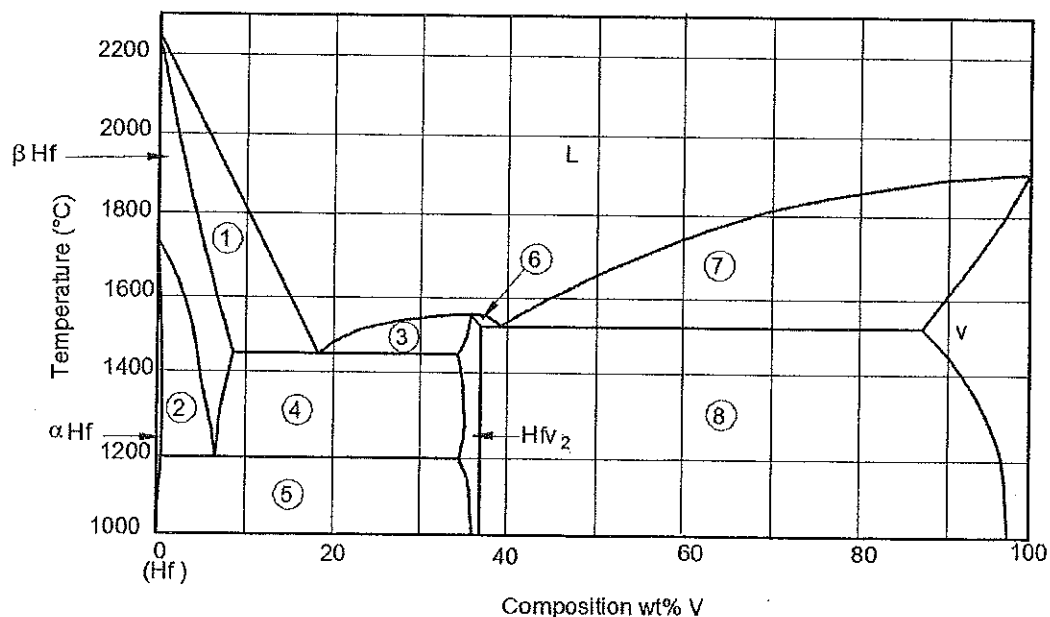


Fig. Q1

QUESTION 02 (20 marks)

- (a) What is a copolymer? Discuss the types of copolymers available. (6 marks)
- (b) Differentiate between Addition polymerization and Condensation polymerization. (6 marks)
- (c) A copolymer of ABS (Acrylonitrile-Butadiene-Styrene) contains equal weights fractions of each polymeric component. What is the mole fraction of each component? Monomer structures of ABS copolymer are given below. Atomic weights are C-12, H-1, N-14. (8 marks)

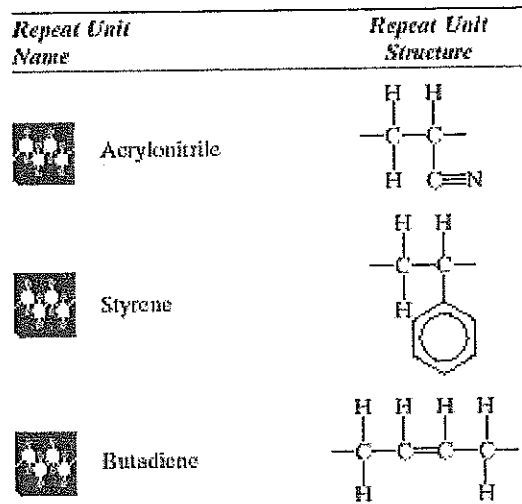


Fig. Q2

QUESTION 03 (20 marks)

- (a) State Fick's 1st and 2nd laws of Diffusion. (4 marks)
- (b) The diffusion coefficients of Carbon in Titanium were determined at the following temperatures.

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

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

- i. Constant D_0 . (5 marks)
- ii. Activation Energy Q . (5 marks)
- iii. The diffusion coefficient at 500°C. (6 marks)

QUESTION 04 (20 marks)

- (a) List the types of Primary bonds and Secondary bonds present in materials. Explain two of them briefly with the aid of sketches. (4 marks)
- (b) State Hund's rule on pairing of electrons in atoms with an example. (4 marks)
- (c) Write the electronic configuration of Cr^{2+} and Fe^{3+} ions. Atomic numbers of Cr and Fe are 24 and 26 respectively. (5 marks)
- (d) Calculate the mass in grams of one atom of Aluminum. Atomic mass of Aluminum is 26.98 g/mol and Avogadro's number is $6.023 \times 10^{23} \text{ mol}^{-1}$. (7 marks)

QUESTION 05 (20 marks)

- (a) Describe the edge and screw type dislocations with illustrations. (6 marks)
- (b) What types of strain fields are surrounded both types of dislocations? (6 marks)
- (c) "Smaller the grains size higher the strength of a material." Explain this statement with the help of Hall-Petch equation. (8 marks)

QUESTION 06 (20 marks)

- (a) Distinguish between traditional and engineering ceramic materials and give examples of each. (6 marks)
- (b) Describe the steps in the slip-casting process for ceramic products. (6 marks)
- (c) Explain the types of bonds present and resultant properties in ceramics. (8 marks)

QUESTION 07 (20 marks)

Discuss and analyze the significance of any **four** of the following from an Engineering point of view

- (a) Creep failure occurs in materials. (5 marks)
- (b) Invariant reactions in the Iron-Carbon diagram. (5 marks)
- (c) Pilling-Bedworth ratio. (5 marks)
- (d) Mechanical properties of materials. (5 marks)
- (e) Difference in service corrosion and stress corrosion cracking. (5 marks)