051

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	**: DMX5204 - Materials Engineering**
Academic Year	: 2020/ 21
Date	: 22nd January 2022
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
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.

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.

i. Label the phase/s in areas marked **1-8** in the phase diagram. (8 marks)

ii. For an alloy containing **60 wt%** Vanadium and **40 wt%** Hafnium, describe the process of solidification from **2000°C**. (3 marks)

iii. Calculate the amount of liquid and vanadium present at **1600°C** and at **60 wt%** Vanadium. (5 marks)

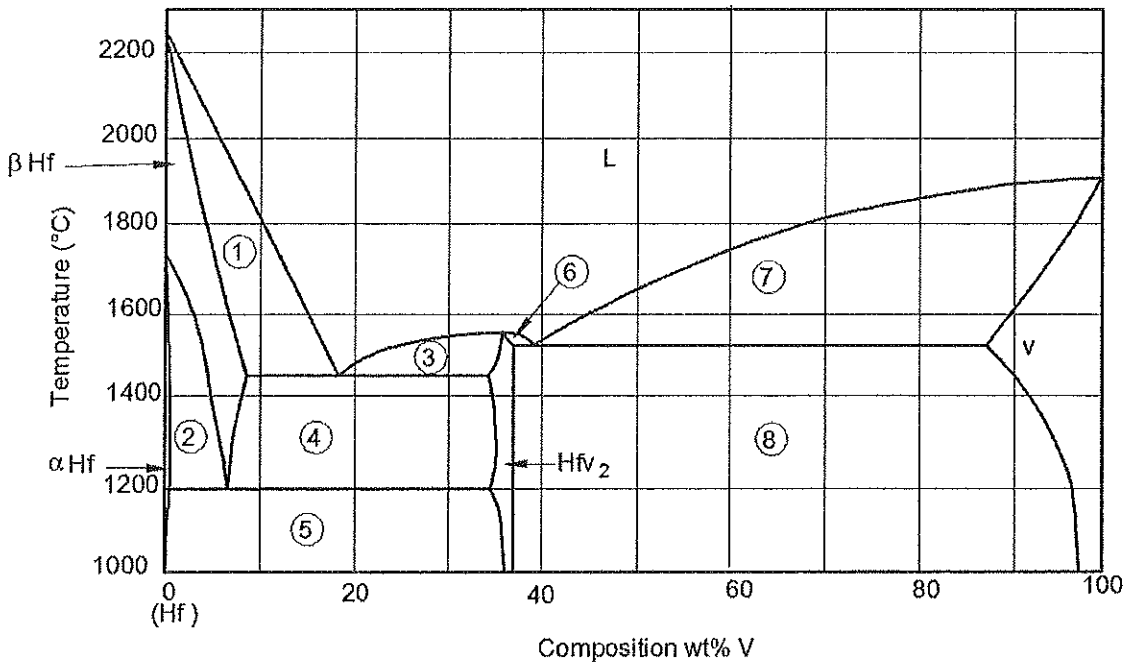


Fig. Q1

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)

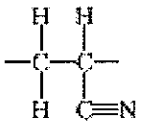
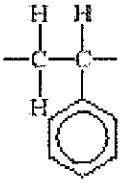
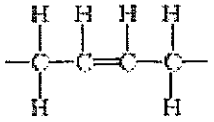
Repeat Unit Name	*Repeat Unit Structure*
Acrylonitrile	
Styrene	
Butadiene	

Fig. Q2

QUESTION 03 (20 marks)

(a) Explain the effect of following failure mechanisms on materials.

i. Fatigue (4 marks)

ii. Creep (4 marks)

(b) A shaft with a diameter of **30 mm** is to be carry a load of **35 kN** at a temperature of **250°C**. The experimental data showed that the steady state creep rate of the material follows the Norton equation given by, $\boldsymbol{d\varepsilon/dt = C\sigma^n}$ Where $C = 4.43 \times 10^{-15}$ and $n = 4.2$ when stress is given in MPa and strain in m/m/hr.

Calculate the following.

i. Strain rate at 250°C. (6 marks)

ii. If the maximum tolerable strain is to be 0.1%, useful life expectancy of the shaft. (6 marks)

QUESTION 04 (20 marks)

(a) With the aid of Iron-Carbon phase diagram, explain the effect of following heat treatment processes on plain carbon steel.

i. Annealing (3 marks)

ii. Normalizing (3 marks)

(b) i. Briefly describe the most popular 18-8 stainless steel. (18 Cr - 8 Ni). (4 marks)

ii. Why does stainless steel have corrosion properties? (4 marks)

(c) Discuss the types of fibers and matrix materials used in composites. (6 marks)

QUESTION 05 (20 marks)

(a) Derive an equation for Elastic modulus of a lamellar continuous fiber and matrix composite for isostrain condition. (8 marks)

(b) A continuous and aligned carbon fiber-reinforced epoxy matrix composite is to be produced consisting of **64 vol%** carbon fibers and **36 vol%** epoxy matrix. Mechanical characteristics of these two materials are as follows.

	Tensile modulus of Elasticity (GPa)	Tensile strength (MPa)
Carbon fiber	372.6	2136
Epoxy matrix	3.65	63.5

Compute the following

i. The tensile modulus of elasticity of the composite. (4 marks)

ii. The tensile strength of the composite. (4 marks)

iii. Fraction of the load carried by the carbon fiber. (4 marks)

QUESTION 06 (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 07 (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 08 (20 marks)

(a) What is the difference between Hardness and Hardenability? (4 marks)

(b) A cylindrical component of diameter **62.5 mm** will be made with alloy steel. The candidate materials are 8660, 8640, 8630 and 8620 alloys. The component will be Austenized and quenched in moderately agitated water or oil and the surface and center hardnesses must be at least 50 and 40HRC respectively.

i. What is the carbon content in each of these 4 alloys? (4 marks)

ii. Determine the hardenesses of these alloys at the surface and center, if they were quenched in moderately agitated water. Comment on which of the alloys satisfy the requirements. (Show your calculations. Refer Fig. Q8(a) (i) & Fig. Q8(b)). (6 marks)

ii. Determine the hardness of these alloys at the surface and center, if they were quenched in moderately agitated oil. Comment on which of the alloys satisfy the requirement. (Show your calculations. Refer Fig. Q8(a) (ii) & Fig. Q8(b)). (6 marks)

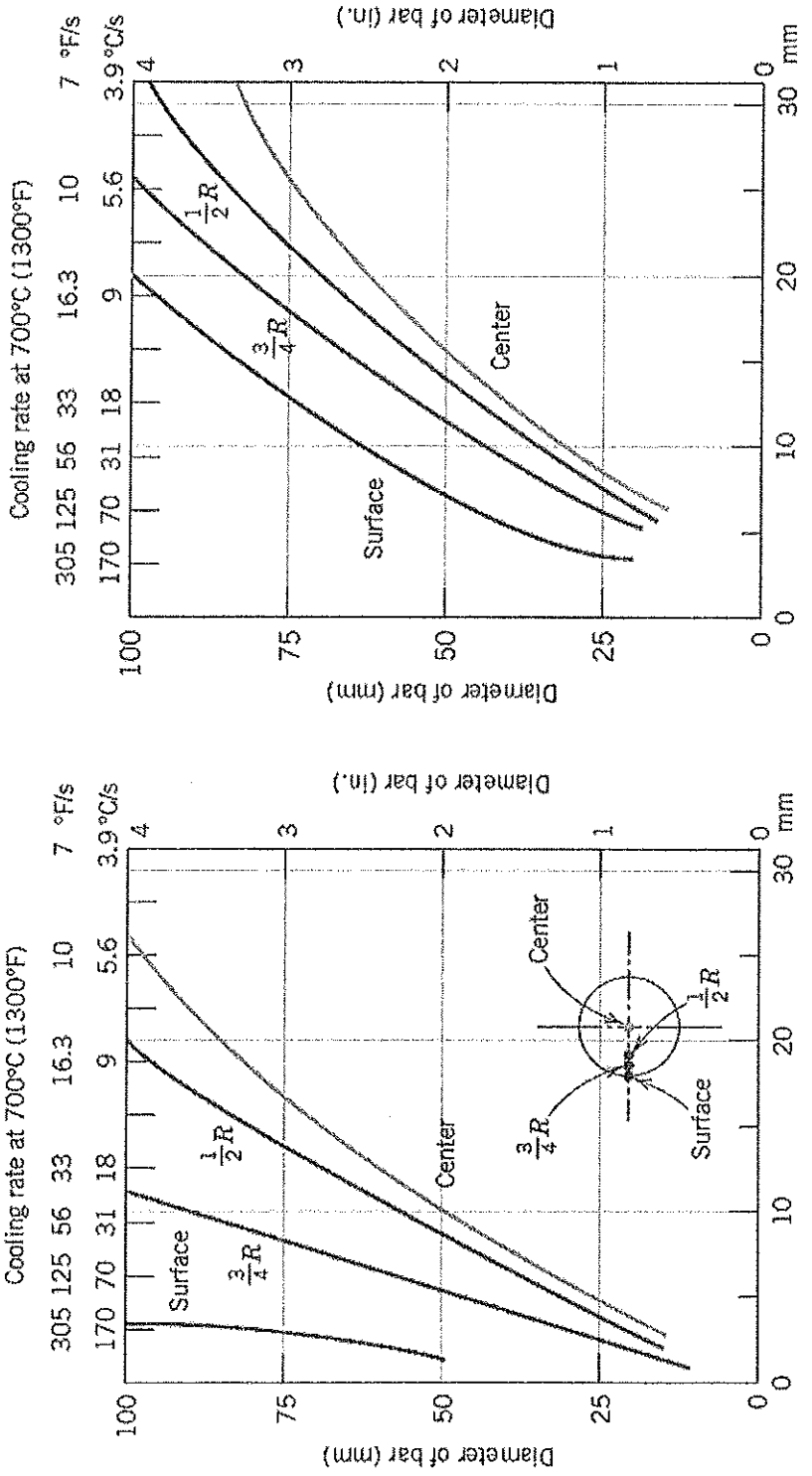


Fig. Q8(a) – Cooling rate as a function of diameter at surface, three-quarter radius (3/4R), mid radius (1/2R) and center positions for cylindrical bars quenched in moderately agitated (i) water and (ii) oil. Equivalent Jominy positions are included in bottom axis.

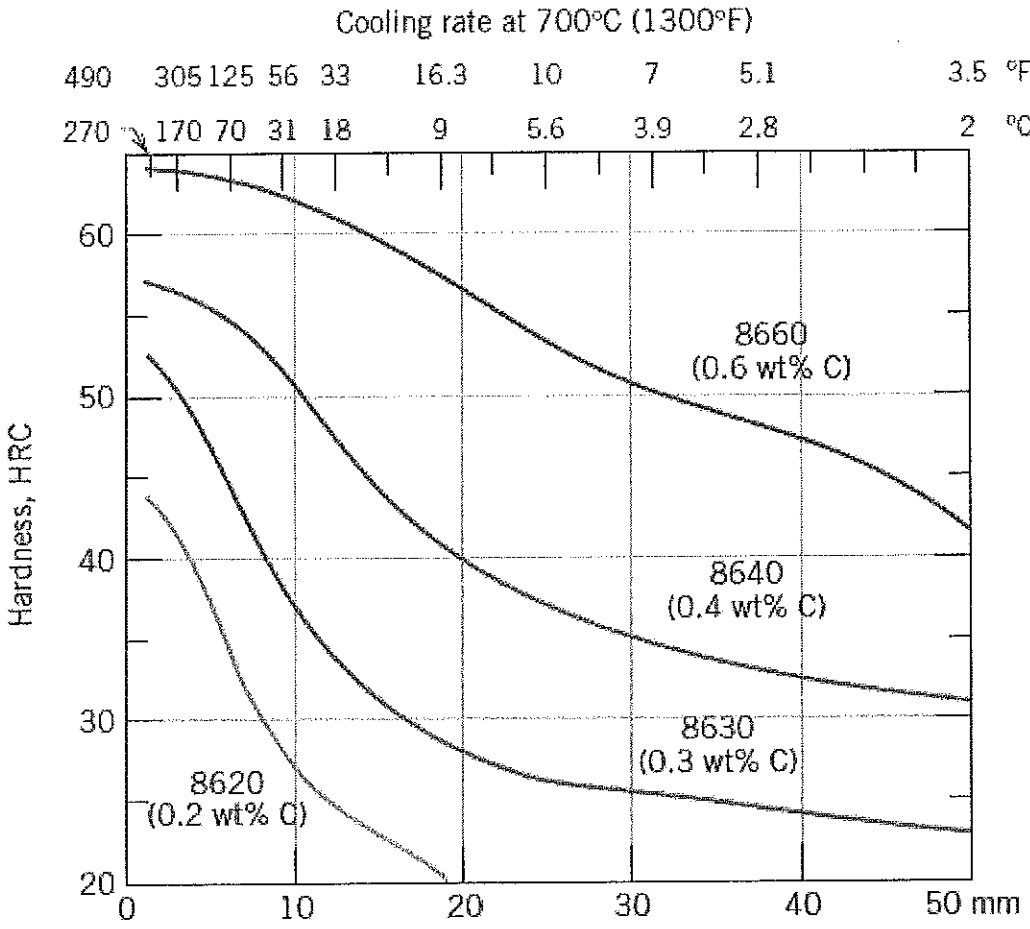


Fig. Q8(b) –Hardenability curves for four 8600 series alloys