Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019

Course: Materials Engineering — **Semester: III**
Program: B. Tech Mechanical — **Time 03 hrs.**
Course Code: MEMA 2003 — **Max. Marks: 100**

Instructions: Internal choice in Q 6, 10 & 11. Do not over attempt.

SECTION-A (20 marks)

S. No.		**Marks**	**CO**
Q 1	Classify following materials into their class of materials (metal/alloy, polymer, ceramic, composite): a) Superalloy, b) Teflon, c) Bronze, d) Alumina, e) Duralumin, f) Reinforced concrete, g) Carbon fibre reinforced polymer, h) Titanium Oxide	4	CO1
Q 2	Discuss the effect of grain size on the strength of a polycrystalline material.	4	CO4
Q 3	Discuss the effect of temperature on diffusivity.	4	CO1
Q 4	Draw a schematic stress-strain curve for a ductile material and show how to calculate resilience and toughness graphically from this diagram.	4	CO2
Q 5	List the Hume-Rothery rules which govern solubility in substitutional solid solutions.	4	CO1

SECTION-B (40 marks)

Q 6	A hypothetical A–B alloy of composition 40 wt% B–60 wt% A at 300°C is found to consist of mass fractions of 0.66 and 0.34 for the α and β phases, respectively. The composition of the α phase is 13 wt% B–87 wt% A at 300°C. a) Plot the above information in a phase diagram. b) What is the composition of β-phase at 300°C?	 5 5	CO3
	OR		
	For alloys of two hypothetical metals A and B, there exist an α, A-rich phase and a β, B-rich phase. At 300°C, the fractions of α & β phases is given in below table for two different alloy compositions.		

Alloy Composition	*Fraction α Phase*	*Fraction β Phase*
70 wt% A–30 wt% B	0.78	0.22
35 wt% A–65 wt% B	0.36	0.64

a) Plot above information in a schematic phase diagram. — 5

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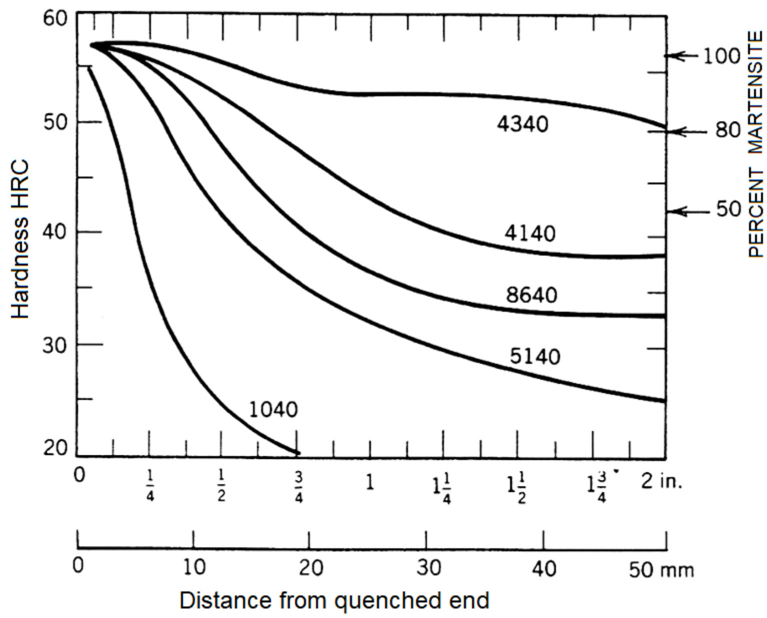
<tr><td></td><td>b) Determine the composition of the phase boundary (solubility limit) for both α and β phases at 300°C.</td><td>5</td><td></td></tr>
<tr><td>Q 7</td><td>a) Define hardenability.
b) Discuss the Jominy-end quench test used for measuring hardenability.
c) The graph below depicts the Jominy-end quench test results for 5 different grades of steel – 1040, 4140, 4340, 5140 and 8640. Using the graph below, measure the hardenability of each steel.

</td><td>2
4
4</td><td>CO2</td></tr>
<tr><td>Q 8</td><td>Consider one such alloy that initially has a uniform carbon concentration of 0.25 wt% and is to be treated at 950°C. If the concentration of carbon at the surface is suddenly brought to and maintained at 1.20 wt%, how long will it take to achieve a carbon content of 0.80 wt% at a position 0.5 mm below the surface? Use the equation and data given below:
The diffusion coefficient for carbon in iron at 950°C = $1.6 \times 10^{-11} m^2/s$

$$\frac{C_x - C_0}{C_s - C_0} = 1 - \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$$

<table><tr><th>z</th><th>erf(z)</th></tr><tr><td>0.35</td><td>0.3794</td></tr><tr><td>0.40</td><td>0.4284</td></tr></table></td><td>10</td><td>CO4</td></tr>
<tr><td>Q 9</td><td>a) Define endurance limit of a material; and draw a schematic S-N curve for a material that exhibits an endurance limit.

b) Draw a typical creep curve of a material subject to constant stress at elevated temperatures.</td><td>5

5</td><td>CO2</td></tr>
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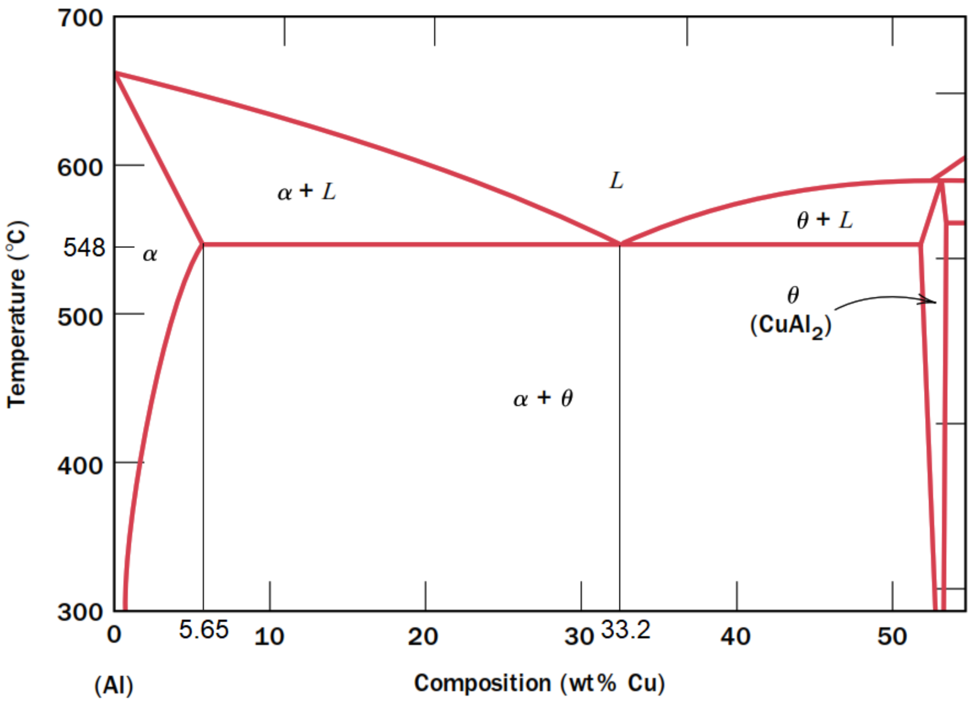
SECTION-C (40 marks)

Q 10	Consider an Al-Cu alloy with phase diagram as shown in figure below:  a) Based on above phase diagram, identify the composition range over which Al-Cu alloys can be precipitation hardened. Briefly describe the approach used for obtaining this range. Consider an Al-4% Cu alloy and **<u>answer any three of the following</u>**: b) Show the solution heat treatment and precipitation heat treatment using a cooling curve (temperature vs time curve). c) Draw a schematic diagram showing strength of the precipitation hardened alloy as a function of ageing time. d) Briefly describe the microstructural evolution during precipitation hardening as the alloy changes from a supersaturated phase → transition phase → equilibrium phase. e) Calculate the maximum wt. % of θ phase that can exist in the precipitation hardened alloy if the room temperature solubility of Cu in Al is 0.2 wt.% and room temperature composition of θ phase is Al-53 wt.% Cu.	5 5 5 5 5	CO4

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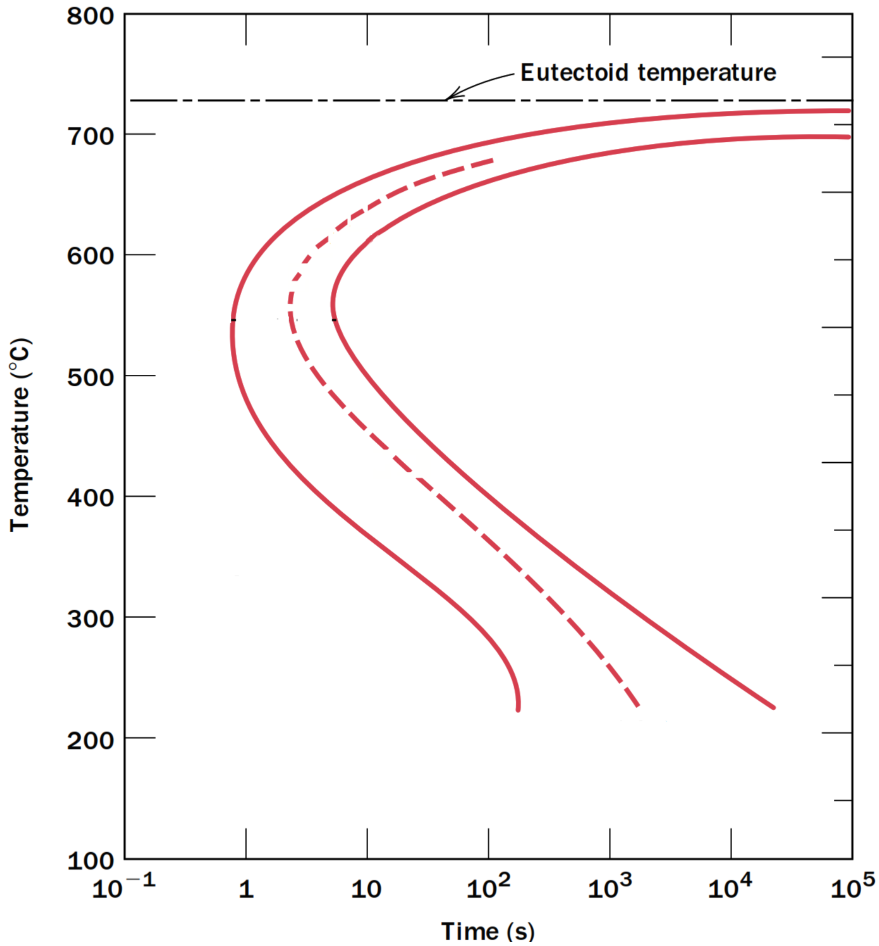
<tr><td>Q 11</td><td>a) Draw the Fe-C equilibrium phase diagram depicting eutectoid and eutectic phase transformation.



A eutectoid plain carbon steel is heated to 760ºC and held at this temperature to achieve a complete and homogenous austenitic structure. Show <u>any two of the following</u> heat treatment processes on the T-T-T curve drawn above and specify the final microstructure (in terms of phases present):

b) Rapidly cool to 350ºC, hold for 10^4 s, and quench to room temperature.

c) Rapidly cool to 250ºC, hold for 100 s, and quench to room temperature.

d) Rapidly cool to 650ºC, hold for 20 s, rapidly cool to 400ºC, hold for 10^3 s, and quench to room temperature.</td><td>10

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5</td><td>CO1

CO5</td></tr>
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