Name: Enrolment No:	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
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Program Name : B. Tech. ADE **Semester : IV**
Course Name : Material Science **Time : 03 Hrs**
Course Code : MEMA 2001 **Nos. of page(s) : 04** **Max. Marks : 100**

NOTE: This question paper has 2 sections; **Section A** and **Section B.**

SECTION-A (1 x 25 = 25 Marks)

Section A carries 25 marks. This section has multiple-choice objective questions. All the questions of Section A are compulsory and carry equal marks.

1. What is a surface imperfection, which separates crystals of different orientations in a poly-crystalline aggregate, called?
(a) Edge dislocation (b) Stacking fault (c) Grain boundary (d) Screw dislocation

2. The lattice parameter relationship for monoclinic crystal system is
(a) $a \neq b \neq c$ and $\alpha = \beta = \gamma$ (b) $a \neq b \neq c$ and $\alpha = \gamma = 90^o \neq \beta$
(c) $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90^o$ (d) $a = b \neq c$ and $\alpha = \beta = 90^o$, $\gamma = 120^o$

3. During normalizing process of steels, the specimen is heated
(a) Between upper and lower critical temperature and cooled in the furnace
(b) Above the upper critical temperature and cooled in the still air
(c) Above the upper critical temperature and cooled in the furnace
(d) Between upper and lower critical temperature and cooled in still air

4. Copper has a FCC structure and an atomic radius of 0.128 nm. What is the inter-planer spacing of d_{111} planes?
(a) 0.307 nm (b) 0.208 nm (c) 0.397 nm (d) 0.298 nm

5. Which of the following factors is more relevant to represent complete solubility of two metals in each other?
(a) Chemical affinity (b) Valency (c) Crystal structure (d) Relative size

6. Lead has FCC structure with inter atomic distance of 3.499 Å. Calculate the number of atoms per square millimeter on plane (100) of the structure.
(a) 8.2×10^{12} /mm^2 (b) 5.7×10^{12} /mm^2 (c) 6.2×10^{12} /mm^2 (d) 4.1×10^{12} /mm^2

7. The Miller indices h, k, and l of parallel planes in a BCC lattice should satisfy which of the following X-ray Diffraction Reflection rules
(a) h + k + l should be even (b) h, k, and l should all be either even or odd
(c) h, k, and l should form Pythagoras triplet (d) all planes allow reflections

8. Nodular gray cast iron is obtained from gray cast iron by adding a small amount of
(a) Manganese (b) Phosphorous (c) Magnesium (d) Chromium

9. An alloy consists of 90% aluminium and 10% copper by weight. The atomic weights of aluminium and copper are 26.98 g/mol and 63.55 g/mol respectively. The atomic percentage of copper in the alloy is
(a) 4.5 (b) 3.5 (c) 6.0 (d) 5.0

10. Which of the following defects affect the density of the material?
(a) Schottky (b) Frenkel (c) Stone-Wales (d) Antisite

11. Which one of the following pairs is not correctly matched?

Space Lattice	Relation between Atomic radius **r** and Edge element **a**
(a) Simple cubic structure	$a^2 = 4r^2$
(b) Body-centered cubic structure	$3a^2 = 16r^2$
(c) Triclinic	$2a^2 = 3r^2$
(d) Face-centered cubic structure	$a^2 = 8r^2$

12. On completion of heat treatment, the resulting structure will have retained austenite if the
(a) Rate of cooling is greater than the critical cooling rate
(b) Rate of cooling is less than the critical cooling rate
(c) Martensite formation start temperature is above the room temperature
(d) Martensite formation finish temperature is below the room temperature

13. Material suitable for bearings subjected to heavy loads is
(a) Silicon bronze (b) White metal (c) Monel metal (d) Phosphor bronze

14. Convert direction [2 $\bar{1}$ $\bar{1}$ 1] from four-index system to three-index system.
(a) [2 1 0] (b) [3 0 1] (c) [111] (d) [121]

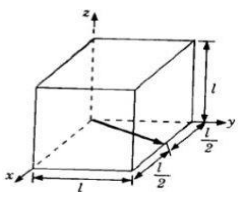
15. The material property that depends purely on the basic crystal structure is
(a) Fatigue Strength (b) Fracture strength (c) Yield strength (d) Elastic Modulus

16. Duralumin contains
(a) 3.5 – 4.5% Cu, 0.4 – 0.7% Mg, 0.4 – 0.7% Mn and balance Al
(b) 3.5 – 4.5% Cu, 1.2 – 1.7% Mn, 1.8 – 2.3% Ni, 0.6% each of Si, Mg & Fe and balance Al
(c) 4.0 – 4.5% Mg, 3.0 – 4.0% Cu and balance Al
(d) 5.0 – 6.0% Sn, 2.0 – 3.0% Cu and balance Al

17. Alnico, an alloy used extensively for permanent magnets contains iron, nickel, aluminium and cobalt in the following ratio
(a) 50:20:20:10 (b) 40:30:20:10 (c) 50:20:10:20 (d) 30:20:30:20

18. The phosphorous percentage in phosphor bronze is
(a) 0.5 (b) 1 (c) 2.5 (d) 5.5

19. A unit cell of a crystal is shown in the given figure. The Miller indices of the direction (arrow) shown in the figure is
(a) [0 1 2] (b) [0 2 1] (c) [1 2 0] (d) [2 0 1]



20. Alloying element mainly used to improve the endurance strength of steels is
(a) Nickel (b) Vanadium (c) Molybdenum (d) Tungsten

21. From the list given below, choose the most appropriate set of heat treatment processes and their corresponding characteristics:

	PROCESS		**CHARACTERISTICS**
P-	Tempering	1.	Austenite is converted into bainite
Q-	Austempering	2.	Austenite is converted into martensite
R-	Martempering	3.	Cementite is converted into globular structure
		4.	Both hardness and brittleness are reduced
		5.	Bainite is converted into martensite

(a) P-3, Q-1, R-5 (b) P-4, Q-3, R-2 (c) P-4, Q-1, R-2 (d) P-3, Q-5, R-4

22. A screw dislocation
1. Lies parallel to its Burger's vector
2. Lies perpendicular to its Burger's vector
3. Moves in a perpendicular direction to the Burger's vector
4. Moves in an inclined direction to the Burger's vector
Select the correct answer using the codes given below:
Codes: (a) 1 and 4 (b) 1 and 3 (c) 2 and 3 (d) 2 and 4

23. Match List I with List II and select the correct answer:

List I (Phase diagram)	List II (Characteristic)
A. Isomorphous system	1. One liquid decomposes into another liquid and solid
B. Eutectic system	2. One liquid and another solid combine to form a new solid
C. Peritectic system	3. Two metals are completely soluble in liquid state and completely insoluble in solid state
D. Monotectic system	4. Two metals, soluble in solid and liquid state

Codes:

	A	B	C	D
(a)	2	3	4	1
(c)	2	1	4	3

	A	B	C	D
(b)	4	1	2	3
(d)	4	3	2	1

24. Match List I (Alloying elements for tool steel) with List II (Improved mechanical property) and select the correct answer using the codes given below the Lists.

List I (Alloying elements for tool steel)	List II (Improved mechanical property)
A. Carbon	1. Hardness
B. Manganese	2. Hot Hardness
C. Chromium	3. Lower Critical Temperature
D. Vanadium	4. Toughness

Codes:

	A	B	C	D
(a)	1	3	4	2
(c)	1	4	3	2

	A	B	C	D
(b)	2	4	3	1
(d)	2	3	4	1

25. Which one among the following is the most effective strengthening mechanism of non-ferrous metal?
(a) Solid solution hardening (b) Strain hardening
(c) Grain size refinement (d) Precipitation hardening

SECTION-B (15 x 5 = 75 Marks)

Section B carries 75 marks. All the questions of Section B are compulsory and carry equal marks.

Q. No.		Marks	CO
1.	Sketch a completely labelled Fe-Fe_3C equilibrium phase diagram showing all the necessary temperatures, compositions, invariant points and phases/micro-constituents. Differentiate between hypo-eutectoid and hyper-eutectoid alloys.	**09**	**CO2**
	A 0.80 % C steel is slowly cooled from 750 °C to a temperature slightly below 723 °C. Assuming that the austenite is completely transformed to α-ferrite and cementite, describe the structure/morphology at room temperature, which will be thus formed in each case with the help of appropriate diagrams and calculate: a) the weight percent of ferrite formed, b) the weight percent of cementite formed.	**06**	**CO3**
2.	Define critical cooling rate. Sketch completely labelled TTT curve for eutectoid plain carbon steel and state its utility and limitations. Plain carbon steel containing 0.6 wt. % carbon is heated 25 ^oC above the upper critical temperature and heat treated separately as follows: (a) Quenched in cold water (b) Quenched in water and reheated at 600 ^oC Describe the structure/morphology at room temperature, which will thus formed in each case with the help of appropriate diagrams.	**10**	**CO4**
	What do you understand by case hardening? Briefly describe the Cyaniding process of case hardening.	**05**	
3.	What are non-ferrous alloys? How they are classified. How the aluminium alloys are designated? Discuss the composition, properties and applications of the two main alloys of Aluminum, Magnesium, Copper and Nickel.	**10**	**CO3**
	Define composite. What is synergistic effect? How the composites are classified? Give broad classification of composites.	**05**	
4.	What is cast iron? Enumerate different types of cast irons and briefly describe how they are produced? Draw the microstructures of each type and discuss their important properties and applications.	**10**	**CO3**
	What is a crystal defect? Enumerate different types of crystal defects.	**05**	**CO1**
5.	What is fatigue? Draw S-N curve for mild steel and aluminium and explain endurance limit of a material.	**05**	
	What is creep and creep rate? Draw a classical creep curve and explain all stages of a classical creep curve.	**05**	**CO5**
	Fused silica has a surface energy of 4.32 J/m^2 and an elastic modulus of 69 GPa. A large plate of this material is to withstand a nominal stress of 35 MPa. Using Griffith's theory of fracture, determine the largest internal flaw size that can be tolerated without fracture.	**05**	