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Question Paper Code	13974
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**B.E. / B.Tech. - DEGREE EXAMINATIONS, NOV / DEC 2025**

Third Semester

**Mechanical Engineering**

**24MEPC302 - ENGINEERING METALLURGY**

Regulations - 2024

Duration: 3 Hours

Max. Marks: 100

**PART - A (MCQ) (10 × 1 = 10 Marks)**

Answer ALL Questions

	Marks	K- Level	CO
1. What is the name of the intermetallic compound of iron and carbon with the formula Fe <sub>3</sub> C?	1	K1	CO1
(a) Ferrite                      (b) Austenite                      (c) Cementite                      (d) Pearlite			
2. What is the maximum solubility of carbon in austenite (FCC iron)?	1	K1	CO1
(a) 0.022 wt%                      (b) 2.14 wt%                      (c) 6.67 wt%                      (d) 4.30 wt%			
3. Which cooling method is used in full annealing?	1	K1	CO2
(a) Quenching in water                      (b) Slow cooling inside a furnace (c) Cooling in an oil bath                      (d) Air Cooling			
4. Heat treatment of metal is necessary	1	K1	CO2
(a) To produce certain desired properties                      (b) To make good appearance on the component (c) To increase strength of the metal                      (d) To make the metal corrosion resistant			
5. Using your understanding of heat treatment, explain why martempering is preferred over conventional quenching for carburized parts.	1	K1	CO3
(a) Martempering eliminates the need for tempering (b) Martempering accelerates cooling to avoid the formation of bainite (c) Martempering reduces thermal stresses and distortion by holding the part at the martensite start temperature (d) Martempering is simpler and cheaper than austempering			
6. The vacuum hardening process in industrial application is considered more environmentally friendly than other hardening methods because,	1	K1	CO3
(a) It generates more waste material during processing (b) It eliminates the use of harmful gases and reduces pollutant emissions (c) It requires open flames and consumes more energy (d) It increases corrosion and surface oxidation			
7. Infer how chromium addition affects the corrosion resistance and hardenability of steel.	1	K1	CO4
(a) Reduces tensile strength (b) Decreases corrosion resistance but increases ductility (c) Has no effect on corrosion resistance or hardenability (d) Increases corrosion resistance and hardenability			
8. Which property primarily differentiates engineering polymers from commodity polymers in industrial applications?	1	K1	CO4
(a) High transparency                      (b) Ease of recycling (c) Enhanced mechanical and thermal stability                      (d) Low cost and high-volume production			
9. Carbon Composites are known for being extremely _____ offering high stability and an attractive appearance.	1	K1	CO5
(a) Durable                      (b) Heavy                      (c) Corrosive                      (d) Light			
10. Ductility is indicated by	1	K1	CO6
(a) Percentage of elongation                      (b) Percentage of reduction                      (c) Poisson ratio                      (d) Creep			

**PART - B (12 × 2 = 24 Marks)**

Answer ALL Questions

- |   |   |    |     |
|---|---|----|-----|
| 11. Define solid solution.  | 2 | K1 | CO1 |
| 12. State Gibb's phase rule.  | 2 | K1 | CO1 |
| 13. State the process of Heat treatment.  | 2 | K1 | CO2 |
| 14. The tempering process follows the hardening process. Justify.               | 2 | K2 | CO2 |
| 15. Illustrate the micro structural evolution in steel during mar tempering.    | 2 | K2 | CO3 |
| 16. Outline the impact of case depth on wear resistance in case-hardened parts. | 2 | K2 | CO3 |
| 17. Why is cupronickel preferred for marine environments?                       | 2 | K2 | CO4 |
| 18. Differentiate commodity and engineering polymers with examples.             | 2 | K2 | CO4 |
| 19. Pen down the differences between a composite material and an alloy.         | 2 | K2 | CO5 |
| 20. Illustrate how SIALON ceramics are used in cutting tool applications.       | 2 | K2 | CO5 |
| 21. Infer how grain refinement helps in improving ductility and toughness.      | 2 | K2 | CO6 |
| 22. Differentiate ductile fracture and brittle fracture.                        | 2 | K2 | CO6 |

**PART - C (6 × 11 = 66 Marks)**

Answer ALL Questions

- |           |  |    |    |     |
|-----------|--|----|----|-----|
| 23. a)    | Utilize the iron-carbon diagram, sketch and label the microstructure of steel with 0.6%C cooled from the austenite region to below 723°C.  | 11 | K3 | CO1 |
| <b>OR</b> |  |    |    |     |
| b)        | Utilize your knowledge of dislocation theory to explain the mechanism of slip as the main mode of plastic deformation in crystalline solids, and evaluate how differences in slip systems determine the ductility of FCC, BCC, and HCP metals.                               | 11 | K3 | CO1 |
| 24. a)    | Apply your understanding on Critical Cooling Rate (CCR) with respect to heat treatment process and discuss its importance in detail.   | 11 | K3 | CO2 |
| <b>OR</b> |  |    |    |     |
| b)        | In a metallurgical experiment, a eutectoid steel rod is rapidly cooled to a temperature just above the "nose" of the TTT curve and held there until the transformation is complete. Identify the resulting microstructure and describe the transformation process in detail. | 11 | K3 | CO2 |
| 25. a)    | The following data shows hardness (in HRC) measured at various distances (in mm) from the quenched end of a specimen during a Jominy end quench test.  | 11 | K3 | CO3 |

Distance from Quenched End (mm)	1.5	3	7	9	11	13	15	20	25	30
Hardness (HRC)	58	55	50	48	45	42	40	36	33	29

Construct the Jominy hardness curve and interpret the steel's hardenability.

**OR**

- |           |  |    |    |     |
|-----------|--|----|----|-----|
| b)        | Apply your understanding of case hardening process to explain flame hardening and induction hardening.   | 11 | K2 | CO3 |
| 26. a)    | In detail pen down the chemical structure, properties and application of the PP, PVC, ABS, PEEK, PTFE.   | 11 | K2 | CO4 |
| <b>OR</b> |  |    |    |     |
| b)        | Illustrate, with suitable examples and applications, how different micro-alloying elements influence the mechanical and metallurgical properties of steel. | 11 | K2 | CO4 |

27. a) Apply your understanding of metal-matrix composites (MMCs) by explaining how the reinforcement of SiC in Al can improve the properties as desired for automobile applications. 11 K2 CO5

**OR**

b) Apply your understanding of engineering ceramics to categorize their types based on industrial applications, and describe any three engineering ceramics in detail. 11 K2 CO5

28. a) Compare Brinell, Vickers, and Rockwell hardness tests based on indenter type, load range, and applications. 11 K3 CO6

**OR**

b) Analyze how cold working prior to aging affects precipitate nucleation and enhances the strength of precipitation-hardened alloys. 11 K3 CO6