Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S3 (S,FE) (FT/WP) / S5 (PT) Examination November/December 2025 (2019 Scheme)

Course Code: MET205

Course Name: METALLURGY & MATERIAL SCIENCE

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks Marks

1 Distinguish between homogeneous and heterogeneous nucleation. (3)

2 Briefly explain the steps involved in the determination of miller indices of a crystallographic direction with an example. (3)

3 What are the causes of interstitial impurities in solids? (3)

4 A beam of x-rays of wavelength 0.071 nm is diffracted by (110) plane of rock salt (FCC) with lattice constant of 0.28 nm. Find the glancing angle (in degree) for the second- order diffraction. (3)

5 What is the necessity of alloying? (3)

6 Define isomorphous system with an example. (3)

7 What are the factors necessary to cause fatigue failure? (3)

8 Briefly cite the differences between recovery and recrystallization processes (3)

9 What are the stages after necking in ductile fracture? (3)

10 State the Griffith criterion for crack propagation in brittle solid (3). (3)

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

11 a. On a simple cubic lattice of spacing = 1, draw the [100], [010], [110], [001] and [111] directions. (5)

b. In uniaxial tensile loading of a ductile material, explain the following with neat sketches (9)

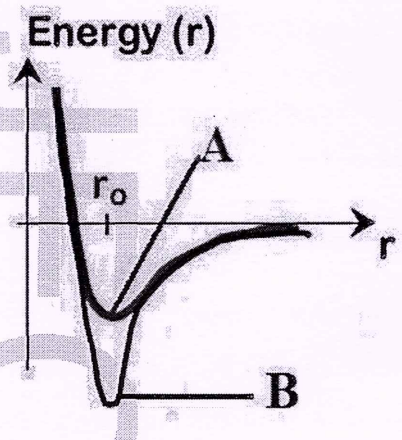
i. What is resolved shear stress

ii. What is critically resolved shear stress

iii. Why there is no resolved shear stress on a plane either parallel or perpendicular to the stress axis.

12 a. Calculate the radius of vanadium atom, given that V has a BCC crystal structure, a density of 5.96 g/cm^3 and an atomic weight of 50.9 g/mol. (6)

b. Potential energy (E) Vs Interatomic distance (r) graph of two materials A and B are given below. Compare the elastic modulus, melting temperature and coefficient of thermal expansion of the materials A and B with justifications. (8)



Module 2

13 a. The yield strength of mild steel with an average grain size of 0.05 mm is 137.9 MPa. The yield strength of same steel with a grain size of 0.007 mm is 275.8 MPa. What will be the grain size of the same steel with a yield stress of 206.9 MPa? Assume that Hall Petch relation is valid and change in yield stress is only due to change in grain size. (9)

b. Calculate the number of vacancies in one mole Nickel (Ni) at a temperature of 500 K. Enthalpy of formation of vacancies in Nickel = 168 $\times 10^3$ J/mole, Avogadro number N=6.023 $\times$ 10^{23} atoms per mole, R=8.314 J/mole/K. (44) (5)

14 a. The diffusion coefficients for iron in nickel are given at two temperatures: (4) (9)

Temperature, T (K)	Diffusion coefficient, D (m^2/s)
1273	9.4×10^{-16}
1473	2.4×10^{-14}

i. Determine the value of pre-exponential factor, D_o and activation energy.

ii. What is the value of diffusion coefficient at 1100°C?

b. What is slip plane? How is it related to dislocation? Explain with the slip plane and slip direction in FCC, BCC and HCP crystals. (5)

Module 3

15 For equilibrium cooling of 1 kg of Iron (Fe) – Carbon (C) alloy containing 1.15 wt% C to below 727°C (14)

i. What is the proeutectoid phase?

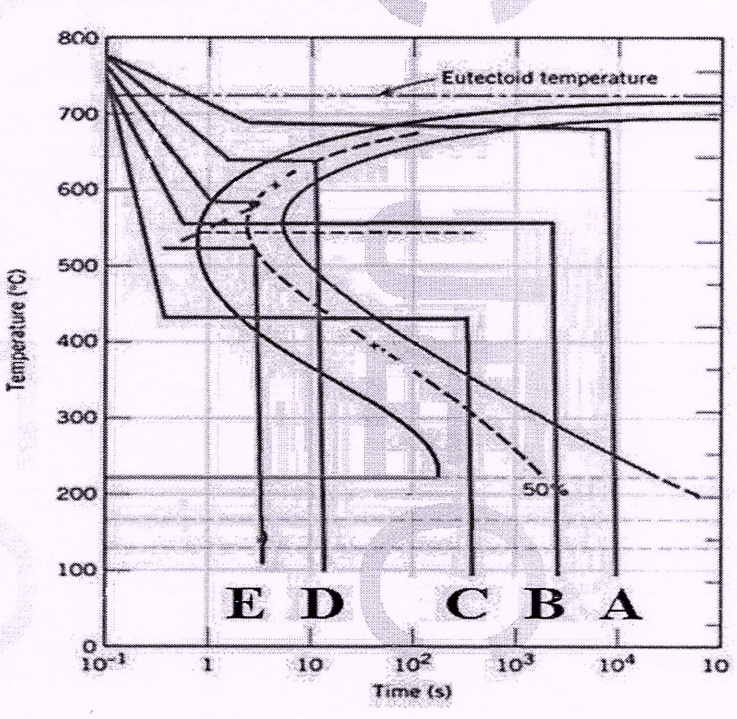
ii. How many kilograms each of total ferrite and cementite form?

iii. How many kilograms each of pearlite and proeutectoid phase form?

iv. Schematically sketch and label the resulting microstructure.

16 a. State and explain the rules that led to the formation of conditions which favour extensive substitutional solid solubility. (8)

b. The figure shows the isothermal continuous cooling transformation diagram for iron carbon alloy of eutectoid composition. Determine the final microstructure yield for each continuous cooling curve labelled as (a), (b), (c), (d) and (e)? (6)



Module 4

17 a. With neat sketch explain Mean Stress, Range, Amplitude and Stress Ratio in completely reversed stress cycle. (6)

b. What is the effect of cold work on ductility, hardness, strength, electrical conductivity and internal stress? Explain how can we restore the above properties to initial values? (8)

18 a. Explain the composition and properties of any 2 Aluminium alloys. (6)

b. With a neat labelled sketch explain rotating beam fatigue testing machine. (8)

Module 5

19 a. With a neat sketch list the salient features of cup and cone type of fracture. (5)

b. With a neat sketch explain the three stages of an ideal creep curve. (9)

20 a. What is composite material? Explain with classification and types. (7)

b. Why brittle fracture is more dangerous than ductile fracture in engineering applications? What are the circumstances in which ductile to brittle transition can happen? (7)

***