

School of Minerals, Metallurgical and Materials Engineering

Written Test Syllabus for PhD Admissions

The written test features two sections.

Section - A

Engineering Mathematics

Linear Algebra: Matrices and Determinants, Systems of linear equations, Eigen values and Eigen vectors.

Calculus: Limit, continuity and differentiability; Partial derivatives; Maxima and minima

Vector Calculus: Gradient; Divergence and Curl; Line, Surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs

Probability and Statistics: Definitions of probability and sampling theorems, conditional probability, Mean, median, mode and standard deviation-

General aptitude & reasoning

Logical reasoning, Verbal reasoning, Non-verbal reasoning, Data interpretation

English

Sentence formation from phrases, Sentence correction/improvement, Completing statements, Comprehension

Section - B

Principles of Metallurgy and Materials Engineering

Atomic structure and Bonding: Electrons in atoms, Bonding forces and energies, Ionic bonding, Covalent Bonding, Metallic Bonding, Secondary bonding.

Structure of Crystalline Solids: Crystalline and noncrystalline materials, Crystal structures in metals and ceramics, Miller indices, Structure of surfaces and interfaces, nano-crystalline and amorphous structures; solid solutions; solidification;

Imperfections in Solids: Point defects, Line defects and dislocations, Interfacial defects, Bulk or volume defects, significance of defects in materials

Diffusion mechanisms, Steady and non-steady state diffusion, Factors that influence diffusion, heat transfer – conduction, convection and heat transfer coefficient relations, radiation, mass transfer – diffusion and Fick's laws, mass transfer coefficients; momentum transfer – concepts of viscosity, shell balances, Bernoulli's equation, friction factors.

Phase Diagrams: Definitions and basic concepts, Types of phase transformations, Gibbs Phase Rule, Interpretation of binary phase diagrams

Mechanical Properties of Materials: Elastic deformation, Plastic deformation, elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, yield criteria, Interpretation of tensile stress-strain curves, Measurement of hardness in materials

Electrical Properties of Materials: Electrical conduction, Semiconductivity, Dielectric Behaviour, Ferroelectric and Piezoelectric Behaviour

Thermal Properties: Heat capacity, Thermal expansion, Thermal conductivity, Thermal stresses

Magnetic Properties: Basic concepts, Diamagnetism, Paramagnetism, Ferromagnetism, Antiferromagnetism, Ferrimagnetism, Influence of temperature, Domains and Hysteresis

Optical Properties: Interaction of light with solids, Optical properties of metals and non-metals

Thermodynamics and Rate Processes

Laws of thermodynamics, activity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, basic kinetic laws, order of reactions, rate constants and rate limiting steps; principles of electro chemistry- single electrode potential, electrochemical cells and polarizations.

Physical Metallurgy

Principles of heat treatment of steels, and aluminium alloys; recovery, recrystallization and grain growth; elements of X-ray and electron diffraction; principles of optical, scanning and transmission electron microscopy.

Mechanical Metallurgy

Strengthening mechanisms; tensile, fatigue and creep behaviour; Superplasticity; fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle transition, fracture toughness.

Manufacturing Processes

Metal casting – patterns and moulds, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding; Hot, warm and cold working of metals; Metal forming – fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming; Metal joining – soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints; Powder metallurgy – production of powders, compaction and sintering; NDT using dye penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.