

PhD Entrance Test

Metallurgical and Materials Engineering

Syllabus

Metallurgical Thermodynamics Laws of Thermodynamics: First law – energy conservation, Second law - entropy; Enthalpy, Applications to metallurgical systems, solutions, ideal and regular solutions; Gibbs phase rule, phase equilibria, binary phase diagram and lever rule, free-energy vs. composition diagrams; Equilibrium constant, Activity, Ellingham and phase stability diagrams.

Transport Phenomena and Rate Processes Momentum Transfer: Concept of viscosity, shell balances, Bernoulli's equation, mechanical energy balance equation, flow past plane surfaces and through pipes. Heat transfer: Conduction, Fourier's Law, 1-D steady state conduction.

Mineral Processing and Extractive Metallurgy: Principles and processes for the extraction of non-ferrous metals – aluminium, copper and titanium. Iron and Steel Making: Material and heat balance in blast furnace; Structure and properties of slags and molten salts – basicity of slags - sulphide and phosphate capacity of slags; Primary Steel Making: Basic oxygen furnace, oxidation reactions, electric arc furnace. Secondary Steel Making: Ladle process – deoxidation, argon stirring, desulphurization, inclusion shape control, principles of degassing methods; Basics of stainless steel manufacturing. Continuous Casting:

Physical Metallurgy: Ionic, covalent, metallic, and secondary bonding in materials, Crystal structure of solids – metals and alloys, X-ray Diffraction: Bragg's law, optical metallography, principles of SEM imaging. Crystal Imperfections, Homogeneous and heterogeneous nucleation, Precipitation, eutectoid transformation, diffusionless transformations; Precipitate coarsening. Principles of heat treatment of steels, TTT and CCT diagrams; Surface hardening treatments; Recovery, recrystallization and grain growth; Basic forms of corrosion and its prevention.

Mechanical Metallurgy: Plastic deformation by slip and twinning. Dislocation Theory: Edge, screw and mixed dislocations, source and multiplication of dislocations, stress fields around dislocations. Strengthening Mechanisms: Work/strain hardening, strengthening due to grain boundaries, solid solution, precipitation and dispersion. Fracture behaviour, Griffith theory, linear elastic fracture mechanics, fracture toughness, fractography, ductile to brittle transition. Fatigue: Cyclic stress strain behaviour - low and high cycle fatigue, crack growth. Mechanisms of high temperature deformation and failure; creep and stress rupture,

Manufacturing Processes: Metal Casting, Gating and risering, casting defects. 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. Principles of soldering, brazing and welding, welding metallurgy, defects in welded joints. Dye-penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle inspection methods.