

Metallurgical and Material Engineering Department

Syllabus for PhD Entrance Examination (Departmental Subject)

· Thermodynamics and Kinetics:

Free Energy of reactions, Equilibrium constant, Application of thermodynamics to produce metal from ores/waste, Ellingham diagram, Ideal and Non Ideal solution, Raoult's and Henry's laws, Chemical potential, Free Energy composition diagram, Gibbs Phase rule.

Homogenous and Heterogeneous reaction, Rate of reactions, reactions mechanism from kinetics data, diffusion controlled, chemical controlled, contracting geometry, Activation Energy, Rate of reaction dependent on temperature, pressure, concentration and particle size. Diffusion, Fick's 1st and 2nd laws of diffusion.

· Pyro, Hydro and Electro metallurgical Process:

Roasting, Smelting, matte smelting, converting for Metal sulphides/oxides/chlorides, Principle of Leaching of oxides/sulphides/ chlorides/ pure metal, E-pH diagram, Solvent extraction, Ion exchange, Electrowinning, Electrorefining Aqueous solution and Fused salt electrolysis by Electrometallurgy.

· Corrosion

Electrochemical Principle of Corrosion, E-pH diagram, Corrosion of steel in aqueous environment, Polarization, Rate of corrosion, Ecorr, Icorr, Forms of Corrosion, Atmospheric corrosion, Principle of corrosion protection by Inhibitor, coatings, anodic and cathodic protection.

· Mineral Dressings

Principle of Beneficiation of ore by sizing, sieve analysis, Magnetic separation, Gravity separation by Jigging, Tabling. Froth Floatation of sulphide ores.

· Iron and Steel Technology

Cokemaking. Review of Ironmaking Processes like Blast Furnace, Corex, DR Plant (coal & gas based) and other modern processes. Review of steelmaking processes like LD, LDAC, OBM, EAF, IF and other modern processes. Secondary steel making, deoxidation, desulphurization and degassing. Principles of alloy steel making process in view of stainless steel production, AOD, VOD. Casting pit practice, solidification defects & remedies, killed, semi killed & rimming steel. Continuous casting process. Basics of ferro alloy production. Principles and techniques of ferro alloy production like FeMn, FeCr, FeSi, SiMn, CaSi, FeTi, FeV, FeW, FeNb, FeNi, FeMo.

· Physical Metallurgy

Crystals, symmetry elements, symmetry groups, atomic packing, crystal structure.

Alloy theory, Fe-C system, steel and iron microstructures with phase relations, Free energy-composition diagrams. Ideal and non-ideal behaviour of alloy systems. Diffusion: Diffusion laws, Kirkendall effect, activation energy, uphill diffusion etc. Solidification and solid-state transformation. Nucleation and growth reactions: Homogeneous & Heterogeneous nucleation. Dendritic solidification; Super cooling,

Interface calculation etc. Segregation precipitation reaction. Diffusional phase transformation process massive transformation, recrystallisation, precipitation transformation, order disorder, eutectoid and spinoidal transformations. Optical microscopy: Construction, image formation and resolution

Phase transformation in steel, Kinetics of transformation, TTT & CCT curves, pearlitic transformation with different factors, characteristic of bainitic transformation, Diffusional phase transformation process: Diffusionless transformation; characteristics of martensitic transformation with stabilization and micro associated phenomena. Role of alloying elements in Steel-Equilibrium diagrams etc. Structure and properties. Alloy classification and families- Stainless steel, High speed steel etc. Heat treatment of different alloy steels, special heat treatment processes, atmospheres etc. Tool steels, bearing steels.

Hardenability, Different heat treatments- Annealing, Normalizing, Hardening, Tempering surface treatment etc. Thermo mechanical treatments, Different heating atmospheres and salt baths, Carburizing, nitriding and its varieties, and induction hardening.

X ray diffraction, electron microscopy

· Material Engineering

Detailed description and metallurgy of following metals and their alloys-specifications, properties and applications - Cu, Al, Ti, and super alloys. Bearing, cryogenic, aerospace, nuclear, cutting tools, etc. Materials for electrical contact, heating element, thermocouples, antifriction, magnetic materials, reactor, heat resistance, cryogenic purpose.

· Heat treatment technology

Heat treatment of different nonferrous metals. Failures and defects associated with heat treatment.

· X-RAY & ELECTRON MICROSCOPY

Stereographic projection. Reciprocal lattice concepts. Generation of X-Ray. Continuous and characteristic spectrum of X-ray. Filters. Coherent scattering and diffraction under nonideal conditions. Intensity of diffracted beams, Laue & Powder method. Indexing of cubic and non-cubic crystals. Application particle size determination.

Electron microscopy principles.

· Casting Technology

Foundry Fundamentals, Bonding, Sand & Clay, Testing, Solidification, Gating, Riser, Defects, Casting Processes, casting Design, Methoding, Steel and Iron castings, Light Metal Casting, New Casting Technologies.

· Joining of Materials

Fundamental of bonding, welding arc and arc physics, power sources for arc welding. Welding, Brazing, Soldering, Adhesive Bonding, Micro-joining, Micro-plasma, Micro-resistance, Ultrasonic Welding, Low Power Laser, Microwave Welding, Plastics & Ceramics, Joining of Advanced Materials, Defects in welded, brazed and soldered joints and its significance, Destructive and Non-destructive testing of welded joints, weldability test.

· Plastic Deformation and Metal Working Processes

Concepts of stress & plastic state of deformation – principal stress, normal stress, hydrostatic stress, shear stress etc., Yield Criteria – Von Mises and Tresca.

Critical resolved shear stress, Dislocation concept for plastic deformation, Types of dislocation, Dislocation reaction, Lomer-Cottrell barrier, Bauschinger Effect, Tensile, Fatigue, Creep and Impact behavior of metals, Strain rate sensitivity, strain hardening, superplasticity, Equicohesive temperature, Annealing process, Recrystallisation Temperature, Linear elastic fracture mechanics, Fracture Toughness.

Elements of metal deformation processes – Rolling: hot rolling & cold rolling; Forging: open die forging, closed die forging & press forging; Extrusion: direct, indirect & Aluminium extrusion; Wire drawing; Sheet metal working; Stretch forming for foils. Defects & limitations, thermomechanical processing, recovery, recrystallization and grain growth, microstructure development during forming.