Metallurgical Engineering and Materials Science

1. Engineering Mathematics:-

Linear Algebra, calculus,vector calculus, ordinary differential equations, partial differential equations, data analysis and interpretation:-

2. Thermodynamics, Rate and Kinetic of processes:-

Fundamentals of thermodynamics, basic kinetic laws, order of reactions order of reactions, rate constants and rate limiting steps. Principles of electro chemistry, characterization and control. Heat transfer – conduction, convection and heat transfer coefficient relations, radiation, Concepts of viscosity, shell balances, Bernoulli's equation, friction factors; Homogenous reactions. Ideal batch reactors, continuous stirred tank reactors, plug flow reactors. Residence time & RTD. Mixing. Design of reactors, Elements of mass transfer, diffusion in fluids, ordinary & Knudsen diffusion, pore size distribution. Adsorption : Physical vs chemical, Adsorption isotherms, BET method. Surface reactions & their kinetics.

3. Extractive and Process Metallurgy:-

Minerals of economic importance, comminution techniques, size classification, flotation, gravity etc; agglomeration, pyro-, hydro-, and electro-metallurgical processes; material and energy balances; principles and processes for the extraction of non-ferrous metals; Separation techniques. Iron and steel making, Concepts in process metallurgy such as calcination, gas producers and heat balance. Material balance of slag, flux & concentrates.

4. Physical Metallurgy:-

Crystal structure and bonding characteristics of metals, alloys, ceramics and polymers, structure of surfaces and interfaces, nano-crystalline and amorphous structures; solid solutions; solidification; phase transformation; principles of heat treatment of steels, cast iron and aluminium alloys; surface treatments; recovery, recrystallization and grain growth; structure and properties of industrially important ferrous and non-ferrous alloys; Ceramics; Polymers and composites

5. Mechanical Metallurgy:-

Elasticity, yield criteria and plasticity; defects in crystals; theory of dislocation; 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; failure analysis; mechanical testing.

6. Manufacturing Processes:-

Metal casting, forming and joining. Solidification, Powder metallurgy

7. Characterization techniques:-

X-ray diffraction, spectroscopic techniques like UV-vis, IR, Raman. Optical and Electron microscopy, DTA, TGA, DSC, their working principles and applications.

8. Structure of Materials:-

Metals, alloys, intermetallics, oxide and non-oxide ceramics, polymers, composites, semiconductors. Atomic, molecular, crystal structures and microstructure of materials. Crystals (single and polycrystalline) and amorphous materials. Structure-property correlations in materials.

Elements of Crystal symmetry, point defects, dislocations, grain boundaries, surface energy and equilibrium shapes of crystals.

Processing of materials:- Powder synthesis, sintering, chemical methods, crystal growth techniques, zone refining, preparation of nanoparticles and thin films

Phase Diagrams

9. Properties of Materials:-

Mechanical properties, Electronic properties, Magnetic properties, Thermal Properties, Optical properties

10:- Elements of Quantum mechanics and Statistical Mechanics:-

Postulates of quantum mechanics; uncertainty principle; Schrodinger equation; one-, dimensional potential problems; particle in a box, transmission through one dimensional potential barriers, harmonic oscillator, hydrogen atom;

Macrostates and microstates; phase space; ensembles; partition function; Maxwell-Boltzmann distribution, Bose-Einstein Statistics and Fermi-Dirac distribution.