# MATERIAL SCIENCE FOR CHEMICAL ENGINEERS
## (PROFESSIONAL ELECTIVE-II)

**Course Code: 20CH1153**

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**Course Outcomes:** At the end of the Course, the Student will be able to

**CO1:** Identify various crystal systems.

**CO2:** Identify parameters for simple crystal structures

**CO3:** Predict the properties of simple alloys and steels based on their phase diagrams, phasetransitions and heat treatment.

**CO4:** Describe the mechanical behavior, failure and strengthening mechanisms of various metals,alloys and plastics.

**CO5:** Identify various types of corrosion and its prevention.

**UNIT-I** **12 Lectures**

INTRODUCTION AND CRYSTAL GEOMETRY:

Classification of Engineering Materials – Fundamental Blocks of Matter. A brief review on Atomic(micro) Structure and Atomic Bonding- Energy of the Atomic system . Ionization potential, ElectronAffinity- Ionic radii and Equilibrium Distance, Bond Length, ΔH Crystal, HLattice, Ionic, Covalentand metallic Bonding , Secondary bondingProperty relation to Bond characteristics. Space lattice, Unit cellPrimitive cell, Double Cell, Triple Cell, Multiple Cell-Crystal and Crystalline Substance,Amorphous Material-Bravais lattices, Crystal systems and their characteristics with suitable examples. Lattice points –Lattice Co-ordinates, Miller indices for directions and planes, MillerBravais indices, Linear and Planar Densities, Slip Directions and slip Planes, Packingefficiencies and fractions Close Packed Structures(CPS) , C/A ratio for HCP Structures.

**Learning Outcomes:** After the completion of the Unit I, the student will be able to

1. Describe the fundamentals of crystal geometry and structure determination(L2)
2. Discuss the different types of bonding and their dependence on structural properties(L2)
3. Explain the classification of engineering materials(L2)

**UNIT-II** **12 Lectures**

CRYSTAL STRUCTURE DETERMINATION AND CRYSTAL DEFECTS:

Bragg's law of X-Ray Diffraction and determination of Cubic Crystal structure, Lattice Constant and identification of metals using powder method, problems relating to these topics. What is a crystal defect and how does it arise in Crystal point ( Zero dimensional and one dimensional defect)Types of point Defect, configurational Entropy, Determination of defect concentration , expressionfor one and two – dimensional defect concentration , Significance of point defects in the determination of properties of materials- Dislocations, Line defectsEdge and Screw Dislocations, Burgers Vector, Burgers Circuit , Dislocation motion – Dislocation reactions– Role of Dislocationson the properties of materials , dislocation density-surface defects, dislocation Energy , stress required to move a dislocation , multiplication of dislocation – Frank read source and mechanism of dislocations.

**Learning Outcomes:** After the completion of the Unit II, the student will be able to

1. Determine the crystal structure by Bragg's X-ray diffraction and powder method(L3)

2. Explain different crystal imperfections and the types of dislocations due to defects(L2)
3. Infer the role of dislocation on crystal properties and surface defects(L4)

**UNIT-III** **12 Lectures**

BASIC THERMODYNAMIC FUNCTIONS:

Free Energy of Transformation – Criteria for transformation – Nucleation and Growth – Homogeneous and Heterogeneous nucleation and their applications. Solid Solutions- Polymorphs – Types of Solid Solutions – Temp – Time – Cooling curves for different systems – Solid – Solid phase equilibrium – Tie Line, Lever Rule and its application. Phase Rule, Phase Changes and its application to Thermal Equilibrium diagrams or Phase Diagrams of Unary System, - Binary Systems – Eutectic Eutectoid alloys – Cu-Ni, Bi-Cd, Pb-Sn, Fe-Fe3 C systems. Phase transformations in steels – Modifications in structure of Steel by Heat Treatment – Time – Temperature – Transformation Curves for Eutectoid Steel – Classification of Steels and Cast Irons – Types and their properties. Alloys of Steel and their uses in Chemical Industry.

**Learning Outcomes:** After the completion of the Unit III, the student will be able to
1. Apply phase diagrams and phase transformation to primary and binary systems(L3)
2. Discuss the effect of alloying elements on properties of steels(L2)
3. Discuss the applications of different types of steels, alloys and other metals in chemical industry.(L2)

**UNIT-IV** **12 Lectures**

Mechanical behavior of metals and alloys- Elastic, Plastic and anelastic behavior of materials. Viscoelastic materials, behavior of polymers and plastics. Critical Resolved Shear strength, Schmidt's

Law and prediction of Tensile Strength of materials, Strengthening mechanisms – Work Hardening or Strain Hardening, Alloying – Cold and Hot working – Recovery and Recrystallization, Grain Growth, Grain Size and Yield Strength, Age hardening of Aluminum alloys – Al-Cu system. Composite Materials and their mechanical behavior, expressions for Tensile Strength and strains inComposite Materials – Fracture of Materials Ductile, Brittle, Creep and Fatigue fractures – SimpleProblems related to these topics.

**Learning Outcomes:** After the completion of the Unit IV, the student will be able to
1. Demonstrate the elastic and plastic deformations in solid materials(L3)
2. Discuss the mechanism of creep and the methods to reduce creep(L2)
3. Explain the fatigue mechanisms and methods to improve fatigue resistance(L3)

**UNIT-V** **12 Lectures**

Corrosion- Materials in the service of Chemical and Marine Environments – Basis for corrosion, Corrosion reactions and Mechanisms of Corrosion – Eight forms of Corrosion- Uniform Corrosion,Galvanic , Differential Aeration Corrosion, Stress corrosion Cracking, Intergranular Corrosion, Localized Corrosion and Fatigue Corrosion. Corrosion of Stainless steel- Oxidation, Tarnishing, behaviour of non-ferrous materials used in Chemical Industry – Effect of environmental factors oncorrosion. Corrosion Prevention , Pilling – Bedworth ratios Conventional methods – Estimation ofCorrosion rates, different Corrosion rate expressions, Remedial measures for Galvanic, Stress Corrosion Cracking, Intergranular and Pitting

Corrosion, Anodic and Cathodic protection techniques, Conventional methods on organic and Inorganic coatings, Electroplating, Alloying – Cladding- Design Procedures of chemical equipment and structure to mitigate or completely preventcorrosion in Chemical Plants.

**Learning Outcomes:** After the completion of the Unit V, the student will be able to

1. Demonstrate the mechanism of oxidation and methods to protect materials from corrosion(L3)
2. Discuss the types of corrosion and estimation of corrosion rates.(L2)
3. Demonstrate the Anti-Corrosion techniques used by chemical plants (L3)

**Text Book:**

Materials Science and Engineering,William D. Callister Jr., David G. Rethwisch, 10th Edition,Wiley,2019.

**References:**


1. Elements of Materials Science and Engineering, Van Vlack, 6th edition, Pearson Education India,2002.
2. Corrosion Engineering, Fontana M.G., 3rd edition, Tata McGraw Hill, 2005.
3. Science of Engineering Materials, vols. 1&2, Manas Chanda, McMillan Company of India Ltd,1981.
4. Materials Science and Engineering, V. Raghavan, PHI Learning Pvt. Ltd., New Delhi, 6th edition, 2015.