KIT 257/3 – Material Chemistry

Course Objective : To introduce the chemical aspects and properties of materials and their applications – metals and alloys, polymers, ceramics and composites.

Topic	Content	Number of lecture hours	Expected outcome - upon completion of this course, the student should be able to:
1. Introduction	• Materials science and engineering • The importance of materials in life and industry • Classification of materials • Different levels of structure in materials • Relation among structure, processing and properties	1	• Understand the importance of materials in life and the role of materials scientists in the future development of industry. • Classify the solid materials and cite the distinctive chemical features of each. • Understand the relation among structure, processing and properties of materials.
2. Atomic Structure and Chemical Bonding	• Atomic structure • Chemical bonding and binding energy • Properties from bonding • Unit cells • Crystal structure of solids • Crystallographic directions and planes • Determination of crystal structures	3	• Understand the fundamental concepts of chemical bonding. • Describe the type of bonds and note which materials exhibit those bonding types. • Understand the assembly of atoms in solid structures and the classification of crystals (crystal systems). • Specify and sketch the crystallographic directions and planes within a unit cell. • Distinguish between single crystals and polycrystalline materials.
3. Imperfection in Solid	• Types of imperfections/defects • Defects in ceramic structures • Defects in alloys • Characterization of defects	2	• Describe the types of defects in solids. • Understand the criteria of equilibrium in solid structures. • Calculate the equilibrium number of vacancies in a material. • Understand the techniques for characterizing defects.
4. Diffusion in Solids	• Types of diffusion • Diffusion mechanisms • Factors that influence diffusion • Effects of diffusion on the structure and properties of materials	2	• Understand and describe the mechanisms of diffusion within solid materials. • Distinguish between steady-state and non steady –state diffusions. • Calculate the diffusion coefficient and activation energy for some materials under a given temperature. • Understand the factors that influence diffusion.

Topic	Content	Number of lecture hours	Expected outcome - upon completion of this course, the student should be able to:
5. Ceramics	• Basic categories of ceramics • General properties of ceramic materials • Structure of ceramics • Silicates and glasses • New and modern ceramics • Biodegradable and bioactive ceramics • Applications of ceramic materials	3	• Understand the basic categories of ceramics. • Understand the types of bonding, structure and defects in ceramic structures. • Understand the importance of silicates in ceramic materials. • Relate ceramic structures with its properties and applications. • Understand the features of modern ceramic materials.
6. Polymers	• Structures and types of polymers • Molecular weight, degree of polymerisation • Amorphous and crystalline polymers • Synthesis of polymers • Phase transition of polymers	2	• Understand the basic microstructural features of polymers. • Understand the types of polymers, properties and applications. • Calculate the number-average and weight-average molecular weights and degree of polymerisation for specified polymers. • Describe the crystalline state of polymers. • Understand the basic route for polymer synthesis. • Understand the phase transition in polymers when heated.
7. Metals and Alloys	• Classification of metals and alloys • Bonding in metals • Metallic structure • Phase diagram of metals (iron)	1	• Understand the bonding in metals and alloys. • Understand the conduction and insulation in materials. • Understand the structures of a metal and its phase diagram.
8. Composites	• General requirements for composites • Types of composites • Forms of matrices and reinforcement phases • Concrete and hybrid composites • Benefits and applications of composite materials	3	• Understand the requirements of composite materials. • Describe the types of composites according to the matrix and reinforcement phases. • Understand the types of interfacial bonding in composites. • Understand the factors that influence the performance and properties of composites. • Understand the features of modern composite materials and its applications.

Topic	Content	Number of lecture hours	Expected outcome - upon completion of this course, the student should be able to:
9. Phase Diagrams	• Basic concepts of a phase equilibrium • Classification of phase diagrams • Interpretation of phase diagrams • The Lever Rule • Development of microstructures • Phase transformations • Factors that influence the phase transformation	6	• Understand the parameters of a phase diagram. • Determine the type of phases, the compositions and the mass fractions of phases for a given phase diagram. • Understand and use the Lever Rule for characterising a given phase diagram. • Understand the development of microstructure in a given phase diagram when heated or cooled. • Describe the phase transformation and relate the process with the microstructure of materials.
10. Properties of Materials	• Mechanical properties: Stress, strain, elastic and plastic behaviour, strength, hardness, ductility and toughness • Electrical properties: conductivity, electron energy bands, electron mobility, semiconductors and dielectric materials • Magnetic properties: magnetic force, magnetic field, classification of magnetic materials and its magnetic properties • Thermal properties: heat capacity, thermal conductivity, thermal expansion and thermal stress/shock • Optical properties: reflection, refraction, absorption and transmission, colour and fiber optic	8	• Understand the relationship among material properties, structure and performance for the classes of engineering solids (metals, polymers, ceramics, semiconductors and composites). • Understand and describe mechanical properties such as stress, strain, strength, hardness, ductility and toughness. • Understand and describe electrical properties such as conductivity, resistivity, electron mobility, conduction in semiconductors and dielectric materials. • Understand and describe magnetic properties such as magnetic force, magnetic field and magnetic susceptibility. Differentiate the types of magnetic materials. • Understand and describe thermal properties such as heat capacity, thermal conductivity, thermal expansion and thermal stress/shock. • Understand and describe optical properties such reflection, refraction, absorption and transmission, colour and the fiber optic.
11. Corrosion and Degradation of Materials	• Corrosion of metals: corrosion reaction and corrosion rate, factors that influence the corrosion, forms of corrosion, corrosion protections • Degradation of polymer: swelling, dissolution, bond rupture and weathering.	5	• Describe the corrosion reaction and the influence of environment conditions on the corrosion rate. • Describe the nature of corrosion process, forms of corrosion and methods of corrosion prevention. • Explain why ceramic materials are very resistant to corrosion. • Describe the common process of degradation in polymers.
TOTAL		**36**	