KIT 254/2 – Polymer

Course Objectives : 1) To study the polymerization mechanisms and kinetics.
2) To introduce the physical chemical principles and properties of polymers.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of this course, the student should be able to:
1. Introduction to Polymers	• The importance of polymers to man • Basic concepts • Classification of polymers • The architecture of polymer molecules • Polymer morphology • Copolymers • Plastics • Elastomers • The effects of temperature on polymers • Geometrical arrangement of atoms in polymer molecules • Chemical bonds in polymer molecules • Crystallinity of polymers	2	• Differentiate the advantages and disadvantages of polymer materials compared to other substances (for example: metals and wood) on the basis of their properties. • Understand the basic terms: polymer, monomer, degree of polymerisation (DP), repeating units, chain molecules. • Recognise the basic structures of a polymer: linear, branched, cross-linked and network. • Differentiate the molecular arrangement in an amorphous, crystalline and semicrystalline polymers. • Understand the influence of morphology on the physical properties of polymers. • Understand the difference between homopolymer and copolymer. • Recognise the structure of random, alternate, block and graft copolymers. • Understand the differences in properties between thermoplastic, thermoset and elastomer. • Understand the term glass transition temperature and its relationship with the chemical structure of a polymer. • Understand why a polymer behaves as plastic or elastic. • Identify several types of intermoleculecular forces and their influence on the physical properties of polymers. • Understand the factors that influence the crystallinity of polymers.
2. Polymerisation Mechanisms	• Step reaction polymerisation • Chain reaction polymerisation • Comparison between step and chain reaction polymerisation	1	• Understand the general characteristics and differences between step reaction and chain reaction polymerisation.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of this course, the student should be able to:
3. Step Reaction Polymerisation	• Examples of condensation polymers • Kinetics of step polymerisation: - Self-catalysed - External-catalysed • Quantitative aspects of step polymerisation • Molecular weight control	3	• Recognise the structure of condensation polymers and their monomers. • Derive the kinetic equations for self-catalysed and external-catalysed step polymerisation. • Understand the effect of both types of catalysis to DP and molecular weight. • Understand the use of the Carothers equation. • Understand the methods to control molecular weight and use the appropriate equations in calculations.
4. Radical Chain Polymerisation	• Examples of chain polymers • Main characteristics • Free radical initiators • Mechanism of polymerisation • Kinetics of chain polymerisation: - system with initiator - system without initiator • Kinetic chain length	3	• Write the three-step mechanism for a vinyl monomer. • Understand the main characteristics of a radical chain polymerisation. • Recognise several examples of free radical initiators and know their functions. • Understand the schematic mechanism of radical chain polymerisation. • Derive the kinetic equations for each step of the mechanism. • Understand the steady state concept. • Derive equations of the rate of polymerisation for a system with initiator and without initiators. • Understand the term ‘kinetic chain length’. • Derive the equation for kinetic chain length.
5. Chain Transfer Reaction	• Types of chain transfer reactions • The effects of chain transfer • Kinetics of a chain transfer reaction • Control of molecular weight by chain transfer	3	• Understand the concept of a chain transfer and the effects on the molecular weight of polymers. • Derive kinetic equations that relate DP with the rate of polymerisation and the rate of a polymer formation. • Understand a method of molecular weight control by a kinetic chain transfer.

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6. Ionic Polymerisation	• Reaction mechanisms in ionic (cationic and anionic) polymerisation of vinyl monomer • Kinetics – polymerisation kinetics of anion and cation processes, influence of solvent, counter-ion and temperature • Crosslinking formation in polymers and their applications in industries	3	• Choose monomer that can be polymerised through anionic and/or cationic polymerisation techniques. • Write polymerisation reaction mechanisms involved in anionic and cationic systems. • Illustrate rate and degree of polymerisation from kinetic schemes. • Relate factors that influence polymerisation with kinetic equations. • Understand and write crosslinking reaction mechanisms of a given polymer and can select special routes to crosslink different polymers. • Relate crosslinking behaviour with polymer based products.
7. Polymers Characterisation	• Polymer molar mass – molar mass distributions; average molar masses • Determination techniques on molar mass: gel permeation (size exclusion) chromatography and membrane and vapour pressure osmometry • Determination of polymer viscosity: dilute solution viscometry ; intrinsic viscosity and the Mark-Houwink relationship for M_v	4	• Calculate molar mass using an equation and identify their distribution in the polymer matrix. • Use the instruments to measure the molar mass of polymers. • Indicate some equipments to characterise polymers.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of this course, the student should be able to:
8. Physical and Mechanical Behaviour of Polymers	• Physical : basic concepts of glass transition temperature, melting behaviour in polymers and factors effecting melting and glass transition temperatures • Mechanical : basic concepts of mechanical behaviour in polymers and composites. Experimental studies on polymer films and fibres. Yields criteria e.g. determination of stress, strain, modulus,UTS and elongation at break • Equipments and techniques to determine glass transition temperature, melting temperature, mechanical properties.	5	• Understand a basic knowledge of the physical properties of solid polymeric materials and how properties and chemical and materials structures are related. • Calculate modulus, UTS, elongation at break from tensile tests and 3 point bending data. • Choose equipments for the estimation of physical and mechanical properties of polymers.
TOTAL		**24**	

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