VII Semester

Open Elective **21CHE754**

ADVANCED POLYMER CHEMISTRY FOR ENGINEERS

Course Code	21CHE754	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

CLO 1	Impart the knowledge of polymers and their processes.
CLO 2	Understand the basic mechanism and kinetics of polymerization.
CLO 3	Master the knowledge about ionic polymerization and biopolymers.
CLO 4	Enlighten the needs and utilization of thermodynamics of polymer solutions
CLO 5	Acquire the knowledge of polymer films in sensor applications

Pedagogy (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

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1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Show Video/animation films to convince abstract concepts.
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

Module1- Introduction to Polymers- 08 hours

Definitions, origin, classification of Polymers; molecular weight (MW), Determination of molecular weight – methods for measuring number average, weight average, viscosity average MW; gel permeation chromatography; spectroscopic techniques to determine chemical composition and molecular microstructure. Colligative properties, osmotic pressure, light scattering, refractive index, viscosity, small angle X-ray scattering.

Pedagogy	**Chalk and talk/power point presentation:** Definitions, origin, classification of Polymers; molecular weight (MW), Determination of molecular weight – methods for measuring number average, weight average, viscosity average MW **Videos/Learning material:** spectroscopic techniques to determine chemical composition and molecular microstructure. Colligative properties, osmotic pressure, light scattering, refractive index, viscosity, small angle X-ray scattering. **Self-study:** Classification of polymers.

Module2-Mechanism and Kinetics of Polymerization- 08 hours

Step-Growth Polymerization: Reactivity of functional groups; kinetics; molecular weight in open and closed system cyclisation vs. linear polymerization, cross-linking and gel point; process condition. Free radical Polymerization: Nature of chain polymerization and comparison of step polymerization; radical and ionic polymerizations; kinetics of chain polymerization; chain transfer, inhibition, retardation, auto-acceleration; energetic characteristics; techniques of radical polymerization – bulk, solution, emulsion and suspension polymerization.

Pedagogy	**Chalk and talk/power point presentation**: Step-Growth Polymerization: Reactivity of functional groups; kinetics; molecular weight in open and closed system cyclisation vs. linear polymerization, cross-linking and gel point; process condition.

	Videos/Learning material: Free radical Polymerization: Nature of chain polymerization and comparison of step polymerization; radical and ionic polymerizations; kinetics of chain polymerization. **Self-study:** Polymerization mechanism of polyvinylchloride.

Module3-Ionic Polymerization and Biophysics- 08 hours

Propagation and termination of cationic polymerization, anionic and ring opening polymerization, active polycarbanions. Copolymerization: types of copolymers, copolymer compositions, reactivity ratio; radical and ionic co-polymerizations; Block and Graft copolymer synthesis, examples. Chemistry and synthesis of bio polymers, industrial applications. Production of smart polymers with examples.

Pedagogy	**Chalk and talk/power point presentation**: **Ionic Polymerization and Biopolymers:** Propagation and termination of cationic polymerization, anionic and ring opening polymerization, active polycarbanions. **Videos/Learning material**: Copolymerization: types of copolymers, copolymer compositions, reactivity ratio; radical and ionic co-polymerizations; Block and Graft copolymer synthesis, examples. **Self-study:** Synthesis, properties and applications of Polylactic acid (PLA).

Module4 -Thermodynamics of Polymer Solutions -08 hours

Thermodynamics of polymer solutions: Flory-Huggin's theory, theta conditions; solubility parameters; fractionation of macromolecules, osmotic pressure, lower critical solution temperature. Naturally occurring polymers, biodegradability, biosynthesis, polymers from renewable resources.

Pedagogy	**Chalk and talk/power point presentation**: Flory-Huggin's theory, theta conditions; solubility parameters; fractionation of macromolecules. **Videos/Learning material**: Naturally occurring polymers, biodegradability, biosynthesis, polymers from renewable resources. **Self-study:** Flory-Huggins interaction parameter calculation to understand the polymer-solution interaction or affinity.

Module-5- Polymers for Electronics - 08 hours

Polymer resists for integrated circuit fabrication, lithography and photolithography, Electron beam, X-ray and ion sensitive resists, Conducting polymers, types, properties and applications, electroluminescence, molecular basis of electrical conductivity, Photonic applications and non-linear optics, optical information storage. Fibers: Polyesters, mechanical requirements for fibers, drawing, orientation and crystallinity, stress strain curves; Carbon fibres and nanotubes, Polymer blends and composites: characteristics, types and applications; Polymer films in sensor applications.

Pedagogy	**Chalk and talk/power point presentation**: Polymer resists for integrated circuit fabrication, lithography and photolithography, Electron beam, X-ray and ion sensitive resists, Conducting polymers, types, properties and applications, electroluminescence, molecular basis of electrical conductivity, Photonic applications and non-linear optics, optical information storage. **Videos/Learning material**: Fibres: Polyesters, mechanical requirements for fibers, drawing, orientation and crystallinity, stress strain curves; Carbon fibres and nanotubes, Polymer blends and composites: characteristics, **Self-study:** Amorphous and crystallinity nature of natural polymers.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

CO 1	Discuss the fundamental principles knowledge of polymers and their processes.
CO 2	Explain the concepts of basic mechanism and kinetics of polymerization.
CO 3	Enumerate the methods of ionic polymerization and biopolymers.
CO 4	Describe the thermodynamics of polymer solutions.
CO 5	Illustrate the applicability of polymers in electronic field to fabricate integrated circuit fabrication.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(To have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module. Marks scored out of 100 shall be reduced proportionally to 50 marks

Suggested Learning Resources:

Books

1. M.G. Cowie, Polymers: Chemistry and Physics of Modern Materials, CRC Press, 2007.
2. P. J. Flory, Principles of Polymer Chemistry, Cornell University Press,1953.
3. H. R. Allcock, F. W. Lampe and J. E. Mark, Contemporary Polymer Chemistry, Pearson , 2004.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=IIXyihmtnNg
2. https://www.youtube.com/watch?v=54urJPOnaeU&list=PLyqSpQzTE6M_KQ5MqUkoOqAxxOrdvFOMB

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- https://www.vlab.co.in/broad-area-chemical-sciences
- https://demonstrations.wolfram.com/topics.php
- https://interestingengineering.com/science