DEPARTMENT OF POLYMER SCIENCE
UNIVERSITY OF MADRAS

M.Sc. POLYMER CHEMISTRY
2011-2012 onwards
(Choice Based Credit System)

REGULATIONS

1. Duration of the programme:

The two year post-graduate programme in M.Sc. Polymer Chemistry has four semesters under Choice Based Credit System.

2. Eligibility for admission:

A candidate who has passed the B.Sc. degree examination with Branch IV - Chemistry as the main subject with Mathematics or Physics as one of the allied subject of study or an examination of some other University accepted by the Syndicate as equivalent thereto shall be permitted to appear and qualify for the M.Sc. degree examination of this University after a course of two academic years in the Departments of this University.

UNIVERSITY OF MADRAS
DEPARTMENT OF POLYMER SCIENCE
M.Sc. Polymer Chemistry course under CBCS [w.e.f. 2011-2012]

Course Code	Title of the Course	C/E/S	Credit			
			L	T	P	C
	SEMESTER I					
CHE C401	Physical Chemistry – I	C	3	1	0	4
CHE C402	Organic Chemistry – I	C	3	1	0	4
CHE C403	Inorganic Chemistry – I	C	3	1	0	4
CHE C404	Chemistry Practicals –I	C	0	0	4	4
CHE E401	Introduction to Polymers	E	2	1	0	3
CHE E402	Reagents in Organic Synthesis	E	2	1	0	3
UOM S 001	Soft Skill	S				2
	SEMESTER II					
CHE C405	Physical Chemistry – II	C	3	1	0	4
CHE C406	Organic Chemistry – II	C	3	1	0	4
CHE C407	Inorganic Chemistry – II	C	3	1	0	4
CHE C408	Chemistry Practicals – II	C	0	0	4	4
CHE E403	Essentials of Polymer Physics	E	2	1	0	3
CHE E404	Molecular Spectroscopy	E	2	1	0	3
UOM S 002	Soft Skill	S				2
	SEMESTER III					
CHE C409	Polymer Chemistry	C	3	1	0	4
CHE C410	Physical Chemistry of Polymers	C	3	1	0	4
CHE C411	Polymer Physics	C	3	1	0	4
CHE C412	Polymer Practicals	C	0	0	4	4
CHE E405	Speciality Polymers	E	2	1	0	3
UOM S 003	Soft Skill	S				2
UOM I 001	Internship – Industrial training	S				2
	SEMESTER IV					
CHE C413	Plastics Technology	C	3	1	0	4
CHE C414	Rubber and Fibre Technology	C	3	1	0	4
CHE C415	Research Project	C				6
CHE E406	Applied Polymer Science	E	2	1	0	3
CHE E407	Phenolic resins and aminoplastics	E	2	1	0	3
UOM S 004	Soft Skill	S				2

Semester I + Semester II + Semester III + Semester IV = 24+24+23+22 = 93 credits

M.Sc. POLYMER CHEMISTRY

(Choice Based Credit System)
2011-2012

FIRST YEAR - FIRST SEMESTER

Core Courses:

CHE C 401 Physical Chemistry - I (70 hours)

1. Quantum mechanics - mathematical preliminaries - classical mechanics and its failure black body radiation - photoelectric effect - wave-particle duality - quantum mechanical postulates - operator algebra - linear and Hermitian operators - construction of quantum mechanical operators - Schrodinger equation - the concept of spin-Pauli exclusion principle - particle in a box - simple harmonic oscillator - rigid rotator - hydrogen atom - helium atom. Born-Oppenheimer approximation - hydrogen molecule ion - hydrogen molecule - approximation methods.

2. Valence and structure of molecules: MO and VB theories. Application to diatomics and polyatomics - hybridization and shapes of molecules - types of chemical bonds, ionic bonds, hydrogen bonds - Vander Waals forces - Donor-acceptor complexes - metal olefin complexes - bonding in metals - the band model.

3. States of Matter-Gases: Principles of equipartition of energy - Maxwell's law of distribution of velocities - mean free path. Liquids: Viscosity - surface tension - liquid crystals. Solids: Elements of crystallography - Bragg's law and application.

4. Symmetry, Group theory and spectroscopy: elements of group theory - symmetry of molecules - character tables - Principles and applications of molecular refraction, polarization, dipole moments, optical rotation, ultra violet, infra-red and Raman spectra. Microwave spectroscopy - Nuclear magnetic resonance and electron spin resonance spectroscopy.

CHE C 402 Organic Chemistry - I (70 hours)

1. Stereochemistry - optical isomerism - chirality and dissymmetry - geometrical isomerism and stereoisomerism in cyclic compounds - conformatic analysis - conformation and reactivity in acyclic and cyclohexane systems.

2. Methods of determining reaction mechanisms - effect of structure on reactivity - the Hammett and Taft equation - nucleophilic substitution - electrophilic substitution - principles and typical examples.

CHE C 403 Inorganic Chemistry - I (70 hours)

1. Periodic properties and electronic configurations - the chemical bonds - ionic, covalent and metallic bond.

2. Acids, bases and non-aqueous solvents - protonic concept - the Lewis concept - solvolysis and hydrolysis reaction in non-aqueous media.

3. Principles of analytical chemistry - formation and treatment of precipitates, acid-base, oxidation-reduction, precipitation and complexometric titrations, colourimetric analysis chromatographic techniques.

4. Chemistry of hydrides - chemistry of silicates - hard clay, soft clay, precipitated and fumed silica, a comparative study of the transition elements and inner transition elements.

CHE C 404 Chemistry Practicals - I
Physical Chemistry Practicals:
1. Viscosity of mixtures
2. Cryoscopy, rast amd Ebulioscopy
3. Phase rule - transition temperature, c.s.t., eutectic, compound formation partition
4. Heat of neutralisation, combustion

Organic Chemistry Practicals:

Analysis of two component and three component mixtures separation and characterization with emphasis on characterization by derivatives.

Inorganic Chemistry Practicals:

Quantitative analysis of inorganic mixtures by gravimetric, titrimetric and colourimetric methods (Mixtures as met with in common ores and alloys)

Elective course:

CHE E 401 Introduction to Polymers (30 hours)

1. Long-chain molecules - step-growth polymerization - chain growth polymerization kinetics - stereochemistry of polymers

2. Number average, weight average and viscosity average molecular weight of polymers - determination of molecular weight - molecular weight distribution

3. Glass transition temperature of polymers and copolymers - determination and importance of glass transition temperature

CHE E 402 Reagents in Organic Synthesis (30 hours)

Use of the following reagents in organic synthesis and functional group transformations: Complex metal hydrides, Gilman's reagent, lithium dimethylcuprate, lithium diisopropylamide (LDA), dicyclohexylcarbodiimide, I,3-Dithiane (reactivity umpulong), trimethylsililyl iodide, tri-n-butyltin hydride, Woodward and Prevost hydroxylation, osmium tetroxie, DDQ, Selenium dioxide, phase transfer catalysts, crown ethers and Merrifield resin, Peterson's synthesis, Wilkinson's catalyst and baker yeast.

UOM S 001 Soft Skill

FIRST YEAR - SECOND SEMESTER
Core Courses:

CHE C 405 Physical Chemistry - II (70 hours)

1. Elements of statistical mechanics - concept of partition - function - laws of thermodynamics and their applications - free energy calculations - activity coefficients - chemical equilibria phase rule and its applications to two and three component systems.

2. Theory of strong electrolytes - galvanic cells - applications of e.m.f. measurements principles of electrolytic conductance and applications - overvoltage - polarography – cyclic voltametry - electro-synthesis.

3. Kinetics of chemical reactions collision and transition state theories - probability factor - photochemistry - chain reactions - fluorescence – photosensitization - chemiluminescence acid-base catalysis - heterogeneous reactions and catalysis - enzyme catalysis.

CHE C 406 Organic Chemistry - II (70 hours)

1. Free radical reactions - addition to carbon-carbon and carbon-oxygen multiple bonds - elimination reactions - molecular rearrangements - oxidation reduction mechanisms.

2. Heterocyclic chemistry - biologically important compounds like thiamine, riboflavin, pyridoxine, anthocyanin, penicillin.

3. Natural and synthetic polymers - vinyl polymers - condensation polymers - proteins -nucleic acids - carbohydrates.

4. Concepts of aromaticity - non-benzenoid aromatic compounds - photosynthesis - applications of photochemistry in organic reactions.

CHE C 407 Inorganic Chemistry - II (70 hours)

1. Structural inorganic chemistry - use of x-ray, electron and neutron diffraction in the study of inorganic crystals.

2. Coordination chemistry of transition metal ions; Stability constants of complexes and their determination; stabilization of unusual oxidation states. Stereochemistry of coordination compounds. Ligandfield theory, splitting of d-orbitals in low-symmetry environments. Jahn-Teller effect; interpretation of electronic spectra including charge transfer spectra; spectrochemical series, nephelauxetic series Magnetism: Dia-, para-, ferro- and antiferromagnetism, quenching of orbital angular moment, spinorbit coupling, inorganic reaction mechanisms; substitution reactions, trans effect and electron transfer reactions, photochemical reaction of chromium and ruthenium complexes. Fluxional molecules iso- and heteropolyacids; metal clusters. Spin crossover in coordination compounds.

CHE C 408 Chemistry Practicals - II
Physical Chemistry Practicals:
1, Determination of e.m.f., pH, potentiometric titrations
2. Determination of conductivity - titrations
3. Kinetics of ester hydrolysis - inversion of cane sugar
Organic Chemistry Practicals:
1. About 10 preparations involving two or three stages involving the following processes, nitration, acylation, halogenation, diazotization, rearrangements, hydrolysis, reduction, alkylation and oxidation.
2. Estimation of phenol, methyl ketones, glucose, nitro, amino and methoxy groups unsaturation
Inorganic Chemistry Practicals:
1. Semimicro qualitative analysis of common cation and anion containing the following less familiar elements: Tl, W, Sc, Te, Mo, Ce, Th, Ti, Zr, V, Be, U, Li and Cs.
2. Simple inorganic preparations including some complex compounds.

Elective course:

CHE E 403 Essentials of Polymer Physics (30 hours)

1. Physical aspects of polymer solutions: Criteria for polymer solubility - conformations of dissolved polymer chains - thermodynamics of solutions
2. Rheology: viscosity - intrinsic viscosity - treatment of Intrinsic viscosity data - theories in relation to the intrinsic viscosity of flexible chains - chain entanglement
3. Kinetic theory of rubber elasticity - viscoelasticity description and theories
4. Physical properties of crystalline and amorphous polymers - determination methods.

CHE E 404 Molecular Spectroscopy (30 hours)

Theoretical treatment and applications of rotational, vibrational, electronic, magnetic resonance, Mossbauer and photoelectron spectroscopy.

UOM S 002 Soft Skill:

TEXT BOOKS
Physical Chemistry:
Physical Chemistry, W.J.Moore, Orient Longman
Physical Chemistry, G.M.Barrow, McGraw Hill
Mathematics for Quantum Chemistry, J.M.Anderson, W.A.Benjamin Inc.

Organic Chemistry:
Advanced Organic Chemistry, Jerry March, McGraw Hill
Organic Chemistry, Morrison & Boyd, Prentice Hall, 1969
Chemistry of Heterocyclic Compounds, Badgar

Inorganic Chemistry:
Advanced Inorganic Chemistry, Cotton and Wilkinson, Wiley
Inorganic Chemistry, J.W.Huheey, Harper and Row
Inorganic Chemistry, K.F.Purcell and J.C.Kots, Saunder Co.

Polymer Physics:
Text Book of Polymer Science, F.W.Billmeyer, Jr.
Physical Chemistry of Macromolecules - basic principles and issues, S.F.Sun, John Wiley & Sons, Inc., 1994
Polymer Science, V.R.Gowariker, N.V.Viswanathan, J.Sreedhar, New Age International P Ltd., Publishers, 1986
Principles of Polymer Systems, Fourth edition, Ferdinand Rodrigues, Taylor, Francis,1996

Rubber:
Rubber: Natural and Synthetic by H.J.Stern, McLaren & Sons Ltd., London 1954

SECOND YEAR - THIRD SEMESTER
Core Courses:
CHE C 409 Polymer Chemistry (70 hours)

1. Origin of Macromolecules - development of polymer science - intermolecular forces and physical properties - classification of polymerization mechanism and polymers.

2. Account of radical, ionic, coordination, metallocene, condensation, hydrogen-polyaddition, ring-opening, electrochemical, ring-opening metathesis and group transfer polymerisation.

3. Kinetics of free-radical, cationic, anaionic, coordination and catalysed and uncatalysed condensation polymerisation - molecular weight control and its distribution in addition and condensation polymers - gelation.

4. Different kinds of copolymers - kinetics of free radical copolymerisation – reactivity ratios - composition of copolymers - mechanism of copolymerisation - block and graft copolymers.

5. Bulk polymerization - solution polymerization - suspension polymerization and emulsion polymerization with examples. Melt polycondensation – solution polycondensation - interfacial polycondensation - solid phase polymerization and gas phase polymerization with examples.

6. Thermal degradation - mechanical degradation - photodegradation and stabilisation - degradation by high energy radiation - oxidative and ozone and stabilisation - hydrolytic degradation - depolymerisation - biodegradation.

CHE C 410 Physical Chemistry of Polymers (70 hours)

1. Chemical and geometrical structure of macromolecules.

2. Concept of average molecular weight - number average, weight average and viscosity average molecular weight - molecular weight distribution - theoretical considerations and empirical distribution model - degree of polymerization and molecular weight - influence of molecular weight on physical properties.

3. Molecular weight determination - gel permeation chromatography - light scattering - viscometry - molecular weight distribution curve.

4. The glassy state and the glass transition temperature - influencing factors (Main chain structure, side groups, H-bonding, molecular weight, plasticisation, etc.) - glass transition temperature and copolymers - relation between T_g and T_m - relation between T_g and softening temperature - importance of glass transition temperature.

5. Determination of glass transition temperature (DSC method) - dynamic mechanical analysis.

6. Crystal structures of polymers - crystallisability - polymercrystallisation - factors affecting crystallisability - Morphology of crystalline polymers - crystallisation and melting - strain induced morphology - effect of crystallinity on the properties of polymers.

CHE C 411 Polymer Physics (70 hours)

1. Physical aspects of polymer solutions: Criteria for polymer solubility - conformations of dissolved polymer chains - thermodynamics of solutions - phase separation in polymer solution - fractionation of polymers by solubility.

2. Rheology and mechanical properties - viscosity - expression for Newtonian and non-Newtonian fluids - intrinsic viscosity - treatment of intrinsic viscosity data - theories in relation to the intrinsic viscosity of flexible chains - chain entanglement. Viscosity of biological polymers.

3. Kinetic theory of rubber elasticity - viscoelasticity description and theories - glassy state and glass transition.

4. Mechanical propertries of crystalline and amorphous polymers.

CHE C 412 Polymer Practicals:

1. Polymer synthesis in bulk
2. Polymer synthesis by suspension method
3. Polymer synthesis by emulsion method

4. Preparation of polyurethane foams
5. Suspension copolymerization
6. IR and NMR spectra of polymers
7. Photopolymerization
8. Kinetics of addition polymerization
9. Verification of Mark-Howinck's equation
10. Thermal analysis of polymers
11. Compression Moulding
12. Injection moulding

Elective course:

CHE E 405 Speciality Polymers (30 hours)

Dendrimers: Divergent and convergent synthetic methods, properties and applications, some common examples - Hyperbranched polymers: Properties and applications, some common examples - Non-linear optical and photonic polymers: non –linear optical responses, chromophores, poling and characterization. Important considerations for photonic polymers, temporal stability, applications of photonic polymers - Liquid crystalline polymers: classification, criteria for forming liquid crystal polymer, applications - conducting polymers - biodegradable polymers.

UOM S 003 Soft Skill

UOM I 001 Industrial Training [Internship]:

SECOND YEAR - FOURTH SEMESTER

Core Courses:

CHE C 413 Plastics Technology (70 hours)

1. Additives for plastics - fillers - plasticisers - lubricants and flow promoters - anti aging additives - flame retarders - colourants - blowing agents - cross linking agents - uv-stabilisers

2. Processing techniques - injection moulding - compression moulding - blow moulding - rotational moulding - transfer moulding - extrusion - pultrusion - calendering - die casting - thermoforming - foaming - reinforcing

3. Manufacture and properties of polyethylene - polypropylene - polystyrene - polyacrylonitrile - polymethyl methacrylate - polyesters - polyformaldehyde - poly-p-phenylene, polycarbonate - polysulphone - polyimide - polyamide - polyurethane - polyureas - polyvinyl acetate - polyvinyl chloride – polytetrafluoroethylene- polyvinylidene chloride - polyvinylidene fluoride - polyvinyl carbazole - thermosetting resins.

CHE C 414 Rubber and Fibre Technology: (70 hours)

1. Molecular requirements for a rubber substance - natural rubber - outline of rubber processing - mastication - compounding ingredients - mixing - moulding - extrusion - calendering - vulcanisation - ebonite - properties of vulcanised rubbers - manufacturing of rubber based articles - tyres

2. Manufacture, compounding and applications of isoprene - butyl-butadiene-chloroprene - EPDM - thiokol and silicon rubbers

3. Critical considerations for fibre forming materials - textile and fabric properties spinning methods - uniaxial orientation - fibre after treatments.

CHE C 415 RESEARCH PROJECT:

Each student shall undertake a project under the supervision of a faculty member and submit a report which shall be evaluated by the board of examiners consisting of the supervisor, head of the department and an external subject expert. The examiners shall also examine the candidate in a viva-voce examination.

Elective course:

CHE E 406 Applied Polymer Science (30 hours)

1. The chemistry and physical properties of structural adhesives, pressure-sensitive adhesives rubber based and contact bond (film) adhesives and hot-melt adhesives

2. Solvent-based coatings - high solid coatings - powder coatings

3. Composites - role of fibre and matrix - constituent and composite properties - fabrication.

CHE E 407 Phenolic resins and aminoplastics (30 hours)

1. Phenolic resins: Introduction – raw materials – chemical aspects – resin manufacture – moulding powders – phenolic laminates – applications – resorcinol-formaldehyde adhesives – Friedel-Crafts and related polymers – phenolic resin fibres and polybenzoxazines.

2. Aminoplastics: Introduction – raw materials, manufacturing methods and applications of urea-formaldehyde resins and melamine-formaldlehyde resins – melamine-phenolic resins – aniline-formaldehyde resins and resins containing thiourea.

UOM S 004 Soft Skill:

TEXT BOOKS

Text Book of Polymer Science, Fred W.Billmeyer, Jr., John Wiley & Sons

Polymer Science, V.R.Gowariker, N.V.Viswanathan and Jayadev Sreedhar,
New Age International P Ltd., Publishers, 1986

Principles of Polymer Systems, Fourth Edition,
Ferdinand Rodriguez, Taylor, Francis, 1996

Plastics materials, J.A.Blrydson, Butterworth, 1982

Encyclopedia of Polymer Science and Engineering,
H.F.Mark et.al., Second edition, Vol.5, p.462-507 and vol.9, p.1/61

Photonic polymer systems, D.L.Wise et.al., Marcel Dekker, Inc, NY, 1998

Rubber: Natural and Synthetic, H.J.Stern, Maclaren & Sons Ltd, London, 1954

Synthetic rubbers, D.C.,Blkacley,l Applied Science Publishers, London, 1983

Rubber Technology, Maurice Morton, Third Ed., Von Nostrand Reinhold, NY, 19

Adhesion and adhesives technology, Alphonsus V.Pocius, Hanser Publishers, 19

Contemporalry Industrial Coatins, Ernest W.Flick, Noyes Publication, 1985

Encyclopedia of polymer science and engineering, H.F.Mark, Vol.3, p.552-675, 776-820 and vol.4, p.1-36, 1985 &1986

Physical Chemistry of Macromolecules - basic principles and issues, S.F.Sun,
John Wiley & Sons, Inc., 1994

Polymer: Science & Technology, Joel R.Fried, Prentice-Hall of India Private Ltd,
New Delhi, 2000