DEPARTMENT OF POLYMER SCIENCE

University College of Science
MOHANLAL SUKHADIA UNIVERSITY, UDAIPUR–313 009

Syllabus of M.Sc. Polymer Science CBCS Scheme

Semester I

S. No.	Course Code	Title of the Course	L-T-P	No. of Credits	Max. Marks		
					Uni. Exam	Int. Exam	Total
1	M 1 POLY 01-CT 01	Inorganic Chemistry	3-1-0	4	80	20	100
2	M 1 POLY 02-CT 02	Organic Chemistry	3-1-0	4	80	20	100
3	M 1 POLY 03-CT 03	Physical Chemistry	3-1-0	4	80	20	100
4	M 1 POLY 04-CT 04	Spectroscopy in analysis-I	3-1-0	4	80	20	100
5	M 1 POLY 13-CP 13	Practical-A-I	0-0-8	4	80	20	100
6	M 1 POLY 14-CP 14	Practical-B-I	0-0-8	4	80	20	100
Total			**12-4-16**	**24**	**480**	**120**	**600**

Semester II

S. No.	Course Code	Title of the Course	L-T-P	No. of Credits	Max. Marks		
					Uni. Exam	Int. Exam	Total
1	M 2 POLY 05-CT 05	Environmental and green chemistry	3-1-0	4	80	20	100
2	M 2POLY 06-CT 06	Instrumental techniques	3-1-0	4	80	20	100
3	M 2 POLY 07-CT 07	Spectroscopy in analysis-II	3-1-0	4	80	20	100
4	M 2 POLY 08-CT 08	Fundamental of Polymer Chemistry	3-1-0	4	80	20	100
5	M 2 POLY 15-CP 15	Practical-A-II	0-0-8	4	80	20	100
6	M 2 POLY 16-CP 16	Practical-B-II	0-0-8	4	80	20	100
7	M 2 POLY 01-SE 01	Skill Course I	1-0-2	2	40	10	50
Total			**13-4-18**	26	520	130	650

Semester III

S. No.	Course Code	Title of the Course	L-T-P	No. of Credits	Max. Marks		
					Uni. Exam	Int. Exam	Total
1	M 3 POLY 09-CT 09	Physical and chemical properties of polymers	3-1-0	4	80	20	100
2	M 3 POLY 10-CT 10	Speciality polymers	3-1-0	4	80	20	100
3	M 3 POLY 19-ET 01	Materials for compounding and Reinforcement	3-1-0	4	80	20	100
5	M 3 POLY 25-ET 07	Compounding and uses of Plastics					
4	M 3 POLY 20-ET 02	Tyre and rubber processing operations	3-1-0	4	80	20	100
6.	M 3 POLY 26-ET 08	Plastic Processing technology					
11	M 3 POLY 17-CP 17	Practical-A-III	0-0-8	4	80	20	100
12	M 3 POLY 23-EP 05	Testing of Latex and identification of rubbers	0-0-8	4	80	20	100
13	M 3 POLY 29-EP 11	Identification of plastics					
		Total	**12-4-16**	**24**	**480**	**120**	**600**

Semester IV

S. No.	Course Code	Title of the Course	L-T-P	No. of Credits	Max. Marks		
					Uni. Exam	Int. Exam	Total
1	M 4 POLY 11-CT 11	**Project Work (at Research Laboratory or Industry or Institute of repute)(60 DAYS)**	0-0-8	4	-	-	100
2	M 4 POLY 12-CT 12	Polymer and Environment	3-1-0	4	80	20	100
3	M 4 POLY 21-ET 03	Rubber Product Technology	3-1-0	4	80	20	100
4	M 4 POLY 27-ET 09	Identification and testing of plastics					
5	M 4 POLY 22-ET 04	Testing and characterization of rubber product	3-1-0	4	80	20	100
6	M 4 POLY 28-ET 10	Textile Technology					
7	M 4 POLY 18-CP 18	Practical-A-IV	0-0-8	4	80	20	100
8	M 4 POLY 24-EP 06	Mechanical properties and testing of rubber	0-0-8	4	80	20	100
9	M 4 POLY 30-EP 12	Mechanical properties and testing of plastics					
10	M 4 POLY 02-SE 02	Skill Course II	1-0-2	2	40	10	50
		Total	**10-3-18**	26	520	130	650

List of Courses
Core Courses: Theory

Course Code	Tittle of Course
M 1 POLY 01-CT 01	Inorganic Chemistry
M 1 POLY 02-CT 02	Organic Chemistry
M 1 POLY 03-CT 03	Physical Chemistry
M 1 POLY 04-CT 04	Spectroscopy in analysis-I
M 2 POLY 05-CT 05	Environmental and green chemistry
M 2 POLY 06-CT 06	Instrumental techniques for analysis
M 2 POLY 07-CT 07	Spectroscopy in analysis-II
M 2 POLY 08-CT 08	Fundamental of Polymer Chemistry
M 3 POLY 09-CT 09	Physical and chemical properties of polymers
M 3 POLY 10-CT 10	Specialty Polymers
M 4 POLY 11-CT 11	Industrial Training and Project work
M 4 POLY 12-CT 12	Polymer and Enviournment

Core Courses: Practicals

Course Code	Title of Course
M 1 POLY 13-CP 13	Practical-A-I
M 1 POLY 14-CP 14	Practical-B-I
M 2 POLY 15-CP 15	Practical-A-II
M 2 POLY 16-CP 16	Practical-B-II
M 3 POLY 17-CP 17	Practical-A-III
M 4 POLY 18-CP 18	Practical-A-IV

Discipline Specific Courses
Theory and Practicals

Subject code	Title of Course
Rubber Technology Discipline (Group A)	
Theory	
M 3 POLY 19-ET 01	Materials for compounding and Reinforcement
M 3 POLY 20-ET 02	Tyre and rubber processing operations
M 4 POLY 21-ET 03	Rubber Product Technology
M 4 POLY 22-ET 04	Testing and characterization of rubber product
Practicals	
M 3 POLY 23-EP 05	Testing of Latex and identification of rubbers
M 4 POLY 24-EP 06	Mechanical properties and testing of rubber
Plastic Technology Discipline (Group B)	
Theory	
M 3 POLY 25-ET 07	Compounding and uses of Plastics
M 3 POLY 26-ET 08	Plastic Processing technology
M 4 POLY 27-ET 09	Identification and testing of plastics
M 4 POLY 28-ET 10	TextileTechnology
Practicals	
M 3 POLY 29-EP 11	Identification of plastics
M 4 POLY 30-EP 12	Mechanical properties and testing of plastics
Skill Based Courses	
I	Polymer Processing Management
II	Paint Technology

Note: -

1. Skill based courses will be offered on payment basis, which is Rupees 4000 per course with a minimum intake of 10 students in each course.
2. Candidate has to select two papers from any group A/B in the III semester, the selected group will continue in the IV semester. Practical examinations will be conducted by the board of examiners consisting of one internal (to be appointed by the Head of Department) and one external examiner (to be appointed by the University).

Core Courses: Theory

SEMESTER-I

M 1 POLY 01-CT 01

Inorganic chemistry

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit I

Metalloenzymes: General discussion of enzymes, function of metal ions, vitamin B_{12} and B_{13} coenzymes.

Unit II

Nitrogen fixation, its mechanism, nitrogenase,dinitrogen complexes,cytochromes and ferrodoxins ,role of metals and non metals in metabolism ,metal and non metal deficiency, toxicity, ionophores.

Unit III

Structure and bonding in homo and hetroneuclear molecules, including shapes of molecules (VSEPR Theory) MO theory homoneuclear and diatomic molecules.

Unit IV

Crystal field theory of coordination compounds : details of crystal field theory for weak and strong field complexes, comparison of VBT and CFT theories , John – Teller effect , complexes of non cubic symmetry.

Unit V

Concepts of acids and bases, pH and PKa, acid-base concept in non-aqueous media HSAB concept. Buffer solution.

Recommended Books:

Inorganic chemistry: Puri, Sharma, Kalia

SEMESTER-I

M 1 POLY 02-CT 02

Organic chemistry

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit I

Structure and bonding : localized and delocalized chemical bond, Vander walls interaction,charge transfer complexes ,resonance, hyper conjugation ,aromaticity, , electomeric, inductive and field effects, hydrogen bonding, types of organic reactions, energy consideration, brief idea of reactive intermediates (formation and stability), neighboring group participation.

Unit II

Reagents in organic synthesis: use of the following reagents in organic synthesis and functional group transformation, Gilmans reagent,LDA,DCC,1,3-dithiane trimethylsilyl iodide, tributyltin hydride, DDQ, Baker yeast, Petersons synthesis, Merrifield resins, Wilkinsons catalyst, seleniumdioxide, Osmium tetraoxide, Lithiumdiisopropyl amide, Phase transfer catalyst, crown ethers.

Unit III

Addition to carbon –carbon multiple bond : mechanistic and stereochemical aspects of addition reaction involving electrophiles,nucleophiles and free radicals.region and chemo selectivity , orientation and reactivity.

Addition to carbon – hetero multiple bonds .Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds,acids,esters and nitriles.

Unit IV

Free radical reaction: Type of free radical reactions. Free radical substitution mechanism ,neighbouring group assistance ,reactivity for aliphatic and aromatic substrate at a bridgehead ,reactivity in the attacking radicals, effects of solvents on the reactivity, allylic halogination (NBS) ,oxidation of aldehydes to carboxylic acids , auto-oxidtion,coupling of alkynes and arylation of aromatic compounds by diazonium salts , Sandmeyer reaction , free radical rearrangement , Hunsdiecker reaction.

Unit V

Green chemistry: principles, design for polymer degradation, polymers from renewable resources, and polymer recycling, industrial case studies in context with green chemistry.

Photochemistry : cis-trans isomerisation , Paterno – Buchi reaction , Norrish type I and II reaction , photo reduction of ketones , dimethane rearrangement , photochemistry of alkanes .

Recommended Books:

1.Organic reaction mechanism. K. Ahluwalia

2.Reaction mechanism in organic chemistry:S. M. Mukherji,S.P. Singh

SEMESTER-I

M 1 POLY 03-CT 03

Physical chemistry

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit I

Thermodynamics: partial molar free energy, partial molar volume and partial molar heat content. Their significance and determination. Concept of fugacity and variation with temperature and pressure. Determination of gugacity by graphical method and in gas mixtures (Lewis Randall rule). Activity and activity coefficient. Debye Huckel theory for activity coffocient of electrolyte solution. Determination of activity and activity coefficients.

Unit II

Chemical kinetics :- theories of reaction rates; Activated Complex Theory (Equolubrium and statistical); Theory of Unimolecular reactions (Lindemann and Hinshelwood treatments). Gernal features of fast reactions; study of fast reaction by flow method. Relaxation , flash photolysis and magnetic resonance method.

Unit III

Surface Chemistry :- surface tension and surface free energy, Young and Laplace equation, Kelvin Equation. Gibbs Adsorpation isotherm. The B.E.T. equation and determination of surface area. Method of determining surface structure and composition by SEM,LEED,AES and PES. Kinetics of gaseous reactions on solid surfaces (unimolecular and bimolecular)

Unit IV

Micelles: - surface active agents, classification of surface active agents, micellization, critical micelles concentration (CMC) factors affect the CMC of the surfactants , thermodynamics of micellization, micro-emulsion, reverse micelles.

Collolidal state:- Defining and classification of colloids. Sol, gel and emulsions; preparation and properties. Application of colloids.

Unit V

Chemical equilibrium :- free energy and entropy of mixing, partial molar quantities, Gibbs – Duhem equation, Equilibrium constant, temperature – dependence of equilibrium constant , phase diagram of one and two component system, phase rule.

Recommended Books:

1. Physical chemistry :Puri, Sharma, Kalia

SEMESTER-I

M 1 POLY 04-CT 04
Spectroscopy in analysis-I

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT-I

Ultra-violet and visible spectroscopy: Electronic transitions, instrumentation, shift of bands with solvents, the isolated double bond, conjugated dienes, effects of geometrical isomerism (steric effect, effect of alkyl substitution and ring residues), exocyclic double bonds, Woodward-Feiser rule, effect of strain around the diene chromophore, polyenes, UV spectra of carbonyl compounds, unsaturated aldehydes and ketones, UV spectra of benzene and its derivatives, other applications of UV spectroscopy

UNIT II

Atomic absorption spectroscopy – Principle, instrumentation and applications
Flame Photometry: Principle, instrumentation and applications

UNIT III

Photoelectron spectroscopy: Franck Condon principle, types of electron spectroscopy, ESCA-theory, instrumentation and applications, Auger emission spectroscopy –theory, instrumentation and applications.

UNIT IV

Infra-red spectroscopy: Molecular vibrations, calculation of vibrational frequencies, instrumentation, finger print region, i.r of alkanes and effect of some functional groups, effect of hydrogen bonding, Fermi resonance, overtones, shifting of bands due to inductive and mesomeric effects, aromatic and heteroaromatic compounds, effect of ring strain, applications of IR spectroscopy, brief idea of FT-IR.

UNIT V

Raman spectroscopy: Theory, Stokes and anti-Stokes lines, Raman depolarization ratio, instrumentation, intensity of Raman peaks, applications

Microwave spectroscopy: Theory, selection rules, diatomic molecule as non-rigid rotator, symmetric top molecules, P-Q-R-bands, instrumentation, limitations and application

Books Suggested

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Interscience.
3. NMR, NQR, EPR and Msssbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
4. Physical Methods in Chemistry, R.S. Drago, Saunders College.
5. Chemical Applications of Group Theory, F. A. Cotton.
6. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
7. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
8. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
9. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
10. Introduction to Magnetic Resonance, A Carrington and A.D. Maclachalan, Harper & Row.
11. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
12. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
13. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
14. Progress in Inorganic Chemistry vol., 8, ed., F.A. Cotton, vol., 15, ed. S.J. Lippard, Wiley.
15. Transition Metal Chemistry edi R.L. Carlin vol. 3, Dekker
16. Inorganic Electronic Spectroscopy,. A.P.B. Lever, Elsevier.
17. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Norwood.
18. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
19. Spectrometric Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. C. Morrill, John Wiley
20. Introduction to NMR Spectroscopy, R. J. Abraham, J. Fisher and P. Loftus, Wiley.

Application of Spectroscopy of Organic Compounds, J. R. Dyer, Prentice Hall

SEMESTER-I

M.Sc. (Polymer Science)
Practicals
M 1 POLY 13-CP 13

Practical-A-1

Two practicals of 100 each (80+20 internal)
Credits : 4+4

1. Organic estimations & Synthesis

a. Two stage preparation (Yield, Crystallization, M.P. Determination)
b. Three stage Preparation: Any three including Crystallization, Percent Yield and M.P.

2. Oil analysis

a. Determination of Aniline point of processing oil.
b. Determination of flash point / fire point and point of given oil.
3. Determination of specific gravity, Surface tension , Viscosity of polymer sample /oil.

M 1 POLY 14-CP 14

Practical-B-1

1. **Water analysis**
a. Total hardness of water
b. Alkalinity-OH^- /CO_3^{2-}/OH^-+HCO_3^-
c. Chloride contents
2. **Coal Analysis**
a. Moisture contents/Volatile matter-C-Coal Analysis
b. Ash contents
c. Fixed carbon
d. Acid strength by conduct metric analysis
e. Colorimetric analysis of Rock phosphate
f. Colorimetric analysis of Iron
g. Determination of Total acid number of Oil
h. Saponification value of vegetable Oils
i. Iodine value

SEMESTER-II

M 2 POLY 05-CT 05

Environmental and Green chemistry

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT I

Principle and concepts of Green Chemistry:-Introduction, definition, principles, atom economy, atom economic and atom uneconomic reaction, reducing toxicity.

Waste- Production, Problems and Preventions: Introduction, problem caused by waste, source of waste, cost of waste, waste minimization techniques, on-site waste treatment, design for degradation, polymer recycling**.**Introduction to catalysis, biocatalysit and phase transfer catalysis.

UNIT-II

Green Solvents: Organic solvents, solvent-free systems, controlling of solvent-free reactions, supercritical fluids (H_2O and CO_2) ,fluorous biphase solvents.

Green Reagents: Introduction, methods of designing safer chemicals, avoidance of toxic functional groups, examples of greener reagents including replacement of phosgene, methylations using dimethyl carbonates and other polymer supported reagents, solid state polymerization, alternative nitrile synthesis.

UNIT-III

Green Synthesis: Design for energy efficiency, classification and applications of Green Synthesis including Microwave Assisted Synthesis green synthesis of polycarbonates, paracetamol, ibuprofen, citral, urethane, adipic acid, styrene, α,β-unsaturated nitroalkenes.

UNIT-IV

Environmental chemistry: Atmosphere –chemical and photochemical reactions in the atmosphere, oxgen and ozone Chemistry, green house gases and effect, hydrosphere-

physical chemistry of sea water, eutro phication, sewage treatment, lithosphere and chemistry envolved, smoke formation acid rains. A brief idea of toxicological effects of arsenice, lead, cadmium mercury, ozone PAN, cyanide, pesticides. Oxide of nitrogen, sulphur and carbon, carcinogens

UNIT-V

Analysis of pollution: Sampling and monitoring of air and water, determination of total dissolved solids, conductivity , acidity, alkalinity, harnnes, chloride, sulphate, fluoride phosphate and different forms of nitrogen phenols, pestisides, surfactants DO, BOD, COD and microorganism. Catalysts of aquatic chemical reactions water pollution lows and standards.

Books Suggested:

1. Green Chemistry: An Introductory Text, Mike Lancaster, Royal Society of Chemicals, Cambridge,
2. Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes, Edited by Paul T. Anastas & Tracy C. Williamson, Oxford University Press.
3. Green Chemical Syntheses and Processes: Edited by Paul T. Anastas, Lauren G. Heine & Tracy C. Williamson, ACS Symposium Series.
4. Green Chemistry: Environment Friendly Alternatives, Edited by Rashmi Sanghi, M. M. Srivastava, Narosa Publishing House, New Delhi.
5. Green Chemistry: Microwave Synthesis, K. R. Desai, Himalaya Publishing House.
6. Green Chemistry: A Teaching Resource, Dorothy Warren, Royal Society of Chemicals, 2001.
7. Green Chemistry: Williams, Charlotte.
8. Environmental Chemistry, S. E. Manahan, Lewis Publishers.
9. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
10. Environmental Chemistry, A. K. De, Wiley Eastern.
11. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
12. Standard Method of Chemical Analysis, F.J. Welcher Vol. Ill, Van Nostrand Reinhold Co.
13. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
14. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.
15. Environmental Chemistry, C. Baird, W. H. Freeman.

SEMESTER-II

M 2POLY 06-CT 06

Instrumental techniques for analysis

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT-I

(a) Thermo Gravimetry Analysis(TGA) and Derivative. Hermogravimetry(DTG): Principle, instrumentation and application, factor affecting TG curves,

(b) Differential Thermal Analysis(DTA):
Principle, instrumentation and application, factor affecting TA curves

(c) **Differential Scanning Calorimeter(DSC**):
Principle, instrumentation and application, factor affecting DC curves, comparison with DTA.

UNIT-II

(a) **D.C.Polarography**: Basic principle, types of currents, experimental technique, Illovic equation (no derivation) and application of polarography

(b) Principle, technique and application of

(i) Voltametric and cyclic voltametery

(ii) Amperometry

(iii) Anodic stripping voltametery

(iv)

UNIT-III

(a) **High Performance Liquid Chromatography(HPLC**): Introductory knowledge of adsorption basic principle, instrumentation and applications of HPLC, comparison with gas liquid chromatography

(b) **Gas Liquid Chromatography**: Principle, instrumentation and applications

(c) **Gel Permeation or Size Exclusion Chromatography:** Introduction, theory and application

UNIT-IV

(a) **Ion Exchange**: Introduction, types-cationic, anionic, chelating and liquid ion exchangers, preparation, action and properties of exchangers and applications of ion exchangers

(b) Solvent Extraction, ion association complexes

(c) **Gel Electrophoresis**: Introduction, Factors affecting ionic migration, detection of separated components and applications of Gel electrophoresis.

UNIT-V

(a) Radioactive Technique: Tracer technique, neutron activation analysis, counting technique such Geiger-Muller, ionization and proportional counters

(b) Light Scattering Techniques: Principle, instrumentation and applications of nephelometery and Raman spectroscopy.

Books recommended:

1. Ion exchange separations in Analytical Chemistry. O.Samuelson, John Wiley
2. Exchangers amd Solvent Extractions, J.A.Marinsky and Y.Parcus, Marcel Dekker
3. Polagraphic Techniques, I.Metes, Interscience
4. Gel Chromatography, Tibor Kremmer and Laszol Boross, Wiley.

SEMESTER-II

M 2 POLY 07-CT 07

Spectroscopy in analysis-II

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT-I

Mass Spectrometry: Introduction, ion production - El, Cl, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement.Retro Diel -Alder reaction, Nitrogen rule. High resolution mass spectrometery. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

UNIT II

Nuclear Magnetic Resonance Spectroscopy: General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Resonance of other nuclei-^{19}F, ^{31}P.

Carbon-13 NMR Spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants.

Two dimension NMR Spectroscopy - COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

UNIT III

Electron Spin Resonance Spectroscopy: Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors,

application to transition metal complexes (having one unpaired electron) including biological systems and inorganic free radicals such as PH_4, F_2 and $[BH_3]$.

UNIT IV

X-ray Diffraction: Bragg condition, -Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules, Ramchandran diagram.

Electron Diffraction: Scattering intensity vs. scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.

Neutron Diffraction: Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cell.

UNIT V

Mössbauer Spectroscopy: Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds - nature of M-L bond, -coordination number, structure (3) detection of oxidation state and equivalent MB atoms

Books Suggested

1. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
2. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
3. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
4. Progress in Inorganic Chemistry vol., 8, ed., F.A. Cotton, vol., 15, ed. S.J. Lippard, Wiley.
5. Transition Metal Chemistry edi R.L. Carlin vol. 3, Dekker
6. Inorganic Electronic Spectroscopy,. A.P.B. Lever, Elsevier.
7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Norwood.

8. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
9. Spectrometric Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. C. Morrill, John Wiley
10. Introduction to NMR Spectroscopy, R. J. Abraham, J. Fisher and P. Loftus, Wiley.
11. Application of Spectroscopy of Organic Compounds, J. R. Dyer, Prentice Hall.
12. Spectroscopic Methods in Organic Chemistry, D. H. Williams, I. Fleming, Tata McGraw-Hill.
13. Modern Spectroscopy, J.M. Hollas, John Wiley.
14. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Interscience.
15. NMR, NQR, EPR and Msssbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
16. Physical Methods in Chemistry, R.S. Drago, Saunders College.
17. Chemical Applications of Group Theory, F. A. Cotton.
18. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
19. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
20. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
21. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
22. Introduction to Magnetic Resonance, A Carrington and A.D. Maclachalan, Harper & Row.

SEMESTER-II

M 2 POLY 08-CT 08

Fundamental of polymer chemistry

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit – I

Introduction of Polymer: Definition of Polymer, Classification of Polymer, Bonding in Polymer, History of Polymer.

Raw Materials: Oil, Natural gas, Coal, Types, Grades and indication of manufacturing, Source of natural Polymers and derivatives

Unit – II

Addition Polymerization: Cationic, Anionic, and Free-radical.

Kinetics of Polymerization – Free radical, cationic, anionic.

Unit – III

Coordination Polymerization: Ziegler Natta Catalysts and Stereo regular polymers **Condensation Polymerization**: Types, extent and degree of Polymerization and kinetics. Carother's equation, ring opening Polymerization.

Unit – IV

Copolymerization: Mechanism, reactivity ratio and composition – Block and graft copolymers. Kinetics of copolymerization.

Unit – V

Polymerization techniques: Bulk, Solution, Suspension, Emulsion, Melt Polycondensation, Solution Polycondensation, Interfacial condensation, solid and gas phase polymerization. Their advantages and disadvantages with application.

Recommended Books:

1. Polymer science: V.R. Goowarikar,N.V. Viswanathan,Jayadev Sridhar

2. Text book of polymer science: Fred W. Billmeyer

3. Polymer science & Technology: Joel R. Fried

4. Polymer Science and Technology: Premamoy Ghosh

SEMESTER-II

M.Sc. (Polymer Science)
Practicals

M 2 POLY 15-CP 15

Practical-A-II

Two practicals of 100 each (80+20 internal)

Credits : 4+4

1. Synthesis of polymers:

- Synthesis of PF resin.
- Synthesis of UF resin.
- PMMA synthesis by free radical polymerization.
- Precipitation polymerization of acrylonitrile.
- Solution polymerization of acrylamide in presence of a redox initiator.
- Synthesis of polymethyl acrylate by emulsion polymerization.

2. Determination of free phenol content in PF resin

3. Determination of free formaldehyde in UF resin.

4. Spectral analysis: Characterization of organic compounds in the basis of given Xerox copies of spectra (UV, IR, NMR and Mass)
5. Identification of natural polymers: carbohydrate, Protein etc.

M 2 POLY 16-CP 16

Practical-B-II

1. Synthesis of polymers:

- Oxidation polymerization of aniline at different rate condition

    (i)Temperature

    (ii)Monomer to oxidant ratio

- Preparation of aniline formaldehyde resin
- Preparation of Epoxy resin using bisphenol A and epichlorohydrine.
- Preparation of polyester resin
- Preparation of Thiokol rubber.
- Preparation of vinyl ester resin .

2. Determine Epoxy equivalent weight of Epoxy resin.
3. Determine Acid value of unsaturated polyester resin.
4. Determination of swelling network polymers.
5. Determination of water absorption of polymers.

SEMESTER-II

M 2 POLY 01-SE 01

Polymer processing management

M.M.80 marks

Credits: 2

Unit- I

Rubber product manufacturing system: The system concept, Prediction, Monitoring and control of process performance, Production organization

Process control and Quality control: The interaction of process control and quality control, Specifications, Process capability studies, Process monitoring, Process control, Quality control.

Unit-II

Plant layout and operation methods: General consideration, transport and storage in manufacture, Handling methods and operations at work stations, Planning and allocating space layout synthesis and evaluation, Installing and commissioning a layout.

Unit-III

Company Philosophy, Organization and Strategy: Philosophy, Company Organization, Market Research and Company Development.

The economics of manufacturing operations: The flow of cash through a company, Cost identification and analysis methods, Standard costs, Business plans and budgets, Budgetary control.

Unit-IV

Production management: Production planning, Purchasing and inventory control, implementing the production plan.

Unit-V

Quality Management Systems: Quality data, Quality audit, Quality costs, Quality policy, Quality objectives, Quality systems, Inspection, Certification and Accreditation. Basic concepts on ISO 9000, QS 9000, ISO 14000, TS 16949, EFQM model and TQM.

Recommended Books:

1 .Physical testing of rubbers: R. P. Brown.

2. Rubber Technology and Manufacturing: C.M. Blow.

3. Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed. By Dr. R. Mukhopadhyay.

SEMESTER-III

M 3 POLY 09-CT 09

Physical and Chemical Properties of Polymers

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit – I

Molecular mass of polymer: Number average and weight average molecular weight. Molecular weight distribution, Polydisparity, Colligative property determination and end group analysis. Light scattering, Ultracentrifugation, Osmotic pressure and viscosity method of molecular mass determination. Gel permeation chromatography.

Unit– II

Polymer Reaction: Introduction, Hydrolysis, Acidolysis, Aminlysis, Hydrogenation, Addition and substitution reaction, Reaction of various specific group, Cyclisation reaction, Cross-linking reaction, Reaction leading to graft and block copolymer, Miscellaneous reaction.

Unit – III

Amorphous and Crystalline state: Polymer chain flexibility, glass transition temperature,

Crystalline state, melting point and general structure property relationship

Electrical properties: orientation, atomic and electronic polarization of polymeric dielectrics .Definition of relative permittivity and values for polymer processing .Various types of polarization .Electric strength and tracking.

Unit – IV

Diffusion in polymer: diffusion of gases, liquids and solids in polymer, solubility parameter, effect of temperature and prediction of solubility parameter of solvent

Solution properties: Behavior of polymers in polar and non polar solvent. Effect of crystallinity and cross linking on solubility.

Unit – V

Rheology : viscosity, plasticity and non Newtonian flow. Time dependent flow. Power low .Effect of temperature and molecular mass on viscosity. Flow properties of polymers, application of rheology and viscometer to predict process ability of polymers. Viscoelastic behavior, hysteresis, creep, stress relaxation.

Polymer degradation and stability: thermal, photo degradation, oxidative and biological degradation .The role of antioxidant and stabilizer.

Recommended Books:

1. Polymer science: V.R. Goowarikar,N.V. Viswanathan,Jayadev Sridhar

2. Text book of polymer science: Fred W. Billmeyer

3. Polymer science & Technology: Joel R. Fried

4. Polymer Science and Technology: Premamoy Ghosh

SEMESTER-III

M 3 POLY 10-CT 10

Specialty Polymers

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit – I

High temperature and fire resistant polymer: Introduction, Polymers for high temperature resistance, Fluropolymer, Aromatic polymers, Hydrocarbon polymers, Polyethers, Polyphenyl sulphide, Polysulphones, Polyesters, Polyamides, Polyketones, Heterocyclic polmers.

Hydrophilic Polymers: Introduction, Natural polymers – Carbohydrate, Proteins, Semi-synthetic polymers, Hydrogel, Polyacrylamides hydrophilic polymers, Polyvinyl alcohol, Polyvinyl pyrrolidone.

Unit – II

Polymers with electrical and electrometric properties: Introduction, Conductive polymers, Photo conducting Polymer, Polymers with piezoelectric, Piezoelectric and ferroelectrics properties, and Photo resists for semiconductor fabrication.

Conducting Polymer: Definition, Inherently conducting polymer: polyacetylene, polydiacetylene, polyaniline, poly (p-phenylene sulphide), photo conducting polymers

Unit – III

Ionic Polymers: Introduction, Classification, Synthesis physical properties and application, Ionomers based on polyethylene, Polystyrene, Ionomers with Polyaromatic backbones, Polyelectrolyte, Polyelectrolyte complexes

Biopolymers: Introduction, Definition, classification, advantages and disadvantages, Applications of Biopolymers in : 1) Drug delivery system, 2) Disposable in Health Care, 3) Packaging, 4) Medication

Structure and properties of natural polymer: - polypeptides Proteins nucleic acid, based, poly lactic acid, PHBV, Carbohydrates.

Unit –I V

Inorganic and Organic Polymer: Introduction, Inorganic reaction mechanism, Condensation organ metallic, polymers, Addition polymers, coordination polymers, Sol Gel, Portland cement, Silicates, Silicon dioxide, Asbestos, Diamond, Graphical, Polysulphur

Unit-V

Outline manufacturing and properties of

Polyethylene	Polyimides
Polypropylene	Polyacrylanitriles
Polystyrene	Polyvinyl alcohol
Polymethylmethacrylate	Polyvinyl acetate
Polyvinyl chloride	Phenol formaldehyde resin
Polyurethanes	Urea formaldehyde resin
Polyesters	Melamine formaldehyde
Polycarbonates	Melamine formaldehyde resin
Polyamides	Epoxy resins.

Recommended Books:

1. Polymer science: V.R. Goowarikar,N.V. Viswanathan,Jayadev Sridhar
2. Text book of polymer science: Fred W. Billmeyer
3. Polymer science & Technology: Joel R. Fried
4. Polymer Science and Technology: Premamoy Ghosh
5. Specialty polymers: R.W. Dyson

SEMESTER III

M 3 POLY 19-ET 01

Materials for compounding and reinforcement

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit I

Latex: - NR Latex, stability, concentration and preservation, nitrile latex, latex foam rubber, latex adhesives

Outline Manufacturing, Vulcanization, and properties of NR/IR/SBR (Emulsion and solution type), BR/NBR/HNBR, and IIR, CR, CSM, and EPR/EPDM, EVA silicone, FKM, ACM and polysulfide rubbers.

Unit II

Compounding ingredients:-Fillers: Reinforcing and extending fillers, carbon black and non-black fillers **Curing systems:** conventional, EV and semi EV, metal oxide and resin curing **.Protective System**: Antioxidants, antioxidants and waxes. **Miscellaneous** : Peptiser, activator, accelerator, softener, oil, retarder, blowing agent, Tackifier Mineral Rubbers, Reclaimed Rubber, Ground crum, Release agents.

Unit III

Textile/reinforcing materials :- textile terminology Definition of fibres, yarn, cord, twist, count, denier, tex, types of textile weaves and their application in different rubber products. properties and outline Manufacturing of cotton, Rayon , Polyamides, polyesters, Glass Fiber, Aramid and Steel wire, their application in rubber products as a composite materials. Textile to rubber bonding systems – Dry and RFL.

Unit IV

Adhesive and bonding :- solvent based, water based and other adhesives based on various polymers, expoxide resins and curing of epoxide resins. Diluents and other additives, Rubber cement for tyre application.

Unit V

Thermoplastic Rubbers: - Classification, Advantage over simple elastomers and application .Application and properties of SBS, PVC blended SBR.

Composite Materials :- Introduction, advantage of composite materials over other polymeric materials, Basic principle of manufacturing, factors influencing the performance. Physical and functional properties of different composites, Fiber reinforced plastic and rubber their properties and application.

Recommended Books:

1 .Rubber Technology and Manufacturing: C.M. Blow.

2. Rubber Technology Handbook: Hoffman.

3 Introduction of Polymer Sc. & Rubber Technology,Vol. I, Ed By Dr. R. Mukhopadhyay.

4. Rubber Engineering, Ed. By K.S. Logonathan.

5. Rubber Technology, Ed. By Maurice Morton.

6. Rubber Processing: An Introduction, Peter S. Johnson.

SEMESTER III

M 3 POLY 25-ET 07

Compounding and Uses of Plastics

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT-I

Compounding: Introduction, mixing theory, Fillers for Reinforcements ,coupling agents, composites ,Nan composites , plasticizers, antioxidants, stabilizer (heat, ultra violet), flame retardants ,colorants, curing agents, blowing agent, lubricants, inhibitors

UNIT-II

(a) Addition polymerization

Introduction -Addition polymerization of Polyethylene , Poly - dependence of rate on the initiator and monomer concentration- degree of poly. And kinetics chain length- factors affecting chain poly. Inhibition and retardation.

(b) Condensation polymerization.

Introduction - types of Condensation Polymers-Condensation reactions for manufacture of Thermoset Plastics like UF, MF, PF,etc.

(c) Co-polymerization

Introduction- Co poly. Composition equation- applications of co polymers composition equation- block and draft copolymers. Determination of reactivity ratios- reactivity ratios and co poly.

Methods of polymerization

Bulk - solution - Suspension - Emulsion - Gas phase polymerization techniques in detail with examples – Suspension polymerization of PVC, Bulk method for manufacture of PMMA sheet, etc. factors affecting the poly methods with respects to various parameters

UNIT-III

Advantages and disadvantages of plastics, Monomer preparation, polymerisation, properties and application of LDPE, HDPE, cross linked and chlorinated PE, PP and PS.

Monomer preparation, polymerisation, properties and application of PVC, polyvinilidine chloride, PVA, polyvinylacetate, PMMA and PAN

Monomer preparation, polymerisation, properties and application of PU, PTFE, PVF, ABS, PC, polyacetal, polyester, SAN, epoxies, PF, novolac, resol, MF and UF

Monomer preparation, polymerisation, properties and application of nylon-5, 6, 66, 612 and polyacrylamide Teflon, Terylene, Acrylics,

UNIT-IV.

Colour dyes and Pigments

Introduction – colour and constitution- modern theory of colour – Dyes –Classification- Application- Pigments and application

Adhesive and bonding :- solvent based, water based and other adhesives based on various polymers, expoxide resins and curing of epoxide resins. Diluents and other additives.

UNIT-V

Resins and Powder coating: Vinyl dispersions- Introduction, rheology, dispersion and blending resin, stabilization, ingredients, spread coating and applications, roll coating, Fabric coating, film casting, deep coating and molding.

Powder coating: Introduction, manufacturing methods, Application methods, types of powder coating.

References

1. K.J. Saunders, "Organic Polymer Chemistry, Chapman and Hall ", London.1973.
2. J.A. Brydson, " Plastic materials", Newnes Butterworths.
3. Encyclopaedia of Polymer Science and Technology.
4. V.R.Gowarikar and N.V.Viswanathan, "Polymer Science",Willey eastern limited.
5. G.S. Misra, "Introductory Polymer Chemistry", Willey eastern limited.
6. Polymers and Resins by Golding
7. Polymers chemistry by Stevens
8. An Introduction to Polymer Physics: I.I.Perepects.
9. "Polymer Science and Technology" by Premamoy Ghosh

Semester III

M 3 POLY 20-ET 02

Tyre and Rubber processing Operations

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit– I

Mixing: Introduction, Material flow to the mixer, feeding, weighing and charging of materials.

Mixing process: Incorporation, dispersion, distribution and plasticization.

Internal mixer operation: Mixing procedure, temperature control, rotor speed, ram pressure, batch size, dump criteria, Take-off systems, dump mills, packaging, single pass system. Mill mixing and Continuous mixing.

Trouble shooting in mixing: Inadequate dispersion or distribution, scorch compound, contamination, poor handling on dump mill and batch to batch variation.

Unit – II

Extrusion: Basic principles of extrusion. Extrude types Ram type and screw types General mechanical construction of a single screw extruder. Screw design, drive mechanism, temperature control, feed arrangement. Description of Die construction. Function and lay out of ancillary equipments. Cold feed extruder, Hot feed extruder, Vented cold feed and Pin extruders.

Trouble shooting – output rate, dimensional stability, excessive heat generation and rough extrudate, rough surface on extrudate, Contamination, porosity in extrudate.

Unit– III

Calendaring: Construction, function and uses of calendaring machinery. Types of calendar rolls, roll positioning and adjustments. Temperature control, bending corrections by different methods. Bearings, drives and lubrication systems. Power requirement. Comparison with extruder, cost – comparison with spreading process.

Calendaring operations: sheeting, fractioning, coating, profiling, embossing etc. Trouble shooting in calendaring: Scorch, blistering, rough or holed sheet, tack, bloom.

Unit – IV

Moulding: Molding of high viscosity materials: Compression, transfer, injection and bladder molding.

Molding of low viscosity material: Casting, reaction injection molding (RIM). Mould design and mould materials. Mould lubrication, mould cleaning, mould shrinkage. Advantages and disadvantages between different molding techniques.

Transfer molding: Equipment used, comparison, costing and safety**.**

Injection molding: Description, comparison of Ram and Screw Injection system. Typical drive systems and requirement of feed analysis. Molding temperature control, requirement of clamping and loading arrangements. Molding defects, their causes and remedies.

Unit– V

Fabrication Techniques: General description of fabrication techniques currently used in industrial practice.

Vulcanization Techniques: Thermal energy for vulcanization, saturated steam method, heated gas method, heat transfer fluid method, direct energy transfer method. **Vulcanization methods:** batch, semi-continuous and continuous vulcanizations and equipment. Open steam vulcaniser, steam tube (autoclave), function of steam trap, control system for steam pressure and temperature. Various allied instrumental control systems. Pressurized gas or liquid vulcaniser, Hot air vulcanising tunnel, continuous microwave oven, liquid or pseudo-liquid curing.

Recommended Books

Rubber Technology and Manufacturing: C.M. Blow.

Rubber Technology Handbook: Hoffman.

Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed By Dr. R. Mukhopadhyay.

Rubber Engineering, Ed. By K.S. Logonathan.

Rubber Technology, Ed. By Maurice Morton.

Rubber Processing: An Introduction, Peter S. Johnson.

SEMESTER-III

M 3 POLY 26-ET 08

PLASTIC PROCESSING TECHNOLOGY

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT-I

Introduction:

What is Plastic Processing - Introduction to various processing methods for thermoplastics and thermo sets - consideration for selection of particular method of processing - flow behavior of polymer melts. Principle of processing of Plastic

UNIT-II

Compression molding:

Introduction - types of processes : up stroking, down stroking - materials used and selection criteria - preheating - bulk factor - performance -process steps - process advantages and disadvantages - process variables - molding machine details - mold types : flash, semi positive, positive -charging - post curing - cooling fixtures - finishing - molding defects : causes and remedies.

UNIT-III

Transfer molding:

Introduction - transfer molding process types - techniques of transfer molding: pot and plunger types - advantages and disadvantages - process variables ,molding materials , types of molds - pot dimensions and its effects ,trouble shooting ,comparison with compression molding.

UNIT-IV

Thermoforming:

Introduction-definition-various process steps-types of materials-material selection criteria in detail with properties like melt stability, plastic memory, etc. sheet thickness in detail required by the process- limitations as regards the types of sheets that can be used, etc., - advantage and disadvantage with the injection molding process-types of machine, molds and its Material in brief-various process variables-cold forming process With advantage and disadvantage-trouble shooting for the process-Rheology, its importance and applications. Types of thermoforming processes like plug assist, reverse draw forming, bubble type forming, twin sheet thermoforming, etc. Differences between pressure and vacuum forming techniques, types of vacuum forming techniques in detail along with advantages and limitations of each in detail. Engineering applications of thermoformed articles in detail, along with latest developments.

UNIT-V

Blow molding: Introduction - Basic process - Plastic materials for Blow molding Extrusion blow molding - Continues extrusion process, Intermittent extrusion process, Parison programming Injection Blow molding - Basic process of IBM, Stretch / orienting blow molding Processing parameters, Troubleshooting of blow molding Advantages & Dis-advantages of Bow molding

Reference Books:

1. Thermosetting resins by J.F.Monk.
2. Plastics Processing Data Handbook by Rosato
3. Thermoforming by Throne.
4. Plastic engineering by Crawford.
5. “Process Heat Transfer” : D. Q. Kern, Mcgraw Hill.
6. “Fundamentals of Heat Transfer”: M. Mikheyev, MIR Publications.
7. Unit operations of Chemical Engineering”: W. L. Mccabe and J. C. Smith, Mcgraw Hill,
8. “Principles of Unit Operation” : A. S. Foust et al, Wiley International, 1990.
9. Plastics material and processes by Schwartz and Goodman
10. Plastics Engg. Handbook by Joel Frados 5.“Heat transmission” : W. H. Mcadams, Mcgraw Hill, 3rd edition

SEMESTER-III

M.Sc. (Polymer Science)
Practicals
M 3 POLY 17-CP 17

Practical-A-III

Credits: 4

1. Synthesis of polymers:

- Preparation of Polyvinyl acetate.
- Polymer modification- preparation of polyvinyl alcohol From poly vinyl acetate.
- Depolymerization of polymethyl methacrylate
- Synthesis benzoic acid-formaldehyde resin
- Synthesis Aniline formaldehyde resin
- Synthesis Aniline formaldehyde resin
- Synthesis DGEBA Epoxy resin

2. Determine of mol. Wt. by end group analyzing
3. Sheet casting using methyl methaacrylate
4. Mol. Wt. determination by non aquous conductometric titration.
5. Determine Saponification value of polyvinyl acetate.

SEMESTER-III

M.Sc. (Polymer Science)
Practicals

M 3 POLY 23-EP 05

Testing of Latex and identification of rubbers

Credits: 4

1. Testing of natural rubber latex:

(i)Determination of total solid content (% TSC)

(ii)Determination of dry rubber content (% DRC)

(iii)Determination of mechanical stability

(iv)Termination of total alkalinity

(v)Determination of KOH number

(vi)Determination of viscosity of latex by Brookfield viscometer

(vii)Determination of coagulum content

(viii)Determination of magnesium in latex

2. Identification of rubber

- Preliminary test.
- Solubility test.
- Elemental analysis.
- final identification by chemical test

Group 1- Rubber containing nitrogen

Group 2- Rubber containing chlorine

Group 3- Rubber containing bromine

Group 4- Rubber containing fluorine

Group 5- Rubber containing sulphur

Group 6- Rubber not containing nitrogen, halogen and sulphur

M 3 POLY 29-EP 11

Identification of plastics

1. Identification of plastic
   - Preliminary test.
   - Solubility test.
   - Elemental analysis (test for heteroatom).
   - final identification by chemical test
2. Specific identification test

   (a) Plastic containing nitrogen
   (b) Plastic containing chlorine
   (c) Plastic containing fluorine
   (d) Plastic containing sulphur
   (e) Plastic not containing nitrogen, sulphur and halogens.

3. Spectral analysis: Characterization of Plastics in the basis of given Xerox copies of spectra (UV, IR, NMR and Mass)

4. Thermal characterization: Study of polymer using TGA,DTA, and DSC on the basis of given data.

5. Determination of chlorine content of PVC resin

SEMESTER-IV

M 4 POLY 11-CT 11

Project Work (at Research Laboratory orAny Industry or Institute of repute)(60 DAYS)

Credits: 4 **Max Marks:100**

General Guidelines for Preparation of Project Report

(For specific details the students are advised to consult their respective supervisors)

1. Strictly follow the format given to write the manuscript of the project.
2. On the front page include title of the project (font size 21, centered). The title should not contain abbreviation and scientific names of organisms should be in *italics.* This page should not be numbered.
3. Starting from second page, the pages must be numbered consecutively, including figures and table.
4. Text should be 1.5 point spaced type written using Times New Roman Font, Font Size 12, on one side of A 4 Size paper, with 1.5 inch margins throughout. Scientific names of the organisms should be in *italics.* Main headings (Summary, Introduction, Chapter details, Conclusions and References) should be bold type, justified and separated from the text.
5. The full text of project should not exceed 20-25 one side typed pages.
6. Literature citation in the text should be cited in alphabetic order. The form and style of references should be as indicated below.

(a) Journal article

Carvalho, L.C., Goulao, L., Oliveira, C., Goncalves, C.J. and Amancio, S. 2004. Rapid assessment for identification of clonal identity and genetic stability of *in vitro* propagated chestnut hybrids. Plant Cell Tiss. Org. Cult. 77:23-27.

Chae, W.B., Choi, G.W. and Chung, I.S. 2004. Plant regeneration depending on explant type in *Chrysanthemum coronarium* L. J. Plant Biotech. 6:253-258.

(b) Book reference

Salisbury, F. B., Ross, C. W. 1992. Plant Physiology. 4th edn. Wadsworth Publishing Company. Belmount.

(c) Edited books

Constantine, D.R. 1986. Micropropagation in the commercial environment. In : "Plant Tissue Culture and its Agricultural Applications". L.A. Withers and P.G. Alderson (Eds.) pp. 175-186. Butterworths, London, UK.

(d) Paper presented at a conference

Chaturvedi, H.C. 1992. Hardening of *in vitro* raised plants for transplant success. A state of art report. Paper presented in DBT Project Monitoring Committee Meeting held on 6th-7th July, 1992 in DBT, New Delhi, India.

(e) Proceeding of a symposium

Rajsekharan, P. E., Ganeshan, S. 2005. Designing *exsitu* conservation strategies for threatened medicinal plant species of South India. In: " Proc. Natl. Symp. and 27th Annual Meeting of PTCA(I)." A.K. Kukreja *et al* (Eds). Pp.159-164. CIMAP, Lucknow, India.

(f) Thesis/ Dissertation

Dave, N. 2004. Factors influencing micropropagation of two varieties of *Achras sapota* and their rootstock *Mimusops hexandra*. Ph.D. Thesis, Mohanlal Sukhadia University, Udaipur, India.

(g) Patent

Trepaginer, J.H. 2000. New surface finishings and coatings. US Pat 1276323 (to DuPont Inc, USA). 27 June, 2000. Chem Abstr, 49 (2000) 27689.

(h) Reports

Anonymous, 1976. The Wealth of India. Raw Meterials. Vo. X. pp. 44-48. CSIR, New Delhi, India.

TITLE MUST BE IN CAPITAL LETTERS, SIZE 21 AND CENTERED, WITH *Scientific names* IN ITALICS

A Project Report submitted

for the partial fulfillment of the Degree of Master of Science

By

(**Name of student**)

[M.Sc. Polymer Science]

DEPARTMENT OF Polymer Science

University College of Science

MOHANLAL SUKHADIA UNIVERSITY

UDAIPUR

2015-16

INSTITUTE NAME AND LOGO

Ref no.-…….. Date……

CERTIFICATE

This is to certify that the dissertation/project report entitled "**……**" submitted towards the partial fulfillment for the award of the degree of Master of Science in Polymer Science, from Mohanlal Sukhadia University, Udaipur (Rajasthan) India is the result of bonafide work compiled by **Mr./Ms. ……** carried outunder the guidance of **Dr./Mr/Ms. ……** at **……..** under my supervision in the academic year of …….. It has no part the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date

Name & Signature of the supervisor

Seal of the supervisor

Declaration

I, **……..** Roll No. **_____**student of M. Sc. IV Semester Biotechnology (Session 2010-11) hereby declare that the project entitled "……." is my own compilation. I have strictly adhered to the guidelines provided by the department for the preparation of the project report.

Dated: Signature of the Student

MARKING SCHEME FOR Project Work

M. Sc. Polymer Science semester IV

S. No.		Maximum Marks	Marks Obtained
1	**Project Report** a. Review of Literature b. Methodology c. Outcome d. Discussion	 10 10 10 20	
2	Presentation	25	
3	Viva – voce	25	
	TOTAL MARKS	**100**	

SEMESTER-IV

M 4 POLY 12-CT 12

Polymer and Environment

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

1.

Unit I

Plastic waste management :- introduction, recent trends in plastic industry, sources of plastics waste, waste management in the global , legislation, strategy, UNIDO programme on polymer.

Unit II

Equipment for plastics recycling: - introduction, extruder, degassing m meltifilitring , pelletiser.

Application of recycled plastics: - recycled LDPE, recycled PVC, recycled polystyrene (PS) , recycled commingled plastic waste.

Unit III

Recycling of rubber: - introduction, recycling methods, devulcanistion.

Unit IV

Recycling of rubber tyres and polyurethane: process of recycling polyurethane, rubber recycling , novel rese of scrap tyres.

Unit V

Rubber waste disposal: - introduction, physical waste reduction, waste tyre disposal.

SEMESTER IV

M 4 POLY 21-ET 03

Rubber Product Technology

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

Unit – I

Pneumatic Tyre: Functions of tyre, tube and rim assembly. Components of a tyre and their function. Tyre Construction (Bias, Radial, Bias-belted). Tyre Types. Tread design (Lug, Rib and Semi Lug). **Compounding** for casing, tread and bead. Tyre reinforcing materials (Rayon, Nylon, Polyester, Aramid, Glass Fiber and Steel Wire). Organic cord treatment (Dipping), Metal to rubber bonding.

Tyre Design and performance: Criteria for cycle, motorcycle, truck, aircraft and tube-less tyres. Tyre Manufacturing process, Defects observed and remedial action.

Lateral Stiffness, Torsional Stiffness, Cornering power, Rolling Resistance, Friction and Wet Grip. Destructive and Non-destructive tests of tyre.

Unit– II

Tube and Valves: Principles of Tube Design, Manufacturing of Tubes: Tube extrusion, valving, splicing, inflation, curing. Compounding of tube and tube valve. Tube Defects and Tube Testing.

Conveyor Belting: Functions, Components, component requirement, compounding and Belt design. Defects and testing of belt.

Flat Belt and V-Belt: Functions, Components, component requirement, compounding and Belt design. Defects and testing of belt.

Unit – III

Hoses: Hose Compounding , Design and Construction, Reinforcing Materials, Moulded, Machine made, hand made and circular woven hoses.

Rubber Footwear: Hot air vulcanized, compression molded, direct molded. Process for shoe bottoming, injection molded sole and heel units. Safety, conductive and anti static footwear. Footwear compounding.

Unit – IV

Rubber to metal bonded components: Metal cleaning, application of bonding medium, equipment lining and molding.

Cellular Rubber: Expansion technology, Compounding of sponge rubber, expanded rubber by nitrogen gas and chemical blowing agents.

Sports Goods: Compounding and Process of Tennis Ball, Football, Basketball, Volleyball and Golf Ball.

Unit – V

Cables: Compound formulations and evaluations, application of insulator and sheath, curing techniques and specialized cable components.

Latex Products: Manfacturing Process of Dipped Goods, Threads and Foams. Mix design of Rubber Rollers.

Dipping Process: Dipping process for Nylon and Polyester.

Recommended Books:

1 .Rubber Technology and Manufacturing: C. M. Blow.

2. Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed. By Dr. R. Mukhopadhyay.

3 .Rubber Engineering, Ed. By K. S. Logonathan.

SEMESTER-IV

M 4 POLY 27-ET 09

Identification and Testing of Plastic

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT I

Mechanical Behavior of materials – Stress – Strain curve, Elastic deformation Characteristics of elastic deformations, atomic mechanism of elastic deformation, Inelastic deformation, Strain-Time curves, Damping capacity, Viscous deformation, Plastic deformation, Mechanism of plastic deformation- slip & twinning, Schmidt's law, critical resolved shear stress. determination of Melt flow index (MFI)

UNIT II

Mechanical testing and fracture of materials – tensile test, stress-strain curves for ductile and brittle materials – mild steel, copper, proof stress, yield point phenomena, Luder's bands, compression test, hardness test – various hardness tests. Impact test – ductile-brittle transitions. Fatigue- Stress cycles for fatigue testing, endurance limit, fatigue limit, S-N curve, Creep-curve, primary creep, secondary creep, tertiary creep. Fracture – ideal fracture stress, brittle fracture- Griffith's theory- fracture toughness, ductile failure, cup & cone type fracture, fatigue failure.

UNIT-III

Chemical Characterization: Identification of materials by thermal, elemental and solubility analysis. Identification by colour tests. Estimation of specific chemical characteristics like acid number, saponification value and hydroxyl values. Solvent extraction and its analysis for polymers.

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UNIT-IV

Thermal Characterization: Study of the instrumentation and application of the following techniques to polymer – TGA, DTA, DSC and TMA.

Spectroscopic Characterization: Basic principles, instrumentation and applications of the following techniques – UV and Visible, IR, FTIR with ATR, HPLC, GPC and GC- MS.

UNIT-V

Production and application of biodegradable plastics: based on PVOH, lactic Acid, polypeptides ,Proteins ,nucleic acid, poly lactic acid, PHBV, Carbohydrates.

REFERENCE BOOKS

1. M. Arumugham, Material Science, Anuradha Agencies, 1st Ed., 1987.
2. G. E. Dieter, Mechanical metallurgy, McGraw-Hill, 2000.
1. Klaus Stoeckhert, Mold making handbook for the Plastic engineers, Hanser Pub.
2. Data book on Plastics – CIPET, Chennai.
3. J. C. Anderson, K. D. Leaver, R. D.Rawlings, J. M. Alexander, Material Science,
4. Donald S. Clark and Wilbur R Warney, Physical metallurgy, Affltd. East west press.
5. C. W. Richards, Engineering material Science, Prentice Hall Of India.
6. Polymer science: V.R. Goowarikar,N.V. Viswanathan,Jayadev Sridhar
7. Text book of polymer science: Fred W. Billmeyer
8. Polymer science & Technology: Joel R. Fried
9. Polymer Science and Technology: Premamoy Ghosh

SEMESTER IV

M 4 POLY 22-ET 04

Testing and Characterization of Rubber Products

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT -I

1. **Testing of Tyres** :

1.1 Pulley wheel and plunger testing for endurance.
1.2 Pulley wheel testing for mileage and temperature build up.
1.3 Measurement of stiffness,
1.4 Rolling resistance.
1.5 Ply to ply adhesion, sidewall to ply adhesion. Breaker / belt to ply adhesion.
1.6 Stress-Strain property of tread, side wall compound.
1. 7 Determination of Mooney viscosity and moony scorch of Tread , sidewall compound.
1.8 Determination of Rheometric properties of Tread , sidewall by Rheometer.
1.9 Determination of hardness of rubber vulcanizate.

UNIT-II

2. Testing of Tubes : Air permeability, testing, growth of tube testing, set and swelling. Aging test of tube, splice testing of tube, Valve testing.

3. Testing of power transmission belt and conveyor belt : Drum friction test, steel test, tensile testing, ply adhesion testing, Specific gravity test of compound. Heat buildup test by good rich flexometer.

UNIT -III

4. Testing of Footwear:

4.1 Taber abrasion testing, Flex to fatigue test for sole compound by Rose Flexing machine.
4.2 Compression set measurement, Constant stress and constant strain test. Hardness testing of sole.

UNIT -IV

5. Testing of Hoses:
5.1 Leakage test,
5.2 Bursting strength,
5.3 Impulse test,
5.4 Oil resistance,
5.5 Flame resistance etc.

UNIT-V

6. Testing of Cables : Permittivity, resistivity, die electric strength, Cornadischarge.

7. Testing of Moulded and Extruded Rubber Goods : Compression set, swelling, ageing in Ozone , aging test by heat.

8. **Testing of Raw material :** DBP Adsorption of Carbon Black, Dipped Pick up test for Nylon, H- Adhesion test for textile and rubber, Strip Adhesion Test.

SEMESTER IV

M 4 POLY 28-ET 10

Textile Technology

Time: 3 Hrs. **M.M. 80 marks**

Credits: 4

UNIT-I

Introduction to the linear polymer and raw material – DMT, TPA, MEG,Caprolactum. Process of polymerization and importance of Production process of PET polymer, Nylon 6, Nylon 66, Acrylic polymer, Polypropylene polymer etc.

Basic concept related to the structure of Textile Fibers like wool, silk, linen etc.

General Physical and Chemical properties of various textile fibres – Natural and Manmade fibres. Brief idea of processing of raw silk & Jute Outline of degumming methods for silk.

UNIT-II

General principles of manufacturing man made fibres by melt spinning, dry spinning and wet spinning.

Object, process details and properties of end product for various processes such as bleaching, stitching, brushing, shearing, singeing, desizing, washing, pressure mangling, drying etc. Machines used for various processes.

Outline of steps for the manufacture of polyamide, polyeaster, polyacrylics & polypropylene fibres. Introduction to new fibres like Tencel, Lycra, Aramide, Model etc.

UNIT-III

Type of Weaving

1. Winding (a) Warp Winders: Central idea of development of Winding Machines Precision Winding; Tension Control; Slub Catchers; Study of Automatic. Winders such as Barber & Auto-corner, Winding faults & remedies. (b) Pirn Winders: Need for Pirn Winding; Brief outline of non-automatic pirn winders; Study of automatic pirn commonly used. Modern developments in winding.

2. Plain Loom : Basic Weaving Mechanism such as shedding; picking & beating Shuttle and shuttle boxes; shuttle flight control; Slay movement; General idea of tappet design; Secondary motion. negative let off motion, brake motion; weft fork stop motion etc. Heads & reeds & Temples. Timings & Settings of plain looms. Simple cloth faults and their remedies.

UNIT-IV

Yarn Manufacturing

1. General idea of Ginning & Baling Processes, Characteristics of bales and importance of contaminations.

2. Objects of Mixing; Methods of Mixing; Different types of conventional feeders; openers & cleaners; Use of air currents for cleaning & Transportation; Blow Room sequence for different cotton & manmade fibres; Construction & working of machines for single process Blow Room, Modern openers & cleaners.

UNIT-V

Principles & objects of carding; construction of working of revolving flat card; card clothing and its effect on sliver quality.,mounting; Grinding & stripping with integrated grinding system., card settings; High Production Cards. Card waste and importance of suction hood for waste optimization at. card

Recent developments, all modern attachment like pre and post carding elements etc, Tandem Card-Chute feeding system-Auto levelers at card. Common defects and remedies in product delivered at each machine. Maintenance of machines.

Reference Books:

1. A practical guide to opening and carding- W .klein.
2. Spun yarn technology, volume I, Blow room processes - A.Ventasubramani.
3. Spun yarn technology, volume II, carding - A.Ventasubramani
1. Principles of weaving by Marks & Robinson, Textile Institute
2. Plain Loom Motions by Aswani
3. Woven Fabric Production Part I, NCUTE publication
4. Yarn Preparation Vol. I by Sengupta

SEMESTER-IV

M.Sc. (Polymer Science)
Practicals
M 4 POLY 18-CP 18

Practical-A-IV

Credits: 4

1. Viscosity and mol. Wt. determination by ubbelhele/ostwaldviscomels

2. Study of antioxidants/amino acids by thin lay chromatography/ Paper chromatography.

3. Estimation of some physical properties of polymers:

(a) Determination of percentage of filler/ fibre contents in the polymer composite.

(b) Determination of ash content of given polymer.

(c) Determination of moisture content of the polymer sample.

(d) Determination of water absorption of the polymer sample

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(e) Determination of melting point of the polymer sample.

(f) Determination of density of the polymer.

(g) Determination of bulk density for polymer powder or granules.

SEMESTER-IV

M.Sc. (Polymer Science)
Practicals
M 4 POLY 24-EP 06

Mechanical properties and testing of rubber

Credits: 4

Mechanical testing and Processing of Polymers

(i)Tensile impact strength of polymers

(ii)MFI of thermoplastics

(iii)Abrasion loss, Abrasion index of rubber Vulcanisate

(iv)Swell index and volume fraction of cured rubber stock

(v)Stress –strain properties of organic Tyre cord

(vi)Textile to rubber adhesion by H- adhesion technique

2. Testing and characterization of polymer : volatile matter, ash content, mooney viscosity

M 4 POLY 30-EP 12

Mechanical properties and testing of plastics

Mechanical testing and Processing of Polymers

(i)Tensile impact strength of polymers

(ii)MFI of thermoplastics

2. Testing and characterization of polymer : volatile matter, ash content, MOISTURE CONTENT, mooney viscosity, water absorption
3. Determination of plastisizer in PVC
4. Estimation of resistance of plastic films to chemicals and to measure the weight change of films after immersion in chemicals as per ASTM D 1239-55 method

SEMESTER-IV

M.Sc. (Polymer Science)

M 4 POLY 02-SE 02

Skill Course II: PAINT TECHNOLOGY

Credits: 2 **M.M. 100 marks**

UNIT-I

Basic introduction nature of paint, pigment, binder. Classification of paint. Pigment volume concentration, solvent.

General Physical properties of pigment: Colour, colour measurement, colour system and Atlases, Opacity, Characteristic pigment and, toxicity of pigment.

SAFETY- - Knowledge of safety - Safety equipments - personnel protective equipments - safety in handling - safety from fire, explosion, electrical hazards - first aid - emergency procedures - storage of paints

UNIT-II

Processing of pigment: Internal pigment and external pigment, manufacturing of pigment, General Principal of manufacturing paints filtration of paint, Drying of paints. Describe properties and charteraization of different white pigment and extender like Titanium Dioxide,zinc Oxide, Zinc phosphate, amtimony oxide, white lead, extender, barium compound ,calcium compound and Silica compound.

The process of pigmentation: Non Aqueous Paint and Aqueous emulsion paint

UNIT-III

Properties, Toxicity and identification test of Colour inorganic pigment: The chrome Pigments, Zinc chrome Pigment, barium cromate strontium cromate, cadmium colour, Titanium nickel yellow, red lead, Ultra mine blue, prussian blues Green Pigmenet. Black, matelic, and miscellaneous pigment and luminous pigment. Organic Pigment: Azo Group, Azo Toner, phtalocyanine pigment, Quinacaridon pigment, DPP, pigment from basic dyes. General Properties of Solvent and diferent classes of solvents, Plastisizer.

UNIT-IV

PAINT MANUFACTURING- - Equipments used in manufacturing such as ball mills, pebble mills, pin disc mill, sand mill, horizontal bead mill, micronizers, mixers, pug mixers, thinning mixers, edge runners, strainers & sieves, attritors, sand mills- construction & working. Method of pigmentation Plastic milling pug mixer,

UNIT-V

Testing And Evaluation of Paint: ICI cone and plate viscometer, ther ferrantishirley viscometer ,brookfiled viscometer, Application and wet films. Test on dry films, measurement of film thikness, optical properties, opacity of dry film, colour comparison, mechanical properties, Adhesion. Flexibility and extensibility .

REFERENCE BOOKS:

1. Outlines of paint technology,W.M. Morgans