Proposed Syllabus and Scheme of Examination

for

B.Sc. (H) Polymer Science

Submitted to

University Grants Commission

New Delhi

Under Choice Based Credit System

2015

Preamble

The B. Sc (H) Polymer Science is an interdisciplinary program consisting of Polymer Science, Chemical Technology and Material Science. This program is designed to provide fundamental understanding of polymer engineering and technology. It also aims to expose the students to latest development in polymeric materials. This will develop skilled manpower for the fast expanding polymer industry in India in the following fields:

- Polymer manufacturing
- Polymer processing
- Performance evaluation & quality assurance
- Marketing and sales
- Mold and Die designing
- Fiber Technology
- Rubber Technology
- Paints & Coatings
- Polymer waste management

After schooling, students with PCM background are eligible for the course and students with PCMB will get 3% relaxation. Since 2004, the undergraduate program on Polymer Science (Honors) course has been running successfully at Bhaskaracharya College of Applied Sciences. Students after passing out are well placed in various Polymer Industries and academic Institutions in India and abroad.

The objectives of this program are as follows:

- Students will understand the basics of polymer science, and the synthetic techniques by which polymers can be prepared. They will be expected to conceptualize polymer synthetic schemes, to analyze synthesis problems and to create theoretical solutions to the basic challenges of polymer synthesis.
- Students will be prepared to enter the polymer science senior level program with sufficient knowledge of the physical aspects of polymer science.

- Students will acquire sufficient information to ensure that they have an ample knowledge of polymer science and the typical role of the polymer scientist in today's society.
- Students will have sufficient background to participate in pioneering research on variety of topics such as fuel cells, drug delivery, coatings, and composites, stimuli responsive and engineering materials. Apply the knowledge gained in the classroom on independent research.
- Students will have the expertise to characterize the physical properties of polymers and to accurately and fully report the results of their experiments in written form through knowledge gained in polymer techniques.

Students will demonstrate that they have gained an overall knowledge required to participate at entry-level positions in a variety of polymer related industries.

COURSE STRUCTURE

SEMESTER I

Paper Code	Name of paper	Lecture	Tutorial/ Presentation	Practical	Credit	Marks (T+P)
C-101	Introduction to Polymer Science	4	1	4	6	100+50
C-102	Raw Materials of Polymers	4	1	4	6	100+50
AECC1	English/MIL Communication or EVS	2	1	-	2	50
GE1	Generic Elective	4	1	4	6	100+50

SEMESTER II

Paper Code	Name of paper	Lecture	Tutorial/ Presentation	Practical	Credit	Marks (T+P)
C-201	Polymer Technology	4	1	4	6	100+50
C-202	Unit Operations	4	1	4	6	100+50
AECC2	English/MIL Communication or EVS	2	1	-	2	50
GE2	Generic Elective	4	1	4	6	100+50

SEMESTER III

Paper Code	Name of paper	Lecture	Tutorial/ Presentation	Practical	Credit	Marks (T+P)
C-301	Polymer Rheology	4	1	4	6	100+50
C-302	Polymer Additives	4	1	4	6	100+50
C-303	Polymer Degradation	4	1	4	6	100+50
SEC1	Skill Enhancement Course	2	1	-	2	50
GE3	Generic Elective	4	1	4	6	100+50

SEMESTER IV

Paper Code	Name of paper	Lecture	Tutorial/ Presentation	Practical	Credit	Marks (T+P)
C-401	Polymer Processing & Mold Design	4	1	4	6	100+50
C-402	Polymer Testing	4	1	4	6	100+50
C-403	Recycling and Waste Management	4	1	4	6	100+50
SEC2	Skill Enhancement Course	2	1	-	2	50
GE4	Generic Elective	4	1	4	6	100+50

SEMESTER V

Paper Code	Name of paper	Lecture	Tutorial/ Presentation	Practical	Credit	Marks (T+P)
C-501	Polymer Characterization	4	1	4	6	100+50
C-502	Specialty Polymers	4	1	4	6	100+50
DSE1	Discipline Specific Elective	4	1	4	6	100+50
DSE2	Discipline Specific Elective	4	1	4	6	100+50

SEMESTER VI

Paper Code	Name of paper	Lecture	Tutorial/ Presentation	Practical	Credit	Marks (T+P)
C-601	Polymer Blends and Composites	4	1	4	6	100+50
C-602	Fiber Science and Rubber Technology	4	1	4	6	100+50
DSE3	Discipline Specific Elective	4	1	4	6	100+50
DSE4	Discipline Specific Elective	4	1	4	6	100+50

C: Core Courses; GE: Generic Elective; AECC: Ability Enhancement Compulsory Course; SEC: Skill Enhancement Courses; DSE: Discipline Specific Elective

GE 1-4: Generic Electives (any one paper per semester in semester 1- 4)

GE: Paper 1- Atomic structure, Bonding General Organic Chemistry & Aliphatic Hydrocarbons

GE: Paper 2- Thermodynamics, Equilibria & Functional Group Organic Chemistry

GE: Paper 3- Solutions, Conductance, Electrochemistry and Functional Group Chemistry

GE: Paper 4- Mathematics

GE: Paper 5- Basics of Computer

GE: Paper 6- Material Sciences

GE: Paper 7- Thermal Physics

GE: Paper 8- Organizational Behavior

SEC 1-2: Skill Enhancement Courses (any one per semester in semesters 3-4)

SEC: Paper 1- Biopolymers

SEC: Paper 2- Estimation of Polymers and Polymeric Compounds

SEC: Paper 3- Wire and Cable Technology

SEC: Paper 4- Footwear Technology

DSE 1-4: Discipline Specific Elective (any two per semester in semesters 5-6)

DSE: Paper 1- Conducting Polymer

DSE: Paper 2- Fiber Manufacturing Technology

DSE: Paper 3- Paints, Coatings and adhesive

DSE: Paper 4- Polymeric Nanomaterials

DSE: Paper 5- Tyre Technology

DSE: Paper 6- Packaging Technology

DSE: Paper 7- Fabrication of Polymeric products

DSE: Paper 8- Polymer in Biomedical Applications

*(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

Ist SEMESTER

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C101: Introduction to Polymer Science

Unit 1. (15 L)

Introduction and history of polymeric materials, classification of polymers. Configuration and conformation of polymers. Nature of molecular interaction in polymers, cumulative interaction, entanglement, random chain model and RMS end-to-end distance. Various structures of copolymers such as linear branched and cross-linked copolymers and their types.

Unit 2. (10 L)

Crystal morphologies: extended chain crystals, chain folding, lamellae, and spherulites. Crystallization and crystallinity, determination of melting point and degree of crystallinity.

Unit 3. (10 L)

Properties of polymers (physical, thermal, flow & mechanical properties).

Unit 4. (5 L)

Glass transition temperature (T_g) and measurement of T_g. Factors affecting the glass transition temperature. WLF equation.

Unit 5. (10 L)

Polymer solution – solubility parameter, properties of dilute solutions.

Unit 6. (10 L)

Nature and structure of polymers – structure-property relationships. Molecular weight of polymers (M_n, M_w etc.), molecular weight distribution and determination of molecular weight.

Practicals:

1. Determination of heat deflection temperature, VICAT softening point.
2. Measurement of glass transition temperature (T_g).
3. To determine the melting point of crystalline polymers.
4. To check the solubility of the given polymeric sample in different solvents.
5. Determination of molecular weight by solution viscosity.
6. Determination of molecular weight by end group analysis.

7. Chemical identification of polymers-
    - Unsaturation
    - Testing of functional groups (associated with polymers).

Suggested Readings:

1. Plastics Materials by J. A. Brydson, Butterworth Heinemann (1999).

2. Polymer Science and Technology: Plastics, Rubbers, Blends and Composites by P. Ghosh, Tata McGraw Hill (2010).

3. Polymer Science by V.R. Gowarikar, New Age International Publishers Ltd. (2010).

4. Textbook of Polymer Science by Fred W. Billmeyer, Wiley, India (2007).

5. Polymer Crystallization by Schultz, American Chemical Society (2001).

6. Polymer Chemistry by R. B. Seymour and C. E. Carraher, Marcel Dekker (2000).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C102: Raw Materials of Polymers

Unit 1. (10 L)

Oil, natural gas, coal: Capabilities and limitations. General consideration of petrochemicals, an overview of petroleum refining, desalting, distillation, cracking and its types.

Unit 2. (20 L)

Preparation of important monomers: Formaldehyde, ethylene, vinyl acetate, vinyl chloride, ethylene oxide and ethylene glycol, acrylonitrile, glycerol, toluene di-isocyanate, methyl methacrylate, isoprene, phenol, styrene, terephthalic acid, adipic acid.

Unit 3. (20 L)

Natural rubber from latex: Collection, concentration and stabilization of latex. Latex compounding: Vulcanizing agents, latex compounding acids, wetting, dispersing and emulsifying agents, stabilizers, thickening agents, fillers & other additives.

Unit 4. (10 L)

Manufacture of latex products: Spreading, casting, dipping, latex thread, latex coated coir and latex foam.

Practicals:

1. Fractional distillation of petroleum.
2. To calculate DRC of Latex.
3. To find out the coagulation strength of latex.
3. Prepare balloon by Dipping process of manufacturing.
4. Latex compounding for balloon and other products.
5. Determination of composition of petroleum product.

Suggested Readings:

1. Chemistry and Technology of Petroleum by Speight, CRC Press (2006).
2. Latex Technology by D. Kumar and R. Chandra, Dhanpat Rai & Co. (2001).
3. Modern Petroleum Refining Processes by B.K.B. Rao, Oxford and IBH (2007).
4. Introduction to Petrochemicals by S. Maiti; Oxford & IBH Publ. Co (2002).
5. Text book on Petrochemicals by B.K.B. Rao, Khanna Publishers (2007).
6. Hand book of Rubber Technology by Smith and Martin, CBS Publishers (2007).

IInd SEMESTER

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C201: Polymer Technology

Unit 1. (10 L)

Criteria for polymer synthesis. Classification of polymerization processes. Basic methods of polymerization and their mechanism: Addition, condensation, mass (bulk), suspension, emulsion and solution processes.

Unit 1. (20 L)

Concept of functionality, Carother's equation and its applications in polymerization reactions. Polymer formation by step growth polymerization and chain growth polymerization and their kinetics. Mayo's equation, cage effect, auto-acceleration, inhibition and retardation. Kinetics of copolymerization, Zeigler-Natta catalysts.

Unit 1. (30 L)

Brief introduction to the preparation, structure, properties and applications of the following polymers:

a) Polyolefins (PE,PP)
b) Polystyrene and its copolymers
c) Poly(vinyl chloride) and related polymers
d) Poly(vinyl acetate) and related polymers
e) Acrylic polymers
f) Fluoropolymers
g) Aliphatic polyamides
h) Unsaturated polyester resins
i) Phenol formaldehyde resins
j) Polymers from amines
k) Polyurethanes
l) Silicones
m) Epoxides

Practicals:

1. Suspension polymerization of Styrene/MMA.
2. Preparation and testing of UF/PF/MF resins.
3. Preparation and testing of Diglycidyl ether of bis phenol-A (DGEBA).
4. Bulk and solution polymerization of Methyl Methacrylate/Styrene.
5. Emulsion polymerization of Styrene/ Methyl Methacrylate.
6. Copolymerization of styrene & MMA and determination of reactivity ratios.
7. Preparation of Poly(vinyl butyral).

Suggested Readings:

1. Principles of Polymerization by G. Odian, Wiley – Interscience (2004).

2. Plastics Materials by J. A. Brydson, Butterworth-Heinemann (1999).

3. Principles of Polymer Chemistry by P. J. Flory, Asian Books Private Limited (2006).

4. A Text book of Polymer Science by F.W. Billmeyer, John-Wiley and Sons (2011).

5. Polymer Chemistry by R. B. Seymour and C.E. Carraher, Marcel Dekker (2003).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C202: Unit Operations

Unit 1. (5 L)

Industrial stoichiometry – material balance of physical and chemical processes, energy balance. Energy transport in non isothermal systems.

Unit 2. (15 L)

Velocity distribution in flow system, interface transport, microscopic and macroscopic balances. Flow of fluids in pipes –Bernoulli's equation and calculations for pipe size and pressure drop, flow measuring instruments, various types of pumps.

Unit 3. (10 L)

Mechanical operations –size reduction and its equipment, filtration and types of filters.

Unit 4. (15L)

Heat transfer – conduction, convection, radiation, heat exchangers.

Unit 5. (15 L)

Mass transfer – diffusion and its mechanism, gas absorption, various types of distillation, drying.

Practicals:

1. Handling of jaw crusher, ball mill for crushing and grinding.
2. Distillation of various mixtures.
3. Diffusion experiments.
4. Filtration of solids from slurry.
5. Calculation of pressure drop and pipe size.

Suggested Readings:

1. Unit Operations in Chemical Engg. by Mccabe, Smith and Harriott, McGraw- Hill Professional (2004).
2. Unit Operations in Chemical Engg. (Vol 1&2) by P. Chattopadhaya, Khanna Publishers (2003).
3. Chemical Engg. (Vol. 1 to 6) by Coulsan and Richardson, Elsevier (2010).
4. Heat and Mass Transfer by D. S. Kumar, S K Kataria & Sons Delhi (2009).
5. Solved Example in Chemical Engg. by G. K. Rao, Khanna Publishers (2002).
6. Mass Transfer Operations by R. Treybal, Tata McGraw Hill (2012).

IIIrd SEMESTER

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C301: Polymer Rheology

Unit 1. (10 L)

Viscosity and polymer processing, other rheological properties of fluids, shear stresses in polymer systems, non-Newtonian flow, practical melt viscosities, flow in channels, simple shear flow, melt-flow index.

Unit 2. (15 L)

Types of fluids and rheological models, techniques for rheological measurements by capillary, parallel plate and cone & plate viscometers. Simple elongational flow and its significance. Dynamic flow behavior, time dependent fluid responses.

Unit 3. (15 L)

The elastic and viscoelastic state of polymers – viscoelasticity - relationships of various approaches taken in describing the viscous and elastic properties, Maxwell model and Voigt model, Boltzmann superposition principles, dynamic mechanical testing.

Unit 4. (10 L)

Mixing: Types of mixing, concept and importance of master batches. Mixing of additives with the polymers, melt compounding and calendaring.

Unit 5. (10 L)

Types of mixers: High speed mixer, two roll mill, internal batch mixers (Banbury, Haake), single screw & twin screw extruders, flow mechanism, analysis of flow (drag, pressure and leak flow).

Practicals:

1. Determination of melt flow index.
2. Determination of intrinsic viscosity by Ubbelohde viscometer.
3. Determination of rheological properties of polymer melt by rheometers.
4. Measurement of resin/paint viscosity by Ford cup 4.
5. Measurement of viscosity by Brookfield Viscometer.
6. Compounding of polymers in the internal mixer and measurement of torque.

Suggested Readings:

1. Introduction to Polymer Viscoelasticity by J. Aklonis and W. J. Macknight, John Wiley & Sons (2005).

2. Polymer Science and Technology of Plastic and Rubber by P. Ghosh, Tata McGraw Hill (2010).

3. Fundamental Principles of Polymeric Materials by S.L. Rosen, Wiley-Interscience (2012).

5. Melt Rheology and Its Role in Plastic Processing by J. M. Dealy and K.F. Wissbrum, Springer (1999).

6. Applied Rheology in Polymer Processing by B. R. Gupta, Asian Books (2004).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C302: Polymer Additives

Unit 1. (5 L)

Importance of additives and their selection criteria for commercial polymers.

Unit 2. (20 L)

Additives for plastics and their mechanism of function:

a. Stabilizers
b. Fillers
c. Plasticizers
d. Lubricants
e. Flame retardants
f. Foaming agents
g. Cross linking agents
h. Metal deactivators

Unit 3. (20 L)

Additives for rubbers and their mechanism of function:

a. Vulcanizing agents and retardants
b. Accelerators
c. Activators
d. Fillers
e. Softeners
i. Colors and pigments
f. Tackifying agents
g. Blowing agents
h. Surface property modifiers

Unit 4. (15 L)

Illustration of few formulations and their compounding procedures.

Practicals:

1. Determination of gravity of fillers.
2. Determination of bulk density of fillers.
3. Determination of pore size and net size of fillers.
4. Determination of heat stability of heat stabilizers.
5. Measurement of flash point of plasticizer.
6. Identification of additives.

Suggested Readings:

1. Polymer Modifiers and Additives, by Lutz, Marcel Dekker (2001).

2. Chemistry and Technology of Polymer Additives, by Al- Malaika, Elsevier Applied Science (1999).

3. Plastic Materials, by J. Brydson, Butterworth-Heinemann (1999).

4. Handbook of Rubber Technology, by Martin and Smith, CBS Publisher (2007).

5. Polymer Science and Technology: Plastic, Rubber Blends and Composites, by P. Ghosh, Tata McGraw Hill (2010).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C303: Polymer Degradation

Unit 1. (25 L)

Introduction to degradation. Various types of polymer degradation:

(i) Thermal degradation
(ii) Oxidative degradation
(iii) Degradation by radiation
(iv) Mechanical degradation
(v) Chemical degradation
(vi) Biological degradation

Unit 2. (25 L)

Degradation of specific polymers.

(i) Polyolefins (PE and PP)
(ii) PVC
(iii) Natural Rubber
(iv) Polyamides
(v) PMMA
(vi) Cellulose
(vii) SBR
(viii) Polyacrylonitrile (PAN)
(ix) Polystyrene (PS)
(x) PET
(xi) PU

Unit 3. (10 L)

Degradation studies using DSC, TGA, DTA and DMA.

Practicals:

1. Biodegradation of polymers.
2. Mechanical degradation of polymers and its effect on properties.
3. To calculate the rate of Thermal ageing of polymer under various conditions.
4. Thermal analysis by DSC, DTA and TGA.

5. Photo-degradation of PVC.
6. Environmental stress cracking resistance of polymers.

Suggested Readings:

1. Encyclopedia of Polymer Science and Technology by W. J. Pesce and P. B.Wiley (2007).
2. Thermal Characterization of Polymeric Materials, E. A. Turi, Academic Press (1997).
3. Handbook of Polymer Degradation by S. H. Hamid and M. B. Amin, Marcel Dekker (1992).
4. Thermal analysis of plastics by G. W. Ehrenstein, G. Riedel and P. Trawiel, Hanser (2004).

IVth SEMESTER

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C401: Polymer Processing and Mold Design

Unit-1 (10 L)

Extruder and die design: Extrusion process, the extrusion die, extruder and die characteristics. Classification of extrusion dies, die swell.

Unit 2. (10 L)

Injection moulding: Principles, the moulding cycle, the injection moulding machine, some aspects of product quality, reaction injection moulding (RIM).

Unit 3. (5 L)

Blow moulding: Blow moulding principles, extrusion blow moulding, injection blow moulding, stretch blow moulding, blow moulding of PET.

Unit 4. (5 L)

Compression and transfer moulding: Introduction, thermosetting compounds, compressing moulding process, transfer moulding.

Unit 5. (5 L)

Thermoforming: Principles, types and applications. Miscellaneous processing methods – casting and rotational moulding.

Unit 6. (7 L)

Mould Making – introduction, casting, electrodeposition, cold hobbing, pressure casting, spark machining, bench fitting. Feed system: Runner and gates.

Unit 7. (8 L)

Ejection: Ejector grid, ejector plate assembly, ejection techniques, ejection from fixed half and sprue pullers.

Unit 8. (10 L)

Moulding internal undercuts: Form pin, split cores, side cores, stripping internal undercuts, moulds for threaded components. Daylight moulds – general, underfeed moulds, triple daylight mould.

Practicals:

1. Compounding of PVC and rubbers in two roll-mills with fillers and reinforcing agents.
2. Preparation of Polymeric sheets by Compression moulding.
3. Preparation of testing specimens by Injection moulding.
4. To find out output of various polymeric materials by single screw and twin screw extruders.
5. Solution casting of polymeric membranes.
6. Measurement of the rheological properties of rubber compounds by Oscillating Disc Rheometer (ODR).
7. Tool room visits.

Suggested Readings:

1. Injection mould design, by R.G.W. Pye, Affiliated East West Press Pvt. Ltd (2000).
2. Plastics: Materials & Processing by A. B. Strong, Prentice Hall (2005).
3. Injection Moulding Handbook, by Dominick V. Rosato and D. V. Rosato, CBS Publisher (2000)
4. Polymer Processing by Morton and Jones, Chapman & Hall (2007).
5. Plastic Engg. by R. J. Crawford, Butterworth-Heinemann (1998).
7. Plastic Processing Data Handbook by D. V. Rosato, Springer (2001).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C402: Polymer Testing

Unit 1. (10 L)

Principles and methods of standardization, statistical method of analysis. Standards: BIS standards – BIS standards of few polymers. ASTM standards – ASTM standards of few polymers. Evaluation of errors in polymer testing.

Unit 2. (15 L)

Mechanical properties: Thermal and mechanical analysis of polymers

(a) Short term strengths: Tensile, Flexural, Impact, Tear resistance, Abrasion etc.
(b) Long term strengths: Creep and fatigue properties.
(c) Thermal properties: Thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, heat distortion temperature, vicat softening point, low temperature flexibility etc.

Unit 3. (10 L)

Flow properties: Melt flow index, cup flow test, solution and inherent viscosity, melt viscosity etc.

Unit 4. (5 L)

Flammability properties: Oxygen index, critical temperature index, smoke density, flammability tests etc.

Unit 5. (5 L)

Optical properties: Gloss, haze, refractive index, degree of yellowness etc.

Unit 6. (15 L)

Permeability: Definition, permeability to gases, standard methods of measuring, permeability of gases, other methods of measuring permeability. Environment resistance – cause of deterioration of polymer by weathering, assessment of deterioration, natural weathering, artificial weathering. Chemical resistance.

Practicals:

1. Determine the melt flow index of LLDPE, PP etc.
2. Evaluate limiting oxygen index (LOI) of Poly(vinyl chloride) and Nylon- 6.
3. Determination the Heat Distortion Temperature and Vicat softening temperature of polymer film.
4. Measurement of abrasion resistance of polymer sheets.
5. Determination the coefficient of friction and izod Impact strength of PVC and PP samples.
6. Determination of environment stress cracking resistance of PE/PP films.
7. Determination of Shore Hardness of plastics.

Suggested Readings:

1. Handbook of Plastic Testing & Technology by V. Shah, Wiley-Interscience (2007).
2. Rubber Technology Handbook by Martin and Smith, Smithers Rapra Technology (2009).
3. SPI Plastic Engineering Handbook by M.L. Berins. Springer-Verlag (1991).
4. An Introduction to the Mechanical Properties of Solid Polymers by I. M. Ward and J. Sweeney, Wiley (2004).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C403: Recycling and Waste Management

Unit 1. (10 L)

Definition of plastic wastes and litter, basis for assessing plastic wastes, applications of plastics and their potential as sources of waste. Separation techniques (density - float sink and froth floatation methods, optical, spectroscopic, sorting by melting temperature etc.).

Unit 2. (10 L)

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle (mechanical and chemical), recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples.

Unit 3. (15 L)

Disposal processes and Various waste treatment methods – controlled tipping, pulverization, compositing, Energy from waste –(incinerators- pyrolysis, factors affecting incineration), new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling.

Unit 4. (15 L)

Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides (Nylon-6 and Nylon-6,6).

Unit 5. (10 L)

Recycling of Thermosets –reclaiming of rubber –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber.

Practicals:

1. Primary recycling of various waste collected from environment.
2. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
3. To study Composting of natural polymers
4. Preparation of plasticizer from polyester waste.
5. Preparation of curing hardness for epoxy from polyester waste.
6. Preparation of reclaim from tyre waste.

Suggested Readings:

1. Rubber and Plastic Waste: Recycling, Reuse and Future Demand by R. Chandra and A. Adab, CBS Publisher (2004).

2. Medical, Municipal and Plastic Waste Management Handbook by NIIR Board of Consultant and Engineers, National Institute of Industrial Research (2007).

3. Polymer Recycling by J. Scheirs, John Wiley & Sons (1998).

4. Handbook of Rubber Technology by S. Blow, Hanser Gardner (2000).

5. Recycling and Recovery of Plastics by J. E. Bandrup, Hanser Gardner (1996).

6. Introduction to plastics recycling by V. Goodship, Rapra (2007).

Vth SEMESTER

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C501: Polymer Characterization

Unit 1. (15 L)

Basic principles of spectroscopy, molecular and atomic spectra, Lambert-Bear law, Frank-condon principal, electromagnetic radiation, properties of electromagnetic radiation, interaction of radiation with matter: A classical picture, uncertainty and the question of time scale.

Unit 2. (15 L)

Applications of spectroscopy: IR, UV, ESR, Raman, NMR and mass spectroscopy of polymers.

Unit 3. (10 L)

Chromatography: Thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography.

Unit 4. (10 L)

Applications of optical microscope, SEM, TEM and XRD in polymers.

Unit 5. (10 L)

Thermal analysis of polymers using DSC-DTA, TGA, DMA, MDSC etc

Practicals:

1. To Verify Lambert-Beers law by UV-Vis. spectrophotometer.
2. Calculate % amount of Inorganic and organic ingredient in polymeric compound.
3. Analyze the thermal behavior of polymers.
4. To Calculate Percentage Crystallinity of Polymeric Sample by XRD.
5. Identification of polymer components by Chromatography.
6. FTIR and Raman analysis of polymers.

Suggested Readings:

1. Instrumental method of analysis, by Willard et,al., Wadsworth Publishing Company (1988).
2. Principle of Instrumental Analysis, by Skoog et.al., Harcourt College Pub (1997).

3. Handbook of Plastic Testing, Technology, by V. Shah, Wiley-Interscience (2007).
4. Experimental Methods in Polymer Sciences, by T.Tanaka, Academic Press (1999).
5. Spectrometric identification of organic compounds. Silverstein, Robert M. John Wiley (1991).
6. A complete introduction to NMR spectroscopy by Roger S .Macomber, Wiley-Interscience (2008).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C502: Speciality Polymers

Unit 1. (30 L)

Preparation, properties and applications of the following polymers

i. Polyether ether ketone resins (PEEK)
ii. Polyamideimide resins (PAI)
iii. Sulphur based polymers (Polysulphone and polyphenylene sulfide)
iv. Polyamide resins
v. Polyetherimide resins (PEI)
vi. Polyester resins
vii. Polycarbonate (PC)
viii. Acetal resins
ix. Polyphenylene oxide (PPO)

Unit 2. (10 L)

Conducting polymers: Synthesis, properties and application of polyaniline, polypyrole and polythiophene.

Unit 3. (10 L)

Biopolymers (Polylactic acid, polycaprolactone, starch, etc.)

Unit 4. (10 L)

Inorganic Polymers (Silicon and Nitrogen containing polymers)

Practicals:

1. To find out conductivity of polymeric sample.
2. To find out Bio-degradability and bio compatibility of polymeric compound.
3. Synthesis of conducting polymers.
4. Preparation of Nylon 6, 10 by interfacial polymerization.
5. Phenol formaldehyde (Resol/Novolac).
6. Urea-formaldehyde preparation.

Suggested Readings:

1. Plastic Materials by J. A. Brydson, Butterworth-heinemann (1999).
2. Engg. Plastics by R. W. Dyson, Blackie, Chapman and Hall, 1990
3. Engg Materials Handbook (Vol. 1 to 3) by ASTM Internaional, USA.
4. Handbook of Biodegradable Polymer by A. J. Domb. Gordon and Breach Science Publishers (1997)
5. High Performance Polymers, their origin and development, by Seymour R. B. and Kirshenbaum G. S, Elsevier (1986).

VIth SEMESTER

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C601: Polymer Blends and Composites

Polymer blends

Unit 1. (15 L)

Methods of blending, the incompatibility problem, methods of compatibilization. Properties of blends (mechanical, morphological, rheology and thermal), comparison between polymer blends, copolymers, grafted copolymers and IPNs

Unit 2. (10 L)

Different types of polymer blends (TPE, elastomeric blends and plastic blends).Characterization of blends by various techniques.

Polymer composites

Unit 3. (5 L)

Introduction and classification of composites, selection criteria for polymer matrices for composites.

Unit 4. (15 L)

Fabrication techniques: Prepreg technology, injection and compression moulding, vacuum bag moulding, hand-lay up process, spray-up technique, filament winding process, fiber placement process, pultrusion, reaction transfer molding, laminating techniques, expansion processes, radiation processes, coating processes, fabrication processes: adhesion, cohesion and mechanical processes & FRPs.

Unit 5. (15 L)

Design of composite products: Basic design practice – material considerations, product considerations and design considerations.

Practicals:

1. To prepare polymer blends by melt, solution and latex blending.
2. To find out Compatibility of blends by loop compatibility tester.
3. Preparation of laminates.
4. Preparation of composites with various fillers and various filler loading.
5. Mechanical properties of blends and composites.

Suggested Readings:

1. Polymer Blends Volume 1 & 2, by D. R. Paul and C. B. Bucknall, Wiley-Interscience (2000).
2. Polymer Blends by Lloyd M. Robeson, Hanser Gardner Pubns (2007).
3. Polymer Blends Volume 1 & 2, by D. R. Paul and Seymour Newman, Academic Press (1978).
4. Polymer Blends Handbook Vol 1 & 2 by L. A. Utracki, Kluwer Academic Pub (2003).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

Paper C602: Fiber Science and Rubber Technology

Unit 1. (10 L)

Introduction – classification and terminology of fibres, salient features of fibre forming polymers and their properties. Basic structure of a fibre. General properties of a fibre such as moisture absorption, tex, denier, tenacity, elongation at break and elastic recovery.

Unit 2. (10 L)

Naturally occurring fibres – Vegetable fibres, animal fibres, mineral fibres.

Unit 3. (10 L)

Man made and synthetic fibres –properties and uses of viscous rayon, cellulose acetate, nylon – 66, polyester, acrylic, carbon fibre and aramid fibres.

Unit 4. (15 L)

Physical properties of raw rubber and mastication. Theories and phenomena of vulcanization, rheocurve of compounded rubber, mechanism of sulphur vulcanization with and without accelerators, theories of non sulphur vulcanization, properties of vulcanized rubber.

Unit 5. (15 L)

Natural rubber and synthetic rubber, styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber.

Practicals:

1. Determination of tensile strength, modulus, elongation at break, tear strength, abrasion resistance, heat build-up resilience, hardness, flex resistance for rubber compounds.
2. Determination of curing time on physical properties of NR compound.
3. Identification of fibres through solubility tests.
4. Identification of fibres by chemical methods
5. Analysis of reaction of fibres towards heat & flame.
6. To determine viscosity using Mooney viscometer.

7. Qualitative analysis of Cellulose –Polyester blends.

8. Distinguish POY & FDY polyester filament yarn based on extensibility & shrinkage behavior.

10. Determination of Twist, elongation, TEX, Tenacity, Denier, and count of yarn, fiber & filament.

Suggested Readings:

1. Hand Book of Rubber Technology by Smith and Martin, CBS Publisher, (2007).
2. The Science and Technology of Rubber by J. E. Mark, B. Erman and F.R. Eirich, Elsevier Academic Press (2005).
3. Hand Book of Textile Fibers, by J. G. Cook, WoodheadPublishing Volume 1 (1984) and & Volume 2 (2009).
4. Hand Book of Rubber Technology by S. Blow, Hanser Gardner (2000).
5. Understanding Textiles by Collier and Tortora, Prentice Hall (2009).
6. Physical Properties of Fibers by Morton & Hearle, CRC Press (2008).

GE 1- 4: Generic Electives

(Any one paper per semester in semesters 1- 4)

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper-1: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons

Section A: Inorganic Chemistry-1

Unit 1. (15 L)

Atomic Structure: Recapitulation of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation ($H\Psi = E\Psi$) and meaning of various terms in it. Significance of Ψ and $\Psi 2$, Schrodinger equation for hydrogen atom in Cartesian coordinates (x,y,z). Need of polar coordinates, transformation of Cartesian coordinates (x,y,z) into polar coordinates (r,θ,φ). Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals. (Only graphical representation), Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distances with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers mr and ms. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit 2. (15 L)

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Lande equation for

calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: *VB Approach*: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. *MO Approach* : Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combination of atomic orbitals, non- bonding combination of orbitals ,MO treatment of homonuclear diatomic molecules of 1^{st} and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^{+}. Comparison of VB and MO approaches.

Section B: Organic Chemistry-1

Unit 3. (8 L)

Fundamentals of Organic Chemistry

Physical effects, electronic displacements: Inductive effect, electromeric effect, resonance and hyperconjugation. Cleavage of bonds: Homolysis and heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles.

Reactive intermediates: Carbocations, carbanions free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Huckel's rule.

Unit 4. (7 L)

Stereochemistry

Conformations w.r.t. ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds) . Threo and erythro; D and L; *cis* - *trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

Unit 4. (15 L)

Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Alkanes: (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent.

Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cisaddition (alkaline. KMnO4) and trans-addition (bromine). Addition of HX (Markownikoff's and anti-Markownikoff's addition). Hydration, Ozonolysis, oxymecuration-demercuration, hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) *Preparation:* Acetylene from $CaCO_3$ and conversion into higher alkynes; by dehalogenation of tetra halides, dehydrohalogenation of vicinaldihalides.

Reactions: Formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

Practicals:

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry

1. Detection of extra elements (N,S,Cl,Br,I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)
   (a) Identify and separate the components of a given mixture of two amino acids

(glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

Suggested Readings:

1. A new Concise Inorganic Chemistry by J. D. Lee, E L. B. S (1991).
2. Basic Inorganic Chemistry by F. A. Cotton & G. Wilkinson, John Wiley (1976).
3. Concepts and Models in Inorganic Chemistry by Douglas, McDaniel and Alexader, John Wiley (1984).
4. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Ellen Keiter and Richard Keiter, Pearson Publication (1975).
5. Organic Chemistry by T. W. Graham Solomon, John Wiley and Sons (2009).
6. Organic Chemistry by R. T. Morrison & R. N. Boyd, Prentice Hall (1992).
7. Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
8. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
9. Textbook of Practical Organic Chemistry, A.I. Vogel, Prentice Hall, 5th edition.
10. Practical Organic Chemistry, Mann F. G. & Saunders B. C, Orient Longman, (1960).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper 2

Thermodynamics, Equilibria & Functional Group Organic Chemistry

Section A: Physical Chemistry-1

Unit 1. (15 L)

Chemical Thermodynamics

What is thermodynamics? State of a system, state variables, intensive and extensive variables, concept of heat and work, thermodynamic equilibrium, thermodynamic properties, various types of systems and processes. First Law of thermodynamics. Calculation of work (*w*), heat (*q*), changes in internal energy (ΔU) and enthalpy (Δ*H*) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of *w*, *q*, ΔU and Δ*H* for processes involving changes in physical states.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Various statements of Second Law of thermodynamics, concept of entropy, Gibbs free energy and Helmholtz energy, Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity. Gibbs – Helmholtz equation. Maxwell's relations. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 2. (5 L)

Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between Δ*G* and Δ*G*ɵ, Le Chatelier's principle. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.

Unit 3. (10 L)

Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Section B: Organic Chemistry-2

Unit 4. (7 L)

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions : (Case benzene) : Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation). (Upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (Upto 4 carbons on benzene).

Unit 5. (8 L)

Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN2, SN1 and SNi) reactions. *Preparation:* from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & iso-nitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit 6. (8 L)

Alcohols, Phenols and Ethers (Upto 5 Carbons)

Alcohols: *Preparation:* Preparation of 1, 3-alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acid. dichromate, con. HNO_3). Oppeneauer oxidation.

Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer - Tiemann Reaction, Gattermann-Koch Reaction, Houben – Hoesch Condensation, Schotten – Baumann Reaction

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Unit 7. (7 L)

Aldehydes and Ketones (aliphatic and aromatic):

(Formaldehye, acetaldehyde, acetone and benzaldehyde) *Preparation:* From acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff-Kishner reduction. Meerwein-Pondorff verley reduction.

Practicals:

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH.

Section B: Organic Chemistry

1) Purification of organic compounds by crystallization (from water and alcohol) and distillation.

2) Criteria of purity: Determination of melting and boiling points.

Suggested Readings:

1. A new Concise Inorganic Chemistry by J. D. Lee, E L. B. S (1991).
2. Basic Inorganic Chemistry by F. A. Cotton & G. Wilkinson, John Wiley (1976).
3. Concepts and Models in Inorganic Chemistry by Douglas, McDaniel and Alexader, John Wiley (1984).
4. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Ellen Keiter and Richard Keiter, Pearson Publication (1975).
5. Organic Chemistry by T. W. Graham Solomon, John Wiley and Sons (2009).
6. Organic Chemistry by R. T. Morrison & R. N. Boyd, Prentice Hall (1992).
7. Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall, 7^{th} Edition.
8. Vogel's Quantitative Chemical Analysis, A. I. Vogel, Prentice Hall, 6^{th} Edition.
9. Textbook of Practical Organic Chemistry, A. I. Vogel, Prentice Hall, 5^{th} edition.
10. Practical Organic Chemistry, Mann F. G. & Saunders B. C, Orient Longman, 1960.
11. Organic Chemistry by I. L. Finar: (Vol. I & II), E. L. B. S (1963).
12. Physical Chemistry by Barrow, G. M. Tata McGraw-Hill (2007).
13. General Chemistry by Kotz, J. C., Treichel, P. M. & Townsend, J. R., Cengage Lening India Pvt. Ltd.: New Delhi (2009).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper 3

Solutions, Conductance, Electrochemistry and Functional Group Chemistry

Section A: Physical Chemistry-2

Unit 1. (8 L)

Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law-non-ideal solutions. Vapor pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids. Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Unit 2. (7 L)

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs phase rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

Unit 3. (7 L)

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit 4. (8 L)

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Section B: Organic Chemistry-3

Unit 5. (10 L)

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of Esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) *Preparation:* Acid chlorides, Anhydrides, Esters and Amides from acids and their inter-conversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Unit 6. (5 L)

Active methylene compounds:

Preparation : Claisen ester condensation. Keto-enol tautomerism *Reactions:* Synthetic uses of ethyl acetoacetate (preparation of non-hetero molecules having up to 6 carbon).

Unit 7. (7 L)

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons)

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. *Reactions:* Hofmann Vs Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: *Preparation:* from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

Unit 8. (8 L)

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Practicals:

Section A: Physical Chemistry

1. pH measurements

a) Measurement of pH of different solutions, like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

2. Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

Section B: Organic Chemistry

Preparations: Mechanism of various reactions involved to be discussed.

Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Nitration of Nitrobenzene

(b) Preparation of carboxylic acid by alkaline hydrolysis of ester/amide.

(c) Oxidation of alcohol/aldehydes/hydrocarbons to carboxylic acid

(d) Osazone from glucose/fructose

(e) Amides and anilides from carboxylic acid.

(f) Preparation of methyl orange.

Suggested Readings:

1. Physical Chemistry by Barrow, G. M. Tata McGraw-Hill (2007).
2. Physical Chemistry 4th Ed. by Castellan, G. W. Narosa (2004).
3. General Chemistry by Petrucci, R. H. Macmillan Publishing Co. New York (1985).
4. Advanced organic Chemistry by Jerry March, John Wiley & Sons, (1968)
5. Practical Organic Chemistry, Mann F. G. & Saunders B. C, Orient Longman, (1960).
6. Senior Practical Physical Chemistry, B. D. Khosla, R. Chand & Co. (1985).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper 4

Differential Equations and Mathematical Modeling

Unit 1. (8 L)

First order ordinary differential equations: Basic concepts and ideas, Modeling: Exponential growth and decay, Direction field, Separable equations, Modeling: Radiocarbon dating, Mixing problem.

Unit 2. (5 L)

Modeling: Newton's law of cooling, Exact differential equations, Integrating factors, Bernoulli equations, Modeling: Hormone level in blood, Logistic equation.

Unit 3. (7 L)

Orthogonal trajectories of curves, Existence and uniqueness of solutions, Second order differential equations: Homogenous linear equations of second order.

Second order homogenous equations with constant coefficients, Differential operator, Euler-Cauchy equation.

Unit 4. (5 L)

Existence and uniqueness theory: Wronskian, Nonhomogenous ordinary differential equations, Solution by undetermined coefficients.

Unit 5. (5 L)

Solution by variation of parameters, Higher order homogenous equations with constant coefficients, System of differential equations, Modeling: Mixing problem involving two tanks.

Unit 6. (8 L)

System of differential equations: Conversion of *n*th order ODEs to a system, Basic concepts and ideas, Homogenous system with constant coefficients, Phase plane, Critical points.

Unit 6. (7 L)

Criteria for critical Points and stability, Qualitative methods for nonlinear systems: Linearization of nonlinear systems, Lotka−Volterra population model

Power series method: Theory of power series methods, Legendre's equation, Legendre polynomial.

Unit 6. (5 L)

Partial differential equations: Basic Concepts and definitions, Mathematical problems, First order equations: Classification, Construction, Geometrical interpretation, Method of characteristics.

Unit 6. (10 L)

General solutions of first order partial differential equations, canonical forms and method of separation of variables for first order partial differential equations

Classification of second order partial differential equations, Reduction to canonical forms, second order partial differential equations with constant coefficients, General solutions.

Practicals:

1. To determine whether a given number is prime or composite.
2. To find the sum of digits of a number and decide its divisibility.
3. To compute the roots of a quadratic equation.
4. To Linear Sort a given set of numbers.
5. To compute higher degree polynomials using Horner's method.
6. To plot the direction field of first order differential equation.
7. To find the solution and plot the growth and decay model (both exponential and logistic).
8. To find the solution and plot the Lotka−Volterra model.
9. To find the solution of Cauchy problem for first order partial differential equations.
10. To plot the integral surfaces of a given first order partial differential equations with initial data.

Note: Programming is to be done in any one of Computer Algebra Systems: MATLAB/MATHEMATICA/MAPLE.

Suggested Readings:

[1] Advanced Engineering Mathematics by Erwin Kreyszig, John Wiley & Sons, Inc., (2006).

[2] Linear Partial Differential Equations for Scientists and Engineers by TynMyint–U and Lokenath Debnath, Springer, Indian Reprint (2009).

[3] A Course in Ordinary Differential Equations by Randall J. Swift and Stephen A. Wirkus, , Chapman & Hall /CRC, (2007)

[4] Partial Differential Equations, An Introduction with Mathematica and Maple by Ioannis P. Stavroulakis and Stepan A. Tersian, World Scientific, (2004).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper 5: Basics of Computer

Unit 1. (15 L)

Computer Fundamentals: Introduction to Computers - Characteristics of Computers, Uses of computers, Types and generations of Computers.

Basic Computer Organization - Units of a computer, CPU, ALU, memory hierarchy, registers, I/O devices User Interface with the Operating System, System Tools. Programming Types.

Unit 2. (15 L)

Introduction to programming in C/C^{++}: Fundamental data types- integer, floating point and enumerated data types, Expressions: arithmetic, relational and logic operators, access to standard library, standard I/O-getchar, putchar, Formatted I/O, scanf, printf, error handling, line input and output.

Unit 3. (10 L)

Statements: simple and compound statement, control structures, variable, loop and conditional statement, BREAK, COINTINUE, DO WHILE, FOR, GO TO, IF, RETURN, SWITCH, WHILE statements.

Unit 4. (10 L)

Functions in C/C++ programming: Function structure, Declarations and liberary built in functions, parameter mechanism, storage classes-scope, function arguments, visibility, string function and life time of variables, AUTO, EXTERN, STATIC and REGISTER modifiers, Recursion.

Unit 5. (10 L)

Data structure-Arrays and Pointers:

Arrays: Types and size of arrays, sorting, selection sort, search-linear search and binary search, Structures and union.

Pointers: Pointers types and addresses of variables, arrays of pointer, function returning pointers, pointers to function, pointer arithmetic, pointers to structures, array of structures, preprocessor directive, command line arguments, pointer structure.

Practicals:

1. Study of commands use in C/C++. Broad introduction.
2 Programming using Control structures & pointers.
3. Searching & sorting.
4. Creation and use of databases.
5. Writing exercises of programming in C.

Suggested Readings:

1. Computer Fundamentals & Programming in C by Pradip Dey &Manas Ghosh, Oxford, (2013).
2. Computer Fundamentals by Dr. Varghese Paul (EPD), (2007).
3. Programming in C by B.S. Gotfried (Schaum series, TMH) (1996).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper 6: Materials Science

Unit 1. (15 L)

Structure: Crystalline structure of materials, unit cells and space lattices, x-ray diffraction of crystal structures, miller indices of planes and directions, packing geometry in metallic, covalent and ionic solids. Concept of amorphous, single and polycrystalline materials. Crystal growth techniques. Imperfections in crystalline solids.

Unit 2. (15 L)

Solid solutions, solubility limit, phase rule, phase diagrams, intermediate phases, intermetallic compounds, **Ceramics:** Structure, properties, processing and applications of traditional and advanced ceramics.

Unit 3. (20 L)

Advanced Materials and Tools: Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nanomaterials – synthesis, properties and applications, biomaterials, superalloys, shape memory alloys.

Unit 4. (10 L)

Magnetic Properties: Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, ferromagnetism, antiferro magnetism, magnetic hysterisis.

Practicals

1. To check hardness of Metal, Ceramics, composites by Rockwell hardness tester.
2. To determine % composition of metals, fillers etc.
3. To determine magnetic properties of materials.
4. To determine mechanical properties of materials.

1. Preparation of advanced material for biological applications.
2. To prepare safety glass.

Suggested Readings:

1. Materials Science And engineering Handbook, Third Edition by James F. Shackelford, CRC Press, New York, (2010).
2. Fundamentals of Materials Science: The Microstructure–Property Relationship Using Metals as Model Systems by Mittemeijer, Eric J, Springer, (2011).
3. Materials Science and Engineering an Introduction, by William D. Callister, Jr. and David G. Rethwisch, (1940).
4. Material Science by S. L. Kakani and Amit Kakani New Age International, (2006).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper 7: Thermal Physics

Unit 1. (22 L)

Laws of Thermodynamics:

Thermodynamic description of system: Zeroth law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, various thermodynamical processes, Applications of first law: General relation between CP & CV, work done during isothermal and adiabatic processes, compressibility & expansion coefficient, reversible & irreversible processes, second law & entropy, carnot's cycle & theorem, entropy changes in reversible & irreversible processes, entropy-temperature diagrams, third law of thermodynamics, unattainability of absolute zero.

Unit 2. (15 L)

Thermodynamcial potentials: Enthalpy, gibbs, Helmholtz and internal energy functions, Maxwell's relations & applications - Joule-Thompson effect, Clausius-clapeyron equation, expression for (CP –CV), CP/CV, TdS equations.

Unit 3. (15 L)

Kinetic theory of gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, mean free path (Zeroth Order), Transport phenomena: viscosity, conduction and diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

Unit 4. (8 L)

Theory of radiation: Blackbody radiation, spectral distribution, concept of energy density, derivation of Planck's law, deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann law and Wien's displacement law from Planck's law.

Practical:

1. To determine Stefan's Constant.
2. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.

3. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.

4. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.

5. To study the variation of thermo emf across two junctions of a thermocouple with temperature.

6. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system

7. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Suggested Readings:

1. Study of commands use in C/C^{++}. Broad introduction.
2 Programming using Control structures & pointers.
3. Searching & sorting
4. Creation and use of databases
5. Writing exercises of programming in C**:**

(i) Thermal Physics by S. Garg, R. Bansal and C. Ghosh, Tata McGraw-Hill, (1993).

(ii) A Treatise on Heat by Meghnad Saha, and B. N. Srivastava, Indian Press, (1969).

(iii) Thermodynamics by Enrico Fermi, Courier Dover Publications, (1956).

(iv) Thermodynamics, Kinetic theory & Statistical thermodynamics by F. W. Sears & G. L. Salinger. (1988).

(v) University Physics by Ronald Lane Reese, Thomson Brooks/Cole, (2003).

(vi) Advanced Practical Physics for students by B. L. Flint & H. T. Worsnop, Asia Publishing House, (1971).

(vii) Practical Physics, C.L Arora, , S. Chand and Co. (2001).

(viii) B.Sc. Practical Physics by Geeta Sanon, , R. Chand and Co. (2009)

(ix) A Text Book of Practical Physics by Indu Prakash and Ramakrishna, 11th Edition, Kitab Mahal, New Delhi, (2011).

(x) A Laboratory Manual of Physics for Undergraduate Classes by D. P. Khandelwal, Vani Publication, (1985).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation/Week) (Total Credits -6)

GE: Paper 8: Foundations of Organizational

Unit 1. (10 L)

Introduction to Organizational Behavior: Defining organizational behavior; Organizational structure; Organizational climate and culture.

Unit 2. (8 L)

Individual Behavior – Personality: Foundations of individual behavior; Personality; meaning and importance; Determinants of personality; Theories and models of personality.

Unit 3. (7 L)

Learning, Attitudes, Job Satisfaction & Values Learning: Definition and importance; Theories of learning; Shaping as managerial tool.

Unit 4. (10 L)

Attitudes and Job Satisfaction: Sources and types of attitudes; attitude formation and change; Cognitive dissonance theory; job satisfaction; job involvement; organizational commitment; organizational citizenship behavior; psychological contract; work engagement.

Values: Meaning, importance, source and types; applications in organizations.

Unit 5. (5 L)

Work Motivation

Work motivation: Theories and application; Indian perspective.

Unit 6. (5 L)

Basic approaches to Leadership: Defining leadership; trait theories; behavioral theories, contingency theories; leader-member exchange theory; inspirational approaches to leadership; contemporary approach; challenges to leadership.

Unit 7. (7 L)

Managing organizational Conflict & Stress

Managing Organizational conflict: Meaning & views to conflict; Sources of conflict; Resolution techniques and stimulation techniques.

Stress: Meaning; factors responsible for stress; consequences of stress; Stress management and coping strategies.

Unit 8. (8 L)

Positive Organizational Behavior

Optimism; Emotional intelligence; Self-efficacy; work-life balance.

Practicals:

Students would be required to complete four practicum from any of the topics discussed in PS404: 'Foundations of organizational behavior'. Assessment would not solely focus on testing and quantitative analysis, it would be coupled with qualitative analysis as well. Proposed practical group size should not exceed 10 as an experiential hands on training is needed and close contact with the students is required.

1. Case studies, group discussions, exercises, games, role-plays & psychological instruments will be adopted.
2. Term paper, small group interaction, group tasks and presentations will be made

Suggested Readings:

1. Industrial Organizational Psychology by Aamodt, M. G. India: Cengage Learning (2001).
2. Organizational Behavior by Debra l. Nelson & James C. Quick Thomson South Western, (2009).
3. Organizational Behavior by Luthans, F. New Delhi: McGraw Hill. (2006).
4. Psychology Applied to Work: An Introduction to Industrial and Organizational Psychology by Muchinsky, P.. NC: Hypergraphic Press, (2009).
5. Understanding Organizational Behaviour by Pareek, U. Oxford: Oxford University Press, (2010).
6. Organizational Behavior in India: An Indigenous Perspective by Prakash, A. in G. Misra (Ed.), Handbook of Psychology. New Delhi: Oxford University Press, (2011).
7. Organizational Behavior by Hodegetts, R. M. Macmillan, (2009).
8. Organizational Behavior by Kreitner, R., & Kinicki, A. McGraw-Hill, (2009).

SEC 1-2: Skill Enhancement Courses

(any one paper per semester in semesters 3- 4)

(2 L/Week)
(1 Presentation /Week) (Total Credits -2)

SEC: Paper 1: Biopolymers

Unit 1. (5 L)

Biopolymers, classifications of biopolymers based on chemical structure, application and functions.

Unit 2. (15 L)

Biopolymers: Starch, cellulose, chitosan, gelatine, keratin, fatty acids, lipids, aliphatic polyesters (PLA, PHB), cellulose and its esters and cellulose-regenerating processes.

Unit 3. (5 L)

Biodegradability: Natural biodegradable polymer, synthetic and modified biodegradable polymers, testing methods of biodegradability of biopolymers.

Unit 4. (5 L)

Use of biomaterials for manufacture of plastic films, blends, various types of films and their applications.

Suggested Readings:

1. Polymer Chemistry by Seymour and Carraher's, Sixth Edition, Hardcover (2003)
2. Biomaterials –novel materials from biological sources by D. Byrom - Stockton press.
3. Hand Book of Biodegradable polymers by Catia Bastioli, - Rapra Tech.(1987).
4. Surface modification of biomaterials: Methods analysis and applications by R Williams - Woodhead Publishing Series in Biomaterials (2010).
5. Biopolymers by R.M. Johnson, L.Y. Mwaikambo and N. Tucker, Rapra Technology (2003).
6. Hand Book of Bioplastics & Biocomposites for Engineering Applications by Srikanth Pillai, Wiley (2011)
7. Biopolymers by Steinbuechel Alexander Vol. 1-10 Wiley (2003).

(2 L/Week)
(1 Presentation /Week) (Total Credits -2)

SEC: Paper 2: Estimation of polymers and polymeric compounds

Unit 1. (10 L)

Quantitative and qualitative estimation of the basic raw materials such as fillers, plasticizers, initiators, inhibitors, antioxidants and heat stabilizers etc. used in polymer industries. Determination of purity of solvents, monomers and other auxiliaries.

Unit 1. (10 L)

Determination physical properties such as boiling point, melting point, viscosity, refractive index, specific gravity, swelling index and gel content of polymer materials.

Unit 1. (10 L)

Analysis of Polymer Compounds: Iodine value, Carbon black content, Free sulphur content, Total inorganic content, Silica content. hydroxyl value, acid value, flash point.

Suggested Readings:

1) Rubber Analysis: Polymers, Compounds and Products. by M. J. Forrest, Rapra Tech. Ltd. (2001).
2) Analysis of Rubber and Rubber-like Polymers. by M.J. Loadman, Springer, (2012).
3) Characterization and Analysis of Polymers edited by Arza Seidel, Willey (2008).
4) Molecular Characterization and Analysis of Polymers edited by John M. Chalmers, Robert J. Meier, Elsevier (2008).

(2 L/Week)
(1 Presentation /Week) (Total Credits -2)

SEC: Paper 3: Wire and Cable Technology

Unit 1. (5 L)

Introduction to Insulator, semiconductor and conductor, classification wire and cables (eg. Electric, telecommunication etc.), cable characteristics.

Unit 2. (10 L)

General properties of cable insulating materials:

i) Electrical: Volume and surface resistivity, break down voltage, dielectric constant, dielectric loss etc.

ii) Thermal: Heat resistance, permissible temperature, effect of overloading on the life of an electrical appliances and thermal conductivity

iii) Chemical: Solubility, chemical resistance, weatherability

iv) Mechanical and physical: Mechanical strength, porosity, density, brittleness, mouldability.

Unit 3. (5 L)

Factors affecting the electrical, thermal, chemical and mechanical properties of cable insulating materials. Selection of cable insulating materials

Unit 4. (10 L)

1. Polymers for cable insulation and sheathing (eg. CM, CSM, HDPE, LDPE, PVC, NBR, PTFE, EPDM, EVA, EMA etc.)

Suggested Readings:

1) Polymers for wire and cables- changes within an industry, by Keith Cousins, iSmithers Rapra Publishing, (2000).
2) The History of Electric wire and Cables, by R. M. Black, (1983).
3) Hand book of Rubber Technology by Smith and Martin, CBS Publishers (2007).

(2 L/Week)
(1 Presentation /Week) (Total Credits -2)

SEC: Paper 4: **Footwear Technology**

Unit 1. (10 L)

Shoe Soles: Soling requirements, soling materials, compounding and processing. Individual soling compounding-PVC, thermoplastic rubber, polyurethane, ethylene vinyl acetate, etc.

Unit 2. (10 L)

Adhesives: Soling adhesives and types of adhesives, adhesion principle, adhesive selections, Heel covering; sole attaching, neoprene, PU, hot melt and liquid curing adhesives, adhesion problems. Coated fabrics: PVC, PU coated fabric.

Unit 3. (5 L)

Soles Materials: Molded and pre fabricated units, individual solings – rubbers, vulcanized rubbers, nylons, polyesters, PVC, thermoplastic rubbers, PU, EVA.

Unit 4. (5 L)

Processing Technology: Injection moulding, sponge moulding, direct molded shoes, thermoplastic moulding, polyurethane injection moulding, insert moulding, HF flow moulding.

Suggested Readings:

1. Footwear Materials & Process Technology, A. J. Harvey, Shoe Trades Publishers (1982).

2. Modern Footwear Materials & Process, W E Cohn, Fairchild Publicatins, (1969).

3. Introductin to Modern Footwear Technology, B. Venkatappaiah, B. Sita Publishers (1997).

DSE: Discipline Specific Elective

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 1- Conducting Polymers

Unit 1. (10 L)

Basic of conducting polymers- Band structure, electrical conductions, resistance, capacitance and impedance of conducting polymers

Unit 2. (15 L)

Synthesis of conducting polymers- Chemical polymerizations, electro-chemical polymerizations of polyaniline, polypyrole, polythiophene etc, effect of chemical doping on properties of conducting polymers

Unit 3. (15 L)

Blends of conducting polymers-nanoblends/Composites of polyaniline, polyaniline derivatives and their blends, comparison of the morphological and conductivity characteristics of polyaniline blends, blends of polythiophene, blends of polypyrole,

Unit 4. (10 L)

Compositions of conducting polymers-properties and applications of conducting polymer compositions, Bio-components matrices and effect of compositions

Unit 5. (10 L)

Applications- Electronic devices, Chemical sensors, Solar cells, Light emitting devices, Biomedical devices, bio-system, organ transplant, artificial mussels etc.

Practicals:

1. Synthesis of conducting polymers such as polyaniline, polypyrole, polythiophene etc,
2. Prepare film/ sheet of conducting polymers
3. Determination mechanical properties of conducting polymer films/sheet.
4. Testing thermal properties of conducting polymers
5. Testing the electrical properties of conducting polymer films/ sheet.

Suggested Readings:

1. Conducting Polymers, fundamentals and applications: A practical approach by Prasanna Chandrasekhar, Springer (1999).

2. Handbook of Organic Conductive Molecules and Polymers: Conductive polymers: synthesis and electrical properties, Hari Singh Nalwa, Wiley (1997).
3. Handbook of Conducting Polymers by Terje A. Skotheim, Ronald L. Elsenbaumer, John R. Reynolds , Taylor & Francis Group (2007).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 2- Fiber Manufacturing Technology

Unit 1. (5 L)

Introduction to manmade fibers: Definition of made fibers, brief history of manmade fibers, relative merits and demerits of manmade fibers and natural fibers.

Unit 2. (15 L)

Conversion of polymers into fibers: Basic production systems of the man made fiber. Concept of melt spinning, dry spinning and dry jet wet spinning process. Factors influencing selection of a particular process for fibre formation. Relative merits and demerits of melt, dry and wet spinning processes. Effect of parameters on fiber breakage and fiber structure. Spin ability and factors affecting chain length. Variables of spinning. Different components of spinning process, i.e., extruder, gear pump, filters, manifold, spinning head, quenching chamber, winders. Quenching/solidification techniques.

Unit 3. (10 L)

Melt spinning: Raw material, technology of polymerization and extrusion of polyester, nylon -6, nylon 66 and polypropylene. Effect of process parameters on structure and properties of melt spun filament. Characteristic features of PET, polyamide and polypropylene spinning.

Unit 4. (10 L)

Solution dry spinning: Dry spinning of cellulose acetate. Acetylation of cellulose. Dope preparation and spinning of cellulose diacetate and triacetate. Dry spinning of acrylic. Significance and types of co-monomers used during polymerization of acrylic.

Unit 5. (10 L)

Solution wet spinning: Wet spinning of viscose rayon. Formation of structure in viscose and thermoplastic fibres. Influence of various additives and temperature of the regeneration bath and their influence on the process and properties of viscose rayon.

Unit 6. (10 L)

Drawing and heat setting of fibres: Introduction to drawing and heat setting in thermoplastic fibres. Concept of neck drawing. Effect of drawing conditions on the structure and properties of fiber. Effect of heat setting parameters on the structure and properties of fiber.

Practicals:

1. Melt spinning of Nylon 6 and 66.
2. Solution spinning of Acrylic fiber.
3. Preparation of PP tape by extruders.
4. Heat seating of Fibers.
5. Thermal analysis of fibers.
6. Chemical modifications of fibers.

Suggested Readings:

1. Production of Synthetic Fibres by A A Vaidya, 1st Ed., Prentice Hall of India, New Delhi, (1988).

2. Manufactured Fibre Technology by V B Gupta and V K Kothari, 1st Ed., Chapman and Hall, London, (1997).

3. Synthetic Fibres by J. E. Macintyre, Wood Head Fiber Science Series, UK, (2003).

4. Textile Fibers: Developments and Innovations by V K Kothari, IAFL Publications, New Delhi (2000).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 3- Paints, Coatings and Adhesives

Unit 1. (15 L)

Introduction, function and properties of adhesives, mechanical interlocking, adsorption and surface reaction. Surface topography, wetting and setting, thermodynamic work of adhesion, influence of constitution on adhesion, interfacial bonding, and surface preparation of adherents. Types of adhesives (Structural, elastomeric and pseudo plastic based).

Unit 2. (15 L)

General information, paints composition, selection and water solubility, interface-surface treatment, properties manufacturer of paints and uses of paints.

Unit 3. (15 L)

Definition and importance of coating, raw materials and composition of coating, manufacture of coatings, criteria and type of coatings.

Unit 4. (15 L)

The technology for preparation of paints, coatings and adhesives and their use in different fields, coating operations.

Practicals:

1. Formulation of paints (water and solvent based).
2. To find out adhesive strength by Peel Test method.
3. Adhesive formulation and compounding.
4. Measurement of Wettability of adhesives.
5. Measurement of resin/paint viscosity by Ford cup 4 and Brookfield viscometer.

Suggested Readings:

1. Outline of Paint Technology by W. M. Morgan, CBS Publisher (2000).
2. Paints, Coatings and Solvents by D. Stoye, Wiley-VCH (2008).
3. Adhesion and Adhesives Technology by A. V. Pocius, H. Carl, Hanser-Verlag (2002).

4. Coatings of polymers and plastics by R. A. Ryntz, P. V. Yaneff, Marcel Dekker (2003).
5. Adhesion aspects of polymer coatings by K.L. Mittal, VSP (2003).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 4- Polymeric Nanomaterials

Unit 1. (10 L)

Introduction to general aspects of nanostructured materials, e.g. nanocomposites, block copolymers, interaction parameter. Phase behaviour morphology and phase diagrams, microphase separation transition.

Unit 2. (15 L)

Preparation, structure and properties of nanoreinforcing agents: eg. nanoclays, POSS, carbon nanostructures and nanoparticles.

Unit 3. (10 L)

Effect of factors such as loading, dispersion and percolation, influence of size, shape and diameter of nanotubes, functionalization of nanoparticles and nanoplatelets.

Unit 4. (15 L)

Structural and morphological characterization

- Morphology of crystalline polymers.
- Nanostructure development in semicrystalline polymer during deformation by X-ray scattering & diffraction technique.
- Nanostructure of two component amorphous block copolymers: Effect of chain architecture.

Unit 5. (10 L)

Polymer nanocomposites: Technical challenges and understanding of interfacial dynamics using LJ Potential and many body problems approach. Applications of polymeric nanomaterials.

Practicals:

1. Particle size analysis of nanofillers.
2. Preparation of polymer nanocomposites by solution & melt compounding.
3. Determination of mechanical properties of nanocomposites.
4. Characterization of nanocomposites by optical microscope, SEM, TEM, DSC, DMA, TGA etc.
5. Determination of electrical properties of nanocomposites.

Suggested Readings:

1. Polymer Nanocomposites by J.H. Koo, McGraw-Hill (2010).
2. Polymeric Nanocomposites-Theory and Practice by S. N. Bhattacharya, Hanser Gardner (2008).
3. Mechanical Properties of Polymer based on Nanostructure and Morphology by G. H. Michler and F. J. Balta, CRC Press (2005).
4. Introduction to Nanotechnology by- C. Papoose, F. J. Owens, Wiley, John & Sons (2003).
5. Nanocrystalline Materials by S.C. Tjong, Elsevier Science (2006).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 5- Tyre Technology

Unit 1. (20 L)

Tyre classification: Solid tyre, pneumatic tyre, radial tyre, bias and bias belted tyre and tubeless tyre.

Unit 2. (20 L)

Tyre design, tyre mechanics, caracas design, contour shape, cord path and their characteristics. Cord tension. load capacity of tyre, stresses in tyre, tread design, bead design.

Unit 3. (20 L)

Tyre manufacturing: Tyre building drum, cure finishing. Tyre testing. laboratory test, proving ground, inspection of tyre, earth moving tyres & ADV tyre.

Practicals:

1. To tested mechanical properties of vulcanized rubber: a) Tensile strength b) Elongation at break %, c) Hardness d) Tear strength.
2. To perform oil and air aging properties of rubber and rubber to fabric ply.
3. To determined bonding strength of rubber to fabric and rubber to metal ply .
4. To calculate abrasion loss of tyre tread.

Suggested Readings:

1. Heavy Duty Truck Tire Engineering SAE's 34th L. Ray Buckingdale Lecture, by T. L. Ford and F. S. Charles, SP729 (1988).
2. Engineering Data Book, "Over-The-Road Truck Tyres," The Goodyear Tyre & Rubber Company (2001).
3. The Science and Technology of Rubber by J. E. Mark, B. Erman, F.R. Eirich, Elsevier (2005).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 6- Packaging Technology

Unit 1. (15 L)

Introduction, definition, importance, scope of packaging, packaging materials, origin of packaging materials, types, properties, advantages & disadvantages of packaging materials.

Unit 2. (10 L)

Types of packaging, box, bottle, tetra, pouch, shrink, vacuum, gas, controlled atmosphere packaging (CAP), modified atmosphere packaging (MAP), aseptic etc.

Unit 3. (15 L)

Polymers in packaging, LLDPE, HDPE, HMHDPE, PP-Properties and applications, PVC packaging, nylon packaging, polyester packaging, polycarbonate and PS and expanded polystyrene.

Unit 4. (10 L)

Packaging techniques, Thermoforming in packaging, co-extrusion, extrusion-stretch blow molding, LDPE, BOPP films.

Unit 5. (10 L)

Performance properties of packaging materials, bursting strength, tensile strength, tearing strength, drop test, puncture test, impact test etc.

Practicals

1. To Identification of polymeric package material by using FT-IR, DSC and TGA.
2. Determination of bursting strength, tensile strength, tearing strength, drop test strength, puncture test strength, impact strength etc.
3. Determination of water vapor transmission rate of packaging material
4. To tested sealing strength integrity of packaging materials

Suggested Readings:

1. Food Packaging Principles and Practice by Gordon L. Robertson, CRC press (2005).
2. A Handbook of Food Packaging by Paine F. A. and Paine H. Y., Blackie Academic and Professional (1992).

3. Food Packaging – Principles and Practice by Robertson G. L., CRC Press Taylor and Francis Group (2012).
4. Food Packaging Technology by Coles R, McDowell D., Kirwan M. J., Blackwell (2003).
5. Food Packaging – Principles and Practice by Robertson G. L., CRC Press Taylor and Francis Group (2012).
6. Polymers for packaging materials for preservation of food stuffs by L. A. Sukhareva, V. S. Yakolev, O. A. Legonkova, (2008).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 7- Fabrication of Polymeric Products

Unit 1. (15 L)

FRP Laminates: Introduction, FRP processing methods contact moulding hand lay up, spray up method vacuum bag & pressure bag moulding, filament welding, centrifugal casting, pultrusion, matched die moulding laminates, definition of terms high, pressure laminating process, types of machinery, impregnation systems – decorative and industrial laminates, continuous high pressure laminating process, application.

Unit 2. (15 L)

Cellular Plastics: Introduction process to create foam in resins mechanical foaming, chemical foaming, physical foaming proceses to shape and solidify foams low pressure foam moulding, high pressure foam moulding, RIM extrusion foaming, casting foams, steam chest moulding structural foam moulding applications.

Unit 3. (10 L)

Machinery & joining of Plastics: Introduction – Importance of machining methods viz. cutting, drilling, blending, filling, etc. Joining principles cohesion principle, adhesion principle- solvent cementing, DOP cementing, welding, vibration welding, hot plate welding, ultrasonic welding, adhesive bonding examples: Mechanical fasteners.

Unit 4. (10 L)

Casting Processes: Dip casting, slush casting, continuous casting, cell casting, processes and applications. Calendering – Types of calendaring systems.

Unit 5. (10 L)

Coating Processes: Roller coating, powder coating, fluidized bed coating, electrostatic spray coating, processes and applications. Other Secondary Processes: Printing, painting, hot stamping, in mould decoration, electro plating and vacuum metallising, decorating.

Practicals

1. To Prepare unit cell products such as close and open cell
2. To prepare rubber-fabric play and composite by calendaring.
3. To prepare powder cotes such as epoxy, polyester and epoxy-polyester type.
4. To Prepare PMMA sheet using bulk polymerizations

5. To repair polymer products by different processing techniques.
6. RTM handling

Suggested Readings:

1. Plastics Finishing and Decoration by Donatar Satar, Van Nostrand Reinhold company, New York (1986).

2. Decorating Plastics by James M. Margolis, Hanser Publishers, New York (1986).

3. Manufacturing of polymer Composites by B. T. Astrom, Chapman and Hall, London (1995).

5. Plastics Processing Data Book by Donal V.Rosato and Dominick V.Rosato, Van Nostrand Reinhold, New York (1990).

6. Plastics: Materials and Processing by A. Brent Strong, Practice- Hall, New Jersey, (1996).

7. Joining Plastics in Production by M.N.Watson, The Welding Institute, Cambridge, (1988).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 8- Polymers in Biomedical Applications

Unit 1. (10 L)

Basics of biomaterials: Concept of biocompatibility, responsiveness, degradation, estimations of degradation and biocompatibility, technically important form of polymers: Hydrogel, bioceramics, bioelastomers, and membrane.

Unit 2. (10 L)

Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, porosity, adsorption, physical (electrical, optical, magnetic, thermal), chemical and biological properties.

Unit 3. (10 L)

Polymers used as Biomaterials: Silicone rubber, dacron, poly (methyl methacrylate), polyurethanes, cellulose, properties and applications.

Unit 4. (10 L)

Organ Transplants: Properties of polymers for organ transplant, different polymers used for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc.

Unit 5. (10 L)

Tissue Engineering: Regeneration, important polymers used in tissue engineering, cellulose, chitoson and alginate.

Unit 6. (10 L)

Drug Delivery: Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogel.

Practical

1. Evaluate the biocompatibility of polymeric samples.
2. Determine the degradation behavior of polymers such as thermal, hydrolytic etc.
3. Prepare membranes and measure absorption behavior.
4. Preparation and characterization of dental cement.
5. Prepare a hydro gel and characterization.
6. Determine the mechanical strengths of polymers.

Suggested Readings:

1. Nanomaterials in drug delivry, Imaging and Tissue Engineering by Ashutosh Tiwari and Atul Tiwari, Wiley (2013).
2. Handbook of Bioplastics and Biocomposites engineering applications by Srikanth Pilla, Wiley (2011).
3. Biomaterials Science, An Intoduction to Materials in medicine, Eds. B. D. Ratner and A. S. Hoffman, Academic Press, New York, (1996).
4. Drug delivery – Engineering principles for drug therapy, Editor: Saltzman W. M. Oxford University Press, USA (2001).
5. Biopolymers: Biomedical and Environmental Applications by Susheel Kalia and Luc Averous, John Wiley & Sons (2011).