PROPOSED SCHEME OF EXAMINATION FOR B. TECH (Chemical Technology)
THIRD SEMESTER B. TECH (CHEMICAL TECHNOLOGY)

Sr. No	Code Theory (T) Practical (P)	Subject	Board	Work Load (Hours)				Credit				Marks				Total Marks	Min. % of Marks Required for Passing
				L	P	T	Total	L	P	T	Total	Theory		Practical			
												College Assessment	University	College Assessment	University		
1	CT-PCC-301T	Material & Energy Balance Computations	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
2	CT-PCC-302T	Particle & Fluid Particle Processing	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
3	CT-PCC-303T	Thermodynamics – II	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
4	CT-GES-304 T	Material Science	BGE	3	-	0	3	3	0	0	3	30	70	--	--	100	45%
5	CT-BS-305 T	Maths-3	BGE	3	0	0	3	3	0	0	3	30	70	--	--	100	45%
6	CT-BS-306 T	Elementary Molecular Approach	BGE	3	-	0	3	3	-	0	3	30	70	--	--	100	45%
7	CT-GES-307P	Material Science Laboratory	BGE	0	2	0	2	0	1	0	1	-	-	25	25	50	50%
8	CT-BS-308 P	Elementary Molecular Approach – Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
9	CT-PCC-309P	Particle & Fluid Particle Processing Lab	BCE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
		Total		**18**	**8**	**03**	**29**	**18**	**4**	**3**	**25**	**180**	**420**	**75**	**75**	**750**	

PROPOSED SCHEME OF EXAMINATION FOR B. TECH (Chemical Technology)
FOURTH SEMESTER B. TECH (CHEMICAL TECHNOLOGY)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Work Load (Hours)				Credit				Marks				Total Marks	Min. % of Marks Required for Passing
												Theory		Practical			
				L	P	T	Total	L	P	T	Total	College Assessment	University	College Assessment	University		
1	CT-PCC-401T	Process Technology & Economics	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
2	CT-CS-402T	*Special Technology I	BCHT	3	0	0	3	3	0	0	3	30	70	--	--	100	45%
3	CT-PCC-403T	Fluid Mechanics	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
4	CT-PCC-404T	Numerical Methods in Chemical Engineering	BCE	2	0	0	2	2	0	0	2	15	35	--	--	50	45%
5	CT-BS-405 T	Inorganic Process Technology	BGE	3	0	0	3	3	0	0	3	30	70	--	--	100	45%
6	CT-HSMC-HS - 406 T	HASS II Functional English	BGE	2	0	0	2	2	0	0	2	15	35	--	--	50	45%
7	CT-PCC-407P	Fluid Mechanics Lab	BCE	0	2	0	2	0	1	0	1	--	--	25	25	50	50%
8	CT-PCC-408P	Numerical Methods in Chemical Engineering Lab	BCE	0	2	0	2	0	1	0	1	--	--	25	25	50	50%
9	CT-BS-409 P	Inorganic Process Technology Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	--	--	25	25	50	50%
10	CT-GES-410 P	Engineering Workshop	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
11	MC	Environmental Sciences	--	0	0	0	0	0	0	0	Audit	--	--	--	--	--	
		Total		**16**	**10**	**02**	**28**	**16**	**5**	**02**	**23**	**150**	**350**	**100**	**100**	**700**	

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- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

Scheme of Absorption for old Scheme to New Scheme Third Semester B. Tech (Chemical Technology)						
As per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Scheme (CBS)				As per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme (CBCS)		
Sub Code (Board) Theory / Practical	**Subject**	**Theory / Practical**		**Sub Code (Board) Theory / Practical**	**Subject**	**Theory / Practical**
BTCHT 301T (BCHT)	Chemical Process Calculations	Theory		CT-PCC-301T (BCE)	Material & Energy Balance Computations	Theory
--	--	--		CT-PCC-302T (BCE)	Particle & Fluid Particle Processing	Theory
--	--	--		CT-PCC-303T (BCE)	Thermodynamics – II	Theory
BTCHT 302T (BGE)	Organic Process Technology	Theory		--	--	--
--	--	--		CT-GES-304 T (BGE)	Material Science	Theory
BTCHT 303T (BGE)	Engineering Mathematics III	Theory		CT-BS-305 T (BGE)	Maths-3	Theory
--	--	--		CT-BS-306 T (BGE)	Elementary Molecular Approach	Theory
--	--	--		CT-GES-307P (BGE)	Material Science Laboratory	Practical
--	--	--		CT-BS-308 P (BGE)	Elementary Molecular Approach –Laboratory	Practical
				CT-PCC-309P (BCE)	Particle & Fluid Particle Processing Lab	Practical
BTCHT 304T (BGE)	Electronics & Instrumentation	Theory		--	--	--
BTCHT 305T (BCHT)	*Special Technology I	Theory		--	--	--
BTCHT 306P (BGE)	Organic Process Technology	Practical		--	--	--
BTCHT 307P (BGE)	Electronics & Instrumentation	Practical		--	--	--
BTCHT 308P (BCHT)	*Special Technology I	Practical		--	--	--

Scheme of Absorption for old Scheme to New Scheme Fourth Semester B. Tech (Chemical Technology)						
As per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Scheme (CBS)				As per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme (CBCS)		
Sub Code (Board) Theory / Practical	**Subject**	**Theory / Practical**		**Sub Code (Board) Theory / Practical**	**Subject**	**Theory / Practical**
--	--	--		CT-PCC-401T (BCE)	Process Technology & Economics	Theory
BTCHT 305T	Special Technology I	Theory		CT-CS-402T (BCHT)	Special Technology I	Theory
--	--	--		CT-PCC-403T (BCE)	Fluid Mechanics	Theory
BTCHT 401T (BGE)	Strength of Materials	Theory		--	--	--
BTCHT 402T (BGE)	Applied Physical Chemistry II	Theory		--	--	--
BTCHT 403T (BGE)	Numerical Methods & Computer Programming	Theory		CT-PCC-404T (BCE)	Numerical Methods in Chemical Engineering	Theory
BTCHT 404T (BGE)	Inorganic Process Technology	Theory		CT-BS-405 T (BGE)	Inorganic Process Technology	Theory
--	--	--		CT-HSMC-HS -406 T (BGE)	HASS II- Functional English	Theory
BTCHT 405T (BCHT)	*Special Technology II	Theory		--	--	--
				CT-PCC-407P (BCE)	Fluid Mechanics Lab	Practical
BTCHT 406P (BGE)	Numerical Methods & Computer Programming	Practical		CT-PCC-408P (BCE)	Numerical Methods in Chemical Engineering Lab	Practical
BTCHT 407P (BGE)	Inorganic Process Technology	Practical		CT-BS-409 P (BGE)	Inorganic Process Technology	Practical
BTCHT 408P (BGE)	Machine Drawing	Practical		--	--	--
BTCHT 409P (BGE)	Applied Physical Chemistry II	Practical		--	--	--
--	--	--		CT-GES-410 P (BGE)	Engineering Workshop	Practical
--	--	--		MC	Environmental Sciences	Theory

Science and Technology,

R.T.M. Nagpur University, Nagpur.

Syllabus for B.Tech. Chemical Technology

(Third Semester)

Material & Energy Balance Computations (Theory)

Subject Code: CT - PCC -301 T(BCE)

Lecture: 3 Hrs **Tutorial: 1 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Objective: This course will prepare students to make analysis of chemical processes through calculations, which need to be performed in the chemical processing operations. The students are introduced to the application of laws and also to formulate and solve material and energy balances in processes with and without chemical reactions.

Course outcomes: After completion of the course, students will be able:

CO1: To understand the basic concept, units, and conversion of chemical process calculations.

CO2: To understand the application of various gas laws, volume changes, humidity and saturation, solubility and crystallization.

CO3: To perform material and energy balances on chemical processes/equipment without and with reactions.

CO4: To do energy balances on chemical processes/equipment without and with reactions.

CO5: To perform energy balances on chemical processes/equipment with chemical reactions and heat and combustion problems

Unit I Basic principles, the concept of gram atom and gram mole, conversion of units from one system to another, concept of excess reactant, conversion and yield, Selectivity and degree of completion of reaction.

Unit II Ideal gases, partial pressure, vapor pressure, application of ideal gas laws, volume changes with changes of composition, dissociating gases, humidity and saturation, solubility and crystallization.

Unit III Material balance without chemical reaction, recycle, purge and bypass calculations, material balance with chemical reaction.

Unit IV Energy balance without chemical reaction, combined material and energy balances.

Unit V Energy balance with chemical reaction, combined material and energy balances, Fuels and combustion, types of fuels, heating values of fuels, theoretical and excess air, heat and combustion problems.

Books Recommended:

1. Stoichiometry and Process Calculation by Narayana K.V., Laxmikutty B. , Prentice Hall of India 2006.

2. Basic Principles and Calculations in Chemical Engineering by Himmalblau D.M. & Riggs, J.B.

3. Prentice Hall of India 6 th Edition (2011)

4. Stoichiometry by Bhatt B.I. , Vora S.M. Tata-McGraw-Hill 4 th Edition 2004

5. Chemical Process Calculation by Hougen A., Watson, M. John Wiley & Sons, Third Edition 2000

Particle & Fluid Particle Processing

Subject Code: CT - PCC -302T (BCE)

Lecture: 03 Hrs **Tutorial: 01 Hr** **No. of Credits: 04**

University: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Objective: The course aims at providing an overview of the approaches, methods and techniques of particle and fluid particle processing. The objectives include the understanding of concepts like physical properties and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, sedimentation, agitation and mixing of liquids , and flow through packed and fluidized beds.

Course outcomes: After completion of the course, students will be able to understand:

CO 1: Solid particle characterization & relevance of fluid and particle mechanics and mechanical operations in chemical engineering

CO 2: Crushing and screening principles and equipment's used for them.

CO 3: Handling & transportation of solids and fluid solid systems.

CO 4: Separation of solids from fluids by using sedimentation and basic principles, operation and equipment's used for them.

CO 5: Separation of solid from fluids by using Filtration, flotation and classification and basic principles, operation and equipment's used for them

Unit-I: Relevance of fluid and particle mechanics and mechanical operations in chemical engineering process. Solid particle characterization: particle size, shape and their distribution, relation among shape factors and particle dimensions, specific surface area, measurement of surface area. Flow around immersed bodies, concept of drag, boundary layer separation, skin and form drag, drag correction

Unit II: Solids: size reductions, types of equipment's used in the various stages of reductions, laws of crushing and grinding power requirements. Screening screening equipment's, effectiveness of screens, sieve analysis, particle size distribution, classification of particles, size enlargement, nucleation and growth of particles.

Unit III: Handling of solids: Belt conveyer, screw conveyer, flight conveyer, bucket conveyer, pneumatic conveyer. Capacity and power requirement of conveyer, transport of fluid solid system, terminal settling velocity, hindered settling velocity.

UNIT IV: Separation of solids from fluids: sedimentation free settling, hindered settling, Kynch theory of sedimentation, design of settling tank, sedimentation equipment's Centrifugation principles of a centrifuge. Collidal particles: stabilization, flocculation

UNIT V: Filtration: filtration theory, equipments for filtration, constant rate and constant pressure filtration filter calculation optimum filtration and filter aid, equipments used for filtration. Classification Principle of classification, equipment's for classification, design of

cyclone and hydrocyclone, flotation cells and calculation for flotation cell. Application of fluidization.

List of Books:

1. McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill.

2. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.

3. Unit operation by Brown G.G., CBS publication First Edition 1995, reprint 2005

Suggested References Books

1. Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester ; New York, 2008.

2. Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.

3. Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.

4. Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2 nd Ed., Wiley, 2013.

Thermodynamics II

Subject Code: CT - PCC -303T (BCE)

Lecture: 3 Hrs **Tutorial: 1 Hr** **No. of Credits: 4**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Objective: The objective of this course is to introduce the principles of Chemical Engineering Thermodynamics and illustrate their application to design of chemical process plants. To understand the laws of thermodynamics and their applications in the flow/non-flow processes. To familiarise with the estimation of volumetric and key thermodynamic properties of real fluids and mixtures, solution thermodynamics, phase and chemical reaction equilibria. To understand the applications phase and reaction equilibria which include liquid-liquid equlibria, vapour liquid-liquid equlibria, solid-liquid, and solid-vapour equilibria.

Course outcomes: After completion of the course, students will be able to:

CO 1: Understand and apply the laws and rules of thermodynamics, equilibrium and phase rule.

CO 2: Understand various thermodynamics properties and relationships, and coefficients of species and their properties.

CO 3: Understand Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing

CO 4: Understand different Equilibria, equilibrium criterion , evaluation of equilibrium constant and equilibrium conversion at different conditions.

CO5: Understand molecular/statistical thermodynamics

Unit I: Review of first and second law of thermodynamics, Vapor-liquid equilibrium: phase rule, simple models for VLE; VLE by modified Raoult's law; VLE from K-value correlations; Flash calculations.

Unit II: Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties

Unit III: Liquid phase properties from VLE, Models for excess Gibb's energy, heat effects and property change on mixing. Introduction to UNIFAC and UNIQUAC models

Unit IV: Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria., Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multireaction equilibria.

Unit V: Introduction to molecular/statistical thermodynamics

Suggested Text Books

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, “Introduction to Chemical Engineering Thermodynamics”, 7th edition, McGraw-Hill International Edition,2005.

2. K.V.Narayanan, "Chemical Engineering Thermodynamics", Pentice Hall India 2006

Suggested References Books

1. S.Sandler, “Chemical, Biochemical and Engineering Thermodynamics”, 4 th edition,Wiley,India.

2. Y.V.C.Rao, “Chemical Engineering Thermodynamics”, University Press, Hyderabad,1997.

Material Science

Subject Code: CT -GES-304 T (BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment:70 **Marks College Assessment :30 Marks**

Duration of Examination: 03 Hours

Objectives:

- The objective of the course will be to give the students a basic introduction to the different classes of materials relevant to engineering in general and Chemical Engineering in particular.
- The intent of the course will be to relate the underlying molecular structure of the materials to their physical and chemical properties and their processing and performance characteristics.

Course outcomes:

CO 1: At the end of this course, students will have a fair understanding of hard and soft materials, including polymers and composites, their characterization, properties, and use in engineering applications.

Unit 1: Introduction to materials, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, Van der Waals bond, thermal expansion, elastic modulus and melting point of materials, Role of materials selection in design, structure-property-processing-performance relationships.

Unit 2: Miller Indices of planes and directions, packing of atoms inside solids, close-packed structures, structure of ceramics, ionic solids, glass and polymers, density of various materials.

Unit 3: Imperfections in solids: vacancies, equilibrium concentration of vacancies, interstitial and substitutional impurities in solids, dislocations, types and characteristics of dislocations, interfacial defects, stacking faults.

Unit 4: Structure of materials and Strength of Materials: Yield strength, tensile strength and ductility of materials: stress strain behaviour of metals, ceramics and polymers, tensile test, plastic deformation, necking, creep behaviour and fatigue.

Unit 5: Amorphous materials, Polymer nano-composite materials, Environmental Degradation: Corrosion and oxidation of materials, prevention, Biomaterials.

Suggested Books

1. V. Raghavan, Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.

2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

Suggested Reference Books

1. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
2. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley Publisher.
3. B. S. Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Maths –III:

Subject Code: CT-BS-305 T (BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment :30 Marks**

Duration of Examination: 03 Hours

Course Outcomes:

Students will be able to

CO1: Represent the solution of Differential Equations in the form of series.

CO2: Understand Laplace transforms and inverse Laplace transforms of various functions involved in engineering field.

CO3: Apply Laplace transform to solve Ordinary and Partial Differential Equations as well as to evaluate the integral equations & solve hyperbolic, parabolic, elliptical PDEs using various Numerical methods and apply these methods to solve various engineering problems.

CO4: Apply Fourier Transform to Solve Integral Equations.

CO5: Evaluate the integration of function of complex variable. Also, able to transform the function from one plane to another.

Unit I: Series Solution and Special Function

Method of infinite series solution for ordinary D. E. when x = o as a ordinary point & x = a as a regular singular point by Fresenius method,

Special Function: Bessel's equation, Bessel's functions: recurrence relations, orthogonality property, generating function, Legendre's equation, Legendre Polynomials: Rodrigue's formula generating function, recurrence relations, orthogonality property.

Unit II: Laplace Transforms

Important Formulae, Properties of Laplace Transforms, Laplace Transform of Unit Step Function, Impulse Function, Periodic Function, Dirac Delta Function, Bessel Function, Error Function,

Inverse Laplace Transforms: Important Formulae, Properties of Inverse Laplace Transforms, Partial fraction Method, Convolution Theorem,

Unit III: Solution of Differential Equations:

i) By Laplace Transform: Solutions of ordinary differential equations, simultaneous ordinary differential equations, partial differential equations and evaluation of Integrals using Laplace Transform method.

ii)Solution of Partial Differential Equations by Numerical Techniques:

Numerical solution of parabolic, elliptic and hyperbolic Partial Differential Equations using finite difference technique.

Unit IV: Fourier Transform

Definition and Properties (excluding FFT), Fourier Integral Theorem, Relation with Laplace Transform, Applications of Fourier Transform to Solve Integral Equations.

Unit V: Complex Variables: Integration

Integration of function of complex variables, Cauchy's integral theorem and integral formula, Residue theorem and its use for evaluating Integrals of function of complex variables, evaluation real definite integrals by contour integration; conformal transformations and bilinear transformations.

References

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. Higher Engineering Mathematics by B. S. Grewal

Elementary Molecular Approach

Subject Code: CT -BS -306 T (BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment :30 Marks**

Duration of Examination: 03 Hours

Unit 1: Thermodynamics of solutions

A] Raoult's Law, Vapour Pressures of ideal solutions; Activity of ideal solution; chemical potential of ideal solution; Gibb- Duhem- Margules Equation; Free energy, entropy, and enthalpy of mixing

B] Vapour Pressures of real solutions, Vapour Pressure-composition and Boiling Point composition Curves of completely Miscible Binary Solutions; Binary miscible liquids (ideal and non-ideal), azeotropes, lever rule; Nernst distribution law and its Applications, Numericals.

Unit 2: Liquids and Phase equilibria

A] Phase Equilibria: Concept of phases, components and degrees of freedom; derivation of Gibbs Phase Rule for nonreactive and reactive systems; *Clausius-Clapeyron equation*: derivation and its applications to solid liquid, liquid-vapour and solid-vapour equilibria; *Phase diagram for one component systems*: water, CO2 and sulphur. *Two component Eutectic system:* Pb- Ag system, Eutectic system with congruent and incongruent melting point, *Three component systems:* water-chloroform-acetic acid system.

B] Partially miscible liquids: Systems with UCST, LCST and both LCST and UCST-phenol-water, trimethylamine-water, nicotine-water systems. Effect of temperature on CST.

Unit 3: Macromolecules

A] Basic Concepts: Introduction, *Classifications of polymer*: based on origin, structure, mode of synthesis; interparticle forces and thermal response; monomer unit, tacticity and physical properties; degree of polymerization, polydispersity index, *Molecular weights*: Number average, Weight average, Viscosity average molecular weight; *Methods of molecular weight determination*: viscosity, light scattering method, sedimentation velocity method and membrane osmotic pressure method.

B] Polymerization Techniques: *Chain growth/Addition polymerization*: free radical, cationic, anionic; Step growth polymerization; Coordination polymerization; Ziegler-Natta catalyst.

Unit 4: Molecular Absorption spectroscopy

A] Photochemistry: Thermal and photochemical reaction, Electromagnetic radiation, interaction with atoms and molecules, Lambert Beer law (derivation and deviations from it), laws of photochemistry; Quantum yield, determination of quantum yield, Reasons for high and low quantum yield, numerical; Jablonskii diagram, singlet and doublet state, fluorescence and phosphorescence.

B] Electronic spectroscopy: Characteristics of electromagnetic radiation, Various electronic transitions, Effect of solvent on electronic transitions, Ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes and conjugated polyenes. Fieser Woodward rules for conjugated dienes and carbonyl compounds, Ultraviolet spectra of molecules.

Unit 5: ^{1}H NMR SPECTROSCOPY

A] Introduction, Nuclear spin, nuclear magnetic moment, shielding of magnetic nuclei; Chemical shifts, factors influencing chemical shift, Spin-spin splitting; low- and high-resolution spectra, isotopic abundance; Factors influencing coupling constant 'J' – Classification (ABX, AMX, ABC, A2B2etc.), spin decoupling.

B] 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 and amides; use of NMR in molecular structure diagnostics.

Reference Books-

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8 th Ed., Oxford University Press (2006).
2. Castellan, G. W. Physical Chemistry 4 th Ed. Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
4. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
5. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
6. Laidler, K.J. & Meiser, J.H. 2nd Edition Physical chemistry, CBS publishers, New Delhi (1999).
7. Banwel, Fundamentals of Molecular Spectroscopy, 4th Edition, McGraw Hill Education

Text Books-

1. C.N. R. Rao, University General Chemistry. Mc. Millan Publication.
2. Puri B.H., Sharma L.R. and Pathania M.S.; Principles of Physical Chemistry, Vishal Publishing Co., 42nd Edition.
3. Alka L Gupta, Polymer Chemistry, Pragati Prakashan.
4. V R Gowarikar, N V Viswanathan, J Sreedhar, Polymer Science, New Age International.
5. D.N. Sathyanarayana, Handbook of Molecular Spectroscopy.

Material Science Laboratory

Subject Code: CT -GES -307 P (BGE)

Lecture: 0 Hrs **Practical Duration: 02 Hr** **No. of Credits: 01**

University Assessment: 25 Marks **College Assessment: 25Marks**

Duration of Examination: 3 Hours

List of Experiments

1. To study the crystal structure of a given specimen.
2. To study the imperfection in crystal.
3. To study the microstructure of mild steel with the help of microscope.
4. To study heat treatment processes (annealing & tempering) applied to a given specimen.
5. To study the thermosetting plastics.
6. To study the creep behaviour of a given specimen.
7. To study the thermosetting plastics.
8. Tensile test on mild steel sample using UTM.
9. Fatigue test on the mild steel sample.

Suggested Books

1. V. Raghavan Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.
2. 2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

Elementary Molecular Approach Laboratory

Subject Code: CT -BS-308 P (BGE)

Lecture: 0 Hrs **Practical Duration: 03 Hrs** **No. of Credits: 1.5**

University Assessment: 25Marks **College Assessment :25 Marks**

Duration of Examination: 03Hours

- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to the concepts of Physical Chemistry for engineering applications.
- Students will be able to clearly communicate the results of scientific work in oral, written and electronic formats their professional career.
- Students will be able to explore new areas of research in solution thermodynamics, phase eutectic systems, liquid-liquid extraction, electrochemistry, concept of interfaces and surfaces chemistry, photochemistry and polymers.
- Students will be able to function as a member of an interdisciplinary problem solving team in both chemistry and allied fields of science and technology.

Course Outcomes:

CO1. To acquire practical knowledge on the basic chemistry principles for apply in chemical engineering.

CO2. To acquire training in accurate and precise data collection

CO3. To acquire practical knowledge of the phase diagrams and its application in metallurgy,

CO4. To acquire practical knowledge of analytical techniques like conductometric and spectroscopic techniques and solvent extraction process to deal with practical problems.

LIST OF EXPERIMENTS

1. To study the distribution of succinic acid in H_2O- toluene, H_2O-ether and comparison of distribution coefficient.
2. To study the $KI_3 \rightarrow KI + I_2$ equilibrium in aqueous solution.
3. To construct the phase diagrams of two components system (phenol- water) and study the effect of 1% NaCl, 1% succinic acid, 0.5% naphthalene on CST in phenol-water systems.
4. To study the phase diagram of ternary system (Toluene-Acetic acid-water; Ethyl acetate-acetic acid, water).
5. To study the mutual solubility of a) Nicotine-water, and b) glycerol-m-toluidine and determine consolute points.
6. To find out the constant of conductivity cell and hence determine the dissociation constant of a weak acid.

7. To determine CST of phenol and water in presence of a) 1% NaCl, b) 0.5% naphthalene and c) 1%succinic acid.
8. To determine the conductometric titration curve in the neutralization of strong /weak acids against a strong/weak bases.
9. To determine the volume percentage of pure ethanol in a given solution of it in Benzene by surface tension measurement.
10. To study the coagulation of ferric hydroxide sol with KCl, K_2SO_4 and $K_3[Fe(CN)_6]$ and find their coagulating value.
11. To determine the wavelength of maximum absorption and to verify the Beer's law for $KMnO_4$ / $K_2Cr_2O_7$ solution.
12. To determine ferrous ions in a given sample spectrophotometrically by O-phenathroline method.
13. To determine the molecular weight of a high polymer (polystyrene) by viscosity measurement.
14. Potentiometric titration of acetic acid against NaOH and to determine the dissociation constant of acid.
15. To study the molecular condition of benzoic acid in Toluene by determining the partition co-efficient between Toluene and water.

Reference books

1. Practical Physical Chemistry 3rd edition A.M.James and F.E. Prichard , Longman publication
2. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
3. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
4. Advanced Experimental Chemistry. Vol-I J.N.Gurtu and R Kapoor, S.Chand and Co.
5. B. Vishwanathan, P.S. Raghavan; Practical Physical Chemistry, Viva Books, 2010.

Particle & Fluid Particle Processing Lab

Subject Code: CT - PCC -309P(BCE)

Lecture: 0 Hrs **Practical Duration: 03 Hrs** **No. of Credits: 1.5**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 3 Hours

Objective: The course aims at performing the experiments and getting hands-on experience on concepts such as, the properties, size-reduction and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, agitation and mixing of liquids, and packed and fluidized beds

Course Outcomes:

CO 1: The student would understand the physical properties, property measurement and handling of solid-solid and solid-fluid mixtures.

CO2 . The student would understand separation processes for solid-solid and solid-fluid mixtures.

CO3. To understand the processes involved in agitation and mixing of liquids

CO4: To understand the working and applications of solid-storage and conveying, and flow through packed and fluidized beds

List of Experiments:

1) To study relationship between the Drag coefficient and modified Reynolds number for bo dy falling throughfluid (Cd Vs NRE)

2) To carry out the batch sedimentation test and use results to design the thickener

3) To determine the efficiency of Mineral Jig

4) To establish the filtration equation for the leaf filter system and to evaluate compressibility of cake.

5) To study the power consumption of an agitator with Reynolds and Froude number

6) To verify the laws of crushing and grinding

7) To determine the mean arithmatic diameter, mean surface diameter and mean volume diam eter

8) To determine the size distribution in a given sample (Elutriation)

9) To determine the effectiveness of vibrating screen

10) To separate the various size fraction in a mixture on the basis of their settling velocities in a fluid (size separation)

11) To determine the efficiency of a cyclone separator.

12) To study separation in cone classifier.

13) To study the operation of hammer mill and determination of efficiency of hammer mill

14) To study working principle of froth flotation cell

15) To study the magnetic separator and to determine the efficiency of magnetic separator.

Science and Technology

R.T.M. Nagpur University, Nagpur.

Syllabus for B.Tech. Chemical Technology

(Fourth Semester)

Process Technology & Economics (Theory):

Subject Code: CT-PCC-401T (BCE)

Lecture: 03 Hrs **Tutorial: 1 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 03 Hours

Course Objectives: The objective of this course is to introduce students with basic block diagram and simplified process flow diagram for manufacture of various inorganic chemicals, Petrochemicals, Petroleum refining and cracking operations. This course also provides basic understanding for common utilities required for manufacturing process. It also provides understanding for various components of project cost and their estimation.

Course Outcomes: After completion of the course, students will be able:

CO1: Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing of inorganic chemicals.

CO2: Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing for Petroleum refining and cracking operations, syngas and hydrogen.

CO3: Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing of various Petrochemicals.

CO4: Industrially relevant fuels, coal, coal-based chemicals and fuels Common utilities

CO 5: Introduction to project, Various components of cost of production and their estimation and analysis of working results project.

Unit 1: Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of inorganic chemicals, such as: inorganic acids, chlor-alkali, ammonia, fertilizers, etc.

Unit 2: Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for Petroleum refining and cracking operations, syngas and hydrogen,

Unit 3 Description, raw material and energy sources and consumption, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Petrochemicals: C1, C2, C3, C4, etc., benzene, toluene, xylene and other petrochemicals from these basic building blocks

Unit 4 Industrially relevant fuels, coal, coal-based chemicals and fuels Common utilities such as electricity, cooling water, steam, hot oil, refrigeration and chilled water

Unit 5: Introduction to project cost and cost of production, Various components of cost of production and their estimation, Various components of project cost and their estimation, Estimation of working capital. Analysis of working results project: Balance sheets, Project financing, concept of interest, time value of money, depreciation. Profitability Analysis of Projects

Suggested Text Books

1. Shreve's Chemical Process Industries, George T. Austin, McGraw-Hill International Editions Series, 1984
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, Marshall Sittig, East West Press, 1997
3. Chemical Project Economics, Mahajani V. V. and Mokashi S M., MacMillan India Ltd. 2005
4. Plant Design and Economics for Chemical Engineers, Max Peters, Klaus Timmerhaus, Ronald West, McGraw Hill International Edition, 2013
5. Process Equipment Design Vol 1 & 2 , S.D.Dawande Denett Publication Seventh Edition,2015

Suggested References Books

1. Chemical Process Technology, Moulijn, M. and van Dippen, Wiley, 2013

Food Technology I

(Chemistry of Foods)

Subject Code: CT - CS-402/1 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objective:

The main objectives of this course is for students to differentiate chemical interactions and reactions of food components and their effect on sensory, nutritional, and functional properties of foods, and how processing influences these properties.

Course Outcome(s): By learning this course students will develop

CO1: Ability to understand the structure and composition of carbohydrates and its metabolism.
CO 2: Ability to demonstrate the structure, composition, physical and chemical properties of different types of fats.
CO 3: Ability to recognize the function of the proteins and enzymes and understand their practical implications.
CO4: Ability to describe the importance of water, colloidal systems and effect of water activity on shelf life of food products.
CO 5: Ability to understand the importance of micro nutrients in food products and able to find the energy value of different foods.

Course Content:

Unit I: Chemistry of Carbohydrates

Nomenclature, Classification and Structure of carbohydrates. Chemical Reactions of Carbohydrates. Physical and Chemical properties of sugars, starch, pectic substances, gums and other polysaccharides. Functional properties of carbohydrate in food. Digestion of carbohydrate-based food and its metabolism

Unit II: Chemistry of Lipids

Definition and classification of lipids, Chemistry of fatty acids and glycerides. Chemistry of processing of fats and oils, hydrogenation of fats, shortening confectionery fat etc. Rancidity of fats and oils, its prevention and antioxidants. Functional properties of lipids in foods. Metabolism of lipids.

Unit III: Chemistry of Proteins and Enzymes

Importance of proteins. Nomenclature, classification, structure and chemistry of amino acids, peptides and proteins. Sources and distribution of proteins, isolation, identification and purity of proteins. Denaturation, Physical, Chemical and Biochemical characterization of proteins, Metabolism of proteins, Introduction classification and nomenclature of enzymes, specificity. Industrial applications of Enzymes, kinetics, Techniques of immobilization of enzymes.

Unit IV: Water

Importance of water in foods. Structure of water and ice. Concept of bound and free water, their implications. Water Activity and its influence on shelf life of foods. Physical Properties of Food Systems. Colloidal Properties of food, Sensory perception of tastes, flavour, aroma and texture. Sensory analysis of foods.

Unit V: Micronutrients of food

Energy value of food. BMR and its measurement. Energy requirement of individuals. Nutritional evaluation of proteins. Recommended dietary allowances of proteins, fats and carbohydrates, Antinutritional factors in food, Vitamins – Classification, sources, functions and deficiency symptoms, assay of vitamins. Minerals – Micro & Macro Minerals. Loss of nutrients during processing, Enrichment and fortification.

Books Recommended:

1. Food Chemistry : L H Meyer, Van Nostrand Reinhold Co New York 1960

2. Principles of Food Science, Ed. Owen R Fennema Part I, Food Chemistry, Marcel Dekker Inc New York

3. The Chemical analysis of foods and food products : Morris B Jacob, 3rd Edition, Vam Nostrand Co, Princeston, New Jersey

4. Instrumental Methods of Analysis: Peksock and Shields

Technology of Oil, Fats & Surfactants- I

(Basics of Oils, Fats and Waxes)

Subject Code: CT - CS-402/2 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Outcomes (COs):

After final completion of the course, students will be able to:

1. Thoroughly understands the basic knowledge about sources of Oils & Fats.
2. They are able to classify oils & fats in detail, structure & composition of oil seeds.
3. Capable to differ oils & fats from its constituents.
4. Knowledge of physical & chemical characteristics their determination processes as well as Indian standards & finding adulteration becomes clear after completion of this course.
5. This course gives knowledge of various aspects in the field of waxes also it includes sources, manufacturing process, refining of wax & highly applicable Chemical reaction and Bio-chemical reactions of fats and their fatty acids in industry.

Unit I: Natural Fats and Oils

Their sources and classification, Constituents of Natural Fats, Glycerides. Phospholipids, Fatty acids, non-glyceride constituents, toxic constituents and detoxification. Nutritional functions of fats. Biosynthesis of Oils and Fats.

Unit II: Glyceride Components and Analytical Studies of Oils and Fats

Glycerides and Fatty Acids: Nomenclature, Structure, Occurrence in Oils and Fats. Physico chemical properties of fats and fatty acids, solution properties and spectral properties. Determination of Reichert – Missel, Polenske, and Kirshner values.

Unit III: Analysis of Oils and Fats

Physical and Chemical characteristics of Oils and Fats, Elementary methods of analysis of oils, fats and fatty acids. Determination of Color by Lovibond Tintometer, Determination of viscosity by Brookfield viscometer. Identification of fats and oils. Detection of adulteration in oils and fats. Indian Standards for fats and oils.

Unit IV: Natural Waxes and Synthetic waxes

Natural sources, composition, classification, extraction, refining and processing of waxes, general properties and uses of Paraffin wax, vegetable wax, Animal wax, Microcrystalline compound wax, Compound wax Mineral wax. Synthetic Wax: Esters, Ketones and Industrial waxes. Industrial applications of Waxes.

Unit V: Chemical reaction and Bio-chemical reactions of fats and their fatty acids

Modern enzymatic reaction of oils, fats and fatty acids viz; extraction of oil, transesterification, hydrogenation, polymerization, sulphation and sulphonation, interesterification. Antioxidants and synergists.

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Books Recommended:

1. Industrial Oils and Fat Products: Ed A E Bailey Vol I
2. Fatty acids: K.S. Markely, Inter Science Publishers, 2nd Edition, New York
3. Analysis of Fats and Oils: V.C. Mehlan Bacher
4. Inhibition of fat oxidation processes: K.A. Allen
5. An introduction to the Chemistry and BioChemistry of Fatty acids: Gunstone
6. Industrial Chemistry of Fats and Waxes: T Hilditch
7. B S I Methods of Analysis of Fats and Oils
8. Rancidity of Edible Fats: C H Lea
9. ISI Methods of analysis of oils and fats IS 548 (1964)
10. AOCS Methods of Analysis of Oils and Fats

Petroleum Refining and Petrochemical Technology- I

(Oil & Gas Technology)

Subject Code: CT - CS-402/3 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objective:

- Enable the students to understand basic principles of petroleum geology.
- Enable the students to understand Drilling operations & various well Drilling Equipment.
- Enable the students to understand and follow the concepts of oil and gas production & processing techniques.

Course Outcome:

After successful completion of the course, the students are expected to

- understand & apply the knowledge of petroleum engineering.
- understand the various rocks along with migration of oil & gas from source rock to reservoir rock.
- get the knowledge about the purpose and uses of the well testing.
- create an information about the basic concepts of Enhanced Oil Recovery Mechanisms
- analyze various surface operations and associated equipment.

UNIT I Geology for Petroleum Engineers

Introduction to subject, history of petroleum, elements of petroleum geology, types & ages of rocks, lithography & classification of rocks, source rock, reservoir rock, entrapment & accumulation of hydrocarbons, traps for oil & gas along with structural details, theories of petroleum origin.

UNIT II Geophysical exploration & drilling technology

Overview of petroleum exploration, introduction to geophysical / geological methods used in petroleum exploration, introduction to oil well drilling, types of drilling – cable tool, rotary drilling rigs & components, drilling fluids, Drilling Fluids: Function, composition, and classification, casing & cementation, well control.

UNIT III Well completion & testing

Well completion: definition of well completion, types of completion, naturally flowing completions, artificial lift completions, well drill stem tests (DST); production tests, pressure tests on gas wells; formation interval testing and other well testing techniques, well stimulation techniques, acidizing concept, types of acids and additives, hydraulic fracturing.

UNIT IV EOR methods

Enhanced oil recovery techniques, introduction: historical background and review of primary and secondary recovery, injection rate and pressures in secondary recovery, gas injection, carbon dioxide flooding, polymer flooding, steam flooding, environmental factors associated with oil recovery, unconventional hydrocarbon resources, coal bed methane, gas hydrates, shale gas / oil, heavy oil.

UNIT V Field processing of Oil & gas

Gathering & collection of oil & gas, flash and stage separation of oil & gas, design of oil & gas separators. Demulsification, stabilization and desalting of crude oil. Dehydration and sweetening of gas. Special problems in oil and gas separation. Removal of suspended solid & water from oil & gas. Scrubbers and wash tank. Safety features in oil and gas separation system.

Reference Books:

- Standard Handbook of Petroleum and Natural Gas Engineering. 2nd Edition. William C Lyons, Gary C Plisga. Gulf Professional Publishing.
- Geology of Petroleum, A.I. Levorsen,2ndEdition. CBS, Publishers, 2006.
- Carl Gatlin; Petroleum Engineering: Drilling and Well Completions, Prentice Hall, Technology and Engineering, 1960.
- L.P.Dake L Elsevier, “Fundamentals of Reservoir Engineering”, Development in Petroleum Science. 1980
- Katz D.L. “Natural Gas Engineering (Production &storage)”,TataMcGraw-Hill, Singapore, 6th edition,2007

Pulp and Paper Technology- I

(Chemistry of Paper Making Raw Material)

Subject Code: CT - CS-402/4 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Outcome

a. Knowing the different raw materials used in the manufacture of paper, understanding the source of cellulose and availability.
b. Understand the anatomy of different fibrous raw material. Study the various morphological properties relevant to paper manufacture.
c. Identify the chemical composition of wood which gives an idea of cellulose, hemicelluloses, lignin and extractives present in the wood.
d. Study the chemistry of cellulose and hemicelluloses. Understanding the role played by each wood component, reactions of cellulose and hemicelluloses with chemicals.
e. Understanding the relevance of lignin, reactions of lignin with different chemicals and their effect, qualitative and quantitative analysis of lignin, utilization of lignin as different polymeric products

Unit I: Species used as papermaking raw material

Wood species, anatomy and physical properties of wood – classification of woods, non woody fibres used in pulping – bast, fruits, grass, leaf, animal, mineral and synthetic fibres. Gross structure of trunk, structural elements of wood, fiber dimensions.Water conducting system, food conducting system, bark and its structural elements.

Unit II: Anatomy of fibrous raw material and their chemistry

Fibre morphology – Cell formation and growth, fiber structure, gymnosperm and angiosperm fiber morphology, sapwood, heart wood, spring wood, summer wood, role played by growth rings, chemical composition of wood, proximate analysis of fibrous raw material, physical properties of fiber, decay of wood, physical properties of wood, extractives and it’s chemical composition.

Unit III: Chemistry of cellulose

Cellulose – Chemistry and location in the cell, isolation, molecular constitution, microfibrils, crystalline and amorphous cellulose, biogenesis of cell wall polysaccharides, sorption, swelling and solution of cellulose, degradation reaction of cellulose.

Unit IV: Identification and formation of hemicelluloses and lignin

Hemicelluloses it's structure and characteristics in wood. Lignin – lignification in wood, biological and biochemical aspects of lignin formation, chemical aspects of lignin formation, lignin carbohydrate bonds, heterogenity of lignin, laboratory separation of lignin.

Unit V: Chemistry of lignin

Structure and properties of lignin, various commercial separation methods, qualitative analysis of lignin, quantitative analysis of lignin, structural analysis and utilization of lignin, low molecular weight products, polymeric products from lignin.

Books Recommended:

1) Biermann's Handbook of Pulp and Paper: Volume 1: Raw Material and Pulp Making Paperback by Pratima Bajpai Dr., Elsevier, 2018.
2) Papermaking Science and Technology, Vol- 2 Forest Resource and Sustainable Management, Joint Textbook Committee of TAPPI and Finnish Paper Association, TAPPI PRESS, 2002.
3) Papermaking Science and Technology, Vol- 3 Forest Products Chemistry, Joint Textbook Committee of TAPPI and Finnish Paper Association, TAPPI PRESS, 2002.
4) Pulping Process by S.A. Rydholm, John Wiley and Sons, New York
5) Pulp and Paper Chemistry and Chemical Technology : James P Casey, John Wiley and Sons, New

Plastics and Polymer Technology- I

(Polymer Science)

Subject Code: CT - CS-402/5 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objective:

Enable the students to learn the basics of Polymer-structure, reaction and molecular weight.

Course Outcomes (COs):

After successful completion of the course, students will be able to

1. Select suitable raw material for the manufacture of a polymer.
2. Corelate the structure of polymer with property.
3. Apply appropriate polymerization reaction and technique for polymer synthesis.
4. Suggest suitable polymer for particular application on the basis of thermal transition.
5. Compute molecular weight of polymers by using different methods.

Unit 1: Raw Materials for Polymer

Manufacture and properties of raw materials for polymers (monomers): Ethylene, Acetylene, Tetrafluoroethylene, Propylene, Butadiene, Vinyl Chloride, Vinyl acetate, Vinylidene Chloride, Styrene, Acrylic acid, Methyl methacrylate, Acrylonitrile, Acrylamide, Dibasic acids such as Maleic acid, Adipic Acid, Terephthalic acid, Maleic Anhydride, Phenol, Urea, Formaldehyde, Isocyanate, Polyol, Caprolactam, Hexamethylene Diamine, Bisphenol A, Ethylene glycol, Epichlorohydrin, Melamine.

Unit 2: Polymer Classification and Structure

Introduction to Monomer, Oligomer, Polymer, Polymerization, Degree of polymerization, Monomer functionality and its importance, Classification of polymers, on the basis of Source, thermal behaviour, structure, Tacticity and C-C Linkages,Configuration and conformation, Co-polymers- random, alternating, block and graft. Amorphous and crystalline polymers, factors affecting crystallinity, effect of crystallinity on polymer properties, Molecular Flexibility: concept, factors affecting, properties affected.

Unit 3: Polymerization Mechanism and Techniques

Addition Polymerization: Free radical Polymerization, Ionic Polymerization-Anionic and Cationic Polymerization, Co-ordination polymerization, Kinetics of Polymerization

Step Polymerization: Polycondensation, Polyaddition polymerization and Ring opening Polymerization.

Bulk Polymerization, Solution Polymerization, Suspension Polymerization, Emulsion Polymerization, Interfacial Polymerization, Merits and demerits of different techniques.

Unit 4: Thermal Transition in Polymers

Transitions in Polymers, Glass Transition Temperature, factors affecting Glass transition temperature, Glass transition temperature of Copolymers, Relation between Glass transition temperature and Melting temperature, Practical Significance of glass transition temperature, Methods of determination of glass transition temperature.

Polymer degradation, Types: Mechanical, Oxidative, Thermal, UV Degradation, Prevention of degradation.

Unit 5: Polymer Molecular Weight

Average Molecular Weights in polymers: Number average and weight average molecular weight, viscosity average molecular weight, practical significance of molecular weight, Polydispersity and molecular weight distribution in polymers, Analytical techniques used to determine molecular weight: End group analysis, Light scattering, Viscometry, Cryoscopy, Ebulliometry, Membrane Osmometry, Ultra centrifugation.

Books Recommended:

1. Polymer Science by V. R. Gowarikar, New Age Int (P) Ltd.
2. Principles of Polymerization by George Odian, Wiley Interscience.
3. Text Book Of Polymers by Billmeyer, Wiley Interscience.
4. A Textbook of Polymer (Chem. & Tech. of Polymer) vol. I &II by M. S. Bhatnagar, S. Chand.
5. Outlines of Polymer Technology by R. P. Sinha, S. Chand.
6. Polymer Structure, Property and Applications by Deanin, ACS.
7. Physical Chemistry of Polymers by Tager, Mir Publication.
8. Advanced Polymer Materials: Structure Property Relationship by Shonaike, Advani, CRC Press.

Surface Coating Technology-1

(Chemistry and Technology of Drying Oils and Polymerization)

Subject Code: CT - CS-402/6 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objectives: After studying this course students must able to understand the:

1**.** classification of the paint/coatings and role of various ingredients.

2. the concept and role of film-formation in coatings.

3. the chemistry and technology of oils.

4. modifications of oils and use of modified oils as film-former in coatings.

5. the chemistry and mechanism involved in the synthesis of polymerization.

Course Outcomes (COs)

On the successful completion of the Course, students will be able to:

CO 1: Understand and classify the paint/coatings and role of various ingredients

CO 2: Understand the concept and role of film-formation in coatings

CO 3: Understand the chemistry and technology of drying oils

CO 4: Understand the modifications of oils and use of these oils/modified oils as film-former in coatings

CO 5: Understand the chemistry and mechanism involved in the synthesis of polymer

Unit 1: Introduction to Surface Coatings: History of developments of surface coatings, Global scenario and past, present and future of Indian Coating Industry. Classification, definition of paints, varnishes, lacquer, General composition of surface coatings, function of pigments, extenders, binders, driers, additives in surface coatings.

Unit II: Film Formation: Fundamental of film formation; Chemical Composition, functionality and degree polymerization and film properties. Concept of functionality. Types of coatings, convertible and non-convertible.

Unit III: Vegetable and marine Oils : Chemistry of oils and fats, Classification of oils, and fats; Characterization of oils – physical and chemical; Sources and composition of major oils;

Fatty acids composition and characteristics of individual oils; Constitution of fatty acids, Extraction of oils; Processing of oils; Reactions in oils: Oxidation, hydrolysis, glycerolysis, sulfonation, and epoxidation; Evaluation & properties and uses of oils; Non- drying, drying and semidrying oils.

Unit IV: Drying of Oils: Chemistry and mechanism of oxidative polymerization of drying oils; Thermal polymerization of drying oils; Modification of drying oils; Stand, blown and boiled oils; Limed oils, Isomerized oils, Treated Oils. Dehydrated castor oil (DCO); Co-polymerized oils; film formation and deterioration.

Unit V: Polymerization: Linear and branched polymers; Cross-linked polymers; Degree of polymerization; Chemical classification of polymers; Addition polymerization: Monomers used in addition polymerization; Mechanism of addition polymerization; Manufacturing methods; Condensation polymerization, Characteristics of condensation polymerization; Co-polymerization and hetero-polymerization. Molecular weight of polymer, glass transition temperature

Books Recommended:

1. Organic Coating Technology, H F Payne, Vol I, John Wiley and Sons, New York
2. Paint Technology Manual, Vol I, Oil and Colour Chemists Association
3. Paint Technology Manual, Vol II, Oil and Colour Chemists Association
4. The Chemical Constitution of Natural Fats, T P Hilditch, 2nd Edition, John Wiley and Sons,
5. Protective and Decorative Coatings, J J Matellio, Vol I, John Wiley and Sons
6. Surface Coatings, Vol I, Raw Materials and their useage, Oil and Colour Chemists Association, Australia
7. Text Book of Polymer Science: W Billmeyer, Interscience Publishers Inc, New York
8. An Introduction to Polymer Chemistry: W R Moore, Aldine Publishing Co. Chicago
9 Principles of Polymer Science, by Bahadur and Sastry, Narosa Publishing House.
10. Polymer Science by Gowarikar, Johan Wiley and Sons 1986.
11. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc

Fluid Mechanics

Subject Code: CT - PCC-403T (BCE)

Lecture: 03 Hrs **Tutorial: 01 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 03Hours

Objective: The objective of this course is to understand the fundamentals of fluid flow phenomena. Deriving the mass and momentum balance equations from first principles. To learn about the transportation of fluids and flow measuring devices.

Course Outcomes: After completion of the course, students will be able:

CO1: To understand the basic properties, classification of fluid and fluid statics.

CO2: To understand the fluid energy balance, energy losses and various pipe fitting

CO3: To understand Velocity Distribution, Fluid Friction and Two-phase flow, and flow patterns in two phase flows.

CO4: To understand various flow working principle and expressions for flow rate measuring meters

CO5: To understand Transportation of fluids, Classification of pumps and their properties.

Unit –I

Introduction to fluids: fluid, Properties of fluids, Classification of fluids, Continuum hypothesis, Forces on fluids, Normal and shear stresses, Shearing and flow, characteristics of Newtonian and Non-Newtonian fluids, Shear stress distribution of fluids. Fluid statics: Pascal law, Hydrostatic equilibrium law, Pressure distribution & Manometry, U-tube, Inverted U-tube, Differential and Inclined manometers.

UNIT-II

Bernoulli`s equation, Continuity equation, Frictional loss in pipe, Hydraulic mean diameter, losses due to enlargement and contraction of pipe cross - section. Equivalent length of pipe, Pipe fittings, Gate, Globe, Check and Butterfly valves, Boundary layer development

Unit-III

Velocity Distribution for, Viscous & Turbulent flow through Pipe & Parallel plates. Fluid Friction in pipe: Friction factor, Head loss in pipe flow, Colebrook and White equation, Moody diagram, Two-phase flow, Flow patterns in two phase flow. The Baker diagram, Erosion in two phase flow.

Unit-IV

Flow measurement: Flow rate measurement, Working principle and expressions for flow rate through Pitot tube, Orifice meter, Venturimeter, variable area flow meter, Notch and Weir, Coefficient of discharge.

Unit-V

Transportation of fluids - Classification of pumps, Positive displacement pumps, Reciprocating, Pump, Plunger pump, Diaphragm pump, Metering pump, Rotary gear pump, Rotary lobe Pump, Rotary vane pump, Flexible vane pump, Mono pump, Cetrifugal pump, Volute pump, Volute pump with vortex chamber and diffuser vanes, Cavitation, Priming, Net positive suction head

Suggested Text Books

1. M. White, Fluid Mechanics, 8 th Edition, Tata-McGraw Hill, 2016.

2. V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2 nd Edition, New Age International 2011.

3. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7 th Edition, McGraw-Hill International Edition 2005.

4. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005.

5. R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7 th Edition, Wiley-India 2010.

6. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed.,Wiley (2007).

7. R.P. Vyas, Fluid Mechanics , Second Edition, Dennet & Co. Publication,2008

Suggested References Books

1. R.K. Bansal, Fluid Mechanics and Hydraulic Mechines Laxmi Publication 7th Publication 2017.
2. B. R. Munson, D. F. Young, T. H. Okiishi and W. W. Huebsch, 6 th Edition, Wiley-India 2010.
3. R. L. Panton, Incompressible Flow, 3 rd Edition, Wiley-India 2005.
4. R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, 2 nd Edition, Wiley-India 2002.

Numerical Methods in Chemical Engineering

Subject Code: CT - PCC -404T (BCE)

Lecture: 02 Hrs **No. of Credits: 02**

University Assessment: 35 Marks **College Assessment :15Marks**

Duration of Examination: 03 Hours

Objective: This course has been designed to develop the understanding the computational methods to solve the problems related to the chemical engineering applications. The students are exposed to learn the basic principles, and logical skills in solving the problems using computational methods.

Course Outcomes: After completion of the course, students will be able:

CO1: To understand and apply various linear algebraic equations to chemical engineering problems

CO2: To understand and apply Root finding methods for solution on non-linear algebraic equations to chemical engineering problems

CO 3: To understand and apply Interpolation and Approximation various methods to chemical engineering problems

CO4: To understand and apply various methods of: Numerical integration and numerical differentiation to chemical engineering problems

CO5: To understand and apply various Ordinary Differential Equations and Partial Differential Equations to chemical engineering problems

Unit I: Introduction, Approximation and Concept of Error & Error Analysis, Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations

Unit II: Root finding methods for solution on non-linear algebraic equations: Bisection, Newton- Raphson and Secant methods, Chemical engineering problems involving solution of non-linear equations

Unit III: Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression

Unit IV: Numerical integration: Trapezoidal rule, Simpson’s rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration

Unit V: Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single,and a system of ODEs . Introduction to Partial Differential Equations:

Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method

Suggested Text Books

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.

Suggested References Books

1. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer
2. Applications", McGraw Hill Book Company, 1985.
3. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.
4. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.
5. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Inorganic Process Technology

Subject Code: CT- BS-405 T(BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 03 Hours

Course Objectives:

Students will be able to understand sources and processes of manufacture of various important inorganic chemicals having industrial applications.

Course Outcomes: The student on completion of course will be able:

CO1 To understand the knowledge of unit operations and apply them in production of industrial gases & acids.

CO2 To understand the concepts, remember & apply the knowledge in the production process of different types of Industrial carbon and pigments.

CO3 To understand the concepts, remember & apply them in the manufacture of industrially important marine chemicals and processes in nuclear industries

CO4 To understand the manufacturing processes of Electrolytic & electro-thermal products

CO5 To understand the production process of different fertilizers.

Unit I Industrial gases & Acids: Manufacture of CO_2, H_2, N_2 & O_2, Ar, ammonia and C_2H_2 and their industrial applications. Manufacture of nitric acid, sulphuric acid, Phosphoric acid and their industrial applications.

Unit II Industrial Carbon & Inorganic pigments: Manufacture & applications of, Lamp black, Carbon black, Activated carbon, Graphite, Industrial diamond. Manufacture, properties & uses of white pigments- white lead, zinc oxide, titanium dioxide and Lithophone.

Unit III Nuclear industries: Nuclear fission & fusion reactions, Feed materials, extraction of Uranium, uranium enrichment, nuclear reactor, reprocessing of nuclear materials, protection from radioactivity.

Unit IV Chloro-Alkali & Electrolytic and Electrochemical industries: Manufacture of Soda ash by Solvay's & modified Solvay's process, Types of electrolytic cells for Caustic soda & Chlorine manufacture – Nelson, Hookers, Castner Kellner, De-Nora & Membrane cells. Manufacture of potassium chlorate & per- chlorate. Artificial abrasives: Calcium carbide, Silicon carbide.

Unit V Fertilizers: Classification of fertilizers, manufacture & applications of urea, ammonium nitrate, ammonium sulphate, Super phosphates & triple super phosphates, monoammonium and Diammonium phosphate, Potassic, compound & complex fertilizers.

Books Recommended:

1. Industrial Chemistry by B.K.Sharma, Goel Pub. House, Meerut.
2. Dryden, C. E. “Outlines of Chemical Technology” (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press. Pvt. Ltd, New Delhi, 3rd Edition (1997).
3. Austin G. T,”Shreve’s Chemical Process Industries”, 5th ed., McGraw Hill.(1984).
4. G.N.Pandey, "Text book of Chemical Technology", Vol. I, 2nd revised edition, (1994).
5. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.

HASS II Functional English

Subject Code: CT- HSMC-HS-406 T (BGE)

Lecture: 02 Hrs. **No. of Credits: 02**

University Assessment: 35 Marks **College Assessment: 15 Marks**

Duration of Examination: 02 Hour

Objective: At the end of the semester, students will have enough confidence to face competitive examinations (IELTES/ TOEFL/CAT/ MAT/ XAT/SNAP/GMAT/GATE etc.) to pursue master's degree. They will also acquire language skills required to write their Reviews/Projects/Reports. They will be able to organize their thoughts in English and hence face job interviews more confidently.

Scope: The Curriculum designed is student –centered and it is guidance for their career

Unit 1. Functional Grammar:

Common errors, Transformation of Sentences, Phrases, Idioms & Proverbs.

[50 sentences of common errors, 50 examples of Transformation of Sentences, (5 each type), 50 noun/prepositional phrases, 50 idioms/proverbs]

Unit II. English for Competitive Exams & Interview Techniques:

IPA (vowel & consonant phonemes), Word building (English words /phrases derived from other languages), Technical Jargons, Synonyms/Antonyms, Analogies, Give one word for, Types & Techniques of Interview

Assignment: [25 Words for teaching IPA, 25 words/phrases of foreign origin, 25 technical jargons, 25 words for Synonyms/ Antonyms, 25 words for Analogies, 50 examples of give one word for]

Unit III. Formal Correspondence

Business Letters, e-mail etiquettes [Orders, Complaints, Enquiries, Job applications and Resume Writing, Writing Memorandum, Circulars, notices], Analytical comprehension:

[Four fictional & four non-fictional unseen texts]

Unit IV. **Technical & Scientific Writing:**

Features of Technical Writing, Writing Scientific Projects, Technical Report writing, Writing Manuals, Writing Project Proposals, Writing Research papers.

Assignment: (Any one project/review as assignment)

Reference Books:

1. Effective technical Communication by Barun K. Mitra, Oxford University Press,
2. Technical Communication-Principles and Practice by Meenakshi Raman & Sharma, Oxford University Press, 2011, ISBN-13-978-0-19-806529-
3. The Cambridge Encyclopaedia of the English Language by David Crystal, Cambridge University Press
4. Contemporary Business Communication by Scot Ober , Published by Biztantra,
5. BCOM- A South-Asian Perspective by C.Lehman, D. DuFrene & M. Sinha, Cenage Learning Pvt. Ltd.2012
6. Business English, by Dept of English, University of Delhi, Published by Dorling Kindersley (India), Pvt.Ltd.,2009, ISBN 978 81 317 2077 6
7. How to Prepare a Research Proposal: Guidelines for Funding and Dissertations in the Social and Behavioural Sciences by Krathwohl & R David
8. Technical Writing- Process and Product by Sharon J. Gerson & Steven M. Gerson, 3rd edition, Pearson Education Asia, 2000
9. Developing Communication skills by Krishna Mohan & Meera Banerjee

Fluid Mechanics Lab

Subject Code: CT - PCC -407P (BCE)

Lecture: 0 Hrs **Practical Duration: 02 Hrs** **No. of Credits: 1**

University Assessment: 25 Marks **College Assessment :25 Marks**

Duration of Examination: 3 Hours

Objective: The course aims on the properties of fluids and the energy relationships in fluid systems. The fluid mechanics approach to solve typical problems in turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow, volumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps

CO1: The student must be able to approach and solve typical problems in fluid dynamics at the appropriate level.

CO 2. Students will be able to understand the fluid dynamics and also the principles of turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow.

CO3. Learn to measure volumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps.

CO4. Ability to understand and analyze the applications to industrial flows.

List of Experiments

1) To verify Bernoullis equation

2) To calibrate venturimeter and and obtain its coefficient of discharge

3) To calibrate orificemeter and obtain its coefficient of discharge

4) To calibrate Rotameter

5) To calibrate notched weir and and obtain its coefficient of discharge

6) To study friction factor Vs Reynolds number for flow of water in a pipe

7) To study friction factor Vs Reynolds number for flow of air in a pipe

8) To study the relationship between Fanning friction factor Vs Reynolds number for flow of fluid through coils.

9) To obtain equivalent length of pipe for various pipe fittings

10) To study the operating characteristics of centrifugal pump.

11) To study the hydrodynamic characteristics of packed bed

12) To study the hydrodynamic characteristics of a fluidized bed

13) To study two phase flow.

Numerical Methods in Chemical Engineering Lab (Practical)

Subject Code: CT - PCC -408P (BCE)

Lecture: 0 Hrs **Practical Duration :02 Hr** **No. of Credits:1**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 03 Hours

List of Experiments

1. Introduction to use of computers for numerical calculations
2. Solution of linear algebraic equations using Gauss elimination, Gauss-Siedel etc.
3. Solution of a non-linear equations using bracketing and Newton-Raphson method
4. Interpolation and Approximation
5. Numerical integration
6. Euler method
7. Runge-Kutta methods for ODEs
8. Solution of system of ODEs using simple methods
9. Solution of simple PDEs

Inorganic Process Technology Laboratory

Subject Code CT- BS-409 P (BGE)

Lecture: 0 Hrs **Practical Duration: 03 Hr** **No. of Credits:1.5**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 03 Hours

LIST OF EXPERIMENTS

1. To Prepare the Crystals of Chrome alum.
2. To Prepare Mohr's salt.
3. To estimate the amount of impurities in a given sample of common salt.
4. To purify the given sample of Common salt.
5. To Prepare Cuprous Chloride.
6. To estimate the % available Chlorine in a given sample of Bleaching powder.
7. To Prepare the Crystals of Sodium Thiosulphate.
8. To estimate the amount of ferrous & ferric in pigment Red Oxide.
9. To Prepare the Crystals of Ferrous Sulphate from Kipp's apparatus waste.
10. To estimate Sulphate in a given solution by EDTA method.

Engineering Workshop

Subject Code: CT-GES-410 P

Lecture: 0 Hrs **Practical Duration: 03 Hrs** **No. of Credits: 1.5**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 3 Hours

Objectives:

The idea of this course is to understand the concepts involved in product realization by carrying out manufacturing shop exercises. Hands-on practice with manufacturing shop exercises and assembly leading to realization of a new product in a group. Students will also be introduced to the importance of manufacturing planning.

Course outcomes

Students will realize the importance of:

- Manufacturing planning.
- Computer numerically controlled machines.

Contents:

1. Introduction to the course and its objectives; mandatory briefing on shop-floor safety. Introduction to all manufacturing forms and introduction to basic tools (hand tools and power tools).

2. Overview of engineering materials and forms in which they are commonly available as raw materials. Typical component manufacture with materials like wood.

3. Overview of shape realization by manufacturing, measurement of manufactured parts. Associated with: Machine shop exercises- involving sawing, turning and drilling, milling, grinding and joining. Inspection of manufactured component using simple metrology instruments.

4. Overview of computer numerically controlled machines Machine shop exercise using CNC - Part modelling, CNC program generation and cutting part on CNC milling machine.

5. Use of plastics and composites as engineering materials. Practical: Hands-on exercise involving plastics - use of injection moulding, extrusion etc.

Texts/References

1. Elements of Workshop Technology, Vol. I by S. K. Hajra Choudhury, 13th Edition, 2003, Asia Publishing House.

2. Elements of Workshop Technology, Vol. II by S. K. Hajra Choudhury, 13rt Edition, 2003, Asia Publishing House.

3. Workshop Practice by H. S. Bawa, 1st Edition, Tata-McGraw Hill, 2004.

Environmental Sciences: MC Audit Course

Course Objectives:

The student on completion of course will understand the Ecosystem, Environmental issues related with social and human population, Biodiversity and its conversion.

Course Outcomes: The student on completion of course will be able:

CO 1: To understand and apply the Multidisciplinary nature of environmental studies.

CO 2: To understand the importance of Natural Resources and its conservation.

CO 3: To understand the classification of ecosystem and importance of conservation of biodiversity.

CO 4: To understand the sources of pollution, ill effects of pollution and prevention methods of pollution.

Unit 1: Multidisciplinary nature of environmental studies: Definition, scope and importance, Need for public awareness.

Unit 2: Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Energy resources: Growing energy needs, renewable and non-renewable, energy sources, use of alternate energy sources. Case studies.

d) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

Unit 3: Ecosystems: Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids.

Introduction, types, characteristic features, structure and function of the following ecosystem: -

a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and its conservation: Introduction – Definition: genetic, species and ecosystem diversity. Biogeographical classification of India, Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National

and local levels, India as a mega-diversity nation, Hot-sports of biodiversity. Threats to biodiversity.

Unit 4: Environmental Pollution: Definition • Cause, effects and control measures of: - a. Air pollution b. Water pollution c. Noise pollution d. nuclear hazards. Solid waste Management: Causes, effects and control measures of urban and industrial wastes. • Role of an individual in prevention of pollution. • Pollution case studies.

Project work: Case studies

Text Books:

1. Erach Bharucha: "A Text Book of Environmental Studies"

2. M. N. Rao and HVN Rao: "Air Pollution"

3. S.S. Dara: "Environmental Chemistry and Pollution Control"

4. Mahesh Rangarajan: "Environmental Issues in India"

5. D.L. Manjunath: "Environmental Studies".