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**NORTH MAHARASHTRA UNIVERSITY,
JALGAON - 425 001**

**SYLLABUS
FOR**

**M. Sc. [Chemical Technology]
From June, 1993**

Semester I to IV

Department of Chemical Technology

M.Sc. CHEMICAL TECHNOLOGY

FIRST YEAR

- CHT-101 APPLIED MATHEMATICS
- CHT-102 APPLIED CHEMISTRY
- CHT-103 BASIC PRINCIPLES OF CHEMICAL PROCESSES
- CHT-104 COMPUTER PROGRAMMING AND UTILIZATION
- CHT-105 LABORATORY COURSE-I

SEMESTER - II

- CHT-201 MOMENTUMS TRANSFER
- CHT-202 CHEMICAL ENGINEERING THERMODYNAMICS
- CHT-203 CHEMICAL PROCESS CALCULATIONS
- CHT-204 CHEMICAL PROCESSES TECHNOLOGY
- CHT-205 LABORATORY COURSE-II

SEMESTER - III

- CHT-301 MATERIAL TECHNOLOGY
- CHT-302 CHEMICAL REACTION ENGINEERING
- CHT-303 MASS TRANSFER OPERATIONS
- CHT-304 HEAT TRANSFER OPERATIONS
- CHT-305 LABORATORY COURSE III

SEMESTER - IV

- CHT-401 INSTRUMENTATION AND PROCESS CONTROL.
- CHT-402 CHEMICAL EQUIPMENT DESIGN
- CHT-403 UNIT PROCESSES IN ORGANIC SYNTHESIS.
- CHT-404 LABORATORY COURSE-IV
- CHT-405 PROJECT

M.Sc. [CHEMICAL TECHNOLOGY]

{Two year Course}

FIRST YEAR SEMESTER - I

Subject codes	Subject	Scheme of Examination		
		Internal	External	Total Marks
CHT-101	APPLIED MATHEMATICS	40	60	100
CHT-102	APPLIED CHEMISTRY	40	60	100
CHT-103	BASIC PRINCIPLES OF CHEMICAL PROCESSES	40	60	100
CHT-104	COMPUTER PROGRAMMING AND UTILIZATION	40	60	100
CHT-105	LABORATORY COURSE-I	40	60	100
TOTAL		200	300	500

CHT-101 : APPLIED MATHEMATICS

A) STATISTICS - Frequency distribution, Measures of centre, tendency, mean, median, mode, Measure of variability, Range, Percentiles, Variance, standard Deviation, skewness, moments, Discrete random variables, Normal distribution, Properties of normal distribution, Coefficient of correlation, Lines of Regression, Rank Correlation, Time series.

B) NUMERICAL METHODS :- Finite Differences of first and higher order, Forward, Backward, Central and Divided differences, Difference tables, Taylors operators-D, shift-operator, Averaging, operator- Differences of polynomials, Factorial polynomials, Newtons forward and backward difference, interpolation, polynomials, Stirling and Bessel's interpolation formulae, Lagrang's and Newtons divided difference interpolation polynomials, solution of Linear algebraic simultaneous equation by Gaussian elimination, Gauss-seidel, and Jacobi, iterative methods.

C) DEFINITION OF TRIGONOMETRIC AND FOURIER SERIES:- Fourier coefficients Dirichlet's conditions, statement of Dirichlet's theorem, Expansion of functions in Fourier series, Even and odd functions, Half range Fourier series complex form of Fourier series, Differentiation and integration of Fourier series, Fourier series with respect to set of orthogonal functions over (a,b) . [Fourier Series over $(-1, 1)$, $(0,2)$ and for arbitrary range $(a, a+2L)$ must be treated].

(1) Water Treatment : Soft water, hard water, methods of softening of hard water, lime-soda, zeolite and ion exchange processes. Calculation of softening reagents. Estimation of hardness of water - EDTA and soap titration method. Characteristics of boiler feed water and boiler troubles.

(2) Fuels : Fuels and their classifications, calorific value, types of coal and its analysis, preparation and properties of metallurgical coke, classification origin and refining of petroleum, -methods of cracking, synthetic gasoline, purification of gasoline, knocking, octane number, cetane number. Natural gas, coal gas, producer gas water gas. Simple problems based on calorific value and combustion calculations.

(3) Synthetic Fibers : Classification, types of polymerization, classification of plastics, constituents of plastics. Fabrication of plastics, Engineering properties and uses of plastics. Manufacture, properties and uses of plastics. Manufacture, properties and uses of thermoplastics like polyethylene, polystyrene, and thermosetting resins like urea-formaldehyde, phenol-formaldehyde. Common types of synthetic rubber like neoprene, Thiokol, Silicone, polyurethane. Industrial uses of rubber recovery of waste rubber.

(4) Lubricants : Mechanism of lubrication, classification, properties, testing and selection of lubricants.

(5) Refractories : Definition, Criteria of good refractory, classification, properties, conditions which lead to failure of refractories and testing of refractories, manufacture, properties and uses of common refractories.

(6) Corrosion : Electrochemical corrosion, factors affecting the rate of corrosion, different types of corrosion, Metallic, in-organic and organic coating for corrosion protection.

(7) Environmental Pollution :

- i. Air pollution : Introduction, environmental segments, composition of the atmosphere, atmospheric structure, classification of air pollutants and their effects, control of air pollution, techniques employed for the control of air pollution.
- ii. Water pollution: Introduction, classification of water pollutants, methods used in waste water treatment.
- iii. Soil pollution : Introduction, causes of soil pollution, control of soil pollution.

Recommended Books :-

1) Engineering Chemistry	-	P.C. Jain
2) Engineering Chemistry	-	S.S. Dara
3) Engineering Chemistry	-	Agrawal
4) Polymer Chemistry	-	Gowariker.

Importance of Chemical Industry, its Development and Growth.

-Importance of the chemical Industry, New Developments in Chemical Technology, The Quality and production cost of Chemical products,

Basic Principles of Chemical Technology

-A Chemical Technological process, Classification of Chemical Technological process, Chemical Equilibrium, Rates of Technological Processes, Method of increasing the process rates, Technological Schemes.

Reactors types

-For homogeneous processes, Heterogenous processes in Gas-liquid, liquid-solid & Gas-Solid.

Introduction to unit processes and unit operations

Industrial Processes

Sulphur Industries - Production of Sulphuric acid

Nitrogen Industries - Production of Nitric acid, Ammonia, Urea, Ammonium Nitrate.

Phosphorus Industries - Production of Calcium phosphates

Cement and lime Industries

Starch and sugar industries

Recommended Books

1. C.E.Dryden, Outline of Chemical Technology - Ed. by M.Gopal Rao & Marshall Sittig Affiliated East-West Press.
2. R.N.Shreve & J.A. Brink, Chemical Process Industries, McGraw Hill, 3rd Ed.

1. Logical organization of computer system, introduction to number systems, introduction to computer programming. Algorithms & flow charts, programs development process.
2. Introduction to FORTRAN-77, Character set, data types, expressions, operations, standard functions.
3. Sequential Structures:
 - .Assignment Statement
 - .Input & output statements (List-directed)
 - .STOP Statement
 - .END Statement
4. Selective Structures
 - .GOTO Statements : Assigned GOTO, Computed GOTO.
 - .IF Statements : Logical IF, Block IF, Arithmetic IF.
 - .Nested Block IF structures
 - .Multi - alternative selective structure
5. Repetative Structures :
 - .IF Loop
 - .DO Loop
 - .Nested DO Loop
6. Subscripted variables : Notation
 - Arrays
 - .DIMENSION Statement
 - .Input/Output of arrays
 - .PARAMETER Statement
7. Format - Directed Input & Output
 - .Input/Output Statements
 - .FORMAT Statement
 - .Format Specifications
8. Subprograms
 - .Purpose & use
 - .Functions : Library, Statement, Function subporgrous
 - .Subroutine : CALL Statement
 - .DATA, SAVE, COMMON Statements.
9. File processing
 - .Opening & closing files
 - .Obtaining information about a file
 - .File input & output
 - .File positioning

10. Additional features.
Writing FORTRAN - 77 programs for the following.
1. Finding largest/smallest of given number using array & without array.
 2. For arranging given numbers in Ascending/Descending order using array & without array.
 3. Matrix Multiplication
 4. To find Transpose of a given Matrix
 5. Find $\sin x$ using Taylor's series & compare the obtained value with the value obtained using standard function.
 6. To accept any $\sqrt{\text{integer}}$ number & write it in reverse order. Also find sum of its digits.
 7. Generate first 100 prime number starting from any prime no.
 8. Find GCD of given numbers.

Text Books

1. V. Rajaraman, Computer programming in FORTRAN-77, PHI (1990).
2. Programming with FORTRAN-77, Ram Kumar, TMH

Reference

1. Device & Hoffma FORTRAN-77 : A structured
Disciplined style
Mc Graw Hill
2. Kernighan B.W. & Plughter P.J. : Elements of programming
style
Mc Graw Hill, New York

List of Experiments for 1st Semester

PART A

1. Kinetics (Volumetric and colourimetry).
2. Saponification value.
3. Refractometry
4. Determination of D.O.D.
5. Ore Analysis
6. Iodine Value
7. Complex preparation
8. Spectrophotometry

PART B

1. Conductometric titration of mixture of acids
2. Column **chromatography**
3. pH metric titrations.
4. Experiments on Potentiometry
5. Separation techniques
6. Flame photometry

PART C : LIST OF EXPERIMENTS FOR COMPUTER PROGRAMMING

1. Finding Largest/Smallest of given numbers using array & without array.
2. Arranging numbers in ascending & descending order using array & without array.
3. Matrix Multiplication
4. To find Transpose of a given matrix
5. Find $\sin(x)$ using Taylor Series Expansion & Compare the obtained value with the value obtained using standard function.
6. To accept any integer number & write it in reverse order. Also find sum of its digits.
7. Generate first 100 prime numbers starting from any prime number.
8. Find GCD of given numbers.

NOTE :

STUDENTS ARE ADVISED TO COMPLETE AT LEAST 6 EXPERIMENTS FROM "PART, A" AND 5 EXPERIMENTS FROM "PART B & C" .

M.Sc. [CHEMICAL TECHNOLOGY]

SEMESTER - II

Subject codes	Subject	Scheme of Examination		
		Internal	External	Total Marks
CHT-201	MOMENTUM TRANSFER	40	60	100
CHT-202	CHEMICAL ENGINEERING THERMODYNAMICS	40	60	100
CHT-203	CHEMICAL PROCESS CALCULATIONS	40	60	100
CHT-204	CHEMICAL PROCESSES TECHNOLOGY	40	60	100
CHT-205	LABORATORY COURSE-II	40	60	100
TOTAL		200	300	500

In the summer vacation students should undergo industrial training and submit a report.

a) Introduction

Scope and applications of fluid mechanics. Newton's law of viscosity, Classification of fluids, Newton's and non-Newtonian fluids, Ideal and real fluids, systems of units, Physical properties of fluids - density, specific weight, specific volume, specific gravity, viscosity, (dynamic and kinematic viscosity). Compressibility, cohesion, adhesion, surface tension, capillarity, vapour pressure.

(b) Fluid Statics

Liquid pressure at a point, Variation of pressure in a liquid, Pascal's law, Atmospheric pressure, gauge pressure, negative pressure & absolute pressure

Measurement of pressure - simple manometer, differential manometer, mechanical gauges

Total pressure & centre of pressure, total pressure on plane and curved surfaces, pressure diagram, practical applications of total pressure and centre of pressure for gates and tanks.

Relative equilibrium, fluid masses subjected to uniform linear acceleration and rotation, free and forced vortices.

(c) Kinematic fluids flow

Velocity of fluid particle, types of fluid flow - steady and unsteady, uniform and non-uniform, laminar, and turbulent, one, two and three dimensional flows, stream lines, path lines and streak lines, stream tubes. Equation of continuity for one dimensional and three dimensional flows.

Acceleration of fluid particle, rotational irrotational motions stream functions, velocity potential and equipotential lines, flow net, graphical and experimental methods of drawing flow nets. use of flow net.

(d) Dynamics of fluid

Forces acting on fluids in motion, Euler's equation of motion along streamline and in three dimensional form, Bernoulli's equation as an integration of Euler's equation of motion. simple applications of continuity and Bernoulli's equations such as pitot tube, venturimeter, orifice meter cavitation.

(e) Flow through Opening

Orifices, mouthpieces, coefficients of velocity, contraction and discharge, flow through nozzles, sluice gates, flow through orifice and mouth piece under varying head, time of emptying of tank by means orifices.

(f) Flow through pipes

Laws of fluid friction, Darcy-Weisbach equation, Reynold number, Energy losses in pipeline, hydraulic gradient line and total energy line pipes in series or compound pipe, equivalent pipe, pipes in parallel, flow through, a bye-pass, branched pipes.

Water hammer - cause, effect and remedial measures.

(g) Centrifugal pump

Typical lay out of accessories, component parts working and types of centrifugal pump, Head of a pump, efficiency & power for a centrifugal pump, selection, troubles and remedies of centrifugal pump.

Books Recommended

1. Fluid mechanics and hydraulics by Ranald V. Giles.
2. Fluid mechanics and hydraulics by Modi & Seth
3. Fluid mechanics and hydraulics by Jagdish Lal
4. Fluid mechanics by Kumar
5. Fluid Mechanics by K.R.Arora

CHT 202: CHEMICAL ENGINEERING THERMODYNAMICS

Review of the first and second law of thermodynamics and other basic concepts, carnot's cycle - engine and theorem, otto engine, power engine, Rankine cycle, liquefaction of gases, claud's process, Lende's process, Jule-Thompson effect, volumetric properties of pure fluids, heat effects and thermochemistry, thermodynamic properties of fluids, generalised correlations, property of homogeneous mixtures, partial molar properties, fugacity, fugacity coefficient, activity coefficients, phase equilibria, vapour-liquid equilibria, Gibbs - Duhem equation, chemical reaction equilibria, thermodynamics of flow processes, refrigeration.

Books recommended :

1. Introduction to chemical reaction Thermodynamics
Smith Van Ness, McGraw Hill.
2. Chemical Engineering Thermodynamics - S.N. Pandey,
J.C.Chaudhari, Khanna Publishers, Delhi.
3. Chemical Thermodynamics - Reid, McGraw Hill.



1. Dimensions and Units - Introduction, dimensions and system units, Fundamental quantities, derived quantities, conversions, recommendations for use of units
2. Basic Chemical Calculations - Introduction, mole, atomic and molecular weight, equivalent weight, solids, liquids, solutions, Important physical properties of solutions, Gases
3. Material Balances Without Chemical Reactions - Introduction, Process flowsheets, material balances, Graphical solution of problems, Recycling and bypassing operations
Material balances of unsteady operations
4. Material Balances Involving Chemical Reactions - Introduction, Energy and thermochemistry, energy balances, heat capacity of gaseous mixtures, specific heat of liquid mixtures, latent heats, enthalpy change during phase transfer accompanied by sensible heat changes, equilibrium flash calculations of multicomponent system, enthalpy changes accompanying chemical reactions, absolute enthalpy, Adiabatic reactions, thermochemistry of mixing processes, dissolution of solids, liquid-liquid mixtures, gas-liquid systems, heat of solution by partial molal quantities.
5. Stoichiometry and unit operations - Introduction, distillation, absorption and stripping, extraction and leaching, crystallization, psychrometry, Drying, Evaporation, Len conventional Operations.
6. Combustion, Introduction, Fuels, Calorific Values of Fuels, Coal, Liquid Fuels. Air Requirement & Flue Gases Combustion calculation.
7. Stoichiometry & Industrial Problems Introduction.
8. Stoichiometry & Digital Computation-Introduction, Application/ justification Analog computation Vs Digital Computation, Use of Programmable Calculators, Programming Languages, General Procedure

Books Recommended

1. Stoichiometry- Bhatt B.T. & Vora Ed.2, TataMcGraw Hill
2. Basic Principles and Calculations in Chemical Engineering - Himmelblau D.M., Ed.4, Prentice Hall
3. Chemical Engineering Calculations- Shukla S.D. & Pandey G.N. Lion Press, Kanpur

1. Natural Products Industries-Oils, Soaps, Detergents, glycerine
2. Synthetic Organic Chemical Industries -
 - i. Petrochemicals- refineries
 - pyrolysis and cracking
 - reforming
 - polymerization
 - alkylation
 - isomerization
 - Hydrodealkylation
 - ii. Chemicals from C compounds -
 - 1
 - Methanol
 - Formaldehyde
 - Chloromethanes
 - iii. Chemicals from C compounds -
 - 2
 - ethylene & acetylene
 - vinyle chloride,
 - ethylenoxides
 - iv. Chemicals from C compounds -
 - 3
 - Isopropanol,
 - Cumene,
 - acrylonitrile,
 - oxoprocess.
 - v. Chemicals from C compounds -
 - 4
 - Butadiene
 - vi. Chemicals from aromatics -
 - Phenol,
 - Styrne,
 - Phthalic anhydride
 - Maleic anhydride.
3. Polymerzation Industries: -
 - Phenolformaldehyde

Books Recommended

1. Outlines of chemical industries - Dryden, Affiliated East West Press.
2. Chemical Process Industries - B. Shreve, McGraw Hill, IIIrd edition.

A.

1. Viscosity measurement and its relationship with molecular weight of polymers..
2. End Group analysis
3. Viscosity by Brookfield Viscometer
4. Flash point by Pensky Marken's apparatus
5. Flash point by Abel's Apparatus
6. Synthesis of Novolak resin.
7. Synthesis of polyethylene terphthalate
8. Determination of B.O.D.
9. Relative surface tension of solvents.

B) Instrumental methods.

1. Gas chromatography
2. I.R.
3. N.M.R.

1. Measurement of pressure by 1. manometers 2. Bourdan's gauge
2. Coefficient of venturimeter
3. Verification of Bernoullies theorem
4. To determine coefficient of discharge, coefficient of contraction and coefficient of velocity for a short edge circular orifice
5. To determine coefficient of discharge of a rectangular notch
6. To determine coefficient of discharge of a triangular notch
7. To determine coefficient of friction for a circular pipe
Study Experiments
8. To observe various types of flows a)Reynold experiment
b) Heleshaw apparatus
9. Study and use of component parts of centrifugal pump

M.Sc. [CHEMICAL TECHNOLOGY]

SEMESTER - III

Subject codes	Subject	Scheme of Examination		
		Internal	External	Total Marks
CHT-301	MATERIAL TECHNOLOGY	40	60	100
CHT-302	CHEMICAL REACTION ENGINEERING	40	60	100
CHT-303	MASS TRANSFER OPERATIONS	40	60	100
CHT-304	HEAT TRANSFER OPERATIONS	40	60	100
CHT-305	LABORATORY COURSE III	40	60	100
TOTAL		200	300	500

Chemical Reaction Engineering Practical courses in (1) Material technology (2) Mass Transfer (3) Heat Transfer (4)

Solid State :-

Electrons and Bonding, wave mechanics and electron behaviour, electronic structure of atoms.

Metallic bonding, ionic bonding, and secondary bonding, atomic packing - directionally and non-directionally bonded atoms.

Crystal structure - space lattice, ionic and molecular crystals, interfacing in crystals, point, line surface and volume imperfections.

Noncrystalline solids - Elastomers, Long chain molecular compounds and three dimensional networks.

Electronic Properties of Materials

Electrical conduction, Band model, wave mechanical model, Electrical sensitivity, semiconductors, hall effect, thermoelectricity seebeck, Thomson and Peltier effects, Thermoelectricity in semiconductors.

Magnetism-Magnetization, diamagnetism, Paramagnetism, Ferromagnetism, Magnetic energy and domain structure, Elements of superconducting and dielectric materials. Relation between microstructure and mechanical properties.

Mechanical Properties of Materials

Elasticity, mechanism of elastic action, Linear and nonlinear elastic properties. Elasticity yielding in crystals, dislocations, strain hardening, ductile, brittle and creep characteristics of common engineering materials.

Books Recommended

- 1) The structure and Properties of Materials - W.B. Moffatt, G.W. Peausell, and J. Wulf.
- 2) The Structure and Properties of Materials - A. Rose, L.A. Steford and J. Wulf.
- 3) Experiments in Material Science - E.C. SubbaRao.

CHT 302 Chemical Reaction Engg.

Kinetics- Rate of reaction, variables affecting the rate of reaction order and molecularity, interpretation of kinetic data in batch and flow systems, theories of reaction rate, kinetics of unimolecular reactions

Catalysis, nature of catalytic reactions, adsorption on solid surfaces, physical adsorption and chemisorption, adsorption isotherm, physical properties of solid catalyst, surface area determination, pore size, catalyst preparation and general behaviour.

Kinetics of solid catalytic reaction, diffusion and surface reaction rate controlling, quantitative interpretation of kinetic data, H.R.U. concept, internal diffusion in porous catalyst.

Introduction to reactor design - Classification of reactor, design equation for flow and batch reactors, space velocity and residence time in tubular flow reactors, homogeneous and heterogeneous reactors, Mechanical features of these reactors.

Gas liquid reactions Mass transfer with Chemical reactions.

Books Recommended

- 1) Chemical Reaction Engineering
Levenspiel O., McGraw Hill.
 - 2) Chemical Engineering Kinetics,
Smith J.M., McGraw Hill.
 - 3) Chemical Reactor Theory
Denbigh K.G., and Turner K.G.
 - 4) Chemical kinetics and Reactor Calculations, Prentice Hall,
1974, H.S.Fogler.
 - 5) Chemical Reactor Design, Vol. I, and II 1970 H.W.Rase.
 - 6) Chemical Process Principles, vol. III by Hougen & Watson
 - 7) Reaction Kinetics for Chemical Engineers by Hill
- B. Gas liquid reaction by Dane.

CHT-303 MASS TRANSFER OPERATIONS

Equipment for Gas Liquid operations :

- Plate Columns - Bubbles cap plate column, Sieve plate column, valve plate column
- Packed Columns - Differential types of packings, column internals like packing supports, liquid distributors and redistributors, relative merits of plate and packing columns, flooding, loading characteristics of plate and packed column, Mechanically agitated vessels.
- Distillation - vapour Liquid Equilibrium
P-XY, T-XY, XY diagrams

- Raoult's Law, Dalton's Law
- Derivation of relative relation between various terms like total pressure, vapour pressure, liquid phase and gas phase composition using above laws.

Volatility of components, Relative, Volatility, relation between relative volatility and liquid phase and gas phase composition.

Methods of Distillation - Differential or simple distillation - Material Balance (Raleigh's Equation)

Flash or Equilibrium distillation - Material Balance,
Fractional distillation or rectification - Material Balance
Analysis of Fractionating Column - McCabe and Thiele Method, PONCHON and SAVARIT Method.

Feed plate location = q - line (feed line Equation)
Effect of feed condition on q -line
Reflux Ratio, minimum reflux ratio & optimum reflux ratio Batch distillation,
Azeotropes, Azeotropic distillation, Extractive distillation.

Steam distillation
Packed Column Analysis - Concept of Height Equivalent to theoretical plate (HETP)

Concept of Height of Transfer Unit (HTU) & Number of transfer Unit (NTU)

Height of Packed Bed (Z) Calculation.

Absorption : Gas Liquid equilibria
Raoult's Law, Henry's Law
Material Balance -
(Operating line equation)
- Minimum liquid gas ratio for absorption
- Minimum solvent requirement
Number of theoretical stages required for absorption in plate column.

Packed Column - Concept of HETP (Height equivalent to theoretical plate)
- HTU (Height of Transfer Unit) & NTU (Number of Transfer Unit concept for absorption)

Calculation of packed bed height (Z)
Selection Criteria for solvent in gas absorption.

Extraction:

- Equilibrium condition
- Ternary System - Triangular Diagram
- Right angle triangular diagram
- Partially miscible system
- Invisible system

Extraction Operations: Single stage, multistage, cross-current operation, multistage continuous counter-current operation.

Extraction Equipments: Selection criteria of solvent and extraction.

ADSORPTION: Types of Adsorption, Nature of Adsorbent Equilibrium condition Freundlich Equation.

Single stage operation, minimum adsorbent requirement, multistage, cross-current operations.

Drying - Different terms used in drying process
Rate of drying curves
Time of drying under constant drying condition

Drying Equipment -

Crystallisation - Solution and solubility curves, crystal formation

Mier's super saturation theory
Yield of crystallization system
Methods of super saturation
Equipments for crystallization
Material balance over crystallizer

Books Recommended

1. Chemical Engineering by Richardson & Coulson
2. Unit Operation by Brown and associates
3. Mass Transfer operation by Trybel
4. Absorption & Distillation by Norman

CHT304 HEAT TRANSFER OPERATIONS

Modes of Heat Transfer : Conduction
Convection
Radiation

Conduction:

Fourier's Law of Conduction
Thermal Conductivity
Conduction through single flat wall,
Composite Wall
Electrical Analogy for solving the conduction problem.
Conduction through single cylinder
Composite Cylinder
Conduction through sphere
Composite Sphere.

Convection: Forced convection
Natural convection.

Individual heat transfer coefficient
Overall heat transfer coefficient
Fouling factor
Application of dimensional analysis to heat transfer by

Convection - for Natural convection
- for forced convection

Wilson Plot -

Combined heat transfer by conduction and convection
Condensation- dropwise and filmwise condensation

Condensation on surfaces - Nusselt's theory
Condensation on vertical, inclined, horizontal tubes.

Heat Transfer in Boiling Liquid : Mechanism of Boiling -

Different regimes of boiling like -

Natural convection
Nucleate Boiling
Transition Boiling
Film Boiling

Correlations in Boiling Heat Transfer -

Heat Exchange Equipments : Double pipe heat exchanger, shell &
tube heat exchanger, Finned tube heat
exchanger.

- Condenser
- Reboilers
- Plate Heat Exchanger
- Scraped Surface Exchanger
- Spiral heat Exchanger

Analysis of Heat Exchanger = Co-current, counter-current

Cross current exchanger.
 Calculation of Heat Transfer Coefficient,
 Heat Transfer Area for Process Heat Transfer

Radiation : Basic theory of Radiation Heat Transfer-Wave theory.

- Quantum Theory
- Absorption, Reflection, Transmission
- Black Body
- Kirshoff Law
- Stefan Boltzmann Law
- Wein Displacement Law
- Radiation Heat Transfer

Evaporation: Capacity, Economy, Steam Consumption of evaporation

-Boiling Point Elevation -Duhring's Law
 Material & Enthalpy balance in evaporator
 Types of evaporators
 Multiple Effect Evaporation - Forward feed, Backward feed, mixed-feed evaporation
 Vapour recompression

Books Recommended

- Process Heat Transfer - D.Q.Kern
- Introduction to Chemical Engineering - Badger & Banchero
- Unit Operations in Chemical Engineering - Mc-Cabe & Smith
- Chemical Engineering by Coulson & Richardson Vol-I
- Chemical Engineer's Hand Book - Perry
- Heat Transfer - Mc-Adams

CH-305 Laboratory course III

1. Stefan - Boltzman constant apparatus
2. Thermal conductivity of metal rod
3. Emmisivity of given plate
4. Critical heat flux at various bulk temperatures
5. Energy heat transfer coefficient for vertical tube losing heat by natural convection
6. pin-fin apparatus
7. Thermal conductivity of insulating powder
8. Tube in tube concentric
9. Dropwise and filmwise condensation

M.Sc. [CHEMICAL TECHNOLOGY]

SEMESTER - IV

Subject codes	Subject	Scheme of Examination		
		Internal	External	Total Marks
CHT-401	INSTRUMENTATION AND PROCESS CONTROL	40	60	100
CHT-402	CHEMICAL EQUIPMENT DESIGN	40	60	100
CHT-403	UNIT PROCESSES IN ORGANIC SYNTHESIS.	40	60	100
CHT-404	LABORATORY COURSE-IV	40	60	100
CHT-405	PROJECT	40	60	100
TOTAL		200	300	500

(1) Practical Course in Reaction Engineering and Design.

(6) Project - II : Practical/Theory work and report submission.

CI-401 INSTRUMENTATION AND PROCESS CONTROL

A) Instrumentation -

- i) Flow measurement
- ii) Level measurement
- iii) Temperature measurement
- iv) Pressure measurement
- v) Others
 - a. pH measurement
 - b. Density measurement
 - c. Viscosity measurement
 - d. Gas Liquid Chromatography GLC/HPLC
 - e. Mass Spectroscopy
 - f. I.R. Spectroscopy
 - g. NMR Spectroscopy
 - h. Humidity measurement
 - i. Thermal conductivity measurement

B) Control -

- a. Terminology
- b. Block Diagram, Transfer Function
- c. Feed back and feed forward control system
- d. Servo and regulator operation
- e. Inherent characteristics of control valves

Controllers

- a. ON-OFF, proportional
- b. Proportional Integral (P-I)
- c. Proportional Integral Derivative (PID) action
- d. Response of controllers to different forcing functions
- e. Valve positioners
- f. Valve Sizing

Books Recommended

1. Industrial Instrumentation - Eckman, Donald , Wiley Eastern
2. Instrumentation Devices and System - Rangan C.S., Sarma G.R., Mani V.S.V., Tata McGraw Hill, New Delhi
3. Principles of Industrial Instrumentation Patranabis D. Tata McGraw Hill, New Delhi
4. Instrumentation Measurement and Analysis Nakra B.C., Chaudhary K.K., Tata McGraw Hill, New Delhi
5. Process Control - Eckman, Wiley Eastern
6. Process Control - Peter Harriott, McGraw Hill.

Process & mechanical design of following process equipments

- i) Reaction vessel
- ii) Absorption column ; Sieve tray, Bubble cap
- iii) Distillation column ; tray, Packed column
- iv) Heat exchange equipments- Double pipe heat exchanger, shell tube heat exchanger, condenser, reboiler, evaporators
- v) Rotary drier
- vi) cooling tower

Books Recommended

- 1) Applied Process Design for Chemical and Electrochemical plants vol. I, II & III, 2nd ed. Ernest E. Ludwig
- 2) Process Equipment Design - M.V. Joshi
- 3) Process Equipment Design - Brownell & Young
- 4) Chemical Equipment Design - B.C. Bhattacharyya
- 5) Chemical Engineer's Hand Book - Perry

Amination by reduction - Introduction and definition, methods of reduction, Iron and Metal reduction, other metals and acid reductions, metal and alkali reduction, sulphide reduction

Amination by aminolysis - General discussion, aminating agents, Survey of aminating reaction, physical and chemical factors affecting aminolysis, catalysts used in amination reactions, corrosion and pH of the autoclave charge, kinetics and thermodynamics of aminolysis, design of reactors and auxiliaries, technical alkylation methods.

Alkylation - Introduction and types of alkylation, alkylating agents, factors controlling alkylation, equipment for alkylations, effect of alkylation and technical alkylation methods

Oxidation - Liquid and vapour phase oxidations, kinetics and thermochemistry, apparatus for oxidation, technical oxidation of iso-eugenol, acetaldehyde, cyclohexane, iso-propylalcohol, naphthalene, benzene and naphthalene sulphonic acid

Esterification and hydrolysis - esterification of organic acid, esterification of carboxylic acid derivatives, esters by addition to unsaturated system, interesterification of lard, technical preparation of ethyl acetate, cellulose acetate, nitroglycerine, polyethyl ether, phthalate. Kinetics thermodynamics and mechanism of hydrolysis. Technical preparation involving hydrolysis e.g. hydrolysis of fat preparation of furfural, glycol phenol from chlorobenzenes etc.

Hydrogenation - catalytic hydrogenation, kinetics and thermodynamics of hydrogenation reactions, apparatus and material of construction, Industrial processes, hydrogenation of fatty oils, synthesis of methanol.

Polymerization - general introduction, resin manufacturing process, condensation polymerization, addition polymerization, intermediates for resin - phenolformaldehyde, HMT, vinyl ester, phthalic anhydride.

Books Recommended

- 1) Unit processes in organic synthesis by P.H. Groggins
- 2) Outlines of chemical industries - Dryden.
- 3) Chemical Process Industries - B. Shrieve.

GRAPHICS

Introduction, Lettering, dimensions, and Standards, plane curves, orthographics views. Isometric views, perspective Development of surfaces, Mechanical Drawings (Nuts, Bolts, Screws, Beams etc), Information display techniques.

Isometric projections and oblique parallel projection, isometric scale.

Section of solids by different cutting planes (excluding oblique plane), true shape of section.

Machine elements, rivets, riveted joints, washers, foundation bolts, for locking arrangements.

BOOKS RECOMMENDED

1. Engineering Drawing - N.B. Bhatt.

Other practicals

1. measurements of pH, viscosity & density reaction mixtures
2. IR Spectroscopy
3. NMR Spectroscopy
4. Gas liquid chromatography
5. Humidity measurements
6. Thermal conductivity measurements

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