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**Revised Syllabus of B.Sc. II Year
(Semester III & IV)**

Industrial Chemistry

**Effective from June, 2010-2011
& onwards**

**Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad**

**Revised Syllabus of B.Sc. II Year Industrial Chemistry
(Effective from the Academic Year 2010-2011)
Since June, 2010 & onwards.**

**B.Sc. Industrial Chemistry
(Three Year Course)**

Year	Paper	Course Name	Hours	Marks
B.Sc. – III Semester				
B.Sc. II	IX	Unit Operation – III	45	50
	X	Chemical Reaction Engg – I	45	50
B.Sc. – IV Semester				
	XI	Unit Operation – IV	45	50
	XII	Chemical Reaction Engg – II	45	50
Practical Lab. Course				
	XIII	Unit Operation – III & IV	-	100
	XIV	Chemical Reaction Engg – I & II	-	100

B.Sc. II Year Industrial Chemistry

Hours: 45

Paper: IX

Marks : 50

Semester – III

Total 45 periods

Unit Operations – III

1. Overview of Mass Transfer Operations

General Overview – Introduction to Mass Transfer operations, Benefits, General Principles of Mass Transfer, Various types of Mass Transfer Operations & their importance.

05 Periods

2. Equilibrium Stage Operations

10 Periods

Introduction, Typical distillation equipment, Principles of Stage Processes, Terminology for Stage Contact Plants, Material Balances, Enthalpy balances, Graphical method for two component system, Operating line diagram, Ideal contact stages, Determining the number of ideal stages.

3. Distillation

15 Periods

Introduction, Flash Distillation, Simple Distillation, Steam Distillation, Rectification, Material Balances in Plate Columns, Number of Ideal Plates, McCabe Thiele Method, constant molal overflow, Reflux Ratio, Condenser and Top Plate, Bottom Plate and Reboiler, Feed Plate, Minimum Reflux, Optimum Reflux Ratio, Plate Efficiency, Types, Relations, Factors influencing plate efficiency, Rectification in packed towers, Batch Distillation.

4. Liquid Extraction

15 Periods

Terminology, Introduction to liquid-liquid extraction, Applications of Liquid-Liquid Extraction, Principles of liquid-liquid equilibria, Triangular diagrams, Types of extraction system, I & II, Temperature effects on systems types, Solvent selection, Commercial extraction system, Typical extraction system, Extraction calculations-Single Stage Operations, Multi Stage Cross Current Operation, Continuous multistage counter current operations, Design considerations for packed beds, Extraction Equipments-Mixer Settlers, Spray & Packed extraction towers, Perforated plate towers, Baffle towers, Agitated Tower extractor, Centrifugal Extractors.

Unit Operations – IV
Semester – IV
Total 45 periods

1. Gas Absorption**05 Periods**

Introduction, Design of Packed Towers, Contact between Liquid & Gas, Pressure drop & limiting flow rates, Principles of absorption material balances, Limiting gas-liquid ratio, Temperature variations in packed towers, Rate of absorption, Calculation of tower height, Number of Transfer units.

2. Evaporation**10 Periods**

Introduction, Liquid Characteristics, Types of Evaporators, Performance of Tubular Evaporators, Evaporator Capacity, Boiling Point Elevation and Duhring Rule, Effect of liquid head & friction on temperature drop, Heat Transfer Coefficient, Overall Coefficient, Evaporator economy, Enthalpy balance for single effect evaporator, Enthalpy balance with negligible heat of dilution, Single effect calculations, Multiple effect evaporators, Methods of feeding, Capacity and economy of multiple effect evaporator, Effect of liquid head and boiling point elevation.

3. Crystallization**15 Periods**

Importance of Crystal Size, Crystal Geography, Crystallographic systems, Invariant Crystals, Principles of Crystallization, Purity of Product, Equilibria & its yields, Enthalpy Balances, Super Saturation, Units of Super Saturation, Temperature differential as a potential, Nucleation-Origins of Crystals in crystallizers, Primary nucleation, Homogeneous nucleation, Equilibrium, Kelvin Equation, Rate of nucleation, Heterogeneous nucleation, Secondary nucleation, Contact nucleation, Crystal Growth-Individual & overall Growth Coefficients, Growth Rate, Mass Transfer Coefficient, Surface Growth Coefficient, ΔL law of crystal growth, Crystallization Equipment-variations in crystallizers, Vacuum Crystallizers, Draft Tube Baffle Crystallizer, Yield of Vacuum Crystallizer.

4. Drying of Solids**15 Periods**

Introduction, Classification of Dryers, Solid handling in dryers, Principles of Drying-Temperature Pattern in dryers, Heat Transfer in dryers, Heat duty, Heat Transfer Coefficient, Heat Transfer Units, Mass Transfer in Dryers, Phase Equilibria-equilibrium moisture and free moisture, Bound & unbound water, Cross circulating drying-constant drying conditions, Rate of drying, Constant rate period, Critical Moisture Content & Falling Rate Period, Calculation of Drying Time under constant drying conditions, Drying Equipments-Dryers for Solids & Pastes, Dryers for Solutions & Slurries.

Reference Books:

1. Unit Operations of Chemical Engineering – W.L.McCabe, J.C. Smith, Pter Harriott
2. Mass Transfer Operations- Robbert E. Treybal
3. Chemical Engineering Vol.2 – J.M.Coulson & J.F.Richardson
4. Principles of Mass Transfer Operations- Kiran D. Patil
(Nirali Prakashan, Pune)
5. Unit Operations-II – K.A.Gavhane
(Nirali Prakashan, Pune)

B.Sc. II Year Industrial Chemistry

Hours: 45

Marks : 50

Paper: X

Total 45 periods

Chemical Reaction Engineering –I

Semester – III**Paper - X**

Introduction & Notation in Chemical Reaction Engineering

02 Periods

1. Overview of Chemical Reaction Engineering

Typical Chemical Process, Classification of reactions, Variable Affecting the Rate of Reaction, Definition of Reaction Rate.

03 Periods

2. Kinetics of Homogeneous Reactions

The rate equation, Concentration-Dependent Term of a rate equation, Single & multiple Reactions, Elementary & Non elementary reactions, Molecularity & Order of Reaction, Rate Constant(K), Representation of an Elementary Reaction, Representation of Non elementary Reaction, Kinetic Models for Non elementary Reactions-free radicals, ions & polar substances, Molecules, Transition Complex, Non Chain Reactions, Chain Reactions-Free radicals, Chain reaction mechanism, Molecular intermediates, non chain mechanism, Transition Complex, non chain mechanism. Temperature-Dependent Term of a Rate Equation-Temperature Dependency from Arrhenius Law, Comparison of Theories with Arrhenius law, Activation Energy and Temperature Dependency, (Example 2.3).

20 Periods

3. Interpretation of Batch Reactor Data

Introduction of Batch Reactor, Constant-Volume Batch Reactor, Analysis of Total Pressure data obtained in a Constant-Volume System, Integral Method of Analysis of Data, Irreversible Unimolecular-Type First Order Reactions, Irreversible Bimolecular-Type Second Order Reactions, Zero Order Reactions, Overall Order of Irreversible Reactions from the Half-Life $t_{1/2}$, Irreversible reactions in Parallel, Homogeneous Catalyzed Reactions, Autocatalytic Reactions, Irreversible Reactions in Series, First Order Reversible Reactions, Second Order Reversible Reactions, Reactions of Shifting Order, Differential Method of Analysis of Data, Varying- Volume Batch Reactor, Differential Method of Analysis, Integral Method of Analysis, Zero Order Reactions, First Order Reaction, Second Order Reactions, The Search for a Rate Equation.

20 Periods

Chemical Reaction Engineering –II

Semester – IV

Paper – XII

Total 45 periods

- 1. Introduction to Reactor Design** **05 Periods**
Broad Classification of Reactor Types, Material balance for an element of Volume of the reactor, Energy balance for an element of Volume.
- 2. Ideal Reactors for a Single Reaction** **10 Periods**
Three types of Ideal Reactors, Ideal Batch Reactor, Space Time & Space Velocity, Steady State Mixed Flow Reactor, (Example 5.1, Example 5.3), Steady State Plug Flow Reactor, (Example 5.5), Holding Time & Space Time for flow reactors.
- 3. Design for Single Reactions** **20 Periods**
Size Comparison of Single Reactors, Batch Reactor, Mixed versus Plug Flow Reactors, First & Second Order Reactions, Multiple-Reactor Systems-Plug flow reactors in series and or in parallel, (Example 6.1), Equal size Mixed Flow Reactors in Series, First Order Reaction, Mixed Flow Reactors of Different sizes in Series, finding the conversion in a given system, Determining the Best System for a given conversion, Maximization of Rectangles, Reactors of types in series, Recycle Reactor & its performance equation.
- 4. Design for Parallel Reactions** **05 Periods**
Introduction to Multiple Reactions-Qualitative Discussions about Product Distribution.
- 5. Basics of Non-Ideal Flow** **05 Periods**
The Residence Time Distribution(RTD), E, The Age Distribution of Fluid, Relation among F, C and E curve and 'mean time' for closed vessel.

Reference Books:

1. Chemical Reaction Engineering - Octave Levenspiel
(Wiley India Pvt. Ltd. Third Edn.)
2. Chemical Reaction Engineering - K.A.Gavhane
(Nirali Prakashan, Pune)
3. Principles of Reaction Engineering – S.D.Dawande
(Central Techno Publication)

B.Sc. II Year Industrial Chemistry

Paper : XIII

Marks : 50 for each Lab. Course

Laboratory Course: Experiments on Unit Operations – III & IV

Experiments to be conducted in the academic year

Distillation:

1. To Perform an experiment on **Simple Distillation** using binary mixture (*Methanol+Water or Ethanol+Water*) & Verify the Rayleigh's Equation. Calculate the Material Balance for binary mixtures and find the composition of the distillate & the residue.
2. To Perform an experiment on **Steam Distillation** using *Turpentine* or *Nitrobenzene* and Calculate Material Balance for Steam Distillation..
3. To Perform an experiment on **Distillation with total reflux** using Binary mixture (*Methanol+Water or Ethanol+Water*) and Determine theoretical plates by McCabe-Thiele Method.

Liquid Extraction:

4. To study the experiment on Liquid-Liquid Extraction by using **Mixer Settler** System & Calculate Percentage of Extraction of a given liquid.
5. To study the Liquid-Liquid Equilibria for three component system (**Glacial Acetic Acid +Chloroform+ Distilled Water**) and Calculate the Percentage composition of each component at heterogeneous mixture

Drying:

6. To study the **Rate of Drying of solid** substances (*Saw dust or Card Board*)
7. To study the **Rate of Drying of Liquid** substances.
8. To study the rate of drying in **Tray Dryer**.

Crystallization:

9. To Crystallise the given sample of Phthalic acid from hot water using fluted paper and stemless funnel.
10. To Crystallise the given sample of Benzoic acid from hot water using fluted paper and stemless funnel.
11. To purify the given sample of naphthalene or camphor by simple sublimation method.
12. To purify the given sample of Succinic acid or phthalic acid by vacuum sublimation method.

Reference Books:

- 1 Unit Operations-II - K.A.Gavhane
2. Systematic Experimental Physical Chemistry – S.W.Rajbhoj & T.K.Chondhekar
3. Practical Chemistry – S. Umar, J. Sardar & A. Muley
4. University Practical Chemistry, Vishal Publishing Co. Jalandhar-P.C.Kamboj

B.Sc. II Year Industrial Chemistry**Paper : XIV****Marks : 50 for each lab. course****Chemical Reaction Engineering – I & II****Experiments to be conduct in the academic year.**

1. To Study the Performance of **Batch Reactor** : To study the Saponification of Ethyl acetate with NaOH in order to determine Order of reaction (n) & Rate constant (K) using Batch reactor.
2. To study the residence time distribution in **Mixed Flow Reactor (MFR)**.
3. To Study the Performance of **Plug Flow Reactor (PFR)**: To study the Performance of plug flow reactor used and to calculate thereotical & practical conversion for a second order reaction between Ethyl acetate & NaOH.
4. To find out Residence time distribution in **Plug Flow Reactor or Tubular reactor**.
5. To Study the Performance equation of **Coil Tube Reactor (CTR)**: To study the Performance of plug flow reactor used and to calculate thereotical & practical conversion for a second order reaction between Ethyl acetate & NaOH.
6. To Study the **First Order Reaction**: Hydrolysis of an Ester (Methyl Acetate in presence of HCL).
7. To Study the **Zero Order Reaction**: Investigate the kinetics of Iodination of Acetone.
8. To Study the **Autocatalytic reaction**: Reaction between Potassium Permanganate & Oxalic acid.
9. To Study the Rate of reaction (r_A) between Ethyl bromo acetate & Sodium thiosulphate kinetically using **Batch Reactor**.
10. To determine the Order of reaction (n) of given reaction Kinetics by using **Substitution method, Fractional change method and Differential method**.
11. To determine the Rate Constant (K) of the reaction between Potassium Persulphate & Potassium Iodide having equal concentration of reacting species (a=b) by using **Mixed Reactor**.
12. To determine the Rate Constant (K) of the reaction between Potassium Persulphate & Potassium Iodide having un equal concentration of reacting species (a**≠**b) by using **Mixed Reactor**.
13. To determine rate constant (K) of the reaction between Bromic acid and Hydroiodic acid having equal concentration of reacting species (a=b) using **Batch reactor**.
14. To determine the **Energy of Activation (E_a)** of hydrolysis of Ethyl acetate in presence of NaOH.
15. To determine the **Energy of Activation (E_a)** of the reaction between Potassium Persulphate & Potassium Iodide.

Note: 20 % weightage be given to the viva-voce in the practical examination.

Reference Books: 1.Chemical Reaction Engineering - K.A.Gavhane 2.Systematic Experimental Physical Chemistry – S.W.Rajbhoj & T.K.Chondhekar