**Enclosure - III**

**Shree Manibhai Virani and Smt. Navalben Virani Science College (Autonomous) , Rajkot.**

**Affiliated to Saurashtra University**

Department: **Industrial Chemistry** Programme: **M.Sc.**

| Semester - I | | |
|---|---|---|
| **Course Code** | **Course Title** | **Course Credit** |
| 18PICCC01 | **Core 1: Industrial Stoichiometry & Momentum Transfer Operations** | **3 Credits** |

**Course Description:**
A chemical or process plant is required to carry out transformation of raw material into desired products effectively, economically and safely. Therefore, this course deals with the fundamental concepts of industrial stoichiometry with and without chemical reactions and transportation of fluids as well. It also consists of designing of various flow meters, pressure devise and vacuum producing devises for industrial applications..

**Course Purpose:**

1. To understand and apply the basic concept of fluid flow and its applications in chemical industries.
2. To formulate material balance to solve for compositions and flow rates of process streams.
3. To understand fluid particles system and equipment's in chemical industries.
4. Derive energy balance for chemical processes and integrate with material balance calculations to solve the industrial problems..

**Course Outcomes:** Upon completion of this course, the learner will be able to

| **CO No.** | **CO Statement** | **Blooms taxonomy Level ($K_1$ to $K_6$)** |
|---|---|---|
| $CO_1$ | Understand the elementary concepts material and energy balance with and without chemical reactions. | K1, K2 |
| $CO_2$ | Understand and use process calculations for batch and continuous processes. | K1, K2 |
| $CO_3$ | Know the Design of fluid systems, flow meters, pressure vessels and vacuum producing devices. | K1, K2, K3 |
| $CO_4$ | Understand the basic phenomena for calculations of Rayleigh's and | K1, K2, K3 |

| | | |
|---|---|---|
| | Buckingham π methods for momentum transfer operations. | |
| $CO_5$ | Understand the advanced consideration for designing fluidized bed columns and apply concepts of mass, momentum and energy conservation to flows. | K3 |

| **Course Content** | **Hours** |
|---|---|
| **Module-I :: Industrial Stoichiometry (With Chemical Reaction)** | 10 hrs |
| • Material and Energy balance calculation for processes with chemical reactions recycle purge and by-pass operations<br>• Batch and continuous operations. | |
| **Module-II : Industrial Stoichiometry (Without Chemical Reaction)** | 10 hrs |
| • Material and Energy balance calculation for processes without chemical reactions recycle purge and by-pass operations<br>• Batch and continuous operations. | |
| **Module-III : Transportation Of Fluids** | 9 hrs |
| • Boundary layer concept, Types of fluid, flow pattern, Reynolds experiments.<br>• Construction, Working and power calculation for reciprocating and centrifugal pumps.<br>• Use of air vessels in pumps, Priming, Cavitation, Vapor locking and NPSH.<br>• Design of Flow meters, Pressure and Vacuum producing devices. | |
| **Module-IV : Momentum Transfer Operations-I** | 9 hrs |
| • Dimensionless analysis using Rayleigh's and Buckingham π method<br>• Motion of particles through fluids, calculations of Rayleigh's and Buckingham π method | |
| **Module-V : Momentum Transfer Operations-II** | 10 hrs |
| • Terminal settling velocity of particles settling under Stokes.<br>• Intermediate and Newton's range in free & hindered settling.<br>• Mechanism of fluidization.<br>• Design of fluidized bed columns. | |

| **Suggested laboratory experiments:** |
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| • Not applicable |

| **Pedagogic tools:** |
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| • Chalk and Board |
| • LCD and Videos. |
| • Instruments |

| **Text books** |
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| 1. K.A Gavhane, Introduction to process calculations (Stoichiometry), ISBN-9788190639668, Nirali Prakashan, 13th Edition, 2015. pp. 3.1-4.4.<br>2. Bhatt, H. T and vora S. M., 2004, Stoichiometry, India. Tata Mcgraw Hill Co.<br>3. Sachdeva, R.C, 2009, Fundametals of Engineering: Heat & Mass transfer. India. New age Science.<br>4. D. M., Himmelblau, 1997, Basic Principles and calculations in Chemical Engineering, New Delhi, Prentice Hall of India. |
| **Laboratory Manual/ Book** |
| • |

| **Suggested reading / E-resources** |
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| **Suggested MOOCs** |
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| • Stoichiometry Concepts- NPTEL<br>• Basics of Transport Phenomena by Delft University of Technology, Public University in Delft, Netherlands. |

| **Methods of assessing the Course Outcomes**<br>The COs of the course will be assessed through |
|---|
| • CIE<br>• SEE<br>• Assignment<br>• Quiz<br>• Seminar |

| Semester - I | | |
|---|---|---|
| **Course Code** | **Course Title** | **Course Credit** |
| 18PICCC02 | **Core 2:**<br>**Industrial Unit Operations** | **3 Credits** |

**Course Description:**
This course provides the introduction of Unit Operations and the essential background required to follow the specialized topics that follow.
The content of the course is as follows:

- Basic principles of diffusion and mass transfer
- Mass transfer theory applied to Gas absorption, distillation, extraction, drying, and filtration.
- Basic principles of heat transfer phenomenon in conduction, convection & radiation mode.
- Heat exchange equipment design.

**Course Purpose:**
The purpose of this course is to deepen the student's knowledge of the unit operations with a focus on mass transfer operation and heat transfer operation. This course will introduce student to fundamental principles of chemical processes analysis. The course will expose industrial chemist to various unit operations so as to enable them to improve the design and operation of the chemical industry.

**Course Outcomes:** Upon completion of this course, the learner will be able to

| CO No. | CO Statement | Blooms taxonomy Level ($K_1$ to $K_6$) |
|---|---|---|
| $CO_1$ | Learn fundamentals of mass transfer operations. | K1, |
| $CO_2$ | Apply principles of mass transfer to equipments used in gas absorption, distillation column, extraction, drying, and filtration operation. | K1, K2 |
| $CO_3$ | Understand fundamentals of heat transfer operations.. | K1 |
| $CO_4$ | Apply empirical equations to solve heat transfer problems in conduction, convection and radiation modes. | K1, K2, K3 |
| $CO_5$ | Design and analyze the performance of heat exchangers. | K3 |

| Course Content | Hours |
|---|---|
| **Module-I : Mass Transfer Operations-1** | 10 hrs |
| • Local and Overall Mass Transfer co-efficient:<br>• Gas Absorption: Choice of solvent for absorption, Minimum Liquid – gas ratio for absorbers, HETP in continuous contact equipments. | |

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|---|---|
| • Distillation: Use of McCabe Thiele method in the design of multistage tray towers, q-line equation, Effect of reflux ratio.<br>• Liquid Extraction: Choice of solvent for extraction Binodal solubility curves, Calculations for single stage and multi stage cross &countercurrent extraction. | |
| **Module-II : Mass Transfer Operations-2** | 9 hrs |
| • Drying: Rate of batch drying, Calculations for cross and through circulation drying, Rate of drying for continuous driers, Hold up in rotary driers.<br>• Filtration: Theory of Filtration, Filtration, Filtration in centrifuges. | |
| **Module-III : Heat Transfer – Conduction** | 9 hrs |
| • Local and Overall heat transfer co-efficient: Introduction to thermal diffusivity, Thermal insulators, Critical Radius of insulation, Fourier's law of heat conduction.<br>• Three Dimensional heat conduction equations in rectangular, Effect of variable thermal conductivity, Heat transfer from extended surfaces. | |
| **Module-IV : Heat Transfer – Convection** | 10 hrs |
| • Newton's law of heat convection Free and Forced Convection Calculation involving convection mode of heat transfers in rectangular.<br>• Understanding of overall Heat transfer coefficient for combined conduction & convection mode.<br>• Dropwise and film condensation, Heat transfer in Condensation on vertical, horizontal, inclined plates. | |
| **Module-V : Heat Transfer – Radiation** | 10 hrs |
| • Terminologies in radiation mode of Application for Planck's distribution law, Stefan Boltzmann Law and Kirchhoff's law.<br>• Radiation Shields, LMTD correction factors, Design of single and multi-pass exchangers, Effectiveness and number of transfer units for heat exchangers. | |

| **Suggested laboratory experiments:** |
|---|
| • Not applicable |

| **Pedagogic tools:** |
| --- |
| • Chalk and Board |
| • PowerPoint presentation and Videos. |

| **Text books** |
| --- |
| 1. K. A. Gavhane, 2009. *Unit Operations – II*. Pune: Nirali Prakashan<br>2. Robert E Treybal, 1981. *Mass Transfer Operations*. USA: McGraw Hill<br>3. McCabe & Smith, 2001. *Unit Operations in Chemical Engineering*. USA: McGraw Hill<br>4. Ravi S. Tank, 2016, Industrial Chemistry (Unit Operations), USA:Create Space |
| **Laboratory Manual/ Book** |
| • Not Applicable |

| **Suggested reading / E-resources** |
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| • Ullmann's Encyclopedia of Industrial Chemistry |
| • Perry's Chemical Engineers' Handbook<br>• Albright's Chemical Engineering Handbook<br>• Chemical Engineering Learning Resources by msubbu (http://msubbu.in/lecturenotes.html) |

| **Suggested MOOCs** |
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| • Introduction to Unit Operations (www.openlearning.com)<br>• Mass Transfer Opeartion-I (http://www.iitg.ac.in/cet/moocs.html) |

| **Methods of assessing the Course Outcomes**<br>The COs of the course will be assessed through |
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| • Short answer type questions<br>• Open ended questions<br>• Problem solving<br>• Presentations/ Report Writing<br>• Oral examination<br>• Multiple choice questionnaires<br>• Mid Semester and End Semester written examination |

| Semester - I | | |
|---|---|---|
| **Course Code** | **Course Title** | **Course Credit** |
| 18PICCC03 | **Core 3:**<br>**Organic Synthesis & Disconnection Approach** | **3 Credits** |

**Course Description:** Course comprises of formation, reaction and stability of organic intermediates, organic name reactions and rearrangements. Disconnection analysis and synthesis of various organic molecules using strategies I to IV.

**Course Purpose:** Understand the organic reactions and rearrangements. Able to write mechanism and applications of organic reactions and apply disconnection and design the synthesis.

**Course Outcomes:** Upon completion of this course, the learner will be able to

| CO No. | CO Statement | Blooms taxonomy Level ($K_1$ to $K_6$) |
|---|---|---|
| $CO_1$ | Understand the formation and reactivity and stability of nucleophiles, electrophiles, carbene, nitrene, ylides and alkynes. | K1, |
| $CO_2$ | Design syntheses of organic molecules and prediction of mechanism for organic reactions. | K1, K2 |
| $CO_3$ | Learn Principles, mechanism and applications of various name reactions. | K3,K4 |
| $CO_4$ | Learn principles and mechanism of rearrangements and their applications | K3, K4 |
| $CO_5$ | Design the disconnection and synthesis of various organic aromatic molecules. | K5 |

| Course Content | Hours |
|---|---|
| **Module-I : Free Radicals, Carbocation, Carbanions, Nitrene &Their Reactions** | 10 hrs |

- Introduction, Formation, Stability and name Reactions involving following intermediates: Free radicals, Carbocation, Carbanions & Nitrene.

| Intermediates | Name reactions |
|---|---|
| **Free radicals** | Birch Reduction |
| | Grignard Reaction |
| **Carbocation** | Baeyer-Villiger Oxidation |
| | Vilsmeier-Haack |
| **Carbanions** | Junjappa-Ila Annulation & Heteroannulation |
| | Dieckmann |

| | | |
|---|---|---|
| **Carbenes** | Arndt-Eistert | |
| | Reimer-Tiemann | |
| **Module-II : Enamines, Carbenes, Phosphorus Ylides, Benzyne &Their Reactions** | | 10 hrs |
| Introduction, Formation, Stability and name Reactions involving following intermediates: Enamines, Carbenes, Phosphorus ylides & Benzyne | | |
| **Module-III : Rearrangements** | | 10 hrs |
| • Principles, Reactions, Mechanism and applications of following rearrangements | | |
| **Module-IV : Disconnection Approach Strategy I & II** | | 9 hrs |
| • Basic principle: Synthesis of Aromatic Compounds,<br>• Strategy I: The order of events. One group C-X disconnections<br>• Strategy II: Chemo selectivity. | | |
| **Module-V : Disconnection Approach Strategy III & IV** | | 9 hrs |
| • Strategy III: Reversal of Polarity, Cyclisation reaction,<br>• Strategy IV: Protecting groups, one group C-C disconnection: Alcohols and Carbonyl compounds | | |

| **Intermediates** | **Name reactions** |
|---|---|
| **Phosphorus ylides** | Mitsunobu reaction |
| | Wittig |
| | Appel |
| **Nitrenes** | Hofmann Bromamide |
| | Schmidt |
| **Enamines** | Mannich |
| | Pictet–Spengler |
| | Storke Enamines |
| **Benzyne** | Diels Alder |

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|---|---|
| Claisen | Favorskii |
| Cope | Stevens |
| Pinacol- pinacolone | Wolff |
| Benzilic acid | 1,2-Wittig |
| Fries | Schlosser |
| Curtius | Beckmann |
| Lossen | |

| **Suggested laboratory experiments:** |
|---|
| • Not applicable |

| **Pedagogic tools:** |
|---|
| • Chalk and Board |
| • LCD and Videos. |

| **Text books** |
|---|
| • Ahluwalia, V. K. 2010. Organic Reaction Mechanism. India: Narosa Publishing House.<br>• Kurti, L. and Czako, B. 2005. Strategic Applications of Named Reactions in Organic Synthesis: Background and Detailed Mechanism. USA : Elsevier Academic Press.<br>• Bansal, R. K. 2007. A Textbook of Organic Chemistry. India: New Age International Pvt. Ltd.<br>• Warren, S. and Wyatt, P. 2009. Organic Synthesis – The disconnection approach, 2nd edition. Cambridge: Willey. |
| **Laboratory Manual/ Book** |
| • Not Applicable |

| **Suggested reading / E-resources** |
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| **Suggested MOOCs** |
|---|
| • Organic chemistry-1 & 2 on SWAYAM |

| **Methods of assessing the Course Outcomes**<br>The COs of the course will be assessed through |
|---|
| • Assignments<br>• Test<br>• Seminar<br>• Quiz |

| Semester - I | | |
|---|---|---|
| **Course Code** | **Course Title** | **Course Credit** |
| 18PICCC04 | **Core Practical 1:**<br>**Fluid Mechanics, Heat Transfer Operations,**<br>**Liquid Liquid extraction, Organic Synthesis** | **6 Credits** |

**Course Description:**

The practical course provides experience in a number of important chemical/pharmaceutical engineering unit operations and organic synthesis ensuring a thorough understanding of the principles of unit operation and the appropriate theory.

The course includes experiment design and development, experimental execution, data and error analysis, skills development in oral presentation, technical report writing, and team-building. The experiments are designed to illustrate the principles of fluid mechanics, heat transfer, liquid-liquid extraction, and organic synthesis.

**Course Purpose:**

The purpose of this course is to

1. Demonstrate skills in safe operation of laboratory equipment.
2. Analyze experimental data and observed phenomena.
3. Communicate experimental findings through formal written reports in high quality, and communicate with other team members
4. Work as part of a team in a mature and professional manner.

**Course Outcomes:** Upon completion of this course, the learner will be able to

| CO No. | CO Statement | Blooms taxonomy Level ($K_1$ to $K_6$) |
|---|---|---|
| $CO_1$ | Plan experiments and present the experimental data meaningfully. | K1, K2 |
| $CO_2$ | Apply theoretical concepts for data analysis and interpretation. | K2, K3 |
| $CO_3$ | Visualize and understand chemical engineering unit operations related to fluid and particle mechanics, and mass transfer operations such as extraction. | K3 |
| $CO_4$ | To critically evaluate data collected to determine the identity, purity, and yield of products. | K3, K4 |
| $CO_5$ | Employ safe laboratory practices handling laboratory glassware, equipment, and chemical reagents to perform common laboratory techniques, including reflux, distillation, steam distillation, recrystallization, vacuum filtration, aqueous extraction, thin layer chromatography, column chromatography. | K5 |

**Suggested laboratory experiments:**

**Fluid Mechanics:**

1. To determine the Reynolds number for flowing fluid using a Closed Circuit Reynolds Apparatus.
2. To determine the coefficient of discharge for a flow meter using closed circuit venturimeter and orifice meter apparatus.
3. To verify Bernoulli's theorem using Bernoulli's apparatus.
4. To calculate and study the energy losses in pipe fittings such as sudden contraction, sudden enlargement, bends & elbows and to determine flow through a Rotameter.
5. To calculate and study the energy loss due to pipe friction.
6. To determine coefficient of discharge Cd for notches and weirs of different shapes.

**Heat Transfer Operations:**

7. To find the critical radius of insulation thickness on a cylinder.
8. To determine the Emissivity measurement of grey surface at different temperatures.
9. To find out heat transfer coefficient and heat transfer rate from vertical in natural convection and to find emissivity of the cylinder surface.
10. To determine the Thermal conductivity of insulating powder (Asbestos) at various heat inputs.
11. To determine the thermal conductivity of poor conducting material, say asbestos sheet.
12. To determine the overall heat transfer coefficient of the composite wall & compare the same with that calculated from the equation.
13. To study and compare temperature distribution, heat transfer rate, overall heat transfer coefficient in parallel flow and counter flow heat exchanger.
14. To determine the value of Stefan Boltzmann constant for radiation heat transfer.
15. To plot the radial temperature distribution and to determine the thermal conductivity of pipe insulation.
16. To determine the thermal conductivity of a good conductor material, any brass.
17. To determine the variation of temperature along the length of pin fin under forced convection.
18. To determine the values of heat transfer coefficient under forced condition and to find theoretical values of temperature along the length of fin and effectiveness and efficiency of the pin-fin for insulated and boundary condition.
19. To determine and compare surface heat transfer coefficient for
    a) drop wise condensation & b) film wise condensation
20. To determine the average theoretical and experimental value of coefficient of heat transfer for forced convection for the fluid flowing through a pipe.

**Liquid-Liquid Extraction:**

21. To determine the distribution coefficients of carbon tetra chloride solvent for 20% aqueous acetic acid solution
22. To determine the distribution coefficients of Ethyl Acetate solvent for 20% aqueous acetic acid solution
23. To determine the distribution coefficients of Benzene solvent for 20% aqueous acetic acid solution
24. To develop solubility curve for the Ternary System Water(A) –CTC (B)-Acetic Acid(C)
25. To develop solubility curve for the Ternary System Water(A) –$CHCl_3$ (B)-Acetic Acid(C)
26. To develop solubility curve for the Ternary System Water(A) –Benzene (B)-Acetic Acid(C)

27. To determine the theoretical number of stages required for extracting acetic acid from its 10% solution of acetic acid in chloroform (50 ml) using water as solvent so as to limit its concentration in the final Raffinate to almost zero % and % recovery of acetic acid from its mixture using calculated number of stages in multistage cross current extraction.
28. To determine the quantity of Oil Present in a Oil Bearing Material.

**Organic Synthesis:**

29. To prepare Benzilic acid from Benzil (Benzil-Benzilic acid rearrangement)
30. To Prepare Hippuric acid from Glycine. (Benzoylation)
31. To Prepare Phenylurea from Aniline.
32. To Prepare 3-Methyl-1-phenyl-5-pyrazolone from Ethyl acetoacetate. (Cyclization)
33. To Prepare Resacetophenone from Resorcinol.
34. To Prepare m-Nitroaniline from m-Dinitrobenzene (Selective Reduction)
35. To Prepare p-Bromoacetanilide from Acetanilide (Bromination)
36. To prepare Acetanilide from Aniline (N-Acetylation)
37. To Prepare p-Bromo aniline from p-Bromoacetanilide (Hydrolysis)
38. To prepare p-Nitro acetanilide from Acetanilide (Nitration)
39. To Prepare p-Bromonitrobenzene from Bromobenzene (Nitration)
40. To Prepare p-Nitroaniline from p-Nitroacetanilide (Hydrolysis)
41. To prepare t-Butylchlrode from t-Butanol (Functional Grp Conv. Chlorination)
42. To Prepare Benzaldine aniline (Schiff Base) from Aniline. (Solvent free reaction)
43. To prepare Benzalacetophenone (Chalcone) from Acetophenone. (Carbanion)

| **Pedagogic tools:** |
| --- |
| • Chalk and Board |
| • PowerPoint Presentation and Videos. |

| **Text books** |
| --- |
| • Not Applicable |
| **Laboratory Manual/ Book** |
| • Manual of Industrial Chemistry Department, Shree M. & N. Virani Science College (Autonomous), Rajkot |

| **Suggested reading / E-resources** |
| --- |
| • Not Applicable |

| **Suggested MOOCs** |
| --- |
| • Not Applicable |

| **Methods of assessing the Course Outcomes**<br>The COs of the course will be assessed through |
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| • Performance in conduction of experiment.<br>• Record book.<br>• MCQ/Quiz.<br>• Viva Voce.<br>• Mid Semester & Semester End Practical Exam. |