



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code : 3144402

Semester : 4

Subject Name : Unit Process

Type of course : Basic Science

Prerequisite : Basics of organic chemistry and thermodynamics

Rationale : Process in which only physical changes and not chemical changes takes place are known as a unit operation. Process in which chemical changes takes place are considered as unit process. Unit process is grouped operations in chemical manufacturing system that are classified based on similarities and separated from others. A unit process is the smallest element considered in the life cycle analysis for which input and output data are quantified. Unit processes include processes such as oxidation, reduction, nitration, sulfonation, etc. Each unit process is a group having similarity characteristic features and factors, which can be studied as group like reacting agents, thermodynamic mechanism, kinetic considerations, equipment design, and process applications. All the unit operation processes wherein chemical reaction is made to take place to improve the efficiency of the equipment also falls under unit processes. For example, reactive distillation, reactive extraction, reactive absorption, etc.

Teaching and Examination Scheme :

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weigh tage
1	Introduction to Unit Processes : Concept of unit operation and unit processes, role of unit processes in chemical synthesis, classification of unit processes, characteristic features of unit processes, applications of thermodynamics in unit processes, factors affecting chemical processes, thermochemistry.	6	10
2	Hydrogenation : Hydrogen production technologies and properties, Catalytic hydrogenation and hydrogenolysis, Kinetics and thermodynamics of hydrogenation reactions, hydrogenation reactors, and Industrial processes.	6	10
3	Sulfonation and Sulfation : Sulfating-Sulfonating agents, Applications, Chemical and physical factors in sulfonation and sulfation, Thermodynamics mechanism, Kinetic considerations, Industrial equipment and techniques, Sulfonation of benzene, aniline.	8	12
4	Nitration : Classification of nitro-compounds, nitrating agents, Aromatic nitration, Thermodynamics, Kinetics of nitration process, Nitration of benzene, Toluene, Phenol, Glycerine, Naphthalene, Industrial equipment for nitration, Preparation of m-dinitrobenzene, tri-nitro toluene, Chloro-nitro benzenes, Continuous nitration process.	8	12



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5	Amination by Reduction : Methods of reduction, Bechamp method, Reduction mechanism, Catalytic hydrogenation, Sulfide reductions, Electrolytic reductions, Metal and alkali reductions, Sulfite reductions, Miscellaneous reductions, Preparation of Aniline, p-phenylene diamine, p-aminophenol.	8	12
6	Halogenation : Halogenating agents, Thermodynamic and kinetic considerations, Chlorination of methane, Ethane, Propane, Photo-halogenation, Manufacture of allyl chloride, Chloroacetic acid, Chloral hydrate, Ethylene chlorohydrin, Chloromethane(s), Vinyl chloride.	7	12
7	Oxidation : Oxidation reactions, Oxidizing agents, Liquid phase and vapor phase oxidation with air and oxygen, Catalysts used for Oxidation, Kinetics and thermodynamic considerations, Manufacture of phthalic anhydride, Acetaldehyde, Acetic acid, Benzaldehyde, Salicylic acid.	7	12
8	Esterification, Hydrolysis, and Alkylation : General aspects, types, reagents, equipment and typical processes.	9	15
9	Reactive Distillation, Reactive Extraction, Reactive Absorption : General aspects, benefits over conventional reaction-separation system, equipment, operations and applications.	5	5

Suggested Specification table with Marks (Theory) :

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	20	10	5	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books :

1. Groggins, P.H., "Unit Processes in Organic Synthesis", 5th Edition, McGraw Hill Ltd., 1995.
2. Desikan, P and Sivakumar, T.C., Unit Processes in Organic Chemical Industries, Chemical Engineering Education Development Centre, IIT Madras, 1982.
3. Morison, R.T. and Boyd, R.N., "Organic Chemistry", 6th Edition, Prentice Hall of India (P) Ltd, 2006.
4. Mukherjee, S. and Singh, S. P., "Reaction Mechanism in Organic Chemistry", 3rd Edition, Mc Millan India Ltd., 2000.
5. Jerry, M., "Advanced Organic Chemistry – Reactions, Mechanism and Structure", 4th Edition, John-Wiley and Sons, 1992.
6. Bruckner, R., "Advanced Organic Chemistry- Reactions Mechanisms", Academic Press,



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Course Outcomes :

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

Sr. No.	CO statement	Marks % weightage
CO-1	understand classification of Unit processes highlighting characteristic features	25
CO-2	apply thermodynamic and chemical kinetic principles to unit processes and study parameters affecting performance of unit processes	30
CO-3	analyze the factors that influence different unit process and design of reactors	20
CO-4	synthesize best route for various important chemical products applying the unit process principles	25

Suggested list of experiments to be performed (10 experiments are to be given)

Practical based on the syllabus topics to be planned. The list may include following experiments :

1. Sulphonation of Benzene
2. Nitration of Benzene to prepare nitro benzene
3. Nitration of Toluene to prepare tri-nitro toluene
4. Ester manufacturing process from alcohols and acid anhydrides
5. Ester manufacturing process from alcohols and acyl chlorides (acid chlorides)
6. Hydrogenation of Oil
7. Oxidation of Acetaldehyde
8. Water softening using chlorination
9. Phenol-formaldehyde resin manufacturing
10. Acetic Acid manufacturing by the reaction between methanol and carbon monoxide in the presence of iridium – rhodium catalyst
11. Preparation of Butyl propionate by Reactive Distillation (Esterification reaction) of Propionic acid and n-butanol which
12. Reactive adsorption process for the purification of foul smelling gas or H₂S removal from biogas

Design based Problems (DP)/Open Ended Problem :

Students can select any unit process or product to study. Student can synthesize process and simulate it evaluate and analyses the results. Student may simulate any industrial process where they have access to data for validation of results.

List of Open Source Software/learning website :

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the Kerk and Othmer or Ullmans Encyclopedia.
- Student can use DWSIM, COCO, ChemSep open source software for simulation study.
- Students can use recent research articles published in Chemical Engineering and Processing: Process Intensification, Elsevier.