GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering: Green Technology and Sustainability Engineering.
Subject Code: 3174405
Semester – VII

Subject Name: Sustainable Chemical Processes & Operations

Type of course: Basic Science

Prerequisite: Basics of organic chemistry and thermodynamics

Rationale: The knowledge of Chemical Process and Operations is essential for the students of Chemical engineering as it provides an overview of chemical process industries. In general, chemical processes involve the chemical changes during the synthesis; however, chemical operations involve only the physical changes. A sustainable chemical process and operation is design to reduce or eliminate the hazardous substances by following the principals of green chemistry.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	0	3	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weigh tage
1	**Chemical Processes & Operations:** Definition of unit process & unit operation with suitable exam, classification of unit processes & unit operations, effect of operating parameters on unit processes & unit operations for better yield of a product, application of thermodynamics and kinetic considerations in chemical processes and operations for sustainable synthesis.	5	10
2	**Introduction to sustainable processes:** Sustainable processes to make them green, safe and economically acceptable to the society, Concepts of green chemistry.	4	5
3	**Green oxidation:** Principal of green chemistry, Definition and significance of green oxidation, application of green oxidation in the sustainable production of value-added chemicals. Advantages and dis-advantages of green oxidation reactions over conventional oxidation.	6	12
4	**Green Hydrogenation & Hydrogenolysis:** Synthesis of green hydrogen, its handling and storage, application of green hydrogen in Hydrogenation &	6	12

	Hydrogenolysis reactions. Advantages and disadvantages of Green Hydrogenation & Hydrogenolysis over conventional reactions.		
5	**Green Halogenations & Photochemical Processes:** Definition and significance of green Halogenations and photochemical reactions, application of green Halogenations and photochemical reactions for sustainable synthesis of chemicals production, A case study of Green halogenation of aromatic heterocycles. Sustainability of Photochemical Reactions.	**8**	**12**
6	**Introduction to sustainable operation in chemical process industries:** Sustainable operation to make them green safe and economically acceptable to the society, their significance and benefits over conventional operations.	**3**	**4**
7	**Reactive Operations:** **Reactive Distillation -** Principle of reactive distillation, design, control and applications in sustainable production. Case study of biodiesel production using RD. **Reactive Extraction** - Definition and principle of reactive extraction. Case study of FAME production using RE. **Reactive Absorption** - Introduction of Reactive Absorption technology. Application of Reactive Absorption in sulfuric acid and nitric acid production.	**10**	**25**
8	**Membrane Separation for Green synthesis:** Introduction to membrane and Membrane Separation process, membrane technology in metal ion removal from waste water, membrane technology in acid removal from waste water, membrane technology in hydrocarbon removal from waste water, membrane process for water desalination.	**6**	**20**

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)

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering: Green Technology and Sustainability Engineering.
Subject Code: 3174405
Semester – VII

Subject Name: Sustainable Chemical Processes & Operations

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. Dryden, C. E. "Outlines of Chemical Technology" (Edited and Revised by M. Gopala Rao and M. Sittig) East West Press. Pvt. Ltd, New Delhi, 3 rd Edition (1997)
2. Austin G. T. Shreve's Chemical Process Industries", 5th Edition, McGraw Hill (1984).
3. Process Intensification for Green Chemistry, Engineering Solutions for Sustainable Chemical Processing by Kamelia Boodhoo, Adam Harvey, Willey 2013.
4. Introduction to Green Chemistry, Matlack A.S. Publisher: Marcel Dekker, Newyork, 2001.
5. Green Chemistry: Theory and Practice, Anastas P.T. and Warner J.C. Oxford University Press, 1998.
6. Handbook of Green Chemistry and Technology, Clark J.H. and Macquarrie D.J. Wiley Blackwell Publishers, 2002

Course Outcomes:

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the principles of green chemistry and sustainable operations	15
CO-2	To explore sustainable chemical operations in chemical synthesis	25
CO-3	To apply concepts of green chemistry and operations in industrial processes	35
CO-4	To Identify and solve challenges using sustainable chemical processes & operations for chemical synthesis	25

Design based Problems (DP)/Open Ended Problem:

Students can select any green chemical process or operation to study. Student can synthesize product using these processes and operations and simulate it evaluate and analyses the 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.