GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester - II

Course Title: Industrial Chemistry
(Course Code: 4320501)

Diploma programmes in which this course is offered	Semester in which offered
Chemical Engineering	Second

1. RATIONALE

Industrial Chemistry deals with the transformation of raw materials into required products that are beneficial to humanity using physical and chemical processes and fundamental principles of chemistry.

In chemical industries, during processes various organic compounds are used. The knowledge of physical and chemical properties of these compounds helps the diploma engineers how to use and control processes effectively. Therefore, for a diploma engineer, the skills and fundamental information related to industrial chemistry are essential for understanding the parameters which control chemical processes such as Halogenation, Oxidation, Nitration, Pyrolysis, Isomerisation, Dehydrogenation, Phase rule, Adsorption, etc. Production of synthetic materials like fertilizers, pesticides, dyes, drugs, plastics, cosmetics, etc used by human beings is harmful to living beings. This pollutes environment. For this, presently, scientists are trying to develop methods to produce environmentally favourable chemical synthesis by Green Chemistry and judicious use of them.

This course is developed in the way by which fundamental information will help the diploma engineers to apply the basic concepts of industrial chemistry to solve broad problems in chemical industries.

2. COMPETENCY

Thepurpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use principles of industrial chemistry to solve broadly-defined chemical engineering problems.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Solve various engineering problems applying the concepts of organic compounds on the basis of their properties.
b) Use relevant aliphatic and aromatic compounds to solve domestic and industrial applications.
c) Illustrate the principles of one component system using phase rule for industrial applications.

d) Apply different adsorption phenomena and its isotherms for domestic and industrial applications.
e) Solve the engineering problems using eco-friendly chemicals and synthesis methods using the principles of green chemistry.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	2	4	30*	70	25	25	150

(*):Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs** marked **'*'** (in approx. Hrs column) are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

S. No.	Practical Outcomes (PrOs)	Unit No.	Option	Approx. Hrs. Required
1	Identify the functional group (Carboxylic acid, Alcohol, Ketone, Aldehyde) present in given organic compound.	I		02
2	Perform tests for saturation and unsaturation using Br_2 water and Baeyer's ($KMnO_4$) solution of given aliphatic compound.	I		02*
3	Determine aliphatic/aromatic nature of given organic compounds.	II		02*
4	Determine the nature (acidic, phenolic, basic, neutral) of the given organic compound by preliminary tests of organic qualitative analysis.	I, II		02
5	Identify the given organic compound (Acetic acid, Oxalic acid, Benzoic acid) by organic qualitative analysis.	I, II		02*
6	Identify the given organic compound (Aniline, N-methyl aniline) by organic qualitative analysis.	I, II		02
7	Identify 1^o, 2^o, 3^o alcohols by Lucas Test.	II		02
8	Identify the given alcohol (Methanol, Ethanol) by organic qualitative analysis.	II		02
9	Identify the given organic compound (Phenol, Catechol, Resorcinol, Quinol) by organic qualitative analysis.	II		02
10	Purify raw (brown) sugar using activated charcoal.	IV		02*
11	Prepare a solution of given concentration in terms of	IV	Any	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Option	Approx. Hrs. Required
	percentage weight by weight (% w/w) for a given compound.		Two	
12	Prepare a solution of given concentration in terms of percentage volume by volume (% v/v) for a given compound.	IV		02
13	Prepare a solution of given concentration in terms of percentage weight by volume (% w/v) for a given compound.	IV		02
14	Determine boiling point of azeotropic mixture.	IV		02
15	Synthesize p-methoxy chalcone by grinding method.	V		02
	Total			**28 Hrs.**

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

*ii. The following are some **sample** 'Process' and '#Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare experimental setup accurately	10
2	Handling of apparatus/glasswares for precise measurements	20
4	Record observations correctly	10
3	Practice and adapt good and safe measuring techniques	10
5	Housekeeping	10
6	Observance/Follow safety rules	10
#7	Does Calculations, Interpret the Results and their Conclusion/s	10
#8	Prepare report of practical in prescribed format	10
#9	Viva-voce	10
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO.No.
1	**Laboratory Weighing Balance:** Type of Laboratory Balance: Analytical, Sensitivity (mg): 1 mg, Maximum Capacity of weighing (grams): 200 g, Shape of PAN:	10, 11,13,15

S. No.	Equipment Name with Broad Specifications	PrO.No.
	Circular, Power Supply: Single Phase, Display: LED.	
2	**Hot Plate With Magnetic Stirrer:** Number of stirring Positions:1, Calibration: Automatic Calibration, Magnetic stirrer with a hot plate, Speed Control Accuracy of set speed (+/-) (RPM): 5, Maximum Stirring capacity per position: 3000 mL, Top plate Material: Stainless steel	10, 11, 12,13

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Inculcate professional skills and ethical values in the context of industrial chemistry.
b) Work as a leader/a team member.
c) Follow ethical practices
d) Observance/Follow safety rules
e) Housekeeping
f) Time management
g) Does Calculations, Interpret the Results and their Conclusion/s
h) Practice environmentally friendly methods and processes for industrial purposes. (Environment-related Green Chemistry aspects)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I **Concepts of Organic Chemistry**	1a. Write the IUPAC name of organic compounds. 1b. Write structural formula from IUPAC names of organic compounds. 1c. Draw structures of alkanes and compare their reactivity. 1d. Describe the preparation	1.1 IUPAC nomenclature of organic compounds 1.2 Alkanes, Alkenes, Alkynes and Cycloalkanes: Preparation, Properties (Halogenation, Oxidation, Nitration, Pyrolysis, Isomerisation, Dehydrogenation) and Uses 1.3 Structures and Reactivity of Alkanes

	methods, properties and uses of alkanes, alkenes, alkynes and cycloalkanes.	(1^o, 2^o, 3^o) 1.4 Alkenes: Action of Ozone, Halogen acids, Sulphuric acid; Hydrogenation, Polymerization
Unit – II **Aromatic and Aliphatic compounds**	2a. Explain aromaticity. 2b. Deduce the structure of benzene. 2c. Explain preparation, properties and uses of benzene. 2d. Classify alkyl halides and alcohols. 2e. Describe the preparation, properties and uses of Alkyl halides, Alcohols and Phenol.	2.1. Concepts of Aromaticity; Structure of Benzene; Preparation, Properties (Halogenation, Hydrogenation, Pyrolysis) and Uses of Benzene 2.2. Alkyl halides: Classification, Isomerism, Preparation, Properties (Substitution and Elimination reactions) and Uses 2.3. Alcohols: Classification, Preparation (Methanol, Ethanol), Properties and Uses 2.4. Phenol: Preparation, Properties and Uses
Unit– III **Phase Rule**	3a. Explain the terms of Phase rule. 3b. Use phase diagrams to identify stable phases at given temperatures and pressures, and to describe phase transitions resulting from changes in these properties. 3c. Describe one component (water) system. 3d. State the applications and limitations of Phase rule.	3.1. Phase Rule - Phase, Components, Degrees of Freedom 3.2. Phase Diagrams 3.3. One Component System - Water Systems 3.4. Applications of Phase Rule 3.5. Limitations of Phase Rule
Unit– IV **Adsorption and Solutions**	4a. Explain the differences between absorption and adsorption. 4b. Describe the types of adsorption. 4c. Comprehend the different factors affecting adsorption. 4d. Explain adsorption isotherms. 4e. State the applications of adsorption. 4f. Describe solutions and indicators. 4g. Explain ideal and non-ideal solution. 4h. Describe azeotropic mixture.	4.1. Adsorption and Absorption, Desorption, Sorption with suitable examples 4.2. Differences between Adsorption and Absorption 4.3. Types of Adsorption - Physical adsorption, Chemical adsorption 4.4. Factors influencing Adsorption 4.5. Adsorption Isotherms - Freundlich adsorption isotherm, Langmuir adsorption isotherm 4.6. Applications of Adsorption 4.7. Solutions and Indicators 4.8. Ideal solution and Non-ideal solution

		4.9. Azeotropic mixture
Unit– V **Green Chemistry**	5a. Familiarize with green chemistry. 5b. Explain briefly basic principles of green chemistry. 5c. Learn about green synthesis. 5d. Justify the need of green chemistry. 5e. State the applications of green chemistry in different fields.	5.1. Concept of Green Chemistry 5.2. Basic Principles of Green Chemistry 5.3. Examples of Green Synthesis - Synthesis of Adipic acid from Cyclohexene, Synthesis of soluble Polyphenol 5.4. Advantages of Green Chemistry 5.5. Green Chemistry in day-to-day life - In dry-cleaning of clothes, In bleaching of paper 5.6. Applications of Green Chemistry in Industries

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Concepts of Organic Chemistry	12	5	7	8	20
II	Aromatic and Aliphatic compounds	11	6	7	5	18
III	Phase Rule	5	3	5	2	10
IV	Adsorption and Solutions	6	4	3	3	10
V	Green Chemistry	8	4	6	2	12
Total		**42**	**22**	**28**	**20**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare tabular classification of functional groups with examples.
b) Prepare chart on IUPAC nomenclature of organic compounds.
c) Prepare table of organic compounds of relevant topics with structure and industrial applications.
d) Library survey of different aliphatic hydrocarbons used in industries.
e) Library survey of different aromatic hydrocarbons used in industries.
f) Prepare a table showing the difference between aliphatic and aromatic compounds.

g) Market survey of different aliphatic and aromatic compounds, and differentiate by their physical and chemical properties.
h) Prepare a category-wise list of all compounds with their IUPAC names/common names and structural formulae covered in the syllabus.
i) Make a list of all probable organic conversions with their reaction-equations covered in the syllabus.
j) Make a chart showing examples of different terms of phase rule.
k) Collect different adsorbates and adsorbents and make a chart based on their type, properties, and uses. Also write examples illustrating absorption, adsorption, desorption and sorption.
l) Make a chart showing differences between Freundlich adsorption isotherm and Langmuir adsorption isotherm.
m) Give seminar on any relevant topic.
n) Prepare a PowerPoint presentation or animation for the given topic.
o) Identify green synthesis of various intermediates and renewable raw materials of organic compounds used in industries.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability with reference by using the knowledge of this course.
g) Open Educational Resources (OER), NPTEL, Vlabs and Olabs can be used to teach different concepts.
h) Guide students for using websites, web links, blog/s and applications for micro-project work and learning.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar

presentation of it before submission. The duration of the microproject should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) **Organic compounds:** Prepare a chart for classification of organic compounds.
b) **IUPAC Nomenclature:** Prepare a PowerPoint presentation or animation that can explain the IUPAC nomenclature system.
c) **Aliphatic hydrocarbons:** Prepare molecular models of alkanes, alkenes and alkynes to demonstrate the structures.
d) **Aromatic characteristics of Benzene:** Prepare a chart/poster showing aromatic characteristics of Benzene.
e) **Standard methods used in Industries:** Make a list of standard methods used to prepare different aliphatic and aromatic compounds in industries.
f) **Terms of Phase rule :** Prepare a chart or PowerPoint presentation showing calculation of the number of phases, components and degrees of freedom in different systems.
g) **Adsorption :** Collect different types of adsorbates and adsorbents. Observe adsorption process in relevant materials and prepare report based on observations.
h) **Eco-friendly Indicators:** Prepare eco-friendly acid-base indicators by extraction from flowers and vegetables. Also demonstrate it by chart/poster/PowerPoint presentation.
i) **Use of Chemicals in Day-to-day Life:** Prepare a chart/poster on chemicals which are used in day-to-day life - their names, structures, physical and chemical properties and uses.
j) **Green Synthesis:** Prepare a list of green synthesis of organic renewable raw materials used in industries. Discuss the findings with your teacher and classmates.
k) **Green Chemistry:** Compile report of green synthesis methods used in industries. Discuss the findings with your teacher and classmates.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Textbook of Organic Chemistry	Rakesh K. Parashar, V. K. Ahluwalia	Viva Books Private Limited, New Delhi, 2012, ISBN: 9788130917740
2	A Textbook of Organic Chemistry	Bahl Arun, Bahl B. S.	S. Chand & Company Ltd., New Delhi, 2016, ISBN: 9352531965
3	Organic Chemistry Volume 1: The Fundamental Principles	I. L. Finar	ELBS, Singapore, ISBN: 058240746 X

S. No.	Title of Book	Author	Publication with place, year and ISBN
	(6th Edition)		
4	Text Book of Chemistry for Class XI & XII (Part - I, Part - II)	NCERT	NCERT, New Delhi, 2017-18, Class XI, ISBN: 81-7450-494-X (part-I), 81-7450-535-O (part-II), Class-XII, ISBN: 81-7450-648-9 (part-I), 81-7450-716-7 (part-II)
5	Advanced Physical Chemistry Book	D. N. Bajpal	S. Chand Publishing, 2001, New Delhi, 2001, ISBN: 8121904080
6	Engineering Chemistry	P. C. Jain & Monica Jain	Dhanpat Rai and Sons Publishing Company (P) Ltd., New Delhi, 2015, ISBN: 8187433175
7	Principles of Physical Chemistry	B. R. Puri, L. R. Sharma and Madan S. Pathania	Shoban Lal Nagin Chand & Co., Jalandhar, 1989.
8	Vogel's Textbook of Practical Organic Chemistry (4th Edition)	Furniss, Hannaford, Rogers, Smith, Tatchell	ELBS, Singapore, ISBN: 0582002478
9	Handbook of Green Chemistry and Technology	Clark James	Wiley India Pvt. Ltd, New Delhi, ISBN: 9788126548002
10	Green Chemistry	V. K. Ahluwalia	Narosa Publishing House Pvt. Ltd., New Delhi, 2012, ISBN: 8184872011

14. SOFTWARE/LEARNING WEBSITES

a) https://ndl.iitkgp.ac.in
b) https://vlab.amrita.edu/index.php?sub=2&brch=190
c) www.vlab.co.in
d) http://www.olabs.edu.in/
e) www.chemistry.msu.edu
f) www.chemistryteaching.com
g) https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf
h) https://www.mygreenlab.org/uploads/2/1/9/4/21945752/green_chemistry_principles_and_lab_practices_2.0.pdf
i) https://www.ikbooks.com/home/samplechapter?filename=195_Sample-Chapter.pdf

15. PO-COMPETENCY-CO MAPPING

Semester II	Industrial Chemistry (Course Code: 4320501)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Use principles of industrial chemistry to solve broadly-defined chemical engineering problems.						
Course Outcomes							
CO a) Solve various engineering problems applying the concepts of organic compounds on the basis of their properties.	3	1	-	1	-	-	2
CO b) Use relevant aliphatic and aromatic compounds to solve domestic and industrial applications.	3	1	-	1	-	-	2
CO c) Illustrate the principles of one component system using phase rule for industrial applications.	3	2	-	-	-	-	1
CO d) Apply different adsorption phenomena and its isotherms for domestic and industrial applications.	3	1	-	1	-	-	1
CO e) Solve the engineering problems using eco-friendly chemicals and synthesis methods using the principles of green chemistry.	3	2	-	2	3	-	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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