



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma in Engineering

Level: Diploma

Branch: Chemical Engineering

Course / Subject Code : DI02000031

Course / Subject Name : Industrial Chemistry

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Basic Science Courses (BSC)

Prerequisite:	Fundamental knowledge of Chemistry and basic Arithmetic for simple calculations.
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, Isomerisation, Nitration, Pyrolysis, Hydrogenation, Hydrohalogenation, Ozonolysis, Polymerization, Sulphonation, Alkylation, Acetylation, Esterification, Dehydration, 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 and 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. India is a rising player in the global semiconductor industry and will explore to grow semiconductor ecosystem. There will be a futuristic development of a sustainable semiconductor in industries. 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.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Solve various engineering problems applying the concepts of organic compounds on the basis of their properties.	R/U/A



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02	Use relevant aliphatic and aromatic compounds to solve domestic and industrial applications.	R/U/A
03	Illustrate the principles of one component system using phase rule for industrial applications.	R/U/A
04	Apply different adsorption phenomena and its isotherms for domestic and industrial applications.	R/U/A
05	Solve the engineering problems using eco-friendly chemicals & synthesis methods using the principles of green chemistry and semiconductors for domestic and industrial applications.	R/U/A

*Revised Bloom's Taxonomy (RBT)

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Concepts of Organic Chemistry 1.1 The IUPAC System of Nomenclature of Organic Compounds having Functional Groups and simple Substituent groups. 1.2 Alkanes: Reactivity of Alkanes (1° , 2° , 3°), Methods of Preparation, Physical Properties, Chemical Properties (Halogenation, Controlled Oxidation, Isomerisation, Nitration, Pyrolysis) and Uses. 1.3 Cycloalkanes: Methods of Preparation, Properties (Halogenation, Oxidation) and Uses. 1.4 Alkenes: Methods of Preparation, Physical Properties, Chemical Properties (Addition reactions with – Dihydrogen (Hydrogenation), Halogen (Halogenation), Hydrogen halide (Hydrohalogenation - Markovnikov's rule), Sulphuric acid; Oxidation, Ozonolysis, Polymerization) and Uses.	12	29% (20 Marks)



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	1.5 Alkynes: Methods of Preparation, Physical Properties, Chemical Properties (Addition reactions with – Dihydrogen (Hydrogenation), Halogen (Halogenation); Polymerization) and Uses.		
2.	Aromatic (Arenes) and Aliphatic Compounds 2.1. Benzene: Structure of Benzene based on Chemical properties, Structure of Benzene based on Physical Properties, Methods of Preparation, Physical Properties, Chemical Properties (Nitration, Sulphonation, Chlorination, Bromination, Alkylation, Acetylation, Hydrogenation, Pyrolysis) and Uses. 2.2. Huckel's rule with examples, Concept of Aromaticity/Aromatic characteristics. 2.3. Alkyl halides/Halo alkanes (R-X): Definition, Classification (on the basis of no. of halogen atoms, on the basis of no. of carbon atoms attached to C_{sp^3-X}), Methods of Preparation, Chemical Properties (Nucleophilic Substitution reactions (S_N2 & S_N1) and Elimination reactions) and Uses. 2.4. Alcohols (R-OH): Definition, Classification (on the basis of no. of –OH groups, on the basis of no. of carbon atoms attached to C_{sp^3-OH}), Methods of Preparation (Methanol, Ethanol), Physical Properties, Chemical Properties (Reaction with Sodium, Oxidation, Esterification, Dehydration) and Uses. 2.5. Phenol: Definition, Methods of Preparation, Physical Properties, Chemical Properties (Nitration, Halogenation, Kolbe reaction, Reaction with Zn-dust) and Uses.	12	26% (18 Marks)
3.	Phase Rule 3.1. Phase Rule. 3.2. Phase, No. of Phases (P). 3.3. Components, No. of Components (C). 3.4. Degrees of Freedom, No. of degree of freedom (F). 3.5. Phase Diagrams and its Uses. 3.6. Phase Rule for One Component Systems - Water Systems. 3.7. Applications/Merits of Phase Rule. 3.8. Limitations of Phase Rule.	6	14% (10 Marks)
4.	Adsorption and Solutions Adsorption:	7	14% (10 Marks)



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	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. Solutions: 4.7. Solutions and Indicators. 4.8. Raoult's Law for a non-volatile solution. 4.9. Ideal solutions and Non-ideal solutions. 4.10. Azeotropic mixture/Azeotropes.		
5.	Green Chemistry and Semiconductors Green Chemistry: 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, Synthesis of Chemicals (Ethanal from Ethene), 'Green Solution' to Clean Turbid Water. 5.6. Applications of Green Chemistry in Industries. Semiconductors: 5.7. Definition and Properties of Semiconductors. 5.8. Types/Classification of Semiconductors: 1. Elemental Semiconductors: Intrinsic Semiconductors, Extrinsic Semiconductors (n-type extrinsic semiconductors, p-type extrinsic semiconductors). 2. Non-elemental/Compound Semiconductors: Inorganic semiconductors, Organic semiconductors and Semiconducting Organic Polymers. 5.9. Applications of Semiconductors in Industries.	8	17% (12 Marks)
	Total	45	100% (70 Marks)

Suggested Specification Table with Marks (Theory):



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Distribution of Theory Marks (in %)

R Level	U Level	A Level	N Level	E Level	C Level
24 Marks (35 %)	32 Marks (45%)	14 Marks (20 %)	-	-	-

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

Note: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to 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 slightly vary from above table.

References/Suggested Learning Resources:

(a) Books:

Sr. 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 (6 th Edition)	I. L. Finar	ELBS, Singapore, ISBN: 058240746 X
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



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Sr. No.	Title of Book	Author	Publication with place, year and ISBN
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 (4 th 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

(b) Open source software and website:

1. <https://ndl.iitkgp.ac.in>
2. <https://vlab.amrita.edu/index.php?sub=2&brch=190>
3. www.vlab.co.in
4. <http://www.olabs.edu.in/>
5. www.chemistry.msu.edu
6. <https://www.chemistry-teaching-resources.com/>
7. <https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf>
8. https://www.mygreenlab.org/uploads/2/1/9/4/21945752/green_chemistry_principles_and_lab_practices_2.0.pdf
9. <https://ncert.nic.in/textbook/pdf/leph206.pdf>

Suggested Course Practical List:

Sr. No.	Practical Outcomes (PrOs)	Unit No.
1.	Identify the functional group (Carboxylic acid, Alcohol, Ketone, Aldehyde) present in given organic compound.	1
2.	Perform tests for saturation and unsaturation using Br ₂ water and Baeyer's (KMnO ₄) solution of given aliphatic compound.	1
3.	Determine aliphatic/aromatic nature of given organic compounds.	2
4.	Determine the nature (acidic, phenolic, basic, neutral) of the given organic compound by preliminary tests of organic qualitative	1, 2



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Sr. No.	Practical Outcomes (PrOs)	Unit No.
	analysis.	
5.	Identify the given organic compound (Acetic acid, Oxalic acid, Benzoic acid) by organic qualitative analysis.	1, 2
6.	Identify the given organic compound (Aniline, N-methyl aniline) by organic qualitative analysis.	1, 2
7.	Identify 1°, 2°, 3° alcohols by Lucas Test.	2
8.	Identify the given alcohol (Methanol, Ethanol) by organic qualitative analysis.	2
9.	Determine the given alcohol using qualitative analysis.	2
10.	Determine the given aldehyde using qualitative analysis.	2
11.	Identify the given aromatic carboxylic acid using qualitative analysis.	2
12.	Identify the given aromatic amine using qualitative analysis.	2
13.	Identify the given organic compound (Phenol, Catechol, Resorcinol, Quinol) by organic qualitative analysis.	2
14.	Purify raw (brown) sugar using activated charcoal.	4
15.	Determine the adsorption isotherm of acetic acid by activated charcoal.	4
16.	Determine boiling point of azeotropic mixture.	4
17.	Synthesize p-methoxy chalcone by grinding method.	5

Note:

- Practical Exercises of at least 30 Hrs.** should be completed by the end of the term.
- 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.
- 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.



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Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %	Maximum Marks for PA/CA (I)
➤	“Process” related skills		
1.	– Prepare experimental setup accurately. – Handling of apparatus/glassware for precise measurements.	20	4
2.	– Practice and adapt good and safe measuring techniques. – Record observations correctly.	20	4
3.	– Housekeeping. – Observance /Follow safety rules.	20	4
➤	“Product” related skills		
4.	– Does Calculations. (if any) – Interpret the Results and their Conclusion/s.	20	4
5.	– Prepare report of practical in prescribed format. – Viva-voce.	20	4
Total		100	20

Sr. No.	Name of Equipments / Instruments	Practical No.
1	Electronic Weighing Balance / Digital Weighing Balance (OR Analytical Balance)	10, 11,13,15
2	Hot Plate with Magnetic Stirrer	10, 11, 12,13

List of Laboratory/Learning Resources Required:

- <https://ndl.iitkgp.ac.in>
- <https://vlab.amrita.edu/index.php?sub=2&brch=190>
- www.vlab.co.in
- <http://www.olabs.edu.in/>
- www.chemistry.msu.edu
- <https://www.chemistry-teaching-resources.com/>
- <https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf>
- https://www.mygreenlab.org/uploads/2/1/9/4/21945752/green_chemistry_principles_and_lab_practices_2.0.pdf
- https://www.ikbooks.com/home/samplechapter?filename=195_Sample-Chapter.pdf



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Suggested Project List:

- Organic compounds:** Prepare a chart for classification of organic compounds.
- IUPAC Nomenclature:** Prepare a PowerPoint presentation or animation that can explain the IUPAC nomenclature system.
- Aliphatic hydrocarbons:** Prepare molecular models of alkanes, alkenes and alkynes to demonstrate the structures.
- Aromatic characteristics of Benzene:** Prepare a chart/poster showing aromatic characteristics of Benzene.
- Standard methods used in Industries:** Make a list of standard methods used to prepare different aliphatic and aromatic compounds in industries.
- 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.
- Adsorption :** Collect different types of adsorbates and adsorbents. Observe adsorption process in relevant materials and prepare report based on observations.
- Eco-friendly Indicators:** Prepare eco-friendly acid-base indicators by extraction from flowers and vegetables. Also demonstrate it by chart/poster/PowerPoint presentation.
- 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.
- Green Synthesis:** Prepare a list of green synthesis of organic renewable raw materials used in industries. Discuss the findings with your teacher and classmates.
- Green Chemistry:** Compile report of green synthesis methods used in industries. Discuss the findings with your teacher and classmates.
- Semiconductors:** Classify Semiconductors with examples. Enlist Semiconductor Devices. Also collect Semiconductors.

Suggested Activities for Students:

- Prepare tabular classification of functional groups with examples.
- Prepare chart on IUPAC nomenclature of organic compounds.
- Prepare table of organic compounds of relevant topics with structure and industrial applications.
- Library survey of different aliphatic hydrocarbons used in industries.
- Library survey of different aromatic hydrocarbons used in industries.
- Prepare a table showing the difference between aliphatic and aromatic compounds.
- Market survey of different aliphatic and aromatic compounds, and differentiate by their physical and chemical properties.



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- 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.

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