GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

I/II – Semester

Course Title: **Engineering Chemistry**

(Course Code: C4300006)

Diploma programme in which this course is offered	Semester in which offered
Electrical Engineering, Power Electronics Engineering	First
Biomedical Engineering	Second

1. RATIONALE

The background of chemistry allows engineers to get the most out of raw elements in creating fuels, drugs, new and modern materials, construction materials etc. needed in wide variety of engineering and technological applications. The in-depth comprehension of concepts and chemical reactions involved in chemistry would be applicable in solving the problems of engineering in spectrum of engineering branches like, electrical, Power Electronics Engineering, Biomedical Engineering etc.

The deep understanding of various topics/ subtopics of engineering chemistry course would enable the diploma engineers to understand and solve the various engineering problems, developments and breakthrough in engineering and technology in a very systematic and scientific way.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competencies through various teaching-learning experiences:

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

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge, and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

- Apply the principles of chemical bonding and solutions to solve various engineering problems.
- Solve engineering problems using the concepts of electrochemistry and corrosion.
- Use relevant fuels and lubricants for domestic and industrial applications.
- Select appropriate engineering materials for industrial applications.
- Choose various types of electrochemical devices for domestic and industrial applications.

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 the integration of COs, and the remaining 20 marks are the average of 2 tests to be taken during the semester for 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 subcomponents of the COs.

S. No.	Practical Outcomes (PrOs)	Unit No.		Approx. Hrs. required
1	Prepare a standard solution of oxalic acid or potassium permanganate.	I		02
2	Determine the strength of the given sodium hydroxide solution by titrating against standard oxalic acid solution using phenolphthalein indicator.	I		02
3	Standardize potassium permanganate solution by standard oxalic acid solution and estimate ferrous ions.	II	Any three	02
4	Determine pH-Values of given samples of Solution by using Universal Indicator and pH-meter.	II		02
5	Determine emf of an electrochemical cell (Daniel cell).	II		02
6	Determine electrochemical equivalent of copper metal using Faraday's first law.	II		02
7	Determine the rate of corrosion for different metals in the given solution.	III		02
8	Determine the rate of corrosion of metal in the solution of different pH.	III		02
9	Determine the calorific value of solid or liquid fuel using a bomb calorimeter.	IV		02
10	Determine the percentage of moisture content in the given sample of coal by proximate analysis.	IV		02
11	Determine the ash content of the given sample of coal by proximate analysis.	IV		02
12	Determine the viscosity of the lubricating oil using a Redwood viscometer.	V	Any three	02

S. No.	Practical Outcomes (PrOs)	Unit No.		Approx. Hrs. required
13	Determine the Acid value of the given lubricating oil.	V		02
14	Determine the Saponification value of the given lubricating oil	V		02
15	Determine flash point and fire point of the given lubricating oil using Pensky Martens/Cleveland open cup/Able's flashpoint apparatus.	V		02
16	Prepare Polystyrene and Bakelite. (Any one)	VI		02
	Total Hrs.			**28**

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	Use apparatus for precise measurements.	20
3	Practice and adapt good and safe measuring techniques.	10
4	Good Record keeping of the observations accurately.	20
5	Interpret the results and their conclusion.	20
6	Prepare Report in prescribed format	10
7	Viva-Voce	10
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure the conduction of practice in all institutions across the state in a proper way so that the desired skills are developed in students.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1.	**Digital pH Meter:** Type: Microcontroller Based, Display: LED / LCD / Touch Screen, 3 digits, Calibration: up to 3 points with auto buffer, pH Range (pH): 0.00 to 14.00, +/- 0.05, Power Requirements: 230 V +/- 10, 50 Hz AC, Modes: pH mV- C, Temperature Compensation Type: Automatic,	4

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Temperature Compensation Range (Degree C): 0 to 100, Temperature Accuracy (Degree C): +/- 0.3, Resolution (pH): 0.01	
2.	**Bomb Calorimeter:** Calorimeter outer container: Aluminum with rolled rim, Shape of the container: Cylindrical, Type of top cover: Removable, Calorimeter vessel: Copper, Calorimeter vessel size (Height x dia.), in mm: 100x75, Material of Stirrer: Copper, Stirrer size (Height x dia.), in mm, (min): 100 x 3.5, Stirrer with a loop at the bottom to fit inside the Calorimeter, Thermometer holder, removable: Nickel-plated brass.	9
3.	**Hot Air Oven:** Temperature is controlled by digital temperature indicator cum controller from ambient to 250°C with ± 0.1°C Accuracy. Power supply: 220/230V, 50Hz single phase, Capacity (Approx.): 50 – 100 liter, Type of Shelves: 03, Material of Inner Chambers: SS 304, Material of Outer Chamber: MS with powder coated paint, Material of Shelves: SS wire mesh.	10
4.	**Muffle Furnace:** The Furnace should be provided with a fast response temperature probe and with high-density energy-saving Ceramic Wool, Temperature Range 0-1200 °C. Muffle Size (approx.): 6" X 6" X 12", Display: LED.	11
5.	**Redwood viscometer:** Flow Range (Viscosity) in second: 20-2000, Redwood Viscometer Model No.: 01, Material: Stainless Steel, Bath Capacity (Approx.): 7 liters, Temperature Required: 95 ℃, Power supply: 220 Volt, 800 Watt, 50 Hz.	12
6.	**Pensky Martens flash point apparatus:** Voltage: 220-240V, Phase: Single phase, Power Source: Electric, Timing Range: 999.9s OR **Cleveland Open Cup apparatus:** Temperature range: Ambient to 370℃, Temp. measurement PT100 temp. sensor, Temp. scale resolution 0.1℃, Ignition source gas or electric, cooling forced air cooling, heating coil, heating 888W,220V, AC. OR **Abel's flash point apparatus:** Material: Stainless Steel, Power Source: Electric, Voltage: 115V/220-240V, 50-60 Hz, Dimensions: 230 mm x 470 mm x 470 mm (W x D x H) Temperature Range: 70 ℃, Resolution: 0.1 ℃	15
7.	**Laboratory weighing balance:** Type of Laboratory Balance: Analytical, Sensitivity (mg): 1 mg, Maximum Capacity of weighing (grams): 200 g, Shape of PAN: Circular, Power Supply: Single Phase, Display: LED.	All
8	**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	1,2,3,4,13,14

S. No.	Equipment Name with Broad Specifications	PrO. No.
	(+/-) (RPM): 5, Maximum Stirring capacity per position: 3000 ml, Top plate Material: Stainless steel.	

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 fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow ethical practices
c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and processes. (Environment-related)

The ADOs are best developed through 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 the attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I **Atomic Structure, Chemical Bonding and Solutions**	1a. Apply the different atomic theories, models and principles for structural illustration. 1b. Explain Pauli's exclusion principle, Hund's rule and Aufbau rule with examples. 1c. Write the electronic configurations of different elements. 1d. Describe the different types of chemical bonds. 1e. Differentiate among the ionic, covalent and coordinate compounds based on the type of chemical bonding.	1.1. Atomic Structure: Concepts of orbit and orbital, Pauli's exclusion principle. 1.2. Hund's rule of maximum multiplicity, 1.3. Aufbau rule, electronic configuration of atom (up to atomic number 30) 1.4. Chemical Bonding: Concept of chemical bonding, types of chemical bonds, Ionic bond, and its characteristics (example NaCl), Covalent bond and its characteristics (example H_2, O_2, N_2, HF, NH_3, H_2O, CH_4), Coordinate covalent bond (example NH_4^+, H_3O^+), Metallic bond and its

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
	1f. Explain various properties of Materials depending upon bond formation. 1g. Prepare the solution of given concentrations (Normality, Molarity).	characteristics, Hydrogen bonding, its types, and Significance, Intermolecular force of attraction. 1.5. Molecular arrangement in solid, liquid and gases, Structure of solids - Molecular solid, Ionic solid, Network solid, and Metallic solid. 1.6. Solutions: The Idea of solute and solution, Methods to express the concentration of solution - Normality, Molarity (*M* = mole per liter), ppm, mass percentage, volume percentage, and mole fraction.
Unit – II **Concepts of Electrochemistry**	2a. Explain the theory of ionization and the factors affecting it. 2b. Describe pH value and its industrial application. 2c. Describe different types of buffer solutions and their application. 2d. Differentiate electrolyte and nonelectrolyte. 2e. Describe the construction and working of an electrochemical cell and standard hydrogen electrode (SHE) 2f. State the Nernst equation and Faraday's laws of electrolysis and its application. 2g. Use the different electrolysis process such as electro metallurgy, electroplating and electrorefining to solve wide variety of industrial problems.	2.1. Arrhenius theory of ionization. 2.2. Electronic concept of oxidation, reduction, and redox reactions. 2.3. Degree of ionization and factors affecting the degree of ionization. 2.4. Definition of pH, pH of acid, base and neutral solution, pH calculations for acid, base, and salt solutions at different concentrations, Importance of pH in various fields. 2.5. Definition of buffer solution, buffer action and types of buffer solution, Application of buffer solution. 2.6. Definition of terms: electrolytes, non-electrolytes with suitable examples, Types of electrolytes. 2.7. Construction and working of Electrochemical Cell. 2.8. Construction and working of Standard Hydrogen Electrodes (SHE). 2.9. Nernst theory of single electrode potential and Nernst equation. 2.10. Electrochemical series. 2.11. Electrolysis, Faraday's laws of electrolysis. 2.12. Industrial application of electrolysis: Electro metallurgy, electroplating, and electro refining.
Unit– III	3a. Describe the various types of corrosion.	3.1. Corrosion: Dry or Chemical corrosion: Oxidation corrosion-

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Corrosion of metals and its prevention	3b. Identify the different factors affecting the rate of corrosion. 3c. Explain the various type of protective measures to prevent corrosion. 3d. Select relevant method to prevent metal from corrosion	mechanism, Corrosion by other gases. 3.2. Wet or Electrochemical corrosion- H_2 liberation and O_2 absorption mechanism of electrochemical corrosion. 3.3. Galvanic corrosion mechanism. 3.4. Concentration cell corrosion. 3.5. Pitting corrosion, Waterline and Crevice corrosion. 3.6. Factors affecting the rate of corrosion: Nature of the metal, Nature of surface film, Relative areas of the anodic and cathodic parts, Purity of metal, Temperature, Humidity of air, Influence of pH. 3.7. Internal and External corrosion preventive measures: Modification of environment, Modification of the properties of metal, Use of protective coatings, Anodic and cathodic protection, Modification in design and choice of material
Unit– IV **Fuels and Combustion**	4a. Classify various types of fuels. 4b. Calculate the calorific value of various fuels using Dulong's formula. 4c. Determine proximate analysis of coal for assessing its quality for domestic and industrial use. 4d. Assess the efficiency of coal by determining the calorific value of fuel. 4e. State the significance of octane and cetane number. 4f. Justify the need for alternative fuels.	4.1. Definition and Classification of fuels, Calorific values and their units. Determination of calorific value using a bomb calorimeter. 4.2. Characteristics of good fuel. 4.3. Comparison between solid, liquid, and gaseous fuels. 4.4. Theoretical calculation of HCV and LCV of fuel using Dulong's formula. 4.5. Solid fuels: Coal, Classification of coal, Proximate and ultimate analysis of coal. 4.6. Liquid fuels: Petroleum, Origin of petroleum and classification of petroleum, Refining of petroleum. 4.7. Petrol and Diesel-fuel rating (Octane and Cetane numbers), Power alcohol and Bio-diesel. 4.8. Chemical composition, Calorific values, and Applications of LPG, CNG, water gas, coal gas, producer gas, and biogas.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit– V **Lubricants**	5a. Explain terms lubricant and lubrication 5b. Describe the types of lubricants. 5c. Describe the physical and chemical properties of a lubricant. 5d. Selection of proper lubricants for engineering use. 5e. Select relevant lubricant based on their function and characteristic properties for use in different kind of machinery. 5f. Determine viscosity, flash and fire point of given lubricant for their specific use. 5g. State the biodegradable lubricants.	5.1. lubricants and Lubrication, Functions of lubricants. 5.2. Mechanism of Lubrication: Fluid lubrication, Boundary lubrication. Classification of lubricant with examples: Solid, Semi-solid, liquid and synthetic lubricants. 5.3. Physical Properties of lubricants: Viscosity and viscosity index, Flash and fire point, Cloud and pour point, Oiliness. 5.4. Chemical properties of lubricants: Saponification number, Neutralization number, Emulsification number. 5.5. Selection of lubricants for different types of Machinery like: Gears, Cutting tools, Steam turbine, Transformers. 5.6. Biodegradable lubricants
Unit– VI **Polymers, Elastomers, and Insulating Materials**	6a. Classify Polymers based on molecular structures and monomers. 6b. Differentiate thermoplastic and thermosetting polymers with examples. 6c. Explain polymerization reactions with examples. 6d. Describe the applications of thermoplastic and thermosetting polymers. 6e. Describe the application of biodegradable polymers. 6f. Explain the properties and application of synthetic rubbers. 6g. Explain the process of vulcanization of rubber. 6h. Use relevant insulating materials for engineering applications.	6.1. Definition of Monomer, Polymer and Polymerization. 6.2. Classification of Polymers based on molecular structure: Linear Polymers, branched polymers, Cross-linked polymers. 6.3. Classification of polymers based on Monomer: Homopolymer, Copolymer. 6.4. Classification of polymers based on thermal behavior: Thermoplastics and Thermosetting polymers. 6.5. Types of polymerizations: Addition and condensation polymerization 6.6. Simple reactions involved in the preparation and their properties and application of thermoplastics and thermosetting polymers: Polyethylene, Polypropylene, Polyvinyl chloride, Polytetrafluoroethylene (Teflon), Polystyrene, Polyacrylonitrile, Bakelite, Epoxy resins. 6.7. Biodegradable Polymers:

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		Introduction, chemical composition, and application: Polyβ- hydroxybutyrate–co-β-hydroxy valerate (PHBV), Nylon-2–nylon-6. 6.8. Rubber: Natural rubber and its properties, Vulcanization of rubber, Synthetic rubber – simple reaction involved in the preparation and their properties and application: Buna-S rubber, Buna-N rubber, Neoprene rubber 6.9. Insulating Materials: Types and Properties of Insulating materials, Application of Thermal and Electrical Insulating Materials.
Unit– VII **Electrochemical Energy Sources**	7a. Describe the construction and working of various batteries. 7b. Explain the working of fuel cell. 7c. Describe the solar cells. 7d. Use the different types of fuel cells based on their mechanism and characteristics.	7.1 Batteries: An electrochemical source of energy, Types of Batteries: Primary, Secondary and Fuel batteries 7.2 Dry cell - construction and working. 7.3 Lead-acid storage cell - construction and working. 7.4 Nickel/Cadmium battery - construction and working. 7.5 Fuel cells - definition, example Hydrogen fuel cell, and biochemical fuel cell, Characteristics of fuel cells, Solar Cells.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Atomic Structure, Chemical Bonding, and Solutions	06	03	03	02	08
II	Concepts of Electrochemistry	07	02	06	04	12
III	Corrosion of metals and its prevention	05	02	04	02	08
IV	Fuels and Combustion	07	03	05	04	12
V	Lubricants	05	02	04	02	08

VI	Polymers, Elastomers, and Insulating Materials	07	03	06	05	14
VII	Electrochemical Energy Sources	05	02	04	02	08
Total		**42**	**17**	**32**	**21**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (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.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, the 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 the following activities in group and prepare small reports of about 5 pages for each activity. They should also collect/record physical evidence such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare a PowerPoint presentation or animation showing different types of chemical bonds and atomic structures.
b) Prepare a model of an atom with the help of a ball and stick or of any other items.
c) pH Calculations for acid, base, and salt solutions at different concentrations.
d) Preparation of a table showing the different methods used for prevention of corrosion.
e) Solve simple problems on hardness calculation.
f) Market survey of different lubricating oil and compare their physical and chemical properties.
g) Library survey regarding polymers, synthetic rubber, and adhesives used in different industries.
h) Collect different polymers and prepare the chart/ PowerPoint based on their type, properties, and uses.
i) Market survey of different batteries and differentiate primary and secondary batteries.

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/subtopics.
b) Guide student(s) in undertaking micro-projects/activities.
c) Different types of teaching methods i.e. video demonstration, activity-based learning, case study, m-learning need to be employed by teachers to develop the outcomes.

d) **Some *of the topics/sub-topics*** which are relatively simpler or descriptive are to be given to the students for ***self-learning*** but to be assessed using different assessment methods.
e) Teachers need to ensure to create opportunities and provisions for ***co-curricular*** activities.
f) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course.
g) OERs, Vlab, and Olabs may be used to teach for the teaching of different concepts.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at 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 the integration of PrOs, UOs, and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro-project should be about **14-16 *(fourteen to sixteen) student engagement hours*** during the course e. The students ought to submit micro-project by the end of the semester (so that they develop industry-oriented COs).

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

a) Prepare a PowerPoint animation that can explain the structure of an atom.
b) Prepare a chart of the modern periodic table which gives information about the atomic number and mass number of different elements.
c) Prepare common salt crystals from NaCl solution
d) Prepare a chart representing compounds and solutions which affect human life positively and negatively.
e) Prepare a model of an atom with the help of a ball and stick or of any other items.
f) Form three groups of students in the class. Consider a hypothetical situation of exchanging/ sharing/giving of different items/belongings and demonstrate the type of ionic, covalent, and co-ordinate bonding amongst the students in a simulated situation. Present your findings.
g) Model of electronic configurations for different atoms (Z=30)
h) Prepare a model to demonstrate the application of electrolysis cells.
i) Collect three metallic strips of Al, Cu, Fe, strips, Place them in different acidic and alkaline solutions of the same concentration. Observe and record the loss in weight of metals due to an acidicand alkaline environment. Discuss the findings with your teacher and colleagues.
j) Classify the surrounding corrosion into dry corrosion and wet corrosion.
k) Collect different samples of utensils reinforced materials, iron, copper, brass, bronze, and other alloys. Place them in an open environment under tin shade. Observe the corrosive properties overa period of four weeks. Record your observations. Discuss the findings with your teacher andcolleagues.
l) Collect samples of petrol, kerosene oil, diesel, any edible oil, coconut oil. Find out the

flash point and fire point, cloud and pour point, and viscosity of the same. Compare the properties and justify their use in relevant applications.

m) Depending on the type of machinery, the load applied, speed of the machine, heat generated, etc, select the appropriate lubricant which can be applied to the machinery. Discuss with your teachers and colleagues and present the same.

n) Make a table showing the availability of natural rubber in India and show places on the India map.

o) Collect different polymers and prepare the chart/ PowerPoint based on their type,properties, and uses.

p) Collect fuel samples from different sources and prepare a chart showing their calorific values and uses.

q) Mapping of energy resources in India.

r) Collection of data of various electrochemical cells-batteries used in equipment and devices and available in the market.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with the place, year and ISBN
1	Engineering Chemistry	Jain & Jain	Dhanpat Rai Publishing Co.(P) Ltd., New Delhi, 2015, ISBN: 93-521-6000-2
2	A Textbook of Engineering Chemistry	Dr. S. S. Dara & Dr. S. S. Umare	S. Chand & Co.(P) Ltd., New Delhi, 2014, ISBN:81-219-0359-9
3	Textbook of Chemistry for Class XI & XII (Part-I & 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)
4	Engineering Chemistry	Shikha Agarwal	Cambridge Uni. Press, New Delhi, 2019, ISBN: 978-1-108-72444-9
5	Understanding Chemistry	C.N.R. Rao	World scientific publishing Co., 2009, ISBN: 9789812836045
6	Engineering Chemistry	Dr. Vikram, S.	Wiley India Pvt. Ltd., New Delhi, 2013, ISBN: 9788126543342
7	Applied Chemistry Laboratory Practices, Vol. I & II	Dr. G.H. Hunger & Prof. A.N. Pathak.	NITTTR, Chandigarh, Publication, 2013-14
8	Chemistry for Engineers	Rajesh Agnihotri	Wiley India Pvt. Ltd., 2014, ISBN: 9788126550784
9	Fundamental of Electrochemistry	V. S. Bagotsky	Wiley International N. J.,2005, ISBN: 9780471700586

14. SUGGESTED LEARNING WEBSITES

a) http://www.chemguide.co.uk/atommenu.html

b) https://www.visionlearning.com

c) http://www.chem1.com

d) http://www.em-ea.org
e) https://ncert.nic.in
f) www.onlinelibrary.wiley.com
g) www.rsc.org
h) www.chemcollective.org
i) www.wqa.org
j) https://docslib.org/insulation-materials-science-and-application
k) http://www.olabs.edu.in/
l) http://chemcollective.org/activities/type_page/1
m) http://www.presentingscience.com/vac/corrosion/index.htm
n) https://vlab.amrita.edu/index.php?sub=2&brch=190

15. PO-COMPETENCY-CO MAPPING

Semester I/II	Engineering Chemistry (Course Code: C4300006)						
	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 engineering chemistry to solve broadly-defined engineering problems.**	3	2	2	1	1	1	1
Course Outcomes CO1: Apply the principles of chemical bonding and solutions to solve various engineering problems.	3	1	-	1	-	-	1
CO2: Solve engineering problems using the concepts of electrochemistry and corrosion.	3	1	-	1	1	-	1
CO3: Use relevant fuels and lubricants for domestic and industrial applications.	3	1	1	1	1	-	1
CO4: Select appropriate engineering materials for industrial application.	3	1	-	1	1	1	1
CO5: Choose various types of electrochemical devices for domestic and industrial applications.	3	1	-	1	1	1	1

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

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Dr. Narendra Makwana, Lecturer in Chemistry	Government Polytechnic, Chhotaudepur	9909911391	ngmakwana@yahoo.com
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NITTTR Resource Persons

S. No.	Name and Designation	Department	Contact No.	Email
1.	Dr. Bashirulla Shaik, Assistant Professor	Dept. of Applied Science Education	9981382711	bshaik@nitttrbpl.ac.in
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