GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Sem 1: Metallurgy Engineering

Sem 2: Civil/Environmental/Mining/Ceramic Technology

Course / Subject Code: DI01021011

Course / Subject Name: Applied Chemistry

w. e. f. Academic Year:	2024-25
Semester:	**1** or **2**
Category of the Course:	BSC

Prerequisite:	Fundamental knowledge of Chemistry and basic Arithmetic for simple calculations.
Rationale:	Applied Chemistry deals with solving the various issues and problems of industries, the environment, and day-to-day life for the benefit of people at large, through applications of various concepts and principles of chemistry. Applied chemistry helps to develop and enhance the thinking capabilities of the diploma pass outs in line with the modern trends in engineering and technology through the inclusion of various creative activities/micro projects etc. Many global problems/issues and their in-depth understanding is addressed through the inclusion of topics of relevance like atomic structure, chemical bonding and solutions; electrochemistry; corrosion; water treatment; cement, glass and refractories; paints, varnishes and insulating materials; polymers, elastomers, adhesives and semiconductors in this course.

Course Outcome:

After Completion of the Course, Student will able to:

No.	Course Outcomes	RBT Level
01	*Apply* the principles of atomic structure, chemical bonding and solutions to solve various engineering problems.	R/U/A
02	*Solve* engineering problems using the concepts of electrochemistry and corrosion.	R/U/A
03	*Use* relevant water treatment methods to solve domestic and industrial problems.	R/U/A
04	*Select* appropriate engineering materials like cement, glass, refractories, paints, varnishes and insulating materials for industrial applications.	R/U/A
05	*Choose* various types of engineering materials like polymers, elastomers, adhesives 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
				Theory		Tutorial / Practical		
L	T	PR	C	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.	**Atomic Structure, Chemical Bonding and Solutions** **Atomic Structure:** 1.1. Concepts of orbits and orbitals. 1.2. Pauli's exclusion principle, Hund's rule of maximum spin multiplicity, Aufbau rule. 1.3. Electronic configuration of elements having atomic number 1 to 30. **Chemical Bonding:** 1.4. Concept of chemical bond, Octet rule, Types of chemical bonds : 1.4.1 Ionic (Electrovalent) bond and its characteristics (Example NaCl.), 1.4.2 Covalent bond and its characteristics (examples–Non-polar covalent bond: H_2, O_2, N_2, CH_4; Polar covalent bond: HCl, H_2O, And NH3.), 1.4.3 Coordinate covalent (Dative) bond (examples – NH_4^+, H_3O^+), 1.4.4 Metallic bond and its characteristics, 1.4.5 Hydrogen bond, its types and significance, 1.4.6 Intermolecular force of attraction (van der Waals bond). 1.5. Structures of solids: Ionic solids, Molecular solids, Network solids, and Metallic solids. **Solutions:** 1.6. Definitions of solute, solvent, solution and concentration, Modes of expressing concentration of solutions – Molarity (M = mole/liter), Normality (N), Molality (m), mass	08	17% (12 Marks)

	percentage (%w/w), volume percentage (%v/v), mass by volume percentage (%w/v), mole fraction (χ), ppm (μg/mL).		
2.	**Electrochemistry** 2.1. Arrhenius theory of ionization. 2.2. Electronic concept of oxidation, reduction, and redox reactions. 2.3. Degree of ionization (α) and the factors affecting on it. 2.4. Concept of pH and pOH; pH scale for acids, bases and neutral solutions, Calculations of pH and pOH for dilute solutions of acids and bases, Importance of pH in various fields. 2.5. Buffer solutions, Types of buffer solutions: Acidic buffers and Basic buffers, Applications of buffer solutions. 2.6. Definition of Electrolytes, Non-electrolytes with suitable examples, Types of Electrolytes with examples. 2.7. Construction, working, cell-reactions and symbolic representation of an Electrochemical cell. 2.8. Conditions for a half-cell to be standard. 2.9. Construction and working of Standard Hydrogen Electrode (SHE). 2.10. Measurement of Standard half-cell potential / Standard electrode potential (E^o_R or EoL), Electrochemical/electromotive force (emf) series, Standard cell potential (E^o_{cell}). 2.11. Construction of Electrolytic cell and Electrolysis. 2.12. Faraday's Laws of Electrolysis. 2.13. Industrial applications of electrolysis: 2.13.1 Electrometallurgy, 2.13.2 Electroplating, 2.13.3 Electro-refining.	07	15% (11 Marks)
3.	**Corrosion of metals and its prevention** 3.1. Definition of Corrosion with example. 3.2. Dry or Chemical corrosion: Oxidation corrosion, Corrosion by other gases. 3.3. Wet or electrochemical corrosion: Liberation of H_2, Absorption of O_2. 3.4. Galvanic (Bimetallic) corrosion. 3.5. Concentration cell corrosion. 3.6. Pitting corrosion, Waterline corrosion and Crevice corrosion. 3.7. Factors affecting the rate of corrosion: Nature of the metal,	05	12% (8 Marks)

	Nature of surface film, Relative areas of the anodic and catholic parts, Purity of metal, Temperature, Humidity of air, Influence of ph. 3.8. Preventive measures for internal corrosion and External corrosion: Modification of environment, Modification of the properties of metal, Use of protective coatings, Anodic and catholic protection, Modification in design and choice of material.		
4.	**Water treatment** 4.1 Sources of water, hard water and Soft water. 4.2 Types of hardness of water (Temporary/Carbonate harness and Permanent/Non-carbonate hardness), salts causing it and simple numerical based on it. 4.3 Units of hardness. 4.4 Problems caused by the use of hard water in boilers and its prevention: 4.4.1 Scale and sludge formation, 4.4.2 Priming and Foaming, 4.4.3 Caustic embrittlement, 4.4.4 Boiler Corrosion. 4.5 Water softening techniques: 4.5.1 Soda-lime process, 4.5.2 Zeolite (Permutit) process, 4.5.3 Ion-exchange/De-ionization process, 4.5.4 Reverse Osmosis (R.O.) process. 4.6 Treatment of Municipal drinking water: 4.6.1 Screening, 4.6.2 Sedimentation, 4.6.3 Coagulation, 4.6.4 Filtration, 4.6.5 Sterilization of water by Chlorination, Break-point (Free-residual) Chlorination. 4.7 Enlist Indian standard specifications of drinking water.	07	14% (10 Marks)
5.	**Cement, Glass and Refractories** **Cement :** 5.1 Definition and Classification of Cement. 5.2 Manufacture of Portland cement. 5.3 Chemical Composition of Cement. 5.4 Chemical Constitution of Portland cement.	05	12% (8 Marks)

	5.5 Setting and Hardening of Portland cement. **Glass:** 5.6 Definition and General Properties of Glass. 5.7 Manufacture of Glass. 5.8 Types of Glasses and their Applications. **Refractories:** 5.9 Definition and Characteristics of Refractory. 5.10 Applications of refractories. 5.11 Classification of refractories: Acid, Basic and Neutral refractories.		
6.	**Paints, Varnishes and Insulating Materials** **Paints:** 6.1 Definition of paints, the purpose of oil paints, characteristics of oil paints. 6.2 Ingredients of paints: Function and example of each ingredient. **Varnishes:** 6.3 Definition and Constituents of Varnishes. 6.4 Types of varnishes. 6.5 Differentiate between Paints and Varnishes. **Insulating Materials:** 6.4 Definition, Types and Properties of insulating materials. 6.5 Applications of Thermal, Acoustic, Waterproofing and Fireproofing insulating materials.	05	10% (7 Marks)
7.	**Polymers, Elastomers, Adhesives and Semiconductors** **Polymers:** 7.1 Definition of Monomer, Polymer, Polymerization, Degree of polymerization (n) and Repeating unit. 7.2 Classification of polymers based on Molecular structure: Linear polymers, Branched polymers, Cross-linked polymers. 7.3 Classification of polymers based on Monomer: Homo polymer, Co-polymer. 7.4 Classification of polymers based on Thermal behavior: Thermoplastic polymers and Thermosetting polymers. 7.5 Types of polymerizations: Addition polymerization and Condensation polymerization 7.6 Preparation (by simple reactions), Properties and Uses of some thermoplastic polymers and thermosetting polymers: Polyethylene (PE), Polypropylene (PP), Polyvinylchloride (PVC), PolyTetraFluoroEthylene (PTFE, Teflon, and Fluon),	08	20% (14 Marks)

	Polystyrene (PS), PolyAcryloNitrile (PAN), Bakelite, and Epoxy resins. 7.7 Biodegradable Polymers: Definition, Chemical composition and Uses of Poly–β–HydroxyButyrate–co–β–hydroxyl Valerate (PHBV), Nylon–2–nylon-6. **Elastomers (Rubbers):** 7.8 Natural rubber and its Properties. 7.9 Vulcanization of rubber and its Advantages. 7.10 Synthetic rubbers: Preparation (by simple reactions), Properties and Uses of Buna-S (GR-S or Styrene) rubber, Buna-N (GR-A or Nitrile) rubber, Neoprene (GR-M) rubber. **Adhesives:** 7.11 Definition and Characteristics of Adhesives. 7.12 Classification of Adhesives. 7.13 Applications of Adhesives. **Semiconductors:** 7.14 Definition and Classification of Semiconductors. 7.15 Enlist Semiconductor Devices. 7.16 Elemental Semiconductors: Intrinsic Semiconductors, Extrinsic Semiconductors (n-type Semiconductors, p-type Semiconductors).		
	Total	**45**	**100% (70 Marks)**

Suggested Specification Table with Marks (Theory):

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 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	Chemistry for Engineers	Rajesh Agnihotri	Wiley India Pvt. Ltd., 2014, ISBN: 9788126550784
8	Fundamental of Electrochemistry	V. S. Bagotsky	Wiley International N.J., 2005, ISBN: 9780471700586

(b) Open source software and website:

1. http://www.chemguide.co.uk/atommenu.html
2. https://www.visionlearning.com/
3. http://www.chem1.com/
4. https://www.wastewaterelearning.com/elearning/
5. https://www.capital-refractories.com/
6. https://www.wqa.org/
7. https://ncert.nic.in/
8. https://docslib.org/insulation-materials-science-and-application
9. http://www.olabs.edu.in/
10. http://chemcollective.org/activities/type_page/1
11. http://www.presentingscience.com/vac/corrosion/index.htm
12. https://vlab.amrita.edu/index.php?sub=2&brch=190

Suggested Course Practical List:

Sr. No.	Practical Outcomes (PrOs)	Unit No.
1	Prepare a standard solution of oxalic acid or potassium permanganate.	1
2	Prepare a solution of given concentration in terms of percentage weight by weight (% w/w) of a given compound.	1
3	Prepare a solution of given concentration in terms of percentage volume by volume (% v/v) of a given compound.	1
4	Prepare a solution of given concentration in terms of percentage weight by volume (% w/v) of a given compound.	1
5	Determine the strength of the given sodium hydroxide solution by titrating against standard oxalic acid solution using phenolphthalein indicator.	1
6	Standardize potassium permanganate solution by standard oxalic acid solution and estimate ferrous ions.	2
7	Determine pH-Values of given samples of Solution by using Universal Indicator and pH-meter.	2
8	Determine emf of an electrochemical cell (Daniel cell).	2
9	Determine electrochemical equivalent of copper metal using Faraday's first law.	2
10	Determine the rate of corrosion for different metals in the given solution.	3
11	Determine the rate of corrosion for metal in the solutions of different ph.	3
12	Estimate total hardness of given water sample using standard EDTA solution.	4
13	Estimate alkalinity of given water sample using 0.01M sulphuric acid solution.	4
14	Determine Total Dissolved Solid (TDS) and Total Suspended Solid (TSS) in a given sample of water.	4
15	Determine the iron content in a given cement sample using a colorimeter.	5
16	Prepare Polystyrene and Bakelite. (Anyone)	7

Note:

i. ***Practical Exercises*** *of* ***at least 28 Hrs****. should be completed by the end of the term.*

ii. *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.*

iii. *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.*

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. – Interpret the Results and their Conclusion/s.	20	4
5.	– Prepare report of practical in prescribed format. – Viva-voce.	20	4
Total		100	**20**

List of Laboratory Equipment's/Learning Resources Required:

No.	Equipment's / Instruments	Practical No.
1	Electronic Weighing Balance / Digital Weighing Balance (OR Analytical Balance)	1, 2, 4, 9, 10, 11, 14, 16
2	Digital pH meter	7, 11
3	Voltmeter	8
4	6 V Battery	9
5	Ammeter	9
6	Rheostat	9
7	Dryer	10, 11
8	Hot air oven	14
9	Vacuum Pumps with glass filter	14
10	Colorimeter	15
11	Hot plate with Magnetic stirrer	1, 5, 6, 7, 12, 14, 15

Suggested Project List:

1. Prepare a model of an atom with the help of a ball and stick or of any other items.
2. Prepare a PowerPoint animation that can explain the structure of an atom.
3. Prepare a chart showing (1) Atomic number ($Z = e^- = p^+$) 1 to 30, (2) Name of the element, (3) Symbol, (4) Electronic configuration and (5) Condensed Electronic configuration of elements in tabular form.
4. Prepare a chart of the modern periodic table which gives information about the atomic number and mass number of different elements.
5. Prepare crystals of common salt from NaCl solution.
6. 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.
7. Prepare a chart representing compounds and solutions which affect human life positively and negatively.
8. Classify the surrounding corrosion into dry corrosion and wet corrosion.
9. 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 over a period of four weeks. Record your observations. Discuss the findings with your teacher and classmates.
10. Collect three metallic strips of Cu, Al and Fe. Place them in different acidic and alkaline solutions of the same concentration. Observe and record the loss in weight of metals due to an acidic and alkaline environment. Discuss the findings with your teacher and classmates.
11. Prepare a model to demonstrate the application of electrolysis.
12. Collect water samples from different water sources and measure the hardness of the water.
13. Collect the water sample from different sources of ground and surface water (at least five). Explore the new and simplest softening and water treatment methods by creating the different assemblies and manipulative techniques.
14. Collect data of various cement, glass and semiconductors available in the market.
15. Make a table showing the availability of natural rubber in India and show places on the map of India.
16. Prepare a chart showing (1) name & formula of the Polymer, (2) name and formula of the Monomer/s used to prepare that polymer, (3) simple reaction equation for Preparation of polymer, (4) Properties in short and (5) Uses in tabular form.
17. Collect different polymers and prepare the chart/ PowerPoint based on their type, properties, and uses.
18. Classify Semiconductors with examples. Enlist Semiconductor Devices. Also collect Semiconductors.

Suggested Activities for Students:

1. Prepare a Power point presentation or animation showing different atomic structures and different types of chemical bonds.
2. Calculate pH of acid solutions and base solutions having different concentrations.
3. Prepare a chart showing different methods used for the prevention of corrosion.
4. Enlist the formulae to solve the numericals based on hardness of water. Calculate the Molecular mass of salts responsible for hardness of water. Show calculations for some numericals based on hardness of water.
5. Prepare a table showing general chemical composition of cement and glass with their applications.
6. Do market survey of different types of cement, glass and semiconductors and compare their properties and applications.
7. Do library survey regarding polymers, synthetic rubber, insulating materials and semiconductors used in different industries.

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