Semester: I						
CHEMISTRY OF SMART MATERIALS AND DEVICES **Category: Applied Science Course** **Stream: Computer Science (Common to AI, BT, CS, CY, CD & IS Programs)** **(Theory and Practice)**						
Course Code	**:**	CM211IA		**CIE**	**:**	100 Marks
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	100 Marks
Total Hours	**:**	42L+ 30P		**SEE Duration**	**:**	03 Hours

Unit – I	**08 Hrs**
Sustainable Chemistry and E-waste management **Biomaterials:** Introduction, bio-degradable and bio-compatible polymeric materials: synthesis and applications (Polymers and hydrogels in drug delivery). **Green Chemistry**: Introduction, 12 principles with real life examples, validation of greenness. **E-waste:** Hazards and toxicity, segregation and recycling (Hydrometallurgy, pyrometallurgy and direct recycling). Extraction of valuable metals from E-waste. Battery waste management and recycling, circular economy- case studies.	
Unit – II	**08 Hrs**
Computational Chemistry: Scope, cost and efficiency of computational modeling. Stabilizing interactions: Bonded and non-bonded interactions. Molecular topology, topological matrix representation, topological indices, QSAR/QSPC concept for insilico prediction of properties. 3D co-ordinate generation for small molecules, geometry optimization.	
Unit – III	**08 Hrs**
Materials for Memory and Display Technology **Materials for memory storage:** Introduction to materials for electronic memory, classification (organic, polymeric and hybrid materials), manufacturing of semiconductor chips. Green computing: Bio-composite based memory devices. **Fabrication of Smart Materials and Devices:** photo and electro active materials for memory devices, materials for display technology (Liquid crystals display, organic light emitting diode and light emitting electrochemical cells).	
Unit – IV	**09 Hrs**
Smart Sensors and Devices **RFID and IONT materials:** Synthesis, properties and applications in logistic information, intelligent packaging systems (Graphene oxide, carbon nanotubes (CNTs) and polyaniline). **Sensors:** Introduction, types of sensors (Piezoelectric and electrochemical), nanomaterials for sensing applications (Strain sensors, gas sensor, biomolecules and volatile organic compounds).	
Unit – V	**09 Hrs**
Advanced Energy Systems **Battery technology:** Introduction to electrochemistry, characteristics of battery, Lithium-ion battery metal air batteries. Battery technology for e-mobility. **Super capacitors:** Storage principle, types (EDLC, pseudo and asymmetric capacitor) with examples and applications. **Photovoltaics:** Inorganic solar cells, organic solar cells, quantum dot sensitized (QDSSC's). Green hydrogen	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the principles of chemistry for the synthesis and selection of materials to be used in memory, energy, electronic, biomedical devices and environmental applications. **(PO1, PO11)**
CO2	Utilize the computational/green/sustainable chemistry approaches to compute materials functionalities and properties. **(PO1, PO6)**
CO3	Propose and interpret solutions for the challenges connected to memory, display, energy, smart, green and sustainable technologies. **(PO1, PO6)**
CO4	Analyze the quality parameters of engineering materials associated with environment, energy devices and sensors. **(PO1, PO6, PO8, PO9, PO11)**

Reference Books	
1	E-waste recycling and management: present scenarios and environmental issues, Khan, Anish, and Abdullah M. Asiri. 2019, Springer, Vol. 33. ISBN: 978-3-030-14186-8.
2	Essentials of computational chemistry: theories and models, Christopher J Cramer, 2013, John Wiley & Sons. ISBN: 978-0-470-09182-1.
3	Energy storage and conversion devices: Supercapacitors, batteries and hydroelectric cells, Anurag Gaur, A. L. Sharma, Anil Arya. 2021, CRC press, 1st edition, ISBN: 978-1-003-14176-1.
4	Fundamentals of analytical chemistry: An introduction, Douglas A. Skooget etal., 2004 Thomson Asia pte Ltd., 8th, ISBN: 978-0-495-55828-6
E-books	
5	Functional and smart materials, Chander Prakash, Sunpreet Singh, J. Paulo Davim, 2020, CRC Press, ISBN: 978-036-727-510-5.
6	Electrical and electronic devices, circuits and materials: Technological challenges and solutions. Tripathi, S. L., Alvi, P. A., & Subramaniam, U, 2021, John Wiley & Sons, ISBN: 978-0367564261.

	Laboratory Experiments
1	Estimation of copper from PCB.
2	Determination of total acidity of the soft drinks using pH sensors.
3	Potentiometric estimation of iron.
4	Conductometric estimation.
5	Determination of viscosity coefficient of a given liquid using Ostwald's viscometer.
6	Flame photometric estimation of sodium.
7	Colorimetric estimation of copper from E-waste.
8	Electroplating of copper.
9	Synthesis and fabrication of conducting polyaniline and its application in gas sensing (Demonstration experiment).
10	Study the surface morphology of nanomaterials using scanning electron microscopy (Demonstration experiment).
11	Fabrication of thin-film gas sensors using spin coating and electro-spinning technique (Demonstration experiment).
12	Separation of organic compounds using column chromatographic technique and monitoring by thin layer chromatographic technique (Demonstration experiment).
13	Synthesis of metal oxide nanomaterials using solution combustion synthesis.
14	Green synthesis of nanomaterials.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY WITH LAB)		
#	COMPONENTS	MARKS
1	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE AVERAGE OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**10**
2	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **THREE** tests will be conducted (Two regular tests and one optional improvement test). Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 30 MARKS.**	**30**
3	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10**) ADDING UPTO 30 MARKS**.	**30**

4	**LAB:** Conduction of laboratory exercises, lab report, observation and analysis **(30 Marks)**, lab test **(10 Marks)** and Innovative Experiment/ Concept Design and Implementation (**10 Marks)** adding up to 50 Marks. **THE FINAL MARKS WILL BE REDUCED TO 30 MARKS**	**30**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	10
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit – I: (Compulsory)	14
3 & 4	Unit – II: Question 3 or 4	14
5 & 6	Unit – III: Question 5 or 6	14
7 & 8	Unit – IV: Question 7 or 8	14
9 & 10	Unit – V: Question 9 or 10	14
11	Lab Component (Compulsory)	20
	MAXIMUM MARKS FOR THE SEE THEORY	**100**

Semester: II						
CHEMISTRY OF FUNCTIONAL MATERIALS **Category: Applied Science Course** **Stream: Electronics (Common to EC, EE, EI & ET Programs)** **(Theory and Practice)**						
Course Code	**:**	CM221IB		**CIE**	**:**	100 Marks
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	100 Marks
Total Hours	**:**	42L+ 30P		**SEE Duration**	**:**	03 Hours

Unit – I	**08 Hrs**
Energy Storage and Conversion Devices **Battery**: Introduction, types, characteristics, components/materials, working and applications of Lithium cobalt oxide and metal air batteries. **Super-Capacitors:** Introduction, types (EDLC, pseudo capacitors, asymmetric capacitors), mechanism with examples and applications. **Energy Conversion Devices:** Introduction, characteristics, materials, working and applications of H2-O2 fuel cells, amorphous Si and quantum dye sensitized solar cells.	
Unit – II	**09 Hrs**
Nanomaterials and Thin Film Fabrication Techniques **Nanomaterials:** Introduction, classification and properties. Synthesis- solution combustion, sol-gel method for thin films. **Carbon Nanomaterials:** Types, synthesis, properties, functionalization and applications of CNT and Graphene. **Thin Film Deposition Techniques**: Fabrication of thin films using CVD and PECVD and Metal organic chemical vapor deposition (MOCVD)-principle, fabrication and applications.	
Unit – III	**09 Hrs**
Chemistry of electronic materials **Inorganic semiconducting materials:** Introduction, types with examples. Semiconductors- p-type, n-type materials. Production of electronic grade silicon-Czochralski process and float zone methods. Electronic and chemical properties, applications of Gallium arsenide (GaAs), Silicon-germanium (SiGe), and Indium phosphide (InP). **Organic Semiconducting Materials**: Introduction, pentacene and fullerene derivatives, conducting polymer, principle, synthesis of polyaniline, applications in electronic devices. **Magnetic Materials**: Data storage materials, dielectric materials: Examples, properties and applications.	
Unit – IV	**08 Hrs**
Advanced Electronic Materials and E –waste: Materials, mechanism, examples and applications of photochromic, thermochromic, electrochromic, electrostrictive, magnetostrictive, RFID, MEMS and NEMS, e-skin, e-nose devices. **E-waste** - Types, environmental risks, recycle management.	
Unit – V	**08 Hrs**
Sensors and Instrumental Methods of Analysis **Sensors:** Introduction, types, principle, materials used and applications of optoelectronic sensors, piezoelectric sensor, electrochemical sensor and gas sensors. **Instrumental Method of Analysis:** Principle, instrumentation: Colorimetry, potentiometry, flame photometry and conductometry.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply principles of chemistry for the synthesis and properties of electronic materials. **(PO1, PO11)**
CO2	Evaluate the materials for their futuristic application in the field of electronics. **(PO1, PO6)**
CO3	Propose and interpret solutions for engineering problems associated with electronic materials. **(PO1, PO6)**
CO4	Analyze the quality parameters of engineering materials associated with electronic devices. **(PO1, PO6, PO8, PO9, PO11)**

Reference Books	
1	Chemistry in microelectronics, Yannick Le Tiec, 2013, Wiley Publications, ISBN: 9781848214361.
2	Electronics properties of materials, Rolf E, Hummel, 2012, Springer Publications New York, 4th Edition, ISBN 9781441981639.
3	Smart nanomaterials for sensor application, Li S, Ge Y, Li H, 2012, Bentham Science Publishers, ISBN: 9781608055425.
4	Energy storage and conversion materials, Skinner S, 2019, Royal society of chemistry, ISBN: 9781788010900.
E-Books	
5	Smart materials, Harvey, James A. Handbook of materials selection, 2002, John Wiley & Sons Canada, Limited, ISBN: 9780471359241.
6	Engineering Chemistry, Suba Ramesh, Vairam, Ananda Murthy, 2011, Wiley India, ISBN: 9788126519880.
7	Energy storage and conversion devices; Supercapacitors, batteries and hydroelectric Cells Editor: Anurag Gaur, 2021, CRC Press, ISBN: 9781000470512.
8	An overview of advanced nanomaterials for sensor applications, Rohilla D, Chaudhary S, Umar A. Engineered Science publisher. 2021, 16:47-70. DOI: 10.30919/es8d552.

Laboratory Experiments (ME stream)	
1	Estimation of copper in the E-waste.
2	Determination of pKa of a weak acid using pH sensor.
3	Potentiometric estimation of iron.
4	Colorimetric estimation of copper from PCBs.
5	Conductometric estimations.
6	Flame photometric estimation of sodium.
7	Determination of viscosity coefficient.
8	Electroplating of copper.
9	Preparation of polyaniline for sensor application (Demonstration experiment).
10	Preparation of semiconducting TiO_2 nanoparticles for DSSC applications (Demonstration experiment).
11	Determination of band gap of semiconducting material using UV-vis spectrophotometer (Demonstration experiment).
12	Study the surface morphology of nanomaterials using scanning electron microscopy (Demonstration experiment).
13	Thin films fabrication using PECVD and sputtering technique (Demonstration Experiment).
14	Fabrication of coin cell super capacitor prototype (Demonstration experiment).
15	Synthesis of iron oxide nanomaterials using solution combustion synthesis.
16	Green synthesis of nanomaterials.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY WITH LAB)		
#	**COMPONENTS**	**MARKS**
1	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE AVERAGE OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**10**
2	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **THREE** tests will be conducted (Two regular tests and one optional improvement test). Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 30 MARKS.**	**30**
3	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10**) ADDING UPTO 30 MARKS**.	**30**

4	**LAB:** Conduction of laboratory exercises, lab report, observation and analysis **(30 Marks)**, lab test **(10 Marks)** and Innovative Experiment/ Concept Design and Implementation (**10 Marks)** adding up to 50 Marks. **THE FINAL MARKS WILL BE REDUCED TO 30 MARKS**	**30**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	10
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit – I: (Compulsory)	14
3 & 4	Unit – II: Question 3 or 4	14
5 & 6	Unit – III: Question 5 or 6	14
7 & 8	Unit – IV: Question 7 or 8	14
9 & 10	Unit – V: Question 9 or 10	14
11	Lab Component (Compulsory)	20
	MAXIMUM MARKS FOR THE SEE THEORY	**100**

Semester: II						
CHEMISTRY OF ENGINEERING MATERIALS **Category: Applied Science Course** **Stream: Mechanical (Common to AS, CH, IM & ME Programs)** **(Theory & Practice)**						
Course Code	**:**	CM221IC		**CIE**	**:**	100 Marks
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	100 Marks
Total Hours	**:**	42L+ 30P		**SEE Duration**	**:**	03 Hours

Unit – I	**08 Hrs**
Fuels: Thermochemistry, calorific value of fuels, numerical, knocking in internal combustion engines, reasons for knocking, octane and cetane number, antiknocking agents. Biodiesel, power alcohol **Alternative Fuels**: Green fuel- hydrogen production and storage. Rockets Fuels: Properties, characteristics and types.	
Unit – II	**09 Hrs**
Energy Storage and Conversion Devices **Batteries and Super Capacitors:** Working principle, classification, fabrication and applications of lithium-ion battery, metal air batteries, supercapacitors and super batteries. **Fuel cells and renewable energy:** Hydrogen - oxygen fuel cell, direct methanol fuel cell and their applications. Solar cell – principle, construction and working of Quantum Dot sensitized solar cells.	
Unit – III	**08 Hrs**
Corrosion Science and Management **Corrosion:** Electrochemical theory of corrosion. Types: differential aeration (pitting and water line), differential metal and stress corrosion. Factor affecting rate of corrosion. Case studies on corrosion failure. **Corrosion Control:** Metal coating-galvanization and tinning, surface conversion coating - anodizing and phosphating. Cathodic protection - sacrificial anode method. Corrosion testing by weight loss method. Corrosion penetration rate (CPR)-numerical problems. Metal finishing: Electroplating of chromium and Electroless plating of copper:	
Unit – IV	**08 Hrs**
Chemistry of Nanomaterials **Size dependent properties:** Surface area, optical and catalytic properties. Classification of nanomaterials. Synthesis: Solution combustion and Sol-gel methods. **Synthesis and applications:** Synthesis, properties and applications of carbon nano tubes and graphenes. Nano lubricants: Types of nanoparticles as lubricant additives and their application in defense, automobile and spacecrafts.	
Unit – V	**09 Hrs**
Engineering Polymers and Nanocomposites: Thermosets-bakelite and epoxy, thermoplastics- polycarbonate and polyether sulfones- preparation and specific applications in industries. Biodegradable polymer: Introduction, synthesis, properties, and application of poly lactic acid (PLA). Significance of glass transition temperature (Tg) and factors affecting Tg. **Reinforcements and testing**: Glass, carbon and natural fiber - synthesis, properties and applications in polymer composites. ASTM standards of material testing-tensile strength, flexural strength, ILSS and impact strength. Applications of polymer nanocomposites in injection moulded products, paints and 3D printing.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply principles of chemistry for the synthesis of materials and evaluation of their properties with the energy devices, polymer materials and corrosion science. **(PO1, PO11)**
CO2	Evaluate the properties of materials for the engineering application. **(PO1, PO6)**
CO3	Propose and interpret solutions for the challenges related to material performance and sustainability in engineering practices. **(PO1, PO6)**
CO4	Analyze the quality parameters of materials for sustainable engineering application. **(PO1, PO6, PO8, PO9, PO11)**

Reference Books	
1	Understanding nanomaterials, Malkiat S. Johal, Lewis E. Johnson, 2017, CRC Press, Taylor and Francis Group, ISBN: 9780815354383.
2	Engineering chemistry, Shubha Ramesh et.al., 2011, Wiley India, 1st Edition, ISBN: 9788126519880.
3	Fundamentals of analytical chemistry, Douglas A. Skoog et.al., 2004, 9th edition, Thomson Asia pte Ltd., ISBN: 9780495558286
4	Energy storage and conversion devices, Anurag Gaur, A. L. Sharma, Anil Arya, 2021, CRC Press, Taylor and Francis Group, 1st Edition, ISBN: 9781003141761.

Laboratory Experiments	
1	Volumetric analysis.
2	Analysis of alloy (Brass).
3	Ore analysis (Haematite).
4	Determination of pKa of a weak acid.
5	Potentiometric estimation of iron in rust.
6	Colorimetric estimation of copper.
7	Conductometric estimations.
8	Determination of viscosity coefficient of a given liquid using Ostwald's viscometer.
9	Flame photometric estimation of sodium in the given saline solution.
10	Preparation of nanomaterials by solution combustion method.
11	Preparation of thin films by dipcoating technique and characterization of thin film.
12	Determination of relative and kinematic viscosities of given lubricating oil at different temperatures using Redwood viscometer (Demonstration experiment).
13	To find of Tg of polymer using DSC (Demonstration Experiment).
14	Study of surface morphology of materials using SEM (Demonstration experiment).
15	Phase analysis of alloys by XRD (Demonstration experiment).
16	Synthesis of metal oxide nanomaterials using solution combustion synthesis (Demonstration experiment).
17	Green synthesis of nanomaterials (Demonstration experiment).

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY WITH LAB)		
#	COMPONENTS	MARKS
1	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE AVERAGE OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**10**
2	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **THREE** tests will be conducted (Two regular tests and one optional improvement test). Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 30 MARKS.**	**30**
3	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10**) ADDING UPTO 30 MARKS**.	**30**
4	**LAB:** Conduction of laboratory exercises, lab report, observation and analysis **(30 Marks)**, lab test **(10 Marks)** and Innovative Experiment/ Concept Design and Implementation (**10 Marks)** adding up to 50 Marks. **THE FINAL MARKS WILL BE REDUCED TO 30 MARKS**	**30**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	10
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit – I: (Compulsory)	14
3 & 4	Unit – II: Question 3 or 4	14
5 & 6	Unit – III: Question 5 or 6	14
7 & 8	Unit – IV: Question 7 or 8	14
9 & 10	Unit – V: Question 9 or 10	14
11	Lab Component (Compulsory)	20
	MAXIMUM MARKS FOR THE SEE THEORY	**100**

Semester: I						
ENGINEERING AND ENVIRONMENTAL CHEMISTRY **Category: Applied Science Course** **Stream: Civil (Only to CV Program)** **(Theory and Practice)**						
Course Code	**:**	CM221ID		**CIE**	**:**	100 Marks
Credits: L:T:P	**:**	3:0:1		**SEE**	**:**	100 Marks
Total Hours	**:**	42L+ 30P		**SEE Duration**	**:**	03 Hours

Unit – I	**08 Hrs**
Green Chemistry: Introduction, principles of green chemistry, E-factor, atom economy, microwave and ultrasound assisted reactions, examples of green synthesis. **Water Chemistry**: Impurities in water, emerging pollutants, water quality parameters as per BIS, determination of fluoride, DO, BOD and COD, numericals, desalination of water by RO. Sewage treatment process.	
Unit – II	**09 Hrs**
Materials in Civil Engineering **Cement:** Chemical composition of cement, manufacturing process of portland cement, process of setting and hardening, types (Mortar, concrete, RCC and CSH Gel) and their applications. **Glass:** Manufacture, properties, types and applications. **Ceramics and Refractory Materials:** Properties, types and applications.	
Unit – III	**08 Hrs**
Corrosion Science and Engineering **Corrosion:** Electrochemical theory, types: differential aeration (waterline and pitting), differential metal and stress corrosion (caustic embrittlement). Factors affecting rate of corrosion. **Corrosion Control**: Metal coating-galvanization and tinning, surface conversion coating - anodizing and phosphating. Cathodic protection - sacrificial anode method. Corrosion testing by weight loss method, corrosion penetration rate (CPR), numerical problems. **Metal finishing**: Electroplating of chromium and electroless plating of copper	
Unit – IV	**09 Hrs**
Polymers and Polymer Composites: Synthesis, properties, and applications of PMMA, PVC, polyester, polystyrene. Polymer concretes and biopolymer. **Smart Polymers**: Thermo chromic polymers, electrochromic polymers, polymer coatings, polymer binders and self-healing polymers. **Polymer Composites**: Carbon fiber composites, CNT and graphene-based composites. **Adhesives**: Synthesis and application of epoxy resins. **Geo Polymers**: Properties, types, geo polymer concrete. **Biodegradable Polymers**: Polylactic acid and its application.	
Unit – V	**08 Hrs**
Chemistry of Nanomaterials and Analytical Techniques: Properties (surface area, electrical, optical and catalytic properties), synthesis of nanomaterials: Top down and bottom-up approaches, synthesis by sol-gel, and solution combustion method. Civil engineering applications of carbon nanotubes. **Analytical Techniques**: Principle, instrumentation and applications of conductometry, potentiometry, colorimetry and pH-sensor (glass electrode).	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the principles of chemistry in synthesis of materials and evaluating their properties associated with green chemistry, water chemistry, civil engineering and corrosion science. **(PO1, PO11)**
CO2	Evaluate the materials for their application in environmental monitoring and civil engineering. **(PO1, PO6)**
CO3	Propose and interpret solutions for the challenges connected to engineering applications. **(PO1, PO6)**
CO4	Analyse the quality parameters of materials associated with sustainable environmental monitoring and civil engineering. **(PO1, PO6, PO8, PO9, PO11)**

Reference Books	
1	Chemistry for Engineers, Teh Fu Yen, Imperial college press, 2008, ISBN: 97818609747742.
2	Advances in corrosion science and technology, M.G. Fontana, R.W. Staettle, Springer publications, 2012, ISBN: 9781461590620.
3	Fundamentals of analytical chemistry, Douglas A. Skoog et.al., 8th edition, 2004, Thomson Asia pte Ltd. ISBN: 9812435131.
4	Engineering chemistry, Shubha Ramesh et.al., Wiley India, 1st Edition, 2011, ISBN: 9788126519880.

Laboratory Experiments	
1	Volumetric analysis.
2	Estimation of water quality parameter: chemical oxygen demand.
3	Estimation of CaO in cement solution.
4	Determination of pKa of a weak acid using pH meter.
5	Potentiometric estimation of iron.
6	Colorimetric estimation of copper.
7	Conductometric estimation.
8	Determination of viscosity coefficient of a given liquid using Ostwald's viscometer.
9	Flame photometric estimation of sodium.
10	Determination of relative and kinematic viscosities of given lubricating oil at different temperatures using Redwood viscometer (Demonstration Experiment).
11	To find of Tg of polymer using DSC. (Demonstration Experiment).
12	Study of surface morphology of materials using SEM (Demonstration Experiment).
13	Synthesis of iron oxide nanomaterials using solution combustion synthesis
14	Green synthesis of nanomaterials.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY WITH LAB)		
#	COMPONENTS	MARKS
1	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE AVERAGE OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**10**
2	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **THREE** tests will be conducted (Two regular tests and one optional improvement test). Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 30 MARKS.**	**30**
3	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10**) ADDING UPTO 30 MARKS**.	**30**
4	**LAB:** Conduction of laboratory exercises, lab report, observation and analysis **(30 Marks)**, lab test **(10 Marks)** and Innovative Experiment/ Concept Design and Implementation (**10 Marks)** adding up to 50 Marks. **THE FINAL MARKS WILL BE REDUCED TO 30 MARKS**	**30**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	10
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit – I: (Compulsory)	14
3 & 4	Unit – II: Question 3 or 4	14
5 & 6	Unit – III: Question 5 or 6	14
7 & 8	Unit – IV: Question 7 or 8	14
9 & 10	Unit – V: Question 9 or 10	14
11	Lab Component (Compulsory)	20
	MAXIMUM MARKS FOR THE SEE THEORY	**100**