

**GUJARAT UNIVERSITY**  
**Bachelor of Science (Hons.)**  
**Effective from June 2023**

**Semester I**  
**CHEMISTRY**

**Course Structure with credits, hours, and marks**

Course Type	Course	Credit	Work Hours/ week	Exam hours	Marks		Total Marks
					Internal	External	
Discipline specific Courses – Core	DSC-C-101	3	3	3	30	70	100
	DSC-C-102P	2	4	4	15	35	50

**N.B.: Each practical batch will have 10 students.**

**Learning Objectives:**

The objective of this Course is to understand different types of chemical bonds present in the molecules. It explains the formation of ionic bond, covalent bond, and co-ordinate bond in different compounds. It gives basic knowledge about hybridization and shape of molecules. It gives fundamental concepts of organic chemistry and basic knowledge of hydrocarbons. It also explains the mechanism of organic reaction. It also develops basic and advanced concepts of thermodynamic laws and concepts. It also provides knowledge regarding different types of chemical processes. It gives the basic idea about rate of reaction, order of reaction, molecularity, and derivation of rate constant.

The laboratory course of this semester gives the idea regarding how to use different glass wares and chemicals in the laboratory and the practical knowledge of preparation of different standard solution. It also gives the skill regarding identification of inorganic salts.

## **Course outcomes:**

### **By the end of the course, the students will be able to:**

- Solve the problems regarding hybridization and types of bonding.
- Draw the structures, shapes, and geometry of the different molecules.
- Understand characteristics of different types of compounds.
- Learn the preparations of alkanes, alkenes and alkynes, their reactions.
- Draw the IUPAC and Bond line structures of hydrocarbons.
- Understand the mechanism of organic reactions.
- Learn the different equations regarding the law of thermodynamics.
- Understand the different chemical processes occurring in the nature.
- Derive the rate equations of different types of order of reactions.
- Understand the different types of reactions regarding the order of reactions.
- Prepare different types of standard solutions.
- Handle properly chemical and glass wares.
- Calibrate the apparatus used in the titrations.
- Understand the theory and applications of acid base titrations.
- Determine the positive and negative ions present in the inorganic salts.

**B. Sc. (Hons.) Semester I**  
**DSC-C-101**  
**Basic Chemistry**

**Unit – I: Bonding and Structure**

**[24 Marks]**

Chemical bond, Types of bond (Ionic, Covalent, Coordinate and Metallic Bond), Conditions and factors governing the formation of ionic Bond, Conditions for formation of covalent bond, Co-ordinate covalent Bond, Characteristics of ionic and covalent compounds, Polar Covalent bond, Condition for Hydrogen bonding, Types of hydrogen bonding, Metallic bond, Sidgwick Powel theory, VSEPR theory and its application for  $\text{CH}_4$ ,  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{ClF}_3$ ,  $\text{SF}_4$ ,  $\text{SF}_6$ ,  $\text{I}_3^-$ ,  $\text{IF}_7$ , Hybridization of atomic orbitals, Rules for Hybridization, Types of hybridization and Shape of molecules with  $sp$ ,  $sp^2$ ,  $sp^3$ ,  $sp^3d$ ,  $sp^3d^2$  hybridization.

**Unit – II: Aliphatic Hydrocarbon**

**[24 Marks]**

**Alkane:**

Introduction, IUPAC Nomenclature and Bond line Structure, Methods of Preparation: - Wurtz reaction, Corey–House Synthesis (Gilman reagent), Hydrolysis of R-Mg-X, Decarboxylation of carboxylic acids and Kolbe electrolysis, Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity (with Energy considerations), Nitration of alkane (only reaction).

**Alkene:**

Introduction, IUPAC Nomenclature and Bond line Structure, Methods of Preparation:- Dehydration of alcohols (with mechanism), Regioselectivity in alcohol dehydration, dehalogenation, dehydrogenation, dehydro halogenation of alkyl halides, The Saytzeff rule, Hofmann elimination (Only introduction, without mechanism for both the rules), Mechanisms involved in hydrogenation, electrophilic and free radical additions, Markovnikov's rule, peroxide effect, hydroboration-oxidation, and oxymercuration - reduction. Epoxidation,

ozonolysis, hydration, hydroxylation and oxidation (i) with cold alkaline  $\text{KMnO}_4$  (Baeyer's reagent), (ii) Oxidative cleavage with acidified or hot  $\text{KMnO}_4$  (iii) Ozonolysis ( $\text{O}_3$ ), Polymerization of alkenes, substitution at the allylic and vinylic positions of alkenes.

### **Alkynes:**

Introduction, IUPAC Nomenclature and Bond line Structure, Methods of Preparation: Dehydrohalogenation, dehalogenation, Acidity of Alkynes (Na, Ag, Cu), Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal ammonia and metal reductions (cis and trans), and polymerization.

### **Unit – III:**

#### **[A] Thermodynamics: - [11 Marks]**

Zeroth law, First law, Limitations of first law and need for the second law, Second law of thermodynamics, Proof of second law (Carnot's Cycle), Entropy of Gas and calculation of entropy for different processes, Entropy change during phase change, entropy of mixing of ideal gases, Entropy change in reversible and irreversible process, Kirchhoff's equation.

#### **[B] Chemical Kinetics: - [11 Marks]**

Basic terms: Molecularity, Order of reactions. Unit for rate constant, Derivation of: first order rate constant, Second order rate constant for ( $a=b$ ) and ( $a \neq b$ ), Third order rate equation ( $a=b=c$ ), Determination of Half Life Time for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> order reactions, Kinetics of opposing and consecutive reaction.

## REFERENCE BOOKS

1. '**Concise Inorganic Chemistry**' by J. D. Lee, 5<sup>th</sup> Ed., 2013, Wiley India.
2. '**Basic Inorganic Chemistry**' by F. A. Cotton, Geoffrey Wilkinson, Carlos A Murillo and Manfred Bochmann, 6<sup>th</sup> Ed., Wiley publication,
3. '**Inorganic Chemistry**' by Shriver & Atkins, 5<sup>th</sup> Ed., 2013, Oxford University Press.
4. '**Introductory Quantum Chemistry**' by A. K. Chandra, 4<sup>th</sup> Ed., 2017, Tata Mc Graw Hill Publishing Company Limited, New Delhi.
5. '**Elements of Quantum Mechanics**' by Michael D. Fayer, Indian Ed., Oxford University Press.
6. '**Satya Prakash's Modern Inorganic Chemistry**' by Dr. R. D. Madan, S Chand, New Delhi.
7. '**Organic Chemistry**' by G. Marc Loudon, 4/E, 2010, Indian Edition, Oxford University press.
8. '**Organic Chemistry**' by Robert Thornot Morrison, Robert Neilson Boyd, 6/E, 1992, Prentice Hall of India Pvt Ltd, New Delhi.
9. '**Text book of Organic Chemistry**' by P. L. Soni and H. Chawla, 26/E, 1995, Sultan Chand & Sons Publication, New Delhi.
10. '**Text book of Organic Chemistry**' by P. S. Kalsi, 1999, MacMillan of India Pvt. Ltd.
11. '**Organic Chemistry**' by Bhupinder Mehta, Manju Mehta, Prentice Hall of India Pvt. Ltd, New Delhi.
12. '**Elements of Physical Chemistry**' by Peter Atkins & Julio De Paula, 5/E, Indian Edition, Oxford University Press.
13. '**Physical Chemistry**' by P. W. Atkins, 7/E, 2002, Indian Edition Oxford University Press.
14. '**Physical Chemistry**' by W. J. Moore, 6/E, 1996, MacGraw Hill Publication.
15. '**Principle of Physical Chemistry**' by Puri, Sharma & Pathania, 41/E, Vishal Publishers.
16. '**Essentials of Physical Chemistry**' by Bahl & Tuli, 22/E, S. Chand publication, New Delhi.
17. '**Advanced Physical Chemistry**' by Gurdeep Raj, 19/E, Goel Publishing House Meerut.

**B. Sc. (Hons.) Semester I**  
**DSC-C-102P**  
**PRACTICAL**

(a) Introduction to chemical laboratory, use of glass wares, chemical and reagents, organic and inorganic solvents, bench reagents, side reagents, safety practices in the chemistry laboratory, knowledge about toxic chemicals and safety precautions in their handling.

**(b) Volumetric Analysis (Acid and Base):**

Preparation of standard solution of Succinic Acid, Oxalic Acid (Hydrated & Anhydrous)

(1) Succinic Acid → NaOH or KOH

(2) Oxalic Acid (Hydrated & Anhydrous) → NaOH or KOH

(3) Na<sub>2</sub>CO<sub>3</sub> → HCl

(4) Determination of the amount of calcium carbonate in chalk using standard HCl and NaOH solutions (back-titration)

**(c) Inorganic Qualitative Analysis (Two Radicals) (Minimum Eight Salts)**

Water Soluble and Insoluble Inorganic salts of following cations and anions:

**Cations:** Na<sup>+</sup>, K<sup>+</sup>, NH<sub>4</sub><sup>+</sup>, Mg<sup>+2</sup>, Ba<sup>+2</sup>, Ca<sup>+2</sup>, Sr<sup>+2</sup>, Fe<sup>+2</sup>, Fe<sup>+3</sup>, Al<sup>+3</sup>, Cr<sup>+3</sup>, Zn<sup>+2</sup>, Mn<sup>+2</sup>, Co<sup>+2</sup>, Pb<sup>+2</sup>, Cu<sup>+2</sup>

**Anions:** S<sup>-2</sup>, SO<sub>4</sub><sup>-2</sup>, CO<sub>3</sub><sup>-2</sup>, PO<sub>4</sub><sup>-3</sup>, CrO<sub>4</sub><sup>-2</sup>, NO<sub>3</sub><sup>-</sup>, Cl<sup>-1</sup>, Br<sup>-1</sup>, I<sup>-1</sup>, O<sup>-2</sup>

## Reference Books

1. **Vogel's Textbook of Macro and Semi Micro Qualitative Inorganic Analysis**', 5<sup>th</sup> Ed., Longman Ltd, New York.
2. **'Vogel's Textbook of Quantitative Chemical analysis'** Revised by G. H. Jeffery, J. Bassett, J. Mendham & R. C. Denney, ELBS (English Language Book Society) Longman. 5<sup>th</sup> Ed., New York.
3. **'Analytical Chemistry'** by Dhruba Charan Dash, 2011, PHI Learning Private Ltd, New Delhi.
4. **'Analytical Chemistry'** by Gary D. Christian, 4<sup>th</sup> Ed., John Wiley & Sons.
5. **'Advanced Practical Inorganic Chemistry'** by Gurdeep Raj, 9<sup>th</sup> Ed., Goel Publishing House, Meerut.

**GUJARAT UNIVERSITY**  
**Bachelor of Science (Hons.)**  
**Semester II**  
**CHEMISTRY**  
**Course Structure with credits, hours, and marks**

Course Type	Course	Credit	Work Hours/ week	Exam hours	Marks		Total Marks
					Internal	External	
Discipline specific Courses – Core	DSC-C-103	3	3	3	30	70	100
	DSC-C-104P	2	4	4	15	35	50

**N.B.: Each practical batch will have 10 students.**

**Learning Objectives:**

The course develops the basic knowledge and conceptual ideas regarding the structure of atoms, it explains the different models to explain the structure of atoms. It also gives basic knowledge of quantum mechanics. It explains the shapes of the different atomic orbitals. It provides knowledge regarding the quantum numbers and filling of electrons in the different atomic orbitals. The course explains the fundamental concepts of stereo chemistry and concept of visualizing the organic molecules in three-dimensional space. It develops ideas to understand different isomers of organic molecules. The course gives conceptual knowledge of different electrolytes and their electrical conductance. It provides an explanation regarding the relation between dilution and conductance. It also gives the explanation of pH – scale and its equations. It gives the knowledge of hydrolysis of different salts and their different equations. It gives the relationship between pH range buffer solution and indicator.



Laboratory course of this semester gives the knowledge regarding Normality, Molarity of the solutions. Students will learn about fundamentals of redox titrations; students will also learn about functional groups present in the organic molecules.

**Course outcomes:**

**By the end of the course, the students will be able to:**

- Learn scientific theory of atoms, concept of wave functions, the fundamentals of quantum mechanics.
- Solve the conceptual questions regarding quantum numbers, electronic configuration, shapes of the orbitals, radial and angular distribution curves.
- Understand the fundamental concepts of stereochemistry of the organic molecules.
- Learn the different types of electrolytes and conductance, dissociation of electrolytes and their applications.
- Solve the conceptual questions regarding hydrolysis of salts, pH of the solutions and buffer solutions.
- Know the knowledge of theory and principle of volumetric analysis.
- Identify organic molecules.

**B. Sc. (Hons.) Semester II**  
**DSC-C-103**  
**General Chemistry**

**UNIT -I: Atomic Structure**

**[24 Marks]**

Bohr's principle and its limitations, Atomic spectrum of Hydrogen atom, Development leading to Quantum or Wave mechanical model of atom, de Broglie equation, Heisenberg's Uncertainty principle and its significance, Need of Quantum mechanical model of atom, Schrodinger wave equation, significance of  $\psi$  and  $\psi^2$ , Quantum mechanical model of atom (Concept of atomic orbital), Difference between orbit and orbital, Quantum numbers and their significance, Radial and angular wave function for hydrogen atom, Radial function plots, Radial probability distribution plots, Shape of s, p and d atomic orbitals, Boundary surface diagram, Relative energies of orbitals, Aufbau principle and its limitations, Pauli Exclusion principle, Hund's rule of maximum multiplicity.

**UNIT – II:**

**(A) Fundamentals of Stereochemistry: -**

**[24 Marks]**

Introduction, Stereochemical aspects of organic molecules, Chirality, Optical isomerism of lactic acid and tartaric acid, Enantiomers and Diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D - L and R-S system of nomenclature, Geometric isomerism — determination of configuration of geometric isomers, E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds, Difference between configuration and conformation, Conformational analysis of Ethane, n-Butane & Cyclohexane, Axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives (only one example), Newman projection and Sawhorse formula, Fischer and flying wedge formula.

### **UNIT III: Ionic equilibrium**

**[22 Marks]**

Definition of basic terms: Electrical conductance, Specific conductance, Equivalent conductance, Molar conductance, Cell constant and its determination, Incomplete dissociation, Degree of dissociation, Oswald's dilution law and its limitations, Kohlrausch law and its application, Debye – Huckel theory, Self-ionization of water and Ionic product of water  $K_w$ , pH Scale, Hydrolysis of different salts (strong acid and weak base, strong base and weak acid, weak acid and weak base) including relation between  $K_a$ ,  $K_b$ ,  $K_h$ ,  $h$ ,  $K_w$  and their pH equation, Buffer Solutions, Henderson – Hasselbalch equation, Indicator theory, useful pH range of indicator for acid and base titration.

## REFERENCE BOOKS

1. **'Introductory Quantum Chemistry'** by A. K. Chandra, Mc Graw Hill, 4<sup>th</sup> Ed., 2017.
2. **'Concise Inorganic Chemistry'** by J. D. Lee, 5<sup>th</sup> Ed., Blackwell Science.
3. **'Inorganic Chemistry'**, by James E. Huheey, Pearson, 4<sup>th</sup> Ed, 2012.
4. **'Elements of Quantum Mechanics'** by Michael D. Fayer, Indian Ed., Oxford University Press.
5. **'Basic Inorganic Chemistry'** by F. A. Cotton, 6<sup>th</sup> Ed., Wiley publication.
6. **'Inorganic Chemistry'** by Shriver & Atkins, 5<sup>th</sup> Ed, 2013, Oxford University Press.
7. **'Satya Prakash's Modern Inorganic Chemistry'** by Dr. R. D. Madan, S Chand, Revised Edition.
8. **'Quantum chemistry'** by **R. K. Prasad**, 2<sup>nd</sup> Ed., 1996, New Age International publishers,
9. **'Organic Chemistry'** by G. Marc Loudon, 4/E, 2010, Indian Edition, Oxford University Press.
10. **'Organic Chemistry'** by Robert Thornot Morrison, Robert Neilson Boyd, 6/E, 1992, Prentice Hall of India Pvt Ltd, New Delhi.
11. **'Text book of Organic Chemistry'** by P. L. Soni and H. M. Chawla, 26/E, 1995, Sultan Chand & Sons Publication, New Delhi.
12. **'Textbook of Organic Chemistry'** by P. S. Kalsi, 1999, MacMillan of India Pvt. Ltd.
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15. **'Physical Chemistry'** by P. W. Atkins, 7/E, 2002, Indian Edition, Oxford University Press..

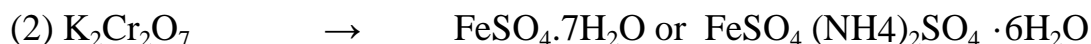
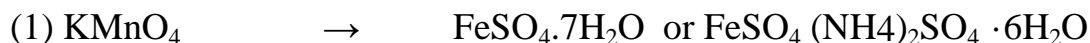
16. **'Physical Chemistry'** by W. J. Moore, 6/E, 1996, McGraw Hill Publication,
17. **'Principle of Physical Chemistry'** by Puri, Sharma & Pathania, 41/E, Vishal Publishers.
18. **'Essentials of Physical Chemistry'** by Bahl & Tuli., 22/E, S. Chand publication, New Delhi.
19. **'Advanced Physical Chemistry'** by Gurdeep Raj, 19/E, Goel Publishing House, Meerut.

**B. Sc. (Hons.) Semester II**  
**DSC-C-104P**  
**PRACTICAL**

**(a) Volumetric Analysis:-**

**Redox Titrations:-**

Preparation of standard solution of  $\text{KMnO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$



**Complexometric Titration by EDTA:-**

Preparation of standard solution of EDTA



**(b) Organic Spotting :- (06 Solids and 04 Liquids).**

List of organic compounds having different mono functional groups:

**Solids:**

**Acids:** (1) Benzoic acid (2) Oxalic acid (3) Succinic acid

**Phenols:** (1)  $\beta$ -Naphthol (2)  $\alpha$ -Naphthol

**Neutral:** (1) Urea (2) Thiourea (3) Naphthalene

**Liquids:**

(1) Aniline (2) Nitrobenzene (3) Benzaldehyde (4) Ethanol (5) Ethyl acetate

(6) Chlorobenzene (7) Acetone

## REFERENCE BOOKS

1. **‘Vogel’s Textbook of Quantitative Chemical analysis’** Revised by G. H. Jeffery, J. Bassett, J. Mendham & R. C. Denney, ELBS (English Language Book Society) 5<sup>th</sup> Ed., Longman, New York.
2. **‘Analytical Chemistry’** by Dhruva Charan Dash, 2011, PHI Learning Private Ltd, New Delhi.
3. **‘Analytical Chemistry’** by Gary D. Christian, 4<sup>th</sup> Ed., John Wiley & Sons.
4. **‘Comprehensive Practical Organic Chemistry – Qualitative Analysis’** by V. K. Ahluwalia, Sunita Dhingra, 2010, First Indian Reprint, University Press (India) Private Limited, Hyderabad.
5. **‘Organic Analytical Chemistry theory and Practice’** by Mohan Jag, 2003, Narosa Publication, New Delhi.
6. **‘Elementary Practical Organic Chemistry Part-2, Qualitative Organic Analysis’** by Arthur I. Vogel- CBS Publishers & Distributers, 2<sup>nd</sup> Ed., reprint 2004, New Delhi.
7. **‘Advanced practical Organic Chemistry’** by J. Leonard, B. Lygo, G. Procter, First Indian reprint, 2004, Publication-Stanley Thornes (Publishers) Ltd.

**GUJARAT UNIVERSITY**  
**Bachelor of Science (Hons.)**  
**Effective from June 2023**

**SEMESTER I**

**SEC-101**

**CHEMISTRY**

**Course Structure with credit, hours and marks**

Course Type	Course	Credit	Work hours/week	Exam hours	Marks		Total Marks
					Internal	External	
Skill Enhancement Course	SEC-101	3	3	3	30	70	100

**Course Title: Introduction to skill development in the chemical laboratory**

**Learning Objectives:**

1. Learn what to do in case of an accident. Understand basic safety rules and discipline of working behaviour in the laboratory. Minimize injury risk.
2. Learn how to exhibit the skill of analysis and inference producing mindset to achieve more definitive conclusions.
3. Check accuracy, repeatability, and determination of traceability in the measurement.
4. Learn the concentration and content of a substance.
5. Know the importance of safety and some chemical laboratory techniques.

**Course Outcome:**

1. Gain detailed knowledge of chemical laboratory techniques such as Glassware calibration, preparation of standard solutions and their methods.
2. Gain the skill to calibrate different type of glass wares.
3. Gain the skill to prepare standard solutions and know their applications.
4. Gain the knowledge of various types of indicators and their applications.

**Assessment Methods:**

1. Class participation and engagement
2. Quiz tests and Written assignments.
3. Final examination.



## **UNIT - 1:**

### **[A] Basic Safety and Precautions.**

**[12 marks]**

General instruction for work in the laboratory, safety precautions, laboratory accidents and first aid, Eye accidents and protection, laboratory apparel, Burns, Cuts, fires, poison, flammable, handling of hazards.

### **[B] Calibration and Uses of glass wares.**

**[12 marks]**

Introduction to glass wares and its uses. Definition and method of calibration of volumetric glass wares like burette, pipette, weighing balance, measuring flask, measuring cylinder, Thermometer.

## **UNIT - 2: Basic Experimental Techniques.**

**[24 marks]**

Introduction to laboratory apparatus, cleaning and drying of glass wares, cork and rubber, cutting and bending of glass tubing, heating bath, cooling bath. Reading and adjusting meniscus, filling vessel, draining vessel. Addition, Homogenization, Stirring, Heat transfer (heating, cooling, freezing), Melting, Boiling, Separation, Filtration, Distillation, Evaporation, Condensation, Drying, Crystallization, and sublimation. Weighing procedure and calculations. Theory and experimental determination of melting point and boiling point, mixed melting point. Fluted filter paper.

## **UNIT – 3:**

### **[A] Preparation of Standard Solutions**

**[11 marks]**

Concept of primary and secondary standard, solute, solvent, Definition of standard solution, Calculations for the preparation of standard solution of  $\text{KMnO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ ,  $\text{NaOH}$ ,  $\text{KOH}$ , Oxalic acid, Succinic acid, Sodium thiosulphate, EDTA, Iodine,  $\text{KBr-KBrO}_3$ . Preparation of standard solution of  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$ . Use of density, Concept and calculations of Normality, Molarity, gm/ltr, Molality, W/V, V/V, W/W.

### **[B] Preparation of Titrimetric Indicator Solutions.**

**[11 marks]**

Introduction to indicators, General type of indicators, Preparation of solutions of Phenolphthalein, Methyl orange, Diphenyl amine, Eriochrome black T, Murexide, Xylenol orange and Starch. Use of indicators in acid-base, Redox, Complexometric and Iodometric titrations.

## REFERENCE BOOKS

1. **'Elementary Practical Organic Chemistry'** by Arthur I. Vogel, 3<sup>rd</sup> edition.
2. **'Hazardous Chemicals Handbook'** by Phillip Carson, Clive Mumford, 2<sup>nd</sup> edition.
3. **'Quantitative Chemical Analysis'** by D.C. Harris, 9th ed., W. H. Freeman, NY, 2016.
4. **'The Calibration of small volumetric laboratory glass ware'** by Josephine Lemback, IBS, NBS Washington DC, 1974.
5. **'Chemical Safety Manual'** by I.I.T. Bombay.
6. **'Fundamentals of analytical chemistry'** by Skoog, Douglas A., West Donald M. F. James Holler. ISBN-13: 978-0495558286, ISBN-10: 0495558281.
7. **'Advanced university practical chemistry' vol-I**, (English, Paperback, P.C. Kamboj) ISBN: 9788014976320, 8014976320.
8. **'Shreve's Chemical Process Industries'** by Austin George, Publisher: McGraw Hill Education India, ISBN: 9781259029455, 9781259029455

**GUJARAT UNIVERSITY**  
**Bachelor of Science (Hons.)**  
**Semester II**  
**SEC-102**

**Course Structure with credits, hours, and marks**

Course Type	Course	Credit	Work hours/week	Exam hours	Marks		Total Marks
					Internal	External	
Skill Enhancement Course	SEC-102	3	3	3	30	70	100

**Course Title: Basics of Chemical Safety and Security**

**Learning Objectives:**

1. Understand the principles of chemical safety and security, including hazard identification, risk assessment, and risk management.
2. Learn the basic concepts of chemical safety management, including chemical inventory, labeling, storage, handling, and disposal.
3. Understand the importance of emergency response planning and incident management, including the use of personal protective equipment (PPE), hazard communication, and evacuation procedures.
4. Gain knowledge of the relevant laws, regulations, and standards governing chemical safety and security.

**COURSE OUTCOME**

1. Understanding of the basic principles of chemical safety, including hazard identification, risk assessment, and control measures.
2. Knowledge of the regulations and standards related to chemical safety.
3. Understanding of the importance of personal protective equipment (PPE) and its proper use.
4. Understanding of safe handling and storage practices for chemicals, including proper labeling and segregation.
5. Knowledge of emergency procedures and response to chemical spills and incidents.
6. Understanding of the principles of risk management and mitigation.

**Assessment Methods:**

- Class participation and engagement
- Quizzes and exams
- Written assignments, such as research papers or case studies
- Group projects or presentations
- Final exam or project

**Unit 1: Introduction to Chemical Safety, Hazards, Handling and Storage, Emergencies, Waste Disposal, and Regulations** [Marks 24]

- Definitions of key terms and concepts
- Safety culture, Personal protective equipment (PPE)
- Accountability and responsibility for laboratory safety
- Classification Toxic Chemicals, Toxicity, Exposure routes and their effects
- Sources of Information – MSDS sheets
- Physical, chemical, and toxicological hazards – Exposure limits
- Flammable, reactive and explosive chemical hazards
- Transportation, transfers and shipping the chemicals.
- Bulk and laboratory storage and tracking of chemicals.
- Use of high temperatures, pressures and cryo conditions
- Prevention of fires with fire safety and accidents
- Emergency response planning – institutional and outside resources
- Chemical spill cleanup procedures, Hazardous chemical waste disposal
- Safety rules and regulations and policies
- Overview of chemical safety regulations and compliance

**Unit 2: Introduction to Chemical Security, Hazardous, Toxic and Dual-use Chemicals and Risk Assessment** [Marks 24]

- Definitions of key terms and concepts
- Security culture, accountability, and responsibility
- Types of hazardous and toxic chemicals
- Introduction to Chemical Weapons Convention (CWC), scheduled chemicals and their details
- Detection, analysis and impacts of the dual-use chemicals
- Threats, security concerns of dual-use chemicals and their consequences
- Hazard identification and risk assessment
- Vulnerability to Intrusion System Analysis (VISA)

**Unit 3: Chemical Security Management, Emergency Response, Preventive Measures and Regulations** [Marks 22]

- Cyber security controls and countermeasures
- Security audits and inspections
- Personnel security measures and background checks
- Chemical Incident, Emergency and Management
- Emergency Response – Communication and coordination during emergencies.
- Importance of security culture and Indian Regulations
- Chemical Weapons Conventions (CWC) and Organization for the Prohibition of Chemical Weapons (OPCW), Chemical Facility Anti-Terrorism Standards (CFATS)

## Recommended Readings/Textbook/Reference Material:

1. **Laboratory Safety Manual**, The University of Texas at Austin, Environmental Health and Safety (December 2017)
2. **The Security of Dual use Chemicals: Hazards, Vulnerability and Risk Assessment**; Chemical Industry Digest. Annual - January 2017 (Page no. 111-121)
3. **"Chemical Safety Training Videos"** by the University of California Davis:  
<https://safetyservices.ucdavis.edu/training/online-training/chemical-safety-training-videos>
4. **A Proposed Integrated Framework for Chemical Safety and Chemical Security**; Journal of Chemical Education, 2020, 17, 1769-1774;  
<https://dx.doi.org/10.1021/acs.jchemed.9b00999>
5. **Chemical Safety and Chemical Security**; AJCE, 2014, 4(3), Special Issue (Part II) ISSN 2227-5835
6. **Prudent Practices in the Laboratory, Handling and Management of Chemical Hazards**, National Research Council of the National Academies, The National Academies Press, Washington, D.C., 2011
7. **Security Risk Assessment and Management in Chemical Plants: Challenges and New Trends**, Process Safety Process, 2017. DOI: 10.1002/prs.11914
8. **Chemical Safety and Security Challenges in Academic Institutions in Developing Countries**, Responsible Conduct in Chemistry Research and Practice: Global Perspectives ACS Symposium Series; American Chemical Society: Washington, DC, 2018. Chapter 6.
9. **Identifying University Chemicals That Pose Security Risks: A Simple Qualitative Approach**, ACS Chemical Health and Safety 2022, 29, 289–298.  
<https://doi.org/10.1021/acs.chas.0c00082>

**NB: Regarding requirement of material for any topic of the above-mentioned syllabus can be met with National Association of Chemical Security (NACS) either from its website <http://nacsindia.in> or one can email: [nachemsec@gmail.com](mailto:nachemsec@gmail.com)**