# MAHARAJA'S COLLEGE, ERNAKULAM

**(Govt. Autonomous -Affiliated to MG University, Kottayam)**

# UNDERGRADUATE PROGRAMMES

# (HONOURS)

# SYLLABUS

# MCE-UGP (Honours)

# (2024 Admission Onwards)

## Faculty: Science

## BoS: Chemistry

## Programme: B Sc Chemistry (Honours)

**with Specialization in Environment & Water Management**

**Maharaja's College, Ernakulam**
**(Govt. Autonomous)**
**Park Avenue Road, Marine Drive**
**Ernakulam– 682011, Kerala, India**

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# PREFACE

The Board of Studies in Chemistry take this opportunity to express our deep appreciation to all academicians and professionals who participated in the series of workshops organized by the Board for restructuring curriculum and syllabi of the Four Year UG Programme (FYUGP) (Honours) in Chemistry with specialization in Environment and Water Management, Maharaja's College, Ernakulam.

The Higher Education Department, Government of Kerala is set to introduce a four-year undergraduate program commencing in the academic year 2024-2025. Based on the guidelines of the M. G. University for the Four-Year Undergraduate Programme (FYUGP), the U. G. BoS in Chemistry, Maharaja's College conducted several workshops with the wholehearted support and involvement of all the members of Board of Studies, the curricula and syllabi brings out in the present form.

We express our profound gratitude to the Honorable Vice-Chancellor, Pro-Vice Chancellor, Members of the Syndicate and Members of the Academic Council, Mahatma Gandhi University, for their sincere co-operation and guidance for completion of this work. Our special thanks are due to Chairman and members of the Governing Council, Chairman and members of the Academic Council, Maharaja's College, Ernakulam. We also extend our gratitude to Dr. Binitha N N, Professor. Department of Chemistry, University of Calicut. Kerala. Dr. Byju K V, Assistant Professor, Kannur University, Kerala, Dr. Beena Mathew, Professor, School of Chemical Sciences, Mahatma Gandhi University, Kottayam, Dr. Benny Antony, Managing director, Arjuna Natural Pvt. Limited, Aluva, Kerala, and Dr. P Unnikrishnan, General Manager, Sud-Chemie India Pvt. Limited, Cochin, Dr. Anu. Gopinath, Professor, KUFOS, Panangad, Kerala, who were entrusted with the responsibility as experts for the revision of the syllabus of different subjects. The Board of Studies in Chemistry expresses wholehearted gratitude to all those who have helped in this endeavor. The task of preparing the curricula and syllabi and bringing it out in the present form for the FYUGP programme was not simple but it was possible with dedicated efforts and wholehearted support and involvement of all the members of the BoS and the faculty members of the Department of Chemistry. I would like to express my sincere thanks to all my fellow members of BoS and the faculty members of the Department of Chemistry for all their help, cooperation, encouragement, active participation and useful suggestions for the completion of syllabus.

**Dr. Femina K S**
Chairperson
Board of Studies

## CURRICULUM COMMITTEE

1. **Dr. Femina K S,** HOD & Professor, Department of Chemistry, Maharajas College, Ernakulam (**Chairperson**)

2. **Faculty Members of Department of Chemistry, Maharaja's College, Ernakulam**

    1. **Smt. Aneetha M R**, Assistant Professor of Chemistry
    2. **Dr. Amrutha S Rajan**, Associate Professor of Chemistry
    3. **Dr. Sreesha Sasi**, Professor of Chemistry
    4. **Dr. Jolly V Antony**, Professor of Chemistry
    5. **Dr. Suja N R**, Associate Professor of Chemistry
    6. **Dr. Venugopal B,** Associate Professor of Chemistry
    7. **Dr. Prasanthkumar K.P**, Associate Professor of Chemistry
    8. **Dr. Zeena P Hamza**, Associate Professor of Chemistry
    9. **Dr. Rejimon P.K,** Assistant Professor of Chemistry
    10. **Dr. Sobhi Daniel**, Professor of Chemistry
    11. **Dr. Seena E.B**, Associate Professor of Chemistry
    12. **Dr. Sandhya P V**, Professor of Chemistry
    13. **Dr. Neena George**, Assistant Professor of Chemistry
    14. **Dr. Sajith Menon**, Assistant Professor of Chemistry
    15. **Dr. Jincy E M**, Assistant Professor of Chemistry
    16. **Dr. Julie Chandra C S.**, Assistant Professor of Chemistry
    17. **Smt. Jomol P John,** Assistant Professor of Chemistry
    18. **Dr. Deepak J Prabhu**, Assistant Professor of Chemistry
    19. **Sri. Sujithkumar M C**, Assistant Professor of Chemistry
    20. **Dr. Asha S,** Assistant Professor of Chemistry
    21. **Smt. Remya Chandran**, Guest Lecturer, Dept. of Chemistry

## EXTERNAL EXPERTS

1. **Dr. Anu. Gopinath**, Professor, KUFOS, Panangad, Kerala
2. **Dr. Binitha N N,** Professor. Department of Chemistry, University of Calicut. Kerala
3. **Dr. Byju K V,** Assistant Professor, Kannur University, Kerala
4. **Dr. Beena Mathew**, Professor, School of Chemical Sciences, Mahatma Gandhi University, Kottayam
5. **Dr. Benny Antony**, Jt Managing director, Arjuna Natural Pvt. Limited, Aluva, Kerala
6. **Dr. P Unnikrishnan**, General Manager, Sud-Chemie India Pvt. Limited, Cochin,

# Curricular Structure of the MCE – UG(Honours) Programme

## 3 Year UG Degree – 6 Semesters

| No. | Course Type | No. of Courses | Total Credits |
|---|---|---|---|
| 1 | Foundation: Ability Enhancement Courses (AEC) | 4 | 12 |
| 2 | Foundation: Multi – disciplinary Courses (MDC) | 3 | 9 |
| 3 | Foundation: Skill Enhancement Courses (SEC) | 3 | 9 |
| 4 | Foundation: Value Addition Courses (VAC) | 3 | 9 |
| 5 | Discipline Specific Courses: Major (DSC A/DSE) | 17 | 68 |
| 6 | Discipline Specific Courses: Minor (DSC B & C) | 6 | 24 |
| 7 | Internship | | 2 |
| | Total | **36** | **133** |

## 4 Year UG Degree (Honours) – 8 semesters

## 4 Year UG Degree (Honours with Research) – 8 Semesters

| No. | Course Type | No. of Courses | Total Credits |
|---|---|---|---|
| 1 | Foundation: Ability Enhancement Courses (AEC) | 4 | 12 |
| 2 | Foundation: Multi – disciplinary Courses (MDC) | 3 | 9 |
| 3 | Foundation: Skill Enhancement Courses (SEC) | 3 | 9 |
| 4 | Foundation: Value Addition Courses (VAC) | 3 | 9 |
| 5 | Discipline Specific Courses: Major (DSC A/DSE) | 17 | 68 |
| 6 | Discipline Specific Courses: Minor (DSC B & C) | 6 | 24 |
| 7 | Discipline Capstone Courses: Major (DCC/DCE) | 8 | 32 |
| 8 | Research Project | | 12/8 |
| 9 | Internship | | 2 |
| | Total | 44 | 177 |

## Programme Outcomes (POs)

| | |
|---|---|
| **PO1** | Critical Thinking and Analytical Reasoning |
| **PO2** | Scientific Reasoning and Problem Solving |
| **PO3** | Multidisciplinary/Interdisciplinary/Trans disciplinary Approach |
| **PO4** | Communication Skills |
| **PO5** | Leadership Skills |
| **PO6** | Social Consciousness and Responsibility |
| **PO7** | Equity, Inclusiveness and Sustainability |
| **PO8** | Moral and Ethical Reasoning |
| **PO9** | Networking and Collaborating |
| **PO10** | Lifelong Learning |

## Evaluation Scheme

**(A) Courses without Practical**

| **Components** | **Marks (4 Credits)** | **Marks (3 Credits)** |
|---|---|---|
| Continuous Comprehensive Assessment (CCA) | 30 | 25 |
| End Semester Examination | 70 | 50 |
| Total | **100** | **75** |

**(B) Courses with Practical**

| **Components** | **Marks (4 Credits)** | | **Marks (3 Credits)** | |
|---|---|---|---|---|
| | ***Theory*** | ***Practical*** | ***Theory*** | ***Practical*** |
| Continuous Comprehensive Assessment (CCA) | 25 | 15 | 15 | 15 |
| End Semester Examination | 50 | 35 | 35 | 35 |
| Total | **125** | | **100** | |

**SYLLABUS INDEX**
**Name of Major: Chemistry**

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<tr><td>MCE3DSECHE203</td><td>Environmental Pollution</td><td rowspan="3">Environment & Water Management Specialization</td><td rowspan="3">Any one</td><td rowspan="3">DSE</td><td>4</td><td>4</td><td>4</td><td></td><td>0</td><td></td></tr>
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<tr><td>MCE4DSECHE202</td><td>Atmospheric Chemistry & Air Pollution</td><td rowspan="2">Environment & Water Management</td><td rowspan="2">Any one</td><td rowspan="2">DSE</td><td>4</td><td>4</td><td>4</td><td></td><td>0</td><td></td></tr>
<tr><td>MCE4DSECHE203</td><td>Environmental</td><td>4</td><td>4</td><td>4</td><td></td><td>0</td><td></td></tr>
</table>

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering | Specialization | | | | | | | | |
| MCE4DSECHE204 | Environmental Microbiology & Biotechnology | | | | 4 | 4 | 4 | | 0 | |
| MCE4SECCHE200 | Basic Analytical and Cosmetic Chemistry | | | SEC | 3 | 3 | 3 | | 0 | |
| MCE4VACCHE200 | Basic Environmental Chemistry | | | VAC | 3 | 3 | 3 | | 0 | |
| MCE4INTCHE200 | **Internship** | | | **INT** | **2** | | | | | |

**SEMESTER V**

| **Course Code** | **Title of the Course** | | | **Type of the Course** | **Credits** | **Hours/ week** | **Hour Distribution /week** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **L** | **T** | **P** | **O** |
| MCE5DSCCHE300 | Organic Chemistry - 3 | | | DSC A | 4 | 5 | 3 | | 2 | |
| MCE5DSCCHE301 | Physical Chemistry- 2 | | | DSC A | 4 | 5 | 3 | | 2 | |
| MCE5DSECHE300 | Quantum Mechanics, Spectroscopy & Group Theory | | Any three | DSE | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE301 | Green chemistry for sustainable development | | | | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE303 | Nanotechnology for Energy Applications | | | | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE304 | Medicinal Chemistry | | | | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE305 | Main Group Elements | | | | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE306 | Environment & Water Management | Environment & Water Management Specialization | | | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE307 | Environmental Toxicology & Occupational Health | | | | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE308 | Natural Hazards & Disaster Management | | | | 4 | 4 | 4 | | 0 | |
| MCE5DSECHE309 | Water Resource Management | | | | 4 | 4 | 4 | | 0 | |
| MCE5SECCHE300 | Analytical Chemistry and Professional skills | | | SEC | 3 | 3 | 3 | | 0 | |

**SEMESTER VI**

| **Course Code** | **Title of the Course** | | | **Type of the Course** | **Credits** | **Hours/ week** | **Hour Distribution /week** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **L** | **T** | **P** | **0** |
| MCE6DSCCHE300 | Inorganic Chemistry-2 | | | DSC | 4 | 5 | 3 | | 2 | |
| MCE6DSCCHE301 | Physical Chemistry- 3 | | | DSC | 4 | 5 | 3 | | 2 | |
| MCE6DSECHE300 | Organic Chemistry- 4 | | Any one | DSE | 4 | 5 | 3 | | 2 | |
| MCE6DSECHE305 | Analytical Methods in Environmental Monitoring | Environment & Water Management Specialization | | | 4 | 5 | 3 | | 2 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MCE6DSECHE302 | Industrial Inorganic Chemistry and Nuclear Chemistry | Any one | DSE | 4 | 4 | 4 | | 0 | |
| MCE6DSECHE303 | Spectroscopic Methods of Chemical Analysis | | | 4 | 4 | 4 | | 0 | |
| MCE6DSECHE304 | Fundamentals of Biochemistry | | | 4 | 4 | 4 | | 0 | |
| MCE6SECCHE300 | Data Analysis using Python and Soft skills | | SEC | 3 | 3 | 3 | | 0 | |
| MCE6VACCHE300 | Intellectual Property Rights | Any one | VAC | 3 | 3 | 3 | | 0 | |
| MCE6VACCHE301 | Research Methodology for Chemistry | | | 3 | 3 | 3 | | 0 | |

| **SEMESTER VII** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Title of the Course** | **Type of the Course** | **Credits** | **Hours/ week** | **Hour Distribution /week** | | | |
| | | | | | **L** | **T** | **P** | **O** |
| MCE7DCCCHE400 | Coordination and Organometallic Chemistry | DCC | 4 | 4 | 4 | | 0 | |
| MCE7DCCCHE401 | Organic Chemistry-5 | DCC | 4 | 5 | 3 | | 2 | |
| MCE7DCCCHE402 | Molecular Spectroscopy | DCC | 4 | 4 | 4 | | 0 | |
| MCE7DCECHE400 | Drug Therapy and Drug Design | DCE | 4 | 4 | 4 | | 0 | |
| MCE7DCECHE401 | Industrial Chemistry | | 4 | 4 | 4 | | 0 | |
| MCE7DCECHE402 | Advanced Chemistry of Main Group Elements | | 4 | 4 | 4 | | 0 | |
| MCE7DCECHE403 | Statistical Thermodynamics and Bioenergetics | | 4 | 4 | 4 | | 0 | |
| MCE7DCECHE404 | Novel Inorganic Solids | | 4 | 4 | 4 | | 0 | |
| MCE7DSECHE400 | Analytical Chemistry | DSE* | 4 | 4 | 4 | | 0 | |
| MCE7DSECHE401 | Biophysical Chemistry | | 4 | 4 | 4 | | 0 | |
| MCE7DSECHE402 | Nano chemistry and Technology | | 4 | 4 | 4 | | 0 | |

*Minor

| SEMESTER VIII | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Course Code | Title of the Course | | | Type of the Course | Credits | Hours/ week | Hour Distribution | | | |
| | | | | | | | L | T | P | O |
| MCE8DCCCHE400 | Advanced Coordination and Organometallic Chemistry | | | DCC | 4 | 6 | 2 | | 4 | |
| MCE8DCCCHE401 | Physical Chemistry- 4 | | | DCC | 4 | 6 | 2 | | 4 | |
| MCE8DCECHE400 | Organic Chemistry-6 | | For B Sc (Hons.) without research | DCE | 4 | 5 | 3 | | 2 | |
| MCE8DCECHE401 | Group Theory and Quantum Chemistry | Any two | | | 4 | 4 | 4 | | 0 | |
| MCE8DCECHE402 | Instrumental Methods of Chemical Analysis | | | | 4 | 4 | 4 | | 0 | |
| MCE8DCECHE403 | Molecular Modelling | | | | 4 | 4 | 4 | | 0 | |
| MCE8DCECHE404 | Crystallography and Electrochemistry | | | | 4 | 4 | 4 | | 0 | |
| MCE8PRJCHE400 | **Project** | | | **PRJ** | **8** | | | | | |
| MCE8PRJCHE401 | **Project** | | | **PRJ** | **12** | | | | | |

# SEMESTER I

| | |
|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Fundamentals of Chemistry - I** |
| **Type of Course** | **DSC A** |
| **Course Code** | **MCE1DSCCHE100** |
| **Course Level** | **100-199** |
| **Course Summary** | This course covers the basic principles and concepts of atoms, elements, compounds, and fundamentals of organic chemistry. Students explore atomic structure, electron displacements in organic chemistry, reactive intermediates, and the periodic table to understand the foundation of chemical interactions. |

| **Semester** | I | Credits | | | 4 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | Atomic models (J.J. Thomson model and Rutherford model) | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Apply atomic models to forecast and explain electronic configurations, atomic behaviour, and characteristics. | A | 1, 2 |
| 2 | Describe the relevance of organic chemistry, catenation and hybridisation. | U | 1, 2, 10 |
| 3 | Evaluate electron displacement patterns in organic molecules using arrow notation. | E | 1, 2 |
| 4 | Utilize arrow-pushing mechanisms to illustrate and solve simple chemical reactions involving reactive intermediates. | A | 1, 2 |
| 5 | Analyse periodic trends, the relationship between electronic configuration and the chemical reactivity of elements, including the formation of chemical bonds. | An | 1, 2 |
| 6 | Identify metals through flame and spot tests, chloride in water, and lead in food samples, and acquire skill in organic preparation. | S | 1, 2, 10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | | **Atomic Structure** | | |
| | 1.1 | Atomic spectrum of hydrogen atom, explanation using Bohr atom model, limitations of Bohr atom model. | 4 | 1 |
| | 1.2 | Dual nature of matter, de Broglie equation, Heisenberg's uncertainty principle and its significance. | 2 | 1 |
| | 1.3 | Concept of orbit and orbital. Types of orbitals, shapes of *s*, *p* and *d* orbitals. | 2 | 1 |
| | 1.4 | Quantum numbers and their significance. | 2 | 1 |
| | 1.5 | Pauli's Exclusion Principle, Hund's rule of maximum multiplicity and Aufbau principle. | 2 | 1 |
| | 1.6 | Electronic configuration of atoms (upto atomic number 30). Stability of half-filled and completely filled electronic configurations. | 3 | 1 |
| 2 | | **Fundamentals of Organic Chemistry** | | |
| | 2.1 | Relevance of organic chemistry in day-to-day life (with 2-3 examples). Carbon: catenation and hybridisations (with examples ethane, ethene and ethyne). | 3 | 2 |
| | 2.2 | Arrow notations, bond fissions: curved arrow notation, drawing electron displacements with curved arrows, curved and fishhook arrows in organic reaction mechanisms. Polarity of bonds (basic concepts only). | 2 | 3, 4 |
| | 2.3 | Homolysis and heterolysis with examples. Reactive intermediates: formation, structure and stability of carbocations, carbanions, and free radicals. | 4 | 3, 4 |
| | 2.4 | Electron displacement effects: inductive effect-influence of inductive effect in the acidity of carboxylic acids. Resonance effect (delocalization, contributing structures, and stability) – hyperconjugation. | 6 | 3, 4 |
| 3 | | **Chemistry of Elements and Molecules** | | |
| | 3.1 | Modern periodic law – long form periodic table. Classification of elements- *s*, *p*, *d* and *f* block, metal, non-metals and metalloids. | 4 | 5 |
| | 3.2 | Diagonal relationship and anomalous behaviour. | 1 | 5 |
| | 3.3 | Periodicity in properties: Atomic and ionic radii - ionization enthalpy - electron affinity (electron gain enthalpy) – electronegativity. Electronegativity scales: Pauling Scale. | 5 | 5 |
| | 3.4 | Effective nuclear charge – Slater rule and its applications. | 2 | 5 |

| | | | | |
|---|---|---|---|---|
| | 3.5 | Valency and oxidation state with examples. | 1 | 5 |
| | 3.6 | Introduction to molecules- types of bonds, ionic bond, covalent bond, coordinate bond. | 2 | 5 |
| **4** | **Foundation Course - 1: Practical** | | | |
| | 4.1 | 1. Demonstration of atomic models using software (non-evaluative)<br>2. Detection of sodium, potassium, calcium, barium and strontium ions through flame test.<br>3. Spot test of nickel, zinc and copper.<br>4. Chloride ion detection in well water and tap water.<br>5. Detection of lead in food samples.<br>6. Draw structures of simple organic molecules and resonance structures using chem-sketch / chemdraw.<br>7. Preparation of 5-nitrosalicylic acid from salicylic acid.<br>8. Preparation of *p*-nitroacetanilide from acetanilide. | 30 | 6 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

| | |
|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>1. Lecture sessions<br>2. Interactive sessions<br>3. Discussions<br>4. Demonstrations and experiments to engage students actively<br>5. Use of visual aids like presentations, videos, and models to enhance understanding<br>6. Encourage students to ask questions during or after the lectures<br>7. Begin with safety instructions<br>8. Guidelines for lab work<br>9. Allow students to conduct experiments under supervision (for lab work)<br>10. Use of virtual lab to model chemical reactions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 Marks)**<br>i) Assignments: 5 marks<br>ii) MCQ: 10 marks<br>iii) Viva: 5 marks<br>iv) Involvement in classroom activities: 5 marks<br>**Practical (15 Marks)**<br>i) Lab skill / analysis: 15 marks |
| | **B. End Semester Examination (ESE)**<br>**Theory (50 Marks- 1.5 Hrs)**<br>i) MCQ 10 questions: 10 x 1 = 10 |

| | |
|---|---|
| | ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 4 questions (out of 6): 4 x 7 = 28<br><br>**Practical (35 Marks- 1 Hr)**<br><br>i) Lab report: 10<br>ii) Viva: 15<br>iii) Writing procedure: 10 |

**References**


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4. R.T Morrison, R.N. Boyd and S.K. Bhattacharjee, *Organic Chemistry*, 7th Edn. Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
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10. F. P. Miller, A. F. Vandome, McB. John, *Flame Test*, VDM Publishing, 2010.
11. S M. Basavarajaiah, G. Y. Nagesh, K. R. Reddy, *Compendious Practical Organic Chemistry: Preparations, Isolation, and Chromatography*, Notion Press, 2021.


**SUGGESTED READINGS**


1. J. E. Huheey, E. A. Keitler and R. L. Keitler, *Inorganic Chemistry–Principles of Structure and Reactivity*, 4th Edn, Pearson Education, New Delhi, 2013.
2. I, Clayden, I. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, 2nd Edn. Oxford University Press, 2012.

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|---|---|---|---|---|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | | | | | | |
| **Course Name** | **Food Chemistry and Nutrition** | | | | | |
| **Type of Course** | **MDC** | | | | | |
| **Course Code** | **MCE1MDCCHE100** | | | | | |
| **Course Level** | **100-199** | | | | | |
| **Course Summary** | This course provides a comprehensive understanding of the composition and health implications of various food items. | | | | | |
| **Semester** | I | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 2 | | 1 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Describe the concept of nutrition. | U | 1, 2, 3 |
| 2 | Identify the use of various food additives. | A | 1, 3, 10 |
| 3 | Describe the health effects of food adulterants. | U | 1, 2, 3, 6, 8, 10 |
| 4 | Evaluate different adulterants in food. | E | 1, 2, 3, 6, 10 |
| 5 | Apply the concept of food chemistry to conduct simple laboratory experiments. | A | 1, 2, 3, 4, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | **Introduction to Nutrition & Food Additives** | | | |
| | 1.1 | Functions of food, nutrients in food- energy yielding nutrients (carbohydrates, proteins and lipids) and protective nutrients (vitamins and minerals). | 3 | 1 |
| | 1.2 | Food additives- definition, importance of food additives, types of additives -natural, synthetic and artificial- with one example. E- number. | 5 | 2 |
| | 1.3 | Preservatives, food colours, flavour enhancers, sweeteners, emulsifiers, stabilizer, glazing agents, thickeners, gelling agents. (definition and applications with examples). | 7 | 2 |
| 2 | **Food Adulteration and Safety** | | | |
| | 2.1 | Food adulterants- definition, types (intentional and incidental contamination) and health effects. | 3 | 3 |
| | 2.2 | Common adulterants in different foods, their health effects and detection: milk, ghee, butter, honey, sweets, chilli powder, turmeric, tea, sugar and salt, black pepper, wheat and rice. | 7 | 3 |
| | 2.3 | Food adulteration act- objectives. | 1 | 4 |
| | 2.4 | Modern food habits- introduction, health effects of fast food, junk food and instant food. Composition and health effects of soft drinks. a comparative study of traditional and modern food habits | 4 | 4 |
| 3 | **Food Chemistry and Nutrition Practical** | | | |
| | 3.1 | 1. Detection of adulterants in food items-milk, turmeric powder and chili powder.<br>2. Demonstration of preparation of value-added food products- jam, squash.<br>3. To find out the moisture content of a given food sample by Lab oven method.<br>4. Test the solubility of vegetable oils in different solvents. | 30 | 5 |
| 4 | **Teacher Specific Content** | | | |
| | | | | |

| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>1. Lecture sessions |
|---|---|

| | |
|---|---|
| | 2. Interactive sessions<br>3. Discussions<br>4. Demonstrations and experiments to engage students actively<br>5. Use of visual aids like presentations, videos, and models to enhance understanding<br>6. Encourage students to ask questions during or after the lectures<br>7. Begin with safety instructions<br>8. Guidelines for lab work<br>9. Allow students to conduct experiments under supervision (for lab work)<br>10. Use of statistical software for food analysis |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (15 Marks)**<br>i) Assignments: 5 marks<br>ii) MCQ: 10 marks<br>**Practical (15 Marks)**<br>i) Lab involvement / report /Lab test |
| | **B. End Semester Examination**<br>**Theory (35 Marks- 45 minutes)**<br>i) MCQ 35 questions: 35 x 1 = 35<br>**Practical (35 Marks- 1Hr)**<br>i) Lab report: 10<br>ii) Viva: 10<br>iii) Writing procedure: 15 |

**References**


1. M. Swaminathan, *Food Science and Experimental Foods*, Ganesh and Company, 2005.
2. Jayashree Ghosh, *Fundamental Concepts of Applied Chemistry*, S. Chand & Co. Publishers, 2010.
3. Thankamma Jacob, *Text Books of Applied Chemistry for Home Science and Allied Sciences*, Macmillan, 2015.
4. Sreelakshmi, *Food Science*, New Age, 2018.
5. S. Roday, *Food Science and Nutrition*, 3rd Edn. Oxford University Press, 2018.
6. M. Weaver, J. R. Daniel, *The Food Chemistry Laboratory*, CRC Press, 2005.
7. I, Bevier, *Food and Nutrition Laboratory Manual*, Forgotten Books, 2018.
8. S. Sehgal, *A Laboratory Manual of Food Analysis*, International Publishing, 2016.
9. T. P. Coultate, *Food – The Chemistry of its Components*, Royal Society of Chemistry, London, 2000.
10. M. Zeece, *Introduction to the Chemistry of Food*, Elsevier Science, 2020.

# SEMESTER II

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|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Fundamentals of Chemistry-2** |
| **Type of Course** | **DSC A** |
| **Course Code** | **MCE2DSCCHE100** |
| **Course Level** | **100-199** |
| **Course Summary** | This course provides a basic understanding of the physical nature of matter, reactions in organic chemistry and the analytical tools for chemical investigations and identifications. |

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|---|---|---|---|---|---|---|
| **Semester** | II | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Make use of fundamental principles of analytical chemistry to solve quantitative titrimetric problems. | A | 1,2 |
| 2 | Classify various types of organic reactions based on their mechanisms. | U | 1,2 |
| 3 | Describe the fundamental principles governing the behaviour of different states of matter. | U | 1,2 |
| 4 | Compare and contrast the properties of solids, liquids, and gases. | An | 1,2 |
| 5 | Apply the basic principles of analytical chemistry in preparation of standard solutions, acid-base titrations and in the determination of viscosity and surface tension. | S | 1,2,10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**
**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Basic Concepts in Analytical Chemistry** | | |
| | 1.1 | Molecular mass – mole concept. Oxidation and reduction (electron concept only) | 2 | 1 |
| | 1.2 | Titrimetric analysis - fundamental concepts-analyte, end point, indicators etc. Methods of expressing concentration: Weight percentage, molality, molarity, normality, mole fraction, ppm and ppb. Primary and secondary standards, quantitative dilution – problems | 6 | 1 |
| | 1.3 | Acid base concepts Arrhenius definition, Bronsted-Lowry definition and conjugate acid-base pairs, Lewis concept, ionization of acids and bases. | 2 | 1 |
| | 1.4 | Acid base titrations- strong acid -strong base, strong acid – weak base, weak acid – strong base weak acid – weak base - pH indicators (phenolphthalein and methyl orange), redox titrations | 5 | 1 |
| 2 | | **Introduction to Organic Reactions** | | |
| | 2.1 | Representation of organic molecules: projection formulae (Fischer, Sawhorse, Flying wedge and Newman) | 3 | 2 |
| | 2.2 | Types of reagents: electrophiles and nucleophiles | 1 | 2 |
| | 2.3 | Addition reactions: Markovnikov's addition, peroxide effect. Elimination reactions: E1 and E2 mechanism. Substitution reactions (SN1, SN2 reactions of alkyl halides only). | 8 | 2 |
| | 2.4 | Polymers- Basic concepts. Addition polymerisation (polyethylene, PVC) | 3 | 2 |
| 3 | | **States of matter** | | |
| | 3.1 | Matter and its different states (elementary idea only), intermolecular forces: dipole-dipole interaction, dipole-induced dipole interaction and induced dipole-induced dipole interaction, ion-dipole interaction, hydrogen bonding: intra and intermolecular hydrogen bonds-effect on physical properties. | 4 | 3,4 |
| | 3.2 | Gaseous state: - postulates of kinetic theory, ideal and real gas behaviour, compressibility factor deviation from ideal behaviour, van der Waals equation (no derivation) | 4 | 3,4 |
| | 3.3 | Liquid state: properties of liquids: vapour pressure, boiling point, surface tension, viscosity. | 3 | 3,4 |

| | | | | |
|---|---|---|---|---|
| | 3.4 | Solid state: types of solids: crystalline and amorphous solids: ionic solids: unit cell, crystal systems, Bravais lattices. | 4 | 3,4 |
| **4** | **Fundamentals of Chemistry-2 Practical** | | | |
| | 1. Calibration of apparatus -Standard flask and preparation of standard molar solutions of any two primary standards -Oxalic acid, Mohr's Salt, $Na_2CO_3$.<br>2. Determination of pH of different water sources, common acids and bases using pH meter/pH strips<br>3. Acid base titration- acidimetry and alkalimetry: titration of strong acid vs. strong base, strong acid vs. weak base and weak acid vs. strong base.<br>4. Estimation of citric acid in citrus fruits.<br>5. Determination of viscosity of liquids using Ostwald viscometer.<br>6. Determination of surface tension of liquids using stalagmometer. | 30 | 5 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>1. Lecture sessions<br>2. Interactive sessions<br>3. Discussions<br>4. Demonstrations, and experiments to engage students actively<br>5. Experiments<br>6. Visual aids like presentations, videos, and models to enhance understanding<br>7. Encourage students to ask questions during or after the lectures<br>8. Begin with safety instructions and guidelines for lab work<br>9. Allow students to conduct experiments under supervision<br>10. Use of virtual lab to model chemical reactions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Assignments: 5 marks<br>ii) MCQ: 10 marks<br>iii) Viva: 5 marks<br>iv) Involvement in classroom activities: 5<br>**Practical (15 marks)**<br>i) Lab involvement / Report/ Lab Test |
| | **B. Semester End Examination**<br>**Theory (50 marks- 1.5 Hrs)**<br>i) MCQ 10 questions: 10 x 1 = 10 |

| | |
|---|---|
| | ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 4 questions (out of 6): 4 x 7 = 28<br>**Practical (35 marks – 1 Hr)**<br>i) Lab report: 10<br>ii) Viva: 10<br>iii) Writing procedure: 15 |

**References**


1. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.
2. J. Mendham, R.C. Denney, J. D. Barnes and M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.
3. *Vogels Textbook of Quantitative Chemical Analysis*, 6th Edn. Pearson Education Ltd, 2009.
4. R.T. Morrison, R.N Boyd and S.K Bhattacharjee, *Organic Chemistry*, 7th Edn., Dorling Kindersley Pvt. Ltd (Pearson Education), 2011.38
5. T.W. Graham Solomon, C.B. Fryhle, S. A. Snyder, *Organic Chemistry*, John Wiley & Sons, 2014.
6. A. Bahl and B.S. Bahl, *Advanced Organic Chemistry*, S. Chand, 2010.
7. J.Clayden, N.Greeves, S. Warren, and P.Wothers, *Organic Chemistry*, Oxford University Press, 2004.
8. Puri, Sharma and Pathania, "*Principles of Physical Chemistry*", 47th Edn. Vishal Publishing Co, 2020.
9. P W Atkins, *Physical Chemistry*, 11th Edn. Oxford University Press, 2018.
10. K. L. Kapoor, *A Textbook of Physical chemistry*, Volume 1, Macmillan India Ltd, 2020.
11. J.B. Yadav, *Advanced Practical Physical Chemistry,* Krishna Prakashan, 2016.
12. K.K. Sharma, *An Introduction of Practical Chemistry,* Vikas Publishing House, New Delhi, 1984.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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| **Programme** | | | | | | |
| **Course Name** | **Diary Chemistry** | | | | | |
| **Type of Course** | **MDC** | | | | | |
| **Course Code** | **MCE2MDCCHE100** | | | | | |
| **Course Level** | **100-199** | | | | | |
| **Course Summary** | This course will enable students to understand various types of milk, processing methods and the production of various dairy products. | | | | | |
| **Semester** | II | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 2 | | 1 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Evaluate the quality and nutritive value of milk by knowing the general chemical composition | E | 1, 2, 3, 6, 10 |
| 2 | Describe the techniques of milk processing | U | 1, 2, 3, 10 |
| 3 | Compare different types of processed milk. | U | 1, 2, 3, 6, 10 |
| 4 | Classify various types of milk products based on their composition and processing methods | An | 1, 3, 10 |
| 5 | Demonstrate the preparation of various milk products | A | 1, 2, 3, 4, 6, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Composition and processing of Milk** | | | |
| | 1.1 | Milk- Definition, general composition of milk (cow, buffalo, goat and human) -water, protein, lactose and fat. Nutritive value of milk.<br>Colostrum: significance, composition, difference between normal milk and colostrum. | 6 | 1 |
| | 1.2 | Physico-chemical properties of milk- color, odour, density, acidity, germicidal properties, viscosity.<br>Adulteration of milk and detection. Preservatives and neutralizers. | 5 | 1 |
| | 1.3 | Quality assurance – FSSAI, PFA, AGMARK. | 1 | 1 |
| | 1.4 | Importance of milk processing- filtration, clarification, boiling, homogenization and pasteurization. Types of pasteurization- LTLT and HTST. | 3 | 2 |
| 2 | **Special milk and Milk products** | | | |
| | 2.1 | Standardised milk - definition – merits.<br>Homogenised milk, flavoured milk, vitaminised milk, toned milk, incitation milk, vegetable toned milk, condensed milk – definition, composition and nutritive value. | 4 | 2 |
| | 2.2 | Butter - definition -composition - theory of churning – desi butter, salted butter.<br>Ghee - major constituents - common adulterants added to ghee and their detection - rancidity - definition – prevention.<br>Cream- definition composition-chemistry of creaming process. | 6 | 2 |
| | 2.3 | Fermented milk products -fermentation of milk - definition and conditions.<br>Yogurt and Curd (introduction and methods of production).<br>Khoa and chana -definition and preparation - sweets – peda, burfi, gulab jamun, rasogolla.<br>Milk powder - definition | 5 | 4 |
| 3 | **Dairy Chemistry Practicals** | | | |
| | 1. Demonstration of preparation of khoa based products- peda, milk cake<br>2. Demonstration of preparation of chana based products- paneer<br>3. Determination of pH of milk<br>4. Determination of moisture content in paneer by lab oven method | | 30 | 5 |

| 4 | Teacher Specific Content |
|---|---|
| | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>1. Lecture sessions<br>2. Interactive sessions<br>3. Discussions<br>4. Demonstrations, and experiments to engage students actively<br>5. Experiments<br>6. Visual aids like presentations, videos, and models to enhance understanding<br>7. Encourage students to ask questions during or after the lectures<br>8. Begin with safety instructions and guidelines for lab work<br>9. Allow students to conduct experiments under supervision<br>10. Preparation and exhibition of milk products<br>11. Conduction of surveys |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (15 marks)**<br>i) Assignments: 5 marks<br>ii) MCQ: 5 marks<br>iii) Viva: 5 marks<br>**Practical (15 marks)**<br>i) Lab involvement / report/ Lab test |
| | **B. End Semester Examination**<br>**Theory (35 marks -45 min)**<br>i) MCQ 35 questions: 35 x 1 = 35<br>**Practical (35 marks -1 Hr)**<br>i) Lab report: 10<br>ii) Viva: 10<br>ii) Writing procedure: 15 |

**References**


1. R. Jenness and S. Patom, *Principles of Dairy Chemistry*, Wiley, 2017.
2. K.S.Rangappa and K.T Acharya., *Indian Dairy Products*, Asia Publishing House, 1975.
3. F.P. Wong., *Fundamentals of Dairy Chemistry*, Springer, 2012.
4. L.M. Lampert., *Modern Dairy products*, Chemical Publishing Company Inc., 1998.
5. J. N. Warner, *Principles of Dairy Procesing*, Wiley, 1976.
6. Sukumar De, *Outlines of Dairy technology*, Oxford, 2001.
7. D, Richmond, *Laboratory Manual of Dairy Analysis*, Biotech Books, 2008.

# SEMESTER III

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|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Inorganic Chemistry-1** |
| **Type of Course** | **DSC A** |
| **Course Code** | **MCE3DSCCHE200** |
| **Course Level** | **200-299** |
| **Course Summary** | This course addresses bonding concepts in molecules, chemistry of p, f and d block elements and discusses the fundamentals of coordination chemistry. The practical component includes preparation of complexes and complexometric titrations. |

| **Semester** | III | Credits | | | 4 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Apply the bonding concepts to molecules. | A | 1, 2, 10 |
| 2 | Compare the physical and chemical properties of lanthanides and actinides. | An | 1, 2 |
| 3 | Explain different nuclear reactions. | U | 1, 2 |
| 4 | Differentiate the theories of coordination complexes of d-block elements. | An | 1, 2 |
| 5 | Apply the knowledge for estimation of Zn, Ca and Mg using complexometric titrations and complex preparations. | S | 1, 2, 10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Chemical Bonding** | | |
| | 1.1 | Properties of ionic compounds, lattice energy of ionic compounds - Born- Lande equation with derivation - solvation enthalpy and solubility of ionic compounds – Born-Haber cycle and its applications. | 3 | 1 |
| | 1.2 | Polarisation of ions – Fajan's rule and its applications. | 2 | 1 |
| | 1.3 | Covalent Bond: VSEPR theory- Postulates and applications<br>Valence Bond Theory and its limitations. Hybridization: definition, characteristics, and shape of molecules ($BeCl_2$, $BF_3$, $NH_4^+$, $H_3O^+$, $PCl_5$, $SF_6$, $XeF_2$, $XeF_4$, $XeOF_2$, $XeOF_4$, and $XeF_6$). | 5 | 1 |
| | 1.4 | Properties of covalent compounds - polarity of bonds – percentage of ionic character – dipole moment and molecular structure. | 2 | 1 |
| | 1.5 | Molecular Orbital Theory: LCAO - bonding and antibonding molecular orbitals – bond order and its significance. MO diagrams of homonuclear and heteronuclear diatomic molecules: $N_2$, $O_2$, $F_2$, CO and NO – comparison of bond length, magnetic behaviour and bond energy of $O_2$, $O_2^+$, $O_2^{2+}$, $O_2^-$ and $O_2^{2-}$ | 3 | 1 |
| 2 | | **Chemistry of f-block elements and radioactivity** | | |
| | 2.1 | Lanthanides: lanthanide series, abundance and natural isotopes, separation of lanthanides, lanthanide contraction, similarity in properties, occurrence, oxidation states, chemical properties of Ln(III) cations, magnetic properties, colour and electronic spectra of | 6 | 2 |
| | 2.2 | Chemistry of actinides – actinide series, abundance and natural isotopes, occurrence, preparation of actinides, oxidation states, general properties. | 2 | 2 |
| | 2.3 | Radioactivity – natural and artificial radioactivity; types of radioactive decay, Group displacement law, rate of disintegration - half life, nuclear fission and nuclear fusion reaction, chain reactions. | 4 | 3 |
| | 2.4 | Applications of radioactive decay: carbon dating, and nuclear medicine. Nuclear pollution and hazards. | 3 | 3 |
| | | **d-block elements and coordination compounds** | | |

| | | | | |
|---|---|---|---|---|
| **3** | 3.1 | Transition Metals: General characteristics. | 2 | 4 |
| | 3.2 | Werner's theory, types of ligands, coordination number, oxidation state. Geometry of complexes with coordination numbers 4 and 6. | 2 | 4 |
| | 3.3 | Stability of complexes: factors affecting the stability of metal complexes. Chelates, chelate effect. Theory of complexometric titrations. | 2 | 4 |
| | 3.4 | Isomerism in coordination compounds – structural isomerism and stereoisomerism (complexes with 4 and 6 coordination numbers). | 2 | 4 |
| | 3.5 | Valence bond theory, geometries of tetrahedral, square planar and octahedral (inner and outer orbital) complexes. Limitations of VB theory. | 3 | 4 |
| | 3.6 | Crystal field theory, splitting of d-orbitals in octahedral, tetrahedral, and square-planar complexes-introduction to Mulliken symbol, low spin and high spin complexes. Spectrochemical series-strong and weak field ligands, CFSE, pairing energy. | 4 | 4 |
| **4** | **Inorganic Chemistry-1 Practical** | | | |
| | 4.1 | Identify salts visually –<br>Cobalt chloride, copper chloride, copper sulphate, ferrous sulphate, ferric chloride, potassium dichromate and nickel chloride**.** | 2 | 5 |
| | 4.2 | Preparation of simple coordination complexes such as hexaaquacobalt (II), hexaaquacopper (II), hexaaquanickel (II) ions and prussian blue. | 8 | 5 |
| | 4.3 | Complexometric titration using EDTA Estimation of Ca, Mg and Zn Determination of hardness of water | 10 | 5 |
| | 4.4 | **Permanganometry**<br>1. Estimation of $Fe^{2+}$<br>2. Estimation of oxalic acid<br>3. Estimation of calcium | 10 | 5 |
| **5** | **Teacher Specific content** | | | |
| | | | | |

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| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>● Lecture (chalk & board, PowerPoint presentation)<br>● Group discussion<br>● Peer teaching<br>● Demonstration of experiments<br>● Hands-on training |

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| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment**<br>**Theory (25 marks)**<br>i) Assignment /Viva /Class test<br>**Practical (15 marks)**<br>i) Lab involvement / Viva |
| | **B. End Semester Examination**<br>**Theory:** Written examination **(50 Marks-1.5 hrs.)**<br>i) MCQ 10 questions: 10 x1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical: (35 marks)- 1 hr.**<br>i) Certified report- 10 Marks<br>ii) Procedure - 15 Marks<br>iii)Viva voce- 10 Marks |

**References**


1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Blackwell Science, London, 2008
2. B. R. Puri, L. R. Sharma and Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2020
3. F. A. Cotton, G. Wilkinson and P. L. Gaus, *Basic Inorganic Chemistry*, 3rd Edn., John Wiley, 2007
4. B. Douglas, D. Mc Daniel and J. Alexander, *Concepts and models in Inorganic Chemistry,* 3rd Edn Wiely,2006
5. J.E. Huheey, E.A. Keiter, R.L. Keiter and O.K. Medhi, *Inorganic Chemistry Principles of Structure and Reactivity*, 5th Edn. Pearson Education, 2022.
6. H.J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Edn. New Age International Private Limited, 2011.
7. S.N. Goshal, *Nuclear Physics*, S. Chand and Company, 2006.
8. Vogel's *Textbook of Quantitative Chemical Analysis*, 5th Edition, Longman Scientific and Technical, Harlow, 582.
9. D. A. Skoog, D. M. West, and S. R. Crouch, *Fundamentals of Analytical Chemistry,* 8th Edn., Brooks/Cole Nelson, 2004


**Suggested Readings**


1. N.N. Greenwood and A. Earnshaw, *Chemistry of the Elements*, Butterworth-Heinemann, 2012.
2. G.L. Miessler, and A. Tarr, Donald *Inorganic Chemistry* 3rd Edn.(adapted), Pearson, 2009
3. C. E. Housecroft, A.G. Sharpe and C. E. Barnes, *Inorganic Chemistry* 4th Edn. Journal of Chemical Education, 2003.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Organic Chemistry-1** |
| **Type of Course** | **DSC A** |
| **Course Code** | **MCE3DSCCHE201** |
| **Course Level** | **200-299** |
| **Course Summary** | This course explores the chemical principles underlie alkanes, alkenes, alkynes, and aromatic compounds. Additionally, it covers fundamental stereochemistry concepts. The practical segment of the course focuses on some methods used in organic qualitative analysis. |

| **Semester** | III | Credits | | | 4 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Distinguish between aliphatic, aromatic, and non-aromatic compounds. | An | 1,2 |
| 2 | Deduce the logical mechanism of reactions of aliphatic and aromatic compounds. | E | 1, 2, 10 |
| 3 | Outline industrial uses of aliphatic compounds. | U | 1, 2 |
| 4 | Assign R, S, E and Z notation to compounds. | A | 1, 2, 10 |
| 5 | Compare stabilities of conformations of organic molecules. | An | 1, 2 |
| 6 | Determine aromatic/aliphatic, saturated/unsaturated character and physical constants of organic compounds by microscale analysis and systematically record the observations. | An, S | 1, 2, 4, 6, 10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Alkane, Alkenes and Alkynes** | | |
| | 1.1 | Alkanes: physical properties, industrial use -LPG and petrol, preparation-Wurtz reaction. Reactions- Free radical substitutions (chlorination) with mechanism and cracking. | 3 | 1, 2 |
| | 1.2 | Alkenes: physical properties, industrial uses of ethylene, preparation- Saytzeff and Hofmann eliminations, reactions- hydrogenation, hydration, hydrohalogenation, Markovnikov's rule, Kharasch effect, ozonolysis, dihydroxylation using $KMnO_4$ and bromination (with | 7 | 1 |
| | 1.3 | Alkynes: physical properties, industrial uses of acetylene, preparation of acetylenes- dehydrohalogenation of vicinal dihalides, reactions- acidity of alkynes, formation of metal acetylides, alkylation of terminal alkynes and conversion into higher alkynes, addition of water, bromine and alkaline $KMnO_4$, reduction using Lindlar's catalyst | 5 | 1 |
| 2 | | **Aromatic compounds** | | |
| | 2.1 | Aromaticity: Definition, Hückel's rule, benzenoid aromatic compounds-benzene, naphthalene, anthracene; non-benzenoid aromatic compounds- cyclopropenyl cation, cyclopentadienyl anion, tropylium cation, heterocyclic aromatic compounds (pyridine, pyrrole and furan). Non-aromatic and antiaromatic compounds | 6 | 3 |
| | 2.2 | Benzene: molecular orbital picture, resonance energy, reactions - electrophilic aromatic substitution - nitration, halogenation, Friedel- Craft's reactions with their mechanisms. | 4 | 1, 6 |
| | 2.3 | Ring activating and deactivating groups with examples. Orientation of aromatic substitution- ortho, para and meta directing effects of groups. | 3 | 1 |
| | 2.4 | Aromatic nucleophilic substitutions of halobenzenes – bimolecular displacement mechanism, elimination-addition (benzyne intermediate) mechanism. | 2 | 1 |
| 3 | | **Basic Stereochemistry** | | |
| | 3.1 | Stereoisomerism: definition, classification, configuration and conformation, interconversion of wedge formula, Newman, Sawhorse and Fischer projection formulae | 1 | 4 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Geometrical isomerism: Cis–trans and E/Z nomenclature (upto two C=C systems) with Cahn Ingold Prelog (CIP) rules. Methods of distinguishing geometrical isomers. | 4 | 4 |
| | 3.3 | Optical isomerism: optical activity, specific rotation, concept of chirality, stereogenic centres, enantiomerism, diastereomerism and meso compounds, optical isomers of lactic acid and tartaric acid, racemic mixture and resolution. | 5 | 4 |
| | 3.4 | Relative and absolute configuration: D and L, threo and erythro; d and l designations; CIP rules: R/ S notation (up to 2 chiral carbon atoms). | 3 | 4 |
| | 3.5 | Conformations: conformational analysis with respect to ethane, butane, cyclohexane. Relative stability and energy diagrams. | 2 | 5 |
| **4** | **Organic Chemistry-1 Practical** | | | |
| | 4.1 | Microscale organic analysis- test for aromatic character-ignition test, nitration test, picrate test and tests for unsaturation. | 15 | 6 |
| | 4.2 | Determination of physical constants-melting point, boiling point, specific rotation (Polarimetry) | 15 | 6 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>Classroom lecture<br>Hands on training using models<br>Demonstration and practical training in laboratory<br>Use of molecular visualisation software<br>Industrial Visit |

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| **Assessment Types** | **MODE OF ASSESSMEN T**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Pop quiz/ Assigning R and S using molecular models/open book<br>ii) Written tests<br>**Practical (15 marks)**<br>i) Quiz<br>ii) Lab involvement<br>**B. End Semester Examination**<br>**Written examination - 50 Marks- 1.5 hrs.**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical (35 Marks)- 1 hr.**<br>i) Viva voce-10 Marks<br>ii) Written test of practical procedures-15 Marks<br>iii) Certified report of lab works done -10 Marks |

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Nature, 2023.
18. Eliel, E. L.; Wilen, S. H. *Stereochemistry of Organic Compounds;* John Wiley & Sons, 1994.
19. Mislow, K. *Introduction to Stereochemistry;* Dover Publications, 2002.
20. Furniss, B. S.; Hannaford, A. J.; Rogers, V.; Smith, P. W. G.; Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry*; 5th ed.; Pearson Education, 2005.

**Suggested Readings**

1. Hegstrom, R. A.; Kondepudi, D. K. *The Handedness of the Universe*. Sci. Am. 1990, *262* (1), 108–115. DOI:10.1038/scientificamerican0190-108
2. Service, R. F. *Does life's handedness come from within?* Science 1999, *285*, 1282-1283.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Environmental Pollution** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE3DSECHE203** |
| **Course Level** | **200-299** |
| **Course Summary** | A detailed understanding of the various types of environmental pollution, including air, water, soil, noise, thermal, and radioactive pollution. It aims to equip students with the knowledge of sources, impacts, and control measures of pollutants, along with the principles of environmental chemistry and modern mitigation strategies. |

| **Semester** | III | Credits | | | 4 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Explain the principles and scope of environmental chemistry, including the components and toxicity of the environment. | U | 1,2,3 |
| 2 | Describe the classification, properties, and impacts of various air pollutants | U | 1,2,3 |
| 3 | Identify sources and types of water pollution, and control measures for eutrophication, marine pollution, and oil pollution. | U | 1,2,6 |
| 4 | Analyze the sources, impacts, and control measures of soil pollution, including the effects of agricultural practices and industrial waste. | An | 1,2,6,10 |
| 5 | Evaluate the sources and impacts of noise, thermal, and radioactive pollution to propose appropriate mitigation | E | 1,2,6,10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Air Pollution** | | |
| | 1.1 | Introduction to environmental chemistry, components of environment, Pollutants and contaminants, Environmental pollution classification, Structure and composition of the atmosphere Temperature inversion. | 3 | 1,2 |
| | 1.2 | Classification and properties of air pollutants, - Gaseous pollutants (CO, NOx, $SO_2$, $O_3$), Particulate matter (PM2.5, PM10), VOCs (volatile organic compounds) and their role in secondary pollution formation, chemical reactions in the atmosphere. Aerosols: types, production, and distribution, aerosols and radiation, Air Quality Index. | 6 | 1,2 |
| | 1.3 | Environmental impacts of air pollution: global warming and greenhouse effect, major greenhouse gases and their role with focus on methane, ozone depletion and CFCs, Photochemical Smog, Acid rain: causes, effects, and mitigation. Air pollution and human health, Case studies and examples of air pollution in India -Bhopal gas tragedy and recent Case studies of air pollution/status in major Indian cities. | 6 | 1,2 |
| 2 | | **Water Pollution** | | |
| | 2.1 | Definition and significance. Types of water pollution- point and non-point source of water pollution, surface and groundwater pollution. | 4 | 1,3 |
| | 2.2 | Sources of water pollution - domestic, industrial, agricultural and natural sources. Impact of water pollution on human being, animals, plants and environment- Eutrophication and restoration of lakes - control measures of water pollution. | 6 | 1,3 |
| | 2.3 | Marine pollution - definition –role of GESAMP, natural and anthropogenic sources. Types of pollution –heavy metal, pesticides, plastics, oil, radioactive and eutrophication. Pollution status of coastal and ocean waters. Coastal zone management. SDGs and management of marine pollution. | 5 | 1,3 |

| | | | | |
|---|---|---|---|---|
| **3** | **Soil Pollution** | | | |
| | 3.1 | Composition of lithosphere, Types of soil, sources of soil pollution - natural sources and anthropogenic sources agricultural practices, industrial and municipal discharges, municipal solid waste dumping, land fill leachates, plastics, radioactive leakage, | 6 | 4 |
| | 3.2 | Mining activities and electronic wastes. Absorption of toxic metals in soil. Salt stress in soil. Impact of soil / land pollution. | 4 | 4 |
| | 3.3 | Soil fertility - redox reactions in soils. Effects of industrial & urban waste, heavy metal pollutants, effects of soil pollution in plants and animals effect of modern agrotechnology, multi cropping, control measures-Solid waste management | 5 | 4 |
| **4** | **Separation and Purification of Compounds** | | | |
| | 4.1 | Definition and concept of Noise pollution. Sources of noise pollution - Indoor and outdoor noise pollution, natural and anthropogenic sources. Standards for noise. Impact of noise pollution on plants and animals. Control measures adopted for abatement of noise pollution. Noise pollution analyzer - light pollution. | 5 | 1,5 |
| | 4.2 | Thermal and nuclear power plants as source of thermal pollution. Impacts of thermal pollution on aquatic fauna and flora. Controlling measures of thermal pollution**.** | 4 | 1,5 |
| | 4.3 | Radioactive pollution - types of radiation. Sources of Radioactivity-natural and anthropogenic sources, radio waste generated from nuclear power plant, effects of radiation - biological effects of radiations, protection and control from radiation. Disposal of radioactive waste, radioactive pollution episodes | 6 | 1,5 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of experiments<br>o Hands-on training |

| | |
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| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (30 marks)**<br>i) Assignments<br>ii) MCQ<br>iii)Class test<br>iv)Viva<br>**B. End Semester examination (70 marks)- 2 hrs.**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii)Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. Barucha E (2004) A Text Book of Environmental Science ,for University Grants Commission,New Delhi.
2. Biswas T.D. and Mukherji S., (1994). A Text book on soil science, Tata Mc Graw control, S Chand Publishers, New Delhi.
3. De A.K., (2003) Environmental Science, Wiley Eastern Hd, New Delhi.
4. Deshwal S. and Deswal A., (2004). A Basic Course in environmental studies, Dhanpat Rai & Co, Delhi.
5. Dhara S.S., (1993).A Text book on environmental chemistry and pollution
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7. Kaushik A., (2004). Perspectives in Environmental studies, New Age Intl. Publ,
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Energy and Environment** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE3DSECHE204** |
| **Course Level** | **200-299** |
| **Course Summary** | The topic includes the existing energy resources and their advantages, future energy resources and energy resource management. This also includes energy audit and gives an elementary idea about sustainable development and carbon sequestration, foot print and trading. |

| **Semester** | III | Credits | | | 4 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Describe the classification and potential of energy sources, including non-renewable options like fossil fuels and their environmental implications. | U | 1,2,3 |
| 2 | Explain the technologies and applications of renewable energy sources | U | 1,2,3 |
| 3 | Analyze the environmental impact and management of Resources | An | 1,2,6 |
| 4 | Evaluate energy resource management practices, emphasizing energy conservation technologies | E | 1,2,6,10 |
| 5 | Evaluate sustainable development principles in relation to energy | E | 1,2,6,10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Energy Sources** | | |
| | 1.1 | Introduction about Energy. Classification of Energy sources. Scenario of Energy Potential in India. Non-Renewable Sources of Energy (Advantages & Disadvantages). | 5 | 1 |
| | 1.2 | Fossil fuels: classification, Gross-calorific value and net t-calorific value Composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas : extraction, processing and utilization | 5 | 1 |
| | 1.3 | Refinery products of petroleum- LPG, Natural Gas Energy.-LNG, CNG Coal gasification technology, Shale oil, Coal bed Methane, Gas hydrates. | 5 | 1 |
| 2 | | **Renewable energy source- Solar, hydro, wind and geothermal energy** | | |
| | 2.1 | Solar Energy and their applications. Solar Energy Advantages & their limitations. Sun as a source of other energies, Solar energy as heat energy cookers, solar heaters - desalination of sea water, green house technology, solar pond | 6 | 1,2,3 |
| | 2.2 | Solar cells-Photovoltaic and photogalvanic cells-limitations of solar energy | 3 | 1,2,3 |
| | 2.3 | Hydro-Electric Energy (Hydro power). Wind Energy. Geothermal Energy and Environment. Various forms of Geothermal energy Reservoirs & their uses. Tidal Energy and Sea-wave Energy. Ocean Thermal Energy Conversion (OTEC). Hydrothermal energy | 6 | 1,2,3 |
| 3 | | **Biomass, hydrogen and nuclear fuels** | | |
| | 3.1 | Biomass Energy [wood waste, Biofuels viz; Ethanol & Biodiesel] Biomass and the Environment biomass gasification through pyrolysis. Alcohol as a source of Energy (Gasohol, Methanol & Ethanol).Biogas generation Technology. | 8 | 4 |
| | 3.2 | Hydrogen as a fuel and hydrogen based economy<br>Nuclear energy-Power generation through nuclear fission and fusion, Waste management and radiation risks, Safety | 7 | 4 |

| | | | | |
|---|---|---|---|---|
| **4** | **Energy resource management & Sustainable development** | | | |
| | 4.1 | Energy resource management- Objectives, needs and importance of energy conservation, Energy conservation technologies Energy policies-Energy laws and regulations in India. | 5 | 4,5 |
| | 4.2 | Energy audits-objectives and goals, importance, scope and stages- planning, investigating, implementing and sustaining. Energy conservation strategies | 5 | 4,5 |
| | 4.3 | Sustainable development- objectives and goals. Need and importance, carbon sequestration, carbon foot print-concept and reduction methods. carbon credits, carbon trading | 5 | 4,5 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>● Lecture (chalk & board, PowerPoint presentation)<br>● Group discussion<br>● Peer teaching<br>● Demonstration of experiments<br>● Hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**B. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (30 marks)**<br>Assignments/MCQ/Class test/Viva |
| | **B. End Semester examination (70 marks)- 2 hrs.**<br>i. Short answer 5 questions (out of 7): 5 x 4 =20<br>ii. Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii. Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. Bansal N. K., Kleemann M. & Michael, Meliss., (1990), Renewable Energy Sources & Conversion
2. Chakravarty, A. (1998.) Biotechnology and Other Alternative Technologies, Oxford and IBH D.O. Hall & R.P. Overend (1987), John Wiley Biomass- Regenerable Energy,
3. Das K A, Das M (2012) Environmental chemistry with green chemistry. Books and allied publication

4. Deshwal S. and Deswal A., (2004). A basic course in environmental stud8ies, Dhanpat Rai & Co, Delhi.
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6. Rai, G.D. (2001), Non-Conventional Energy Sources Khanna Publishers, New Delhi.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Environment, Ecology, and Biodiversity** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE3DSCCHE205** |
| **Course Level** | **200-299** |
| **Course Summary** | The course includes the fundamentals of environmental science and also deals with Impact assessment and sustainable development, ecology, energy flow, biodiversity -threats to biodiversity and strategies used for the conservation of biodiversity also natural resources and its sustainable use. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Semester** | III | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Able to describe the structure, composition and interactions of different components of environment. | U | **1,10** |
| 2 | Evaluate the importance of ecology, energy flow, impact assessment, sustainable development, biodiversity and natural resources. | E | **1,7,6** |
| 3 | Evaluate the effectiveness of various renewable and non-renewable energy resources in terms of sustainability and environmental impact. | E | **1,2,3,6, 10** |
| 4 | Analyse the energy flow and ecological pyramids through graphs and diagrams. | An | **1,2,3,6** |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| | **Fundamentals of Environmental Science** | | | |
| **1** | 1.1 | Definition and concepts in environmental science principles and scope of environmental science. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. | 5 | 1 |
| | 1.2 | Interaction between Earth, Man and Environment. Biogeographic provinces of the world and agro-climatic zones of India. Concept of sustainable development and environmental impact assessment | 5 | 1 |
| | 1.3 | Global Environmental Issues – Biodiversity loss, Climate change, Ozone layer depletion. Sea level rise. International efforts for environmental protection. Environmental education. | 5 | 2 |
| | **Ecology and Ecosystem** | | | |
| **2** | 2.1 | Concept of an ecosystem (Abiotic and biotic environment), structure and function of an ecosystem –Tropical Levels-Producers, Consumers and decomposers. | 5 | 1,2 |
| | 2.2 | Energy flow in the ecosystem, Nutrient cycle in the ecosystem- Food Chain, food webs, Ecological succession - ecological pyramids. productivity in an ecosystem - primary Productivity-Gross Primary productivity and Net primary productivity, Secondary productivity | 5 | 1,2,3 |
| | 2.2 | Introduction, types, characteristic features, structure and function of the following ecosystems, Forest ecosystem, Grass land ecosystem, Desert ecosystems aquatic ecosystems [ponds, streams, lakes, rivers, ocean estuaries. | 5 | 2,4 |
| | **Concepts and Conservation of Biodiversity** | | | |
| **3** | 3.1 | Biodiversity concepts, components, types - alpha, beta and gamma - ecological and economic importance, Aesthetic value of biodiversity. International Agreements on biodiversity conservation -**CBD, CITES, CMS, ITPGRFA, UNESCO WHC, IPPC, IWC.** | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Key stone umbrella and flagship species - Eco tone and niche. Threats to biodiversity- natural and anthropogenic disturbances with focus on climate change , consequences of biodiversity loss. | 3 | 2 |
| | 3.3 | Need for conservation of biodiversity.Biodiversity conservations - *insitu* conservation - sanctuaries, | 4 | 2 |
| | 3.4 | Biodiversity hotspots, threatened species, IUCN red list Categorisation – endangered species, vulnerable species,rare species, extinct species and endemic species, invasive alien species and impacts on biodiversity. SDGs and Biodiversity. | 4 | 2 |
| **4** | **Natural Resources** | | | |
| | 4.1 | Natural resources-ecological, economic and aesthetic significance, Renewable and non-renewable resources, land as a resource - land degradation and conservation measures. Water resources- sources, use and exploitation of ground water and surface water. | 5 | 2 |
| | 4.2 | Forest resource- Types and classification of forests in India, Economic and aesthetic value of forests, Threats to forest ecosystems. Conservation strategy-reforestation, afforestation, social forestry, Agroforestry | 5 | 2 |
| | 4.3 | Energy resource - Renewable- Solar, hydrothermal, tidal, wind, geothermal sources, Non-renewable-fossil fuel, natural gas, thermal and nuclear energy, future energy sources. Need for resource management and strategies used for resource management | 5 | 2 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>o Lecture (chalk& board, power point presentation)<br>o Group discussion<br>o Peer teaching<br>o Seminars<br>o Assignements |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)Theory:(30 marks)**<br>Assignments/MCQ/Class test/Viva |
| | **B. End Semester examination (70 marks)- 2 hrs.**<br>i. Short answer 5 questions (out of 7): 5 x 4 =20<br>ii. Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii. Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. Agarwal S.K., (2003) Ecology and Environment. S.Chand and company, New Delhi
2. Barucha E (2004) A Text Book of Environmental Science, for University Grants Commission, New Delhi.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | | | | | | |
| **Course Name** | **Chemistry in Everyday Life** | | | | | |
| **Type of Course** | **MDC** | | | | | |
| **Course Code** | **MCE3MDCCHE200** | | | | | |
| **Course Level** | **200-299** | | | | | |
| **Course Summary** | This course provides a comprehensive understanding of how chemistry permeates various aspects in our daily life. | | | | | |
| **Semester** | III | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 0 | | 45 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Explain the uses of fertilizers and pesticides and their impact on the environment. | U | 1, 2, 3. 6, 7, 10 |
| 2 | Compare various types of drugs | An | 3, 6, 7, 10 |
| 3 | Classify soaps and understand its cleansing action | U | 1, 2, 3. 6, 7, 10 |
| 4 | Investigate the chemical components in personal care products. | An | 1, 2, 3. 6, 7, 10 |
| 5 | Make use of theories to prepare cosmetics | A,S | 1, 2, 3, 6. 7. 10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Chemistry in Agriculture and Medicine** | | |
| | 1.1 | Fertilizers – introduction. Types of fertilizers - natural, synthetic, NPK fertilizers. Excessive use of fertilizers and its impact on the environment. Bio-fertilizers and organic manures. | 4 | 1 |
| | 1.2 | Pesticides - Introduction. Classification (brief idea only) - insecticides, fungicides, herbicides (structures not required). Excessive use of pesticides - environmental hazards. Biopesticides | 4 | 1 |
| | 1.3 | Classification of drugs - analgesics, antipyretics, antihistamines, antacids, antibiotics and antifertility drugs with examples (structures not required).<br>Psychotropic drugs - tranquilizers, antidepressants and stimulants with examples (structures not required).<br>Drug addiction and abuse. Prevention and treatment. | 7 | 2 |
| 2 | | **Chemistry in personal care products** | | |
| | 2.1 | Soaps – introduction, types of soaps - toilet soaps, washing soaps, liquid soap, TFM and grades of soaps, cleansing action, environmental aspects. | 5 | 3 |
| | 2.2 | Composition of different types of cosmetics - toothpaste, hair dye, face and skin powders, lipsticks and perfumes, shaving creams<br>Shampoos- ingredients and functions – different kinds of shampoos (anti-dandruff, anti-lice, herbal and baby shampoos).<br>Herbal cosmetics- definition, natural ingredients used- aloe vera, turmeric, henna, amla, neem, clove<br>Harmful effects of cosmetics. | 10 | 4 |
| 3 | | **Demonstration Experiments** | | |
| | 3.1 | 1. Synthesis of Organic manure<br>2. Preparation of Toilet soap<br>3. Evaluate TFM value of soap<br>4. Preparation of Shampoo<br>5. Preparation of Perfume<br>6. Preparation of Sanitizers | 15 | 5 |

| | | | | |
|---|---|---|---|---|
| | | 5. Preparation of Perfume<br>6. Preparation of Sanitizers | | |
| **4** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>Lecture sessions, interactive sessions including discussions, demonstrations, and experiments to engage students actively and visual aids like presentations, videos, and models to enhance understanding. Encourage students to ask questions during or after the lectures. Begin with safety instructions and guidelines for lab work. Allow students to conduct experiments under supervision (for lab work). |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (25 marks)**<br>i) Assignments Viva<br>ii) Classroom participation (participation in class activities)<br>iii) Examination |
| | **B. End Semester Examination Theory: (50 marks)- 1.5 hrs**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 10 questions (out of 12): 10 x 4 = 40 |

**References**


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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | | | | | | |
| **Course Name** | **Forensic Chemistry** | | | | | |
| **Type of Course** | **VAC** | | | | | |
| **Course Code** | **MCE3VACCHE200** | | | | | |
| **Course Level** | **200-299** | | | | | |
| **Course Summary** | This course provides a comprehensive understanding of the basic principles of chemistry as they apply to forensic science. It focuses on enabling non-chemists to comprehend and utilize chemical concepts in forensic analysis. | | | | | |
| **Semester** | 3 | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | Total Hours |
| | | 3 | | | | 45 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Recognize various types of chemical substances, their properties, and their relevance in forensic contexts. | U | 1, 2 |
| 2 | Utilize fundamental chemical principles to understand forensic analysis techniques. | A | 1, 2, 10 |
| 3 | Evaluate and interpret chemical evidence commonly encountered in forensic investigations. | An | 1, 2 |
| 4 | Explain the role of chemistry in forensic science, including its impact on legal proceedings and criminal investigations. | U | 1, 2, 6, 8, 10 |
| 5 | Extract meaningful conclusions from chemical data obtained during forensic analysis. | U | 1, 2, 6, 8 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Poisons** | | |
| | 1.1 | Poisons-types and classification- diagnosis of poisons in the living and the dead – clinical symptoms - post-mortem appearances. | 4 | 1,2,3,4,5 |
| | 1.2 | Heavy metal contamination (Hg, Pb, Cd) of sea foods. | 3 | 1,2,3,4,5 |
| | 1.3 | Use of neutron activation analysis in detecting Arsenic in human hair | 2 | 1,2,3,4,5 |
| | 1.4 | Treatment in cases of poisoning - use of antidotes for common poisons. | 3 | 1,2,3,4,5 |
| 2 | | **Crime Detection** | | |
| | 2.1 | Accidental explosion during manufacture of matches and fireworks. | 2 | 1,2,3,4,5 |
| | 2.2 | Human bombs- possible explosives (gelatine sticks and RDX) | 3 | 1,2,3,4,5 |
| | 2.3 | Metal detector devices and other security measures for VVIP | 2 | 1,2,3,4,5 |
| | 2.4 | Composition of bullets and detecting powder burn | 2 | 1,2,3,4,5 |
| | 2.5 | Analysis of incendiary and timed bombs - spill of toxic and corrosive chemicals from tankers. | 3 | 1,2,3,4,5 |
| 3 | | **Forgery and Counterfeiting** | | |
| | 3.1 | Documents - different types of forged signatures-simulated and traced forgeries – inherent signs of forgery methods - writing deliberately modified - uses of ultraviolet rays - comparison of typewritten letters | 5 | 1,2,3,4,5 |
| | 3.2 | Checking silver line watermark in currency notes, alloy analysis using AAS to detect counterfeit coins | 4 | 1,2,3,4,5 |
| | 3.3 | Detection of gold purity in 22 carat ornaments - detecting gold plated jewels - authenticity of diamond. | 3 | 1,2,3,4,5 |
| 4 | | **Tracks and Traces** | | |
| | 4.1 | Tracks and traces - small tracks and police dogs-footprints- walking pattern or tyre marks | 3 | 1,2,3,4,5 |

| | | | | |
|---|---|---|---|---|
| | 4.2 | Glass fracture – tool mark paints – fibres. | 2 | 1,2,3,4,5 |
| | 4.3 | Analysis of biological substances - blood, saliva, urine and hair | 2 | 1,2,3,4,5 |
| | 4.4 | DNA Finger printing for tissue identification in dismembered bodies -detecting steroid consumption in athletes and race horses | 2 | 1,2,3,4,5 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

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| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>Lecture sessions, interactive sessions including discussions and demonstrations to engage students actively and visual aids like presentations and videos to enhance understanding. Utilize case studies to illustrate how forensic analysis is applied. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (25 marks)**<br>i) Assignments<br>ii) Viva<br>iii) Classroom participation (participation in class activities)<br>iv) Examination |
| | **B. End Semester Examination**<br>**Theory: 50 marks- 1.5 hrs.**<br>i) MCQ 9 questions: 9 x 1 = 9<br>ii) Short answer 5 questions (out of 7): 5 x 4 =20<br>iii) Short essay 3 questions (out of 5): 3 x 7 = 21 |

**References**


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2. Richard, Criminalistics - *An Introduction to Forensic Science* (College Version), 8th Edition, Sofestein, Prentice Hall, 2003.
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4. B.S. Nabar, *Forensic Science in Crime Investigation*, Asia Law House, 2022.
5. Glencoe, *Forensic Laboratory Manual*, McGraw Hill, 2001.
6. S Bell, *Forensic Chemistry*, CRC Press, 2022.

K M Elkins, *Introduction to Forensic Chemistry*, CRC Press, 2019.

# SEMESTER IV

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Organic Chemistry-2** | | | | | |
| **Type of Course** | **DSC A** | | | | | |
| **Course Code** | **MCE4DSCCHE200** | | | | | |
| **Course Level** | **200-299** | | | | | |
| **Course Summary** | A study of the reactions of alcohols, aldehydes, ketones, carboxylic acids, and its derivatives. Practical part includes Qualitative Microscale analysis of organic compounds. | | | | | |
| **Semester** | IV | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Summarize the structure and uses of alcohols, aldehydes, ketones, acids, and acid derivatives. | U | 1,2 |
| 2 | Predict the product and reasonable mechanism for reactions of alcohols, aldehydes, ketones, carboxylic acids, and its derivatives | E | 1, 2 |
| 3 | Apply the functional group chemistry to interconvert alcohol, aldehyde, ketone and acid. | A | 1, 2 |
| 4 | Design synthetic pathways to higher and lower homologous series in acids and alcohols. | A | 1, 2 |
| 5 | Analyse the functional groups and systematically record the observations. (Practical) | S | 1, 2, 4, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Alcohols** | | |
| | 1.1 | Alcohols-classification (monohydric, dihydric, polyhydric, primary, secondary and tertiary), Luca's test, preparation of alcohols using Grignard reagents. | 2 | 1, 2, 3 |
| | 1.2 | Chemical Properties: esterification, reactions with sodium and $KMnO_4$, pinacol-pinacolone rearrangement (with mechanism), ascend and descend in homologous series, alcohol metabolism in human body. | 4 | 1, 3, 4, 5 |
| | 1.3 | Phenol- acidity of phenol, effect of substituent on acidity, comparison of acidity of phenols with alcohols.<br>Hydrogen bonding (inter and intramolecular) in phenols, effect of H-bonding on boiling point and solubility in water. | 4 | 1, 3 |
| | 1.4 | Chemical reactions of phenol: electrophilic substitution reactions-nitration, halogenation, Reimer-Tiemann reaction (with mechanisms)<br>Structure and uses of catechol, resorcinol, quinol and picric acid. | 5 | 3, 4, 5 |
| 2 | | **Aldehydes and Ketones** | | |
| | 2.1 | Structure and industrial uses of representative aldehydes and ketones-formaldehyde, acetaldehyde, benzaldehyde and acetone. | 2 | 1 |
| | 2.2 | Nucleophilicity of carbonyl compounds-comparison between aldehydes and ketones<br>Nucleophilic addition reactions-reaction with HCN, ammonia derivatives (reaction with primary amine, hydroxylamine, phenylhydrazine). | 4 | 1, 3, 4, 5 |
| | 2.3 | Acidity of alpha-hydrogen in aldehydes and ketones, aldol condensation, Claisen condensation, Knoevenagel reaction, Claisen-Schmidt reaction, Perkin condensation, benzoin condensation, Cannizzaro reaction (with mechanisms) | 6 | 1, 3, 4, 5 |

| | | | | |
|---|---|---|---|---|
| | 2.4 | Clemmensen reduction, Wolff-Kishner reduction, iodoform reaction, Beckmann rearrangement (with mechanisms) Tollen's and Fehling's reaction | 3 | 2, 3, 4, 5 |
| **3** | **Carboxylic acids and acid derivatives** | | | |
| | 3.1 | Structure and uses of formic acid, acetic acid, benzoic acid, oxalic acid, phthalic acid, and salicylic acid. | 1 | 1 |
| | 3.2 | Acidity of carboxylic acid- effect of substituents on acid strength for aromatic carboxylic acids. | 1 | 1, 2 |
| | 3.3 | Reactions of carboxylic acids: - reduction, decarboxylation and Hell – Volhard - Zelinsky reaction.<br>Ascend and descend in carboxylic acid homologous series. | 4 | 1, 2 |
| | 3.4 | Acid derivatives - Conversion of acid to acid chlorides, amides, esters and anhydrides<br>Comparative study of nucleophilicity of acyl derivatives. | 3 | 1, 2 |
| | 3.5 | Reactions of acid derivatives with mechanisms: conversion of acid chloride to acid anhydride, ester, amide, aldehyde, and alcohol; conversion of acid anhydride to acid, ester, and amide; conversion of ester to acid, amide, primary and secondary alcohols; conversion of amide to acid, nitrile and primary amine. Reformatsky reaction. | 6 | 1, 2 |
| **4** | **Organic Chemistry-2 Practicals** | | | |
| | 4.1 | Qualitative microscale analysis of organic compounds- identification and preparation of derivatives of alcohols, phenols, aldehydes, ketones, carboxylic acid, and carboxylic acid derivatives. | 30 | 1, 2, 4 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of experiments<br>o Hands-on training |

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| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Pop quiz -5 marks<br>ii) Problem based assignments - 5 Marks<br>iii) Written/MCQ tests -15 Marks<br>**Practical (15 marks)**<br>i) Quiz<br>ii) Lab involvement |
| | **B. End Semester Examination**<br>**Theory: Written examination (50 Marks- 1.5 Hrs)**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical (35 marks – 1 Hr)**<br>i) Viva voce-10 Marks<br>ii) Written test of practical procedures-15 Marks<br>iii) Certified report of lab works done -10 Marks |

**References**


1. R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, *Organic Chemistry*; 7th Edn. Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
2. T.W. Graham Solomon, C.B. Fryhle and S.A. Snyder, *Organic Chemistry*; Wiley, 2014.
3. J. McMurry, *Organic Chemistry*; 7th Edn. Cengage Learning, 2013.
4. J. Clayden, N. Greeves, S. Warren, *Organic chemistry*; Oxford University Press, 2012.
5. I. L. Finar, I, *Organic Chemistry*; Vol. 1& 2; Dorling Kindersley (India) Pvt. Ltd (Pearson Education).
6. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry;* Vishal Publishing Co., 2010.
7. A. Bahl, B. S. Bahl, *Advanced Organic Chemistry*; S. Chand, 2010.
8. F. A. Carey, R. J. Sundberg, *Advanced Organic Chemistry: Part A: Structure and Mechanisms*; Springer Science & Business Media, 2007.
9. R. O. C. Norman, J. M. Coxon, *Principles of Organic Synthesis*; Routledge, 2017.
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11. B. S. Furniss, A. J. Hannaford, V. Rogers, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*; 5th ed.; Pearson Education, 2005.
12. V. K. Ahluwalia, S. Dhingra, *Comprehensive Practical Organic Chemistry- Qualitative Analysis*; University Press, 2000.
13. F. G. Mann, B. C. Saunders, *Practical Organic Chemistry*; 4th ed.; Pearson Education, 2009.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** |

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| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Physical Chemistry- 1** | | | | | |
| **Type of Course** | **DSC A** | | | | | |
| **Course Code** | **MCE4DSCCHE201** | | | | | |
| **Course Level** | **200-299** | | | | | |
| **Course Summary** | This course deals with the fundamental concepts of gaseous state, ionic and phase equilibria, and solutions. | | | | | |
| **Semester** | IV | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Interpret the properties of real and ideal gases and calculate the critical constants theoretically. | E | 1, 2 |
| 2 | Distinguish the different types of molecular velocities and define various terms involved on molecular motion. | An | 1, 2 |
| 3 | Utilize the concepts of acids, bases and buffer solutions to calculate ionic product, pH and ionic strength. | A | 1, 2 |
| 4 | Interpret different phases coexist in phase diagram. | E | 1, 2 |
| 5 | Identify different types of solutions and its properties. | A | 1, 2 |
| 6 | Distinguish the colligative properties of solutions and calculate the molar mass. | U | 1, 2 |
| 7 | Make use of theoretical knowledge and execute experiments in phase equilibria, critical solution temperature and colligative properties. | S | 1, 2, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Gaseous State** | | |
| | 1.1 | Deviation of real gases from ideal behaviour: causes of deviation, van der Waals equation of state for real gases. Boyle temperature. Critical phenomena and Andrew's isotherms of $CO_2$, continuity of states, critical constants and their calculation from van der Waals equation. Virial equation of state, van der Waals equation expressed in Virial form. | 5 | 1 |
| | 1.2 | Maxwell Boltzmann distribution laws of molecular velocities (graphical representation – derivation not required) and their importance. Temperature dependence of these distributions. | 5 | 1, 2 |
| | 1.3 | Collision properties: Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules (No derivation). Relation between mean free path and coefficient of viscosity. | 5 | 2 |
| 2 | | **Ionic Equilibria** | | |
| | 2.1 | Introduction – Concepts (Lowry-Bronsted and Lewis concept) of acids and bases, relative strength of acid-base pairs, influence of solvents, Dissociation constants – acids, bases, and polyprotic acids. Ostwald's dilution law. | 4 | 3 |
| | 2.2 | Degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water- pH. Effects of solvents on ionic strength. | 3 | 3 |
| | 2.3 | Buffer solutions – Mechanism of buffer action, Henderson equation. Hydrolysis of salts (concepts only). | 3 | 3 |
| 3 | | **Phase Equilibria and Solutions** | | |
| | 3.1 | The phase rule (no-derivation). One component system – water and sulphur systems. | 2 | 4 |
| | 3.2 | Two component systems- simple eutectic; lead- silver system. Application to Metallurgy-Pattinson's process. | 3 | 4 |
| | 3.3 | Introduction, binary liquid solutions, Raoult's law, ideal and non-ideal solutions, Vapour pressure – composition | 5 | 5 |

| | | | | |
|---|---|---|---|---|
| | | and temperature – composition curves of ideal and non-ideal binary liquid solutions. | | |
| | 3.4 | Critical solution temperature (CST). Solubility of gases in liquids – Henry's law and applications. Distribution of a solute between two solvents– Nernst distribution law. | 5 | 6 |
| | 3.5 | Colligative properties of dilute solutions – vapour pressure lowering, boiling point elevation and freezing point depression. Molar mass determination (no derivation) -related problems – osmotic pressure –laws of osmotic pressure – reverse osmosis – purification of seawater. Abnormal molecular masses – van't Hoff factor – degree of association and degree of dissociation. | 5 | 6 |
| **4** | **Physical chemistry 1 - Practicals** | | | |
| | 4.1 | 1. Determination of CST of Phenol-water system<br>2. Effect of KCl/Succinic acid on Critical Solution Temperature of phenol-water system<br>3. Determination of unknown concentration of KCl/Succinic acid using CST method<br>4. Transition temperature of salt hydrates. (Sodium thiosulphate, sodium acetate)<br>5. Determination of mass of solvent/molecular mass of solute using transition temperature.<br>6. Construction of phase diagram of simple eutectics (Naphthalene-Biphenyl System)<br>**7.** Molecular weight determination by Rast's method. (Using naphthalene, camphor or biphenyl as solvent and acetanilide, p-dichlorobenzene etc. as solute.) | 30 | 7 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

| | |
|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lecture (chalk & board and PowerPoint presentations)<br>o Interactive sessions and simulations,<br>o Visual aids like videos and models to enhance understanding.<br>o Peer discussions.<br>o Laboratory experiments and hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Pop quiz (5 marks)<br>ii) Assignment 5 (Marks) |

| | |
|---|---|
| | iii) Class test(MCQ/written) (15 Marks)<br>**Practical (15 marks)**<br>i) Lab involvement (6 Marks)<br>ii) Lab Skill (5 Marks)<br>iii) Report of lab works done (4 Marks) |
| | **B. End Semester Examination**<br>**Theory: Written examination (50 Marks- 1.5 Hrs)**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical (35 marks- 1Hr)**<br>i) Viva voce-10 Marks<br>ii) Written test of practical procedures-15 Marks<br>iii) Certified report of lab works done -10 Marks |

**References**


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3. G.M. Barrow, *Physical Chemistry*, Tata McGraw-Hill, 2007.
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7. G. Raj, *Advanced Physical Chemistry*, Goel Publishing House, 2016.
8. I.N. Levine, *Physical Chemistry*, Tata McGraw Hill, 2011.


**Suggested Readings**


1. R P W Atkins, *Physical Chemistry*, Oxford University Press; 12th edition (5 December 2022)
2. R J Silby and R A. Alberty, M G Bawendi, *Physical Chemistry*, (4th Edition) John Wiley & Sons, 2004.
3. J. C. Kotz, P. M. Treichel, J. R. Townsend, *General Chemistry*, Cengage Learning India Pvt. Ltd. New Delhi (2009).
4. Glasstone, Lewis, Elements of Physical Chemistry, Macmillan student editions, 2nd revised, Van Nostrand, 1960.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Atmospheric Chemistry and Air Pollution** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE4DSECHE202** |
| **Course Level** | **200-299** |
| **Course Summary** | This course explores the composition of atmosphere, heat budget and heat balance of the atmosphere, the reactions occur in lower and upper atmosphere, this topic also deals with effects of atmospheric pollution and also suggest some control measures. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Semester** | IV | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Explain weather and climate concepts | K | 1,2,310 |
| 2 | Analyse climate change causes and effects, applying knowledge of vertical radiation balance. | An | 1,2,3 |
| 3 | Analyse atmospheric composition and dynamics, including El Niño and La Niña effects. | An | 1,2,3,6 |
| 4 | Analyse biogeochemical cycles and their impacts of on environmental processes. | An | 1,2,3 |
| 5 | Discuss the effects of atmospheric pollution their associated protocols, with a focus on primary and secondary pollutants and their control measures. | U | 1,2,3,6, 10 |
| 6 | Apply of air pollution control technologies and standards to propose effective mitigation strategies. | A | 1,2,6 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Weather and climate** | | |
| | 1.1 | Basic concepts - weather and climate meteorological factors affecting climate, weather and climate monitoring equipments - meteorological data collection wind rose diagram and its applications. | 4 | 1,2,3 |
| | 1.2 | Composition of atmosphere and structure , chemical composition of earth's atmosphere - major and minor constituents. Energy of atmosphere - earth heat balance - air sea interactions - *el nino* and *la nina* effects | 4 | 1,2,3, |
| | 1.3 | Climate change - causes and effects, regional scenarios in climate change. Vertical structure radiation balance - temperature regulation in thermosphere, stratosphere and troposphere Radiation balance and greenhouse effect. Albedo effect | 7 | 1,2,3 |
| 2 | | **Atmospheric chemistry** | | |
| | 2.1 | Biogeochemical cycles of carbon, oxygen, nitrogen, and sulphur cycles - halogen and trace elements cycle. | 4 | 4 |
| | 2.2 | Photochemical processes - photo dissociation and ionization reaction of chemically excited species - formation, growth and transformation of aerosols - species formation. Physical and chemical properties of aerosols- cloud interaction. | 6 | 4, 5 |
| | 2.3 | Stratospheric chemistry - Chapman model chemical mechanism of polar ozone depletion , anthropogenic impacts , consequences of ozone perturbations , ozone variations and trends, Ozone hole in Arctic and Antarctica. | 5 | 4, 5 |
| 3 | | **Air pollution** | | |
| | 3.1 | Effects of atmospheric pollution - global warming and greenhouse effect – Methane as a major | 5 | 5, 6 |

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|---|---|---|---|---|
| | | greenhouse gas, acid rain - ozone layer depletion - cause and consequences, - Montreal protocol and Kyoto protocol. | | |
| | 3.2 | Primary and Ssecondary pollutants –Long range trans boundary Air Pollution, photochemical smog -London smog and Los Angeles smog, particulates composition and health effects. | 5 | 5, 6 |
| | 3.3 | Air pollution from automobile source and its control-crankcase emission, catalytic converter, air quality standards and index (AQI) air pollution accidents - Bhopal gas tragedy and Chernobyl disaster. AQI of major Indian Cities. | 5 | 5, 6 |
| **4** | **Air pollution Control** | | | |
| | 4.1 | Air quality standards, sampling and analysis of atmospheric pollutants -sampling-analysis of air pollutants-sulphur dioxide-carbon monoxide-nitrogen dioxide-oxidants-ozone-hydro carbons and particulate matter. | 5 | 6 |
| | 4.2 | Control of Gaseous Contaminants- adsorption, absorption, combustion and cold trapping Control of particulate contaminants-gravitational settling chambers-cyclone separators-fabric filters-electrostatic precipitators, wet scrubbers, cascade impactors, | 5 | 6 |
| | 4.3 | Instrumental and analytical techniques for air pollutants - suspended particles, sulphur compounds, hydrogen sulphide, sulphur dioxide, Oxides of nitrogen, carbon monoxide and hydrocarbons. | 5 | 6 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lecture-based approach<br>o Interactive discussions<br>o Flipped classroom<br>o Peer teaching and collaborative learning. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)** |

| | |
|---|---|
| | **Total 30 Marks**<br>i) Assignments: 5 marks<br>ii) MCQ: 5 marks<br>iii) Class test: 15 marks<br>iv) Viva: 5 marks<br>**B. End Semester Examination: Total 70 Marks**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

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|---|---|---|---|---|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Environmental Engineering** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE4DSECHE203** | | | | | |
| **Course Level** | **200-299** | | | | | |
| **Course Summary** | This course provides a comprehensive understanding of environmental engineering principles, focusing on modern trends, water and wastewater treatment processes, solid waste management, and air pollution control technologies. | | | | | |
| **Semester** | IV | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Describe the principles and scope of environmental engineering | U | 4 |
| 2 | Discuss the sources, characterization, and disposal methods of solid wastes | U | 2, 3, 6 |
| 3 | Apply water quality standards to determine suitable treatment processes. | A | 1, 2, 6, 8 |
| 4 | Analyse secondary wastewater treatment methods and their design concepts. | An | 1, 2, 5, 6, 9 |
| 5 | Evaluate air pollution control technologies and their effectiveness in reducing pollutants. | A | 1, 2. 3, 6, 8 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**
**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| | **Introduction to Environmental Engineering and Solid Waste treatment** | | | |
| **1** | 1.1 | Introduction to environmental engineering. Principles and scope of environmental engineering. Modern trends in environmental engineering. | 3 | 1 |
| | 1.2 | Solid waste management - Sources and generation of solid wastes, their characterization, reduce-reuse-recycle paradigm. Chemical composition and classification of solid wastes, methods of disposal – sanitary land fill, secured land fill, incineration, pyrolysis, types of composting and management hospital waste and hazardous waste, rules regarding solid waste management, recycling of waste material, waste minimization technologies. | 12 | 2 |
| **2** | **Conventional Water Treatment** | | | |
| | 2.1 | Water quality monitoring. Water quality requirement and standards for various uses. Quality of water in different sources. Standards of quality for domestic water supplies, treated and untreated water- BIS, WHO, USEPA | 5 | 3 |
| | 2.2 | Conventional Water Treatment Process: Filtration, Slow and Rapid sand filters - Water Treatment, mixing, flocculation, and coagulation, Jar Test, Aeration, Water softening techniques - Lime Soda process, zeolite process, and demineralization. | 5 | 4 |
| | 2.3 | Removal of iron and manganese, Defluoridation of water. Desalination, evaporation, and distillation. Electro dialysis method, reverse osmosis, freezingprocess. Flow diagram for conventional sewage treatment. | 5 | 4 |
| | **Waste Water Treatment** | | | |
| | 3.1 | Municipal, sewage and industrial water Treatment - basic treatment process, pre - treatment and primary treatment-screening, comminuting, equalization and sedimentation, Skimming. | 4 | 4 |
| | 3.2 | Secondary treatment - Design concept, aerobic process, activated sludge process and its modification. Oxidation ponds, oxidation ditch. Trickling filters, rotating | 6 | 4 |

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|---|---|---|---|---|
| | | biological contractors, high-rate anaerobic reactor, up flow anaerobic filters. fluidized bed reactors | | |
| | 3.3 | Tertiary/advanced treatment system, filtration, absorption, nitrogen and phosphorous removal, Biological Nutrient Removal (BNR) Systems.<br>Sewage disposal method. Disinfection - chlorination. Characteristics and treatment of typical industrial waste water. Maintenance of effluent treatment plants, Waste water disposal, reuse and recycle. | 5 | 4 |
| **4** | **Module 4: Air Pollution Control** | | | |
| | 4.1 | Air quality standards, Sampling equipment, Control of particulate matter - gravitational settling chamber, cyclonic separator, fabric filters, electrostatic precipitators, wet Collectors, Venturi Scrubber. Control of Gaseous Contaminants, adsorption, absorption, and combustion. | 7 | 5 |
| | 4.2 | Air quality monitoring techniques for particulates and gaseous contaminants - Instrumental and analytical techniques for monitoring and control of air pollutants - suspended particles, sulphur compounds, hydrogen sulphide, sulphur dioxide, Oxides of nitrogen, carbon monoxide and hydrocarbons. Air pollution from Automobiles-source and control. | 8 | 5 |

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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lectures (chalk & board, multimedia presentations)<br>o Group Discussions<br>o Case studies<br>o Quizzes |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (30 Marks)**<br>i) Quiz (5 marks)<br>ii) Assignment – (5 marks)<br>iii) Problem based test - Open book (5marks)<br>iv) Written exam (15 marks)<br>**B. Semester end examination**<br>**Theory: Written examination theory (70 Marks)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos) |

| | |
|---|---|
| | Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>Essay type question – 15 marks (1 out of 2 nos) |

**References**


1. APHA (1985) Standard methods for examination water and waste water, American public health association. New York. Pvt. Ltd.
2. Das K A, Das M (2012) Environmental chemistry with green chemistry. Books and allied publication pvt ltd, Beliaghata main road, Kolkata.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Environmental Microbiology and Biotechnology** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE4DSECHE204** |
| **Course Level** | **200-299** |
| **Course Summary** | This course recognizes the scope and significance of environmental microbiology along with microbial life in air, water and soil. It also deals with pathogenic diseases and indicator organisms. Basic knowledge about cloning and gene transfer and the application of biotechnology in medical, agriculture and energy sectors is also included. |

| **Semester** | IV | Credits | | | | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Classify microorganisms based on their characteristics and morphology. | U | 1 |
| 2 | Analyse the phases of bacterial growth to understand microbial population dynamics. | A | 1,6 |
| 3 | Examine microbial distribution in different environments | An | 1 |
| 4 | Evaluate the role of microbes in aeromicrobiology and control of bioaerosols | A | 1,6 |
| 5 | Discuss Concepts of Environmental Biotechnology | U | 1,6 |
| 6 | Apply principles of environmental biotechnology to industries and agriculture | A | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**
**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| **1** | **Introduction to Environmental Microbiology** | | | |
| | 1.1 | Scope and history of environmental microbiology - characteristics- classification, identification and morphology of micro organisms- bacteria, archae, fungi, algae, virus and protozoa. | 5 | 1, 2 |
| | 1.2 | Growth curve of bacteria - lag phase - exponential phase - stationary phase - and death phase. | 2 | 1, 2 |
| **2** | **Microbes and Segments of environment** | | | |
| | 2.1 | Earth environment- physico - chemical characteristics of earth environment, soil as microbial environment- biotic stress and abiotic stress, distribution of microorganism in sub surface soil - shallow surface and deep surface. | 8 | 4, 5 |
| | 2.2 | ***Aeromicrobiogy****:* Biogeochemical role of microbes Aeromicrobiology - microbial survival in air, microbiological pathway, bioaerosols and its control. | 8 | 4, 5 |
| | 2.3 | ***Microbes in Aquatic Environment****:*Microbial habitat in aquatic environment - plank tonic, benthic microbial mat and biofilm - microbes in fresh water, brackish water, marine water, subterranean water and wet lands | 8 | 2, 3 |
| **3** | **Microbial diseases and indicator organism** | | | |
| | 3.1 | Environment and human pathogenic microbes - soil borne, water borne and air borne, roots of exposure environmental change and microbial infectious disease. | 6 | 2, 3, 4 |
| | 3.2 | Indicator microorganism, concepts - total coli forms - MPN test, membrane filter technique - other potential indicator species - standards and criteria for indicators. | 4 | 3, 4 |
| **4** | **Environmental biotechnology** | | | |
| | 4.1 | Basic concepts - Elemental information of gene transfer, cloning recombinant DNA technology and its implementation. | 6 | 5 |
| | 4.2 | ***Application of Environmental biotechnology:*** Application in industry - agriculture and energy sectors - bioremediation and phytoremediation. Biotechnological methods - ELISA, FISH, PCR, and Gene probes, dot-immuno binding activity, Principles of cloning - Transgenic Technology, Cryopreservation, Biosafety & Ethics. | 5 | 6 |

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|---|---|---|---|---|
| | 4. 3 | Degradation of xenobiotic in environment-surfactants, pesticides, heavy metals degradative pathways. Microbial management of hazard, exploitation of microbes in copper and uranium extraction. | 5 | 6 |
| | 4.4 | Concept of GM and GMO, biosafety protocol | 3 | 6 |
| **5** | **Teacher Specific content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, powerpoint presentation)<br>o Group discussion<br>o Case studies<br>o Debates<br>o Quizzes |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (30 marks)**<br>i) Assignment- (5 marks)<br>ii) Quiz - (2 Marks)<br>iii) Class test – written (18 Marks)<br>iv) Class test – MCQ (5 Marks)<br>**B. End Semester Examination**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii) Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv) Essay type question – 15 marks (1 out of 2 nos) |

**References**


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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Basic Analytical and Cosmetic Chemistry** | | | | | |
| **Type of Course** | **SEC** | | | | | |
| **Course Code** | **MCE4SECCHE200** | | | | | |
| **Course Level** | **200-299** | | | | | |
| **Course Summary** | This course covers the scientific principles behind the composition, structure, properties, and reactions of food components. It also deals with topics related to the various substances added to food to enhance flavour and taste, improve texture and prolong shelf life. | | | | | |
| **Semester** | IV | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | | | 45 |
| **Pre-requisites, if any** | Nil | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Illustrate the chemistry behind hand care and hygiene products | U | 1,3,10 |
| 2 | Formulate a range of personal care and hygiene products, preparing them for roles in the cosmetic and pharmaceutical industries. | S | 2,3,10 |
| 3 | Discuss the fundamentals of analytical chemistry | U | 1,3 |
| 4 | Apply techniques for soil and water analysis | S | 2,3,10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Hand Care Products and Nail preparation** | | | |
| | 1.1 | Hand Care Products: Introduction, formulation of hand sanitizers and hand wash.<br>General ingredients and preparation of:<br>(a)Hand wash<br>(b)Antibacterial hand wash<br>(c)Hand sanitizer | 8 | 1,2 |
| | 1.2 | Nail preparation: Structure of nail, Nail lacquers, Nail polish remover. General Ingredients and Preparation of: Nail polish and nail polish remover | 7 | 1,2 |
| 2 | **Personal hygiene products and oral hygiene products** | | | |
| | 2.1 | Personal hygiene products: Total fatty matter, alkali content, and pH of soaps. Bathing soap and toilet soap. Antiperspirants and deodorants. General Ingredients and preparation of<br>(a) Soaps<br>(b) Cream Soaps<br>(c) Liquid soaps<br>(hands on training ) | 8 | 1,2 |
| | 2.2 | Oral hygiene products: Common problems associated with teeth and gums. Principles of formulation of Oral hygiene products. Role of herbs in oral care: neem and clove. Flavors and essential oils.<br>General Ingredients and preparation of<br>(a)Tooth powder (chemical-based and herbal)<br>(b)Toothpaste<br>(hands on training ) | 7 | 1,2 |
| 3 | **Analytical Chemistry** | | | |
| | 3.1 | Introduction: Introduction to analytical chemistry and its interdisciplinary nature. Concept of sampling. | 3 | 3 |
| | 3.2 | Analysis of soil: composition of soil, concept of pH and pH measurement.<br>a. Determination of pH of soil samples.<br>(hands on training ) | 5 | 4 |
| | 3.3 | Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, and water purification methods.<br>a. Determination of pH, acidity, and alkalinity of a water sample. | 7 | 4 |

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|---|---|---|---|---|
| | | (hands on training ) | | |
| **4** | **Teacher Specific Content** | | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lectures, discussions<br>o Hands-on training<br>o Presentations and group activities |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (25 marks)**<br>i) Performance in activities- 5 marks<br>ii) Assignments- 5 marks<br>iii) MCQ examination-15 marks |
| | **B. End Semester Examination (50 Marks- 1.5 Hrs.)**<br>i) Short answer 10 questions (out of 12): 10 x 2 =20<br>ii) Short essay 6 questions (out of 8): 5 x 6 = 30 |

**References**


1. H. Butler, *Poucher's Perfumes, Cosmetic and Soap*, Springer,2000
2. E.W. Flick, *Cosmetic and toiletry formulations*, Noyes Publications, New York,2001
3. D.A. Skoog and J.J. Leary, *Instrumental Methods of Analysis*, Saunders College Publications, New York, 1992
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Basic Environmental Chemistry** | | | | | |
| **Type of Course** | **VAC** | | | | | |
| **Course Code** | **MCE4VACCHE200** | | | | | |
| **Course Level** | **200-299** | | | | | |
| **Course Summary** | This course explores various aspects of environmental chemistry such as greenhouse effect, air and water pollution and renewable energy sources. | | | | | |
| **Semester** | IV | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | | | 45 |
| **Pre-requisites, if any** | Nil | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Describe basic concepts of environmental chemistry. | U | 1,2, 3, 4, 5, 6, 8 |
| 2 | Describe strategies for the remediation and purification of contaminated soil, air and water. | U | 1,2,10 |
| 3 | Apply principles of green chemistry to propose sustainable solutions for minimizing environmental contamination. | A | 1,2,6,8,10 |
| 4 | Discuss the basic chemical processes involved in air and water pollution and global warming identifying key sources. | U | 1,2,8 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | **Introduction to the Environment** | | | |
| | 1.1 | Classification of the environment-troposphere, stratosphere, mesosphere, thermosphere, exosphere, hydrosphere, lithosphere and biosphere | 5 | 1 |
| | 1.2 | Greenhouse gases and global warming: natural occurring greenhouse gases, anthropogenic greenhouse gases, other greenhouse gases, ozone, global warming potential (GWP), emission metrics, influence of technology on global warming. | 8 | 4 |
| | 1.3 | Schemes to reduce greenhouse gases: capture and storage of carbon dioxide, sequestration of CO2. other schemes to reduce greenhouse gases, removing CO2 from the atmosphere: direct air capture, carbon dioxide emissions in the future | 7 | 2,4 |
| 2 | **Air and Water Pollution** | | | |
| | 2.1 | Water pollution causes, categories of water pollution, the long-term consequences of water pollution, basic idea of waste water purification and disinfection | 5 | 2,3,4 |
| | 2.2 | Air pollution: particulates, fog smog, acid rain, ozone umbrella, depletion- causes, basic idea of air quality improvement methods. | 5 | 2,3,4 |
| 3 | **Renewable Energy and Sustainability** | | | |
| | 3.1 | Renewable energy: hydroelectric, wind, solar, geothermal, and marine energy and their storage and hydrogen as sustainable energy | 6 | 3 |
| | 3.2 | Biomass energy: biofuels and their resources, decarbonization with biomass utilization. Conversion of biomass to other fuels- ethanol fuel, biodiesel fuel, fuel from algae. Biogas | 6 | 3 |
| | 3.3 | Sustainable materials: environmental effects of mining and mineral extraction, sustainable utilization of geospheric mineral resources- metals and nonmetal mineral resources | 3 | 3 |
| 4 | **Teacher Specific content** | | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lecture-based approach<br>o Interactive discussions<br>o Laboratory sessions<br>o Flipped classroom<br>o Peer teaching<br>o Collaborative learning. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (25 marks)**<br>i) Assignments: 5 mark<br>ii) Viva: 5 marks<br>iii) Classroom participation (participation in class activities): 5 marks<br>iv) Examination: 10 marks |
| | **B. End Semester Examination (50 marks- 1.5Hrs)**<br>i) MCQ 9 questions: 9 x 1 = 9<br>ii) Short answer 5 questions (out of 7): 5 x 4 =20<br>iii) Short essay 3 questions (out of 5): 3 x 7 = 21 |

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2. C H. Middlecamp, *Chemistry in Context: Applying Chemistry to Society*, A Project of the American Chemical Society, McGraw-Hill, 2012.
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# SEMESTER V

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|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Organic Chemistry - 3** |
| **Type of Course** | **DSC A** |
| **Course Code** | **MCE5DSCCHE300** |
| **Course Level** | **300-399** |
| **Course Summary** | This course explores nitro compounds, amines, cyanides, isocyanides ethers and epoxides, heterocyclic compounds, active methylene compounds and organic photochemistry. Practical part of the course includes qualitative microscale analysis and reactions of nitrogen containing compounds |

| **Semester** | V | Credits | | | 4 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 3 | 0 | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Predict the product and reasonable mechanism for the reactions of nitro compounds, amines, diazonium salts, cyanides, and isocyanides | A | 1,2 |
| 2 | Explain the reactions of ethers and epoxides | U | 1 |
| 3 | Identify the aromaticity, properties and biological significance of heterocyclic compounds | A | 1,2,3 |
| 4 | Outline synthetic applications of active methylene compounds | U | 1,2 |
| 5 | Apply photochemical methods to organic synthesis | A | 1,2 |
| 6 | Analyse and prepare nitrogen containing compounds and systematically record the observation | S | 1,2,4, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Nitrogen Containing Compounds** | | |
| | 1.1 | Nitro Compounds: Preparation of aliphatic and aromatic nitro compounds<br>Tautomerism of nitromethane. | 1 | 1 |
| | 1.2 | Reactions of nitro compounds: Reduction products of nitrobenzene in acidic, neutral and alkaline media. Electrolytic reduction, and selective reduction of polynitro compounds. | 3 | 1 |
| | 1.3 | Preparation of amines: Gabriel's phthalimide synthesis,Hoffmann bromamide reaction (with mechanisms). | 2 | 1 |
| | 1.4 | Basicity of aliphatic and aromatic amines – a comparative study, Hinsberg test, Quaternary amine salts as phase-transfer catalysts. | 4 | 1 |
| | 1.5 | Preparation of diazonium salts from aromatic amines, conversion of diazonium salts to benzene, phenol, chloro, bromo, iodo and fluoro benzenes, nitro benzene and azodyes with mechanisms. | 3 | 1 |
| | 1.6 | Cyanides- Preparation from alkyl halides and carboxylic acids. Reactions- hydrolysis, reduction, reaction with Grignard reagent<br>Isocyanides- preparation from alkyl halides and primary amines. Reactions-hydrolysis, reduction. | 2 | 1 |
| 2 | | **Ethers, Epoxides and Heterocyclic Compounds** | | |
| | 2.1 | Williamson's ether synthesis. Reactions of ethers-cleavage with HI, Claisen Rearrangement, Zeisel's method of estimation of alkoxy groups. | 3 | 2 |
| | 2.2 | Structure of epoxides, Reactions of epoxides with alcohols, ammonia derivatives and LAH. | 2 | 2 |
| | 2.3 | Classification of heterocyclic compounds, structure and aromaticity of furan, thiophene, pyrrole, pyridine and indole | 3 | 3 |
| | 2.4 | Synthesis and reactions- furan, thiophene, pyrrole (Paal Knorr synthesis and Knorr pyrrole synthesis), Pyridine (Hantzsch synthesis), Indole (Fischer Indole Synthesis), | 5 | 3 |

| | | | | |
|---|---|---|---|---|
| | 2.5 | Importance of purines and pyrimidines in biological systems- adenine, thymine, guanine, cytosine and uracil | 2 | 3 |
| **3** | **Active Methylene Compounds and Organic Photochemistry** | | | |
| | 3.1 | Structure and synthetic applications of ethyl acetoacetate and diethyl malonate (synthesis of carboxylic acids and ketones) | 5 | 4 |
| | 3.2 | Photochemistry: introduction. Photochemical versus Thermal reactions. Electronic excitation and fate of excited molecules. | 2 | 5 |
| | 3.3 | Photochemical reactions: Norrish type I and II reactions of acyclic ketones, Paterno-Buchi reaction and photo-Fries reaction (with mechanisms), Barton reaction (nitrite ester), di-π methane rearrangement<br>Photochemistry of vision | 8 | 5 |
| **4** | **Organic Chemistry – 3 Practicals** | | | |
| | 4.1 | Qualitative Microscale analysis of organic compounds Identification and preparation of derivatives of amines, amides and nitro-compounds, amides<br>Preparation of m-dinitro benzene from nitro benzene<br>Synthesis of methyl orange<br>Biginelli Reaction | 30 | 6 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture - offline<br>o Practical |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Pop quizes-5 marks<br>ii) Problem based assignments -5 Marks<br>iii) Written/MCQ Tests -15 Marks<br>**Practical (15 marks)**<br>i) Quiz<br>ii) Lab involvement |

| | |
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| | **B. End Semester Examination**<br>**Theory: Written examination (50 Marks-1.5 Hrs.)**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical (35 Marks- 1Hr)**<br>i) Viva voce-10 Marks<br>ii) Written test of practical procedures-15 Marks<br>iii) Certified report of lab works done -10 Marks |

**References**


1. Clayden, J.; Greeves, N.; Warren, S. *Organic Chemistry;* Oxford University Press, USA, 2012.
2. Solomons, T. W. G.; Fryhle, C. B. *Organic Chemistry;* John Wiley & Sons, 2008.3.
3. Carey, F. A.; Sundberg, R. J. *Advanced Organic Chemistry: Part A. Structure and Mechanisms*; 5th ed.; Springer: New York, 2007.
4. Pine, S. H. *Organic Chemistry; 5th ed.;* McGraw-Hill, 2006.
5. Morrison, R. T.; Boyd, R. N. *Organic Chemistry,* 6th ed.; Prentice Hall International, 1992.
6. Norman, R. O. C.; Coxon, J. M. *Principles of Organic Synthesis*; 3rd ed.; CRC Press: 1993.
7. Finar, I. L. *Organic Chemistry Volume 1;* Pearson Education, 2007.
8. Bahl, A.; Bahl, B. S. *A Textbook of Organic Chemistry;* S. Chand, 2010.
9. Jain, M. K.; Sharma, S. C. *Modern Organic Chemistry;* Vishal Publishing Co., 2010.
10. McMurry, J. E. *Fundamentals of Organic Chemistry;* Cengage Learning, 2010.
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12. Bruice, P. Y. *Organic Chemistry;* Pearson, 2017.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Physical Chemistry- 2** | | | | | |
| **Type of Course** | **DSC A** | | | | | |
| **Course Code** | **MCE5DSCCHE301** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course covers the basic ideas of solid state, photochemistry and thermodynamics. | | | | | |
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 3 | 0 | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Illustrate the basic aspects of ionic solids and identify the crystal structure. | An | 1,2 |
| 2 | Explain the types of defects in solids and properties of semiconductors and liquid crystals. | U | 1,2 |
| 3 | Apply the fundamental principles of photochemistry to photochemical reactions. | U | 1,2 |
| 4 | Explain the fundamental laws of thermodynamics and its application in isothermal, adiabatic and Joule-Thomson expansion processes. | U | 1,2 |
| 5 | Apply the principles of chemical thermodynamics to thermochemical processes and systems of variable compositions. | A | 1,2 |
| 6 | Apply principles of physical chemistry to conduct laboratory experiments. | S | 1,2,4, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**
**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Solid State** | | |
| | 1.1 | Anisotropy in crystals, Laws of Crystallography– Law of constancy of interfacial angles, Law of rational indices. Weiss and Miller indices. X–Ray diffraction by crystals, Bragg's law | 4 | 1 |
| | 1.2 | Structure of ionic compounds of the type AX (NaCl, CsCl, ZnS) and $AX_2$ ($CaF_2$, $Na_2O$) Defects in crystals – stoichiometric and non-stoichiometric defects. Electrical conductivity, semiconductors- n-type, p-type, Superconductivity (Elementary ideas) | 6 | 1, 2 |
| | 1.3 | Liquid crystals - Classification, structure thermographic behaviour and applications. | 5 | 2 |
| 2 | | **Photochemistry** | | |
| | 2.1 | Laws of photochemistry-Grothus-Draper law, Stark-Einstein law. Jablonski diagram-fluorescence, phosphorescence, non-radiative processes, internal conversion, intersystem crossing. | 3 | 3 |
| | 2.2 | Quantum yield, examples of low and high quantum yields, photochemical reactions (decomposition of HBr, isomerisation of maleic acid to fumaric acid), photosensitised reactions (photosynthesis, isomerization of 2-butene),chemiluminescence, bioluminescence. | 3 | 3 |
| 3 | | **Thermodynamics** | | |
| | 3.1 | Internal energy and enthalpy. Heat capacities at constant volume (Cv) and at constant pressure (Cp), relationship between Cp, Cv and R First law of thermodynamics – Mathematical statement of first law. Reversible process and maximum work. Calculation of work, heat, internal energy change and enthalpy change for the expansion of an ideal gas under reversible isothermal and adiabatic condition. | 7 | 4 |
| | 3.2 | The Joule-Thomson effect – derivation of the expression for Joule-Thomson coefficient. Significance of Joule-Thomson coefficient, inversion temperature. | 2 | 4 |
| | 3.3 | Limitations of first law. Second law– Different statements of second law, thermodynamic scale of temperature. Carnot cycle and its efficiency, Carnot theorem. | 10 | 5 |

| | | | | |
|---|---|---|---|---|
| | | Concept of entropy– Definition and physical significance. Entropy as a function of volume and temperature, entropy as a function of pressure and temperature. Criteria of spontaneity and equilibrium.<br>Gibbs and Helmholtz free energies and their significances- criteria of equilibrium and spontaneity. Gibbs-Helmholtz equation | | |
| | 3.4 | Third law of thermodynamic-statement and determination of absolute entropies of substances. Partial molar quantities– Chemical potential– Gibb–Duhem equation Zeroth law of thermodynamics | 5 | 5 |
| **4** | **Physical chemistry II- Practicals** | | | |
| | | 1. Heat of neutralization<br>2. Heat of solution– $KNO_3$, $NH_4Cl$ (Determination of heat of solution from solubility measurements)<br>3. Surface tension- Determination of the surface tension of a liquid (Drop number method or Drop weight method).<br>4. Surface tension- Determination of Parachor values<br>5. Determination of the composition of two liquids by surface tension measurements<br>6. Determination of CMC of surfactants by surface tension measurements | 30 | 6 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture Sessions, (chalk & board, PowerPoint presentation)<br>o Interactive sessions and simulations,<br>o Visual aids like videos and models to enhance understanding.<br>o Peer discussions.<br>o Laboratory experiments and hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Pop quiz (5 marks)<br>ii) Assignment (5 marks)<br>iii) Class test (MCQ/written) (15 Marks)<br>**Practical (15 marks)**<br>i) Lab involvement and skill |

| | |
|---|---|
| | ii) Report of lab works done |
| | **B. End Semester Examination**<br>**Theory: Written examination (50 Marks- 1.5 Hrs)**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical: (35 Marks)**<br>i) Viva voce: 10 marks<br>ii) Writing procedure: 15 marks<br>iii) Certified lab report: 10 marks |

**References**


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2. L V Azaroff, "Introduction to Solids", McGraw Hill, 2017.
3. N B Hannay, "Solid State Chemistry", Prentice Hall, 1967.
4. Anthony R. West, "Solid State Chemistry and its Applications", Wiley Eastern, 2022.
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8. Puri, Sharma and Pathania, Principles of Physical Chemistry, 48th Edn. Vishal Publishing
9. Company, 2020.


**Suggested Readings**


1. P. W Atkins, "Physical Chemistry", Oxford University Press, 2019.
2. J. Rajaram, J. C. Kuriakose, Chemical thermodynamics: classical, statistical and irreversible, Dorling Kindersley (India), New Delhi, 2013
3. Glasstone and Lewis, Elements of Physical Chemistry, Macmillan, 1963.
4. I.N. Levine, Physical Chemistry, Tata McGraw Hill, 2011.143

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Quantum Mechanics, Spectroscopy & Group Theory** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE5DSECHE300** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course covers fundamental principles and applications in the realm of molecular structure, behaviour, and interactions. This course deals with the basic principles of quantum chemistry, spectroscopic techniques like rotational, vibrational, electronic and NMR and group theory. | | | | | |
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Demonstrate the fundamental concepts of quantum mechanics and describe its application to simple systems. | U | 1 |
| 2 | Examine the correlation between angular and radial wave functions in determining orbital shapes | An | 2 |
| 3 | Illustrate the basic concepts of various spectroscopic techniques. | U | 2 |
| 4 | Deduce various symmetry elements and point groups in molecules | E | 4,5 |
| 5 | Develop the group theoretical rules to generate group multiplication tables, matrix representations and classes. | A | 2 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**
**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | | **Quantum Mechanics** | | |
| | 1.1 | Classical mechanics: Concepts – Newtonian equations of motion and Hamiltonian equation of motion. | 1 | 1 |
| | 1.2 | Failures of Classical mechanics: Blackbody radiation, photoelectric effect, Compton effect and atomic spectra. | 3 | 1 |
| | 1.3 | Schrodinger wave equation; postulates of quantum mechanics –wave function postulate, operator postulate, Hermitian operator, eigen function postulate, expectation value postulate, time dependent postulate. | 3 | 1 |
| | 1.4 | Application of quantum mechanics to simple systems – Particle in 1-D box, normalization of wave function, application to 1,3 butadiene. | 3 | 1 |
| | 1.5 | Schrödinger equation for hydrogen atom – Coordinate system-cartesian and spherical polar coordinates, wave equation in spherical polar coordinates and its components - Radial and angular functions (derivation not required) | 3 | 1 |
| | 1.6 | Shapes of orbitals (s and p) –sketch of angular and radial wave functions. Radial distribution function | 2 | 2 |
| 2 | | **Molecular Spectroscopy-I** | | |
| | 2.1 | Introduction: electromagnetic radiation, regions of the spectrum, interaction of electromagnetic radiation with matter, various types of molecular spectroscopic techniques, Beer-Lambert's law, intensity of absorption, Factors affecting intensity - signal to noise ratio, natural line width. Doppler broadening, Born-Oppenheimer approximation | 4 | 3 |
| | 2.2 | Rotational spectroscopy: Rigid rotor and derivation of moment of inertia. Rotational energy levels, selection rules, relative population of energy levels, appearance of rotational spectra, calculation of bond length in diatomic molecules | 5 | 3 |
| | 2.3 | Vibrational spectroscopy: harmonic oscillator (concept only), calculation of force constant and energy levels, selection rules, concept of anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, Fermi resonance. Degrees of freedom for polyatomic molecules, IR spectrum of water & carbon dioxide. | 6 | 3 |

| | | | | |
|---|---|---|---|---|
| **3** | **Molecular Spectroscopy-II** | | | |
| | 3.1 | Electronic spectroscopy: singlet and triplet states, selection rules (Spin and Laporte selection rule), Franck-Condon principle –transition, dissociation and predissociation, Polyatomic molecules – qualitative description of σ, π and n- molecular orbitals, their energy levels and the respective transitions. | 9 | 3 |
| | 3.2 | Nuclear Magnetic Resonance (NMR) spectroscopy: Nuclear spin quantum number, energies of nuclei in magnetic field, Larmor precession, chemical shift and δ scale. Factors affecting chemical shift, spin-spin coupling, coupling constant. | 6 | 3 |
| **4** | **Group Theory** | | | |
| | 4.1 | Symmetry elements and operations, determination of distinct symmetry operations of Cn and Sn. | 2 | 4 |
| | 4.2 | Mathematical groups: Properties | 1 | 4 |
| | 4.3 | Point group, classification into MLS, MHS and MSS.Determination of point groups of molecules belonging to Cn, Cs, Ci, Cnv, Cnh, C∞v, Dnh, D∞h, Dnd, Td and Oh point groups. | 5 | 4 |
| | 4.4 | Abelian groups, cyclic groups, sub groups. Similarity transformation, classes - C2v and C3v. Group multiplication tables (GMTs) - $C_2v$ and $C_3v$. Matrix representation of symmetry elements of E, Cn, Sn, i, σ. | 7 | 4, 5 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation, flipped classroom)<br>o Group Discussion – thought problems; mind mapping<br>o Peer interaction<br>o Demonstration using simulations / models |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (30 marks)**<br>i) Quiz (5 marks)<br>ii) Assignment – (5 marks)<br>iii) Problem based test - Open book (5marks)<br>iv) Written exam (15 marks**)** |

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| | **B. End Semester Examination (70 marks- 2Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii) Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv) Essay type question – 15 marks (1 out of 2 nos) |

**References**


1. P.W. Atkins, R.S. Friedman, Molecular Quantum Mechanics, 4th Edn. Oxford University Press, 2005.
2. R.K. Prasad, Quantum Chemistry, New Age International, 2001
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6. L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to spectroscopy, 3rd Edn, Thomson Brooks/Cole, 2001.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Green chemistry for sustainable development** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE5DSECHE301** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course explores fundamentals of green chemistry covering aspects from synthesis design to waste management and energy usage. | | | | | |
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | Basic concepts on green chemistry | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Familiarize the basic concepts of green chemistry | U | 1,2,3,6,7 |
| 2 | Recognize twelve principles and importance of green chemistry | U | 1,2,3,6,7 |
| 3 | Identify alternative methods and solvents for green synthesis | A | 1,2,3,6,7 |
| 4 | Evaluate the adverse effects of chemicals to environment and select safer green methods for synthesis | E | 1,2,3,6,7 |
| 5 | Deduce the importance of green technologies in sustainable growth of Industry and society | E | 1,2,3,6,7 |
| 6 | Apply suitable energy efficient processes | A | 1,2,3,6,7 |
| 7 | Develop cleaner production and treatment mechanisms for pollution prevention. | A | 1,2,3,6,7 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Introduction to green chemistry** | | | |
| | 1.1 | Introduction. Goals and challenges of Green Chemistry: Introduction of Green protocol: Rules - Rio declaration-Montreal protocol, Kyoto protocol. | 3 | 1 |
| | 1.2 | Twelve principles of Green Chemistry with their explanations and special emphasis on the following with examples: Designing a Green Synthesis using these principles; prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products Atom Economy, calculation of atom economy, Atom economic and atom uneconomic reactions: rearrangement (Claisen and fries rearrangements),addition (Michael and Diels Alder reactions),substitution and elimination reactions. | 7 | 2 |
| 2 | **Prevention and minimization of toxic materials (Green alternatives)** | | | |
| | 2.1 | Prevention/ minimization of hazardous/ toxic products: reducing toxicity, measuring toxicity- LD50 & LC50, Ames test Sources of waste, cost of waste, problems caused by waste, waste minimization techniques, on site waste treatment, reuse and recycling. | 5 | 4 |
| | 2.2 | Catalysis and green chemistry-Parameters that affect the inherent greenness of a catalyst, comparison of heterogeneous and homogeneous catalysts, elementary ideas on asymmetric catalysts, photocatalysts, biocatalysts and phase transfer catalysts (definition only) | 5 | 4 |
| | 2.3 | Prevention of chemical accidents- designing greener processes, inherently safer design (ISD), subdivisions of ISD- Minimization, simplification, substitution, moderation and limitation | 5 | 4 |
| | 2.4 | Energy requirements for reactions - alternative sources of energy: use of microwaves- microwave heating, microwave assisted reactions (in water and solvent free reactions) and ultrasonic energy. | 5 | 6 |
| 3 | **Green synthesis** | | | |
| | 3.1 | Green strategies for organic synthesis, green solvents-water, supercritical fluids (supercritical carbon dioxide, supercritical water), ionic liquids, fluorous biphasic solvent, PEG, immobilized solvents and greenness of solvents, solventless processes. | 8 | 3 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Organic synthesis using green reagents- oxygen, singlet oxygen, ozone, hydrogen peroxide and peroxy acids. Polymer supported reagents- poly-n-bromosuccinimide, polymeric organotin dihydride reagent, polystyrene carbodiimide, polystyrene sulfide, polymer supported peracid, organic synthesis using biocatalyst- biochemical (microbial)oxidations, biochemical (microbial) reductions. | 9 | 3 |
| **4** | **Phase Transfer Catalysts and Green Industrial Processes** | | | |
| | 4.1 | Organic synthesis using phase transfer catalysts- mechanism, types of phase transfer catalysts and its advantages. Applications of PTC in organic synthesis: synthesis of nitriles, alcohols, azides and alkyl fluorides from alkyl halides. Green synthesis of following compounds: adipic acid, adiponitrile, ibuprofen, alcohols, aromatic nitriles, cyclohexane oxime, 1-octanol, 3-phenyl catechol. | 9 | 3 |
| | 4.2 | Green industrial processes: Pollution statistics from various industries, polymer industry, textile industry, greener approach of dyeing, eco-friendly pesticides, pharmaceutical industry, wastewater treatment. | 4 | 7 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, powerpoint presentation)<br>o Group discussion<br>o Case studies<br>o Debates<br>o Quizzes |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (Total 30 marks)**<br>i) Assignment- (5 marks)<br>ii) Quiz - (2Marks)<br>iii)Class test – written (18 Marks)<br>iv)Class test - MCQ (5Marks) |
| | **B. End Semester Examination**<br>**Theory: Written examination (70 Marks- 2Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv)Essay type question – 15 marks (1 out of 2 nos) |

**References**


1. P. Anastas, J. C. Warner, Green Chemistry: Theory and Practice New Ed Edition; Oxford University press, USA, 2000
2. M. Lancaster, Green Chemistry; An Introductory Text, Royal Society of Chemistry; Cambridge, UK, 2003
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| | MAHARAJA'S COLLEGE, ERNAKULAM<br>(Govt. Autonomous) | | | | | |
|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Nanotechnology for Energy Applications** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE5DSECHE303** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course explores the intersection of nanotechnology and energy systems. It covers the applications of nanotechnology in the field of energy conversion and storage. | | | | | |
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | Basic understanding of synthesis and properties of nanomaterials. | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Develop a comprehensive knowledge base regarding global energy needs, consumption patterns, classification of energy sources and the energy conservation. | A | 1,2,3, 6,7 |
| 2 | Differentiate between conventional and non-conventional energy sources. | An | 1,2,3, 6,7 |
| 3 | Analyse various photovoltaic technologies, including Solar Cells. | An | 1,2,3, 6,7 |
| 4 | Explain the working principle and architecture of energy storage devices including batteries and capacitors | U | 1,2,3, 6,7 |
| 5 | Discuss about hydrogen storage technologies | U | 1,2,3, 6,7 |
| 6 | Develop a comprehensive knowledge of nanostructured materials | U | 1,2,3, 6,7 |
| 7 | Build a strong foundation in the role of MOFs and two-dimensional materials in energy related applications | A | 1,2,3, 6,7 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**
**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Introduction to energy technologies** | | | |
| | 1.1 | Global energy requirements and consumption. Classification of renewable and non-renewable energy technologies. Conventional energy sources – pros and cons (with relevant case studies). Challenges in the development and implementation of renewable energy technologies | 9 | 1 |
| | 1.2 | Non-conventional sources of energy: Tidal energy, geothermal energy and biomass. | 2 | 1, 2 |
| | 1.3 | Energy conversion, transport, and storage- challenges and outlooks | 4 | 1 |
| 2 | **Nanomaterials for Energy Conversion** | | | |
| | 2.1 | Principles of photovoltaic energy conversion (PV): Types of Solar cells: DSSC, OPV , Bulk Hetero Junction (BHJ-SC),Quantum dots, ,Perovskites and Silicon Solar cells | 8 | 3 |
| | 2.2 | Nano, micro, poly crystalline and amorphous silicon solar cells.<br>Nano and micro Si-composite structure, various techniques of Si deposition. | 4 | 3 |
| | 2.3 | Fuel Cells: Working principle and architecture, micro-fuel cell technologies. | 3 | 3 |
| 3 | **Nanomaterials for Storage Technology** | | | |
| | 3.1 | Introduction to battery technology (working principle and architecture), primary and secondary batteries (Lithium-ion Batteries), cathode and anode materials. | 5 | 4, 6 |
| | 3.2 | Capacitors- Principles and materials design. Electrical double layer model. Pseudocapacitor, electrochemical supercapacitors. | 5 | 4, 6 |
| | 3.3 | Hydrogen storage: Materials and methods, MOFs, metal hydrides and hydrogen storage capacity. | 5 | 5, 6 |
| 4 | **State-of-the-art materials in Energy storage and conversion** | | | |
| | 4.1 | Nanostructured carbon-based materials, nano-oxides, novel hybrid electrode materials. | 5 | 6 |
| | 4.2 | Introduction to MOFs and its role in energy storage and conversion. COFs (elementary idea only). | 5 | 7 |

| | | | | |
|---|---|---|---|---|
| | 4.3 | Elementary idea of the state-of-the-art two-dimensional materials: graphene, boron nitride, carbon nitride, metal chalcogenides ($MoS_2$, $MoSe_2$, etc.). | 5 | 7 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Case studies<br>o Debates<br>o Quizzes |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (30 marks)**<br>i) Assignment- (5 marks)<br>ii) Quiz - (2 Marks)<br>iii)Class test – written (18 Marks)<br>iv)Class test - MCQ (5 Marks) |
| | **B. End Semester Examination (70 marks- 2Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv)Essay type question – 15 marks (1 out of 2 nos) |

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Medicinal Chemistry** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE5DSECHE304** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course explores fundamental aspects of medicinal chemistry such as drug discovery, drug action, different classes of drugs, adverse effects of drugs and drug delivery systems. | | | | | |
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Analyse the fundamental aspects of medicinal chemistry such as drug discovery and drug effectiveness. | An | 1, 2,3 |
| 2 | Examine various aspects of drug action. | An | 1, 2,3 |
| 3 | Describe different classes of drugs with suitable examples. | U | 1, 2,3,6 |
| 4 | Explain adverse effects of drugs. | U | 1, 2,3 |
| 5 | Discuss advanced drug delivery systems. | U | 1, 2,3,7 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | | **Introduction to Medicinal Chemistry** | | |
| | 1.1 | Overview of medicinal chemistry: definition and scope of medicinal chemistry.<br>Drugs: classification, sources and routes of administration. | 5 | 1 |
| | 1.2 | Drug discovery: target identification and validation, lead identification and optimisation, preclinical testing, pharmacology/toxicology and clinical studies- phase I, II and III. Ways of identification of lead compounds. | 7 | 1 |
| | 1.3 | Effectiveness of a drug: chemotherapeutic index and therapeutic index. Drug selectivity. | 3 | 1 |
| 2 | | **Drug Action** | | |
| | 2.1 | The pharmacokinetic phase: absorption, distribution, metabolism and elimination (ADME) of the drug. Bioavailability of a drug.<br>The pharmacodynamics phase. | 5 | 2 |
| | 2.2 | Drug metabolism: sites of drug metabolism and phase I and phase II reactions. Prodrugs. | 6 | 2 |
| | 2.3 | Drug receptors (elementary idea only), agonists and antagonists, partial agonists. Elementary idea of induced fit theory of drug action. | 4 | 2 |
| 3 | | **Classes of Drugs** | | |
| | 3.1 | Definition of the following classes of drugs with use of the given example: anaesthetics- thiopentone sodium, sedatives- phenobarbital, anti-epileptic drugs- clobazam, anxiolytic agents-benzodiazepine, narcotic analgesics – morphine and anticancer drugs- cisplatin. | 5 | 3 |
| | 3.2 | Definition of the following classes of drugs with use of the given example: adrenergic stimulants- adrenaline, adrenergic blockers- tolazoline, cholinergic stimulants- acetylcholine, cholinergic blockers- dicyclomine and cardiotonic drugs- digoxin. | 5 | 3 |
| | 3.3 | Definition of the following classes of drugs with use of the given example: antibiotics- chloramphenicol, antiviral drugs:<br>amantadine, antimalarials- chloroquine, tranquilisers: benzodiazepines and antipsychotics- phenothiazine. | 5 | 3 |
| 4 | | **Adverse Drug Effects and Drug Delivery Systems** | | |

| | | | | |
|---|---|---|---|---|
| | 4.1 | Adverse drug effects: predictable and unpredictable drug reactions and severity. Classification of adverse drug effects, pharmacovigilance and prevention of adverse drug effects. | 7 | 4 |
| | 4.2 | Drug formulations- sustained-release, controlled release, programming the release and prodrugs.<br>Nanomaterials in drug delivery: liposomes, polymer nanoparticles, chitosan nanoparticles, nanosponge and targeted drug delivery in cancer using nanoparticles.<br>Gene delivery: applications of nanoparticles in gene delivery. | 8 | 5 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of Experiments |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (30 marks)**<br>i) Assignment- (5 marks)<br>ii) Quiz - (2 Marks)<br>iii) Class test – written (18 Marks)<br>iv) Class test - MCQ (5 Marks) |
| | **B. End Semester Examination (70 marks- 2Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii) Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv) Essay type question – 15 marks (1 out of 2 nos) |

**References**


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2. K. D. Tripathi, *Essentials of Medical Pharmacology*, Jaypee Brothers Medical Publishers, 2013.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Main Group Elements** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE5DSECHE305** |
| **Course Level** | **300-399** |
| **Course Summary** | This course explores the basic aspects of main group elements |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Understand the classification of S block elements in the periodic table: general trends and properties of elements and structure of molecules | U | 1,2 |
| 2 | Apply knowledge of fundamental chemical principles to explain and predict the behavior of P-block elements and compounds | A | 1,2 |
| 3 | Analyze the structural aspects of boron and silicon compounds | An | 1,2 |
| 4 | Apply knowledge of halogens and interhalogens to predict the outcomes of simple reactions. | A | 1,2 |
| 5 | Apply Valence Bond and Molecular Orbital theories to explain bonding in noble gas compounds | A | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Chemistry of s-Block Elements** | | |
| | 1.1 | General characteristics: melting point, flame colouration, reducing nature, diagonal relationships and anomalous behaviour of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. Common features such as ease of formation, thermal stability, energetics of dissolution, and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates. | 8 | 1 |
| | 1.2 | Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties | 7 | 1 |
| 2 | | **Chemistry of p-Block Elements** | | |
| | 2.1 | Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.<br>Synthetic diamonds (elementary idea) | 8 | 2 |
| | 2.2 | Catenation and heterocatenation` in inorganic compounds. Types of inorganic polymers. Comparison with organic polymer, preparation and uses of borazine - similarities in structure with benzene. Boron nitrides- comparison with graphite. | 7 | 2 |
| | | **Important Group 13 and Group14 compounds** | | |

| | | | | |
|---|---|---|---|---|
| **3** | 3.1 | Comparative studies including diagonal relationship of group 13 and 14 elements. Anomalous behaviour of Boron. Preparation, structure, and bonding of diborane, uses of diborane. STYX numbers and WADE's rule, (Closo, nido, arachno) e.g. $B_{12}H_{12}^{2-}$, $B_5H_9$ and $B_4H_{10}$ | 8 | 3 |
| **4** | 3.2 | Boron nitrides, boranes, carboranes and metallocarboranes. Silicates and classification, aluminosilicates, natural and synthetic zeolites and application of zeolites as molecular sieves.<br>Silicon based polymers-silicones, silicon rubbers (preparation, important properties and uses) | 7 | 3 |
| | **Halogen and Noble Gas Compounds** | | | |
| | 4.1 | Properties of halogens. Interhalogens - classification- general preparation- structures of AB, $AB_3$, $AB_5$ and $AB_7$ types.<br>Reactivity (ClF, $ICl_3$, $ClF_3$, $IF_5$ and $IF_7$).<br>Comparison of pseudohalogens with halogens. | 7 | 4 |
| | 4.2 | Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of $XeF_2$, $XeF_4$ and $XeF_6$; Bonding in noble gas compounds (Valence bond and MO treatment for $XeF_2$), Shapes of noble gas compounds (VSEPR theory). | 8 | 5 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lectures (chalk & board, multimedia presentations)<br>o Group Discussions<br>o Case studies<br>o Quizzes |

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| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (30 Marks)**<br>i) Quiz (5 marks)<br>ii) Assignment – (5 marks)<br>iii) Problem based test - Open book (5marks)<br>iv) Written exam (15 marks)<br>**B. End Semester Examination**<br>**Theory: Written examination (70 Marks- 2 Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii) Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv) Essay type question – 15 marks (1 out of 2 nos) |

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| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Environment and Water Management** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE5DSECHE306** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course acknowledges different elements of Environmental Management, including Environmental Impact Assessment, Environmental Planning, Environmental Auditing, and the ISO 14000 series. It also covers Environmental Laws and Policies, Remote Sensing, Geographic Information Systems (GIS), and It also addresses the management of waste water by treatment methods. | | | | | |
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Evaluate EIA's role in sustainable project planning and risk management | E | 1,6,7 |
| 2 | Analyse environmental planning principles, including EPM and ISO 14000 EMS, integrating life cycle assessment and eco-labelling. | An | 2,6 |
| 3 | Evaluate key principles and regulatory frameworks of sustainable development, including relevant national policies and environmental laws | E | 1,2 |
| 4 | Analyse the role and impact of major international environmental conventions and movements in sustainable development | An | 1,6,7 |
| 5 | Analyse integrated water resource management, freshwater ecosystem conservation, disaster management phases, and hazardous waste handling. | An | 1,6,7 |

| | | | |
|---|---|---|---|
| 6 | Evaluate the role of remote sensing and GIS in disaster management, and hazardous waste handling methods and health impacts. | E | 1,6, 7 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Introduction to Environmental Management** | | | |
| | 1.1 | Introduction: concept, objectives and goals. Origin and development of Environmental Impact Assessment (EIA). Relationship of EIA to sustainable development, EIA in project planning and Implementation - risk assessment and risk management, EIA report. | 5 | 1 |
| | 1.2 | Comparison of alternatives, EIS, EMP, public hearing, review, decision making and monitoring. Methodology of EIA - practices and guidelines in India. EIA case studies. Environmental Planning - principles, concepts and scope of environmental planning, Ecological aspects of EPM - Steps in environmental planning | 5 | 1, 2 |
| | 1.3 | Environmental audit - objectives, scopes and types, audit process, pre and post audit process and advantages of audit Eco labelling - Eco mark, Eenvironment management systems-Objectives and goals, ISO 14000 series- life cycle assessment | 5 | 2 |
| 2 | **Sustainable Development and Environmental Regulation** | | | |
| | 2.1 | Sustainable Development: Basic concepts, principles and measures for sustainable development. Environment Regulating Agencies in India - Ministry of Environment and Forest, Central and State Pollution control Boards. | 3 | 4 |
| | 2.2 | Brunt land commission report - our common future, Agenda 21, National policy statement, National Environment Policy - 2006.<br>The Air (Prevention and control of pollution) Act – 1981. The Environment (protection) Act – 1986, National Environmental Tribunal Act – 1995, The | 8 | 4 |

| | | | | |
|---|---|---|---|---|
| | | National Environmental Appellate Authority Act – 1997, Biodiversity act 2002 and related rules, Policies for solid and hazardous waste management- Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Eco-friendly or green products. The solid waste management rules 2016. | | |
| | 2.3 | Important International Conventions / Conference a) Stockholm Conference – 1973. b) Rio summit – 1992 c) Montreal protocol – 1987. d) Kyoto protocol – 1997 e) Ramsar convention – 1971, National Environmental Movement- Silent valley movement, Chipko movement, Narmada Movement, Appiko movement, Almatti dispute and Tehri dam movement. | 4 | 4 |
| **3** | **Water Management** | | | |
| | 3.1 | History of water management, Integrated water resource management: concepts and theoretical perspectives, Principles and tools for practising IWRM, Issues and challenges in IWRM, Corporate social responsibility in water resource management. | 4 | 5 |
| | 3.2 | Water Harvesting and Water shed Management: Concept and framework of watershed approach, Water harvesting-importance and techniques, A case study of water harvesting | 5 | 5 |
| | 3.3 | Freshwater Ecosystem Management: Artificial recharges of ground water, River basin management, Management of lakes, Management of wetlands, Application of remote sensing and GIS into ground water exploration, mining of mineral resources and wet land Conservation. Case study: Dal Lake, Ganga action plan. | 6 | 5,6 |
| **4** | **Disaster Management and Hazardous Waste Handling** | | | |
| | 4.1 | Various phases of disaster management- Mitigation, preparedness, response, and recovery. Scope of disaster management/emergency preparedness. Tools of disaster management - Emergency Management Information Systems - organizations related to disaster management. National and International Agencies in disaster management, NDMA, NIDM, State level disaster management authorities, role of armed forces and media in disaster management. | 6 | 5 |

| | | | | |
|---|---|---|---|---|
| | 4.2 | Components, principles, stages of remote sensing. Platforms for remote sensing techniques. Sensors - types and resolution role of RS and GIS in disaster management. Aerial photography - characteristics of aerial photographs and image interpretation. Satellite imagery | 3 | 6 |
| | 4.3 | Hazardous waste: Definition, sources, classification, characteristics. Treatment Methods – Precipitation, Oxidation-Reduction, Neutralization, Stabilization, Solidification, Incineration, Final Disposal-Secure landfills and health impacts. | 5 | 5, 6 |

| | |
|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, power point presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of experiments |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**C. Continuous Comprehensive Assessment**<br>**Theory: Total 30 marks**<br>i) Assignment - 5 marks<br>ii) Quiz - 2 Marks<br>iii) Class test - written -18 Marks<br>iv) Class test – MCQ - 5 Marks<br>**B. End Semester Examination**<br>**Theory: Written examination (70 Marks)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv)Essay type question – 15 marks (1 out of 2) |

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Environmental Toxicology and Occupational Health** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE5DSECHE307** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course deals with concepts, principles and classifications and importance of toxicology and principles and methods of occupational health | | | | | |
| **Semester** | V | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Comprehend toxicological principles, including toxicant classification, toxic effects, and dose-response relationships. | U | 1 |
| 2 | Evaluate the toxicity of inorganic substances and organic substances and their environmental impacts. | An | 1,2 |
| 3 | Analyse the mode of action, fate, and transport of toxicants | U | 2,6,7 |
| 4 | Analyse principles of occupational health and their relationship to hygiene, safety, and disease prevention. | An | 2,6 |
| 5 | Apply health surveillance methods to analyze and recommend solutions for health and safety issues in work and living environments. | U | 1 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Fundamentals of toxicology** | | | |
| | 1.1 | Definition of toxicology - Classical toxicology, ecotoxicology and environmental toxicology. Importance and scope of environmental toxicology. | 3 | 1 |
| | 1.2 | Principles of toxicology – toxicants and their Classifications. Categories of toxic effects factors influencing toxicity - Xenobiotics: Definition, types and significance Target organ toxicity, toxic effects due to combination of chemicals - dose response relationship. | 6 | 1 |
| | 1.3 | Inorganic toxicants - entry into the environment cycles and residence time.Toxicity of inorganic substances- Cyanide, Carbon monoxide and nitrates, Toxicity of Arsenic and fluorine in ground water | 6 | 2 |
| 2 | **Toxicity of Organic and Radioactive Compounds** | | | |
| | 2.1 | Toxicological effects of Organic substances- pesticides -organo chlorine, organo phosphate and carbamides.Environmental impact and effects in humans | 5 | 2 |
| | 2.2 | Toxicological effects of insecticides, heavy metals- As,Hg,Pb &Cr, fertlizers- Nitrites &phosphates | 6 | 2 |
| | 2.3 | Environmental Hazards due to radioactive substances and adverse effects in human health | 4 | 2 |
| 3 | **Mode of action of toxicants and its fate and transport** | | | |
| | 3.1 | Mechanism of pollutants in degradable and non-degradable toxic substances. | 3 | 3 |
| | 3.2 | Biotransformation of toxicants - bio accumulation of xenobiotic - bio concentration and bio magnification toxicity tests: LD50 and LC50. | 8 | 3 |
| | 3.3 | Toxicants- Sources, Transportation process-advection, diffusion, Transformation-reversible, irreversible Applications of toxicology anthropogenic activities and environment. | 4 | 3 |
| 4 | **Occupational Health and safety** | | | |
| | 4.1 | Principles and methods of occupational health, Relationship of occupation with hygiene, safety and diseases. | 8 | 4 |
| | 4.2 | Environmental surveillance and health maintenance survey analysis and recommendation regarding health and safety problems in working and living environment | 7 | 5 |
| 5 | **Teacher Specific content** | | | |

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| **Teaching and Learning Approach** | **Classroom procedure (mode of transaction)**<br>o Interactive instruction (chalk& board method, multimedia presentation)<br>o Group discussion<br>o Peer teaching<br>o Experimental demonstrations<br>o Practical training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (30 Marks)**<br>i) Assignments: 5 marks<br>ii) MCQ: 5 marks<br>iii) Class test: 15 marks<br>iv) Viva: 5 marks<br>**B. End Semester Examination (70 Marks)**<br>i) Short answer 5 questions (out of 7): 5 x 4 = 20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Natural Hazards and Disaster Management** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE5DSECHE308** |
| **Course Level** | **300-399** |
| **Course Summary** | This course presents different elements of environmental hazards, their origins, categorization, and effects. It focuses on the approaches for managing these hazards and the strategies and plans of the authorities for mitigating and preparing for these hazards. |

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| **Semester** | V | Credits | | 4 | Total Hours | |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Analyse different natural hazard focusing on causes, impacts, and mitigation strategies. | An | 1 |
| 2 | Understand the impacts of anthropogenic activities on hazard occurrence and severity. | U | 1, 2 |
| 3 | comprehend mitigation strategies, including the utilization of technologies | | |
| 4 | Appreciate the importance of planning, exercises, training in preparedness, and the roles of public and media in hazard preparedness. | Ap | 1, 2, 6 |
| 5 | Understand the importance of planning, exercises, and training in hazard preparedness to enhance mitigation efforts. | U | 2, 6 |
| 6 | Analyse tools used in disaster management, including information systems and organizational frameworks. | An | 2, 6, 7 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Natural Hazards** | | |
| | 1.1 | Concept of hazard, disaster, risk, vulnerability, exposure and response. Distinction between natural hazards and anthropogenic environmental disturbances, | 4 | 1,2 |
| | 1.2 | Flood– cause, nature and frequency of flood, Urbanization and flooding, Flood mitigation methods. Landslides- Causes, Types, prevention and correction. Coastal hazards- Tropical cyclone and tsunamis, coastal erosion, sea level changes and impact on coastal areas. | 6 | 2 |
| | 1.3 | Earthquake-Geographical distribution of earth's zone, seismic waves, intensity and magnitude and causes of earth quake, Measures taken to protect from the hazard. Tsunami- causes and effects | 5 | 3 |
| 2 | | **Anthropogenic hazards** | | |
| | 2.1 | Impacts of anthropogenic activities such as rapid urbanization, ground water exploitation,, deforestation, mangroves destruction, Case studies from Kerala. | 6 | 3 |
| | 2.2 | Large scale developmental projects, like dams and nuclear reactors in hazard prone zones; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster. | 9 | 3 |
| 3 | | **Risk management** | | |
| | 3.1 | Concept of risk and vulnerability; two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses). | 7 | 1 |
| | 3.2 | Mitigation- Concept and types, use of technologies in mitigation such as barrier, deflection and retention systems; importance of planning, exercise, and training in preparedness; role of public and media in hazard preparedness. | 8 | 4 |
| 4 | | **Disaster management** | | |
| | 4.1 | Disaster management- objectives and goals, scope, significance and Stages-Mitigation, preparedness, response, recovery. | 4 | 2, 5 |

| | | | | |
|---|---|---|---|---|
| | 4.2 | Tools of Disaster management .Information Systems organization related to disaster management. Role of RS and GIS in disaster management. | 5 | 2, 5 |
| | 4.3 | National Disaster Management Framework, national response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management. Understanding of Gadgil Report and Kasturirangan Report on Western Ghats(reading and discussions only) | 6 | 2 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lectures (chalk & board, multimedia presentations)<br>o Group Discussions<br>o Case studies<br>o Quizzes |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (30 Marks)**<br>i) Quiz (5 marks)<br>ii) Assignment – (5 marks)<br>iii)Case study (5marks)<br>iv)Written exam (15 marks)<br>**B. End Semester Examination**<br>**Theory: Written Examination (70 Marks)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv)Essay type question – 15 marks (1 out of 2 nos) |

**References**


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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Water Resource Management** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE5DSECHE309** |
| **Course Level** | **300-399** |
| **Course Summary** | The course covers the surface and ground water hydrology along with ground water hydraulics, requirement of water for various purposes and its management. It also deals with fluid mechanism-properties and flow of fluids in a system. |

| **Semester** | V | Credits | | | | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Apply knowledge of hydrological principles to understand the distribution, availability, and management of water resources in various contexts. | Ap | 1 |
| 2 | analyzes the hydrological cycle and budget. | An | 1, 6 |
| 3 | Analyze diverse aspects of surface water hydrology and ground water hydrology | An | 2, 6 |
| 4 | Evaluate the principles and tools essential for implementing Integrated Water Resource Management (IWRM) approaches. | E | 2, 6 |
| 5 | Evaluate various water harvesting techniques and their importance in augmenting water resources in different contexts. | E | 1, 2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Introduction to Hydrology** | | | |
| | 1.1 | Domestic and industrial water supply needs, per capita water demand, water needs for major industries. Water requirement for non-consumptive uses such as power generation and inland navigation. | 9 | 1 |
| | 1.2 | The Water Cycle – precipitation, infiltration, evaporation, transportation, runoff, hydrological cycle, hydrological budget, water balance – global and regional | 6 | 1 |
| 2 | **Surface water Hydrology** | | | |
| | 2.1 | Surface Water Hydrology – runoff process, estimation of runoff, hydrograph, computation of runoff, measurement of rainfall, storage reservoir selection of site for reservoir – dams and intakes | 8 | 3 |
| | 2.2 | Management of streams such as flood and drought structural and non-structural, Micro water shed management and Coastal water management. | 7 | 3 |
| 3 | **Ground water hydrology** | | | |
| | 3.1 | Ground Water Hydrology – Aquifers and its types, determination of aquifer concentration | 6 | 4 |
| | 3.2 | Ground water hydraulics, safe yield, ground water collection system, characteristic well losses, interference among wells –open wells and tube wells. | 9 | 4 |
| 4 | **Integrated Water Resource Management** | | | |
| | 4.1 | History of water management, Integrated water resource management: concepts and theoretical perspectives, Principles and tools for practicing IWRM, Issues and challenges in IWRM, Corporate social responsibility in water resource management | 5 | 5 |
| | 4.2 | Concept and framework of watershed approach, Water harvesting-importance and techniques, Integrated watershed, development, | 5 | 5 |
| | 4.3 | Artificial recharges of ground water, River basin management, Management of lakes, Management of wetlands, Case study: Dal Lake, Ganga action plan | 5 | 5 |
| 5 | **Teacher Specific content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, power point presentation)<br>o Group discussion<br>o Case studies<br>o Debates<br>o Quizzes |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (30 marks)**<br>i) Assignment- (5 marks)<br>ii) Quiz - (2 Marks)<br>iii) Class test – written (18 Marks)<br>iv) Class test - MCQ (5 Marks) |
| | **B. End Semester Examination (70 Marks)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv)Essay type question – 15 marks (1 out of 2 nos) |

**References**


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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Analytical Chemistry and Professional skills** | | | | | |
| **Type of Course** | **SEC** | | | | | |
| **Course Code** | **MCE5SECCHE300** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course provides a comprehensive introduction to analytical chemistry, focusing on interdisciplinary concepts, precision in analysis, and practical applications in soil and water studies. It incorporates hands-on experiences, including workshops, interview training, industrial visits, and expert interactions, culminating in a career-oriented project for enhanced professional readiness. | | | | | |
| **Semester** | V | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 3 | | | | 45 |
| **Pre-requisites, if any** | Nil | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Outline the fundamentals of analytical chemistry | U | 1,2 |
| 2 | Conduct soil and water analysis | An | 1,2,4, 10 |
| 3 | Explain the principles of chromatographic techniques | U | 1,2 |
| 4 | Apply the principles of Thin Layer Chromatography and column chromatography for purification and separation purposes. | A | 1,2,10 |
| 5 | Develop professional skills effectively and contribute meaningfully to their chosen fields. | E | 4,9, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Analytical Chemistry** | | | |
| | 1.1 | **Introduction**: Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision, and sources of error in analytical measurements. | 3 | 1 |
| | 1.2 | **Analysis of soil:** Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators.<br>a. Determination of pH of soil samples.<br>b. Estimation of Calcium and Magnesium ions in soil by complexometric titration. | 6 | 2 |
| | 1.3 | **Analysis of water:** Definition of pure water, sources responsible for contaminating water, water sampling methods, and water purification methods.<br>a. Determination of pH, acidity, and alkalinity of a water sample.<br>b. Determination of the Hardness of water. | 6 | 2 |
| 2 | **Chromatographic techniques** | | | |
| | 2.1 | Introduction to chromatography: Basic principles of chromatography, types of chromatography | 2 | 3 |
| | 2.2 | Theory and Application -Gas chromatography, High-Performance Liquid Chromatography (HPLC) | 5 | 3 |
| | 2.3 | Theory, application, and demonstration of Thin Layer Chromatography and Column Chromatography (Hands on Training) | 8 | 4 |
| 3 | **Professional Development** | | | |
| | 3.1 | o Workshop on career awareness<br>o Training sessions for interviews<br>o Industrial visit<br>o Interaction with industrial experts<br>o Create minor project | 15 | 5 |
| 4 | **Teacher Specific content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lectures<br>o Group discussions,<br>o Group activities,<br>o Seminars<br>o Industrial visits<br>o Study tours |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (25 marks)**<br>i) Performance in activities<br>ii) Industrial visit report<br>iii) Project work |
| | **B. End Semester Examination (50 marks- 1.5 Hrs)**<br>i) Short answer questions – 20 marks (2 marks each – 10 out of 12 nos)<br>ii) Long answer questions – 30 marks (5 marks each – 6 out of 8 nos) |

**References**


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# SEMESTER VI

| | MAHARAJA'S COLLEGE, ERNAKULAM<br>(Govt. Autonomous) | | | | | |
|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Inorganic Chemistry-2** | | | | | |
| **Type of Course** | **DSC A** | | | | | |
| **Course Code** | **MCE6DSCCHE300** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course explores concepts of coordination chemistry, organometallic compounds and bioinorganic chemistry. This course also provides the basic analytical skills on qualitative and quantitative analysis of inorganic ions. | | | | | |
| **Semester** | VI | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | **Inorganic Chemistry-1** | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Compare the theories of coordination chemistry | An | 1,2 |
| 2 | Explain the mechanisms of substitution reactions | U | 1,2 |
| 3 | Describe the key concepts of inorganic and organometallic chemistry | E | 1,2 |
| 4 | Illustrate stability of organometallic compounds, clusters and their application in industrial catalysts. | U | 1, 2, 10 |
| 5 | Explain the importance of various metal ions in biological systems | U | 1,2,10 |
| 6 | Analyse different complexes based on colourimetry and electronic spectra | An | 1,2,10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Coordination Chemistry- 2** | | |
| | 1.1 | Merits and demerits of VBT and CFT | 1 | 1 |
| | 1.2 | Crystal field splitting in tetragonally distorted octahedral geometry, Jahn-Teller distortion in Cu (II) complexes. | 2 | 1 |
| | 1.3 | MO theory, evidences for metal-ligand covalency- Nephelauxetic effect, MO diagram of complexes of octahedral symmetry (sigma bonding only) | 3 | 1 |
| | 1.4 | Spectral and magnetic properties of metal complexes- d-d transition, electronic absorption spectrum of $[Ti(H_2O)_6]^{3+}$ ion. Charge transfer spectra e.g. $KMnO_4$, $K_2Cr_2O_7$ (Elementary idea). Types of magnetic behaviour, spin-only formula, calculation of magnetic moments. | 3 | 1 |
| | 1.5 | Reactivity of metal complexes-Labile and inert complexes | 1 | 2 |
| | 1.6 | Ligand substitution reactions: - $S_N1$ and $S_N2$, ligand substitution reactions in square planar and octahedral complexes | 3 | 2 |
| | 1.7 | Trans effect- theories and applications- polarization and π- bonding theory. | 2 | 1 |
| 2 | | **Organometallic Compounds** | | |
| | 2.1 | Introduction to organometallic compounds, hapticity | 1 | 3 |
| | 2.2 | 18- electron rule, numerical problems and stability | 2 | 3 |
| | 2.3 | Ferrocene: Preparation, structure, aromaticity and reactions (acetylation, alkylation). | 2 | 3 |
| | 2.4 | Metal-alkene complexes – Preparation and structure of Zeise's salt | 1 | 3 |
| | 2.5 | Catalytic properties of organometallic compounds - Zeigler Natta catalyst in the polymerization of alkene. Wilkinson catalyst in the hydrogenation of alkene (mechanism not expected). | 2 | 4 |
| | 2.6 | Preparation and structure of mononuclear carbonyls- $Mo(CO)_6$, $Fe(CO)_5$ and $Ni(CO)_4$ | 3 | 4 |
| | 2.7 | Polynuclear carbonyls, bridged carbonyls and bonding in metal carbonyls – $Mn_2(CO)_{10}$ and $Fe_2(CO)_9$. | 2 | 4 |

| | | | | |
|---|---|---|---|---|
| | 2.8 | Synergic effect and use of IR data in metal carbonyls to explain extent of back bonding | 1 | 4 |
| | 2.9 | Quadruple bond structure of $[Re_2CI_8]^{2-}$. Quintuple bond (non-evaluative) | 1 | 4 |
| 3 | **Introduction to Bioinorganic Chemistry** | | | |
| | 3.1 | Essential and non – essential metals | 1 | 5 |
| | 3.2 | Mechanism of ion transport- Ion pump ($Na^+$ and $K^+$) | 2 | 5 |
| | 3.3 | Porphyrins, Oxygen carriers- hemoglobin and myoglobin- structure and functions, oxygen transport mechanism, cooperativity effect, Bohr effect | 3 | 5 |
| | 3.4 | Cytochromes- Structure and functions of Cytochrome P-450 | 1 | 5 |
| | 3.5 | Non-heme proteins- structure and functions of hemocyanin & hemerythrin | 1 | 5 |
| | 3.6 | Photosynthesis- Chlorophylls (Structure not needed) – Z-scheme (only). | 2 | 5 |
| | 3.7 | Electron transfer proteins- structure and functions of ferredoxin, rubredoxin. Zinc containing metalloenzymes: carbonic anhydrase and carboxypeptidase. Vitamin $B_{12}$ (structure not expected) | 3 | 5 |
| | 3.8 | Toxicity of metals - Cd, Hg, Pb and Cr, with specific examples. | 1 | 5 |
| | 3.9 | Treatment of metal toxicity by chelation therapy (EDTA) | 1 | 5 |
| **4** | **Inorganic Chemistry-2 Practicals** | | | |
| | 4.1 | Colorimetric estimation of Fe, Cu, Ni, Mn, Cr, $NH_4^+$, nitrate and phosphate ions. Or UV- Visible spectral studies of different coordination compounds | 15 | 6 |
| | 4.2 | Study of the reactions of the following radicals with a view to their identification and confirmation. $Pb^{2+}$, $Al^{3+}$, $Zn^{2+}$, $Mn^{2+}$, $Ni^{2+}$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Mg^{2+}$, $NH_4^+$, $CO_3^{2-}$, $SO_4^{2-}$, $Cl^-$, $Br^-$, $CH_3COO^-$ Systematic qualitative analysis of mixtures containing two acid and two basic radicals from the above list without interfering radicals by Semi-micro method only. | 15 | 6 |

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|---|---|---|---|---|
| | | (Minimum of 5 mixtures to be analysed) | | |
| **5** | **Teacher Specific content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of experiments<br>o Hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment**<br>**Theory (25 marks)**<br>i) Quiz (5 marks)<br>ii) Assignment (5 marks)<br>iii) Class test (15 Marks)<br>**Practical (15 marks)**<br>i) Lab involvement and skill<br>i) Report of lab works done |
| | **B. End Semester Examination**<br>**Theory: Written examination (50 Marks-1.5 Hrs)**<br>i) MCQ 10 questions: 10 × 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 × 3 =12<br>iii) Short essay 2 questions (out of 3): 2 × 7 = 14<br>iv) Essay 1 question (out of 2): 1 × 14 = 14<br>**Practical: (35 Marks)**<br>i) Viva voce: 10 marks<br>ii) Writing procedure: 15 marks<br>iii) Certified lab report: 10 marks |

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**SUGGESTED READINGS**

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2. N. N. Greenwood, A. Earnshaw, *Chemistry of the Elements*, Butterworth-Heinemann, 2012.
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4. *Synthesis of a Stable Compound with Fivefold Bonding Between Two Chromium(I) Centers*. SCIENCE, 4 Nov 2005 844-847, 10.1126/science.1116789

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Physical Chemistry- 3** | | | | | |
| **Type of Course** | **DSC** | | | | | |
| **Course Code** | **MCE6DSCCHE301** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course deals with the principles of surface chemistry, colloids, chemical kinetics, electrochemistry, and electromotive force. | | | | | |
| **Semester** | VI | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | **Physical Chemistry-I** | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Assess different kinds of adsorption and adsorption isotherms. | E | 1,2 |
| 2 | Explain different types of colloidal systems, purification methods and properties of colloidal particles. | U | 1,2 |
| 3 | Interpret nature of various chemical reactions and describe the kinetics of parallel and chain reactions. | An | 1,2 |
| 4 | Make use of the principles of chemical kinetics to study the mechanism of homogeneous and heterogeneous catalysis. | A | 1,2 |
| 5 | Describe the mechanism and factors affecting electrolytic conductance. Analyse properties of electrolytic conductance. | A | 1,2 |
| 6 | Utilize conductance measurements in quantitative analysis. | A | 1,2 |
| 7 | Categorise different electrodes based on their function and apply Nernst equation to calculate electrode potential. | A | 1,2 |
| 8 | Apply the theoretical concepts of electrolytic conductance, adsorption and viscosity in practical experiments. | A | 1, 2, 10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| **1** | **Surface Chemistry And Colloidal State** | | | |
| | 1.1 | Adsorption – types, adsorption of gases by solids – factors influencing adsorption, Freundlich adsorption isotherm, Langmuir adsorption isotherm –derivation of Langmuir adsorption isotherm. | 5 | 1 |
| | 1.2 | Types of solutions – true, colloid and suspensions, Classification of colloids: Lyophilic, lyophobic, macromolecular, multimolecular and associated colloids with examples, purification of colloids – ultra filtration and electrodialysis. | 5 | 2 |
| | 1.3 | Properties of colloids: Brownian movement, Tyndall effect, electrophoresis. Electrical double layer and zeta potential. Coagulation of colloids, Hardy-Schulz rule. Micelles and critical micelle concentration, sedimentation and streaming potential. | 5 | 2 |
| **2** | **Chemical Kinetics** | | | |
| | 2.1 | Arrhenius equation, concept of activation energy, Collision theory - kinetic theory of collisions, steric factor. Types of complex reactions - consecutive reactions, opposing reactions, parallel reactions, Chain reactions. Steady state approximation. | 5 | 3 |
| | 2.2 | Catalysis: Homogeneous catalysis, enzyme catalysis – Heterogeneous catalysis – Surface catalysis, Elementary idea about Autocatalysis. | 2 | 4 |
| **3** | **Electrochemistry and Electromotive Force** | | | |
| | 3.1 | Ionic mobility: - relation with ionic conductance (with derivation), influence of temperature on ionic conductance, ionic conductance and viscosity – Walden's rule. Abnormal ionic conductance of $H^+$ and $OH^-$. | 5 | 5 |
| | 3.2 | Debye-Hückel theory of strong electrolytes – the concept of ionic atmosphere, asymmetry and electrophoretic effect, Debye- Hückel-Onsager equation (no derivation). Activity, mean ionic | 5 | 5 |

| | | | | |
|---|---|---|---|---|
| | | activity coefficient, ionic strength, Debye-Hückel limiting law (no derivation). | | |
| | 3.3 | Applications of conductance measurements – determinations of degree of dissociation of weak electrolytes, determination of solubility and solubility products of sparingly soluble salts, conductometric titrations involving strong acid-strong base, weak acid- strong base, strong acidweak base, mixture of a strong acid and weak acid against strong base and precipitation titrations. | 5 | 6 |
| | 3.4 | Reversible cells - Daniel cell. Reference electrodes – Standard Hydrogen Electrode, Calomel electrode. Electrode potential – Electrochemical series. Representation of cells (IUPAC), Electrode reactions and cell reactions. | 4 | 7 |
| | 3.5 | Derivation of Nernst equation for electrode potential and cell potential, Calculation of equilibrium constant from EMF data. Applications of emf measurements –determination of pH using glass electrode. Potentiometric titrations- acid-base and redox reaction. | 4 | 7 |
| **4** | **Physical chemistry – 3 Practical** | | | |
| | 4.1 | 1. Viscosity – Determination of viscosity of sucrose/glycerol.<br>2. Determination of composition of binary liquid mixture using viscometry (toluene-nitrobenzene).<br>3. Determination of molecular weight of a polymer using viscometry (polystyrene in toluene)<br>4. Viscometry: Verification of Kendalls equation-full experiment<br>5. ***Conductometry***:<br>• Determination of equivalent conductance of an electrolyte<br>• Determination of dissociation constant and degree of dissociation of a weak acid<br>• Verification of Onsager equation<br>6. ***Adsorption:*** | 30 | 8 |

| | | | | |
|---|---|---|---|---|
| | | • Verification of Freundlich and Langmuir adsorption isotherm - Charcoal Acetic acid or Charcoal-Oxalic acid system.<br>• Determination of concentration of given acid using the isotherm | | |
| **5** | **Teacher Specific content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture sessions, (chalk & board, PowerPoint presentation)<br>o Interactive sessions and simulations,<br>o Visual aids like videos and models to enhance understanding.<br>o Peer discussions.<br>o Laboratory experiments and hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Pop quiz (5 marks)<br>ii) Assignments (5 marks)<br>iii) Test for each unit (MCQ/written) (15 Marks)<br>**Practical (15 marks)**<br>i) Lab involvement and skill<br>ii) Report of lab works done |
| | **B. End Semester Examination**<br>**Theory: Written examination (50 Marks- 1.5 Hrs)**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical: (35 Marks- 1Hr.)**<br>i) Viva voce: 10 marks<br>ii) Writing procedure: 15 marks<br>iii) Certified lab report: 10 marks |

**References**


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7. G. W. Castellan, *Physical Chemistry*, 4th Edn. Narosa Publishing House 2018.
8. K. L. Kapoor, *A Textbook of Physical chemistry*, Volume 5, 4th edition, Macmillan India Ltd., 2018.

**Suggested Readings**

1. P W Atkins, Physical Chemistry, Oxford University Press (12th Edition), 2020.
2. G. M. Barrow, *Physical Chemistry*, Tata McGraw_Hill (2007).
3. A. McQuarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books Pvt. Ltd., 2019.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Organic Chemistry-4** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE6DSECHE300** |
| **Course Level** | **300-399** |
| **Course Summary** | This course examines the structure and biological importance of polypeptides, amino acids, proteins, nucleic acids, carbohydrates, natural products, lipids, vitamins, steroids, and hormones. Practical part of the course comprises extraction of natural products. |

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|---|---|---|---|---|---|---|
| **Semester** | VI | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Predict the synthetic pathway of polypeptides and amino acids | A | 1,2 |
| 2 | Identify the structure and biological importance of proteins and nucleic acids | A | 1,2,3 |
| 3 | Examine the structure, properties, and industrial applications of carbohydrates | An | 1,2 |
| 4 | Predict the interconversion of carbohydrates | A | 1,2 |
| 5 | Identify the structure and properties of natural products and lipids | A | 1,2 |
| 6 | Describe the classification structure and biological significance of vitamins, steroids, and hormones | U | 1,2,3 |
| 7 | Make use of theory to synthesis and extract various components of oils and tea leaves | S | 1,2,3,4, 10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | **Amino Acids, Peptides, Proteins and Nucleic Acids** | | | |
| | 1.1 | Amino Acids-Classification. Synthesis-Gabriel phthalimides synthesis, Strecker synthesis, Ionic properties and Ninhydrin reaction. Zwitterion structure and Isoelectric point. | 4 | 1 |
| | 1.2 | Polypeptides - Synthesis - DCC method. Merrifield's solid phase peptide synthesis. | 3 | 1 |
| | 1.3 | Primary, secondary, tertiary and quaternary structure of proteins: α-helix and β-pleated sheets. Denaturation of proteins. | 4 | 2 |
| | 1.4 | Nucleic acids: Components of nucleic acids, nucleosides and nucleotides. Structure of DNA, Watson, and Crick model. Differences between DNA and RNA. Protein biosynthesis, Replication of DNA | 4 | 2 |
| 2 | **Carbohydrates** | | | |
| | 2.1 | Classification of carbohydrates. | 1 | 3 |
| | 2.2 | Fischer and Haworth projections of glucose and fructose. Cyclic structure of glucose. Reactions of glucose and fructose - osazone formation, Tollen's reagent. | 4 | 3 |
| | 2.3 | Epimers, mutarotation and anomers. | 3 | 3 |
| | 2.4 | Chain lengthening and chain shortening of aldoses - Kiliani-Fischer synthesis and Wohl degradation. Interconversion of aldoses and ketoses. | 3 | 4 |
| | 2.5 | Sucrose-Structure, reactions and uses of sucrose | 1 | 3 |
| | 2.6 | Structure and properties of starch and cellulose (elementary idea). Industrial applications of cellulose. | 3 | 3 |
| 3 | **Natural products, Lipids, Vitamins, Steroids and Hormones** | | | |

| | | | | |
|---|---|---|---|---|
| | 3.1 | Natural products. Terpenoids: Classification, isoprene rule.<br>Essential oils - citral and geraniol –chemical properties and uses.<br>Alkaloids: Classification based on source, isolation, general properties, physiological effects of coniine and nicotine. | 4 | 5 |
| | 3.2 | Lipids: Oils and fats, biological functions. Trans fat and their effect. Hydrogenation, Rancidity. Acid value, Saponification value, Iodine value and RM value.<br>Soaps: Types and cleansing action.<br>Synthetic detergents - Comparison between soaps and detergents. | 5 | 5 |
| | 3.3 | Vitamins: Classification, structure, biological functions and deficiency diseases of vitamins A, $B_{12}$ and C. | 2 | 6 |
| | 3.4 | Steroids: Diels' hydrocarbon. Structure and functions of cholesterol. Elementary idea of HDL and LDL. | 2 | 6 |
| | 3.5 | Hormones: Biological functions of steroid hormone Oestrogen, peptide hormone - Insulin and amine hormone–Thyroxine. (Structure not required).<br>Artificial hormone –Birth control pill. | 2 | 6 |
| **4** | **Organic Chemistry – 4 Practical** | | | |
| | 4.1 | 1 Extraction of caffeine from tea leaves/tea dust powder<br>2 Extraction of volatile oils by Clevenger's method (Hydro distillation method).<br>3 Solvent extraction -isolation of lycopene from tomato<br>4 Determination of saponification value of the fat and oils by taking any real sample<br>5 Determination of acid value of the fat and oils by taking any real sample | 30 | 7 |
| **5** | **Teacher-Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of experiments<br>o Hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 marks)**<br>i) Quiz (5 marks)<br>ii) Assignment (5 marks)<br>iii) Class test (15 Marks)<br>**Practical (15 marks)**<br>i) Lab involvement and skill<br>ii) Report of lab works done |
| | **B. End Semester examination**<br>**Theory: Written examination (50 Marks- 1.5 Hrs.)**<br>i) MCQ 10 questions: 10 x 1 = 10<br>ii) Short answer 4 questions (out of 6): 4 x 3 =12<br>iii) Short essay 2 questions (out of 3): 2 x 7 = 14<br>iv) Essay 1 question (out of 2): 1 x 14 = 14<br>**Practical: (35 Marks- 1 Hr.)**<br>i) Viva voce: 10 marks<br>ii) Writing procedure: 15 marks<br>iii) Certified lab report: 10 marks |

**References**


1. Clayden, J; Greeves, N; Warren, S. *Organic Chemistry*; Oxford University Press, 2012.
2. Finar, I. L. *Organic Chemistry*; Vol. 1& 2; Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Analytical Methods in Environmental Monitoring** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE6DSECHE305** |
| **Course Level** | **300-399** |
| **Course Summary** | This topic covers the concept of Sampling- types of sampling and criteria of sampling of water and sediments and its various aspects. It also explores the analytical techniques like spectrophotometric and chromatographic techniques and working principles of a few instruments associated with these techniques. It also includes biostatstics for statistical analysis of samples and data. |

| **Semester** | VI | Credits | | | | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | 1 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Analyze regulatory standards for air, water, and soil quality. | An | 1, 2 |
| 2 | Apply principles of environmental sampling and methods for air, water, and soil. | Ap | 2, 4, 6, 9 |
| 3 | explain the general principles and instrumentation of selected analytical techniques | U | 1, 2 |
| 4 | Apply principles of various tools to analyse soil , water and air quality. | Ap | 2 |
| 5 | demonstrate practical laboratory skills with advanced methods and real-time monitoring systems for environmental sample analysis. | S | 1, 2, 4 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Environmental Sampling and Data Analysis** | | | |
| | 1.1 | Air, water, soil quality parameters: Regulatory standards and guidelines (EPA, WHO, local regulations) | 3 | 1 |
| | 1.2 | Principles of sampling, Types of samples (grab, composite, continuous), Sampling methods for air, water, and soil Sample preservation and storage strategies Tabulation of data, Tables, graphs – histograms - box viscor plot - scatter plots, Statistical analysis of environmental data. | 5 | 2 |
| | 1.3 | General principle and basic instrumentation of atomic absorption spectroscopy, flame emission spectroscopy, Inductively coupled plasma mass spectrometry (ICP-MS)), FT- IR and UV-Visible spectroscopy, and fluorescence spectroscopy | 7 | 3 |
| 2 | **Analytical Techniques for Soil Quality Monitoring** | | | |
| | 2.1 | pH and electrical conductivity measurement of soil samples, metal analysis by flame emission spectroscopy (FES), atomic absorption spectroscopy (AAS), and Inductively coupledplasma mass spectrometry (ICP- MS)) | 5 | 3 |
| | 2.2 | Organic matter analysis by loss-on-ignition and Walkley-Black method, Nutrient analysis: Kjeldahl method for nitrogen, colorimetric methods for determination of phosphorus, pesticide residue analysis using GC and types ofcolumns in GC , Hydrocarbon analysis by HPLC | 5 | 2, 3, 4, 5 |
| 3 | **Analytical Techniques for Air Pollution Monitoring** | | | |
| | 3.1 | Ambient air quality monitoring. Principle and methodology analysis for particulate matter (Gravimetry), principle and application of gas chromatography/ mass spectroscopy (GC-MS) in the analysis of volatile organic compounds (VOCs) pesticides and persistent organic pollutants: PCB, PCDD, PCDF | 7 | 2, 4 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Real-time monitoring techniques Automated monitoring systems.- Continuous Emissions Monitoring Systems (CEMS), Determination of carbon monoxide (Infrared Spectroscopy (IR)), nitrogen oxides (Chemiluminescence), $SO_2$ (UV fluorescence), ozone (UV visible spectrometry) determination of suspended particulate matter- Gravimetry, nephlometry. | 8 | 3, 4, 5 |
| **4** | **Analytical Techniques for water Quality Monitoring** | | | |
| | 4.1 | Water analysis physical analysis (turbidity, colour, odour and taste) Physicochemical parameters: pH, conductivity, dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), | 4 | 3, 4, 5 |
| | 4.2 | Chemical analysis total solids (TSS, TDS-Gravimetry), hardness (Complexometry), salinity, acidity and alkalinity , chlorides (Argentometry), sulphates, residual chlorine (Argentometry), iron (Colorimetry), organic matter and pesticides by HPLC, phosphorus, fluorides (SPANDS reagent), Spectrophotometric methods for nutrient analysis – ammonia , nitrate, phosphate | 6 | 3, 4, 5 |
| **5** | **Physico chemical analysis of water, soil and effluent –PRACTICAL** | | | |
| | 1. Determination of pH of water sample<br>2. Determination of Electrical conductivity of water sample<br>3. Determination of turbidity of water sample<br>4. Determination of Acidity and alkalinity of water sample<br>5. Determination of Total Hardness of water sample<br>6. Determination of Calcium and Magnesium hardness of water sample<br>7. Determination of Chloride of water Sample<br>8. Determination of Salinity of water sample<br>9. Determination of DO of water sample<br>10. Determination of electrical conductivity of soil sample<br>11. Determination of water holding capacity of soil sample<br>12. Determination of organic carbon content in soil sample<br>13. Determination of carbonate and bicarbonate in soil sample<br>14. Determination of available nitrogen in soil samples<br>15. Determination of available phosphorous in soil samples<br>16. Determination of Iron in soil and effluent sample<br>17. Determination of BOD and COD of Effluent sample<br>18. Analysis of sodium and potassium in soil and effluent sample | | 30 | 5 |

| 5 | **Teacher Specific content** |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, power point presentation)<br>o Group discussion<br>o Lab sessions<br>o Case studies<br>o Quizzes |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment**<br>**Theory (30 marks)**<br>i) Assignment- (5 marks)<br>ii) Quiz - (2Marks)<br>iii) Class test – written (18 Marks)<br>iv) Class test - MCQ (5 Marks)<br><br>**B. Semester end examination**<br>**Theory: Written examination (70 Marks)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii) Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv) Essay type question – 15 marks (1 out of 2 nos) |

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Industrial Inorganic Chemistry and Nuclear Chemistry** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE6DSECHE302** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course is designed to provide students with a comprehensive understanding of the industrial processes involved in the production of inorganic compounds and the principles governing nuclear reactions. | | | | | |
| **Semester** | VI | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Analyse different industrially important inorganic materials. | An | 1,2, 6 |
| 2 | Evaluate the important processes involved in metallurgy | E | 1,2 ,6 |
| 3 | Explain the catalytic properties of inorganic materials | E | 1,2,6 |
| 4 | Illustrate the basics of chemical explosives and rocket propellants | U | 1,2,6,10 |
| 5 | Analyse different aspects of nuclear chemistry, its applications and associated problems. | An | 1,2,6,10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | **Glass, Ceramic and Cements** | | | |
| | 1.1 | **Glass-**Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate glass, coloured glass and photosensitive glass. | 5 | 1 |
| | 1.2 | **Ceramics -**Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications. Bio-ceramics. | 5 | 1 |
| | 1.3 | **Cement-**Classification of cement, ingredients and their role, manufacture of cement and the setting process, quick setting cements. Bio-cement- Living building materials | 5 | 1 |
| 2 | **Metallurgy** | | | |
| | 2.1 | Minerals in India, mineral processing, chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agents. | 5 | 2 |
| | 2.2 | Electrolytic reduction, hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: electrolytic process, Van Arkel-de Boer process and Mond's process, Zone refining. | 7 | 2 |
| | 2.3 | Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology. | 3 | 2 |
| 3 | **Introduction to Chemical Explosives, rocket propellants and catalysis** | | | |
| | 3.1 | General principles and properties of catalysts, homogenous catalysis, and heterogenous catalysis (catalytic steps and examples), their industrial applications, deactivation, or regeneration of catalysts. Phase transfer catalysts, application of zeolites and metal organic frameworks as catalysts. | 7 | 3 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Origin of explosive properties in inorganic compounds. Categorisation of explosives (low explosives – high explosives – primary, secondary, intermediary, tertiary). Explosive properties of Gun powder, lead azide, TNT, PETN, cyclonite (RDX). | 6 | 4 |
| | 3.3 | A Brief History and introduction of chemical rocket propellants. Liquid propellants, ecofriendly propellants and solid propellants | 2 | 4 |
| **4** | **Nuclear Chemistry** | | | |
| | 4.1 | Nucleus and its classification, nuclear forces, nuclear stability, binding energy, nuclear models. Radioactive decay, radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, halflife, mean life period, units of radioactivity. | 5 | 5 |
| | 4.2 | Measurement of radioactivity, Geiger-Muller detector, scintillation detectors, nuclear reactor: classification of reactors, uranium reactor, breeder reactor. Nuclear reactors in India (Brief Idea). Nuclear fusion and stellar energy. Units of radiation energy (Rad, Gray, Rontgen) | 5 | 5 |
| | 4.3 | Nuclear pollution and radiological safety: interaction of radiation with matter, radiolysis of water, radiation dosimetry. Radioactive isotopes and their applications, isotopic dilution analysis, neutron activation analysis, disposal of nuclear waste, nuclear disaster (nuclear accidents–case study). | 5 | 5 |
| **5** | **Teacher-Specific content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Industrial Visit/ visit to a nuclear Reactor (IGCAR/KNPP etc.) |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) :**<br>**Theory (30 marks)**<br>i) Quiz (7 marks)<br>ii) Class test for each unit (MCQ/written) (23 Marks) |

| | |
|---|---|
| | **B. End Semester Examination**<br>**Theory: Written examination (70 Marks- 2 Hrs)**<br>i) Short answer 5 questions (out of 6): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. Stocchi, *Industrial Chemistry*, Vol-I , Ellis Horwood Ltd. UK, 1990
2. R. M. Felder and R. W. Rousseau, *Elementary Principles of Chemical Processes*, Wiley Publishers,
3. New Delhi, 2004
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7. R. Gopalan, D. Venkappayya, S. Nagarajan, *Engineering Chemistry*, 4th Edn.Vikas Publications, New Delhi.
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9. S.F. Sarner, *Propellant Chemistry*, Reinhold Publishing Co., 1966
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14. J. W. T. Spinks, R.J. Woods R. J. *An Introduction to Radiation Chemistry*, 3rd Edn. Wiley–Blackwell, 1990.
15. H.J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Edn. New Age International Private Limited, 2011.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Spectroscopic Methods of Chemical Analysis** |
| **Type of Course** | **DSE** |
| **Course Code** | **MCE6DSECHE303** |
| **Course Level** | **300-399** |
| **Course Summary** | This course covers various spectroscopic methods, including principles, instrumentation and applications. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Semester** | VI | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Discuss instrumentation in IR, NMR and electronic spectroscopic techniques. | U | 1,2 |
| 2 | Describe the fundamental principles of Raman, EPR, NQR, Mossbauer, Fluorescence and X-ray spectroscopic techniques in chemical analysis. | U | 1,2 |
| 3 | Evaluate the advantages and limitations of Raman spectroscopy, EPR spectroscopy and NQR spectroscopy in different scientific and industrial applications. | E | 1,2,10 |
| 4 | Assess the utility of Mössbauer spectroscopy, Fluorescence spectroscopy and X-ray spectroscopy in various fields. | E | 1,2 |
| 5 | Describe the fundamental principles of AAS, AES and FES. | U | 1,2 |
| 6 | Compare and contrast the advantages and limitations of AAS, AES, and FES in elemental analysis. | U | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C),Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Instrumentation in Electronic, IR and NMR Spectroscopic Techniques** | | | |
| | 1.1 | Instrumentation in UV/ Visible Spectroscopy: Light sources, wavelength dispersion (gratings, prisms, interference filters, lasers). Sample holders, detection of signals (photocells, photo multipliers, and diode arrays), Sensitivity and S/N ratio. Single and double beam instruments. | 5 | 1 |
| | 1.2 | Instrumentation in IR Spectroscopy: Light sources, infrared detectors, sample preparation techniques; liquids, solids. Dispersive I R spectrometer. (FTIR-basicidea only) | 5 | 1 |
| | 1.3 | Instrumentation in NMR Spectroscopy: Magnet: Typesof magnets used in NMR (permanent, resistive, superconducting), Probes and RF coils. Sample handling and temperature control. | 5 | 1 |
| 2 | **Raman and EPR Spectroscopic Techniques** | | | |
| | 2.1 | Raman Spectroscopy: Scattering of light, polarizability and classical theory of Raman spectrum, rotational and vibrational Raman spectrum, Stokes and anti-Stokes lines: their intensity difference, complementarities of Raman and IR spectra, mutual exclusion principle, applications of Raman spectroscopy. | 8 | 2,3 |
| | 2.2 | EPR Spectroscopy: Electron spin in molecules, interaction with magnetic field, g factor, factors affectingg values, fine structure and hyperfine structure, Kramers' degeneracy, applications of ESR spectroscopy. | 7 | 2,3 |
| 3 | **NQR, Mossbauer and Fluorescence Spectroscopic techniques** | | | |
| | 3.1 | Theory and important applications of NQRSpectroscopy. | 3 | 2,3 |
| | 3.2 | Mossbauer Spectroscopy: Principle, Doppler effect, recording of spectrum, chemical shift, factors determining chemical shift, application to complexes of iron. | 6 | 2,4 |
| | 3.3 | Fluorescence Spectroscopy. Instrumentation: light source, monochromator, optical filters, photomultiplier tube, polarizers, application- fluorescence sensing. | 6 | 2,4 |

| | | | | |
|---|---|---|---|---|
| **4** | **Atomic Spectroscopic Techniques** | | | |
| | 4.1 | Atomic absorption spectroscopy (AAS), principle of AAS, absorption of radiant energy by atoms, measurement of atomic absorption, instrumentation: Radiation Sources, Atomizers, Detectors. Analytical Applications of AAS. | 5 | 5,6 |
| | 4.2 | Atomic emission spectroscopy (AES), advantages and disadvantages of AES, origin of spectra, principle and instrumentation, applications. | 5 | 5,6 |
| | 4.3 | Flame emission spectroscopy (FES), flames and flame temperature, spectra of metals in flame, instrumentation, applications. | 5 | 5,6 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>Lecture sessions, interactive sessions including discussions and demonstrations, to engage students actively and visual aids like presentations and videos to enhance understanding. Utilize case studies from various scientific fields (like environmental science, pharmaceuticals, forensics) to illustrate how spectroscopy is applied practically. Form study groups to discuss concepts, compare approaches, and explain concepts to one another. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (30 Marks)**<br>i) Assignments: 5 marks<br>ii) MCQ: 5 marks<br>iii) Class test: 15 marks<br>iv) Viva: 5 marks |
| | **B. End Semester examination (70 Marks- 2Hrs)**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. J W. Robinson, E M S Frame, and G M. Frame II, *Instrumental Analytical Chemistry*, CRC Press, 2021.
2. F A Settle, *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, 1997.
3. J W. Robinson, E M S Frame and G M. Frame II, *Undergraduate Instrumental Analysis*, 7th Edn. CRC Press, 2014.

4. D A. Skoog, D M. West, F. J Holler and S R. Crouch, *Fundamentals of Analytical Chemistry*, 9th Edn. Brooks/Cole, 2014.
5. C N Banwell, E M McCash*, Fundamentals of Molecular Spectroscopy*, 4th Edn. McGrawHill Publishing Company, 2017.
6. Aruldhas, *Molecular Structure and Spectroscopy*, 2nd Edn. Prentice Hall India, 2007.
7. D A. Skoog, F. J Holler and S R. Crouch, *Principles of Instrumental Analysis*, 7th Edn. Brooks/Cole, 2020.
8. P. Gupta, S. S. Das and N. B. Singh, *Spectroscopy*, Jenny Stanford Publishing, 2023.

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Fundamentals of Biochemistry** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE6DSECHE304** | | | | | |
| **Course Level** | **300-399** | | | | | |
| **Course Summary** | This course covers structure and biological functions of amino acids, proteins, enzymes, carbohydrates, nucleic acids and lipids and general features of metabolism. | | | | | |
| **Semester** | VI | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Explain fundamental features of biochemistry such as functions of subcellular organelles, membranes and membrane transport, | U | 1,2 |
| 2 | Analyse the classification, properties and functions of amino acids, proteins, enzymes, lipids and carbohydrates. | An | 1,2 |
| 3 | Describe the catalytic activity of enzymes and enzyme inhibition | U | 1,2 |
| 4 | Examine the functions of DNA and RNA | E | 1,2 |
| 5 | Analyse various metabolic pathways and phases. | An | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | | **Foundations of Biochemistry** | | |
| | 1.1 | Introduction to biochemistry: scope of biochemistry, historical development and significance | 2 | 1 |
| | 1.2 | Subcellular organelles: nucleus, endoplasmic reticulum, golgi apparatus, lysosomes, peroxisomes and mitochondria. Marker enzymes. | 5 | 1 |
| | 1.3 | Plasma membrane and membrane proteins. | 2 | 1 |
| | 1.4 | Membrane transport: active and passive transports and pumps. Ion channels, ligand-gated channels, voltage-gated channels, ionophores.<br>Sodium pump and calcium pump. | 6 | 1 |
| 2 | | **Amino acids and Proteins** | | |
| | 2.1 | Amino acids: Classification-based on structure, side chain, metabolism and nutritional requirements.<br>Physical properties of amino acids, isoelectric point, optical activity and peptide bond formation.<br>Colour reactions of amino acids and proteins-ninhydrin, biuret and xanthoproteic tests. | 6 | 2 |
| | 2.2 | Peptides and proteins: Primary structure and numbering of amino acids in proteins. Secondary structure- alpha helix and beta pleated sheets. Tertiary structure- relationship between structure and function of proteins.<br>Quaternary structure of proteins. | 5 | 2 |
| | 2.3 | Classification of Proteins based on function, composition, shape and nutritional value. | 2 | 2 |
| | 2.4 | Physical properties and precipitation reactions of proteins.<br>Quantitative estimation of proteins by Kjeldahl's method. | 2 | 2 |
| 3 | | **Enzymes** | | |
| | 3.1 | Enzymes; Characteristics, six major classes of enzymes, IUMB system of classification of enzymes-explanation with one example.<br>Coenzymes- Classification, nicotinamide adenine dinucleotide ($NAD^+$) and coenzyme A. Cofactors.<br>Metallo-enzymes. | 6 | 2 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Catalytic power and specificity of enzymes.<br>Mode of action of enzymes- active site, substrate binding, lock and key principle, induced-fit model, entropy effect and stabilisation of transition state. Coupled reactions. | 7 | 3 |
| | 3.3 | Enzyme inhibition- types. | 2 | 3 |
| **4** | **Carbohydrates, Nucleic acids, Lipids and Metabolism** | | | |
| | 4.1 | Carbohydrates- Biological functions of mono, di and polysaccharides. Regulation of Blood Glucose; insulin and diabetes mellitus. | 4 | 2 |
| | 4.2 | Nucleotides and nucleic acids, DNA and RNA, functions of DNA and RNA. | 4 | 4 |
| | 4.2 | Lipids- classification of lipids and fatty acids and functions of lipids. | 3 | 2 |
| | 4.3 | Metabolism: types of metabolic pathways, phases of metabolism, metabolic profile of brain, skeletal muscles and liver. | 4 | 5 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>Lecture sessions, interactive sessions including discussions and demonstrations, to engage students actively and visual aids like presentations and videos to enhance understanding. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (30 Marks)**<br>i) Assignments: 5 marks<br>ii) MCQ: 5 marks<br>iii) Class test: 15 marks<br>iv) Viva: 5 marks |
| | **B. End Semester Examination (70 Marks- 2 Hrs)**<br>i) Short answer 5 questions (out of 6): 5 x 4 = 20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii)Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. D M Vasudevan, S Sreekumari, *Textbook of Biochemistry for Medical Students*, Jaypee Brothers Medical Publishers, 2023.
2. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry*, 7th Edn. W. H. Freeman., 2021.

3. Berg, J.M., Tymoczko, J. L. and Stryer, L. *Biochemistry*. 9th Edn. W.H. Freeman and Co., 2019.
4. U. Satyanarayana, U. Chakrapani. Biochemistry. 6th Edn. Elsevier India, 2021.
5. P.J. Kennelly, *Harper's Illustrated Biochemistry*, 32 Edition, McGraw Hill, 2022.
6. R Singh, R Goyal, *Lippincott's Illustrated Reviews – Biochemistry*, 2020.
7. P Naik, *Biochemistry*, Jaypee Brothers Medical Publishers, 2022.
8. H. P. Gajera, S. V. Patel, B. A. Golakiya, *Fundamentals of Biochemistry*, IBDC, 2000.

**Suggested Readings**

1. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. *Harper's Illustrated Biochemistry*. XXVIII edition. Lange Medical Books/ McGraw-Hill, 2009.

| | MAHARAJA'S COLLEGE, ERNAKULAM<br>(Govt. Autonomous) | | | | | |
|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Data Analysis using Python and Soft skills** | | | | | |
| **Type of Course** | **SEC** | | | | | |
| **Course Code** | **MCE6SECCHE300** | | | | | |
| **Course Level** | **300- 399** | | | | | |
| **Course Summary** | This interdisciplinary course provides a comprehensive exploration of scientific investigation, statistical analysis, and python programming in the context of chemistry. | | | | | |
| **Semester** | VI | Credits | | | 3 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | | | 45 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Apply scientific methods for designing experiments systematically | A | 1,2,3 |
| 2 | Interpret data using various statistical tools. | U | 1,2,3 |
| 3 | Understand the basics of Python | U | 1,2,3 |
| 4 | Utilize Python in data visualization and analysis | A | 1,2,3 |
| 5 | Develop ideas in chemistry that can be grown into startups | C | 4,5,9,10 |
| 6 | Develop comprehensive scientific communication skills | C | 4,10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transactions (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Data Analysis** | | |
| | 1.1 | **The Investigative Approach**: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments. | 3 | 1 |
| | 1.2 | **Analysis and Presentation of Data**: Descriptive statistics. Choosing and using statistical tests. | 4 | 1,2 |
| | 1.3 | **Chemometrics**. Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r, and its abuse. Basic aspects of multiple linear regression analysis. | 8 | 2 |
| 2 | | **Introduction to Python** | | |
| | 2.1 | Introduction to Python Programming<br>Defining numbers, Variables, Strings, Lists and Loops, Comparisons of flow control, functions, data structures, file input/output, Basic Numppy | 7 | 3 |
| | 2.2 | Data Visualization with Python<br>Matplotlib, drawing line plots with a single line, line plots with multiple line, adding legend, drawing bar plots, scatter plots, plot title and axis labels. Saving plots | 8 | 4 |
| 3 | | **Soft skills for chemists** | | |
| | 3.1 | ● Presentation on a hypothetical start-up idea incorporating chemistry background.<br>● Review of recent research articles (writing)<br>● Poster design and presentation skills<br>● Plotting of data using different software (excel, origin etc.)<br>● Fitting of data | 15 | 5,6 |
| 4 | | **Teacher-Specific content** | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lectures<br>o Demonstrations<br>o Discussions |

| | |
|---|---|
| | ○ Hands-on training<br>○ Seminars<br>○ Presentations and assignments. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (25 Marks)**<br>i) Presentation - 5marks<br>ii) writing skills - 5 marks<br>iii) Data analysis skill - 5 marks<br>iv) Examination-10 marks |
| | **A. End Semester examination (50 marks- 1.5 hrs)**<br>i) Short answer questions – 20 marks (2 marks each – 10 out of 12 nos.)<br>ii) Long answer questions – 30 marks (5 marks each – 6 out of 8 nos.) |

**References**


1. Hibbert, D. B. & Gooding, J. J. (2006) *Data analysis for chemistry*. Oxford University Press.
2. D. Topping, J. (1984) *Errors of observation and their treatment*. Fourth Ed., Chapman Hall, London.
3. Harris, D. C. *Quantitative chemical analysis*. 6th Ed., Freeman (2007) Chapters 3-5.
4. *Python Crash Course- A Hands-on, Project Based Introduction to Programming*, Eric Matthes, no starch Press, 2016 edition
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6. Christian Hill. (2020). *Python for Chemists*. Cambridge University Press
7. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics.* CRC Press, Taylor & Francis Group, LLC.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Intellectual Property Rights** |
| **Type of Course** | **VAC** |
| **Course Code** | **MCE6VACCHE300** |
| **Course Level** | **300-399** |
| **Course Summary** | This course covers various aspects of intellectual property law, including patents, trademarks, and copyrights. |

| **Semester** | VI | Credits | | | 3 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | | | 45 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Analyse the fundamental principles of intellectual property rights, distinguishing between patents, copyrights, and trademarks. | An | 1,2 |
| 2 | Interpret the ethical and legal implications of intellectual property infringement in diverse contexts. | U | 1,2 |
| 3 | Evaluate the criteria for patentability, including novelty, nonobviousness, and utility. | E | 1,2 |
| 4 | Identify the fundamental concepts and legal framework surrounding trademarks. | U | 1,2 |
| 5 | Analyse and interpret the fundamental principles and theories underlying copyright law. | An | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Introduction to IPR** | | |
| | 1.1 | Meaning of property, origin, nature, meaning of intellectual property rights | 4 | 1 |
| | 1.2 | Kinds of Intellectual property rights—copy right, patent, trade mark, trade secret and trade dress, design,layout design, geographical indication, plant varieties and traditional knowledge. | 7 | 1, 2, 4 |
| | 1.3 | Significance of IPR and their protection | 3 | 1,2 |
| 2 | | **International Organizations & Treaties** | | |
| | 2.1 | Paris Convention for the Protection of Industrial Property, Patent Cooperation Treaty (PCT), World Trade Organization (WTO) | 5 | 1,2,3 |
| | 2.2 | Trade Related Aspects of Intellectual Property TRIPS,TRIMS, WIPO | 5 | 1,2,3 |
| | 2.3 | Budapest treaty on the international recognition of the deposit of microorganisms for the purpose of patent procedure, international convention for the protection ofnew varieties of plants (UPOV) | 5 | 1,2,3 |
| 3 | | **Patent Rights and Copyrights** | | |
| | 3.1 | Types of patents, inventions which are not patentable, the patent's act 1970- patentable invention, registration procedure, rights and duties of patentee, assignment andlicence, restoration of lapsed patents, surrender and revocation of patents, infringement, remedies & penalties. | 10 | 1,2,3 |
| | 3.2 | Types of copyright, registration procedure, assignment & licence, terms of copyright, piracy, infringement, remedies, copy rights with special reference to software | 5 | 1,2,5 |
| 4 | | **Teacher Specific content** | | |
| | | | | |

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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>Lectures, discussions, group activities and presentations by students. |

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| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (25 Marks)**<br>i) Assignments: 5 marks<br>ii) Examination: 10 marks<br>iii) Viva: 5 marks<br>iv) Classroom participation (participation in class activities) : 5 marks |
| | **B. End Semester Examination (50 Marks- 1.5 Hrs)**<br>i) MCQ 9 questions: 9 x 1 = 9<br>ii) Short answer 5 questions (out of 7): 5 x 4 =20<br>iii) Short essay 3 questions (out of 5): 3 x 7 = 21 |

**References**


1. G.B. Reddy, *Intellectual Property Rights and the Law*, Gogia Law Agency, 2017.
2. B.L.Wadehra, *Law relating to Intellectual Property*, Universal Law Publishing Co, 2017.
3. P. Narayanan, *Intellectual Property Law*, Eastern Law House, 3rd Edn. 2023.
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5. R K Singh. A Banerjee*, Intellectual Property Rights*, Gogia Law Agency, 2022.
6. V K Ahuja, *Law Relating To Intellectual Property Rights*, LexisNexis, 2017.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Research Methodology for Chemistry** |
| **Type of Course** | **VAC** |
| **Course Code** | **MCE6VACCHE301** |
| **Course Level** | **300-399** |
| **Course Summary** | This course covers a wide range of topics aimed at preparing students to conduct a scientific project in chemistry. The aim is to equip students with the skills and knowledge necessary to design, conduct, analyse, and communicate scientific research effectively in the field of chemistry. |

| **Semester** | VI | Credits | | | 3 | Total Hours |
|---|---|---|---|---|---|---|
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 3 | | | | 45 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Apply the tools for literature survey in chemistry in doing and reporting a chemistry project. | A | 1,2 |
| 2 | Describe the methodology of scientific research. | U | 1,2 |
| 3 | Apply the knowledge of scientific writing in preparing a project report. | A | 1,2 |
| 4 | Discuss the ethical aspects of chemistry research. | U | 1,2 |
| 5 | Apply the basic principles of research methodology in the conducting, reporting and presenting a chemistry project. | A | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | | **Literature Survey** | | |
| | 1.1 | Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples | 6 | 1 |
| | 1.2 | Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, Beilstein, SciFinder, Scopus. Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information. | 9 | 1 |
| 2 | | **Methods of Scientific Research and Writing Scientific Papers** | | |
| | 2.1 | Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. | 5 | 2,3 |
| | 2.2 | Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. | 5 | 2,3 |
| | 2.3 | Ethical challenges in chemistry research, Responsible conduct of research, Writing Ethics, Avoiding plagiarism. | 5 | 4 |
| 3 | | **Training on writing a project report** | | |
| | 3.1 | 1. Project selection<br>2. Literature Survey<br>3. Conducting the project<br>4. Preparing a report<br>5. Preparing and displaying a poster<br>6. ICT enabled oral presentation | 15 | 1,2,3,4,5 |
| 4 | | **Teacher-Specific content** | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lectures<br>o Discussions<br>o Group activities<br>o Presentations by students. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (25 Marks)**<br>i) Poster presentation: 5 marks<br>ii) Oral presentation: 10 marks<br>iii) Project report: 5 marks<br>iv) Classroom participation (participation in class activities) : 5 marks |
| | **B. End Semester Examination (50 Marks- 1.5 Hrs)**<br>i) MCQ: 9 questions: 9 x 1 = 9<br>ii) Short answer 5 questions (out of 7): 5 x 4 =20<br>iii) Short essay 3 questions (out of 5): 3 x 7 = 21 |

**References**


1. A T Tyowua, *A Practical Guide to Scientific Writing in Chemistry: Scientific Papers, Research Grants and Book Proposals*, CRC Press. 2023.
2. F. H. Jardine*, How to do your Student Project in Chemistry*, Springer, 1994.
3. A M. Coghill and L R Garson, *The ACS Style Guide: Effective Communication of Scientific Information*, Oxford University Press, 2006.
4. V Bairagi, M V. Munot, *Research Methodology: A Practical and Scientific Approach*, CRC Press, 2019.
5. H G Deal, *Science Research Writing for Native and Non-Native Speakers of English*. World Scientific Publishing Europe Ltd, 2020.
6. D Angelo, G John, *Ethics in Science: Ethical Misconduct in Scientific Research*, Chapman and Hall/CRC, 2018.
7. https://www-library.ch.cam.ac.uk/list-useful-databases
8. https://fordham.libguides.com/Chemistry/Databases

# SEMESTER VII

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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Coordination and Organometallic Chemistry** | | | | | |
| **Type of Course** | **DCC** | | | | | |
| **Course Code** | **MCE7DCCCHE400** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course provides a comprehensive understanding of the structure, bonding, and reactivity of coordination complexes, electronic spectral properties, synthesis, and catalytic applications of organometallic compounds. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | Inorganic Chemistry - 2 | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Compare the stability of metal complexes. | E | 1, 2 |
| 2 | Examine the structure and bonding in coordination and organometallic compounds using the concepts of crystal field theory and molecular orbital theory. | An | 1, 2 |
| 3 | Construct correlation diagrams and explain the spectral properties of metal complexes. | A | 1, 2 |
| 4 | Analyse the reactions of organometallic compounds. | An | 1, 2 |
| 5 | Examine the catalytic properties of various organometallic compounds and their applications. | An | 1, 2, 10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | **Structure and Bonding in Coordination Complexes** | | | |
| | 1.1 | Classification of complexes based on coordination numbers and possible geometries, $\sigma$ and $\pi$ bonding ligands such as CO, NO, $CN^-$, $R_3P$, and $Ar_3P$. | 2 | 1 |
| | 1.2 | Stability of complexes, kinetic and thermodynamic aspects of complex formation - Irving William order of stability. | 2 | 1 |
| | 1.3 | Splitting of *d* orbitals in octahedral, tetrahedral, square planar, square pyramidal and triagonal bipyramidal fields. | 2 | 1 |
| | 1.4 | Crystal Field Stabilization Energy (CFSE) and Dq values, Jahn Teller (JT) distortion ($d^1 - d^{10}$ systems), static and dynamic JT distortion, consequences of JT distortion, theoretical failure of crystal field theory, Ligand Field Stabilization Energy (LFSE) and evidence of covalency in the metal-ligand bond. | 4 | 1 |
| | 1.5 | Ligand field theory and molecular orbital theory - diagrams for octahedral and tetrahedral complexes without and with $\pi$-bonding, experimental evidences for $\pi$ - bonding. | 5 | 2 |
| 2 | **Electronic Spectral Properties of Metal Complexes** | | | |
| | 2.1 | Electronic spectra of complexes: term symbols and microstates of $d^n$ systems, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields, selection rules for electronic transitions - effect of spin-orbit coupling and vibronic coupling. | 5 | 3 |
| | 2.2 | Correlation diagrams: Orgel and Tanabe – Sugano diagrams. | 3 | 3 |
| | 2.3 | Electronic spectra of metal complexes and their interpretation. Charge transfer spectra, luminescence spectra. | 5 | 3 |
| | 2.4 | Electronic spectra of lanthanide and actinide complexes. | 2 | 3 |
| 3 | **Organometallic Compounds-Synthesis, Structure and Bonding** | | | |

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|---|---|---|---|---|
| | 3.1 | Ligands and their bonding with metals: CO, CN, NO, $N_2$, $H_2$, alkene, alkyne, $PR_3$, arenes, dienes, allyl, carbenes – carbynes (Fischer and Schrock) and alkyl. | 5 | 1 |
| | 3.2 | Preparation of metal nitrosyl, dinitrogen, alkyl, aryl, alkene, alkyne, carbenes - carbynes (Fischer & Schrock), arene and phosphine complexes. | 3 | 1 |
| | 3.3 | 18 electron rule. | 1 | 1 |
| | 3.4 | Bridging and non-bridging (polynuclear) metal carbonyls, IR spectra of metal carbonyls, carbonyl clusters, Wade-Mingos rules. | 3 | 1 |
| | 3.5 | Isolobal analogy. | 1 | 1 |
| | 3.6 | Cyclopentadienyl complexes – fluxionality. | 1 | 1 |
| | 3.7 | Ferrocene: structure and bonding. | 1 | 1 |
| **4** | **Reactions of Organometallic Compounds and Catalysis** | | | |
| | 4.1 | Unique reactions in organometallic chemistry: oxidative addition (concerted and stepwise, $C_{aryl}$-H activation – orthometallation), reductive elimination, migratory insertion (1,1 and 1,2), $\beta$-hydride abstraction/elimination. Agostic interactions, σ-bond metathesis (Zr(IV) and Lu(III)). | 6 | 4 |
| | 4.2 | Homogeneous/heterogeneous catalysis: Tolman catalytic loops, hydrogenation by Wilkinson catalyst, olefin isomerization, Wacker process, hydroformylation (Co & Rh), Monsanto & Cativa acetic acid process, Ziegler-Natta polymerization including metallocene based Zr catalyst, water gas shift reaction and the Fischer-Tropsch reaction (synthesis of gasoline). | 7 | 5 |
| | 4.3 | Grubbs (I generation & II Generation) and Schrock catalysts – preparation and characteristics, olefin metathesis, ROMP. | 2 | 5 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, powerpoint presentation)<br>o Group discussion<br>o Peer teaching |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) (30 Marks)**<br>i) Quiz: 5 marks<br>ii) Assignment: 5 marks<br>iii) Class Test (MCQ/written): 20 marks |
| | **End Semester Examination**<br>**Theory: Written examination (70 marks- 2 Hrs)**<br>i) Short answer, 5 questions (out of 6): 5 x 4 = 20<br>ii) Short essay, 5 questions (out of 7): 5 x 7 = 35<br>iii)Essay, 1 question (out of 2): 1 x 15 = 15 |

**References**


1. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry: A Comprehensive Text*, 3rd Edn. Interscience, 1972.
2. J. E. Huheey, E. A. Keiter, *Inorganic Chemistry Principles of Structure and Reactivity*, 4th Edn. Pearson Education India, 2006.
3. K. F. Purcell, J.C. Kotz, *Inorganic Chemistry*, Cengage, 2010.
4. F. Basolo, R. G. Pearson, *Mechanisms of Inorganic Reactions*, John Wiley & Sons, 2006.
5. E. Douglas, D. H. McDaniel, J. J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn. Wiley-India, 2007.
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7. B. N. Figgis, M. A. Hitchman, *Ligand Field Theory and its Applications*, Wiley-India, 2010.
8. J. D. Lee, *Concise Inorganic Chemistry*, 4th Edn. Wiley-India, 2008.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** |
| **Course Name** | **Organic Chemistry - 5** |
| **Type of Course** | **DCC** |
| **Course Code** | **MCE7DCCCHE401** |
| **Course Level** | **400-499** |
| **Course Summary** | This course delves into the concepts of organic chemistry, focusing on reactive intermediates and the underlying physical principles governing their behaviour. It also investigates concerted reactions and advanced stereochemical aspects of organic reactions. |

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| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Predict the reaction mechanism and rationalize the outcome of various organic reactions and obtain practical experience. | A | 1, 2, 4, 10 |
| 2 | Illustrate and practice the transformations and rearrangements of reactive intermediates. | An | 1, 2, 4, 10 |
| 3 | Correlate the reactivity of organic molecules to HSAB concept and various kinetic and thermodynamic conditions and obtain hands-on experience in this area. | An | 1, 2, 4, 10 |
| 4 | Distinguish and predict the stereoselectivity, regioselectivity, and feasibility of pericyclic reactions and their applications. | E | 1, 2, 3, 4, 10 |
| 5 | Master in determining and differentiating chirality, topicity of organic molecules and explore the chemical consequences and applications of conformational equilibria. | C | 1, 2, 4, 9, 10 |
| 6 | Perform raw mechanisms and schemes using chemistry software. | A | 1, 2, 4, 10 |

| **Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)* |
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**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Organic Reactivity and Mechanistic Insights: Exploring Reactive Intermediates and Physical Principles** | | | |
| | 1.1 | Mechanical aspects of $S_N1$, $S_N2$, $S_NAr$, $S_{RN}1$, $S_Ni$, $S_E1$, $S_E2$, effect of substrate, reagent, leaving group, solvent and neighbouring group on nucleophilic substitution ($S_N2$ and $S_N1$). | 5 | 1 |
| | 1.2 | Reactive Intermediates: non-classical carbocations. Structure, generation and reactions of carbenes and nitrenes: insertion reaction of carbene. Simmons-Smith reaction, Lossen reaction, Curtius reaction, Wolff rearrangement and Hoffmann rearrangement. | 5 | 2 |
| | 1.3 | Physical organic chemistry: kinetic versus thermodynamic control of product formation Hammond postulate, Hammet equation, hard and soft acids and bases – HSAB principle and its applications (organic reactions only). | 5 | 3 |
| 2 | **Symmetry and Molecular Transformations: Insights into Concerted Reactions** | | | |
| | 2.1 | Classification: electrocyclic, sigmatropic, cycloaddition, chelotropic, ene and dyotropic reactions. Woodward -Hoffmann rules - frontier orbital and orbital symmetry correlation approaches - PMO method (for electrocyclic and cycloaddition reactions only). | 5 | 4 |
| | 2.2 | Pericyclic reactions in organic synthesis such as Claisen, Cope, Wittig, and Mislow-Evans rearrangements. Diels-Alder and ene reactions (with stereochemical aspects), dipolar cycloaddition (introductory). | 5 | 4 |
| | 2.3 | Unimolecular pyrolytic elimination reactions of acetates, xanthates and tertiary amine oxides, cheletropic elimination. | 5 | 4 |

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|---|---|---|---|---|
| **3** | **Advanced Stereochemistry & Conformational Stability and Reactivity** | | | |
| | 3.1 | Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidenecycloalkanes. | 5 | 5 |
| | 3.2 | Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature, NMR distinction of enantiotopic /diastereotopic ligands. | 5 | 5 |
| | 3.3 | Conformation and reactivity of cyclohexane systems: dehalogenation, dehydrohalogenation, semipinacolic deamination and pyrolytic eliminations, Grob fragmentation. Chemical consequence of conformational equilibrium - Curtin Hammett principle. | 5 | 5 |
| 4 | **Organic Chemistry - 5 Practical** | | | |
| | | (i) Practice Chemdraw (Use ChemDraw / other software to draw and manipulate different organic chemistry structures and reactions)<br>(ii) Virtual Synthesis of aspirin (enable students to undertake an aspirin synthesis, perform recrystallization, Thin Layer Chromatography and calculation of yield using a digital resource).<br>iii) Synthesis of aspirin<br>iv) Experiment on Hammett equation (Experimentally determine the acid dissociation constant ($K_a$) of a series of substituted benzoic acids, correlate the $K_a$ values with known substituent constants ($\sigma x$) and use the correlation generated above to calculate the substituent constants for 'unknown' substituted benzoic acid compounds. | | 6 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>• Lecture using PowerPoint presentation<br>• Google classroom<br>• Group learning<br>• Laboratory work |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (25 Marks)**<br>i) Pop quizzes: 5 marks<br>ii) Problem based assignments: 5 marks<br>iii) Written/MCQ tests: 15 marks<br>**Practical (15 Marks)**<br>i) Quiz<br>ii) Lab involvement |
| | **B. End Semester Examination**<br>**Theory: Written examination (50 marks- 1.5 Hrs)**<br>i) Short answer, 7 questions (out of 9): 7 x 3 = 21<br>ii) Short essay, 2 questions (out of 3): 2 x 7 = 14<br>iii) Essay, 1 question (out of 2): 1 x 15 = 15<br>**Practical: (35 marks- 1 Hr)**<br>i) Viva voce: 10<br>ii) Written test of practical procedures: 15<br>iii) Certified report of lab work done: 10 |

**References**


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| | **MAHARAJA'S COLLEGE, ERNAKULAM**<br>**(Govt. Autonomous)** |

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| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Molecular Spectroscopy** | | | | | |
| **Type of Course** | **DCC** | | | | | |
| **Course Code** | **MCE7DCCCHE402** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course deals with structure elucidation of organic compounds by means of combined spectral techniques such as IR, UV, NMR and mass spectrometry. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Outline the theoretical aspects of various spectroscopic techniques. | U | 1, 2 |
| 2 | Illustrate the basic concepts of infrared spectroscopy. | U | 1, 2 |
| 3 | Apply the principles of electronic spectroscopy to organic compounds. | A | 1, 2 |
| 4 | Demonstrate the underlying principles of NMR spectroscopy. | U | 1, 2 |
| 5 | Explain the concepts of mass spectrometry. | U | 1, 2 |
| 6 | Deduce the structure of organic compounds by means of combined spectral techniques such as IR, UV, NMR and mass spectrometry. | E | 1, 2, 4, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | **Infrared and Electronic Spectroscopic Techniques** | | | |
| | 1.1 | Hooke's law, bond properties and absorption trends, fundamental vibrations, characteristic regions of the spectrum (fingerprint and functional group regions), influence of substituent, ring size, hydrogen bonding & solvent effect. | 3 | 1, 2 |
| | 1.2 | IR spectra of O-H bonds (alcohols and carboxylic acids), C=C bonds (olefins and arenes), C=O bonds (acids, aldehydes, ketones, and esters) and C-H bonds (alkanes, alkenes and alkynes).<br>Spectral interpretation and problems. | 4 | 1, 2 |
| | 1.3 | Nature of electronic transitions, chromophore, auxochrome, representation of electronic spectra, bathochromic shift, hypsochromic shift, hyperchromic shift and hypochromic shift. | 2 | 1, 3 |
| | 1.4 | Influence of substituents, solvent effect, conjugation, ring size and strain on spectral characteristics. | 2 | 1, 3 |
| | 1.5 | Calculations of $\lambda_{max}$ of enones, aromatic hydrocarbons and conjugated polyenes based on Woodward-Fieser and Fieser-Kuhn rules.<br>Spectral interpretation and problems. | 4 | 1, 3 |
| 2 | **Nuclear Magnetic Resonance Spectroscopy** | | | |
| | 2.1 | NMR phenomena based on $^{1}H$ & $^{13}C$ nuclei, $^{1}H$ & $^{13}C$ NMR spectra, relaxation processes. | 3 | 1, 4 |
| | 2.2 | Chemical shift, magnetic anisotropy and shielding/deshielding, chemical equivalence and number of NMR signals. Population densities of nuclear spin states- intensity of the signal. | 3 | 1, 4 |
| | 2.3 | Spin-spin splitting, coupling constant, geminal coupling, Karplus curve, Pople notation - AX, $AX_2$, $A_2X_3$, AB, $AB_2$ type coupling, first order and non-first order spectra, homotopic, enantiotopic and diastereotopic protons. | 4 | 1, 4 |

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|---|---|---|---|---|
| | 2.4 | Simplification of non-first order spectra to first order spectra: spin decoupling and double resonance, off resonance decoupling, NOE and cross polarization and DEPT.<br>Spectral interpretation and problems. | 5 | 1, 4 |
| **3** | **Mass Spectrometry** | | | |
| | 3.1 | Basic principles. Ionization methods: Gas phase ionization methods– electron impact ionization (EI) and chemical ionization (CI); desorption ionization methods – SIMS, FAB and MALDI. Electrospray ionisation (ESI). Comparison between EI and CI. Mass analysers - time of flight analyser and quadrupole analyzer. Nitrogen and ring rules. Determination of molecular weight and molecular formula. HRMS. Tandem mass spectrometry (MS-MS) (concept only). | 7 | 1, 5 |
| | 3.2 | Fragmentation and structural analysis: types of peaks involved (molecular ion, quasi molecular ion, isotopic peak, base peak, parent ion, daughter ion, fragment ion, metastable ion). Fundamental fragmentation processes – Stevenson's rule, $\alpha$-cleavage, two-bond cleavage, retro Diels- Alder cleavage and McLafferty rearrangements. Fragmentation pattern of hydrocarbons, alcohols, phenols, ethers, carbonyl compounds and amines.<br>Mass spectral analysis and problem solving. | 8 | 1, 5 |
| **4** | **Structure Elucidation of Organic Compounds** | | | |
| | 4.1 | Identification of structures of organic compounds based on the data from mass spectrometry, UV-Vis, IR, $^{1}H$ NMR and $^{13}C$ NMR spectroscopy. Interpretation of the given UV-Vis, IR and NMR spectra. | 15 | 6 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>• Lecture (chalk & board, powerpoint presentation, flipped classroom)<br>• Group discussion – thought problems; mind mapping<br>• Peer interaction<br>• Demonstration using simulations / models |

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| **Assessment Types** | **MODE OF ASSESSMENT**<br><br>**A. Continuous Comprehensive Assessment (CCA) (30 Marks)**<br>i) Quiz: 5 marks<br>ii) Assignment: 5 marks<br>iii) Problem based test (open book): 5 marks<br>iv) Test: 15 marks |
| | **B. End Semester Examination**<br>**Theory: Written examination (70 marks- 2 Hrs)**<br>i) MCQ, 10 questions: 10 x 1 = 10<br>ii) Short answer, 8 questions (out of 10): 8 x 3 = 24<br>iii) Long answer, 3 questions (out of 5): 3 x 7 = 21<br>iv) Essay, 1 question (out of 2): 1 x 15 = 15 |

**References**


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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Drug Therapy and Drug Design** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE7DCECHE400** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course explores the fundamental concepts of drug therapy, drug discovery and design, drug delivery systems and computer aided drug design. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| 1 | Explain the principles of drug therapy. | U | 1,2,3 |
| 2 | Analyse the concepts of drug design, leads, analogues, prodrugs and combinatorial synthesis. | An | 1,2,3 |
| 3 | Develop the concepts of enzymes and receptors as targets of drug design. | A | 1,2,3,10 |
| 4 | List the importance of various drug delivery systems. | U | 1,2,3 |
| 5 | Discuss the principles of computer aided drug design. | U | 1,2,3,10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Principles of Drug Therapy** | | |
| | 1.1 | Introduction to drugs. General Principles of drug therapy. Relationship between chemical structure, lipid solubility and biological activity of drugs. Stereochemistry and biological activity. The importance of water solubility. | 6 | 1 |
| | 1.2 | Drug action: the pharmacokinetic phase- ADME of the drug. The pharmacodynamics phase. | 2 | 1 |
| | 1.3 | Drug metabolism: sites of drug metabolism and phase I and phase II reactions. Prodrugs. | 4 | 1 |
| | 1.4 | Classification of drugs: based on chemical structure, pharmacological action and physiological classification. | 3 | 1 |
| 2 | | **Drug discovery and design** | | |
| | 2.1 | Historical outline, rational drug design. The general stages in modern-day drug discovery and design. | 2 | 2 |
| | 2.2 | Leads and analogues: bioavailability, solubility, structure and stability. | 2 | 2 |
| | 2.3 | Sources of leads and drugs. Approaches to lead optimisation. | 4 | 2 |
| | 2.4 | Prodrug design and applications: prodrug forms of various functional groups, prodrugs and intellectual | 4 | 2 |
| | 2.5 | Combinatorial Chemistry: introduction, solid-phase and solution phase strategies. | 3 | 2 |
| 3 | | **Enzymes, Receptors and Drug Delivery Systems** | | |
| | 3.1 | Enzymes as targets of drug design: enzyme inhibition and activation, approaches to the rational design of enzyme inhibitors. | 3 | 3 |
| | 3.2 | Receptors as targets of drug design: receptor theory, receptor complexes and allosteric modulators, molecular biology of receptors, receptor models and nomenclature, receptor binding assays, lead compound discovery of receptor agonists and antagonists. | 7 | 3 |

| | | | | |
|---|---|---|---|---|
| | 3.3 | Drug delivery systems: general consideration, macromolecular drug carrier systems, bio precursor prodrugs, oxidative activation and reductive activation. | 5 | 4 |
| **4** | **Computer-Aided Drug Design** | | | |
| | 4.1 | Basic concepts of CADD, molecular modelling: energy minimization, geometry optimization, conformational analysis, global conformational minima determination; approaches and problems; bioactive vs. global minimum conformations. Automated methods of conformational search. | 5 | 5 |
| | 4.2 | Molecular docking and dynamics: rigid docking, flexible docking, manual docking; advantages and disadvantages of flex-X, flex-S, autodock and dock softwares with suitable examples; Monte Carlo simulations and molecular dynamics in performing conformational search and docking. | 5 | 5 |
| | 4.3 | QSAR: changing size and shape and introduction of new substituents, lipophilicity, electronic and steric effects, Hansch analysis. Structure activity relationships and pharmacological activity. CoMFA analysis, 3D-QSAR. | 5 | 5 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

| | |
|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture Sessions<br>o Interactive sessions including discussions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) Total marks: 30**<br>i) Assignments<br>ii) MCQ<br>iii) Class test<br>iv) Viva<br>**B. Semester end examination Total Marks: 70- 2 hrs.**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


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| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Industrial Chemistry** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE7DCECHE401** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course covers the manufacture and applications of inorganic and organic chemicals, petroleum refining, industrial safety and pollution prevention. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Explain the manufacture and uses of common inorganic and organic chemicals. | U | 1,2 |
| 2 | Describe various processes involved in petroleum | U | 1,2 |
| 3 | Discuss safety aspects of the chemical industry. | U | 1,2 |
| 4 | Analyse various aspects of industrial pollution prevention. | An | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| | **Inorganic Chemicals** | | | |
| **1** | 1.1 | Manufacture and applications of sulphuric acid, phosphoric acid, lime, soda ash, titanium dioxide and sodium chloride. | 7 | |
| | 1.2 | Manufacture and uses of syn gas, nitrogen, oxygen, hydrogen and ammonia. | 4 | |
| | 1.3 | Production of potable water: break-point chlorination and ozonization, flocculation and sedimentation, filtration, removal of dissolved inorganic impurities, activated charcoal treatment. Production of deionized water. Production of freshwater from seawater and brackish water. | 4 | |
| **2** | **Petroleum Refining** | | | |
| | 2.1 | Primary raw materials for petrochemicals- natural gas, crude oil (composition, properties and classification), coal, oil shale, tar sand and gas hydrates. | 5 | |
| | 2.2 | Introduction to petroleum refining, desalting, distillation, hydrotreating or hydroprocessing, cracking or hydrocracking, coking, visbreaking, steam cracking, alkylation, catalytic reformers, removal of the natural gas fraction, sulfur recovery. | 7 | |
| | 2.3 | Hydrocarbon intermediates and liquid petroleum fractions, chemicals based on methane. | 3 | |
| **3** | **Organic Chemicals** | | | |
| | 3.1 | Manufacture and uses of methanol, formaldehyde, formic acid and hydrocyanic acid. | 5 | |
| | 3.2 | Manufacture and uses of ethylene, propene and acetylene. | 3 | |
| | 3.3 | Hydroformylation of olefins, industrial hydroformylation. | 2 | |
| | 3.4 | Manufacture and uses of ethanol, acetaldehyde and acetic acid. | 3 | |
| | 3.5 | Chemicals based on benzene, toluene and xylenes. | 2 | |
| **4** | **Safety Considerations and Industrial Pollution Prevention** | | | |
| | 4.1 | OSHA (Occupational Safety and Health Administration) and PSM (Process Safety Management). | 2 | |

| | | | | |
|---|---|---|---|---|
| | 4.2 | Types of hazards in industries: heat and temperature, pressure, electrical, and mechanical hazards, toxic materials, fire and | 6 | |
| | 4.3 | Types of industrial wastes, public concern over pollution, legislation to waste management, industrial pollution | 7 | |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lecture Sessions<br>o Interactive sessions including discussions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) Total marks: 30**<br>i) Assignments<br>ii) MCQ<br>iii) Class test<br>iv) Viva |
| | **B. End Semester Examination: Total marks: 70- 2 hrs.**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Advanced Chemistry of Main Group Elements** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE7DCECHE402** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course explores the advanced aspects of properties and chemistry of main group elements. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Describe the advanced chemistry of main group elements. | U | 1,2 |
| 2 | Analyse the coordination and aqueous chemistry of group 1 and 2 metals. | An | 1,2 |
| 3 | Analyse the compounds and coordination complexes of group 13 and 14 elements. | An | 1,2 |
| 4 | Analyse the properties and chemistry of group 15 and 16 elements. | An | 1,2 |
| 5 | Compare the chemistry of halogens, and noble gases. | An | 1, 2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | | **Group 1 and Group 2 Metals** | | |
| | 1.1 | Aqueous solution chemistry of group 1 metal compounds, complex formation of group 1 metals with crown ethers, sandwich complexes with crown ethers, cryptates of group 1 metal ions, sodide ion in cryptates, alkalide ions of higher alkali metals, uses of alkali metal cryptands. | 5 | 1,2 |
| | 1.2 | Non-aqueous coordination chemistry of alkali metals. Zintl phases containing alkali metals. Compound formation with aromatic compounds, sodium and potassium alkyls. | 4 | 1,2 |
| | 1.3 | Complex ions of group 2 metals in aqueous solution, complexes of group 2 metal ions with EDTA, $[P_3O_{10}]^{5-}$, crown ethers and cryptands. Complexes of group 2 metal ions with amido and alkoxy ligands. | 6 | 1,2 |
| 2 | | **Group 13 and 14 Elements** | | |
| | 2.1 | Biological aspects of boron, toxicity of aluminium, aqua ions of Al, Ga, In and Tl, coordination complexes of $M^{3+}$ ions of Al, Ga and In. Metal borides- synthesis, structure and applications. | 4 | 1, 3 |
| | 2.2 | Zintl phases of group 13 elements. Spinels and tricalcium aluminate. Chalcogenides of Al, Ga, In and Tl. | 4 | 1, 3 |
| | 2.3 | Complexes containing a naked carbon atom, complexes containing naked dicarbon ligands. Carbides, silicides, germides, stannides and plumbides. Zintl ions containing Si, Ge, Sn and Pb. Polyatomic anions of Ge, Sn, and Pb. Sila- and germa-aromatic compounds. | 7 | 1,3 |
| 3 | | **Group 15 and 16 Elements** | | |
| | 3.1 | Hydrogen azide and azide salts. Nitrides, phosphides, arsenides, antimonides and bismuthides. Organometallic compounds of arsenic, antimony, and bismuth. π-Coordination complexes of phosphorus–carbon compounds. | 7 | 1,4 |
| | 3.2 | Polyanions and polycations of sulfur, selenium, and tellurium. Polysulfides, polyselenides and polytellurides. Compounds of sulfur and selenium with nitrogen. | 4 | 1,4 |

| | | | | |
|---|---|---|---|---|
| | 3.3 | Allotropes of selenium and tellurium. Polyatomic cations and anions of selenium and tellurium. Biological aspects of oxygen, sulphur and selenium. | 4 | 1,4 |
| **4** | **Group 17 and 18 Elements** | | | |
| | 4.1 | Industrial extraction of fluorine, fluoridation of water. Polyhalogen cations, polyhalide anions, oxofluorides of chlorine, bromine and iodine. | 4 | 1,5 |
| | 4.2 | Aqueous solution chemistry of chlorine, bromine and iodine. Biological aspects of fluorine, chlorine, bromine and iodine. Chemistry of astatine. | 4 | 1,5 |
| | 4.3 | Chemistry and uses of helium. Synthesis, structure and reactions of xenon insertion compounds, organoxenon compounds and compounds containing metal–xenon bonds. | 4 | 1,5 |
| | 4.4 | Compounds of argon, krypton and radon and coordination compounds of noble gases. Biological aspects of noble gases. | 3 | 1,5 |
| **5** | **Teacher Specific Content** | | | |
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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lecture sessions<br>o Interactive sessions including discussions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) Total marks: 30**<br>i) Assignments<br>ii) MCQ<br>iii) Class test<br>iv) Viva |
| | **B. End Semester Examination**<br>**Total Marks- 70- 2hrs.**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Statistical Thermodynamics and Bioenergetics** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE7DCECHE403** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course covers the principles of statistical thermodynamics and applications of thermodynamics and statistical thermodynamics to various biological processes. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Describe the basic principles of statistical thermodynamics. | U | 1,2,3 |
| 2 | Apply the principles of statistical thermodynamics to biological processes. | A | 1,2,3 |
| 3 | Analyse the energy changes associated with various biological processes. | An | 1,2,3 |
| 4 | Apply the principles of thermodynamics to various biological processes. | An | 1,2,3 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Statistical Thermodynamics -1** | | | |
| | 1.1 | Probability, Stirling's approximation, macrostates and microstates, ensemble, types of ensembles. | 3 | 1 |
| | 1.2 | Boltzmann distribution law, partition function and its physical significance, relation between molecular partition function and molar partition function, distinguishable and indistinguishable particles, partition function and thermodynamic functions, separation of partition function-translational, rotational, vibrational, and electronic partition functions. The equipartition theorem. | 7 | 1 |
| | 1.3 | Thermodynamic properties: internal energy, heat capacity, entropy, enthalpy and Gibbs free energy. Statistical basis of chemical equilibrium. | 5 | 1 |
| 2 | **Statistical Thermodynamics -2** | | | |
| | 2.1 | Need for quantum statistics, bosons and fermions, Bose-Einstein statistics: Bose-Einstein distribution law, Bose-Einstein condensation, first order and higher order phase transitions, liquid helium, Fermi- Dirac statistics: Fermi-Dirac distribution law, application in electron gas, thermionic emission. Comparison of three statistics. | 10 | 1 |
| | 2.2 | Applications of statistical mechanics to biological processes: helix– coil Transitions, cooperative transitions, internal energy and heat capacity of biological macromolecules, protein heat capacity functions. | 5 | 2 |
| 3 | **Bioenergetics** | | | |
| | 3.1 | Bioenergetics, standard free changes in biochemical reactions, coupled reactions, ATP and its role in bioenergetics, high energy bond, free energy and entropy change in ATP hydrolysis. | 8 | 3 |
| | 3.2 | Thermodynamics of synthesis of ATP, thermodynamic aspects of metabolism and respiration, glycolysis, biological redox reactions and citric acid cycle. | 7 | 3 |
| | **Thermodynamic Aspects of Biological Processes** | | | |

| | | | | |
|---|---|---|---|---|
| 4 | 4.1 | Thermodynamic aspects of photosynthesis, osmosis, dialysis, enzyme-substrate interactions, binding of oxygen to myoglobin and haemoglobin, cooperativity, allostery and proton binding by biomolecules. | 8 | 4 |
| | 4.2 | Thermodynamic aspects of transport of ions across biological membranes, biosynthesis of proteins, buffer action in blood, protein structure, mechanisms of protein folding and unfolding and DNA melting. | 7 | 4 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (mode of transaction)**<br>o Lecture sessions<br>o Interactive sessions including discussions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Total marks: 30**<br>i) Assignments<br>ii) MCQ<br>iii) Class test<br>iv) Viva |
| | **B. End Semester Examination Total Marks: 70- 2hrs.**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Novel Inorganic Solids** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE7DCECHE404** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course covers the synthetic route to novel inorganic solids, properties and applications of inorganic nanomaterials, engineering materials, composite materials and speciality polymers. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Describe different types of novel solids. | U | 1,2 |
| 2 | Discuss synthetic methods of inorganic solids. | U | 1,2 |
| 3 | Explain the synthesis, properties and applications of novel inorganic nanomaterials. | U | 1,2 |
| 4 | Analyse various inorganic engineering materials and materials. | An | 1,2 |
| 5 | Describe the synthesis, properties aapplications of polymers. | U | 1, 2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs | CO No. |
|---|---|---|---|---|
| 1 | **Types of Novel Inorganic Solids and Synthetic Methods** | | | |
| | 1.1 | Solid electrolytes – cationic, anionic and mixed. Inorganic pigments – coloured solids. Molecular material and fullerides, one- dimensional metals, molecular magnets, inorganic liquid crystals. | 7 | 1 |
| | 1.2 | Synthetic methods: conventional heat and beat methods, co- precipitation, sol-gel, chemical vapour deposition, ceramic, alloying, hydrothermal, electrochemical and intercalation methods. Microwave synthesis. | 8 | 2 |
| 2 | **Nanomaterials** | | | |
| | 2.1 | Metal oxide nanostructures: synthesis-sol-gel and electrochemical deposition, applications in photovoltaics, lithium ion batteries, catalysis, gas sensing and biomedical applications. | 4 | 3 |
| | 2.2 | Magnetic nanomaterials for energy storage: synthesis- co- precipitation and chemical oxidation, applications of $Fe_2O_3$ and $Fe_3O_4$ nanomaterials for energy storage. | 4 | 3 |
| | 2.3 | Transition metal dichalcogenide nanomaterials: Synthesis- chemical vapour deposition, doping, applications in electronics, photonics and gas sensing. | 3 | 3 |
| | 2.4 | Inorganic nanotubes: general synthetic methods- sol-gel and hydrothermal methods, applications. | 2 | 3 |
| | 2.5 | Inorganic nanowires: synthesis-vapour phase growth, properties and applications. | 2 | 3 |
| 3 | **Engineering Materials for Mechanical Construction and Composite Materials** | | | |
| | 3.1 | Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes, cutting tool materials, super alloys, thermoplastics, thermosets and composite materials. | 7 | 4 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites. | 8 | 4 |
| **4** | **Speciality Polymers** | | | |
| | 4.1 | Preceramic inorganic polymers: carbon Fiber, silicon carbide (SiC), silicon nitride (Si3N4), boron nitride (BN), boron carbide (B4C), aluminum nitride (AlN), phosphorus nitride. Poly(ferrocenylsilanes) as ceramic precursors. | 8 | 5 |
| | 4.2 | Sulfur-based inorganic polymers: polythiazyl and polythiol. | 3 | 5 |
| | 4.3 | Ferrocene based polymers: synthetic methods, Fc-based polypyrrole and cyclodextrin- synthesis and applications. | 4 | 5 |
| **5** | **Teacher Specific Content** | | | |
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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>Lecture sessions, interactive sessions including discussions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) Total marks: 30**<br>i) Assignments<br>ii) MCQ<br>iii)Class test<br>iv) Viva |
| | **B. End Semester Examination (Total Marks: 70- 2 hrs.)**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

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|---|---|---|---|---|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Analytical Chemistry** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE7DSECHE400** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course covers the fundamentals of analytical chemistry and discusses topics such as precision, accuracy and errors. Additionally, it encompasses qualitative analysis techniques, safety protocols, titrimetric analysis, and the principles and applications of | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Other | |
| | | 4 | | 0 | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Explain fundamental measurement concepts, and errors in analytical chemistry. | U | 1,2,3,10 |
| 2 | Develop safe laboratory methods of chemical analysis. | An | 1,2,3 |
| 3 | Develop a comprehensive knowledge of titrimetric analysis including redox titrations, complexometric titrations, conductometric titrations and potentiometric titrations. | A | 1, 2,3 |
| 4 | Apply the principles of gravimetric analysis. | A | 1, 2,3 |
| 5 | Analyse various separation and purification techniques of compounds. | An | 1, 2,3 |
| 6 | Distinguish between different chromatographic methods based on their principle and mechanism. | An | 1, 2,3,10 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Introduction** | | |
| | 1.1 | The role of analytical chemistry, qualitative and quantitative analysis, general features of a typical quantitative analysis- choosing a method, acquiring the sample, processing the sample, eliminating interferences, calibration and measurement, calculation and evaluation of results. Case study illustrating the use of analytical chemistry to solve a problem. | 6 | 1 |
| | 1.2 | Calculations used in analytical chemistry: units of measurement- mass and weight, the mole, concentrations of solutions, p- functions, density and specific gravity. Chemical stoichiometry and stoichiometric calculations. | 5 | 1 |
| | 1.3 | Errors in chemical analysis: mean and median, precision and accuracy, absolute error and relative error. Random, systematic and gross errors. Sources and effects of systematic errors. Minimising systematic errors. | 4 | 1 |
| 2 | | **Chemicals apparatus and unit operations of analytical chemistry** | | |
| | 2.1 | Selecting and handling reagents and other chemicals. | 2 | 2 |
| | 2.2 | Cleaning and marking of laboratory ware. | 2 | 2 |
| | 2.3 | Evaporating liquids, measuring mass, equipment and manipulations associated with weighing, measuring volume, calibrating volumetric glassware. | 3 | 2 |
| | 2.4 | The laboratory notebook. | 1 | 2 |
| | 2.5 | Sampling, standardization, and calibration. | 4 | 2 |
| | 2.6 | Safety in the laboratory- the four principles of safety, personal protective equipment: eye protection, lab coat, shoes and long pants, gloves, respiratory protection and masks, hair, lead apron and shields. | 3 | 2 |
| 3 | | **Titrimetric and Gravimetric Analysis** | | |
| | 3.1 | Titrimetric analysis – basic concepts of redox reactions, redox titrations involving $KMnO_4$, and $K_2Cr_2O_7$, titration curves, redox indicators. | 4 | 3 |

| | | | | |
|---|---|---|---|---|
| | 3.2 | Complexometric titrations – direct, indirect, back and replacement titrations, EDTA titrations. Precipitation titrations - methods of argentometric titration-indicators. | 6 | 3 |
| | 3.3 | Conductometric and potentiometric titrations – principle, examples and graphical representation. | 2 | 3 |
| | 3.4 | Gravimetric analysis: unit operations in gravimetric analysis - illustrations using iron and barium estimation. | 3 | 4 |
| **4** | **Separation and Purification of compounds** | | | |
| | 4.1 | Separation and purification techniques: filtration, recrystallization, precipitation, distillation, fractional distillation, solvent extraction and sublimation. | 4 | 5 |
| | 4.2 | Chromatography- principle and classification. Chromatographic techniques: paper chromatography, thin layer chromatography, Rf-values. | 3 | 6 |
| | 4.3 | Principle and applications of column chromatography, high- performance liquid chromatography (HPLC), gas chromatography, gel permeation chromatography (GPC), ion exchange chromatography, and reverse phase chromatography. | 8 | 6 |
| **5** | **Teacher Specific content** | | | |
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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of experiments<br>o Hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) Total marks: 30**<br>i) Assignments MCQ<br>ii) Class test<br>iii) Viva<br>**B. End Semester Examination (Total Marks: 70- 2 hrs.)**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


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4. R. Puri, L. R. Sharma, Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2020.
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| | MAHARAJA'S COLLEGE, ERNAKULAM<br>(Govt. Autonomous) | | | | | |
|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Biophysical Chemistry** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE7DSECHE401** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course explores how the principles of thermodynamics, chemical equilibrium, chemical kinetics and quantum mechanics are applied to biological processes. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Apply the principles of thermodynamics to life processes. | A | 1,2 |
| 2 | Analyse biological equilibrium processes. | An | 1,2 |
| 3 | Examine kinetic aspects of biological processes. | An | 1,2 |
| 4 | Apply the principles of quantum mechanics to simple chemical and biological systems. | A | 1,2 |

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| | **Thermodynamics** | | | |
| | 1.1 | Work, heat, internal energy, enthalpy, heat capacity. The first law of thermodynamics. The enthalpy of phase transition- case study- thermal denaturation of a protein. | 5 | 1 |
| | 1.2 | The second law of thermodynamics, entropy and entropy change. Entropy change and life. The Third Law of thermodynamics. | 4 | 1 |
| | 1.3 | Spontaneity and Gibbs free energy. Free energy as maximum work. Proteins- primary, secondary, tertiary and quaternary structures. Gibbs energy change of protein assembly. Basic idea of metabolism and free energy changes of metabolic cycles. | 6 | 1 |
| **2** | **Equilibrium** | | | |
| | 2.1 | Molar free energy of reaction. Reactions at equilibrium and Gibbs free energy change. Relationship between the Gibbs energy and equilibrium constant. Acid–base equilibria. Catalysts and equilibrium | 6 | 2 |
| | 2.2 | Temperature and equilibrium, coupled reactions. Active transport. Binding of oxygen to myoglobin and haemoglobin-thermodynamic aspects, cooperativity and allosteric effect. Standard Gibbs energy of formation and calculation of standard reaction Gibbs energy. | 9 | 2 |
| **3** | **Chemical Kinetics** | | | |
| | 3.1 | Rate of reaction, rate laws and rate constants, order of a reaction, first order and second order reactions. The temperature dependence of reaction rates- the Arrhenius equation and Arrhenius parameters. Reaction rates near equilibrium. | 7 | 3 |
| | 3.2 | Enzymes as biological catalysts- substrate binding, active site and lock and key principle. Enzyme catalysis: the Michaelis–Menten mechanism. The catalytic efficiency of enzymes. Enzyme inhibition. Pharmacokinetics. Fast events in protein folding. | 8 | 3 |

| | | | | |
|---|---|---|---|---|
| **4** | **Quantum Mechanics** | | | |
| | 4.1 | Basics of quantum mechanics, electromagnetic radiation, wave properties of matter, quantization of energy and fundamentals of spectroscopy. Types of spectroscopy. The uncertainty principle. | 7 | 4 |
| | 4.2 | The particle in a box- the electronic structure of β-carotene. Quantum mechanical tunnelling- Scanning probe microscopy (STM and AFM). Particle on a ring- the electronic structure of phenylalanine. | 8 | 4 |
| **5** | **Teacher Specific content** | | | |
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| | |
|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture sessions<br>o Interactive sessions including discussions |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA) Total marks: 30**<br>i) Assignments<br>ii) MCQ<br>iii) Class test<br>**B. End Semester Examination: Total Marks: 70- 2 hrs.**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. P. Atkins, J. Paula, *Physical Chemistry for the Life Sciences*, Oxford University Press, 2006.
2. D. T. Haynie, *Biological Thermodynamics*, 2nd Edn. Cambridge University Press, 2008.
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| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Nano chemistry and Technology** | | | | | |
| **Type of Course** | **DSE** | | | | | |
| **Course Code** | **MCE7DSECHE402** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course explores fundamental concepts of nanotechnology covering synthesis, characterisation, properties and applications of nanomaterials. | | | | | |
| **Semester** | VII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| 1 | Explain the fundamental concepts of nanomaterials. | U | 1,2 |
| 2 | Compare bottom-up and top-down approaches in nanomaterial synthesis. | C | 1,2 |
| 3 | Describe various characterisation techniques of nanomaterials. | An | 1,2 |
| 4 | Explain the properties of different types of nanomaterials. | U | 1,2 |
| 5 | Analyse the applications of nanomaterials in various fields. | An | 1,2,3,10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Introduction** | | |
| | 1.1 | Feynman's hypothesis- scales of nanosystems- Moore's law. | 2 | 1 |
| | 1.2 | Different types of nanomaterials. Classification of nanomaterials based on dimensions and origin. | 3 | 1 |
| | 1.3 | Nano in nature: lotus-leaf effect, Gecko's feet, butterfly wings, and magneto-tactic bacteria. | 2 | 1 |
| | 1.4 | Bottom-up techniques for the synthesis of nanomaterials: chemical vapour deposition, reduction techniques, solvothermal, sonochemical, biomimetic, molecular self- assembly and sol-gel methods. | 4 | 2 |
| | 1.5 | Top-down techniques: mechano-chemical, laser ablation, arc-discharge, sputtering, etching, lithography and electrospinning methods. | 4 | 2 |
| 2 | | **Characterization of Nanomaterials** | | |
| | 2.1 | Imaging through electron microscopy: interaction of electron beam with sample. Scanning electron microscope and transmission electron microscope-comparison, advantages, applications and basic instrumental features. | 4 | 3 |
| | 2.2 | Scanning probe microscopy: scanning tunnelling microscope and atomic force microscope-comparison, applications and basic instrumental features. | 4 | 3 |
| | 2.3 | Characterisation through spectroscopy: UV-visible, IR, X-ray photoelectron and Auger electron spectroscopy. Secondary ion mass spectrometry.<br>X-ray diffraction, dynamic light scattering and zeta potential analysis methods. | 7 | 3 |
| | | **Properties of Nanomaterials** | | |
| | 3.1 | Size effects: quantum confinement, the density of states and high surface area. | 2 | 4 |

| | | | | |
|---|---|---|---|---|
| **3** | 3.2 | Thermal properties: surface energy, thermal conductivity and melting of nanomaterials. | 3 | 4 |
| | 3.3 | Electronic and electrical properties: one dimensional conduction-ballistic conduction, the Coulomb blockade effect, the electron density of states and superconductivity. | 4 | 4 |
| | 3.4 | Magnetic properties: giant magnetoresistance, finite-size effects and surface effects. | 3 | 4 |
| | 3.5 | Optical properties: colour of quantum dots, surface plasmon resonance and quantum fluorescence. | 3 | 4 |
| **4** | **Applications of Nanoparticles** | | | |
| | 4.1 | Medicine and healthcare: applications of nanomaterials in medical diagnosis, advanced drug delivery systems, targeted drug delivery and therapy. | 4 | 5 |
| | 4.2 | Applications of nanotechnology in integrated circuits, data storage and displays. | 2 | 5 |
| | 4.3 | Applications of nanotechnology in water purification and air pollution control. | 2 | 5 |
| | 4.4 | Piezoelectric nanomaterials, hydrogen generation and storage, batteries and solar energy harvesting. | 2 | 5 |
| | 4.5 | Chemical and biosensors using nanomaterials and defence applications of nanotechnology. | 2 | 5 |
| | 4.6 | Applications of grapheme, carbon nanotubes and fullerenes. | 3 | 5 |
| **5** | **Teacher Specific Content** | | | |
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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Interactive instruction (chalk & board method, multimedia presentation)<br>o Group discussion<br>o Peer teaching<br>o Experimental demonstrations<br>o Practical training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (Total 30 marks)**<br>i) Assignments<br>ii) MCQ<br>iii) Class test<br>iv) Viva |
| | **B. End Semester Examination (Total marks: 70- 2hrs.)**<br>i) Short answer 5 questions (out of 7): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. N. Kumar, K. Sunita, *Essentials in Nanoscience and Nanotechnology*, Wiley, 2016.
2. T. Pradeep *NANO: The Essentials: Understanding Nanoscience and Nanotechnology*; 1st Edition ed.; McGraw-Hill Education: New York, 2007
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# SEMESTER VIII

| | MAHARAJA'S COLLEGE, ERNAKULAM<br>(Govt. Autonomous) | | | | | |
|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Advanced Coordination and Organometallic Chemistry** | | | | | |
| **Type of Course** | **DCC** | | | | | |
| **Course Code** | **MCE8DCCCHE400** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course offers a comprehensive exploration of advanced topics in inorganic chemistry, covering magnetic properties, substitution mechanisms, organometallic catalysis including asymmetric catalysis, practical gravimetric analysis, and the separation and identification of cation mixtures. | | | | | |
| **Semester** | VIII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 2 | | 2 | | 90 |
| **Pre-requisites, if any** | Basic knowledge in Coordination and Organometallic Chemistry | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Analyse and explain the magnetic properties of coordination complexes | An | 1, 2 |
| 2 | Evaluate the kinetics and mechanism of ligand substitution reactions in coordination complexes. | E | 1, 2 |
| 3 | Analyse the applications of organometallic compounds in organic synthesis and catalysis | An | 1, 2 |
| 4 | Explain the properties and utility of polyferrocenylsilanes. | U | 1, 2 |
| 5 | Apply gravimetric analysis techniques in estimating metal ions, including nickel (II), copper, iron, and aluminium | A | 1, 2 |

| | | | |
|---|---|---|---|
| 6 | Apply qualitative analysis techniques to distinguish and confirm the presence of specific cations, showcasing a comprehensive understanding of cation separation | A | 1, 2 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| **1** | **Magnetic Properties and Ligand Substitution Mechanisms in Coordination Complexes** | | | |
| | 1.1 | Magnetic properties of complexes - paramagnetic and diamagnetic complexes, molar susceptibility, Gouy method for the determination of magnetic moment of complexes, spin only magnetic moment. | 3 | 1 |
| | 1.2 | Temperature dependence of magnetism- Curie's law, Curie-Weiss law, temperature independent paramagnetism (TIP). | 2 | 1 |
| | 1.3 | Kinetics and mechanism of octahedral substitution- water exchange, dissociative, associative and interchange mechanisms, acid hydrolysis, base hydrolysis, $SN_1cB$ mechanism. | 4 | 2 |
| | 1.4 | Electron transfer reactions: outer sphere mechanism – Marcus' theory, inner sphere mechanism- Taube mechanism, mixed outer and inner sphere reactions, two electron transfer and intramolecular electron transfer. | 4 | 2 |
| | 1.5 | Δ and Λ isomers, linkage isomerism: electronic and steric factors affecting linkage isomerism. | 2 | 2 |
| **2** | **Organometallic Homogeneous Catalysis & Asymmetric versions** | | | |
| | 2.1 | Organometallic reagents in organic synthesis – Petasis, Schwartz reagents for organic transformations. Reppe reaction, Dötz reaction. | 4 | 3 |
| | 2.2 | Hydrogenation reactions- H2 hydrogenation and isopropanol transfer hydrogenations catalyzed by Ru(II) complexes, ionic hydrogenation, hydrosilylation. | 3 | 3 |
| | 2.3 | Asymmetric catalysis- chiral phosphine ligands (structure only) - P-chiral ligands, BINAP, DIOP, ferrocene based ligands - Josiphos, asymmetric hydrogenation, Noyori hydrogenations, Shvo catalyst, transfer hydrogenation of ketones and | 5 | 3 |

| | | | | |
|---|---|---|---|---|
| | | imines, metal-ligand bifunctional catalysis-cooperative effect. | | |
| | 2.4 | Preparation of L-DOPA drug, Matalachlor herbicide | 1 | 3 |
| | 2.5 | Organometallic polymers: synthesis, properties and applications of polyferrocenylsilanes. | 2 | 4 |
| **3** | **Inorganic Practical -4** | | | |
| | | **Part-1**<br>**Gravimetric Analysis:**<br>i. Estimation of nickel (II) using dimethylglyoxime (DMG)<br>ii. Estimation of copper as CuSCN<br>iii. Estimation of iron as $Fe_2O_3$ by precipitating iron as $Fe(OH)_3$.<br>iv. Estimation of Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate). | 30 | 5 |
| **4** | | **Part-2**<br>Separation and identification of a mixture of four cations (a mixture of two familiar ions such as $Ag^+$, $Hg^{2+}$, $Pb^{2+}$, $Cu^{2+}$, $Bi^{2+}$, $Cd^{2+}$, $As^{3+}$, $Sn^{2+}$, $Sb^{3+}$, $Fe^{2+}$, $Fe^{3+}$, $Al^{3+}$, $Cr^{3+}$, $Zn^{2+}$, $Mn^{2+}$, $Co^{2+}$, $Ni^{2+}$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Mg^{2+}$, $Li^+$, $Na^+$, $K^+$ and $NH_4^+$ and two less familiar metal ions such as Tl, W, Se, Mo, Ce, Th, Ti, Zr, V, U and Li). Minimum four mixtures to be given. | 30 | 6 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk &board, PowerPoint presentation)<br>o Group discussion<br>o Peer teaching<br>o Demonstration of experiments<br>o Hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory:15 Marks**<br>i) Quiz<br>ii) Test for each unit (MCQ/Written)<br>**Practical (15 marks)**<br>i) Lab involvement<br>ii) Report<br>iii)Lab test |

| | |
|---|---|
| | **B. End Semester examination**<br>**Theory: Written examination (35 Marks- 1 Hr.)**<br>i) Short answer 5 questions (out of 7): 5 × 3 = 15 marks<br>ii) Short Essay 2 questions (out of 3): 2 × 10 = 20 marks<br>**Practical: 35 Marks-1 Hr.**<br>i) Certified report -10 marks<br>ii) Procedure- 15 marks<br>iii) Viva voce- 10 marks |

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2. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, *Advanced Inorganic Chemistry*, 6th Edn, Wiley-Interscience, 1999.
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5. B.E. Douglas, D.H. McDaniel, J. J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn. Wiley-India, 2007.
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7. B.D. Guptha, A.J Elias, *Basic Organometallic Chemistry*, Universities Press, 2010.
8. Astruc, D., *Organometallic Chemistry and Catalysis*, Springer Verlag, 2007.
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10. J. G. de Vries, C. J. Elsevier (Editors), *Handbook of Homogeneous Hydrogenations*, 3 Volumes, WileyVCH, 2006.
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| | MAHARAJA'S COLLEGE, ERNAKULAM<br>(Govt. Autonomous) | | | | | |
|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Physical Chemistry-4** | | | | | |
| **Type of Course** | **DCC** | | | | | |
| **Course Code** | **MCE8DCCCHE401** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course covers advanced aspects of kinetic theory of gases, chemical kinetics, surface chemistry and physical chemistry practical. | | | | | |
| **Semester** | VIII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 2 | | 2 | | 90 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Explain the molecular velocities of gases, mean free path, collision diameter and effusion. | U | 1, 2 |
| 2 | Illustrate the theories of reaction rates and correlate the thermodynamically measurable parameters. | A | 1, 2 |
| 3 | Compare the nature of reactions in the gas as well as in the solvent phase. | An | 1, 2 |
| 4 | Assess the theories and applications of adsorption with the help of adsorption isotherms. | E | 1, 2 |
| 5 | Explain different methods for the molar mass determination of macromolecules. | U | 1, 2 |
| 6 | Experiment with three component systems, kinetics, polarimetry and refractometry practicals. | S | 1, 2, 9, 10 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Kinetic Theory Of Gases** | | | |
| | 1.1 | Derivation of Maxwell's law of distribution of velocities, graphical representation, experimental verification of the law, most probable velocity, derivation of average, RMS and most probable velocities. | 5 | 1 |
| | 1.2 | Collision diameter, collision frequency in a single gas and in a mixture of two gases, mean free path, frequency of collision, effusion, the rate of effusion, time dependence of pressure of an effusing gas, the law of corresponding states, transport properties of gases. | 5 | 1 |
| 2 | **Chemical Kinetics** | | | |
| | 2.1 | Theories of reaction rates: potential energy surfaces. Conventional transition state theory, comparison of the collision theory and conventional transition state theories. | 4 | 2 |
| | 2.2 | Thermodynamic formulation of the reaction rate-Eyring equation. Significance of $\Delta G^{\#}$, $\Delta H^{\#}$ and $\Delta S^{\#}$, volume of activation. Effect of pressure and volume on velocity of gaseous reactions. Reactions in solution: Effect of solvent on reaction rate, cage effect. Effect of dielectric constant and ionic strength on reaction rate - Bronsted-Bjerrum equation | 6 | 2, 3 |
| 3 | **Surface Chemistry** | | | |
| | 3.1 | Multilayer adsorption-BET theory, use of BET isotherms for surface area determination. | 3 | 4 |
| | 3.2 | Application of Langmuir adsorption isotherm in surface catalysed reactions, the Eley-Rideal mechanism and the Langmuir-Hinshelwood mechanism, flash desorption. Macromolecules: Different averages, methods of molecular mass determination - osmotic, viscosity, sedimentation and light scattering methods | 7 | 4, 5 |
| 4 | **Physical Chemistry IV- Practicals** | | | |
| | 1. Construction of phase diagram of three component system with one pair of partially miscible liquids. | | 60 | 6 |
| | 2. Kinetics of simple reactions e.g. acid hydrolysis of methyl /ethyl acetate | | | 6 |

| | | | |
|---|---|---|---|
| | 3. Kinetics of reaction between $K_2S_2O_8$ and KI | | 6 |
| | 4. Data analysis of kinetic experiments using spreadsheet program (determination of rate constant). | | 6 |
| | 5. Polarimetry:<br>• Kinetics of the inversion of sucrose in presence of HCl.<br>• Determination of the concentration of a sugar solution.<br>• Determination of the concentration of HCl.<br>• Determination of the relative strength of acids. | | 6 |
| | 6. Refractometry:<br>• Identification of pure organic liquids and oils.<br>• Determination of molar refractions of pure liquids.<br>• Determination of concentration of solutions (KCl-water, glycerol—water).<br>• Determination of molar refraction of solids.<br>• Study of complex formation between potassium iodide and mercuric iodide system. | | 6 |
| **5** | **Teacher Specific Content** | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture sessions (chalk & board, powerpoint presentation)<br>o Interactive sessions and simulations<br>o Visual aids like videos and models to enhance understanding<br>o Peer discussions<br>o Laboratory experiments and hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory (15 Marks)**<br>i) Assignment<br>ii) Quiz<br>iii) Test for each for unit (MCQ/Written)<br>**Practical (15 marks)**<br>i) Lab involvement<br>ii) Report<br>iii) Lab test |
| | B. **Semester End examination**<br>**Theory: Written examination (35 Marks-1 Hr)**<br>i) Short answer 5 questions (out of 7): 5 × 3 = 15 marks<br>ii) Short Essay 2 questions (out of 3): 2 × 10 = 20 marks<br>**Practical: (35 Marks-1 Hr)**<br>i) Certified report- 10 marks |

| | |
|---|---|
| | ii) Procedure- 5 marks<br>iii)Viva voce- 15 marks |

**References**


1. K. J. Laidler, *Chemical Kinetics*, 3rd Edn. Pearson education, 2004.
2. I.N. Levine, *Physical Chemistry*, Tata McGraw Hill, 2012.
3. R. P. Rastogi, R. R. Misra, *An Introduction to Chemical Thermodynamics*, 6th Edn. Vikas Pub. Pvt. Ltd., 2003.
4. P. Atkins and J Paula, *The elements of Physical chemistry*, 7th Edn. Oxford University Press, 2017.
5. K. K. Sharma, L.K. Sharma, *A Textbook of Physical Chemistry*, 4th Edn, Vikas publishing House, 2016.
6. Puri, Sharma and Pathania, *Principles of Physical Chemistry*, 48th Edn, Vishal Publishing Company, 2020.
7. G. M. Barrow, *Physical Chemistry*, Tata McGraw-Hill, 2007.
8. G. W. Castellan, *Physical Chemistry*, 4th Edn, Narosa Publishing House, 2018.


**Suggested Readings**


1. P W Atkins, *Physical Chemistry*, Oxford University Press, 12th Edn, 2022.
2. R J Silby and R. A. Alberty, M G Bawendi, *Physical Chemistry*, 4th Edn, John Wiley & Sons, 2021.
3. J. Rajaram, J. C. Kuriakose, *Chemical thermodynamics: classical, statistical and irreversible*, Dorling Kindersley (India), 2013.
4. S. Glasstone, D. Lewis, *Elements of Physical Chemistry*, Macmillan, 1963.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Organic Chemistry-6** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE8DCECHE400** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | A comprehensive study of organic synthesis. | | | | | |
| **Semester** | VIII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 3 | | 1 | | 75 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Apply the knowledge of synthetic reagents and reactions in organic transformations. | A | 1, 2, 3 |
| 2 | Summarize the stereoselective transformations in organic synthesis. | U | 1, 2, 3 |
| 3 | Analyse the structure and formulate a retrosynthetic scheme for the given organic molecule. | An | 1, 2, 3 |
| 4 | Develop a synthetic route for an organic molecule. | A | 1, 2, 3, 6 |
| 5 | Synthesise biologically important molecules. | S | 1, 2, 4 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Synthetic Reagents and Reactions** | | | |
| | 1.1 | Phosphorous based- triphenylphosphine- Mitsunobu reaction, Wittig reaction, Staudinger reaction; Sulphur based- sulphonium salts, sulphur ylides- Corey-Cheykovsky reaction; Si based reagents- -silyl ethers, TMS, TBDMS, TBDPS, TES, TIPS, Julia olefination, Peterson's olefination, NBS, DDQ and DCC, Gilman reagent. | 5 | 1, 4 |
| | 1.2 | Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille, Sonogoshira, Negishi, Kumada, Hiyama, Tsuji-Trost, olefin metathesis and McMurry reaction. | 5 | 1, 4 |
| | 1.3 | Baylis-Hillman reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction, Tebbe olefination, Multi Component Reactions- Passerini reaction and Biginelli reaction, Click reactions- Huisgen 1,3-dipolar addition. | 5 | 1, 4 |
| 2 | **Oxidation and Reduction** | | | |
| | 2.1 | Metal based and non-metal based oxidations of (a) Alcohols to carbonyls- Collins oxidation, Sarett oxidation, PCC; Oppenaeur oxidation, Swern oxidation. (b) Alkenes to diols- Prevost reaction and Woodward modification. | 3 | 1, 4 |
| | 2.2 | (c) Alkenes to alcohols/carbonyls without bond cleavage hydroboration-oxidation, Selenium/chromium based allylic oxidation.<br>(d) Ketones to ester/lactones- Baeyer-Villiger oxidation. | 3 | 1, 4 |
| | 2.3 | Reduction:<br>(a) Catalytic hydrogenation (heterogeneous: Pd, Pt, Rh and Ni; homogeneous: Wilkinson's catalyst)<br>(b) Metal based reductions -Birch reduction, pinacol formation, acyloin formation<br>(c) Hydride transfer reagents from group III and group IV in reductions - $NaBH_4$, $LiAlH_4$ and DIBAL-H | 4 | 1, 4 |
| 3 | **Stereoselective and Total Syntheses** | | | |

| | | | | |
|---|---|---|---|---|
| | 3.1 | Asymmetric induction- Felkin-Ahn model, Zimmerman-Traxler chair-like transition states. | 2 | 2 |
| | 3.2 | Noyori asymmetric hydrogenation, Sharpless epoxidation, CBS reduction, Brown allylation and crotylation reactions. | 4 | 2 |
| | 3.3 | Evans aldol reaction, proline based asymmetric aldol reaction, Jacobsen epoxidation, asymmetric Diels-Alder reaction. | 4 | 2 |
| | 3.4 | Retrosynthesis- basic concepts, Umpolung reactivity – formyl and acyl anion equivalents, protecting group chemistry- protection and deprotection of hydroxy, carboxyl, carbonyl, and amino groups | 4 | 3, 4 |
| | 3.5 | Retrosynthetic analysis and total synthesis of atropine, papaverine, longifolene and juvabione. | 6 | 3, 4 |
| **4** | **Organic Chemistry-6 Practicals** | | | |
| | Synthesis of biologically important molecules<br>I. Preparation of phenytoin: -<br>i) Preparation of benzoin using coenzyme catalysed reaction.<br>ii) Preparation of benzil from benzoin.<br>iii)Preparation of phenytoin from benzoin.<br>II. Preparation of benzocaine<br>i) Preparation of p-aminobenzoic acid from p-nitrobenzoic acid.<br>ii) Preparation of benzocaine from p-aminobenzoic acid.<br>III. Preparation of fluorescein.<br>IV. Preparation of 7-hydroxy- 4-methyl coumarin from resorcinol. | | 15 | 4 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, powerpoint presentation)<br>o Group discussion<br>o Peer learning<br>o Demonstration of experiments<br>o Hands-on learning |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (25 Marks)**<br>i) Pop quiz |

| | |
|---|---|
| | ii) Assignment<br>iii) Written test<br>**Practical: (15 Marks)**<br>i) Lab involvement<br>ii) Report<br>iii) Lab test |
| | B. **Semester End examination**<br>**Theory: Written examination (50 Marks- 1.5Hrs)**<br>i) Short answer 7 questions (out of 9): 7 × 3 = 21 marks<br>ii) Short Essay 2 questions (out of 3): 2 × 7 = 14 marks<br>iii) Essay 1 question (out of 2): 1 × 15 = 15 marks<br>**Practical: (35 Marks- 1 Hr)**<br>i) Viva voce (10 Marks)<br>ii) Written test of practical procedures (15 Marks)<br>iii) Certified report of lab works done (10 Marks) |

**References**


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2. F. A. Carey, R. J. Sundberg, *Advanced Organic Chemistry: Part A. Structure and Mechanisms*; 5th ed.; Springer: New York, 2007.
3. F. A. Carey, R. J. Sundberg, *Advanced Organic Chemistry: Part B. Reactions and Synthesis*; 5th ed.; Springer: New York, 2007.
4. R. O. C. Norman, J. M. Coxon, *Principles of Organic Synthesis*; 3rd Edn. CRC Press: 1993.
5. B. S. Furniss, A. J. Hannaford**,** V. Rogers, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*; 5th Ed.; Pearson Education, 2005.
6. S. Warren, P. Wyatt, *Organic Synthesis: The Disconnection Approach*, 2nd Ed. Wiley, 2008.
7. K. N. Jayaveera, S, Subramanyam, K. Y. Reddy, *Practical Medicinal Chemistry*, S. Chand, 2014.


**Suggested Readings**


1. K. C. Nicolaou, E. J. Sorenson, *Classics in Total Synthesis: Targets, Strategies, Methods*; VCH: Weinheim, 1996.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Group Theory and Quantum Chemistry** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE8DCECHE401** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course deals with the applications of quantum chemistry and group theory and fundamental concepts of computational chemistry | | | | | |
| **Semester** | VIII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | Basic knowledge of quantum chemistry and group theory | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Summarize the quantum mechanical principles of translational, vibrational and rotational motion | U | 1, 2 |
| 2 | Identify the principles of spherical harmonics in solving hydrogen and hydrogen-like systems. | E | 1, 2 |
| 3 | Evaluate the many-body problem, recognize the necessity of approximation methods in quantum mechanics and to outline the basics concepts of bonding in molecules | A | 1, 2 |
| 4 | Outline the basic concepts of different computational chemistry techniques such as ab initio, semi empirical, density functional theory and molecular mechanics. | U | 1, 2 |
| 5 | Construct the character tables for specific point group based on group theoretical principles | A | 1, 2 |
| 6 | Utilise the group theoretical aspects to predict the vibrational modes and electronic transition modes. | A | 1, 2 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Application of Quantum Mechanics to solvable systems** | | | |
| | 1.1 | Translational motion: free particle in one-dimension, penetration into and through barriers (a barrier with finite width-tunnelling), wave function in region I, II & III and their plots. Concept of transmittance and reflection. | 4 | 1 |
| | 1.2 | Vibrational motion: one-dimensional harmonic oscillator (complete treatment), Hermite equation (solving by method of power series), Hermite polynomials, wave functions- their sketch, energies, harmonic oscillator model and molecular vibrations. | 5 | 1 |
| | 1.3 | Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta ($L_x$, $L_y$, $L_z$ and $L^2$). | 4 | 1 |
| 2 | **Rotational Motion and Hydrogen Like Atoms** | | | |
| | 2.1 | Rotational motion: the particle on a ring and its solution. Rigid rotor and its solution for energies and wave function, polar diagrams of spherical harmonics. Spherical harmonics as eigen functions of angular momentum operators $L_z$ and $L^2$. | 6 | 1 |
| | 2.2 | Quantum mechanics of hydrogen-like atoms: Potential energy of hydrogen-like systems. The wave equation in spherical polar coordinates: separation of variables- r, theta and phi equations and their solutions, wave functions and energies of hydrogen-like atoms. Orbitals: Radial functions, radial distribution functions, angular functions, and their plots. | 6 | 2 |
| 3 | **Many Body Systems and Computational Chemistry** | | | |
| | 3.1 | Many-body problem and the need of approximation methods. Born-Oppenheimer approximation. Variation method- illustration of variation theorem using the trial function x(a-x) for particle in a 1D-box and using the trial function $e^{-ar}$ for the hydrogen atom. | 5 | 3 |
| | 3.2 | Perturbation method: time-independent perturbation method (non-degenerate case only), first order | 5 | 3 |

| | | | | |
|---|---|---|---|---|
| | | correction to energy and wave function, illustration by application to particle in a 1D-box with slanted bottom | | |
| | 3.3 | Chemical bonding: Schrödinger equation for molecules, valence bond (VB) theory, VB theory of $H_2$ molecule (elementary idea only)<br>Molecular Orbital (MO) theory, MO theory of $H_2$ molecule (elementary idea only).<br>Comparison of MO and VB theories. | 5 | 3 |
| | 3.4 | Introduction to computational chemistry: scope, potential energy surfaces, global minimum, local minima, saddle points. Tools (methods) of computational chemistry: molecular mechanics, semi empirical methods, Ab initio methods, density functional theory – general introduction. Comparison of ab initio, semi empirical and DFT methods. | 5 | 4 |
| **4** | **Group Theory and its Applications** | | | |
| | 4.1 | Reducible and irreducible representations, statement of great orthogonality theorem (GOT) and properties of irreducible representations. | 3 | 5 |
| | 4.2 | Character table and description of its layout, construction of character tables for $C_{2v}$ and $C_{3v}$. | 3 | 5 |
| | 4.3 | Application to vibrational spectroscopy: Standard reduction formula, normal mode analysis of $H_2O$ and $NH_3$ employing cartesian coordinate method and internal coordinate method. Prediction of IR and Raman activity, rule of mutual exclusion. | 4 | 6 |
| | 4.4 | Application to electronic spectroscopy: Transition moment integral, direct product, transitions between non-degenerate states – criteria for allowed transitions, prediction of electronic transitions in $C_{2v}$ and $C_{3v}$ using direct product terms. Electronic transitions due to the carbonyl chromophore in formaldehyde | 5 | 6 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>Lecture (chalk & board, powerpoint presentation, flipped classroom)<br>Group discussion – thought problems; mind mapping<br>Peer interaction<br>Demonstration using simulations / models |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: 30 Marks**<br>i) Quiz<br>ii) Assignment<br>iii)Problem based test - Open book |
| | **B. Semester End examination (Theory 70 Marks- 2Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv)Essay type question – 15 marks (1 out of 2 nos) |

**References**


1. P.W. Atkins, R.S. Friedman, *Molecular Quantum Mechanics*, 4th Edn. Oxford University Press, 2005.
2. I. N. Levine, *Quantum Chemistry*, 7th Edn. Pearson Education Inc., 2016.
3. D.A. McQuarrie, *Quantum Chemistry*, University Science Books, 2008.
4. R.K. Prasad, *Quantum Chemistry*, New Age International, 2001.
5. T. Engel, *Quantum Chemistry and Spectroscopy*, Pearson Education, 2006.
6. E.G. Lewars, *Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics*, 2nd Edn. Springer, 2011.
7. J.H. Jensen, *Molecular Modeling Basics*, CRC Press, 2010.
8. F. Jensen, *Introduction to computational chemistry*, 2nd Edn. John Wiley & Sons, 2007.
9. A. Leach, *Molecular Modelling: Principles and Applications*, 2nd Edn. Longman, 2001.
10. C.J. Cramer, *Essentials of Computational Chemistry: Theories and Models*, 2nd Edn. John Wiley & Sons, 2004.
11. D.C. Young, *Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems*, John Wiley & Sons, 2001.
12. F.A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn. Wiley Eastern, 1990.
13. S. Swarnalakshmi, T. Saroja, R.M. Ezhilarasi, *A Simple Approach to Group Theory in Chemistry*, Universities Press, 2008.
14. A.S. Kunju, G. Krishnan, *Group Theory and its Applications in Chemistry*, PHI Learning, 2010.
15. K. Veera Reddy, *Symmetry and Spectroscopy of molecules*, New Age International (P) Ltd.,1999.

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| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Instrumental Methods of Chemical Analysis** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE8DCECHE402** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course deals with the theory, instrumentation and applications of various chromatographic techniques, and surface and thermal analytical methods. | | | | | |
| **Semester** | VIII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | Nil | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Describe the basic principles and instrumentation of various chromatographic techniques. | U | 1, 2 |
| 2 | Evaluate the efficiency and effectiveness of different chromatographic methods. | E | 1, 2 |
| 3 | Analyse the basic principles, instrumentation, limitations and applications of various techniques for surface analysis | An | 1, 2 |
| 4 | Analyse the basic principles, instrumentation and applications of various thermal analytical techniques. | An | 1, 2 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Introduction to chromatography** | | | |
| | 1.1 | Adsorption and partition column chromatography- methodology, advantages, limitations and applications. | 3 | 1, 2 |
| | 1.2 | Thin-layer chromatography- introduction, principle, methodology, Rf values, advantages, limitations, and applications. | 4 | 1, 2 |
| | 1.3 | Paper chromatography- Introduction, methodology, development techniques, advantages, limitations, and applications | 4 | 1, 2 |
| | 1.4 | Electrophoresis–introduction, factors affecting electrophoretic mobility, techniques of paper, gel and capillary electrophoresis and its applications. | 4 | 1, 2 |
| 2 | **GC, HPLC and Ion exchange chromatography** | | | |
| | 2.1 | Gas chromatography - introduction, theory, instrumentation, derivatization, temperature programming, advantages, limitations and applications, hyphenated GC techniques (GC-MS, GC-IR, GC-GC, or 2D GC). | 6 | 1, 2 |
| | 2.2 | High-performance liquid chromatography (HPLC)- introduction, theory, instrumentation, advantages and applications, hyphenated techniques in HPLC. | 5 | 1, 2 |
| | 2.3 | Ion exchange chromatography- introduction, classification, ion exchange resins, properties, mechanism of the ion exchange process, factors affecting ion exchange, methodology and applications. | 4 | 1, 2 |
| 3 | **Surface Analysis** | | | |
| | 3.1 | X-Ray photoelectron spectroscopy- instrumentation and sample introduction, applications. | 3 | 3 |
| | 3.2 | Auger electron spectroscopy- instrumentation and applications. | 3 | 3 |
| | 3.3 | Secondary ion mass spectrometry- instrumentation, applications, ToF-SIMS. | 3 | 3 |
| | 3.4 | SEM- basic principles, instrumentation and applications | 2 | 3 |

| | | | | |
|---|---|---|---|---|
| | 3.5 | STM- basic principles, instrumentation, and applications. | 2 | 3 |
| | 3.6 | AFM- basic principles, instrumentation, and applications. | 2 | 3 |
| **4** | **Thermal Analysis** | | | |
| | 4.1 | Thermogravimetry (TGA)- instrumentation, analytical applications of thermogravimetry , derivative thermogravimetry | 3 | 4 |
| | 4.2 | Differential Thermal Analysis (DTA) - instrumentation and analytical applications. | 3 | 4 |
| | 4.3 | Differential Scanning Calorimetry (DSC) - instrumentation and applications. | 3 | 4 |
| | 4.4 | Hyphenated thermal methods. | 1 | 4 |
| | 4.5 | Thermometric titrimetry. | 1 | 4 |
| | 4.6 | Microcalorimetry- basic principles and applications of micro-DSC. | 2 | 4 |
| | 4.7 | Thermomechanical analysis and Dynamic mechanical analysis- applications of TMA and DMA. | 2 | 4 |
| **5** | **Teacher Specific Content** | | | |
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|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>Lecture sessions/interactive sessions/ case studies/ from various scientific fields (like environmental science, pharmaceuticals, forensics) to illustrate how different techniques are applied practically. |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (30 Marks)**<br>i) Assignment -5 Marks<br>ii) MCQ -10 Marks<br>iii) Viva -5 Marks<br>iv) Class Test - 10 Marks |
| | **B. Semester End examination (Total 70 Marks- 2 Hrs)**<br>i) Short answer 5 questions (out of 6): 5 x 4 =20<br>ii) Short essay 5 questions (out of 7): 5 x 7 = 35<br>iii) Essay 1 question (out of 2): 1 x 15 = 15 |

**References**


1. J W. Robinson, E M. Skelly Frame, G M. Frame II, *Undergraduate Instrumental Analysis*, 7th Edition, Taylor & Francis, 2014.
2. M D Graef, M E. McHenry, *Introduction to TEM, SEM, and AFM: The Practical Approach to Materials Characterization*, 1st Edition, CRC Press, 2018.
3. J W. Robinson, E M S Frame, and G M. Frame II, *Instrumental Analytical Chemistry*, CRC Press, 2021.
4. F A Settle, *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, 1997.
5. D A. Skoog, F. J Holler, S R. Crouch, *Principles of Instrumental Analysis*, 7th Edn. Brooks/Cole, 2020.
6. D A. Skoog, D M. West, F. J Holler, S R. Crouch, *Fundamentals of Analytical Chemistry*, 9th Edn. Brooks/Cole, 2014.
7. P. J. Haines, *Principles of Thermal Analysis and Calorimetry*, Royal Society of Chemistry, 2002.
8. E Lundanes, *Chromatography: Basic Principles, Sample Preparations and Related Methods*, Wiley-VCH, 2013.
9. R Stafford, Chromatography: *Principles and Instrumentations*, Nyresearch Press, 2020.

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|---|---|---|---|---|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** | | | | | |
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Molecular Modelling** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE8DCECHE403** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This course provides a comprehensive insight into molecular modelling covering Hartree Fock Method & Post Hartree Fock Methods, various computational chemistry methods and applications of computational chemistry software. | | | | | |
| **Semester** | VIII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | Nil | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Demonstrate the need for the approximations to the Hamiltonian. | U | 1, 2 |
| 2 | Classify different types of basis sets. | U | 1, 2 |
| 3 | Compare and contrast different methods of computational chemistry. | An | 1, 2, 3 |
| 4 | Utilize GAMESS software to solve molecular systems. | A | 1, 2, 4, 9, 10 |
| 5 | Utilize Autodock software to predict protein-ligand interactions. | An | 1, 2, 3, 4, 9 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | **Hartree Fock Method & Post Hartree Fock Methods** | | | |
| | 1.1 | Multi-electron atoms. Hartree method, spin multiplicity, Slater determinant, properties of Slater determinant, Hartree-Fock (HF) equations. Secular determinant, restricted and unrestricted HF models. | 5 | 1 |
| | 1.2 | The Fock matrix, Roothan Hall equations, elements of the Fock matrix (elementary ideas only), steps for HF calculation, Koopmann theorem. | 5 | 1 |
| | 1.3 | The need for post HF methods. electron correlation, post HF methods: configuration interaction and Møller Plesset perturbation theory (elementary ideas only) | 3 | 1 |
| | 1.4 | Roothan's concept of basis functions, Slater type orbitals (STO), Gaussian type orbitals (GTO), sketches of STO and GTO. Differences between STOs and GTOs. | 3 | 2 |
| | 1.5 | Classification of basis sets – minimal basis sets; Pople basis sets (with polarization and diffuse functions), correlation consistent basis sets; double zeta, triple zeta and quadrupole zeta basis sets, split valence basis set, Hartree Fock limit. | 4 | 2 |
| 2 | **Computational Methods** | | | |
| | 2.1 | Semiempirical methods: introduction, neglect of differential overlap method (NDO), complete neglect of differential overlap (CNDO), modified neglect of differential overlap (MNDO); Austin Model 1, parametric method 3 (PM3), zero differential overlap (ZDO) (concepts only). Comparison of semiempirical methods. Software used for semiempirical calculations. | 5 | 3 |
| | 2.2 | Ab Initio method: introduction, computation of correlation energy, computation of Slater determinant of excited states, Möller-Plesset perturbation and coupled cluster method. | 4 | 3 |
| | 2.3 | Density functional theory: introduction, electron density, development of DFT, The functional, Hohenberg and Kohn theorem, Kohn and Sham method, density functionals – exchange and | 6 | 3 |

| | | | | |
|---|---|---|---|---|
| | | correlation functionals with examples, DFT methods, applications of DFT, performance of DFT, advantages of DFT in biological chemistry | | |
| | 2.4 | Molecular Mechanics (MM): introduction, basic theory- bond stretching, angle bending, torsional strain, non-bonded interactions. Force fields – MM2, MM3, MM4, AMBER, CHARMM, Merck Molecular force field, consistent force field, parameterization. | 4 | 3 |
| | 2.5 | Comparison between semiempirical, Ab Initio, DFT and MM methods – merits and demerits. | 1 | 3 |
| **3** | **Computational Software** | | | |
| | 3.1 | Introduction to GAMESS. Setting up the input file with run type - geometry optimization, frequency calculation and single point energy calculations. $ groups, format for input file. Hands-on training using the software | 5 | 4 |
| | 3.2 | Input for molecule – cartesian coordinates and Z-matrix. Z matrix- rules, z-matrix for linear molecules like diatomic molecules, acetylene, hydrogen cyanide and polyatomic molecules like water, ammonia, boron hydride and methane. | 5 | 4 |
| **4** | **Docking** | | | |
| | 4.1 | Introduction to docking (basic ideas only), protein ligand interactions; setting up the protein and ligand using babel and pymol; predicting ADMET of the molecule using PreADMET application; docking procedures using autodock software and result analysis with visualization of interactions using discovery studio. Hands-on training using the software. | 10 | 5 |
| **5** | **Teacher Specific Content** | | | |
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| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture (chalk & board, PowerPoint presentation, flipped classroom)<br>o Group discussion – thought problems; mind mapping<br>o Peer interaction<br>o Demonstration using simulations / models |

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| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (30 Marks)**<br>i) Quiz<br>ii) Assignment<br>iii) Problem based test - Open book<br>iv) Examinations |
| | **B. Semester End examination (Total 70 Marks-2 Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos)<br>iv)Essay type question – 15 marks (1 out of 2 nos) |

**References**


1. K. I. Ramachandran, G. Deepa, K. Namboori, *Computational Chemistry and Molecular Modeling Principles and Applications*, Springer, 2008
2. P.W. Atkins, R.S. Friedman, *Molecular Quantum Mechanics*, 4th Edn. Oxford University Press, 2005.
3. A. Szabo, N. S. Ostlund, *Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory*, Dover Books on Chemistry, 1996.
4. A. Leach, *Molecular Modelling: Principles and Applications*, 2nd Edn. Longman, 2001.
5. E.G. Lewars, *Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics*, 2nd Edn. Springer, 2011.
6. J.H. Jensen, *Molecular Modeling Basics*, CRC Press, 2010.
7. F. Jensen, *Introduction to computational chemistry*, 2nd Edn. John Wiley & Sons, 2007.
8. C.J. Cramer, *Essentials of Computational Chemistry: Theories and Models*, 2nd Edn. John Wiley & Sons, 2004.
9. M. Tuckerman, *Statistical Mechanics: Theory and Molecular Simulation*, Oxford University Press, 2010.

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|---|---|
| | **MAHARAJA'S COLLEGE, ERNAKULAM (Govt. Autonomous)** |

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|---|---|---|---|---|---|---|
| **Programme** | **B. Sc CHEMISTRY(Hons.) with Specialization in Environment & Water Management** | | | | | |
| **Course Name** | **Crystallography and Electrochemistry** | | | | | |
| **Type of Course** | **DCE** | | | | | |
| **Course Code** | **MCE8DCECHE404** | | | | | |
| **Course Level** | **400-499** | | | | | |
| **Course Summary** | This is an advanced physical chemistry course dealing with crystallography, electrochemistry and electro analytical techniques. | | | | | |
| **Semester** | VIII | Credits | | | 4 | Total Hours |
| **Course Details** | Learning Approach | Lecture | Tutorial | Practical/ Practicum | Others | |
| | | 4 | | | | 60 |
| **Pre-requisites, if any** | | | | | | |

**COURSE OUTCOMES (CO)**

| CO No. | Expected Course Outcome | Learning Domains * | PO No. |
|---|---|---|---|
| *Upon the completion of the course, student will be able to:* | | | |
| 1 | Discuss the basic concepts of crystal systems like unit cell, lattice and deduce the crystal structure of NaCl and KCl from XRD patterns | An | 1, 2, 3 |
| 2 | Distinguish different diffraction methods and correlate the structure factor with the peak intensity. | A | 1, 2, 3 |
| 3 | Describe the structure of ionic solution and interpret the laws governing ionic conductivity. | U | 1, 2 |
| 4 | Explain the features of concentration cells and fuel cells. | U | 1, 2 |
| 5 | Explain the causes of corrosion, prevention methods. | U | 1, 2 |
| 6 | Learn the basic principles of voltammetry and describe voltammogram by analysing the peak current and peak potential. | U | 1, 2 |
| 7 | Apply the theory behind electroanalytical techniques to quantitative and qualitative analysis. | A | 1, 2 |
| ***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

**Content for Classroom transaction (Units)**

| Module | Units | Course description | Hrs. | CO No. |
|---|---|---|---|---|
| 1 | | **Crystallography** | | |
| | 1.1 | Symmetry in crystals: symmetry elements – proper rotation (order of axis – 1, 2, 3, 4 and 6 – derivation), mirror plane, rotary inversion axis. 32 crystallographic point groups (derivation not expected), Hermann-Mauguin notation and corresponding Schoenflies notations, translational symmetry elements - glide planes and screw axes, fourteen Bravais lattices, space groups (concept only). Space groups of triclinic and monoclinic systems. | 5 | 1 |
| | 1.2 | Miller indices, inter-planar spacing and method of determining lattice types, reciprocal lattices. X-ray diffractometer: single crystal and powder pattern methods (experimental part). Analysis of powder diffraction patterns of NaCl and KCl. Debye-Scherrer equation. | 6 | 1 |
| | 1.3 | Crystal growth techniques. Structure factor: atomic scattering factor, coordinate expression for structure factor | 4 | 2 |
| 2 | | **Advanced Electrochemistry** | | |
| | 2.1 | Debye-Huckel theory, derivation of Debye-Huckel-Onsager equation, validity of DHO equation for aqueous and non-aqueous solutions, Debye-Huckel limiting law (no derivation) qualitative and quantitative tests of Debye-Huckel limiting law, deviations from DHLL. | 10 | 3 |
| | 2.2 | Concentration cells – with and without transference, liquid junction potential, electrode double layer, electrode-electrolyte interface, different models of double layer, theory of multilayer capacity, electro capillary, Lippmann equation, membrane potential.<br>Fuel cells- theory and working of fuel cells- methanol fuel cell, $H_2$-$O_2$ fuel cell and solid oxide fuel cells. | 10 | 4 |
| | 2.3 | Corrosion and methods of prevention, Pourbaix diagram and Evans diagrams. Electrode polarization:- overvoltage: hydrogen and oxygen overvoltage, theories of overvoltage, Tafel equation and its significance. | 10 | 5 |

| | | | | |
|---|---|---|---|---|
| **3** | **Electro Analytical Techniques** | | | |
| | 3.1 | Electroanalytical techniques: classification – interfacial and bulk methods; idea of static and dynamic methods. | 1 | 6 |
| | 3.2 | Polarography- decomposition potential, residual current, migration current, supporting electrolyte, diffusion current, polarogram, half wave potential, limiting current density, polarograph, explanation of polarographic waves.<br>The dropping mercury electrode, advantages and limitations of DME, quantitative analysis- pilot ion procedure, standard addition methods, qualitative analysis - determination of half wave potential of an ion, advantages of polarography. | 8 | 6, 7 |
| | 3.3 | Cyclic voltammetry – basic principles and fundamentals; cyclic voltammogram for a reversible and irreversible redox process, Scan rate. Amperometric titrations: General principles of amperometry, instrumentation, application of amperometry in the qualitative analysis of anions and cations in solution, merits and demerits of amperometric titrations. | 6 | 7 |
| **5** | **Teacher Specific Content** | | | |
| | | | | |

| | |
|---|---|
| **Teaching and Learning Approach** | **Classroom Procedure (Mode of transaction)**<br>o Lecture sessions (chalk & board, powerpoint presentation)<br>o Interactive sessions and simulations<br>o Visual aids like videos and models to enhance understanding<br>o Peer discussions<br>o Laboratory experiments and hands-on training |
| **Assessment Types** | **MODE OF ASSESSMENT**<br>**A. Continuous Comprehensive Assessment (CCA)**<br>**Theory: (30 Marks)**<br>i) Pop Quiz<br>ii) Assignment<br>iii) Test for each unit (MCQ/written) |
| | B. **Semester End examination**<br>**Theory: Written examination (70 Marks-2 Hrs)**<br>i) MCQ – 10 marks (1 mark each – 10 nos)<br>ii) Short answer questions – 24 marks (3 marks each – 8 out of 10 nos)<br>iii)Long answer questions – 21 marks (7 marks each – 3 out of 5 nos) |

| | |
|---|---|
| | iv) Essay type question – 15 marks (1 out of 2 nos) |

**References**


1. R P W Atkins, *Physical Chemistry*, 12th Edn. Oxford University Press, 2018.
2. N B Hannay, *Solid State Chemistry*, Prentice Hall. 1967.
3. A. McQuarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books Pvt. Ltd., 2019.
4. Anthony R. West, *Solid State Chemistry and its Applications*, Wiley Eastern, 2018.
5. O. Simoska, S. D. Minteer, *Techniques in Electroanalytical Chemistry*, American Chemical Society, 2022.
6. S. Glasstone, *An Introduction to Electrochemistry*, East-West Press (Pvt.) Ltd. 2006.
7. G. Raj, *Advanced Physical Chemistry*, Goel publishing house, 2016.
8. R. J. Silby and R. A. Alberty, M G Bawendi, *Physical Chemistry*, 4th Edn., John Wiley & Sons, 2015.
9. A. J. Bard and L. R. Faulkner, *Electrochemical methods: Fundamentals and Applications*, 2nd Edn., Wiley, 2022.


**Suggested Readings**


1. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd, 1996.
2. S. Glasstone, D. Lewis, *Elements of Physical Chemistry*, Macmillan, 1963.
3. I. N. Levine, *Physical Chemistry*, Tata McGraw Hill, 2011.
4. G. M. Barrow, *Physical Chemistry*, Tata McGraw-Hill, 2007

## Internship Evaluation

All students shall undergo summer internship or apprenticeship in a firm, industry or organization; or training in labs with faculty and researchers or other higher education institutions (HEIs) or research institutions after completion of the fourth semester.

**Evaluation scheme (Total 50 marks)**

**1) Internal Evaluation (15 marks)**
(Internal marks may be obtained from the organization/institution where the student is doing internship using the following format)

### Chemistry Undergraduate Student Evaluation Form for Internship

**Internship Details:**

Student Name:

Date of Evaluation:

Duration of Internship:

Mentor Name:

**Instructions:** Please rate the student's performance based on their abilities, skills, and behaviour during the internship. Provide specific examples or comments where applicable to support your ratings.

**1. Technical Skills and Problem Solving (Marks out of 3) :**

**2. Communication Skills and Collaboration (Marks out of 3) :**

**3. Professionalism (Marks out of 3) :**

**4. Adaptability (Marks out of 3) :**

**5. Overall Performance (Marks out of 3) :**

**Total (out of 15) :**

**Comments and Recommendations:** (Provide specific comments on the student's strengths, areas for improvement, and any additional feedback or recommendations for their future development.)

**Mentor Signature:** (Insert Mentor's Signature) :

**Date:** (Insert Date of Evaluation) :

**2) Final Evaluation (35 marks)**

**Report (20 marks)**

| | | |
|---|---|---|
| i) | Relevance | : 5 marks |
| ii) | Professionalism & ethical considerations | : 5 marks |
| iii) | Result Analysis | : 5 marks |
| iv) | Conclusions | : 5 marks |

**Viva voce (15 marks)**

(Student's skills, work ethics, professionalism and contribution to the organization may be evaluated through viva)

# Project Evaluation

## I. Project with 8 credits (100 marks) (For students who are opting Honors without Research) (MCE8PRJCHE400)

**1) Internal Evaluation (30 marks)**

| | |
|---|---|
| i) Initiative and Independence | : 5 marks |
| ii) Technical Skills | : 5 marks |
| iii) Problem Solving | : 5 marks |
| iv) Communication Skills | : 5 marks |
| v) Professionalism | : 5 marks |
| vi) Overall Performance | : 5 marks |

(If the student is doing project in any outside institution, internal marks may be obtained fromthere (from the project supervisor))

**1) Final Evaluation (70 marks)**

| | |
|---|---|
| i) Novelty of the work | : 10 marks |
| ii) Experimental Section | : 5 marks |
| iii) Results and Discussion | : 10 marks |
| iv) Conclusion | : 5 marks |
| v) Literature Survey | : 5 marks |
| vi) Presentation of the work | : 15 marks |
| vii) Viva voce | : 20 marks |

## II. Project with 12 credits (200 marks) (For students who are opting Honors with Research) (MCE8PRJCHE401)

**1) Internal Evaluation (60 marks)**

| | |
|---|---|
| i) Initiative and Independence | : 10 marks |
| ii) Technical Skills | : 10 marks |
| iii) Problem Solving | : 10 marks |
| iv) Communication Skills | : 10 marks |
| v) Professionalism | : 10 marks |
| vi) Overall Performance | : 10 marks |

(If the student is doing project in any outside institution, internal marks may be obtained from

there (from the project supervisor))

**2) Final Evaluation (140 marks)**

| | |
|---|---|
| i) Novelty of the work | : 20 marks |
| ii) Experimental Section | : 10 marks |
| iii) Results and Discussion | : 20 marks |
| iv) Conclusion | : 10 marks |
| v) Literature Survey | : 10 marks |
| vi) Presentation of the work | : 30 marks |
| vii) Viva voce | : 40 marks |