# University of Mumbai

# DEPARTMENT OF CHEMISTRY

**(AUTONOMOUS)**

# INFORMATION BROCHURE

## FOR M. Sc. DEGREE PROGRAMMES IN INDUSTRIAL POLYMER CHEMISTRY


**DEPARTMENT OF CHEMISTRY**

**UNIVERSITY OF MUMBAI**

**VIDYANAGARI**

**SANTACRUZ (E)**

**MUMBAI – 400 098**


**In Collaboration with**

**Indian Rubber Manufacturers Research Association**

**An Autonomous Body under DPIIT, Min. of Comm. & Ind., Govt. of India**


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**2023-2024**

# CONTENTS

# DEPARTMENT OF CHEMISTRY (AUTONOMOUS)

## 1. A PROFILE

The University Department of Chemistry, University of Mumbai, established in the year 1967, conducts Choice Based Credit System (CBCS) 4-SEMESTER- courses in Physical, Inorganic, Organic and Analytical Chemistry, leading to the award of M. Sc. degree of the Department of Chemistry, University of Mumbai. In addition, it also conducts program leading to Ph. D. degree. The Department is a recipient of DST-FIST and UGC-SAP grants. The Department has been conferred autonomous status from the academic year 2009-10.

Since inception of the department, over 2000 students have taken their Master's degree by papers; more than 250 students have been awarded doctorates, and more than 150 students have taken their M. Sc. Degree by research. Under the M. Phil. programme, 50 teachers from affiliated colleges have received their degrees. After autonomy of the department, over 381 students have taken their Master's degree by papers; more than 93 students have been awarded doctorates, and more than 16 students have taken their M. Sc. Degree by research. It is indeed a pleasure to report that alumni of the department are holding key positions in the industry and academic institutions.

The Department is actively engaged in organizing Refresher Courses for college teachers sponsored by U.G.C. and the State Government. It also conducts workshops for teachers for effective, smooth teaching and uniformity in the implementation of the revised syllabi from time to time. The Department has organized several National and International conferences. In addition, the Department along with other reputed institutes and registered societies jointly organizes lectures, workshops and research scholars' meet, science day etc. for the benefit of teachers and students. The Department also offers consultancy services to the industry, whenever solicited.

A Post-graduate institution is judged not only by maintenance of high teaching standards, but also by its focus on research activity. Though plagued by problems of infrastructure in terms of senior academic positions, the Department has consistently endeavored to raise its standards. The Department runs projects received from the various national funding agencies such as UGC, DST, CSIR, DAE etc. and also from the Industries. It is heartening to point out that members of the faculty have been receiving appreciative comments on their research articles/reviews in standard journals.

## 2. LOCATION

The Department is housed in Lokmanya Tilak Bhavan and the ground floor of Sant Dnyaneshwar Bhavan in the Vidyanagari campus of the University of Mumbai. The Vidyanagari Campus is accessible from both the Central Railway (Kurla) and Western Railway (Santacruz) by the BEST Bus routes. The bus route Nos. 313 and 318 plying between Santacruz (East) and Kurla (West) pass via Vidyanagari. Additionally, route Nos. 37 (between Kurla & J. M. Mehta Marg), 181 (between Seepz-Wadala), 213 (between Santacruz - Pr. Thakre

Udyan), 306 (between Santacruz - Mulund). 312 (between Seepz & Pratiksha Nagar), 374 (between Goregaon-East & Anushakti Nagar), 449 (between Dharavi Depot & Kandivali Bus St.-East) pass via Vidyanagari.

## 3. LABORATORY FACILITIES FOR PAPER AND RESEARCH STUDENTS

There are four M. Sc. Paper Laboratories well equipped with the necessary instruments/ infrastructure to perform experiments in Analytical, Inorganic, Organic, and Physical Chemistry.

All the research students are comfortably accommodated in the various research laboratories.

There is a computer laboratory equipped with twelve computers with an internet connection.

The Department is well equipped with the necessary infrastructure and sophisticated instruments. A 300 MHz NMR and CHN analyzer have been procured through the DST-FIST program. GC-MS instrument has been procured through UGC-SAP program. In addition, the department has FTIR, UV-Visible spectrophotometers, Spectrofluorimeter, HPLC, GC, Digital Polarimeter, Ion meters, Electro-chemical workstations, CVD, Catalytic Hydrogenator, Microwave Oven, Auto-titrator, Ultrasonic reactors, TG/DTA, AAS, GPC, and XRD. The department has also acquired new technological devices such as an Audio-Visual system, LCD Projector, E-Beam System, Media Imager, and Visual Presenter. Internet access is provided to the staff and research as well as paper students.

The Department has a seminar room with a seating capacity of 60.

## 4. LIBRARY

The Department has its own library on the ground floor of Sant Dnyaneshwar Bhavan. In addition, Jawaharlal Nehru Library, which is a central library at the Vidyanagari campus, is well equipped with books, journals, periodicals and Encyclopedias of Chemistry. There is a separate facility for carrying out literature survey. The students enrolled in the Department can avail of reading as well as lending facilities.

## 5. HOSTEL ACCOMODATION FOR STUDENTS

Six rooms in Boy's hostel and Eight in Girl's hostel are reserved for the Department students. These hostel rooms are allotted as per the University rules.

## 6. FINANCIAL ASSISTANCE

**A) M. Sc. By Papers :** As per the rules of University of Mumbai and Government on merit basis (if applicable)

**B) Ph. D. :** Nil

## 7. FACULTY OF THE DEPARTMENT

### *[1] Name: Dr. Shivram S. Garje*

- **Designation:** Professor and Head

| | | | |
|---|---|---|---|
| **PAPERS PUBLISHED:** | 66 | **Ph. D STUDENTS UNDER GUIDANCE:** | 03 |
| **M.Sc (BY RESEARCH) STUDENTS GUIDED:** | 05 | **RESEARCH PROJECTS:** | 03 |
| **Ph. D STUDENTS GUIDED:** | 10 | **Patents** | Granted-02<br>Published-01 |
| **POSTDOC.** | 02 | **BOOK CHAPTER** | 01 |

- **Key Awards/Honors:**
  - "**BOYSCAST Fellowship**", Department of Science and Technology, Government of India (2004)
  - "**Performance Based Incentive Award**", University of Mumbai (2008)

- **Research interests:**
  - Synthesis of novel molecular precursors for the preparation of nanomaterials, nanocomposites and thin films.
  - Applications of nanomaterials for enviornmental remediation and as nanocatalysts, photocatalysts and electrode materials for energy storage devices.

**Key Publications**

1. One pot solvothermal synthesis of bimetallic copper iron sulfide ($CuFeS_2$) and its use as electrode material in supercapacitor applications

A. Ansari, R. A. Badhe, D. G. Babar and S. S. Garje, Appl. Surf. Sci. Adv., 9 **(2022)** 100231.

2. Study of optical properties of $TiO_2$ nanoparticles and CdS@$TiO_2$ nanocomposites and their use for photocatalytic degradation of Rhodamine B under natural light irradiation.

   R. A. Badhe, A. Ansari, S. S Garje, Bull. Mater. Sci, 44 **(2021)** 11.

3. One pot synthesis of bimetallic transition metal sulfide $NiFeS_2$ nanocomposite and its use as a high performance supercapacitor material.

   A. Ansari, R. A. Badhe, S. S. Garje, Mater. Lett., 281 **(2020)** 128636.

4. Nitrogen and phosphorus co-doped carbon dots for selective detection of nitro explosives.

   D. G. Babar, S. S. Garje, ACS omega, 5 (6), **(2020)** 2710-2717.

5. Photocatalytic performance of ZnO carbon composites for the degradation of methyl orange dye.

   P. A. Borade, J. S. Suroshe, K. Bogale, S. S. Garje, S. M. Jejurikar, Mater. Res. Express, 7 (1) **(2020)** 015512.

6. Synthesis of bare and surface modified $TiO_2$ nanoparticles via single source precursor and insights into their interactions with Serum Albumin.

   A. Ansari, S. Sachar and S. S. Garje, New J. Chem., 42 **(2018)** 13358-13366.

7. Lead (II) halide cinnamaldehyde thiosemicarbazone complexes as single source precursors for oleylamine-capped lead sulfide nanoparticles.

   S. Masikhane, C. Gervas, S. Mlowe, A. S. Pawar, S. S. Garje; N. Revaprasadu, J. Mater. Sc.: Mat. Electronics, 29 (2) **(2018)** 1479-1488.

8. Capacitive behaviour of functionalized carbon nanotube/ZnO composites coated on glassy carbon electrode.

   J. S. Suroshe and S. S. Garje, J. Mater. Chem. A, 3 **(2015)** 15650–15660.

9. Synthesis and X-ray single crystal structure of a cadmium(II) acetophenone thiosemicarbazone complex and its use as a single-source precursor for the preparation of CdS nanocrystallites and thin films.

   A. M. Palve, P. V. Joshi, V. Puranik and S. S. Garje, Polyhedron, 61 **(2013)** 195-201.

10. Preparation of ternary metal chalcogenide ($M_{1-x}Fe_xS$, M = Cd and Zn) nanocrystallites using single source precursors.

    S. D. Disale and S. S. Garje, J. Organomet. Chem., 696 **(2011)** 3328-3336.

***[2] NAME: Dr. (Smt.) M. Karve***

- **DESIGNATION:** Professor

| | | | |
|---|---|---|---|
| **PAPERS PUBLISHED:** | **35** | **Ph. D STUDENTS GUIDED:** | **03** |
| **M.Sc (BY RESEARCH) STUDENTS GUIDED:** | **03** | **RESEARCH PROJECTS COMPLETED:** | **01** |

- **RESEARCH INTERESTS:** Solvent Extraction, Solid phase Extraction, Environmental Analysis.

**KEY PUBLICATIONS:**

1. Cyanex272 impregnated on Amberlite XAD-2 for separation and preconcentration of U(VI) from uranmicrolite (leachates) ore tailings, M. Karve and K. Pandey, *J. Radioanal. Nucl. Chem.* 285(2010)627-633.
2. Octadecyl bonded silica membrane disk modified with Cyanex302 for preconcentration and determination of traces of cobalt in urine by flame atomic absorption spectrometry, M. Karve and R. V. Rajgor, *Anal. Lett.* 42 (2009) 2520-2532.
3. Octadecyl bonded silica membrane disk modified with Cyanex302 for separation and flame atomic absorption spectrometric determination of nickel from tap water and CONSULTANCY effluent, M. Karve and R. V. Rajgor,*J. Hazard. Mater.* 166 (2009) 576-580.
4. Selective separation of Scandium(III) and Yttrium(III) from other Rare Earth Elements using Cyanex302 as an extractant, M. Karve and B. Vaidya, *Sep. Sci. Technol.* 43 (2008) 1111–1123.
5. Amberlite XAD-2 impregnated Organophosphinic acid Extractant for separation of Uranium(VI) from rare earth elements, M. Karve and R. V. Rajgor, *Desalination* 232 (2008) 191-197.
6. Amberlite XAD-2 impregnated with Cyanex302 for separation of traces of thorium(IV), M. Karve and R. V. Rajgor, *Sep. Sci. Technol.* 42 (2007) 2255-2273.
7. Solid phase extraction of lead on octadecyl bonded silica membrane disk modified with Cyanex302 and determination by flame atomic absorption spectrometry, M. Karve and R. V. Rajgor, *J. Hazard. Mater.* 141 (2007) 607-613.
8. Extraction of U(VI) with Cyanex 302, M. Karve and C. Gaur, *J. Radioanal. Nucl. Chem.*, 273 (2007) 405-409.
9. Solvent extraction separation of scandium(III) with Cyanex272 as an extractant M. Karve and B. Vaidya, Indian J. Chem, 45A (2006) 2658-2660.
10. Hydrochemistry of Mithi River and associated sediments, Mumbai, T. Gurav, M. Karve, and D. Chandrasekharam, *Journal of Indian School of Mines*, 1 (2006) 33-41.

***[3] NAME: Dr. N. G. Shimpi***

● **DESIGNAT:** Professor

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|---|---|---|---|
| **PAPERS PUBLISHED** | **85** | **Ph. D STUDENTS UNDER GUIDANCE:** | **06** |
| **PATENTS** | **04** | **RESEARCH PROJECTS:** | **07 (Completed)**<br>**02 (in progress)** |
| **Ph. D STUDENTS GUIDED** | **12** | **CONSULTANCY PROJECTS COMPLETED** | **01 (in progress)** |

● **KEY AWARDS/HONORS:**

- AICTE Career Award for Young Teachers (CAYT).
- Young Scientist Award by APA, IIT, New Delhi (International)

● **RESEARCH INTERESTS:** Synthesis of nanomaterials, Conducting polymers, Biodegradable polymer nanocomposites, Gas sensing materials, Organic transformation reactions, Dye degradation and Shape memory polymers

**KEY PUBLICATIONS:**

1. Development of Ni doped ZnO/Polyaniline nanocomposites as high response room temperature $NO_2$ sensor, Shilpa Jain, Narayan Karamkar, Navinchandra Shimpi, Material Science and Engineering: Part B, 2019 (Published online).
2. Studies on effect of ethyl 4-amino cinnamate functionalized multiwall carbon nanotubes (f-MWCNTs) on properties of millable polyurethane rubber (MPU) nanocomposites, M. S Tamore, D. Ratna, N.G. Shimpi, Polymer-Plastics Technology and Materials 58 (11), 1141-1156,2019.
3. High performance visible light photocatalysis of electrospun PAN/ZnO hybrid nanofibers, A.P. Shah, S. Jain, V.J. Mokale, N.G. Shimpi, Journal of Industrial and Engineering Chemistry, 77, 154-177, 2019.
4. Ultrasound-Mediated Synthesis of Novel α-Aminophosphonates Using Graphene Nanosheets-Silver Nanoparticles (GNS-AgNPs) as a Recyclable Heterogeneous Catalyst, S.A Rasal, M.S. Tamore, N.G. Shimpi,ChemistrySelect 4 (8), 2293-2300,2019.
5. Effect of functionalized multi-walled carbon nanotubes on physicomechanical properties of silicone rubber nanocomposites, M.S. Tamore, D. Ratna, S. Mishra, N.G. Shimpi, Journal of Composite Materials, 0021998319827080,2019.
6. Novel sonochemical green approach for synthesis of highly crystalline and thermally stable barium sulphate nanoparticles using Azadirachta indica leaf extract,M. Jha, S. Ansari, N.G. Shimpi,Bulletin of Materials Science 42 (1), 22, 2019.
7. Effect of functionalized multi-walled carbon nanotubes on physicomechanical properties of silicone rubber nanocomposites, M.S. Tamore, D. Ratna, S. Mishra, N.G. Shimpi,Journal of Composite Materials, 0021998319827080, 2019.

8. Spherical nanosilver: Bio-inspired green synthesis, characterizations, and catalytic applications, M. Jha, N.G. Shimpi, Nano-Structures & Nano-Objects 16, 234-249,2018.
9. Reusable zinc oxide nanoflowers for the synthesis of α-aminophosphonates under solvent-free ultrasonication, S. Rasal, S. Jain, N.G. Shimpi, Synthetic Communications 48 (18), 2420-2434, 2018.
10. High-performance polyimide film based hybrid nanostructures: Synthesis, characterization, and properties investigation, N. G. Shimpi, D.P Hansora, S. Mishra, Polymer Composites 39 (8), 2650-2661,2018.

***[4] NAME: Dr. Rajesh M. Kamble***

- **DESIGNATION:** Professor

| | | | |
|---|---|---|---|
| **PAPERS PUBLISHED:** | **42** | **Ph. D STUDENTS UNDER GUIDANCE:** | **06** |
| **M.Sc (BY RESEARCH) STUDENTS GUIDED:** | **01** | **RESEARCH PROJECTS:** | **03** |
| **Ph. D STUDENTS GUIDED:** | **04** | **CONSULTANCY PROJECTS (IN PROGRESS)** | **Nil** |

- **RESEARCH INTERESTS:** Design, Synthesis and characterization of novel AIE and TADF functional organic materials for applications in Organic Light Emitting Devices (OLEDs), Solar cells, as Chemosensors and for Bio-imaging purpose. And the development of composite materials for efficient supercapacitors and electrochemical investigation of materials for supercapacitors. Also to develop sensors in the form of chemically modified electrodes based on the synthesized nanocomposites.

**KEY PUBLICATIONS:**

1. Dicyanopyrazino phenanthrene based charge transfer derivatives: Role of amine donor in tuning of photophysical, aggregation-induced emission, electrochemical

and theoretical properties. Pooja S. Singh, Sajeev Chacko and **Rajesh M. Kamble**, Journal of Molecular Structure, 1271 (2023) 134052 (https://doi.org/10.1016/j.molstruc.2022.134052) (Impact Factor: 3.841)

2. 2,2′,3,3′-Tetrakis(4-bromophenyl)-6,6′-biquinoxaline based novel Donor–Acceptor–Acceptor–Donor (DAAD) Blue–Orange emitting molecules: Opto-electrochemical, AIE and theoretical investigation. Suraj S. Mahadik, Dinesh R. Garud, Mohammed K. Ghadiyali, Sajeev Chacko and **Rajesh M. Kamble**, Journal of Luminescence, 252 (2022) 119350, (https://doi.org/10.1016/j.jlumin.2022.119350) (Impact Factor: 4.171)
3. Blue-red emitting materials based on a pyrido[2,3-*b*]pyrazine backbone: design and tuning of the photophysical, aggregation-induced emission, electrochemical and theoretical properties. Deepak M. Kapse, Pooja S. Singh, Mohammed Ghadiyali, Sajeev Chacko and Rajesh M. Kamble, RSC Advances, 2022, 12, 6888–6905 (DOI: 10.1039/d2ra00128d) (Impact Factor: 4.036)
4. D−A−D based pyrido-pyrazino[2,3-*b*]indole amines as blue-red fluorescent dyes: Photophysical, aggregation-induced emission, electrochemical and theoretical studies. Pooja S. Singh, Mohammed Ghadiyali, Sajeev Chacko and Rajesh M. Kamble, Journal of Luminescence, 2022, 242, 118568 (https://doi.org/10.1016/j.jlumin.2021.118568) (Impact Factor: 4.171)
5. Blue-orange emitting carbazole based donor-acceptor derivatives: Synthesis and studies of modulating acceptor unit on opto-electrochemical and theoretical properties. Pooja S. Singh, Purav M. Badani and Rajesh M. Kamble, J. Photochem. Photobiol. A: Chem, 2021, 419, 113457 (https://doi.org/10.1016/j.jphotochem.2021.113457) (Impact Factor: 5.141)
6. Acridone-amine D-A-D thermally activated delayed fluorescence emitters with narrow resolved electroluminescence and their electrochromic properties. Marharyta Vasylieva, Piotr Pander, Bharat K. Sharma, Azam M. Shaikh, Rajesh M. Kamble, Fernando B. Dias, Malgorzata Czichy and Przemyslaw Data, Electrochimica Acta, 2021, 384, 138347 (https://doi.org/10.1016/j.electacta.2021.138347) (Impact Factor: 7.336)
7. Design, Synthesis and Opto-electrochemical Properties of Novel Donor–Acceptor Based 2,3-di(hetero-2-yl)pyrido[2,3-*b*]pyrazine amine derivatives as Blue-Orange Fluorescent Materials. Suraj Mahadik, Dinesh R. Garud, Anuja P. Ware, Subhash S. Pingale and Rajesh M. Kamble, Dyes & Pigments, 2021, 184, 108742 (https://doi.org/10.1016/j.dyepig.2020.108742) (Impact Factor: 5.122)
8. Synthesis and investigation of the photophysical, electrochemical and theoretical properties of phenazine–amine based cyan blue-red fluorescent materials for organic electronics. Deepali N. Kanekar, Sajeev Chacko and Rajesh M. Kamble, New J. Chem., 2020, 44, 3278−3293 (DOI: 10.1039/c9nj06109f) (Impact Factor: 3.925)
9. Quinoxaline based amines as Blue-orange emitters: Effect of modulating donor system on Optoelectrochemical and theoretical properties. Deepali N. Kanekar, Sajeev Chacko and Rajesh M. Kamble, Dyes & Pigments, 2019, 167, 36−50 (https://doi.org/10.1016/j.dyepig.2019.04.005) (Impact Factor: 5.122)
10. Electrochemically synthesised xanthone-cored conjugated polymers as materials for electrochromic windows. H. F. Higginbotham, M. Czichy, B. K. Sharma, A.

M. Shaikh, R. M. Kamble, P. Data, Electrochimica Acta, 2018, 273, 264−272 (doi.org/10.1016/j.electacta.2018.04.070) (Impact Factor: 7.336)

***[5] NAME: Dr. Vishwanath R. Patil***

- **DESIGNATION:** Professor

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|---|---|---|---|
| **PAPERS PUBLISHED:** | **68** | **Ph. D STUDENTS GUIDED:** | **16** |
| **PATENTS:** | **33** | **Ph. D STUDENTS UNDER GUIDANCE:** | **07** |
| **M.Sc (BY RESEARCH) STUDENTS GUIDED:** | **04** | **RESEARCH PROJECTS COMPLETED:** | **04** |

- **KEY AWARDS/HONORS:**
  - Prof. B. C. Haldar Memorial Research Award – 2002.
  - Best Researcher & Academician Award (Bionano Frontier & University of Mauritius)- 2017.
  - *Dr. Arvind Kumar Memorial* Award for Best Young Scientist in Chemistry, by Indian Council of Chemists, India-2018.
  - Best Teacher Award, University of Mumbai-2019.
  - Fellow of Maharashtra Science Academy-2021.

- **RESEARCH INTERESTS:** Light emitting polymers, Water soluble polymers, biosynthesis of nanoparticles, Polymer-nano campsites, Self-healing polymers, Invisible barcodes, click chemistry, Antiviral nanocoatings,

- **KEY PUBLICATIONS:**
  1. Enhancement of recovered graphite's electrochemical performance during LIB recycling to promote circular sustainable development, Roshan P. Rane, Bhavesh M. Patil, Satyavan P. Varande, Paresh M. Patil, Vasant M. Patil, Kanchan A. Barve, Kamini J. Donde, Quinn Qiao, Sunil N. Peshane, Vishwanath R. Patil, Sustainable Materials and Technologies 36 (2023) e00613, https://doi.org/10.1016/j.susmat.2023.e00613 **(Impact factor: 10.68).**
  2. Gold Separation Recovery Cycle Economic Route from Bio-sensing AuNPs: Nanowaste and Covid-19 Testing Kits, Amol V. Pansare, Shubham V. Pansare,

Priyanka V. Pansare, Bhausaheb P. More, Kamini J. Donde, Amit A. Nagarkar Michel Barbezat, Vishwanath R. Patil and Giovanni P. Terrasi, ***Dalton Trans.***, 2022, **51**, 14686-14699, https://doi.org/10.1039/D2DT01405J ISSN 1477-9234 (Online) **(Impact factor: 4.569).**

3. Blue light-emitting fluorene–dendron hybridized polymers: optophysical features, Rupashri K Kadu, Pramod B Thakur, Santosh W Zote, Kamini J Donde, Michel Barbezat, Giovanni P Terrasi, Vishwanath R Patil, Amol V Pansare, Polymer Bulletin, 2022, https://doi.org/10.1007/s00289-022-04571-x, **(Impact factor-2.014).**
4. Click Gold Quantum Dots Biosynthesis with Conjugation of Quercetin for Adenocarcinoma Exertion, Amol V. Pansare, Priyanka V. Pansare, Amol A. Shedge, Shubham V. Pansare, Vishwanath R. Patil, Giovanni P. Terrasi and Kamini J. Donde, RSC Advances, 2022, 12, 18425, DOI: 10.1039/d2ra02529a, ISSN: 2046-2069, **(Impact Factor: 3.36).**
5. Deciphering the sensing of a-amyrin acetate with hs-DNA: a multipronged biological probe, Amol V. Pansare, Amol A. Shedge, Maryappa C. Sonawale, Shubham V. Pansare, Akshay D. Mahakal, Shyam R. Khairkar, Shraddha Y. Chhatre, Dnyaneshwar K. Kulal and Vishwanath R. Patil, RSC Advances, 2022, 12, 1238–1243, DOI: 10.1039/d1ra07195e, ISSN: 2046-2069, **(Impact Factor: 3.36).**
6. Highly efficient potentiometric sensing device for gadolinium based on Tetraazacyclododecane-1, 4, 7, 10 -tetraaceticacid crown ether and multiwalled carbon nanotube composite, Nayan S Gadhari, Suyog S Patil, Jayram V Gholave, Vishwanath R Patil, Sharad S Upadhyay, Microchemical Journal, Vol.175 (107130) 2022), https://doi.org/10.1016/j.microc.2021.107130, **(Impact factor-4.821).**
7. Biological macromolecule chitosan grafted co-polymeric composite: bio-adsorption probe on cationic dyes, Shyam R. Khairkar, Shubham V. Pansare, Amol A. Shedge, Shraddha Chhatre, Dnyaneshwar K. Kulal, Vishwanath R. Patil, Amol V. Pansare, Polymer Bulletin, 2021 https://doi.org/10.1007/s00289-021-03954-w, **(Impact factor-2.014).**
8. High performance HPLC-UV Method development and validation for sulfodoxine from its potential interfering impurities, Nayan S Gadhari, Jayram V Gholave; Suyog S Patil, Ajay R. Patil, Kiran Shelke, Vishwanath R Patil, Sharad S Upadhyay, Current Chromatography, 2021, **(**DOI **:** 10.2174/2213240608666210813105715) **I**SSN (Print): 2213-2406 ISSN (Online): 2213-2414.
9. Sono-Maceration- A Rapid and Inexpensive Method for the Isolation of Ursolic Acid from Neolamarckia cadamba Leaves, Jennifer George, Gangadhar A. Meshram, Vishwanath R. Patil, Natural Product Research. 2021, (https://doi.org/10.1080/14786419.2021.1971978). ISSN: 1478-6419 (print) 1478-6427 (web) **(Impact factor 2.158).**
10. Enantioselective high performance new solid contact ion-selective electrode potentiometric sensor based on sulphated γ-cyclodextrin-carbon nanofiber composite for determination of multichiral drug moxifloxacin, Nayan S Gadhari, Jayram V Gholave; Suyog S Patil, Vishwanath R Patil, Sharad S Upadhyay, Journal of Electroanalytical Chemistry, 882, 114981, 2021,

https://doi.org/10.1016/j.jelechem.2021.114981, ISSN: 1572-6657 **(Impact factor 3.218).**

***[6] NAME: Dr. Suresh Damodar Pawar***

- **DESIGNATION: Associate Professor**

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|---|---|---|---|
| **PAPERS PUBLISHED:** | **33** | **Ph. D STUDENTS UNDER GUIDANCE:** | **06** |
| **M.Sc (BY RESEARCH) STUDENTS GUIDED:** | **01** | **RESEARCH PROJECTS:** | **03 (Minor)** |
| **Ph. D. STUDENTS GUIDED:** | **02** | **CONSULTANCY PROJECTS (IN PROGRESS)** | **-** |

**RESEARCH INTERESTS:** Solvent Extraction, Coordination Chemistry, Nanomaterials, Metal Organic Framework.

**Key Publications**

1. Synthesis of Fluorescent Cu-MOF and Ni-MOF Sensors for Selective and Sensitive Detection of Arginine and Hydrogen Sulfide, Chaturvedi S. Gujja and Suresh D. Pawar, **Journal of Inorganic and Organometallic Polymers and Materials**, Published online on 20/05/2023.
2. Selective and sensitive detection of hydrogen sulphide using hydrolytically stable Cu-MOF, Chaturvedi S. Gujja, Divyesh S. Shelar, Ekta P. Asiwal, Sudesh T. Manjare, Suresh D. Pawar, **Journal of Molecular Structure**, 1273, 2023, 134277.
3. A Ni-MOF based luminescent sensor for selective and rapid sensing of Fe(II) and Fe(III) ions, Ekta P. Asiwal, Divyesh S. Shelar, Chaturvedi S. Gujja, Sudesh T. Manjare and Suresh D. Pawar, **New Journal of Chemistry**, 2022, 46, 12679.

4. Novel Schiff base scaffolds derived from 4-aminoantipyrine and 2-hydroxy-3-methoxy-5-(phenyldiazenyl)benzaldehyde: Synthesis, antibacterial, antioxidant and anti-inflammatory, Mangesh S. Kasare, Pratik P. Dhavan, Aksh Hina I. Shaikh, Bhaskar L. Jadhav, Suresh D. Pawar, **Journal of Molecular Recognition**, 35(9), 2022, e2976.
5. Design, synthesis and biological evaluation of furan based $\alpha$-aminophosphonate derivatives as anti-Alzheimer agent, Jasmin J. Uparkar, Pratik P. Dhavan, Bhaskar L. Jadhav, Suresh D. Pawar*, **Journal of the Iranian Chemical Society.** Published online on 25/02/2022.
6. In-vitro antibacterial activity of Ni(II), Cu(II), and Zn(II) complexes incorporating new azo-azomethine ligand possessing excellent antioxidant, anti-inflammatory activity and protective effect of free radicals against plasmid DNA, Mangesh S. Kasare, Pratik P. Dhavan, Bhaskar L. Jadhav, Suresh D. Pawar, **Synthetic Communications**, 49(23), 2019, 3311-3323.
7. Synthesis of Azo Schiff Base Ligands and Their Ni(II), Cu(II) and Zn(II) Metal Complexes as Highly-Active Antibacterial Agents, Mangesh S. Kasare, Pratik P. Dhavan, Bhaskar L. Jadhav, Suresh D. Pawar***, Chemistry Select**, 4, 2019, 10792-10797.
8. Extraction of Yttrium (III) from Sodium Acetate and Sodium Succinate Mediums using Cyanex-923, A.H.I. Shaikh and S.D. Pawar*, **Journal of Applicable Chemistry**, 8 (3), 2019, 1231-1240.
9. Liquid-liquid extraction of Cd(II) metal ion using trialkyl Phosphine oxide extractant, A. H. I. Shaikh and S. D. Pawar*, **Journal of Applicable Chemistry**, 7 (4), 2018, 964-972.
10. Extraction studies of Fe(III) metal ion from hydrobromic acid medium using Cyanex-923 extractant, A. R. Bhoir and S. D. Pawar* **Journal Indian Chemical Society**, Vol. 93, December 2016, 1-4.

***[7] NAME: Dr. S. Sachar***

- **DESIGNATION:** Assistant Professor

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| **PAPERS PUBLISHED:** | **27** | **Ph. D STUDENTS UNDER GUIDANCE:** | **4** |
| **M.Sc (BY RESEARCH)** | **-** | **RESEARCH PROJECTS:** | **1** |

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| **STUDENTS GUIDED:** | | | |
| **Ph. D STUDENTS GUIDED:** | **2** | **CONSULTANCY PROJECTS (IN PROGRESS)** | **-** |

- **RESEARCH INTERESTS:**
  - Solubility and stability properties of therapeutic drugs in the pre-formulation stage by complexing with different surface active agents
  - Surface modifications of nanoparticles
  - Colloidal Chemistry and its applications, e.g. in nanotechnology and bio-medical field.

- **KEY PUBLICATIONS:**

1. Surfactant influences the interaction of copper sulfide nanoparticles with biomolecules, Shagufta M. Khan, Shruti Bhatkalkar, Dinesh Kumar, Ahmad Ali, Shweta Sharma, Shilpee Sachar, Journal of Molecular Liquids, 369 (2023) 120881.
2. Incorporation of the poorly soluble drug cefixime inside the micellar core of conventional and gemini surfactants, Aparna Saraf, Shweta Sharma, Shilpee Sachar, New Journal of Chemistry, 46, 8, (2022), 3697-3706.
3. Influence of surfactants on biomolecular conjugation of magnetic nanoparticles Dinesh Kumar, Shruti G. Bhatkalkar, Shilpee Sachar, Ahmad Ali, Journal of Biomolecular Structure and Dynamics, (2021), 1-13.
4. Studies on the antiglycating potential of zinc oxide nanoparticle and its interaction with BSA, Dinesh Kumar, Shruti G. Bhatkalkar, Shilpee Sachar, Ahmad Ali, Journal of Biomolecular Structure and Dynamics, 39 (2020) 6918-6925.
5. Low-frequency ultrasound responsive release and enhanced antibacterial effi- cacy of Sulfamethoxazole decked Silver nanocomposite, Aparna Saraf, Omkar Padave, Shweta Sharma, Pamela Jha, Renitta Jobby, Ahmad Ali, Shilpee Sachar, Polyhedron, 195 (2020).
6. Evaluation of the antiglycating potential of thymoquinone and its interaction with BSA, Dinesh Kumar, Amisha Desa, Sana Chaugle Shruti G. Bhatkalkar, Shilpee Sachar, Dr. Selvaa Kumar C, Ahmad Ali, Journal of Biomolecular Structure and Dynamics, (2021) 1-9.
7. Studies on the antiglycating potential of zinc oxide nanoparticle and its interaction with BSA, Dinesh Kumar, Shruti G. Bhatkalkar, Shilpee Sachar, Ahmad Ali, Journal of Biomolecular Structure and Dynamics, 39 (2020) 6918-6925.
8. Low-frequency ultrasound responsive release and enhanced antibacterial effi- cacy of Sulfamethoxazole decked Silver nanocomposite, Aparna Saraf, Omkar Padave, Shweta Sharma, Pamela Jha, Renitta Jobby, Ahmad Ali, Shilpee Sachar, Polyhedron, 195 (2020).
9. Influence of surfactants on the interaction of copper oxide nanoparticles with vital proteins, Shruti G. Bhatkalkar, Dinesh Kumar, Ahmad Ali, Shilpee Sachar, Journal of Molecular Liquids, 304 (2020) 112791.

10. Evaluation of surfactants as solubilizing medium for Levofloxacin, Aparna Saraf, Shweta Sharma and Shilpee Sachar, Journal of Molecular Liquids, 319 (2020) 114060-114070.

***[8] NAME: Dr. Purav Badani***

- **DESIGNATION:** Assistant Professor

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|---|---|---|---|
| **PAPERS PUBLISHED:** | **33** | **Ph. D STUDENTS UNDER GUIDANCE:** | **02** |
| **M.Sc (BY RESEARCH) STUDENTS GUIDED:** | **--** | **RESEARCH PROJECTS:** | **02** |
| **Ph. D STUDENTS GUIDED:** | **02** | **CONSULTANCY PROJECTS** | **01** |

- **KEY AWARDS/HONORS:**

  Gold Medalist – University of Mumbai

  Young Scientist Awardee- SERB, Govt. of India

  Secretary – Indian Chemical Society (Mumbai Branch)

- **RESEARCH INTERESTS:** Computational Organic Chemistry, Theoretical Chemistry, Artificial intelligence and Machine Learning

- **KEY PUBLICATIONS:**

1. Effect of functional group on dissociation kinetics of ester and acid derivative of bromopropane. N Gulvi,P Maliekal, R Thorat and PM Badani Computational and Theoretical Chemistry 1207 (2022) 113509.
2. Role of non-covalent interactions in deciding the fate of product formation in bifunctional thiourea-assisted chiral organic reactions. P Maliekal, N Gulvi and PM Badani Theoretical Chemistry Accounts 141 (2022) 43.
3. Effect of substitution on dissociation kinetics of $C_2H_5X$ (X= F, Cl, Br and I): A theoretical study. N Gulvi, P Patel, P Maliekal and PM Badani Molecular Physics 119 (2021) e1807635.

4. Origin and turnaround of enantioselectivity in a chiral organocatalysed Diels-Alder reaction: A mechanistic study. P Maliekal, N Gulvi, AV Karnik and PM Badani Journal of Physical Organic Chemistry 33 (2020) e4072.
5. Exploring unimolecular dissociation kinetics of ethyl dibromide through electronic structure calculations. N. Gulvi, P. Patel, PM Badani Chemical Physics 505 (2018) 55-63.
6. Mechanistic and kinetic insights of reduction of indophenol by sodium borohydride: A theoretical study to explore the effect of solvent and counter ion. P. Patel, S. Lingayat, N. Gulvi and P. Badani Chemical Physics 504 (2018) 13-21.
7. Mass spectrometric and charge density studies of organometallic clusters photoionized by gigawatt laser pulses. PM Badani, S Das, P Sharma and RK Vatsa Mass Spectrometry Reviews 36 (2017) 188-212.
8. Rapid, chemoselective and mild oxidation protocol for alcohols and ethers with recyclable N-chloro-N-(phenylsulfonyl) benzenesulfonamide. A Palav, B Misal, P Ganwir, P Badani and G Chaturbhuj Tetrahedron Letters 73 (2021) 153094.
9. Benzyne-Mediated Nonconcerted Pathway toward Synthesis of Sterically Crowded [5]-and [7] Oxahelicenoids, Stereochemical and Theoretical Studies, and Optical Resolution of Helicenoids. P. Gawade, V. Khose, P. Badani, M. Hasan, S. Kaabel, S. Mobin Shaikh, V. Borovkov and AV Karnik The Journal of Organic Chemistry 84 (2018) 860-868.
10. Synthesis of Concave and Vaulted 2 H-Pyran-Fused BINOLs and Corresponding [5] and [7]-Oxa-helicenoids: Regioselective Cascade-Concerted Route and DFT Studies. S. Kamble, P. Maliekal, P Dharpure, PM Badani and AV Karnik The Journal of Organic Chemistry 85 (2020) 7739-7747.

***[9] NAME: Dr. R. G. Thorat***

- **DESIGNATION:** Assistant Professor

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|---|---|---|---|
| **PAPERS PUBLISHED:** | **7** | **Ph. D STUDENTS UNDER GUIDANCE:** | **Nil** |

- **RESEARCH INTERESTS:** Chiral Chemistry, Synthetic Organic Chemistry, Heterocyclic Chemistry
- **KEY PUBLICATIONS:**

1. Synthesis of bis-1, 2, 3-triazole tweezer with BINOL backbone and amide subunits: An efficient sensor for iodide and magnesium ions. **Ramchandra Thorat***, Sushil khot, Manali Nikam & Anil V. Karnik. *Synthetic Communications*, **2022**, 52:22, 2138-2148.
2. Effect of functional group on dissociation kinetics of ester and acid derivative of bromopropane. N Gulvi,P Maliekal, **R Thorat** and PM Badani Computational and Theoretical Chemistry 1207 **(2022)** 113509.
3. Cysteine catalyzed water mediated eco-friendly approach for the synthesis of 5-substituted 1H-tetrazole and its derivatives. Vikas V. Borge, **Ramchandra G. Thorat,** Arun K. Kadu, Vikas M. Bangade, Parag S. Panse, Gangadhar A. Meshram, and Bhushan B. Popatkar*. *Heterocycles*, **2023**, 106, 7, 1175-1186.
4. Voltametric Quantification of the Antibiotic Roxarsone using a Surface modified Screen-printed Carbon Electrode. Mritinjay S.Tiwari, **Ramchandra G.Thorat**, Vikas Borge, Arun K. Kadu. *Chemistry select*. **2023**, 8:18.
5. Voltametric determination of doxycycline in feedstck using modified carbon screen-printed electrode. M.S.Tiwari, **R.G.Thorat,** V.V.Borge, B.B.Popatkar, A.K.Kadu. *Chemistry Select*. **2023**

***[10] NAME: Dr. Bhushan B. Popatkar***

- **DESIGNATION:** Assistant Professor

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| **PAPERS PUBLISHED:** | **8** | **Ph. D STUDENTS UNDER GUIDANCE:** | **01** |

- **RESEARCH INTERESTS:** Synthetic Organic Chemistry, Heterocyclic Chemistry, Green Chemistry, Water analysis.

**KEY PUBLICATIONS:**

1. HBTU-Catalyzed simple and mild protocol for the synthesis of quinoxaline derivatives. **Bhushan B. Popatkar*** and Gangadhar A. Meshram. *Heterocycles*, **2020**, 100, 7, 1009–1018.
2. Assessment of groundwater quality using GIS in Thane Municipal Corporation, Maharashtra, India. Sitaram Shinde, Pandurang P. Choudhari*, **Bhushan Popatkar** and Namit Choudhari. *Modeling Earth System and Environment*, **2021**, 7, 1739-1751.
3. Tomato fruit extract: an environmentally benign catalytic medium for the synthesis of isoxazoles derivatives. **Bhushan B Popatkar***, Ankita A Mane and

Gangadhar A Meshram. *Indian Journal of Chemistry Sect-B*, 60B, **2021**, 1362-1367.

4. One Pot Catalyst-free Synthesis of Substituted Di-amino N-tosyl Benzoyl Thiazoles by Regioselective C−N Bond Cleavage and Its Anticancer Activity.

   Vikas M. Bangade*, Tulshiram L. Dadmal, **Bhushan B. Popatkar**, Prakash R. Mali, Harshadas M. Meshram. *Asian Journal of Organic Chemistry*, **2021** https://doi.org/10.1002/ajoc.202100675

5. Facile, One Pot Synthesis of Indoloquinoxaline and its Derivatives Using Aqueous Orange Peel Extract at Room Temperature. Nitin A. Sasane, Gangadhar A. Meshram, Kirti S. Bhise, **Bhushan B. Popatkar**. *International Journal of Advanced Research in Science Communication and Technology*, **2022**, 2, (3), 129-133.

6. [BMPTFB]-ionic liquid as an efficient catalyst for the rapid, and eco-friendly synthesis of benzimidazole, 2-substituted benzimidazole, and benzothiazole derivatives at room temperature. **Bhushan B. Popatkar***, Nitin A. Sasane and Gangadhar A. Meshram. *Synth. Commun*., **2022**, 52 (23) 2249-2259.

7. [EMIM]$AlCl_4$-ionic liquid catalyzed mechanochemically assisted synthesis of 3,4-dihydropyrimidin-2-(1H)-one and thione derivatives. **Bhushan B. Popatkar***, Nitin A. Sasane and Gangadhar A. Meshram. *J. Heterocycl. Chem*., **2023**, 60 (7) 1199-1209.

8. Cysteine catalyzed water mediated eco-friendly approach for the synthesis of 5-substituted 1H-tetrazole and its derivatives. Vikas V. Borge, Ramchandra G. Thorat, Arun K. Kadu, Vikas M. Bangade, Parag S. Panse, Gangadhar A. Meshram, and **Bhushan B. Popatkar***. *Heterocycles*, **2023**, 106, 7, 1175-1186.

*[11] NAME: Dr. Sudesh T. Manjare*

- **DESIGNATION:** Assistant Professor

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| **PAPERS PUBLISHED:** | **33** | **RESEARCH PROJECTS:** | **03** |
| **Ph. D STUDENTS GUIDED:** | **05** | **Ph. D STUDENTS UNDER GUIDANCE:** | **02** |

- **KEY AWARDS/HONORS:**
- 1. Junior Research Fellowship, awarded by C.S.I.R., New Delhi, India - 2006.
- 2. Post-doctoral Research Fellow from **Institute for Basic Science** in **Korea Advanced Institute of Science and Technology** (**KAIST**)**,** Daejeon, South Korea.

- **RESEARCH INTERESTS: Organometallics, Coordination Chemistry, chalcogen based Sensors.** Synthesis of molecular probes based-on common fluorophore (such as BODIPY, HBT, fluorescein, rhodamine, 1,8-naphthalamide, etc) and chalcogen atoms. Designing and synthesis of new chelating pockets with common fluorophore. These probes can be used for the selective and sensitive detection of various analytes (such as ROS, bio-thiols, amino acids, metal ions and anions) through fluorescence turn 'ON' or 'OFF' response.

- **KEY PUBLICATIONS:**

1. Chapter 14: Chalcogen-based Probes, Gauri S. Malankar ; Beatriz S. Cugnasca ; Felipe Wodtke ; João L. Petrarca de Albuquerque ; Pratiksha P. Deshmukh ; Divyesh S. Shelar ; Alcindo A. Dos Santos ; **Sudesh T. Manjare** (**Chalcogen Chemistry: Fundamentals and Applications**, Edited by Vito Lippolis; Claudio Santi; Eder J. Lenardão; Antonio L. Braga) Published by **RSC, 2023** (15 Feb 2023), DOI: https://doi.org/10.1039/9781839167386, PDF ISBN: 978-1-83916-738-6.
2. Superoxide Targeted "Turn-On" Fluorescence Sensing Enabled by Diselenide Based Quinoline Probe and Its In-Vitro Anticancer Activity in Cancer Cells, Divyesh S. Shelar, Gauri S Malankar, Pinky Singh, Shashikant Prabhakar Vaidya, Rahul V. Pinjari and **Sudesh T Manjare, New J. Chem., 2023,** 47, 6653-6660 (Impact Factor 3.925).
3. Synthesis of Selenium-based BOPHY Sensor for Imaging of Cu(II) in Living HeLa Cells. Gauri S. Malankar, Divyesh S. Shelar, Manikandan M., Malay Patra, **Sudesh T. Manjare**, ***J. Mol. Struct.*** **2022**, 1281, 135118 (Impact Factor 3.841).

4. Synthesis and Photophysical Study of Tetraphenyl Substituted BODIPY Based phenyl-Monoselenide Probe for Selective Detection of Superoxide. Shrikrishna T. Salunke, Divyesh S. Shelar, **Sudesh T. Manjare**, ***J. Fluoresc***. **2022**, DOI: 10.1007/s10895-022-03096-w, (Impact Factor 2.525).
5. Selective and Sensitive Detection of Hydrogen Sulphide Using Hydrolytically Stable Cu-MOF. C. Gujja, Divyesh S. Shelar, E. Asiwal, **Sudesh T. Manjare**, Suresh D. Pawar, ***J. Mol. Struct.*** **2022**, 134277, (Impact Factor 3.841).
6. Selective Detection of Hypochlorous Acid in Living Cervical Cancer Cells with Organoselenium Based BOPPY Probe, Divyesh S. Shelar, Gauri S. Malankar, Manikandan M, Malay Patra, R. J. Butcher and **Sudesh T. Manjare New J. Chem., 2022,** 46, 17610 (Impact Factor 3.925).
7. Synthesis and Single Crystal X-ray Study of Phenylselenyl Embedded Coumarin-Based Sensors for Selective Detection of Superoxide, Gauri S. Malankar, Divyesh S. Shelar, R. J. Butcher and **Sudesh T. Manjare**, **Dalton Trans., 2022**, 51, 10518–10526 (Impact Factor 4.390).
8. BOPHY based Fluorescent Probe for $Hg^{2+}$ via an $NTe_2$ Chelation, Gauri S. Malankar, Divyesh S. Shelar, Manikandan M, Malay Patra, R. J. Butcher and **Sudesh T. Manjare Dalton Trans., 2022,** 51, 10069–10076 (Impact Factor 4.390).
9. An efficient chemodosimeter for the detection of Hg(II) via diselenide oxidation, Pratiksha P. Deshmukh,a Gauri S. Malankar, Arunima Sakunthala, Ambuja Navalkar, Samir K. Maji, Dhiraj P. Murale, Raju Saravanan and **Sudesh T. Manjare, Dalton Trans., 2022**, 51, 2269–2277 (Impact Factor 4.390).
10. Synthesis and study of organoselenium compound: DNA/Protein interactions, in vitro antibacterial, antioxidant, anti-inflammatory activities and anticancer activity against carcinoma cells, Divyesh S. Shelar, Pratik P. Dhavan, Pinky R. Singh, Bhaskar L. Jadhav, Shashikant P. Vaidya, **Sudesh T. Manjare, Journal of Molecular Structure, 2021**, 1244, 130914 (Impact Factor 3.196).

***[12] NAME: Dr. Arun K. Kadu***

**DESIGNATION:** Assistant Professor

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| **PAPERS PUBLISHED:** | **8** | **Ph. D STUDENTS UNDER GUIDANCE:** | **04** |

**RESEARCH INTERESTS:**

Electrochemistry: Development of sensors, nano-composites for sensors and catalyst.

**KEY PUBLICATIONS:**

1. Voltammetric Quantification of the Antibiotic Roxarsone using a Surface Modified Screen-printed Carbon Electrode. Mritinjay S.Tiwari, Ramchandra G.Thorat, Vikas Borge, **Arun K. Kadu**. *Chemistry select*. **2023.**
2. Voltammetric determination of doxycycline in feedstock using modified carbon screen-printed electrode. M.S.Tiwari, R.G.Thorat, V.V.Borge, B.B.Popatkar, **A.K.Kadu**. *Analytical Sciences*. **2023.**
3. Cysteine catalyzed water mediated eco-friendly approach for the synthesis of 5-substituted 1H-tetrazole and its derivatives. Vikas V. Borge, Ramchandra G. Thorat, **Arun K. Kadu,** Vikas M. Bangade, Parag S. Panse, Gangadhar A. Meshram, and Bhushan B. Popatkar. *Heterocycles,* **2020**, 106, 7, 1175-1186.
4. Potentiometric Determination of Proton-Ligand Dissociation Constant of 1-[2-(2-Hydroxybenzilidene) Hydrazono]-1-Phenylpropan-2-One Oxime and Formation Constants of its Complexes with Cobalt, Nickeland Copper in Dioxane-Water System, **A. K. Kadu** and R. G. Deshmukh, Journal of Chemistry and Chemical Sciences, Vol.6(5), 433-442, May 2016.
5. Synthesis and Characterization of Co(II), Ni(II), Cu(II) and Pd(II) Complexes of 1-[2-(5-bromo-2-hydroxybenzilidene)hydrazono]-1-phenylpropan-2-one oxime, **A. K. Kadu** and R. G. Deshmukh, *Journal of Chemical, Biological and Physical Sciences,* JCBPS; Section A; August 2016 – October 2016, Vol. 6, No. 4; 1196-1204
6. Evaluation of Proton-Ligand Dissociation Constant of 1-(2-(1-(2-Hydroxyphenyl) Ethylidene)Hydrazono)-1-Phenylpropan-2-One and Formation Constants of its Complexes with Cobalt, Nickel and Copper in Dioxane-Water System by Potentiometry, **A. K. Kadu**, Sharad S. Sankhe, P. S. Kamble, International Journal for Research in Applied Science & Engineering Technology, Volume 5 Issue IX, September 2017.
7. Synthesis and characterization of Co(II), Ni(II), Cu(II) and Pd(II) complexes of 1-[2-(2-hydroxybenzilidene)hydrazono]-1-phenylpropan-2-one oxime. **A. K. Kadu** and R. G. Deshmukh, Journal of Emerging Technologies and Innovative Research, August 2018, Volume 5, Issue 8.
8. Equilibrium Studies and Effect of Ionic Strength on Binary Complexes of Bivalent Cobalt, Nickel and Copper with 1-[2-(5-bromo-2-hydroxybenzilidene)hydrazono]-1-phenylpropan-2-one, oxime
A. K. Kadu and R. G. Deshmukh, International Journal of Research and Analytical Reviews, August 2018, Volume 5, Issue 3.

## 8. About IRMRA

Indian Rubber Manufacturer's Research Association, popularly known, as IRMRA is Premier National Research and Development organization registered in 1958 under societies act XXI of 1860 to provide hand holding scientific and technological support to the Indian Rubber & Allied Industries. Presently, IRMRA is functioning under the administrative control of Ministry of Commerce & Industry, Govt. of India. The institute is functioning in two locations situated at Wagle Industrial Estate, Thane – 400 604. Institute is funded by Ministry of Commerce & Industry, Govt. of India to create state of art R&D center to support Rubber Industries & end users to improve the quality of rubber products. IRMRA has modern state of art scientific and analytical facilities and is fully equipped with infrastructure for design & development, testing and certification, process optimization, technical consultancy, third party inspection, training, reverse engineering and allied aspects in quality and eco compliance for rubber and allied products. IRMRA is contemplating to establish its regional centers in different parts of country to cater the needs of clusters. To begin with, Eastern and Southern Regional Centers are being set up in SARPOL, Dulhagarh, Kolkata, WB and Sri City, Chittur District AP respectively.

The testing laboratories of IRMRA, including mechanical and chemical area are accredited by National Accreditation Board for Testing & Calibration Laboratories (NABL), Quality Council of India, Ministry of Commerce & Industry, GOI, in compliance with ISO/IEC 17025. In addition, the institute is certified for Quality Management System complying with ISO 9001:2008 and institute is recognized by DSIR as Scientific & Industrial Research Organization (SIRO). The institute is also accredited by NABET as Business Membership Organisation (BMO) under Diamond Grade.

The institute is engaged in pursuit of higher research in all major areas of rubber and polymer Technology having qualified, trained and experienced scientists with doctoral and master's degree holders from premier universities / IITs. IRMRA, Thane is involved conducting various R&D programmes either sponsored by industry and or government organization such as DST, BARC, DBT, CSIR, NAIP, ICAR, IGCAR, MOD etc. in the area of product development, process development / optimization, application development, development of standard test methods, waste recycling etc.

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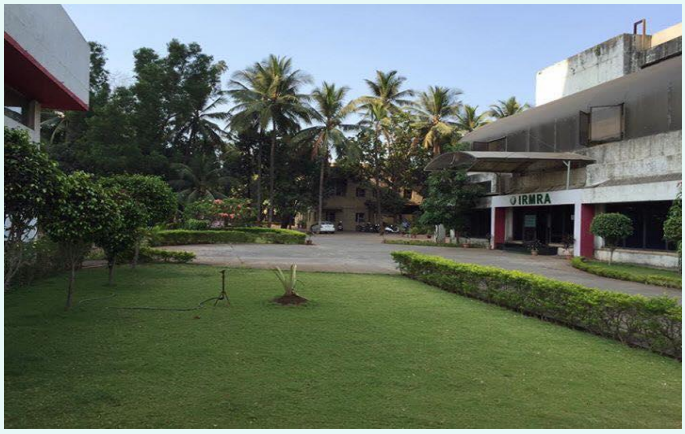
|  | **IRMRA Head Office**<br>Plot No. 254/1B, Road No.16-V<br>Wagle Industrial Estate,<br>Thane - 400 604, Maharashtra |
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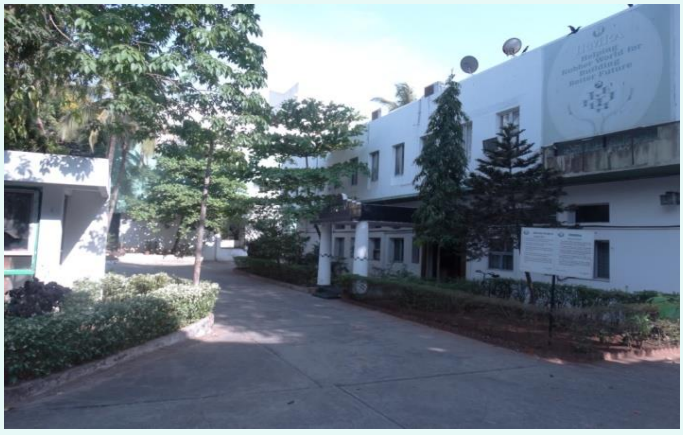
|  | **IRMRA Extension Centre, Thane (Old)**<br>Plot No. B-88, Road No. 24, Wagle Industrial Estate, Thane - 400 604, Maharashtra<br>. |
|  | **IRMRA- South Centre**<br>Sricity Trade Centre,<br>Sri City, Andhra Pradesh -517646 |
|  | **IRMRA-East Centre**<br>Rubber Park, Dhulagarh,<br>Howrah-711302<br>West Bengal |

1. **IRMRA has following quality accreditations / recognitions:**

- **ISO/IEC 17025 Accredited**
- **ISO 9001 Certified**
- **DGMS Accredited**
- **BIS Recognized for various Tyre & Non - Tyre Testing**
- **DSIR Recognized**
- **CEMILAC Approved**
- **NBQP Registered**
- **BMO Accredited**

**Research & Development**

Some of the R&D activities conducted or being conducted is as under:

- Design & Development of Rubber Dams for watersheds
- A value chain for coconut, fibre and its by-product: Manufacture of dissolved products of higher value and better marketability to enhance the economic returns of farmers (Coir Project).
- Radiation effects on styrene–butadiene– ethylene–propylene diene monomer-multiple walled carbon nanotube nano-composites: vulcanization and characterization.
- Development of NBR Based Polymer Nano-composites for High Temperature Application.
- Use of Electron Beam Radiations in Rubber Products especially Tyres, Belts etc – BRNS, BARC
- Design and Development of critical rubber products for defense application. Sponsored by MOD, Govt. of India.
- Development of critical rubber compounds for nuclear applications. Sponsored by Department of Atomic Energy, Government of India,

**Training & Skill development**

The institute conducts following training programmes on relevant areas of interest to the user industry:

- 04 days training on Laboratory Quality Management System (ISO/IEC 17025:2005) and is accredited by National Accreditation Board for Education and Training (NABET), Quality Council of India, Ministry of Commerce & Industry, GOI.
- Short term technical training courses on Rubber Technology & quality control.
- Facilitates conduct of projects/ dissertation work for students pursuing higher learning programmes from leading institutes like IITs, NITs.
- Summer training / internship in polymer and rubber technology.

**Education Programmes**

IRMRA has initiated the following education programs

- 1 Year Online certificate course on, Rubber Material Science & Technology
- 2 Years full time Masters in Rubber Chemistry in collaboration with PG Department of Chemistry, Mumbai University.

## 9. Team of IRMRA Scientist & Faculties

**Dr. K. Rajkumar- Director – IRMRA**

Dr. K Rajkumar was appointed as the Director of IRMRA w.e.f. 12th March 2015 based on the recommendation given by Govt. of India and currently, he is the overall in-charge of IRMRA.

Dr. Rajkumar has completed his M.Tech. in Rubber Technology (1997) from Rubber Technology Centre, Vels University and received his PhD degree in Polymer Nanocomposites (2015) from Bharathiar University, Coimbatore in 2015. He also secured an MBA in Operation Management from Sikkim Manipal University (2013). He has over 20 years of work experience.

He has handled more than 30 sponsored projects and developed more than 25 critical products.

He has published more than 50 research papers and has filed 3 patents in his credit.

He has encouraged and guided more than 50 students in rubber technology and more than 400 lectures/training. He is the Chairman of BIS/PCD 29 Committee and Member of several committees like ISO TC 45, BIS ME 17, TED 7, BIS/PCD 13 and BIS/PCD 28.

Dr. Rajkumar also secured an award from ICAR, Ministry of Agriculture, Govt. of India for his outstanding contribution in completion of project of "Design and Development of Rubber Dam for water sheds. He was involved in various important R&D Projects which include Development of shock vibration isolation mounts, estimation of life of SV mounts, development of hydraulic mounts, development of alternate materials including bio source based materials etc. are some of his major area of interest. He is a Lead Assessor of NABL and also a Lead Auditor of ISO 9001/QMS. He has travelled abroad (more than 20 countries) in different capacities.

**Mr. T. V. Sethumadhavan, Assistant Director – Product Development**

Mr. T. V. Sethumadhavan has completed his M.Sc in Chemistry (1988) from Mahatma Gandhi University, Kerala and M.Tech degree in Polymer Technology (1991) from Cochin University of Science and Technology. He joined IRMRA in 2015 and has 27 years of work experience.

He has handled 18 sponsored projects and developed 18 products. He has filed 2 patents in his credit. He encouraged and guided 5 students in rubber technology and delivered 7 lectures/trainings.

Presently he is heading the Department for Product Development, Contract and Sponsored Research and Third Party Inspection Services in IRMRA. He is also responsible for new product development and project execution for defense, nuclear and other public sector units and other industries.

**Ms. Suchismita Sahoo, Assistant Director- Chemical and Analytical Testing**

Ms. Suchismita Sahoo has completed her M.Sc in Chemistry (2003) from Utkal University, Odisha and received her M.Tech degree in Rubber Technology (2006) from IIT Kharagpur. She joined IRMRA in 2015 and has 13 years of work experience.

She has handled 4 projects and developed 2 products. She has published 7 research papers and has filed 3 patents in her credit. She encouraged and guided 11 students in rubber

technology and delivered more than 25 lectures/trainings. Presently she is heading Chemical and Analytical Testing Laboratory in IRMRA.

**Dr Debdipta Basu – Assistant Director & Center Head, East Center, IRMRA**

Dr Debdipta Basu has completed his Master degree in Material Science (2009) from Sardar Patel University, Gujarat and received his PhD degree in Polymers (2015) from Technical University of Dresden, Germany.

He joined IRMRA in April 2018 and has 3 years of work experience. He has handled 8 sponsored projects and developed 5 products. He has published 15 research papers along with 3 articles / chapters in books. He has encouraged and guided 3 students in rubber technology and given 2 lectures/trainings. Presently he is heading the East Center of IRMRA, located in Kolkata.

**Dr. Rupesh Rohan – Assistant Director & Center Head, South Center, IRMRA**

Dr. Rupesh Rohan has completed his M.Tech in Rubber Technology (2009) from IIT, Kharagpur and received his PhD degree in Chemistry (2015) from National University of Singapore, Singapore.

He joined IRMRA in June 2018 and has 3 years of postdoctoral research experience along with 3 years of Industrial experience. He has handled 7 projects and developed 3 products. He has published 29 research papers and has filed 1 patent in his credit. He has encouraged and guided 3 students in rubber technology and given 10 lectures/training. Presently he is heading Physical Testing, Academics and Training Department in IRMRA.

**Dr. Bharat Kapgate – Assistant Director & Corporate, Head, IRMRA**

Dr. Bharat Kapgate has completed his M.Sc in Organic Chemistry (2008) from RTM Nagpur University and received his PhD degree in Rubber Chemistry & Technology (2015) from VNIT, Nagpur.

He joined IRMRA in October 2015 and has 2 years of academic experience prior to IRMRA. He has handled 5 projects and developed 3 products. He has published 20 research papers, 1 book chapter and has filed 1 patent in his credit. He has encouraged and guided 30 students in rubber technology and over 20 lectures/training. Presently he is heading Corporate Affairs in IRMRA.

**Recent Publication:**

1. Unusual low temperature relaxation behavior of crosslinked acrylonitrile-butadiene co-polymer. **Basu, Debdipta**, Shib Shankar Banerjee, Subhas Chandra Debnath, Mikhail Malanin, Lyaysan Amirova, Philippe Dubois, Gert Heinrich, and Amit Das. Polymer (2020): 123309.
2. Synthesis and chemical modification of crystalline nanocellulose to reinforce natural rubber composites. Singh, Shiva, Gopal L. Dhakar, **Bharat P. Kapgate**, Pradip K. Maji, Chhavi Verma, Monika Chhajed, **Kasilingam Rajkumar**, and Chayan Das. Polymers for Advanced Technologies (2020).
3. Carbon cloth-$MnO_2$ nanotube composite for flexible supercapacitor. Soni, S., Pareek, K., Jangid, D. K., & **Rohan, R**. Energy Storage, e189.
4. In Situ Zirconia: A Superior Reinforcing Filler for High-Performance Nitrile Rubber Composites. Ambilkar, Shubham C., Naresh D. Bansod, **Bharat P. Kapgate**, Amit Das, Petr Formanek, **Kasilingam Rajkumar**, and Chayan Das. ACS omega 5, no. 14 (2020): 7751-7761.
5. A feasibility study on rubberized concrete mortar cubes used in construction industry. Venkatesan, G., Anjali, R., **Kapgate, B**., & **Rajkumar, K.** (2020). Materials Today: Proceedings.
6. Laboratory studies on strength behavior of concrete added with tire derived products. Venkatesan, G., M. Saravanakumar, Bharat P. Kapgate, and K. Rajkumar. Materials Today: Proceedings (2020).
7. Experimental investigation on natural fiber along with silica fume in conventional concrete. Venkatesan Govindan, Bharat P Kapgate, K Rajkumar. South Asian Journal of Engineering and Technology (2019).
8. Synthesis and Characterization of Phenol Furfural Resin from Moringa Oleifera Gum and Biophenol and Its Application in Styrene Butadiene Rubber. Riya Koley Rajkumar Kasilingam Suchismita Sahoo Santanu Chattopadhyay Anil K. Bhowmick., Industrial & Engineering Chemistry Research, (2019).
9. Investigation of compressed hydrogen refueling process of 60 L type IV tank used in fuel cell vehicles, S. Sapre, K. Pareek, R Rohan, P K Singh, Energy Storage, (2019).

10. H2 refueling assessment of composite storage tank for fuel cell vehicle, Shitanshu Sapre, Kapil Pareek, Rupesh Rohan, Pawan Kumar Singh, International Journal of Hydrogen Energy, (2019).
11. Performance optimization of Co2O3-PVDF-CNT based Supercapacitor electrode through multi-response optimization method., Mayank Vyas, Kapil Pareek, Rupesh Rohan, Pawan Kumar., IONICS. (2019).
12. Phase Changing Stearate Ions as active fillers in Multifunctional Carboxylated acrylonitrile butadiene composite: Exploring the role of zinc stearate., Basu D., Agasty A., Das A., Chattopadhyay S., Sahu P., Heinrich G., Journal of Applied Polymer Science, (2019).
13. Evolution of coefficient of friction between tire and pavement under wet conditions using surface free energy technique., Singh, Dharamveer, Harsh Patel, Ayyanna Habal, Aditya Kumar Das, Bharat P. Kapgate, and Kasilingam Rajkumar, Construction and Building Materials, (2019).
14. Incorporation of titania nanoparticles in elastomer matrix to develop highly reinforced multifunctional solution styrene butadiene rubber composites., Das, Chayan, Naresh D. Bansod, Bharat P. Kapgate, K. Rajkumar, Amit Das., Polymer, 2019
15. Flexible supercapacitor based on three-dimensional cellulose/graphite/polyaniline composite., Sharma, Kshipra, Kapil Pareek, Rupesh Rohan, and Pawan Kumar, International Journal of Energy Research, 2019.
16. Functionalization of EPDM rubber toward better silica dispersion and reinforcement., Bansod, Naresh D., Bharat P. Kapgate, Pradip K. Maji, Anasuya Bandyopadhyay, and Chayan Das., Rubber Chemistry and Technology., 2018
17. A unique application of the second order derivative of FTIR–ATR spectra for compositional analyses of natural rubber and polychloroprene rubber and their blends., Manohar, N., J. Jayaramudu, S. Suchismita, K. Rajkumar, A. Babul Reddy, E. R. Sadiku, R. Priti, and D. J. Maurya., Polymer Testing, 2017.
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19. Surface modification of nylon fabric and its optimization for improved adhesion in rubber composites, Krishna Prasad, G., S. Periyasamy, S. K. Chattopadhyay, A. S.

M. Raja, K. Rajkumar, and Santosh Jagadale, The Journal of The Textile Institute, 2017

20. Micro-roughening of polyamide fabric using protease enzyme for improving adhesion strength of rubber-polyamide composite, Periyasamy, S., G. Krishna Prasad, Sajal Kumar Chattopadhyay, A. S. M. Raja, K. Raj Kumar, and Santosh Jagadale, Journal of Polymer Engineering, 2017.
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23. Chitosan composites reinforced with nanostructured waste fly ash, Patil, Akshata G., S. Poornachandra, Ramesh Gumageri, K. Rajkumar, and S. Anandhan, Journal of Material Cycles and Waste Management (2017).
24. Recycled polypropylene/ boehmite alumina nanocomposites: enhanced structure, thermal and mechanical properties. Jarugala, J., J. PreshdReddy, R. Kasilingam, M. Nawale, S. Sahoo, S. Mohan, B. Abbavaram, S. Sinha Ray, and E. Sadiku, Int. J. Adv. Res, (2017).
25. Use of polyolefins in hygienic applications., Manjula, B., Reddy, A. B., Sadiku, E. R., Sivanjineyulu, V., Molelekwa, G. F., Jayaramudu, J., & Kumar, K. R. In Polyolefin Fibres, Woodhead Publishing. (2017).
26. Hybrid natural/synthetic fiber biocomposites. properties, performance and applications, Ibrahim, I. D., Sadiku, E. R., Jamiru, T., Kupolati, W. K., Agwuncha, S. C., Fasiku, V. O., Bandla, M., Jarugala, J., Kasilingam, R. (2017).

# Patents:

## Granted

1. **A Process of making Ozone Resistant Natural Rubber**

   Mrs. Anushree Dukhande & Dr. Madhu Sudan Banerji.

   Indian Patent Application Number 101/MUM/2004

2. **Use of Bio product as multieffective Rubber compounding agent**

Santosh Jagadale, K. Rajkumar

Indian Patent number 350542 Dated 01.02.2019

## Filed

1. **Design, Development and Fabrication of Flexible booting-**

Application number 201821013011 dated 06.04.2018.

**T V Sethumadhawan, Santosh Jagadale, K. Rajkumar**

2. **Rubber segment bearing for propeller shaft –**

T V Sethumadhawan, Chandan Chaudhary, K. Rajkumar

TEMP/E-1/3514/2019-MUM

3. **Coconut Nut Shell Extract (CNSE) as a multifunctional additive in rubber compounds :**

Suchismita Sahoo; Manohar Nawale; Kasilingam. Rajkumar; Bharat Kapgate; Debdipta Basu; Shantaram Naik; Raju Shetty; Deepasha Bharti; Anil Kumar. Bhowmick TEMP/E-1 /16064/2019-MUM

**4. A Bio Based Sealant for Puncture Proof Tire-**

TEMP/E- 1/9837/2019-MUM

Suchismita Sahoo; Manohar Nawale; Kasilingam. Rajkumar; Debdipta Basu; Surjendu Bag , Santosh Jagadale, Rohit Tripathi

5. **Ageing & ozone resistant bio-based rubber formulation containing curcumin & derivatives as an additive.**

Suchismita Sahoo; Manohar Nawale; Priti Rasam, Rupesh Rohan; Kasilingam. Rajkumar; Application number 201921036794 dated 12.09.2019

**6. Treatment of Silica with Turmeric and Its Constituents,**

R. Rohan, M. Nawale, A. Jhadhav, R. Shetty, K. Rajkumar

Intellectual Property India India provisional Application No. 202021000276, filing dated 03/01/2020.

## 10. NEED OF INDUSTRIAL POLYMER CHEMISTRY EDUCATION & ELIGIBILITY

There are about 7000 units comprising of 30 large scale, 300 medium scale and around 6500 small scale and tiny sector units. Rubber is one of the major industrial polymers. Indian Rubber Industry is expected to grow at over 8% per annum in this decade and the industry is envisaged to grow at the rate of 8% per annum. The per capita consumption of rubber in India is only 800 grams compared to 12 to 14 kilos in Japan, USA and Europe. The prospect of growth is further enhanced by a boom in the vehicle (automobile) industry, improved living standards of the people and rapid over-all industrialization. There exists a huge scope for expansion and development and exports in coming years. However, the largest part of the industry includes unorganized small & medium scale rubber industries. Unlike metal and plastic, rubber products are very complex and require a high expertise starting from raw material selection to processing techniques. Rubber product manufacturing involves multiple steps, a single rubber product contains more than 10-15 different ingredients, their mixing and molding requires highly skilled man power. The rubber industry is has a huge demand for the skilled manpower to up lift the level and status of rubber industry. Very few institutes in India offer an educational course on rubber technology; most of them offer courses on chemistry / chemical engineering / mechanical engineering that do not serve the need of the industry. • In view of this IRMRA in collaboration with Department of Chemistry, Mumbai University offers—‖M. Sc. Industrial Polymer Chemistry" for fresh graduates to grow their career in rubber & allied polymer industries. • Any student who has completed B. Sc. in Chemistry can apply for this course. Admission will be given on the basis of merit.

## 11. M. Sc. CHOICE-BASED CREDIT SYSTEM (CBCS)

The Choice-Based Credit System (CBCS) has been introduced for the Master's Program from the Academic Year 2016-17. A minimum of **96** credits have to be earned by students across four Semesters. Semesters I and II form the First year of the M. Sc. programme and comprise the courses from four branches while Semesters III and IV are in the second year of the M. Sc. programme in the respective specialization chosen by the student at the time of admission to the M. Sc. Course.

**The Salient features of Choice-Based Credit System (CBCS) are as follows:**

**Credit:** One credit shall be equal to one hour teaching per week per semester for 15 weeks.

**M. Sc. Course:**

- M. Sc. Course shall be given four teaching hours per week per paper. Each paper shall have 4 credits.
- There shall be four papers of 4 credits each per semester.
- Thus there shall be 16 theory lectures per week.
- There shall be 8 credit practical components for M. Sc.

- Two hours of laboratory component per week shall be considered as 1 credit. Thus, students shall perform 16 hours of practical per week per semester for 15 weeks.

**M. Sc. Program:** Ordinarily, M. Sc. Program shall consist of 96 credits over four semesters.

**Courses:** There shall be four types of courses:

(i) Core Courses
(ii) Elective Courses
(iii) Optional Courses

**Core Courses:** Core-courses shall be offered by parent department.

- Core courses being the absolute necessity for a master's degree in a subject, shall be never less than 75% for any of the semesters.
- Semester I & II shall have 100% core courses.
- Semester III & IV shall have three theory papers (12 credits) each on core courses.
- Semester III shall have 8 credits of practical component. Students shall perform 16 hours of practical per week for 10-15 weeks.
- Semester IV shall have 8 credits of Project component. For this, students shall perform 8 hours per week practical work for 10-15 weeks.

**Elective Courses:**

- Elective Courses shall be offered by the parent department in Semester III and each course will be of 4 credits.

**Optional Courses:**

- Optional courses shall be offered by parent department in Semester IV and each course will be of 4 credits.

**Choice-Based Courses:**

- It shall be made mandatory to offer two Elective courses in the third semester and 2 Optional Courses [OC-1 & OC-2] in the fourth semester.
- The Optional course shall be interdisciplinary in nature.
- Each department shall offer 2 Optional courses for the benefit of students from other disciplines. There shall be a total of 4 lectures required per week for optional courses. There shall be a fixed slot for this component where lectures from core courses and Elective courses shall not be held.
- The Head of the Department shall communicate the internal marks for OC-1 and or OC-2 for the students from other departments to the head of their parent department. The internal marks for all the courses shall be communicated to the COE by the parent departments only.

**The structure:**

- **Semester I:** Theory papers of 4 credits each only on core subject. 8 credits for practical component.
- **Semester II:** Theory papers of 4 credits each only on core subject. Credits for practical component.

- **Semester III:** Theory papers of 4 credits each only on core subject. One theory paper of 4 credits on 2 Elective courses. 8 credits for practical component.
- **Semester IV:** Theory papers of 4 credits each only on core subject. One theory paper of 4 credits on 2 Optional courses. 8 credits of Project component.

**Admission to M. Sc. Choice-Based Credit System (CBCS) Course**

Admission to departments where entrance examination will not be necessary, the admission shall be decided only on the basis of T. Y. B. Sc. Norms give below:

**[1] T. Y. B. Sc. Marks component for Mumbai University Students**

a) The marks secured by the student, without grace marks, with as a major subjects out of 1200 (Sem V & VI) shall be considered.
b) Theory marks shall be given preference in case of a tie in (a).
c) The students with first class shall be given priority over the students who have been declared passed in First Class with grace marks / Second Class with as a single major subject out of 600 (Sem V & VI).
d) The students offering two major subjects, "The Subject Applied for Master's Degree" as one of the subject at T. Y. B. Sc. be admitted in order of merit by considering marks secured in "The Subject Applied for Master's Degree".
e) In case of there is a tie in (a), (b), (c), (d) or (e), aggregate marks without grace marks out of 600 shall be considered.
f) In case of there is a tie in (a), (b), (c), (d) or (e), then all students tied at the rank shall be admitted as per their date/time of birth.
g) In case there is a gap, 2% marks will be deducted.

The final merit list will be displayed on the website of the University and also on the Notice Board of the Department.

**[2] For other University students:**

a) Marks declared by the concerned University at T. Y. B. Sc. Examination and as shown in mark sheet "The Subject Applied for Master's Degree" will be considered for preparing the merit list as per quota available for other University students.
b) In case there is a gap, 2% marks will be deducted.

**Examination**

All examinations for all semesters are conducted by the departments for the students admitted in the departments.

The examinations shall be of two kinds:

I. Internal assessment II. End Semester Examination

**Internal Assessment:** The internal assessment for theory papers shall be for 40% marks.

**End-Semester Examination:** The end semester assessment shall be for 60% marks for theory papers and 100% for practical examination.

# 12. SYLLABI FOR M. Sc. CHOICE BASED CREDIT SYSTEM (CBCS) FOUR-SEMESTER-COURSE IN CHEMISTRY

# Department of Chemistry
# (Autonomous)
# University of Mumbai
### Credit Distribution Structure for Two Years
## (M.Sc. in Industrial Polymer Chemistry)

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Level</th><th rowspan="2">Sem</th><th colspan="4">Major</th><th rowspan="2">RM</th><th rowspan="2">OJT/FP</th><th rowspan="2">RP</th><th rowspan="2">Cum. Cr.</th><th rowspan="2">Degree</th></tr>
<tr><th colspan="3">Mandatory</th><th>Electives</th></tr>
<tr><td rowspan="6">1</td><td rowspan="6">6.0</td><td rowspan="5">Sem I</td><td colspan="3">3*4+ 2=14</td><td>4</td><td>4</td><td rowspan="5"></td><td rowspan="5">-</td><td rowspan="5">22</td><td rowspan="12">PG Diploma (after 3 Years Degree)</td></tr>
<tr><td>Physical Chemistry-I (CHEM 501) / 112016150111</td><td>TH</td><td>4</td><td rowspan="4">Analytical Chemistry-I (CHEM 50511)/ 112016150511<br>(OR)<br>Applied Industrial Chemistry-I (CHEM 50512)/ 112016150512</td><td rowspan="4">Research Methodology (CHEM 506)/ 112016150611</td></tr>
<tr><td>Inorganic Chemistry-I (CHEM 502)/ 112016150211</td><td>TH</td><td>4</td></tr>
<tr><td>Organic Chemistry-I (CHEM 503)/ 112016150311</td><td>TH</td><td>4</td></tr>
<tr><td>Chemistry Practical-I (CHEM 504)/ 112016150411</td><td>PR</td><td>2</td></tr>
<tr><td rowspan="5">Sem II</td><td colspan="3">3*4+ 2=14</td><td>4</td><td>-</td><td>4<br>CHEM 512/ 11201625121 1</td><td>-</td><td>22</td></tr>
<tr><td>Physical Chemistry-II (CHEM 507)/ 112016250711</td><td>TH</td><td>4</td><td rowspan="4">Analytical Chemistry-II (CHEM 51111)/ 112016251111<br>(OR)<br>Applied Industrial Chemistry-II (CHEM 51112)/ 112016251112</td></tr>
<tr><td>Inorganic Chemistry-II (CHEM 508)/ 112016250811</td><td>TH</td><td>4</td></tr>
<tr><td>Organic Chemistry-II (CHEM 509)/ 112016250911</td><td>TH</td><td>4</td></tr>
<tr><td>Chemistry Practical-II (CHEM 510)/ 112016251011</td><td>PR</td><td>2</td></tr>
<tr><td colspan="3">Cum. Cr. For PG Diploma</td><td colspan="3">28</td><td>8</td><td>4</td><td>4</td><td></td><td>44</td></tr>
<tr><td colspan="12">Exit Option: PG Diploma (44 credits) after Three Year UG Degree</td></tr>
</table>

# Department of Chemistry
# (Autonomous)
# UNIVERSITY OF MUMBAI

## Syllabus For M.Sc. Industrial Polymer Chemistry
## Semester I and II
## Choice Based Credit System
## Under New Education Policy (NEP) 2020
**(To be implemented from the academic year, 2023-2024)**

## PROGRAM OUTLINE 2023-2024

| YEAR | | COURSE CODE | COURSE TITLE | CREDITS |
|---|---|---|---|---|
| **M.Sc. Sem-I** | Mandatory Course-I | CHEM 501/ 112016150111 | Physical Chemistry-I | 04 |
| | Mandatory Course-II | CHEM 502/ 112016150211 | Inorganic Chemistry-I | 04 |
| | Mandatory Course-III | CHEM 503/ 112016150311 | Organic Chemistry-I | 04 |
| | Mandatory Course Practical | CHEM 504/ 112016150411 | Chemistry Practical-I | 02 |
| | Elective 1 | CHEM 50511/ 112016150511 | Analytical Chemistry-I | 04 |
| | Elective 2 | CHEM 50512/ 112016150512 | Applied Industrial Chemistry-I | 04 |
| | RM | CHEM 506/ 112016150611 | Research Methodology | 04 |
| **M.Sc. Sem-II** | Mandatory Course-I | CHEM 507/ 112016250711 | Physical Chemistry-II | 04 |
| | Mandatory Course-II | CHEM 508/ 112016250811 | Inorganic Chemistry-II | 04 |

| | | | | |
|---|---|---|---|---|
| | Mandatory Course-III | CHEM 509/ 112016250911 | Organic Chemistry-II | 04 |
| | Mandatory Course Practical | CHEM 510/ 112016251011 | Chemistry Practical-II | 02 |
| | Elective 1 | CHEM 51111/ 112016251111 | Analytical Chemistry-II | 04 |
| | Elective 2 | CHEM 51112/ 112016251112 | Applied Industrial Chemistry-II | 04 |
| | OJT/FP | CHEM 512/ 112016251211 | dustrial Training/Field Project | 04 |

## PROGRAMME SPECIFIC OUTCOME (PSOs)

**1.** Gain knowledge of the advanced concepts in the branch of chemistry, identify and accomplish a solution to problems encountered in the field of research and analysis.

**2.** Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.

**3.** Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.

**4.** Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the Industry.

**5.** Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields.

**6.** Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

**7.** Exhibit professional work ethics and norms of scientific development.

| | | | | |
|---|---|---|---|---|
| **PROGRAM(s): M.Sc.-I** | **SEMESTER: I** | | | |
| **Course: Paper-I** | **Course Code: (CHEM501 / 112016150111)**<br>**Course Title:- Physical Chemistry-I** | | | |
| **Teaching Scheme** | | | | **Evaluation Scheme** |
| **Lectures (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks-50)** | **Semester End Examination (Marks- 50)** |
| **04** | **–** | **04** | **50** | **50** |

**Learning Objectives:**

1.To enable learners to have comprehensive knowledge and understanding of the advanced concepts in reaction kinetics, molecular dynamics and chemical thermodynamics.

2. To apply the basic knowledge of Physical chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

3. Accomplish a solution to problems encountered in the field of research.

**Course Outcomes:**

1. The learners will apply the advanced thermodynamics, Maxwell equation and its applications to ideal gasses.
2. The learners evaluate the different theories of chemical kinetics and effect of temperature on reaction rates.
3. The learners will implement the applications of chemical thermodynamics to real gases, solutions, surfaces and their energetics.
4. The learners will understand the applications of operators and Schrodinger equation in the field of quantum Chemistry.
5. The learners will evaluate the resting membrane potential by using the concept of bio electrochemistry.
6. The learners will try to accomplish a solution to problems encountered in the field of research.

# Semester – I

## Paper -I

## Course Code: CHEM 501 / 112016150111

## PHYSICAL CHEMISTRY-I

**Unit-I THERMODYNAMICS-I [15L]**

State function, exact and inexact differentials, Internal energy, Enthalpy, Heat capacity, Relation between $C_p$ and $C_v$, Limitations of first law of thermodynamics, Joule-Thomson experiment, Joule-Thomson coefficient, Joule-Thomson coefficient for real and an ideal gas, Inversion temperature

Absolute temperature, Spontaneous or irreversible process, Entropy, Thermodynamic equation of state, Maxwell relation, Helmholtz and Gibbs free energy, Third law of thermodynamics, Nernst heat theorem, Determination of absolute entropies, entropy changes in chemical reaction, residual entropy.

**Unit-II FUNDAMENTAL ASPECTS OF QUANTUM CHEMISTRY (15L)**

**Introduction**: Historical background, Old Vs New Quantum Theory, Heisenberg's Uncertainty Principle, The wave nature of matter

**Fundamental Background**: Postulates of Quantum Chemistry, Commutators of operators, Properties of Linear and Hermitian operators, Operators for the dynamic variables of a system such as position, linear momentum, angular momentum and total energy, Expectation Value,

Progressive and standing waves, Conditions on the wave function and its interpretation, Normalization and orthogonality, Separation of variables, Obtaining Schrödinger's time independent wave equation from Schrödinger's time dependent wave equation.

**Application of Quantum Chemistry in Translation motion**: Particle in one dimension box: Differential equation and its solution, Graphical representation of wavefunctions and probability densities, Normalization and orthogonality of wave functions. Even and Odd Functions.

Particle in a two- and three-dimensional box: Differential equation and its solution, Degeneracy, Energy level Diagram.

**Unit-III PHASE RULE AND ITS APPLICATIONS [15L]**

Recapitulation: - Phase rule, Phase diagrams and their classification, Lambda transition.

Two component Liquid systems:

Completely Miscible Liquid Systems: - Vapor pressure – composition diagrams, Temperature-Composition Diagram, fractional distillation of Zeotropic and Azeotropic mixtures.

Partially Miscible Liquid Systems: - Temperature Composition diagram, Critical solution temperature, influence of foreign substances (impurities) on CST.

Three component Liquid systems:

Type I-Formation of one pair of partially miscible liquids: Graphical representations, binodal curves, plait point, influence of temperature-System showing real critical solution temperature, System showing no real critical solution temperature.

Type II-Formation of two pairs of partially miscible liquids.

Type III-Formation of three pairs of partially miscible liquids

Influence of impurities on ternary system, Ternary Azeotropic mixtures, Preparation of absolute alcohol by azeotropic elimination of water.

**Unit-IV CHEMICAL KINETICS [15L]**

Accounting for the rate laws: simple reactions, temperature dependence of reaction rates, consecutive reactions,(rate determining step approximation and steady-state approximation), unimolecular reactions – Lindemann-Hinshelwood mechanism.

Kinetics of complex reactions - Chain reactions, polymerization reactions, explosions, photochemical reactions.

Fast reactions: Study of kinetics by flow methods, relaxation methods, flash photolysis, magnetic resonance method, shock tube method.

***Derivation not expected***

***Note: Numerical and theoretical problems from each Unit- are expected.***

**References books:**


1. Peter Atkins and Julio de Paula, *Atkin's Physical Chemistry*, 7th ed., Oxford University Press, 2002.
2. K. J. Laidler and J. H. Meiser, *Physical Chemistry*, 2nd ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd ed., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill, New Delhi, 2002.
5. G. W. Castellan, *Physical Chemistry*, 3rd ed., Narosa Publishing House, New Delhi, 1983.
6. D. A. McQuarrie and J. D. Simon, *Physical Chemistry - a molecular approach*, Viva Books Private Limited, New Delhi, 1998.
7. S. Glasstone, Text Book of Physical Chemistry, 2nd ed., McMillan and Co. Ltd., London, 1962.
8. D. A. McQuarrie, *Quantum Chemistry*, Viva Books Private Limited, New Delhi, first Indian ed., 2003.
9. B. K. Sen, *Quantum Chemistry including spectroscopy*, Kalyani Publishers, 2003.
10. A. K. Chandra, *Introductory Quantum Chemistry*, Tata Mc Graw-Hill, 1994.
11. R. K. Prasad, *Quantum Chemistry*, 2nd ed., New Age International Publishers, 2000.
12. D. O. Hayward, *Quantum Mechanics for Chemists*, Royal Society for Chemists, 2002.
13. Sydney T. Bowden, *The phase rule and the phase reaction*, McMillan and Co. Ltd., London, 1938.
14. A. N. Cambell, Alexander Findlay, *The Phase Rule and its Applications*, Dover publications.
15. G. L. Agarwal, *Basics Chemical kinetics*, Tata Mcgraw Hill, New Delhi.
16. K. J. Laidler, *Chemical Kinetics*, 3rd ed., Pearson Education.
17. R. P. Rastogi, R. R. Mishra, *An Introduction to Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd.


**List of Books for further reading:**

1. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
2. W. G. Davis, *Introduction to Chemical Thermodynamics – A Non-Calculus Approach*, Saunders, Philadelphia, 1972.
3. I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, 5th ed., John Wiley and Sons, Inc., 1994.
4. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
5. Ira N. Levine, *Quantum Chemistry*, 5th ed., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
6. J. P. Lowe, *Quantum Chemistry*, 2nd ed., Academic Press, New York, 1993.
7. R. Anantharaman, *Fundamentals of Quantum Chemistry*, McMillan India Limited, 2001.
8. Mahendra R. Awode, *Quantum Chemistry*, S. Chand and Co. Ltd., New Delhi, 2002.

| | |
|---|---|
| **PROGRAM(s): M.Sc.-I** | **SEMESTER: I** |
| **Course: Paper-II** | **Course Code: (CHEM502, 112016150211)**<br>**Course Title:- Inorganic Chemistry-I** |

| **Teaching Scheme** | | | | **Evaluation Scheme** |
|---|---|---|---|---|
| **Lectures (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks-50)** | **Semester End Examination (Marks- 50)** |
| **04** | **–** | **04** | **50** | **50** |

**Learning Objectives:**

1. To develop the ability to predict the feasibility and pathways of different chemical reactions.
2. To learn about the existence of various weak chemical forces and their effects on the physical properties of molecules.

**Course outcomes:**

1. The learner will gain an understanding of various mechanisms involved in inorganic chemical reaction.
2. The learner will acquire knowledge about the various aspects of organometallic compounds.
3. The learner will gain understanding of various weak intermolecular forces and wavefunction representation of different hybridization.
4. The learner will know the important fundamental concept of chemical reactivity of different entities.

# Paper II

## Course Code: CHEM 502/ 112016150211

## INORGANIC CHEMISTRY-I

**UNIT I: INORGANIC REACTION MECHANISMS [15 L]**

(i) Rate of reactions, factors affecting the rate of reactions; techniques for the determination of rate of reactions. (Direct chemical analysis, spectrophotometric methods, polarimetric method, electrochemical and flow methods).

(ii) Mechanisms and factors affecting the ligand substitution reactions of (a) octahedral complexes with and without breaking of metal-ligand bond, stereochemistry of substitution reactions of octahedral complexes. (b) square planar complexes – trans-effect, its theories and applications and (c) tetrahedral complexes;

(iii) Redox reactions: inner and outer sphere mechanisms. Complimentary and non-complimentary reactions.

(iv) Isomerization and racemization reactions.

**UNIT II : ORGANOMETALLIC CHEMISTRY [15 L]**

(i) Recapitulation of classification of organometallic compounds, electron counting and eighteen electron rule.

**(ii)** Sixteen electron square planar complexes.

**(iii)** Synthesis, structure and bonding of the following organometallic compounds: (a) Alkyl and Aryl derivatives, (b) Carbenes and Carbynes, (c) Alkene complexes, (d) Alkyne complexes, (e) Allyl complexes, (f) Cyclopentadiene complexes and (g) Arene complexes (sandwich and half sandwich complexes).

**UNIT III : CHEMICAL BONDING [15L]**

(i) Hybridization: Derivation of wave functions for the following orbital hybridisation types: sp ($BeH_2$); $sp^2$ ($BF_3$); $sp^3$ ($CH_4$) considering only sigma bonding.

(ii) Molecular Orbital Theory (LCAO-MO approach) for Electron deficient and Electron rich species.

**(iii)** Weak intermolecular forces: Hydrogen bonding: concept, types, properties, and importance. Van der Waal's forces: ion-dipole, dipole-dipole, London forces.

**(iv)** Bent's Rule: Reactivity of molecules: e.g. chlorofluorides of phosphorous, fluoromethanes, etc.

**UNIT IV: CHEMICAL REACTIVITY [15 L]**

(i) Recapitulation of acidity of cations and basicity of anions. Hard soft acids and bases (HSAB) principle, Acid-base strength and softness and hardness.

(ii) Oxoanions, oxocations, Classification of oxoacids based on Pauling's rules, structural anomalies.

(iii) Classification of Lewis acids and bases based on Frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases; Group13-17 Lewis acids, superacids and bases. Heterogeneous acid base reactions.

(iv) Redox properties of the elements: Latimer diagram: Construction of the diagram, non-adjacent species and disproportionation. Frost Diagram: Construction and interpretation. Pourbaix diagram of Iron in natural water.

**Reference books**

**Unit I**


1. . F. Shriver and P. W. Atkins, *Inorganic chemistry*, 3rd edition, Oxford University Press, 1999.
2. E. Housecroft and A. G. Sharpe, *Inorganic Chemistry*, Pearson Education Ltd. 2nd Edition 2005.
3. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.
4. . L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
5. G. Wilkins, Kinetics and Mechanism of Reactions of Transition Metal Complexes,VCH, 2n edition, 1991.


**Unit II**


1. C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2nd Ed., New Ag International Pvt. Ltd., 2000.
2. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 6th Ed. Oxford University Press, 2016.
3. Ghosh and M.S. Balakrishna, Introduction to Organometallic Chemistry,, Publisher Nationa Programme on Technology Enhanced Learning (NPTEL)
4. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure an Reactivity, 4th Ed., Harper Collins, 1993.


**Unit III**


1. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure an Reactivity, 4th Ed., Harper Collins, 1993.
2. L. Kapoor, A textbook of Physical Chemistry, Volume 4, Mc Millan, 2001.
3. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
4. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.


**Unit IV**


1. . Wulfsberg, Inorganic Chemistry, Viva Books Pvt. Ltd., 2002.
2. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed. Oxford University Press, 2010.
3. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
4. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure an Reactivity, 4th Ed., Harper Collins, 1993.
5. tp://www.meta-synthesis.com/webbook.html

| PROGRAM(s): M.Sc.-I | | | SEMESTER: I |
|---|---|---|---|
| | | | Course Code: (CHEM 503/CHEM 50311/ 112016150311<br>Course Title:-Organic Chemistry-I |
| **Teaching Scheme** | | | **Evaluation Scheme** |
| **Lectures (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks- 50)** | **Semester End Examination (Marks- 50)** |
| **04** | **04** | **50** | **50** |

**Course Objectives:**

1. To enable learners to have conceptual knowledge of organic chemistry to understand detail aspects of physical organic Chemistry.
2. To apply the basic knowledge of chiral chemistry to understand various Stereochemical aspects of Chemistry in detail.
3. To enable learners to understand mechanisms of name reactions and its applications in various pathways of reaction mechanisms.
4. To understand spectroscopic knowledge which provides solutions to problems encountered in structural elucidation of organic compounds.

**Course Learning Outcomes.**

After completing the course students will be able to:

1. predict the reactivity of organic compound from its structure.
2. understand different methods used for determination of Organic Reaction Mechanism
3. understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.
4. Acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.
5. Develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds
6. Understand Organic spectroscopy by problem solving approach for different class of organic compound.

**Paper III**

## Course Code: CHEM 503 / CHEM 50311 / 112016150311:
## ORGANIC CHEMISTRY-I

## Unit-I-PHYSICAL ORGANIC CHEMISTRY [15L]

### 1.1 Acidity-Basicity:

Different concepts and examples; factors affecting acidity and basicity. Electrophilicity and nucleophilicity. Ambident Electrophiles and Nucleophiles. Difference between nucleophilicity and basicity, electrophilicity and acidity.

### 1.2 Linear Free Energy Relationships:

Effect of structural factors on reactivity. Hammett equation, substituent and reaction constants. Through conjugative effects of substituents. Linear free energy relationships in the determination of reaction mechanism.

### 1.3 Arrhenius equation and its application to estimate Eact;

Hammond's postulate, principle of microscopic reversibility; Kinetic vs. thermodynamic control.

### 1.4 Influence of solvent polarity on reaction rates;

Solvent scales (Y-scale), solvatochromism (Z and ET scales); Ionic strengths and salt effect; Acid-base catalysis Bronsted catalysis equation.

## Unit-II STEREOCHEMISTRY [15L]

### 2.1 Molecules with central chirality. Interconversion of projection formulae:

Molecules with central chirality. Tetrahedral geometry for molecules with asymmetric atom. Examples of chiral molecules with carbon, nitrogen, phosphorous, sulphur and silicon atoms in tetra-coordinated / tri-coordinatied states and their relative configurational stabilities. Racemization of nitrogen compounds through pyramidal inversion. Merits and demerits of different projection formulae and interconversion of the same.

**2.2 Molecules with two or more chiral centres**: Nomenclature for relative configuration for constitutionally unsymmetrical molecules; Erythro-threo and syn-anti. Stereochemistry of constitutionally symmetric molecules with odd and even number of chiral centres; the dissymmetric forms and meso forms. Concept of stereogenic, non-stereogenic, chirotopic, achirotopic and pseudoasymmetric centres. The examples of achirotopic but stereogenic centres and chirotopic but non-stereogenic centres. A lack of direct connection between chirotopicity and stereogenicity.

**2.3 Axial and Planar chirality**: Principles, stereochemical features, configurational descriptors of axial, planar chirality. Helicity as a sub-class of molecules with chiral axis. Stereochemical features and configurational descriptors of allenes, alkylidene cycloalkanes, spiranes, biaryls (including binaphthyls), ansa compounds, cyclophanes and helicenes.

**2.4 Concept of prochirality, homotopic, enantiotopic and diastereotopic ligands and faces**. Criteria based on symmetry and substitution/addition. Notations of prochirality for all classes of molecules. Notation for molecules with pro-

pseudosymmetric centres. Notations for molecules with presence of a chiral and a pro-chiral centres. Top-right mnemonic. Discrimination / recognition of stereo-heterotopic ligands and faces by chemical reagents/catalysts and NMR.

**Unit-III METHODS OF C-C BOND FORMATION USING THE CARBONYL FUNCTON [15L]**

**3.1** Reactivity of carbonyl group, Enols and enolates- Regioselective kinetic and thermodynamic enolate formation using LDA. Different types of aldol condensations under acid and base catalysis

**3.2** Generation of dianion derived from active methylene compounds and regioselective C-C bond formation on unstabilized site

**3.3** Mechanism, stereochemistry and applications of the following reactions:Claisen, Darzen, Dieckman, Beckman, Knoevenagel, Mannich, Michael, Robinson Annulation and Stobbe.

**3.4** Enamines as enolate equivalents. Metalloenamines, Synthesis of enamines and selected C-C bond formation.

**Unit- IV SPECTROSCOPY [15L]**

**4.1 UV-Visible Spectroscopy:** Recapitulation of basic concepts and sample handling. Woodward-Fieser rules for calculation of $\lambda_{Max}$ of conjugated dienes, polyenes, enones and aromatic carbonyl compounds.

Problems based on Woodward-Fieser rules.

**4.2 IR Spectroscopy:** Recapitulation of basic concepts and sample handling. Group frequencies and their use in detection and identification of functional groups.

**4.3 PMR Spectroscopy:** Recapitulation of basic concepts and sample handling. Prediction of structure of organic compounds based on the use of chemical shift and J values.

**4.4 Mass Spectrometry:** Recapitulation of basic concepts and sample handling. Fragmentation Pattern of major classes of organic compounds, Retro-Diels Alder reaction, McLafferty rearrangement and ortho effect.

**4.5** Structure determination of organic compounds involving individual or combined use of the above spectral techniques.

**References Books:**


1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.
3. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
4. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
5. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
7. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
8. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.

| PROGRAM(s): M.Sc.-I | | | SEMESTER: I |
|---|---|---|---|
| | | | Course Code: (CHEM 505/ CHEM 50511 / 112016150511<br>Course Title:-Analytical Chemistry-I |
| **Teaching Scheme** | | | **Evaluation Scheme** |
| **Lectures (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks- 50)** | **Semester End Examination (Marks- 50)** |
| **04** | **04** | **50** | **50** |

**Course Objectives:**

1. To enable learners to have comprehensive knowledge, understanding of the various types of instruments.
2. To create, select and apply appropriate techniques, resources and modern technology in multidisciplinary environment.
3. A research oriented learning that develops analytical and integrative problem-solving approaches.
4. To get hands on various advance techniques with laboratory skills on preparation of various solutions, design of some reactions with its work up and isolation.
5. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

**Course Learning Outcomes.**

After completion of this Course, the learner will be able to:

1. Understand various terms used in analytical chemistry.
2. Students will be able to classify the analytical methods; select a method for analysis based on performance.
3. Learn the details of atomic absorption spectrometry and its applications to biological and environmental samples.
4. To learn the applications of UV-Visible spectroscopy for the quantitative determination of trace metals in food, blood and urine samples.
5. In AES, construction and working of plasma sources and their applications in geological, metallurgical, food, agricultural, environmental and biological samples.
6. In IR, the concept of Fourier Transform spectroscopy, various instrumentation like dispersive, non-dispersive and FT-types of instruments and their uses in the detection of CO and CO2 in the atmosphere.
7. Also the practical and theory needs to know to the students about the principle and working of Gas Chromatography and High Performance Liquid Chromatography techniques including discussion on carrier gas/liquid supply, sample introduction on-column and

injection techniques; analytical columns; detectors, mode of separation and applications in various fields with examples.

# Course Code: CHEM 505 / CHEM 50511 / 112016150511
# ANALYTICAL CHEMISTRY- I

**Unit I: Fundamentals in Analytical Chemistry [15L]**

a. Terms: Precision and Accuracy recapitulations and applications
Criteria for the selection of methods. Regression analysis with respect to applications in research, Chemometrics. [6L]

b. Concepts of optical methods: LASER as a source in optical methods, wavelength selectors and their functioning, effective bandwidth. [4L]

c. Concepts of Spectroscopy: Concept of Fourier Transform Spectroscopy, IR spectroscopy: Sample handling, instrumentation, advantages of FT-IR. [5L]

**Unit II: Atomic and Molecular Spectroscopy: Instrumentation and Applications [15L]**

2.1 Atomic Absorption Spectrometry: Recapitulation, Hydride generation technique for trace metal analysis, Cold Vapor technique for the determination of mercury, Importance of electro thermal analyzer in biological samples. [4L]

2.2 Atomic Emission Spectroscopy based on plasma sources, advantages of plasma sources. Applications including sample handling in geo-analysis, metallurgy, agriculture, food samples and environmental analysis. [5L]

2.3 Infrared Spectroscopy (Applications): Non-dispersive IR for detection of environmental gases. [2L]

2.4 UV-Visible Spectroscopy: Derivative and dual wavelength spectroscopy, molecular transitions, application to trace analysis (d-d transition and charge transfer), biological samples and simultaneous determination. [4L]

**UNIT III: Separation methods [15L]**

3.1 Solvent Extraction and Solid Phase Extraction: Recapitulation of basic concepts of solvent extraction and solid phase extraction. Liquid anion and cation exchangers. Mechanism of extraction. Crown ethers as extractants. Extraction equilibria of metal chelates. Factors favoring solvent extraction of metal chelates. Sorbents. [7L]

3.2 Chromatography: General classification of chromatographic methods. Efficiency, resolution, selectivity and separation capability. Broadening of chromatographic peak and van Deemter equation. Optimization of chromatographic conditions. Qualitative and Quantitative Analysis [8L]

**UNIT IV: Column chromatography techniques [15L]**

4.1 Gas Chromatography:

Recapitulation of concepts Principle of GLC and GSC; Instrumentation: carrier gas supply, sample introduction systems, packed & capillary columns; choice of detectors and comparative account of Recapitulation of TCD, FID, ECD & thermionic detector. Use of Temperature programming in separations [4L]

4.2 Applications of GC in environmental, pharmaceuticals, agrochemical, food, chemical analysis and forensic sciences. [3L]

4.3 High Performance Liquid Chromatography (HPLC): Principles of HPLC Types of liquid chromatography, Recapitulation of HPLC, Instrument for LC: mobile phase reservoir and solvent treatment systems, pumping systems, sample introduction systems, columns, Detectors: UV, RI, EC and diode array. [5L]

4.4 Applications of HPLC in environmental, pharmaceuticals, agrochemical, food, chemical analysis and forensic sciences. [3L]

**References:**


1. *Analysis*, 5th ed., Philadelphia: Saunders College Publishing, 1998.
2. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Philadelphia: Saunders College Publishing, 2004.
3. G. D. Christian, *Analytical Chemistry*, 6th ed., John Wiley and Sons, New York, 2003.
4. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th ed., ELBS, Longman Scientific & Technical, England, 2002.
5. H. H. Willard, L. L. Merrit, jr., J. A. Dean and F. A. Settle, Jr., *Instrumental Methods of Analysis*, 6th ed., CBS 1986.
6. R. D. Braun, *Introduction to Instrumental Analysis*, McGraw Hill, 1987.
7. G. H. Morrison and H. Freiser, *Solvent Extraction in Analytical Chemistry*, John Wiley & Sons, New York, 1966.
8. S. M. Khopkar, *Basic concept of Analytical Chemistry*, 3rd ed., Age International Publisher 2008.
9. T. Sekine and Y. Hasegawa, *Solvent Extraction chemistry*, Marcel Dekker, 1977.
10. P. G. Swell and B. Clarke, *Chromatographic Separations, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
11. S. Sindsay, *High Performance Liquid Chromatography, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
12. A. J. Bard and L. R. Faulkner, *Electrochemical Methods*, Wiley, New York, 1980
13. A. M. Bond, *Modern Polarographic Methods in Analytical Chemistry*, Marcel Dekker, New York, 1980.
14. L. C. Thomas and G. J. Chamberline, *Colorimetric Analytical Methods*, 9th ed., The Fintometer Ltd., Salisbury, England, 1980.
15. T. C. Morrili, R. m. Silverstein and G. C. Bassler, *Spectrometric Identification of Organic Compounds*, Wiley, 1981.
16. Vogel's Text Book of Quantitative Organic Analysis, 2th ed. ELBS.
17. R. A. Day, Jr. and A. L. Underwood, *Quantitative Analysis*, 6th ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1993.
18. Jared L. Anderson, Alain Berthod, Veronica Pino, and Apryll M. Stalcup (ed),*Analytical Separation Science (Volume 1-5)*. WILEY-VCH 2015.

19. Jack Cazes (ed) *Ewing's Analytical Instrumentation Handbook,* 3rd edition, Marcel Dekker 2009.
20. R. Kellner, J.M. Mermet, M. Oto, M. Valcarcel, H. M. Widmer (ed), *Analytical Chemistry: A modern Approach to Analytical Science 2nd edition.* WILEY-VCH 2004.
21. Solid phase Extraction- Principles, Techniques and Applications, N. J. K. Simpson, Marcel Dekker, New York, (2000).

**Elective II**

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td>SEMESTER: I</td></tr>
<tr><td colspan="3"></td><td>Course Code: (CHEM 50512/ 112016150512<br>Course Title:-Applied Industrial Chemistry-I</td></tr>
<tr><td colspan="3">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks- 50)</td><td>Semester End Examination (Marks- 50)</td></tr>
<tr><td>04</td><td>04</td><td>50</td><td>50</td></tr>
<tr><td colspan="4">Course Objectives:<br>1. To enable learners to have comprehensive knowledge, understanding of the types of instruments with operations and automated methods of analysis.<br>2. To apply the basic knowledge of quality systems, quality audit and quality managements,.<br>3. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.<br>4. To provide solutions to problems encountered in the field of analysis and research.</td></tr>
<tr><td colspan="4">Course Learning Outcomes.<br>After completing the course students will be able to:<br>1) predict the reactivity of organic compound from its structure.<br>2) understand different methods used for determination of Organic Reaction Mechanism<br>3) understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.<br>4) acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.<br>5) develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds<br>6) identify the nomenclature of various stereochemical phenomena</td></tr>
</table>

# Course Code: CHEM 50512/ 112016150512
# Applied Industrial Chemistry-I

**Unit-I [15 L]**

**Perfumery Chemicals:**

Essential oils and their application in cosmetic industries, synthetic preparation of eugenol, geraniol, phenyl ethanol, civetone, Yara-Yara, β-ionone, synthetic musk, musk ketone, ambrette, and xylene, phenylacetic acid and its' esters derivatives, benzyl acetate, Extraction process of naturally occurring perfumery like sandalwood oil, rose oil, and jasmine.

**Unit-II [15 L]**

**Petrochemicals and Biofuels:**

Petroleum refining, chemicals derived from ethylene, xylene, and naphthalene.

Types of biofuels (bioethanol, biodiesel), synthesis, properties, standard specification and uses of biofuels, Influence of biofuels on the environment and economy, modification of vegetable oils as biodiesel.

**Unit-III [15L]**

**Paper, pulp, and Leather industry:**

Introduction, types of pulping, types, and quality of paper, lignin and lignans, recycling. Introduction, constituents of animal skin, manufacture process, tanning: leather, vegetable, chrome; tanning effluents, pollution control.

**Unit-IV [15 L]**

**Semiconductors in Electronic Industries**

Introductions, applications of phosphorus, gallium, indium, germanium and arsenic and their composites in electronic industries, ferrite and magnetic materials, synthesis and characterizations of organic semiconductors, band gap engineering and its applications,.

**Recommended Books**


1. G. T. Austin, Shrieves Chemical Process Industries, Tata McGraw Hill publication, 2011.
2. M. G. Rao and M. Marshall, Dryden's Outline of Chemical Technology, East west press, 1997.
3. Shah and Pandey, Chemical Technology , Sangam Books Limited, 2000
4. K. R. Smith, Biofuels: Air Pollution and Health, East-West Center, Honolulu, USA, 1987.
5. G. M. Gübitz, M. Mittelbach, M. Trabi, biofuels and Industrial Products from Jatropha Curcas, 1997.
6. B. Billot and F. V. Wells, Perfumery Technology, 1981.
7. P. G .More, Comprehensive Industrial Chemistry, Pragati Prakashan 2018.
8. A. D. Covington, Tanning Chemistry: The Science of Leather, 2015.
9. P. Y. Yu and M. Cardona Fundamentals of Semiconductors: Physics and Materials Properties, 4th Edition, 2010, Springer
10. L. Alcacer, Electronic Structure of Organic Semiconductors: Polymers and Small Molecules, IOP Science and Morgan and Claypool Publishers, UK 2018.

| PROGRAM(s): M.Sc.-I | SEMESTER: I | | | |
|---|---|---|---|---|
| Course: Practical | Course Code: CHEM504 / 112016150411<br>Course Title:- Chemistry Practical-I | | | |
| **Teaching Scheme** | | | | **Evaluation Scheme** |
| **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks-25)** | **Semester End Examination (Marks- 25)** |
| **16** | **NA** | **02** | **25** | **25** |

**Learning Objectives:**

1. To Gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2. To understand advance concept of thermodynamics and chemical kinetics in the chemical reactions.
3. To develop scientific temper and research based skills accomplish to encountered in the field of research.
4. The learners will characterize different coordination compounds with the help of conductivity measurements, electronic and magnetic measurements and spectroscopic measurements.
5. The learners will learn to open up different types of Alloys/Ores and carry out a Quantitative Analysis of the elements present in them.

Inorganic:

1. To gain ability to perform inorganic synthetic reactions.
2. To characterize synthesized compounds using different analytical methods.

**Course Outcomes:**

1. To usage of subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions.
2. Learner will train the handling of equipments like potentiometer, conductivity meter, colorimeter and spectrophotometer.
3. Learner will develop scientific temper and research based skills accomplish to encountered in the field of research.
4. Apply the knowledge of quantitative analysis for the determination of metals from ores/alloys.

5. Able to understand the analysis of various commercial inorganic compounds.

**Inorganic Chemistry**

1.The learner will learn to synthesize different coordination compounds.

2. The learner will gain knowledge and hands on experience of different analytical methods to characterize the synthesized coordination compounds.

# Course Code: CHEM 504 / 112016150411

# Chemistry Practical-I

## Physical Chemistry Practical-I

### Instrumental Experiments*:

***Conductometry and Potentiometry***

1. Titration of a mixture of trichloroacetic acid, monochloroacetic acid and acetic acid with sodium hydroxide conductometrically.
2. Verification of Ostwald's dilution law and determination of the dissociation constant of a weak monobasic acid conductometrically.
3. Study of the effect of substituent on dissociation constant of acetic acid conductometrically.
4. Determination of concentrations and amounts of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.
5. Determination of solubility product of silver chloride potentiometrically using a concentration cell.
6. Determination of the formula of the silver-ammonia complex by potentiometric method.
7. Determination of *pK* values of phosphoric acid by potentiometric titration with sodium hydroxide using a glass electrode.
8. Determination of acidic and basic dissociation constants of an amino acid and hence the iso-electric point of the acid.

(* Any four Physical Chemistry experiments to be performed from the above list)

### Inorganic Chemistry Practical-I

**Synthesis, Purification and Analysis of the following Inorganic Preparations:**

1. Hexamminenickel(II) sulphate
2. Potassium dioxalatocuprate(II) dihydrate
3. Potassium trioxalato chromate (III) trihydrate
4. Potassium trioxalatoaluminate(III) trihydrate

## Organic Chemistry Practical-I

### Separation of Binary mixture by microanalytical technique

Separation of the binary mixtures using physical and chemical methods. Identification of one of the compounds and checking its purity by TLC. Preparation of the derivative of one of the compounds. The following types are expected: Solid-Solid mixtures. Compounds from the same or different chemical classes. The candidate is expected to carry out the separation of 4 mixtures.

### Reference Books:


1. Elementary Practical Organic Chemistry Part-I small-scale preparations, A.L. Vogel (Longman)
2. Laboratory Manual of Organic Chemistry, B.B. Dey and M.V. Sitaram revised by T.R Govindachari (Allied Publishers Ltd. )

**Analytical Chemistry Practical-I**

***Non-Instrumental Experiments*:***

1. Calibration of a 10 mL pipette by weighing at room temperature and reporting the result with statistical data.
2. Determination of Manganese from pyrolusite by potassium permanganate method.
3. Estimation of vitamin C by titration with potassium bromate.
4. Determination of number of nitro group in organic compound by titanium method.
5. Separation and determination of Fe (III) and Mg (II) /Zn (II) using ethyl acetate /ether as a solvent.
6. Determination of exchange capacity of cation ion-exchnage resin.

(* Any four Analytical Chemistry experiments to be performed from the above list)

# Research Methodology

| PROGRAM(s): M.Sc.-I | | | SEMESTER: I |
|---|---|---|---|
| | | | **urse Code: (CHEM 506 / 112016150611**<br>**urse Title:- Research Methodology** |
| **Teaching Scheme** | | | **Evaluation Scheme** |
| **Lectures (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks- 50)** | **Semester End Examination (Marks- 50)** |
| **04** | **04** | **50** | **50** |

**Course Outcomes:**

**At the end of the Course,**

1. To enable the student to be able to extract information from journals and digital resources.
2. Understanding tools to analyse the data, writing and presenting scientific papers.
3. Safe working procedure And ethical handling of chemicals.
4. Describe research, identification of research problems, and preparation of proposals.
5. Practice ethics in all the domains of research.
6. Analyze the results using mathematical and statistical tools.

**Course Learning Outcomes.**

1. To create awareness and understanding the terms like intellectual property, patents, copyright,
industrial designs, trademarks, geographical indications etc.
2. To know trade secrets, IP infringement issues, economic value of intellectual property and study of various related international agreements.
3. To explore cheminformatics to facilitate molecular modeling and structure elucidations.
4. To apply the knowledge gained about various chemistry principles, techniques and tools in drug
designing, target identification and validation, lead finding and optimization..

## Course Code: CHEM 506 / 112016150611

# Research Methodology

**Unit-I LITERATURE SURVEY** **[15L]**

**Print:** **[5L]**

Primary, Secondary, Tertiary sources,

**Journals:**

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, SubjectIndex, Substance Index, Author Index, Formula Index, and other Indices with examples.

**Digital:** **[5L]**

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and commUnit-ites, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-Databases, ChemSpider, Science Direct, SciFinder, Scopus.

**Information Technology and Library Resources:** **[5L]**

The Internet and World Wide Web, Internet resources for chemistry, Finding and citing published information.

**Unit-II DATA ANALYSIS** **[15L]**

**The Investigative Approch:**

Making and recording Measurements, SI Unit-s and their use, Scientific methods and design of experiments.

**Analysis and Presentation of data:**

Descriptive statistics, Choosing and using statistical tests, Chemometrics, Analysis of variance (ANOVA), 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 egression analysis.

**Unit-III METHODS OF SCIENTIFIC RESEARCH & WRITING SCIENTIFIC PAPERS** **[15L]**

Reporting practical and project work, Writing literature surveys and reviews, Organizing a poster display, Giving an oral presentation.

**Writing scientific papers:**

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, Writing ethics, Avoiding plagiarism.

**Unit IV: CHEMICAL SAFTEY & ETHICAL HANDLING OF CHEMICALS** **[15L]**

Safe working procedure and protective environment, protective apparel, emergency procedure, and first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures

for working with gases at pressures above or below atmospheric- safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

**Reference books:**


1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in chemistry*, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B., & Gooding, J. J., (2006), *Data analysis for chemistry*, Oxford University Press.
3. Topping, J., (1984), *Errors of observation and their treatment*, 4th Ed. Chapman Hll, London.
4. Harris, D. C., (2007), *Quantitaive chemical analysis*, 6th Ed., Freeman Chapters 3-5
5. Levie, R. de., (2001*), How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ Press 487 pages.
6. Chemical safety matters-IUPAC-IPCS, Cambridge University Press, 1992.
7. OSU safet manual 1.01

# SEMESTER: II

| PROGRAM(s): M.Sc.-I | SEMESTER: II | | | |
|---|---|---|---|---|
| Course: Paper-I | Course Code: CHEM507 / 112016250711<br>Course Title:- Physical Chemistry-II | | | |
| Teaching Scheme | | | | Evaluation Scheme |
| Lectures (Hours per week) | Tutorial (Hours per week) | Credit | Continuous Assessment (CA) (Marks- 50) | Semester End Examination (Marks- 50) |
| 04 | – | 04 | 50 | 50 |

**Learning Objectives:**

1. To gain knowledge of the advanced concepts in quantum mechanics, applications of HMO theory, chemical kinetics and molecular dynamics.
2. To understand the advanced concepts in chemical thermodynamics and photochemistry.
3. To develop the skill to solve the problems encountered in the field of quantum and electrochemistry.

**Course outcomes:-**

1. To learn the concept of quantum chemistry and able to solve problems related to 1D box, 2D box, 3D box and to explain the role of operators in quantum chemistry.
2. To understand the use of Schrodinger wave equation in one and two electron systems along with applications of HMO.
3. To develop the skill to solve the problems based on chemical thermodynamics, molecular dynamics and quantum Chemistry.
4. To apply the concept of Jabolonski mechanism in photochemical reactions.
5. Learners will get knowledge of advanced chemical kinetics and molecular dynamics.

## Semester II

## Course code: CHEM 507 / 112016250711

## PHYSICAL CHEMISTRY-II

**Unit-I THERMODYNAMICS-II** **[15 L]**

Partial molar quantities, chemical potential for ideal gas, gas mixtures, Gibbs free energy of mixing, entropy and volume of mixing, Gibbs Duhem equation, Variation of chemical potential with pressure and temperature.

Excess functions (Chemical potential, Gibbs free energy and enthalpy function), Equilibrium constant and its dependence on temperature and pressure.

**Unit-II APPLIED ASPECTS OF QUANTUM CHEMISTRY** **[15]**

**Application of Quantum Chemistry in Vibrational motion:**

The one-dimensional harmonic oscillator: Classical and Quantum mechanical treatment, Hermite polynomials**,** Wavefunctions, probability densities, and energy levels

**Application of Quantum Chemistry in Rotational motion:**

Spherical polar coordinates, Separation of variables, The rigid rotor: Legendre functions, energy levels and wave functions*****.

**Application of Quantum Chemistry in Atomic system:**

The hydrogen atom and hydrogen-like ions, Reduction of the two-particle problem to two one-particle problems, Solutions to R($r$), $\Theta(\theta)$ and $\Phi(\phi)$ equations*****, Hydrogen-like orbitals, sketches of wave functions ($\psi$) and probability densities ($|\psi|^2$), polar plots of angular parts, orbital and spin angular momentum, spin orbitals.

**Unit-III APPLICATIONS OF THERMODYNAMICS AND ELECTROCHEMISTRY [15L]**

Experimental techniques for determination of thermodynamic quantities: Bomb Calorimeter, Coffee Cup Calorimeter, Differential Scanning Calorimeter.

Exergonic and endergonic reactions, Thermodynamics of ATP,

Debye-Hückel theory of strong electrolyte, ionic atmosphere, activity coefficients of electrolyte solutions- Debye-Hückel limiting law, extension to higher concentrations.

Electrolytic conductance and ion-ion interactions, Debye-Hückel-Onsager equation, validity of equation, Debye-Falkenhagen effect, Wien effect, weak electrolyte and Debye-Huckel theory.

Determination of thermodynamic functions of cell reaction.

Electrochemistry in water and effluent treatment.

**Unit-IV MOLECULAR REACTION DYNAMICS [15L]**

Collision theory, steric factor, activated complex theory, reaction coordinate and transition state, thermodynamic aspects, reaction between ions, salt effects, and dynamics of molecular collisions.

Homogeneous catalysis – enzyme catalysis, Michaelis-Menten mechanism, acid base catalysis.

Heterogeneous catalysis – Examples: hydrogenation, oxidation, cracking and forming.

****Derivation not expected***

***Note: Numerical and theoretical problems from each Unit- are expected.***

**Reference books:**


1. Peter Atkins and Julio de Paula, *Atkin's Physical Chemistry*, 7th ed., Oxford University Press, 2002.
2. K. J. Laidler and J. H. Meiser, *Physical Chemistry*, 2nd ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd ed., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill, New Delhi, 2002.
5. G. W. Castellan, *Physical Chemistry*, 3rd ed., Narosa Publishing House, New Delhi, 1983.
6. D. A. McQuarrie and J. D. Simon, *Physical Chemistry - a molecular approach*, Viva Books Private Limited, New Delhi, 1998.
7. S. Glasstone, Text Book of Physical Chemistry, 2nd ed., McMillan and Co. Ltd., London, 1962.
8. Derek Pletcher, *Industrial Electrochemistry*, London New York.
9. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
10. Ira N. Levine, *Quantum Chemistry*, 5th ed., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
11. J. P. Lowe, *Quantum Chemistry*, 2nd ed., Academic Press, New York, 1993.
12. R. Anantharaman, *Fundamentals of Quantum Chemistry*, McMillan India Limited, 2001.
13. Mahendra R. Awode, *Quantum Chemistry*, S. Chand and Co. Ltd., New Delhi, 2002.
14. R. K. Prasad, *Quantum Chemistry*, 2nd ed., New Age International Publishers, 2000.
15. D. O. Hayward, *Quantum Mechanics for Chemists*, Royal Society for Chemists, 2002.
16. Samuel Glasstone,*An introduction to electrochemistry*,East West edition, New Delhi.
17. . L. Agarwal, *Basics Chemical kinetics*, Tata Mcgraw Hill, New Delhi.
18. D. R. Crow, *Principles and Applications of Electrochemistry*, 4th edition, Blackie, London, 1994.
19. J.O'm. Bockris and A. K. N. Reddy, *Modern Electrochemistry*-Vol. 1 and 2, Plenum press, New York.
20. R. A. Robinson and R.H. Stokes, *Electrolyte Solutions*, 2nd Edition, Butterworths, London 1959.
21. R. P. Rastogi, R. R. Mishra, *An Introduction to Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd.
22. K. J. Laidler, *Chemical Kinetics*, 3rd ed., Pearson Education.


**List of Books for further reading:**


1. W. G. Davis, *Introduction to Chemical Thermodynamics – A Non-Calculus Approach*, Saunders, Philadelphia, 1972.
2. I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, 5th ed., John Wiley and Sons, Inc., 1994.

3. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.

| PROGRAM(s): M.Sc.-I | SEMESTER: II | | | |
|---|---|---|---|---|
| Mandatory Course -II | Course Code: CHEM 508/ 112016250811<br>Course title : Inorganic Chemistry-II | | | |
| Teaching Scheme | | | | Evaluation Scheme |
| Lectures (Hours per week) | Tutorial (Hours per week) | Credit | Continuous Assessment (CA) (Marks- 50) | Semester End Examination (Marks- 50) |
| 04 | – | 04 | 50 | 50 |

**Learning Objectives:**

1. The course aims at generating awareness about the positive as well as negative aspects of inorganic chemicals on biophysical processes and our environment.
2. The course aims at developing theoretical approach to analyze symmetry, structure and physical properties of molecules.
3. The course aims to impart knowledge of basic concepts and recent advances in nano-sciences.

***Course Outcomes:***

1. The learner will gain understanding regarding the different crystal structures. They will also gain knowledge about the various aspects of nanoscience and nanotechnology.
2. The learner will be able to correlate the structure, symmetry and properties interrelationship of different molecules.
3. The learners will get awareness about the effect of toxic chemicals and radiations on our environment.
4. The learners will understand the role of different metallic compounds in various biological processes and applications.

# Paper II

## Course Code: CHEM-508 / 112016250811

## INORGANIC CHEMISTRY-II

**(Total lectures: 60, Credits: 4)**

**Unit I Solid State Chemistry and Nanomaterials 15 L**

(A) Solid State Chemistry

(i) Recapitulation of basic solid state chemistry.

(ii) Structures of compounds of the type: AB [zinc sulfide (ZnS), nickel arsenide (NiAs)], $AB_2$ [fluorite ($CaF_2$), antifluorite ($Na_2O$), rutile ($TiO_2$) and layer structures viz., cadmium chloride ($CdCl_2$) and cadmium iodide, ($CdI_2$)].

(B) Nanomaterials

(i) Introduction to nanomaterials.

(ii) Preparative methods: Ball milling, Solvothermal, Sol-gel, Biological methods

(iii) Basic characterization techniques for nanomaterials.

(iv) Applications of nanomaterials.

**Unit II Molecular Symmetry and Group theory 15 L**

(i) Symmetry elements and symmetry operations, product of symmetry operations, Cartesian coordinate system and symmetry elements.

(ii) Symmetry classification of molecules: point groups, mathematical requirement for a point group, systematic assignment of point groups to molecules.

(iii) Identification of molecular point groups of molecules having low symmetry, high symmetry and special symmetry.

(iv) Descent in symmetry of molecules with substitution.

(v) Group multiplication tables, classes of symmetry operations. Matrix representation of symmetry elements and point groups.

(vi) Construction of $C_{2v}$ character table.

(vii) Symmetry criteria for optical activity, Symmetry restrictions on dipole moment.

**Unit III Environmental Chemistry 15 L**

(i) Chemical Toxicology: MSDS, LD50, toxic chemicals in the environment, biochemical effects and speciation of toxic elements like arsenic, lead, mercury and cadmium; antidotes for the toxic elements. Biochemical effects of fluoride and pesticides.

(ii) Radiation pollution: Sources and biological implication of radioactive pollutants.

(iii) Non-conventional energy sources: Solar power, Wind power, Geothermal energy, Ocean thermal energy conversion (OTEC), Tidal power.

**Unit IV Bioinorganic Chemistry 15 L**

(i) Biological oxygen carriers: myoglobin, hemoglobin, Hill equation, Bohr effect and their implications, hemerythrene and hemocyanine.

(ii) Reactions of dioxygen in biological system with examples of peroxidase, monooxygenase, superoxide dismutase and oxidase reactions. Biochemical effect of cyanide.

(iii) Nitrogen fixation: Nitrogenase, Hydrogenases.

(iv) Metal ion transport and storage: transferrin and Ferritin.

(v) Metal ions in medicines: Introduction to metallodrugs, cis-platin and related compounds.

**Reference books**

**Unit I**


1. R. West, Solid State Chemistry and Its Applications, John Wiley & Sons, 1987.
2. N. R. Rao and G. Gopalkrishnan, New Directions in solid state chemistry, 2nd Ed., Cambridge University Press, 1997.
3. sley E. Smart and Elaine A. Moore, Solid State Chemistry – An introduction, 3rd Ed., Taylor and Francis, 2005.
4. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone, 2014.
5. K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007.
6. Cao, Nanostructures and Nanomaterials- Synthesis, Properties and Applications, Imperial college Press, 2004.
7. N. R. Rao, A. Muller and A. K. Cheetham, The Chemistry of Nanomaterials- Synthesis, Properties and Applications, Volume-I, Wiley VCH, 2004.


**Unit II**


1. V.Reddy, Symmetry and Spectroscopy of Molecules, 2nd Ed., New Age International Publishers2009.
2. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, 1998.
3. S. Kunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI-Learning, 2010.
4. A. Cotton, Chemical Applications of Group Theory, 2nd Ed., Wiley Eastern Ltd., 1989.


**Unit III**


1. K. De, Environmental Chemistry, 7th Ed., New Age International Publishers, 2007.
2. E. Girard, Principles of Environmental Chemistry, 2nd Ed., Jones and Bartlett publishers, 2011.
3. Kaur, Environmental Chemistry, Pragati Prakashan, 8th Ed., 2014.


**Unit IV**


1. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, 1st Indian Ed., Viva Books, 1998.
2. Banerjea, Coordination Chemistry, Tata Mc Graw Hill, 1993.
3. N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri&Sons, 1988.


**General Inorganic Chemistry Reference books**


1. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.
2. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.

3. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001
4. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5th Ed., Wiley Interscience, 2009.
5. G. O. Spessard and G. L.Miessler, Organometallic Chemistry, Prentice-Hall, 1977.
6. K. F. Purcell and J. C. Klotz, Inorganic Chemistry, Saunders, 1977.
7. B. Douglas, D. H. McDaniel and J. J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd Ed., John Wiley & Sons, 1983.
8. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
9. R. L. Madan and G. D. Tuli, Inorganic Chemistry, 5th Ed., S. Chand, 2012.
10. J. D. Lee, Concise Inorganic Chemistry, 5th Ed., Wiley, 2012.
11. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone, 2014.
12. G. Raj, A. Bhagi and V. Jain, Group Theory and Symmetry in Chemistry, 3rd Ed., Krishna Prakashan, 2010.
13. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
14. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East-West Press Pvt. Ltd., 2014.
15. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry, 3rd Ed., Narosa Publishing House, 2013.
16. S. S. Dara and D. D. Mishra, A Textbook of Enviromental Chemistry and Pollution Control, S. Chand & Company Ltd., 2012.
17. S. K. Banerji, Environmental Chemistry, 2nd Ed., Prentice-Hall of India, 2005.
18. R. A. Bailey, H. M. Clark, J. P. Ferris, S. Krause and R. L. Strong, Chemistry of Environment, 2nd Ed., Academic Press, 2005.
19. R. W. Hay, Bioinorganic Chemistry, Ellis Harwood, 1984.
20. J. A. Cowan, Inorganic Biochemistry-An introduction, VCH Publication, 1993.
21. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Publications, Mill Valley, Caligronic, 1994.
22. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.
23. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989.
24. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.
25. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
26. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.
27. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

28. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.
29. L. V. Azaroff, Introduction to solids, Tata McGraw Hill Book Co, 1977.
30. H. V. Keer, Principles of Solid State, Wiley Eastern Ltd., 1993.

| PROGRAM(s): M.Sc.-I | | | SEMESTER: II |
|---|---|---|---|
| | | | Course Code: (CHEM 509 / CHEM50911/ 112016250911<br>Course Title:-Organic Chemistry-II |
| Teaching Scheme | | | Evaluation Scheme |
| Lectures (Hours per week) | Credit | Continuous Assessment (CA) (Marks-50) | Semester End Examination (Marks- 50) |
| 04 | 04 | 50 | 50 |

**Course Objectives:**

1. To gain knowledge of aromaticity and understand Nomenclature system and various other concepts related to aromaticity
2. To understand various rules of reaction mechanism and various new concepts of elimination and substitution reactions.
3. To introduce new aspects of reaction mechanism and stereo chemical behaviors of reaction mechanism.
4. To study various organic reagents and its applications in synthetic organic Chemistry.

**Course outcomes: -**

After completing the course students will be able to:

1) Recognize the type of mechanism & intermediates involved in the given organic reaction and to prove mechanism for the reaction.
2) Identify the ways to modify aliphatic and aromatic compounds via Nucleophilic and Electrophilic substitution reactions.
3) Predict the mechanism and stereochemistry of important organic reactions.
4) Understand and write the mechanism of rearrangement reactions with stereochemistry and its applications.
5) Understand the HOMO-LUMO concept and it significance in organic chemistry.
6) To understand and recognize use of reagents in various functional group modifications.

## Semester II

## Course Code: CHEM-509 / CHEM 50911/ 112016250911

## ORGANIC CHEMISTRY-II

**UNIT- I: PHYSICAL ORGANIC CHEMISTRY AND AROMATICITY [15L]**

**1.1** Idea about molecular orbitals, application to Hydrogen molecule, ethylene molecule and carbonyl group, **a qualitative approach**. Empirical idea about magnitude of coefficients in molecular orbitals. Discussion on unequal sizes of coefficients in 1,3-butadiene. Relative energies of FMOs of hard/soft electrophiles and nucleophiles. Identification of hard / soft electrophilic centres in allylcation and hard / soft nucleophilic centres in allyl anion. Ambident nucleophiles and ambident electrophiles.

**1.2** Structural, thermodynamic and magnetic criteria for aromaticity. Shielding deshielding effects in NMR due to ring current, DRE, REPE, London diamagnetism, diamagnetic exaltation.

**1.3** Huckel's (4n+2) pi electron rule and idea about closed shell configuration. Frost-Musulin diagram.

**1.4** Concept about Aromatic, antiaromatic and Homoaromatic compounds. Aromaticity of benzenoid systems, annulenes, five-membered and six-membered heterocyclic compounds with one hetero atom, metallocenes, azulenes, tropyliumcation and conjugated monocyclic molecules with exocyclic double bond.

**Unit-II: ELIMINATION AND NUCLEOPHILIC SUBSTITUTION REACTIONS [15L]**

**2.1** Types of elimination reactions, $E_1$and $E_2$ mechanisms

**2.2** Orientation of elimination reactions: Saytzeff and Hoffmann rules. $E_2$ - reactions of vinyl halide, $E_1$cB mechanism. Nomenclature for relative configuration for consstitutuionally unsymmetrical molecules; Erythro-threo and syn-anti. Stereochemistry of constitutionally symmetric molecules with odd and even number of chiral centres; the dissymmetric forms and meso forms. Concept of stereogenic, non-stereogenic, chirotopic, achirotopic and pseudoasymmetric centres. The examples of achirotopic but stereogenic centres and chirotopic but non-stereogenic centres. A lack of direct connection between chirotopicity and stereogenicity.

**2.3** Pyrrolytic elimination: Chugaev reaction, Cope reaction, Hoffmann's and Pyrrolysis of acetates.

**2.4** Aliphatic nucleophilic substitution at $sp^3$ carbon: $S_N1$, $S_N2$, $S_Ni$, $S_N$cA reactions. Ion pair in $S_N1$, reactions, Stereochemistry of all the above reactions, Factors affecting these reactions: substrate nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group.

**2.5** Nucleophilic substitution reactions at $sp^2$ (vinylic) carbon.

**2.6** Aromatic nucleophilic substitution reaction: $S_NAr$, $S_N^1$, Benzynemechanism, ipso, cine and tele substitutions, vicarious substitution.

**Unit-III: REACTIONS AND REARRANGEMENTS [15L]**

**3.1** Mechanism, stereochemistry (if applicable) and applications of the following:

Arndt-Eistert reaction, Baylis-Hilman reaction, McMurry Coupling, Mitsunobu reaction and Mukiyama esterification, Woodward Prevost Hydroxylation.

**3.2** Mechanism, stereochemistry (if applicable) and applications of the following:

Cope rearrangement, Claisen rearrangement, Dienone-Phenol rearrangement, Favroskii rearrangement, Fries rearrangement and Tiffeneau-Demjanov rearrangement.

**3.3** Ester hydrolysis (all 8 mechanisms of acid and base catalyzed hydrolysis)

**Unit-IV: OXIDATION-REDUCTION [15L]**

**4.1 Preparation of reagents (wherever applicable), mechanism and applications of the following:**

Epoxidation: Baeyer-Villiger Oxidation and Oppenauer Oxidation. Oxidations using Osmium Tetroxide, Lead Tetraacetate, Periodic acid, Selenium dioxide, PCC and PDC.

**4.2** Dehydrogenation with DDQ and TCQ, and Ozonolysis

**4.3 Preparation of reagents (wherever applicable), mechanism and applications of the following:** Wolf-Kishner reduction, Clemmensen reduction, Meerwein-Pondorff-Verley reduction, Birch reduction, Reductions with $NaBH_4$, $LiAlH_4$ and DIBAL.

**4.4 Homogeneous reductions:** Wilkinson's catalysts and related systems.

**References Books:**


1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.
3. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
4. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
5. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
7. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
8. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.

9. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
10. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
11. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
12. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks.
14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, John Wiley and Sons.
15. Organic Spectroscopy, William Kemp, W.H. Freeman & Company.
16. Organic Spectroscopy-Principles and Applications-Jagmohan, Narosa Publication.
17. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co.
18. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.
19. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.
20. Physical Organic Chemistry, Neil Isaacs
21. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty
22. Stereochemistry: A Three-Dimensional Insight by Anil V. Karnik and Mohammed Hasan.

| PROGRAM(s): M.Sc.-I | SEMESTER: II |
|---|---|
| Course: | Course Code: CHEM 510 / 112016251011<br><br>Course Title:- Chemistry Practical-II |

| Teaching Scheme | | | | Evaluation Scheme |
|---|---|---|---|---|
| Practical (Hours per week) | Tutorial (Hours per<br><br>week) | Credit | Continuous Assessment (CA) (Marks- 25) | Semester End Examination (Marks- 25) |
| 16 | – | 02 | 25 | 25 |

**Learning Objectives:**

**Physical Chemistry**

1.To gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.

2.To develop scientific temper and research based skills accomplish to encountered in the field of research.

**Inorganic Chemistry**

3. To gain ability to analyze different samples of ores and alloys.

To learn different analytical methods for composition analysis.

**Course Outcomes:-**

**Physical Chemistry**

1.To use the concept of quantum chemistry to interpret the shape and information about the orbitals like 1s, 2pz and 3dz2.

2. To apply the subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions

3. Learner will train to handle the sophisticated instrument like digital potentiometer, conductivity meter, spectrophotometer.

**Inorganic Chemistry**

1.The learner will learn to analyze the composition of different ores and alloys.

2. The learner will gain knowledge and hands on experience of different analytical methods used in the estimation of metals.

## Course Code: CHEM 510 / 112016251011

# CHEMISTRY PRACTICAL-II

## Physical Chemistry Practicals-II

### Non-Instrumental Experiments*:

***Thermodynamics, Phase Rule and Reaction Kinetics:***

1. Determination of heat of solution of benzoic acid by solubility measurements.
2. Determination of heat of solution of salicylic acid by solubility measurements.
3. Study of three-component system: Water-Acetic acid-Chloroform.
4. Study of three-component system: Water–Toluene-Acetic acid.
5. Study of variation of solubility of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product. (Complexometric titration with EDTA)
6. Determination of equilibrium constant of the reaction $KI + I_2 \rightleftharpoons KI_3$ by distribution method.
7. Investigation of the reaction between acetone and iodine.

(* Any four Physical Chemistry experiments to be performed from the above list)

## Inorganic Chemistry Practical-II

**Analysis of Complex Materials:**

1. Lime Stone Ore: Loss on ignition; Ca by EDTA method.
2. Solder Alloy: Sn gravimetrically by oxide method; Pb by EDTA method.
3. Cu-Ni Alloy: Cu by iodometric method; Ni gravimetrically by DMG method.
4. Devarda's Alloy: Cu by EDTA method, Al gravimetrically by oxine method.

**Reference books for practicals**


1. I. Vogel, Vogel's Text Book of Quantitative Inorganic Analysis, 6th Ed., Pearson Education, 2000.
2. J. D. Woolins, Inorganic Experiments, Wiley-VCH Verlag GmbH and Co., 2003.
3. W. G. Palmer, Experiments in Inorganic Chemistry, Cambridge University Press, 1954.
4. G. Raj, Advanced Practical Inorganic Chemistry,
5. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 and 2, Academic Press, 1967.
6. Marr and B. W. Rockette, Practical Inorganic Chemistry, Van Nostrnad Reinhond, 1972.
7. Pass and H. Sutcliffe, Practical Inorganic Chemistry, 2nd Ed., Chapman and Hall, 1985.


## Organic Chemistry Practical-II

**Separation of Binary mixture by microanalytical technique**

Separation of the binary mixtures using physical and chemical methods. Identification of one of the compounds and checking its purity by TLC. Preparation of the derivative of one of the compounds. The following types are expected: (i) Non-volatile liquidNon-volatile liquid (ii) Water-soluble/insoluble solid-Non-volatile liquid with compounds from the same or different chemical classes. The candidate is expected to carry out the separation of 4 mixtures.

**Reference Books:**


1. Systematic Qualitative organic analysis, H. Middleton (Orient Longman)
2. A Handbook of Organic Analysis, H.T. Clark (Orient Longman)
3. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York)


**Analytical Chemistry Practical-II**

**Instrumental Experiments*:**

1. Non aqueous titration: Determination of sodium benzoate / glycine by using perchloric acid in glacial acetic acid by potentiometry using glass-calomel system.
2. Determination of glucose by Folin-Wu method.
3. Determination of nitrite in a water sample by colorimetric method.
4. Determination of chromium and manganese by simultaneous spectrophotometry (to be replaced).
5. Determination of silica by Molybdenum Blue method.
6. Flame Photometric determination of Li /Na/K by standard addition method.

(* Any four Analytical Chemistry experiments to be performed from the above list)

| PROGRAM(s): M.Sc.-I | | | SEMESTER: II |
|---|---|---|---|
| | | | **Course Code: (CHEM 511/ CHEM 51111 / 112016251111**<br>**Course Title:-Analytical Chemistry-II** |
| **Teaching Scheme** | | | **Evaluation Scheme** |
| **Lectures (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks-50)** | **Semester End Examination (Marks- 50)** |
| **04** | **04** | **50** | **50** |

**Course Objectives:**

1. To gain knowledge about electroanalytical techniques and applications of sensing electrodes.
2. To understand basic instrumentation of NMR and Mass techniques.
3. To principle, construction, working and applications of XRF, XRA and XRD techniques.
4. To apply the surface analytical techniques for system.
5. To learn about the automations in chemical analysis and process analytical techniques with some hyphenated techniques.

**Course outcomes: -**

After completion of this Course, the learner will be

1. able to learn the tool for quantitative analysis of analytes using solid state, precipitate and liquid-liquid membrane, enzyme and gas sensing electrodes with applications.
2. able to know the basic concepts of modern voltammetric techniques with electrochemical properties of compounds and systems and also the theory of thermodynamics and kinetics of electrochemistry.
3. The advantages and disadvantages of voltammetric techniques like DPP, CV and Stripping voltammetry of analysis.
4. Students are expected to learn the basic concepts and instrumentation of $^{1}H$, $^{13}C$, $^{19}F$, and $^{31}P$ NMR and Mass Spectrometry.
5. Also the applications of such analytical techniques in various fields like pharma, medical, academia and research.
6. Able to learn about the basic concept of XRA, XRF and XRD techniques and its applications in the various fields.
7. Able to understand the the automation processes in analytical instrumentation and some hyphenated techniques in detail like GC-MS and LC-MS.

# Course Code: CHEM 511 / CHEM 51111/ 112016251111
# ANALYTICAL CHEMISTRY-II

**Unit-I ELECTROANALYTICAL CHEMISTRY[15L]**

1.1 Ion selective potentiometry: Basic concept, solid state, precipitate and liquid-liquid membrane, enzyme and gas sensing electrodes with applications. **[8L]**

1.2 Introduction to modern voltammetric techniques viz., Differential pulse polarography, Cyclic voltammetry and Stripping (cathodic & anodic) voltammetry. **[7L]**

**Unit-II SPECTROSCOPIC METHODS [15L]**

1.1 **Magnetic resonance spectroscopy**:

Basic principles, instrumentation and sample handling, Quantitative applications of proton NMR, Introduction to Carbon–13, Phosphorous-31 and Fluorine-19 with applications. **[8L]**

1.2 **Mass spectrometry**:

Recapitulation, instrumentation; ion sources for molecular studies; EICI, FI, ESI, APCI, FAB & MALDI sources. Mass analyzers: quadrupole, time of flight and ion trap, Applications. [**7L]**

**Unit-III MISCELLANEOUS TECHNIQUES [15L]**

3.1 **X-ray Techniques:**

Principles, instrument components and applications of X-ray fluorescence, absorption and diffraction methods. [**10L]**

3.2 Introduction to surface analytical techniques: ESCA **[5L]**

**Unit-IV: AUTOMATION IN CHEMICAL ANALYSIS AND Process Analytical Techniques [15L]**

4.1 An overview of automated instruments and instrumentation, process control analysis; Types of automatic analytical systems: Flow injection analysis, automatic organic elemental analyzers, Gas monitoring equipment. **[8L]**

4.2 Process Analytical Techniques **[4L]**

4.3 Introduction to hyphenated techniques: GC-MS and LC-MS **[3L]**

**Reference books:**


1. D. A. Skoog, F. J. Holler, and T. A. Nieman, *Principles of Instrumental Analysis*, 5th ed., Philadelphia: Saunders College Publishing, 1998.
2. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Philadelphia: Saunders College Publishing, 2004.
3. G. D. Christian, *Analytical Chemistry*, 6th ed., John Wiley and Sons, New York, 2003.
4. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th ed., ELBS, Longman Scientific & Technical, England, 2002.
5. H. H. Willard, L. L. Merrit, jr., J. A. Dean and F. A. Settle, Jr., *Instrumental Methods of Analysis*, 6th ed., CBS 1986.

6. R. D. Braun, *Introduction to Instrumental Analysis*, McGraw Hill, 1987.
7. G. H. Morrison and H. Freiser, *Solvent Extraction in Analytical Chemistry*, John Wiley & Sons, New York, 1966.
8. S. M. Khopkar, *Basic concept of Analytical Chemistry*, 3rd ed., Age International Publisher 2008.
9. T. Sekine and Y. Hasegawa, *Solvent Extraction chemistry*, Marcel Dekker, 1977.
10. P. G. Swell and B. Clarke, *Chromatographic Separations, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
11. S. Sindsay, *High Performance Liquid Chromatography, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
12. A. J. Bard and L. R. Faulkner, *Electrochemical Methods*, Wiley, New York, 1980
13. A. M. Bond, *Modern Polarographic Methods in Analytical Chemistry*, Marcel Dekker, New York, 1980.
14. L. C. Thomas and G. J. Chamberline, *Colorimetric Analytical Methods*, 9th ed., The Fintometer Ltd., Salisbury, England, 1980.
15. T. C. Morrili, R. m. Silverstein and G. C. Bassler, *Spectrometric Identification of Organic Compounds*, Wiley, 1981.
16. Vogel's Text Book of Quantitative Organic Analysis, 2th ed. ELBS.
17. R. A. Day, Jr. and A. L. Underwood, *Quantitative Analysis*, 6th ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1993.
18. Jared L. Anderson, Alain Berthod, Veronica Pino, and Apryll M. Stalcup (ed),*Analytical Separation Science (Volume 1-5)*. WILEY-VCH 2015.
19. Jack Cazes (ed) *Ewing's Analytical Instrumentation Handbook,* 3rd edition, Marcel Dekker 2009.
20. R. Kellner, J.M. Mermet, M. Oto, M. Valcarcel, H. M. Widmer (ed), *Analytical Chemistry: A modern Approach to Analytical Science 2nd edition.* WILEY-VCH 2004.

| PROGRAM(s): M.Sc.-I | | | SEMESTER: II |
|---|---|---|---|
| | | | **Course Code: (CHEM 51112/ 112016251112**<br>**Course Title:-Applied Industrial Chemistry-II** |
| **Teaching Scheme** | | | **Evaluation Scheme** |
| **Lectures (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks- 50)** | **Semester End Examination (Marks- 50)** |
| **04** | **04** | **50** | **50** |

**Course Objectives:**

1. To enable learners to have comprehensive knowledge, understanding of the types of instruments with operations and automated methods of analysis.
2. To apply the basic knowledge of quality systems, quality audit and quality managements,.
3. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.
4. To provide solutions to problems encountered in the field of analysis and research.

**Course Learning Outcomes.**

After completing the course students will be able to:

2) predict the reactivity of organic compound from its structure.
7) understand different methods used for determination of Organic Reaction Mechanism
8) understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.
9) acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.
10) develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds
11) identify the nomenclature of various stereochemical phenomena

## Course Code: CHEM 51112 / 112016251112
## Applied Industrial Chemistry-II

**Unit-I [15L]**

**Sugar industry-based chemicals and Industrial gases:**

Introduction, manufacturing process of sugar, manufacture processes, properties and uses of oxalic acid, citric acid, ethanol, furfural from sugar by product. Introduction, application of hydrogen, nitrogen, oxygen, carbon dioxide, and liquefied gases.

**Unit-II [15 L]**

**Agrochemicals:**

i). Pesticides: history, invention, development, definition, and importance. Classification: General, based on the mode of action, according to target species and chemical nature. Formulations: conventional and advanced types, uses, and current trends. Pesticide residues, toxicity, warning symbols, safety with pesticides, first aid and antidotes.

ii). Fertilizers**:** Introduction, Manufacture, and uses of nitrogenous, phosphatic and potassic fertilizers, compound fertilizers, Mixed fertilizers: method of preparation and formulation.

iii). Fluid fertilizers: Introduction, manufacturing of nitrogenous and mixed fluids.

**Unit-III [15 L]**

**Corrosion and Protective Coating:**

Introduction dry and wet corrosion(mechanism), galvanic corrosion passivity, pitting corrosion, intergranular corrosion, waterline corrosion, stress corrosion, galvanic series, factors affecting corrosion, and corrosion control.

Introduction to metallic and electroplating, electroplating methods, chemical conversion coating, organic coating, paints, formulation of paints, varnishes, enamels, lacquers, emulsion paints, and special paints.

**Unit-IV [15 L]**

**Lubricant and Adhesives:**

Introduction, classification of lubricants, liquid, semisolid and solid lubricants, synthesis, properties, and application of lubricants. Introduction to adhesives, classification, adhesive action, physical and chemical factors affecting adhesives action, and bonding processes.

**Recommended Books**


1. R. W. Thomos and P. Farago, Industrial chemistry, 1973
2. P. G . More, Comprehensive Industrial Chemistry, Pragati Prakashan 2018.
3. S. K. Handa, Principles of pesticide chemistry, Agrobios (India); 2012.
4. A. Knowles, New developments in crop protection product formulation.T and F Informa UK Ltd. 2005.
5. D.S.Hill, Agricultural insect pests of the tropics and their control. CUP Archive; 1983.
6. S. B.Chattopadhyay, Principles and procedures of plant protection, Oxford & IBH Publishing Company, Pvt. Limited; 1991.
7. Ó. López, J. Fernandez-Bolanos, Green trends in insect control, Royal Society of Chemistry; 2011.
8. U. S. Sree Ramulu, Chemistry of Insecticides and Fungicides, Oxford and IBM Pub., 1979
9. P. S. Magee, G. K. Kohn, J. J. Menn, Pesticides Synthesis through Rational Approaches, American Chemical Society, 1979.
10. M. G. Rao and M. Marshall, Dryden's Outline of Chemical Technology, East west press, 1997.
11. K. S. Yawalkar, J. P. Agrawal, S. Bokde, Manures and Fertilizers, 1967.
12. D. A. Palgrave, Fluid Fertilizers, 1993.

13. G. H. Collings, Commercial Fertilizers, 2002.
14. P.C. Jain, Engineering chemistry, Dhanpat Rai publishing company private Ltd, New Delhi, 16th edition, 2014.
15. S. S. Dara and S. S. Umare, A textbook of Engineering Chemistry, S. Chand& Company Ltd, New Delhi, 20th Edition, 2013.

## Course: On Job Training/ Field Projects

**Course Code: CHEM 512 / 112016251211**

| PROGRAM(s): M.Sc-I | | SEMESTER: II | | | |
|---|---|---|---|---|---|
| Course: On Job Training/ Field Projects | | Course Code: CHEM 512 / 112016251211 | | | |
| Teaching Scheme | | | | | Evaluation Scheme |
| Lectures (Hours per week) | Practical (Hours per week) | Tutorial (Hours per week) | Credit | Continuous Assessment (CA) (Marks-50) | Semester End Examination (Marks- 50) |
| NA | 08 | – | 04 | 50 | 50 |

**Learning Objectives:**

1) To provide students the opportunity to test their interest in a particular career before permanent commitments are made.
2) To develop skills in the application of theory to practical work situations. To develop skills and techniques directly applicable to their careers.

**Course Outcomes:**

**At the end of the Course,**

1) Understand the Organizational Structure of a company.
2) Develop work habits and attitudes necessary for job success (technical competence, professional attitude, organization skills etc.)
3) Develop written communication and technical report writing skills.

## *For on job training students will be sent to the industries listed below;*

1. IRMRA, Thane
2. WRIC, University of Mumbai
3. Galaxy surfactants, Mumbai
4. RCF, Mumbai
5. BASF, Mumbai
6. Aarti Chemicals, Mumbai
7. Bio Era, Pune
8. Shimadzu, Mumbai
9. Mettler Toledo, Mumbai
10. Asian Paints, Mumbai
11. Reliance Laboratories, Mumbai
12. Anchrom, Mumbai

13. Deepak Fertilizers, Mumbai
14. TIFR, Mumbai
15. BARC, Mumbai
16. IIT, Mumbai
17. ONGC, Mumbai
18. Forensic Science Laboratory, Mumbai
19. NMRL, Ambarnath
20. NEERI, Mumbai
21. USV Ltd, Mumbai
22. CIPLA, Mumbai
23. MERCK, Mumbai
24. Glenmark, Mumbai

## SEMESTER-III

| Course Code | Title of Course | No. of Credits | No. of Hours | Examination | | Total Marks |
|---|---|---|---|---|---|---|
| | | | | Continuous Evaluation | End SEM | |
| IPCHEM 351 | Basics of Polymer, Rubber & Additives | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 352 | Rheology & Processing Rubbers | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 353 | Testing of Rubber, allied materials & composites | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 354 EC-I | Biopolymers and Bio composites | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 355 EC-II | Polymer Nano Composites | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 356 | Industrial Polymer Chemistry Practical-I | 04 | - | - | 100 | 100 |
| IPCHEM 357 | Industrial Polymer Chemistry Practical-II | 04 | - | - | 100 | 100 |

**No. of CREDITS: 24** **TOTAL MARKS: 600**

**Note: Students will have to select one of the electives i.e. IPCHEM 356 EC-I or IPCHEM 357 EC-II**

**Practical component involves 16 hour per week of laboratory work for 15 weeks**

## SYLLABUS: SEMESTER III

### IPCHEM 351: BASICS OF POLYMERS, RUBBER AND ADDITIVES

### Unit I POLYMERS & POLYMERIZATION TECHNIQUES

**[15L]**

**Polymers:** monomer, oligomer and polymer, Average Molecular Weight, Molecular weight, Distribution & Poly dispersity Index, classification of polymers, structure of polymer. Types of polymerization.

**Polymerization Techniques:** Mass Polymerization, Bulk Polymerization, Solution Polymerization, Emulsion Polymerization, Suspension Polymerization, Mechanisms with explanation. Characteristics, Relative advantages and disadvantages.

**Classification of Polymers:** Natural and synthetic polymers, Biopolymers, thermoplastic, thermosets, Elastomers, Fibers etc.

**Structure Property Relationship in Polymers:** Structure of polymers, amorphous, semi-crystalline and crystalline states in polymers, glass transition, melting and crystallization temperature. Effect of structure on the chemical, mechanical, electrical and optical properties of polymers.

### Unit II GENERAL PURPOSE RUBBER

**[15L]**

**Natural Rubber (NR):** Origin – Natural Rubber Latex, tapping, processing, properties and applications – Conversion of Latex into dry rubber – Properties of dry rubber – Classification based on technical specifications – Modifications of Natural Rubber

**Styrene-Butadiene Rubber (SBR):** Introduction, polymerization, types of SBR, structure & property variation in Emulsion SBRs and Solution SBRs. Compounding, Processing, Applications.

**Polybutadiene Rubber (PBR):** Manufacture, Structure and Properties of Polybutadienes, Processing and Applications.

**Synthetic Polyisoprene (IR) Rubbers**: Preparation of Synthetic Polyisoprene (IR) Rubbers, Properties, IISRP Numbering System, Processing, Applications.

### Unit III SPECIAL PURPOSE RUBBER

**[15L]**

**Preparation, properties and Application of**: Nitrile Rubber & modified NBR (HNBR & XNBR), Butyl Rubber & Halogenated butyl rubbers, Polychloroprene Rubbers, Ethylene Propylene Rubber and Ethylene Vinyl acetate copolymers – Elastomers based on modified polyethylene (chlorinated polyethylene & chlorosulphonated polyethylene), Acrylate rubbers, Polysulphide rubbers, Hydrin rubbers, Silicones and Fluroelastomers etc.

**Rubber blends:** miscible and immiscible blends,

**Thermoplastic Elastomers** – **Preparation, properties and Application of**: SBS and SIS Block copolymers, Thermoplastic Polyurethane elastomers, Thermoplastic-co-polyesters, Thermoplastic elastomers based on Plastics, Dynamic Vulcanization

**Unit IV NON-RUBBER ADDITIVES**

**[15L]**

**Part A: Vulcanizing ingredients & other additives:** Vulcanizing ingredients & their sequence of mixing: Activators and Accelerators: mechanisms of action. Other cure systems based on metal oxides, peroxides, etc. retarders, inhibitors anti-reversion agents.

**Part B: Fillers**

**Carbon black**-Its preparation, structure, properties and their effect on rubber properties

**Silica** fillers & coupling agents, Other fillers: Clay, Calcium carbonate, titania etc. Nano-fillers:

**Reinforcement by filler:** Reinforcement, Factors influencing elastomers reinforcement, fillers characteristics, main effects of fillers on vulcanizate properties, Influence of fillers characteristics on the cross linking process, Filler incorporation, the role of bound rubber, reinforcement and crosslink density.

**Part C: Processing aids & other additives:** Processing aids, plasticizers, process additives, release agents, Other additives like colourants, blowing agents, factice, Fire Retardants, Antistatic Agents, Deodorants and Reodorants, Biocides and Fungicides etc. **Antidegradants:** Introduction, Autoxidation of Hydrocarbon Polymers, Amine & Phenolic Antioxidants & other types, Antizonants, Prevention of Ozone Attack with the use of waxes & saturated polymer for Ozone Protection.

**References:**


1. F. W. Billmeyer Jr., Text Book of Polymer Science, Ed. Wiley-Interscience, 1984.
2. V. T. Gowariker, N. V. Viswanathan, and J. Sreedar, Polymer Science, 1988.
3. M. Morton, Rubber Technology, Chapman Hall, 1995.
4. J. Brydson, Rubber Chemistry, Butterworths, 1978
5. B. Kothandaraman, Rubber Materials, Ane Books, 2008.
6. I. Franta, Elastomers and Rubber Compounding materials, Elsevier, 1989.
7. B. Kothandaraman, Rubber Materials, Ane Books, 2008.

## IPCHEM 352: RHEOLOGY AND PROCESSING OF RUBBERS

### Unit I RHEOLOGY OF RUBBERS

**[12L]**

Definition of Rheology, Rheological Perspective, The importance of nonlinearity, Solids and liquids, Components of rheological research: Rheometer, Constitutive equations, Complex flows of elastic liquids.

### Unit II COMPOUNDING & MIXING TECHNIQUES

**[12L]**

Rubber mixing mechanism, mixing machinery - Open mill mixing – Internal mixers – Continuous mixers – Factors affecting mixing – Flow behaviour of rubber compound, processibility test, Latex compounding and mixing. Troubleshooting.

### Unit III POSTCOMPOUNDING PROCESSING

**[12L]**

Calendaring: Sheeting –Skim coating – Fractioning – Topping – Doubling – Profiling – Spreading – Roll configurations – Control of thickness. Extrusion; Ram type – Screw type – L/D ratio and its influence – Hot & cold feed extruders – Pin barrel extruder – Twin screw extruder – Criteria for machine selection. Troubleshooting.

### Unit IV MOLDING & VULCANIZING TECHNIQUES

**[12L]**

**Molding:** Mold design, Compression, transfer and injection moulding – Blanks & pre-heating techniques, preparation of surfaces for bonding. Curing: Autoclaves, Hot air chambers, curing of built up articles, continuous vulcanization, L.C.M. (Liquid Curing Media), Fluidized Bed, microwave curing. Hand building and forming equipment for tank, pipe lining, roller covering. Troubleshooting.

### Unit IV FINISHING OF RUBBER PRODUCTS

**[12L]**

Equipment‘s for flash and spew removal – Cryogenic techniques – Hand trimming – roller trim, buffing, tumbling, punching, grinding, shot blasting, painting, lacquering – Guards, Trip devices, Photoelectric and pressure sensitive devices – Maintenance of guards.

**References:**


1. Dr. B. R. Gupta, Rheology of Elastomers.
2. H. A. Barnes, J. F. Hutton and K. Walters, An Introduction to Rheology, Elsevier, 1989.
3. Rubber Processing, James L. White, Hanser Publishers, 1995.
4. C. M. Blow and C. Hepburn, Rubber Technology and manufacture, Butterworths, 1982.
5. C. W. Evans, Practical Rubber Compounding and processing, Applied Science, Publishers, London, 1981.

6. J. L. White, Rubber Processing Technology Materials, Principles, Hanser Publication, New York, 1995.
7. Kleemann, Weber, Elastomer Procesing, Hansar, 2005.

## IPCHEM 353: TESTING OF RUBBER ALLIED MATERIALS & COMPOSITES

### Unit I PRINCIPLES OF TESTING & RAW MATERIAL TESTING

**[15L]**

Principles of Testing, Standards and specification, Nomenclature- ISO and other standards, Laboratory Management System as per ISO/IEC 17025:2005 and Quality Management System as per ISO : 9001:2015.

Molecular weight distribution using GPC, Analysis of antioxidant, process oil and other additives by using GC GCMS, UV-Vis spectrophotometer, ICP-OES and DSC. Polymer identification by FTIR, Ash Content, Melting point, Moisture content and Specific gravity

### Unit II TESTING OF RAW RUBBER & UN-VULCANIZED RUBBER COMPOUND

**[15L]**

**Viscosity Characterization** – Brookfield Viscosity, Mooney viscosity,

Mass, Density, Dimensions Compression plastimeter, plasticity retention index, rotation plastimeters, extrusion rheomter, Scorch and cure rate: oscillating disk rheometer, moving die rheomter, rubber process analyzer etc.

### Unit III TESTING OF VULCANIZATE

**[15L]**

**Mechanical Properties** –Different types of Hardness,( Shore A, Shore D, IRHD and micro hardness) tear, tensile, compression, application of test data, abrasion resistance, Shear, Creep & Stress relaxation, Resilience, Aging and uniaxial, biaxial compression test.

**Thermal Analysis:** Instrumentation, Polymer Identification, Compositional analysis, volatile matter, Rubber, Polymer blends, C-black & ash estimation using Thermal Analysis (TGA). Glass transition, Heat capacity, Thermal history of polymers, State of cure studies by using DSC and Thermal Mechanical Analysis (TMA)

### Unit IV PROCESS & QUALITY CONTROL

**[15L]**

Effect of environment – Oxygen, heat, ozone and swelling media

Fatigue – Flex cracking and cut growth – Heat buildup **Dynamic mechanical testing of rubbers**—Storage modulus, loss modulus, Tan delta, Natural frequency, transmittance and damping factor.

Testing of rubber products like hoses, gaskets, automotive tubes, bearings, Testing of conveyor belts, V-belts and Mounts.

**References:**

1. Standard - ISO / IEC 17025:2005

2. Standard – ISO 9001:2015
3. C. D. Craver and T. Provder, Polymer Characterization, ACS Advances in chemistry Series, Volume 227, 1990
4. J. S. Dick, Rubber Technology Compounding and testing for Performance, Hanser Publisher, 2001.

## ELECTIVE COURSES

### IPCHEM 354: EC-I: BIOPOLYMERS & BIO COMPOSITES

**Unit I BIOPOLYMERS & BIODEGRADATION**

**[15L]**

**Biopolymers:** Classification, Biopolymers from natural origin and mineral origin, isolation, properties.

**Biodegradation:** Mechanism of biodegradation (polyesters, polycarbonates, polyvinyl alcohol, polyurethanes and polyether‘s) factors influencing biodegradation. Types of biodegradable polymers – properties and application.

**Unit II CHARACTERIZATION & TESTING FOR BIODEGRADABILITY**

**[15L]**

Test methods and standards for bio-degradable plastics, Criteria used in evaluation of biodegradable plastics, Description of current test methods – Scanning test for ready biodegradability, Test for inherent biodegradability, Test for simulation studies, Other methods for assessing polymer biodegradability.

**Unit III BIOCOMPOSITES**

**[15L]**

Definition- classification- natural bio, fibre and nano fillers as reinforcement, biodegradable/ bio-based resins as matrices. Properties of biocomposites. Applications in automobile & buildings.

**Unit IV APPLICATIONS OF BIOPLOYMERS**

**[15L]**

Biopolymer Films, Biodegradable mulching, Advantages and Disadvantages, Chemical sensors – Biosensors, Functionalized Biopolymer Coatings and Films, Applications of biopolymers in horticulture Food Packaging, Functional Properties, safety and Environmental aspects, Shelf life, Films and coatings in Food Applications, Materials for edible films and coatings, Biopolymer coatings for paper and paperboard, Bio-nanocomposite films and coatings

**References:**

1) R. Smith, Biodegradable polymers for industrial applications, Woodhead Publishing Ltd, CRC Press, 2005.

2) A. J. Domb, J. Kost and D. M. Wiseman, Handbook of Biodegradable polymers, Harwood Academic Publishers, 1997.

3) R. P. Wool, X. S. Sun, Bio-Based Polymers and Composites, Elsevier, 2005.

4) A. S. Singha and V. K. Thakur, Green Polymer Materials, Studium Press, 2012.

5) A. K. Mohanty, M. Misra and L. T. Drzal, Natural Fibers, Bio Polymers and Bio Composites, CRC Press, 2005.

## IPCHEM 355: EC-II: POLYMER NANO COMPOSITES

### Unit I COMPOSITES

**[15L]**

Characteristics, advantages, and need of composites –Polymer composite materials, classification and theory of composite materials; Polymer matrices - thermoplastics and thermosetting plastics; Fiber reinforcement of elastomers - short and long fiber composites – Other additives

### Unit II NANOMATERIALS USED IN POLYMERS

**[15L]**

Nanofillers in bulk polymers - overview of potential nanostructured fillers - types - nanoparticles, nanofibers, nanotubes, nanosheets; surface features and layers and its modification. Techniques used to characterize nanostructured materials –XRD, AFM, etc.

### Unit III CARBON NANOTUBES & THEIR APPLICATIONS

**[15L]**

Structure of carbon nanotubes, processing methods for nanotube based polymer nanocomposites, nanotube alignment, characterization, properties and applications,

### Unit VI PREPARATION & APPLICATION OF POLYMER NANO COMPOSITES

**[15L]**

Preparations of polymer nanocomposites - melt blending, solution blending, latex coagulation, in-situ polymerization, characterization, properties and application.

Polymers in nanoelectronics, Magnetic polymer nanocomposites, Wear resisting polymer nanocomposites, Packaging, Bio-medical, surface coatings, etc.

**References:**

1) Yiu-Wing Mai and Zhong-Zhen Yu, Polymer Nanocomposites‖, Woodhead Publishing Limited, 2006.

2) K. Friedrich, S. Fakirov and Zhong Zhang, Polymer Composites from Nano to Macro‖, Springer 2005.

3) C. N. R. Rao, A. Muller, and A. K. Cheetham, The chemistry of Nanomaterials‖, Vol 1 & Vol. 2, Wiley-VCH, 2005.

4) J. H. Kao, Polymer Nanocompsoites, McGraw-Hill Publishers, 2006.

## IPCHEM 356: INDUSTRIAL POLYMER CHEMISTRY PRACTICAL-I

1. Preparation of Phenol formaldehyde resin – novolak and resol / polysufide rubber
2. Determination of: acid value / hydroxyl value of given polymer sample
3. Determination of saponification value of given oil
4. Estimation of total alkalinity of the latex
5. Viscosity measurement by Brookfield viscometer
6. Molecular weight determination of polymer by GPC
7. Determination of volatile matter, dirt, ash content in Rubber from Natural sources
8. Estimation of Cu, Fe and Mn in rubber by ICP
9. Rubber identification pyrolysis and spot test by specific reagents (ASTM solution)
10. TGA of different rubber
11. DSC analysis of Rubber Compounds
12. Mixing behaviour of NR on two roll mill / carbon black filled NR / carbon black filled SBR / carbon black filled SBR & NR blend / carbon black filled EPDM / carbon black filled NBR
13. Extrusion characteristics of a filled rubber mix- NR Ex / SBR / NBR / EPDM
14. Calendaring of rubber mix

## IPCHEM 357: INDUSTRIAL POLYMER CHEMISTRY PRACTICAL-II

1. Identification and classification of natural rubber by using FTIR, Mooney, and other chemical methods.
2. Identification and classification of synthetic rubbers by using burning test, FTIR, Mooney, and other chemical methods.
3. Identification and classification of different type of carbon black
    a. DBP absorption
    b. IAN
    c. Surface area Calculation
4. Identification and classification of rubber compounding materials, namely, **Zinc oxide / Stearic acid** / **Sulfur** / **Antioxidants** / **Accelerators** / **Processing oils**
5. Evaluation of tyre tread compound by using abrasion resistance index, heat build-up and
   DMA.
6. Evaluation of properties of seal & gasket rubber compound

7. Tyre testing by Endurance, rolling resistance, plunger energy, bead unseat etc.
8. Testing of: LPG Hose, Pressure cooker rubber gasket / Hose testing / Mount / Conveyor

   Belt / Condom / Tube
9. Design & development of : Tyre tread material / Hose cover / Conveyor belt cover / Gasket compound / footwear compound / latex dipped products / mounts / rubber mats / door profiles / tube compound
10. Curing Process of Rubber Compound- NR filled / SBR filled / NBR filled / EPDM filled / BR filled
11. Curing Process of Rubber Compound- by transfer molding technique
12. Curing Process of Rubber Compound- by injection molding technique of metal to rubber bonded products
13. Curing Process of Rubber mounts / Rubber Gaskets / Rubber Seals / Rubber Gauntlets

## SEMESTER-IV

| Course Code | Title of the Course | No. of Credits | No. of Hours | Examination | | Total Marks |
|---|---|---|---|---|---|---|
| | | | | Continuous Evaluation | End SEM | |
| IPCHEM 451 | Design & Development of Rubber Products | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 452 | Latex Science & Adhesives | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 453 | Tyre Science and Technology | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 454 OC-I | Intellectual Property Rights & Cheminformatics | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 455 OC-II | Research Methodology | 04 | 60 | 40 | 60 | 100 |
| IPCHEM 456 | Research Project | 08 | * | 80 | 120 | 200 |

**No. of CREDITS: 24** **TOTAL MARKS: 600**

**Students will have to select one of the optional courses i.e. IPCHEM 455 OC-I or IPCHEM 456 OC-II.**

**Practical component involves 16 hour per week of laboratory work for 15 weeks**

## SYLLABUS: SEMESTER-IV:

## IPCHEM 451: DESIGN & DEVELOPMENT OF RUBBER PRODUCTS

### Unit I FORMULATION DESIGN OF RUBBER COMPOUNDS

**[15L]**

Basics of compounding, Approach for compounding, Selection of Rubbers, Fillers, Curing agents and Special additives in Rubber Compounding. Rubber compounds feasibility for static and dynamic application, Rubber compounds for general purpose, oil resistant, heat resistant, fire resistant and weather resistance purposes.

### Unit II DESIGN & DEVELOPMENT OF TYRES

**[15L]**

Different components of tyres and their compounding, Tyre materials & Tyre processing techniques**.**

### Unit III CONVEYOR BELT TECHNOLOGY

**[15L]**

Different types of conveyor belts, Mixing, Compounding and Calendaring, Building, Curing and Testing, Finishing and Packaging**. V-belt—Building**

### Unit IV PRODUCT DEVELOPMENT OF HOSES

**[15L]**

Different kind of hoses, Extrusion of cover, Reinforcement, curing by autoclave.

**References:**


1. Setright J. K., Automobile Tyres, Champan & Hall, 1972.
2. The Pneumatic Tire, (Ed) A N Gent & J D Walter, The University of Akron, August. 2005, published by NHTSA, DOT, USA
3. Elastomers: Criteria for Engineering Design, C Hepburn & R J W Reynolds, Applied Science Publishers, London, 1979.
4. Khairi Nagdi, Rubber as an Engineering Material: Guideline for Uses, Hanser Publishers, 1993.


## IPCHEM 452: LATEX SCIENCE AND ADHESIVES

### Unit I LATEX SCIENCE

**[15L]**

Definition of Latex, classification, Latex particle size and distribution, stability and destabilization of latices, Comparison between latices and polymer solution. Characteristic and processing of natural rubber latex.

### Unit II LATEX APPLICATION

**[15L]**

Latex dipped products, latex foam rubber, latex thread, latex and textile based rubber products, latex based surface coating, latex and paper.

**Unit III RUBBER BASED ADHESIVES**

**[15L]**

Natural rubber adhesive, butyl rubber and polyisobutylene, nitrile rubber adhesive, styrene butadiene rubber adhesive, thermoplastic rubber in adhesive, carboxylic polymers in adhesive, neoprene based solvent and latex adhesive, polysulfide sealant and adhesives

**Unit IV RESIN BASED REACTIVE ADHESIVES**

**[15L]**

Phenolics, epoxies, acrylics, anaerobics, cyanoacrylates – Uses of adhesives in civil engineering, automobile, aerospace, electrical & electronic industries.

**References:**


1. D. C. Blackley, High Polymer Latices, Vol 1 and 2, Maclaren & Sons, 1966.
2. R. F. Mausser, The Vanderbilt Latex Hand book, 3rd Edn.
3. R. Waterman, R. F. Mausser & E. E. Miller, Vanderbilt Latex Book on Process and Compounding Ingredients, R T Vanderbilt Publishers.
4. K. O. Calvert, Polymer Latex and Applications, 1985.
5. I. Skiest (Ed), Hand book of Adhesives, Van Nostrand Reinhold, 1990.
6. Shields, Hand Book of Adhesives, Butterworths, 1984.


## IPCHEM 453: TYRE SCIENCE AND TECHNOLOGY

**Unit I TYRE STRUCTURE**

**[15L]**

A historical introduction on the design and development of tyres of various kinds and type the current status of tyre industry in India and its future prospects, tyre sizing and marking on the tyres, different types of tyres bias-belted tyre, tube and tubeless tyre, their basic functions and performance comparisons. Different components of a tyre, its geometry, basic functions. Functions of a pneumatic tyre-load carrying, vibration and noise reduction, tyre function as a spring, contribution to driving control and road adhesion, the tyre friction contribution to driving control, steering control and self aliging torque.

**Unit II TYRE CARCASS AND BUILDING**

**[15L]**

Manufacturing techniques of various tyres like two wheeler and car tyres, truck tyres, OTR, farm tyres, aircraft tyres. Principles of designing formulations for various rubber components. Tyre reinforcement materials (Textile, steel, glass etc.). Criteria of selection, different styles and construction, textile treatment. Tyre mould design, green tyre design principles, methods of building green tyres for bias, bias belted, radial and tubeless tyres, green tyre treatments. Tyre curing methods, post cure inflation, quality control tests. Tyre related products, their design and manufacturing techniques, tubes, valvesflaps, bladders.

Different types, their features and operation of tyre building machines, bead winding machine, wire/glass processing machines, bias cutters, curing presses.

**Unit III [15L]: Tyre Properties**

Tyre wear, rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc. on Tyre wear, rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc. on

**Unit IV TESTING OF TYRE**
**[15L]**

Measurement of tyre properties, dimension and size-static and loaded. Tyre construction analysis, endurance test, wheel and plunger tests, trac- tion, noise measurements. Force and moment characteristics, cornering coefficient, aligning torque coefficient, load sensitivity and load transfer sensitivity. Rolling resistance, non uniformity, dimensional variations, force variations, radial force variation, lateral force variation, conicity and plysteer. Type, balance, mileage, evaluations. Tyre flaws and separations. X- ray holography etc. Foot print pressure distribution. BIS standards for tyres, tubes and flaps.

**References:**


1. Tyre Science&Technology (Journal oftheTyreSociety) Akron,Ohio.
2. Tyre Technology 'Tom French', Adam Higher, New York.
3. Tyre Mechanics & Testing (Sponsored Course, Feb. '83) Roorke....
4. Mechanics of Pneumatic Tyres, Samuel C Lark, US Department of Transportation Washington. .
5. (a) Year Book, (b) Engineering Design Informations, The Tyre & Rim Association.
6. Tyre, Valve & Rim data, ITTAC, New York.
7. LJK Setright. "Automobile Tyres". Chapman & Hall, London.
8. Tyre Technology, F.J.Kovac, GOODYEAR Tyre and Rubber Com- pany, USA.

## OPTIONAL COURSES

## IPCHEM 454 OC-I: INTELLECTUAL PROPERTY RIGHTS & CHEMOINFORMATICS

**Unit-I** **[15L]**

**Introduction to Intellectual Property:**

**[2L]**

Historical Perspective, Different types of IP, Importance of protecting IP.

**Patents:** **[5L]**

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.

**Industrial Designs:**

**[2L]**

Definition, How to obtain, features, International design registration.

**Layout design of integrated circuits:**

**[2L]**

Circuit boards, Integrated Chips Importance for electronic industry.

**Copyrights:** **[2L]**

Introduction, How to obtain, Differences from Patents.

**Trade Marks:**

**[2L]**

Introduction, How to obtain, Different types of marks-Collective marks, certification marks, service marks, Trade names, etc.

**Unit-II** **[15L]**

**Geographical Indications:**

**[2L]**

Definition, rules for registration, prevention of illegal exploitation, importance to India.

**Trade Secrets:**

**[2L]**

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

**IP Infringement issue and enforcement:**

**[5L]**

Role of Judiciary, Role of law enforcement agencies-Police, Customs, etc.

**Economic Value of Intellectual Property:**

Intangible assests and their valuation, Intellectual Property in the Indian Context- Various Laws in India Licensing a technology transfer.

**Different International agreements:** **[6L]**

**(a) World Trade Organization (WTO):**

(i) General Agreement on Tariffs & Trade (GATT) , Trade

Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade related Services (GATS)
Madrid Protocol

(iii) Berne Convention

(iv) Budapest Treaty

**(b) Paris Convention**

**WIPO** and **TRIPS, IPR** and Plant Breders Rights, IPR and Biodiversity

**Unit-III** **[15L]**

**Introduction to Cheminformatics:** **[5L]**

History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular Modeling and Structure elucidation.

**Representation of molecules and chemical reactions:** **[5L]**

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

**Searching chemical structures:** **[5L]**

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

**Unit-IV** **[15L]**

**Applications:**

Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure-Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure-Spectra correlations, Prediction of NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, Analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-Based and Structure Based Drug Design, Application of Cheminformatics in Drug Design.

**Reference books:**


1. Andrew R. Leach & Valerie, J. Gillet, (2007), *An introduction to Cheminformatcs*. Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) Cheminformatics: a text-book. Wiley-VCH.
3. Gupta, S.P. *QSAR and Molecular Modeling*, Springer-Anamaya Pub.: New Delhi.


## IPCHEM 455 OC-II: RESEARCH METHODOLOGY

**Unit-I LITERATURE SURVEY** **[15L]**

**Print:** **[5L]**

Primary, Secondary, Tertiary sources,

**Journals:**

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

**Digital:** **[5L]**

Web sources, 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, SciFinder, Scopus.

**Information Technology and Library Resources:** **[5L]**

The Internet and World Wide Web, Internet resources for chemistry, Finding and citing published information.

**Unit-II DATA ANALYSIS** **[15L]**

**The Investigative Approach:**

Making and recording Measurements, SI Unit-s and their use, Scientific methods and design of experiments.

**Analysis and Presentation of data:**

Descriptive statistics, Choosing and using statistical tests, Chemometrics, Analysis of variance (ANOVA), 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 egression analysis.

**Unit-III METHODS OF SCIENTIFIC RESEARCH & WRITING SCIENTIFIC PAPERS** **[15L]**

Reporting practical and project work, Writing literature surveys and reviews, Organizing a poster display, Giving an oral presentation.

**Writing scientific papers:**

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, Writing ethics, Avoiding plagiarism.

**Unit IV: CHEMICAL SAFTEY & ETHICAL HANDLING OF CHEMICALS**

**[15L]**

Safe working procedure and protective environment, protective apparel, emergency procedure, and first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric- safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

**Reference books:**


8. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in chemistry*, 2nd Ed., Prentice Hall, Harlow.
9. Hibbert, D. B., & Gooding, J. J., (2006), *Data analysis for chemistry*, Oxford University Press.
10. Topping, J., (1984), *Errors of observation and their treatment*, 4th Ed. Chapman Hll, London.
11. Harris, D. C., (2007), *Quantitaive chemical analysis*, 6th Ed., Freeman Chapters 3-5
12. Levie, R. de., (2001*), How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ Press 487 pages.
13. Chemical safety matters-IUPAC-IPCS, Cambridge University Press, 1992.
14. OSU safety manual 1.01


## IPCHEM 456: RESEARCH PROJECT

Each student will be assigned a project involving some design and fabrication work, as well as Theoretical and Experimental studies on some problems related to Rubber and Plastics

Technology. Continuous internal assessment marks for the project will be given during Project Review meeting. The student has to prepare and present a detailed project report at the end of the semester and give a presentation about the work done. End semester examination mark will include viva voce examination.

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## 13. FEES FOR M. Sc. (CHOICE BASED CREDIT SYSTEM) COURSE*

**(*fee structure is likely to undergo revision from the academic year 2023-24)**

| Sr. No. | Fees Head Description | Amount in Rs. |
|---|---|---|
| 1 | Application Form & Prospectus Fee | 100.00 |
| 2 | Caution Money Deposit | 800.00 |
| 3 | Computer & Internet | 500.00 |
| 4 | Development Fee | 500.00 |
| 5 | Group Insurance Fee | 40.00 |
| 6 | Identity Card | 50.00 |
| 7 | Library Fee | 1,000.00 |
| 8 | Gymkhana | 200.00 |
| 9 | Magazine | 100.00 |
| 10 | Student Welfare Fund Contribution | 50.00 |
| 11 | E-Suvidha Fee | 50.00 |
| 12 | Disaster Relief Fund | 10.00 |
| 13 | P.G. Registration Fee | 1,000.00 |
| 14 | P.G. Registration Form Fee | 25.00 |
| 15 | Tution Fee | 45,000.00 |
| 16 | Admission Processing Fee | 200.00 |
| 17 | Utility | 250.00 |
| 18 | Other Fees/ Extracurricular Activity | 250.00 |
| 19 | Sports Activity Fund, University Sport & Cultural Activity | 30.00 |
| 20 | Eligibility Cum Enrolment Fee | - |
| 21 | Sports Contribution | - |
| 22 | National Service Scheme | - |
| 23 | Vise Chancellor's Fund Contribution | 20.00 |
| 24 | E-Charges | 20.00 |
| 24 | Railway Concession | - |
| 25 | Laboratory Fees | 10,000.00 |
| | **Total** | **Rs. 60,195.00** |

* Note:- (Sr.No.20) Eligiblity fees is valid for only other University students. It is 400 for Within Maharashtra University Student and 500 For Outside of Maharashtra University Students, **this Fees is Same For all Category**.

## 14.Information about the availability of seats for admission

**STATEMENT SHOWING THE NUMBER OF SEATS AVAILABLE FOR STUDENTS OF DIFFERENT CATEGORIES FOR ADMISSION TO UNAIDED M. Sc. DEGREE COURSE IN INDUSTRIAL POLYMER CHEMISTRY FOR THE YEAR 2023-2024**

| Branch | Total Seats | Number of Seats for Reserved Category Students | | | | | | | | | Reserved Category | General Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SC<br>13% | ST<br>7% | DT(A) (VJ)<br>3% | NT(B)<br>2.5% | NT(C)<br>3.5% | NT(D)<br>2% | OBC<br>19% | SBC<br>2% | EWS<br>10% | 62% | 38% |
| Industrial Polymer Chemistry | 15 | 1 + 1# | 1 | -- | -- | 1 | -- | 2 + 1* | -- | 2 | 9 | 5 + 1@ |

Seats are reserved as per Government of Maharashtra's directives

1% seats are reserved for Orphan students (marked by ϕ)
3% seats are reserved for Other University students (marked by *)
3% seats are reserved for Physically Handicapped students (marked by #)
3% seats are reserved for the following category students (marked by @)

1. Wards of the Central / State Govt. employees / officers who have been transferred
2. Wards of the present / past defence personnel
3. Students obtaining dexterity at National / State level Sports/ Cultural activities
4. Widow / Deserted female students
5. Wards of the Freedom Fighters

**Proforma – A**

**(Undertaking to be given by candidate who is unable to produce original certificates at the time of his / her admission round, as admission is already taken elsewhere)**

**UNDERTAKING**

I ……have secured admission to M. Sc. (Choice-Based Credit System) (Four-SEMESTER- Course) at the Department of Chemistry, University of Mumbai on ……

I have not produced the following original documents at the time of my admission as I have already secured admission for……Course at ……. College/Institute.

(Please put X against 'not submitted' document)

1. Original Mark sheet of the T. Y. B. Sc. Examination.

2. ……..

3. ……

I have produced the photocopies of the above documents, attested by the Head of the Institution (along with the certification) where my original documents are retained on account of my admission to that college/institute.

I hereby undertake to submit the original documents as mentioned above on or before (within **three** working days)……at Department of Chemistry, University of Mumbai.

**I am aware of the fact that failure on my part to submit the original documents in given time results in cancellation of my admission without any refund of tuition fees as per the provisions of the admission rule**.

Date : ( Name of candidate with signature )

Place : Merit No.

**Proforma- B**

**(Specimen Application form for cancellation of admission)**

(To be submitted in duplicate)

Date:……..

To

The Head,
Department of Chemistry
University of Mumbai

Respected Sir,

Full name of Candidate:……

Branch:.....Date of Admission …….

Merit Number:……

Amount of fees paid: Rs. …….

Fee Receipt Number and Date:…… (Attach Photocopy)

I request you to kindly return my original documents.

……

Signature of candidate

Received the Original Mark Sheet of the T. Y. B. Sc. examination from the Admission Authority.

Signature of the candidate

**Proforma- C**

**(Specimen Application form for refund of fees on cancellation of admission)**

(To be submitted in duplicate)

Date:……..

To

The Registrar,
University of Mumbai

Sir,

I have cancelled my admission to the M. Sc. (Choice-Based Credit System) (Four-SEMESTER-Course). My details are as given below:

Full name of candidate:……

Branch:.....Date of Admission …….

Merit Number:……

Amount of fees paid: Rs. …….

Fee Challan Number and Date:…… (Attach Photocopy)

I request you to kindly refund the fees paid as per the rules.

Signature of candidate

| | | |
|---|---|---|
| **For Office use only:**<br>Full address of the candidate : | | Amount Paid, Rs. |
| | | Amount Deducted, Rs. |
| | | Amount Refunded, Rs. |
| Tel./Mobile No.: | | Cheque No. & date |
| E mail: | | Bank particulars |