MADRAS CHRISTIAN COLLEGE (AUTONOMOUS)

(UGC – College with Potential for Excellence)

DEPARTMENT OF CHEMISTRY

MASTER OF PHILOSOPHY IN CHEMISTRY

(Effective from June 2018)

MADRAS CHRISTIAN COLLEGE (AUTONOMOUS)

DEPARTMENT OF CHEMISTRY

REGULATIONS AND SYLLABI

MASTER OF PHILOSOPHY IN CHEMISTRY

(Effective from June 2018)

Programme Objectives:

- To instill confidence in students to do independent research work.
- To inculcate learning and research skills in students.
- To impart knowledge in advanced concepts in chemistry.

Programme Outcomes:

On completion of Master of Philosophy in Chemistry, the students will

- **Acquire an in depth knowledge on their respective research domain in addition to instrumentation techniques and research methodology**.
- developanalytical skills in chemistry through supervised research project.
- Applycomputer skillsin relevant areas ofresearch.

1. **Eligibility for admission**

   Candidates for the degree of Master of Philosophy in Chemistry shall be required to have passed MSc Chemistry degree with 55 % of marks from any recognized university or an equivalent thereto which is accepted by the syndicate of the University of Madras.

2. **Duration of the course**

   M.Phil is a one year Programme with two semesters.

3. **Choice Based Credit System**

   In conformity with the CBCS pattern of the college and M.Phil regulations of UGC (Minimum Standards and Procedure for Award of M.Phil./Ph.DDegrees) Regulations, 2016) and University of Madras (CBCS Hand book 2017-2018), the following course structure and CBCS framework is adopted for the M. Phil course work.

4. **Structure of the course**

   The course work in Semester I consists of 3 papers (2 core + 1 elective).

   - **Paper I – core** : Scientific Research Methodology
   - **Paper II – core** : Modern Instrumental Techniques
   - **Paper III – elective** :**Content Paper** (Research Advisor Paper)

- Paper I & II shall be common to all.
- Paper I & II consist of 5 unitscovering the subject requirements of the course offered.
- Paper III is the content paper which is prescribed by each research advisor. The syllabus of the content paper encompass the concepts relevant to the field of specialization of the research advisor. The number of specialized papers by the research advisor can be more than one.
- Question Papers for Paper I and II shall be set externally and valued by two examiners, one internal and one external.
- Paper III shall be set and valued by the research advisor.

5. Internal Continuous Assessment and End of Semester Examination

- ICA − I will be conducted during the **sixth week**of the first semester for the syllabus covered till then.
- ICA − II will be conducted during the **eleventh week** of the first semester for the syllabus covered between the seventh and eleventh week of that semester.
- ICA – III: Assignments and seminars suitable to the subject. (To be completed before **14th week** of that semester)
- No passing minimum is stipulated for the Continuous Internal Assessments.
- **In Semester II**, project work will be carried out, followed by submission of dissertation and viva-voce. Prior to the submission of dissertation, Scholar shall make presentation in the department (Open to all) in the last week of June.

6. End of Semester Examination

- The passing minimum for M.Phil. Chemistry course is 50% of the marks in the End of Semester Examination and 50% of the total marks in the Internal Continuous assessment and End of semester examination put together.

CBCS framework for M.Phil (Chemistry) Programme

Paper /Course Code	Title of the paper/ Course	Contact Hours/ week	Library Hours/ Week	Exam Hours	Internal Exam ICA (Marks)	External Exam ESE (Marks)	Total (Marks)	Credits
Semester I								
CH1M01 Core-1	Scientific Research Methodology	5	5	3	50	50	100	5
CH1M02 Core -2	Modern Instrumental Techniques	5	5	3	50	50	100	5
CH1MXX Elective	Content / Research Advisor Paper	5	5	3	50	50	100	5
Semester II								
CH2M01	Dissertation and Viva-Voce				50*	50#	100	21
	Total						**400**	**36**

***Internal Assessment** **50 Marks**

Distribution of Marks

Literature survey	10
Quantum of work	30
Periodical Presentation	10
Total	**50**

 # External Assessment **50 Marks**

Distribution of Marks

Dissertation Evaluation	30
Presentation and Viva – Voce	20
Total	**50**

CH1M01: Scientific Research Methodology

(75 hours)

Learning Objectives:

- To know the methodology of writing a Dissertation, Research article and Review.
- To know the method of writing a Research proposal for funding agencies.
- To learn the scientific method of collecting data and to select an appropriate technique for analysis.
- To learn on the safe handling, storage and disposal of chemicals.
- To learn the various computational skills for research.

Unit I – Scientific Research and Literature Survey (15 hours)

1.1 **General principles of research**: Purpose of research, significance of research, scientific originality. Various stages of scientific research− Observation, Form Hypothesis,Experimentation, Analysis, Validity and Conclusion.

1.2 **Sources**: Primary, Secondary and Tertiary sources −Definition and Examples; Retrospective searching:chemical abstracts, subject index,issueindex,authorindex, formula index; Citation index – Science citation index (SCI), h-Index, i10 index; Search Engine optimization, Impact factor; International Standard Serial Number (ISSN), International Standard Book Number (ISBN): Definition and Significance.

1.3 **Web resources**: E-Journals; Accessing journal articles: Digital Optical Identifier (DOI);Alert Services: Table of Content(TOC) alerts, Citation Alerts; Articles: As Soon As Publishable (ASAP) articles, Hot articles, Special/Theme Issues; UGC INFONET Digital Library Consortium; Electronic books, online discussions with scientific forums and Webinar.

1.4 **Search Engines**: SciFinder, Scopus, Scientific Technical Information Network (STN) International, Google Scholar,Scirus, Chemfinder,OJOSE,ChemIndustry and ChemSpider.

Unit II - Statistical Methods in Data Analysis (15 hours)

2.1 **Errors in chemical analysis**:Classification of errors and their minimization, accuracy, precision and significant figures.

2.2 **Basic statistical methods**: Mean, median, mode and standard deviation; Binominal distribution and Gaussian distribution; Hypothesis testing: t-test; $\chi 2$-test, and F-test, levels of significance and levels of confidence.

2.3 **Variance**: Definition and significance; Analysis of variance (ANOVA) – Basic principle and technique.

2.4 **The method of least squares and its plausibility**:Linear regression analysis, the regression and correlation coefficients and their significance.

UnitIII- Safety and Handling of Chemicals (15 hours)

3.1 **Chemical Safety**: General safety and Safe working procedure.

3.2 **Storage and usage of hazardous chemicals**: Material Safety Data Sheets(MSDS); Globally Harmonized System for Classification and Labelling of Chemicals (GHS); Procedure for the storage of acids, corrosive chemicals, flammable liquids, oxidizers, water reactive chemicals (Handling of sodium metal, aluminium chloride and orgnaolithium compounds) and explosives.

3.3 **Disposal of waste chemicals**: Procedure for disposal - Liquid waste: aqueous solutions of acids, alkalis and metal salts, organic solvents (chlorinated and non-chlorinated); Solid waste: used gloves, syringe, and broken glassware.

UnitIV -Computer Aided Analysis (15 hours)

4.1 **Computer organisation**: Hardware and Software, elementary aspects of digital electronics, Basic fundamentals of electronic circuits and their components used in circuits, common instruments like spectrophotometers, micro-computer interfacing, Computerized instrumentation system –- Computer controlled laboratory automation system.

4.2 **Applications of computer packages**: Data presentations using formulas and functions – generating graphs/charts; Application of packages such as MS-Excel, SPSS, Origin, Chemdraw, ACD/Chemsketch, MarvinSketch, ChemDoodle.

Unit V –Scientific writing (15 hours)

5.1 **Dissertation and Thesis writing**:The general format, chapter format, page format, use of abbreviations, quotations, footnote, tables and figures, results and discussions, bibliography and references.

5.2 **Publications**:Types of publications − communications, full length articles, reviews; Manuscript preparation: Format required for full length articles − title, abstract,

introduction, experimental methods and materials, results and discussions, conclusions, references, tables, figures, graphical abstracts and author guidelines.

5.3 **Intellectual Property Rights (IPR)**:Categories,Patent and copyright: importance; Ethical issues related to publishing; Academic integrity : Plagiarism- Definition, Classification, Causes, Consequences and Prevention

5.4 **Review writing**:Elements of review articles – Guidelines for review articles; Book reviews –General methods and format.

5.5 **Research proposal for funding agencies**:General format for writing a research proposal for funding agencies in India.

References:

1. Websites: http://www.inflibnet.ac.in, www.pubs.acs.org, www.sciencedirect.com, http://spingerlink.com, http://rsc.org,
2. H.F. Ebel, C. Bliefert, W.E. Russcy*The art of Scientific Writing* ,WILEY-VCHVerlasGmbh& Co, 2nd Edn (2004)
3. M. J. Katz, *From Research to Manuscript A Guide to Scientific Writing*, Springer Publication (2006)
4. M. L. Patten and M. Newhart *Understanding Research Methods*, 10th edition, Taylor & Francis, (2017).
5. K. S, Shrader-Frechette, *Ethics of Scientific Research Issues in Academic Ethics*, Rowman& Littlefield Publisher (2004).
6. A. M. Coghill, L. R. Garson, *The ACS Style Guide Effective Communication of Scientific Information,* ACS publication (2006)
7. C. R. Kothari, *Research Methodology: Methods and Techniques*, New Age International Publishers, (2004).
8. S.C. Gupta, and V.K. Kapoor, *Fundamentals of Mathematical Statistics*. Sultan Chand & Sons, New Delhi, (2014).
9. A.A. Fuscaldo, B. J. Erlick, B. Hindman, *Laboratory Safety - Theory and Practice*, Academic Press.(1980).
10. A. Keith, *Introduction CRC Handbook of Laboratory Safety*, CRC press, (2000*).*
11. S. B. Sigmann, L. R. McEwen, A. R. Smith, *Teaching Chemical Safety and Information Skills Using Risk Assessment*, ACS Symposium Series, Vol. 1232. Chapter 3, pp 57–92.(2016).

12. T.R. Sharp, K. R. Gopinath, P. W. Brandt, T.L.Rosenberry, *Microcomputer interface for Computer-Assisted Enzyme Kinetic Studies with UV-VIS Spectrophotometers*, Anal. Biochem, 116, 545-552 (1981).
13. PDP 11, Microcomputer Interfaces Hand Book, 1983-84, Digital.
14. Roberts, Tim S., *Student Plagiarism in an Online World: Problems and Solutions,*Information Science Reference, Hershey, New York, 2008, IGI Global
15. Dr. Ken K Wong, *Avoiding Plagiarism,*2011, I Universe Books, USA

LearningOutcomes

On completion of this course students will be,

- Skilful in collecting the information available from the source.
- Able to prepare articles for journals and proposal for funding agencies.
- Aware of careful handling of chemicals and their disposal.
- Able to analyse/present the data using computer.

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30
Section B: Answer any THREE questions (out of 5) 3 x 10 = 30
Section C: Answer any TWO questions (out of 4) 2 x 20 = 40
Total100

CH1M04: Chemistry of Graphene (75 hours)

Learning Objectives

- Tounderstand the structure of graphene and its derivatives
- To acquire intellectual expertise on the synthesis, characterisation and applications of Graphene and its derivatives.

Unit I- Introduction to Graphene

1.1 Introduction

1.2 Brief History of Graphene, Chemistry of Graphite, Graphite oxide, Graphene oxide and Graphene: Morphology and Structure -Down to Single Layers- Single, Bi-layer and Few-Layer Graphene.

1.3 Properties: Electronic Properties, Optical Properties, Mechanical Properties, Thermal Properties.

Unit II -Synthesis of Graphene

2.1 Top-down approach:Micro mechanical exfoliation of graphite(scotch tape method), Graphite intercalation, Nanotube slicing, Pyrolysis method, Reduction of graphite oxide (GO), Electrochemical exfoliation, Sonication, Ball milling, Radiation based methods.

2.2 Bottom-up approach: Growth from metal-carbon melts, Pulsed Laser Deposition, Chemical vapour deposition, Epitaxial growth onSiC.

Unit III -Graphene Derivatives

3.1 Functionalization by Covalent Bonding: Covalent Attachment of Organic Functionalitiesto Pristine Graphene, Addition of Free Radicals to sp^2 Carbon atoms of Graphene, Addition of Dienophiles to Carbon−Carbon Bonds, Covalent Attachment of Functionalities toGraphene Oxides, Addition of Chromophores, Covalent Linkage to Polymers, Addition of Other Organic Molecules.

3.2 Functionalization from Partially Reduced GrapheneOxide: Covalent Attachments of Hydrogen and Halogens toward Graphene Derivatives, Graphene and Fluorographene (Graphene Fluoride).

3.3 Noncovalent Functionalization of Graphenes: Graphene−Ligand NoncovalentInteractions:Theory, Nonpolar Gas−π Interaction, H−π Interaction, π−π Interaction, Cation−π

Interaction, πcation−π Interaction, Anion−π Interaction, Graphene−Ligand Noncovalent Interaction, Graphene−Ligand.

3.4 Functionalization with Nanoparticles: Deposition of Precious Metal Nanoparticles, Deposition of Metal Oxide Nanoparticles, Deposition of Quantum Dots.

Unit IV -Characterization of Graphene

4.1 **Characterizing Graphene Flakes**: Scanning Probe Microscopy, Raman Spectroscopy, Photoelectron spectroscopy, atomic force microscopy, XRD, SEM and TEM.

4.2 **Characterizing Graphene oxide**: UV, IR, elemental analysis.

Unit V-Applications of Graphene

5.1 Applications: Field Effect Transistors, Sensors, Transparent Conductive Films, Clean Energy Devices, Graphene Based Electrochemical Sensors and Biosensors.

5.2 Extraordinary Devices with Peeled Graphene: High-Speed Electronics, Single Molecule Detection.

5.3Application of Functionalized Graphene: Devices of Doped Graphene, MultilayeredGraphene Intercalates and Composites, Electronic/Spintronic Devices Including Ultrafast DNA Sequencing, Green Chemistry, Bio-imaging.

Learning Outcome:

After completion of the course the student will be able to

- Comprehend the structure of the Graphene and its oxide, synthetic protocols and functionalization methods.
- gain knowledge on various characterisation techniques and applications

References:

1. Matthew J. Allen, Vincent C. Tung,and Richard B. Kaner, Honeycomb Carbon: A Review of Graphene, *Chem. Rev.*110 (2010) 132–145.
2. WonbongChoi ,IndranilLahiri , RaghunandanSeelaboyina& Yong Soo Kang, Synthesis of Graphene and Its Applications: A Review, *Critical Reviews in Solid State and Materials Sciences*, 35 (2010) 52-71.

3. Yuyan Shao, Jun Wang, Hong Wu, Jun Liu, Ilhan A. Aksay and Yuehe Lin, Graphene Based Electrochemical Sensors and Biosensors: A Review, *Electroanalysis*, 22 (2010) 1027-1036.
4. S. Saqib Shams, Ruoyu Zhang and Jin Zhu, Graphene synthesis: a Review, *Materials Science*-Poland, 33 (2015) 566-578.
5. VasiliosGeorgakilas, Michal Otyepka, Athanasios B. Bourlinos, Vimlesh Chandra, Namdong Kim, K. Christian Kemp, PavelHobza, RadekZboril and Kwang S. Kim, Functionalization of Graphene: Covalent and Non-Covalent Approaches, Derivatives and Applications, *Chem. Rev.*, 112 (2012) 6156–6214.
6. C. N. R. Rao, A. K. Sood, Graphene, Synthesis, Properties, and Phenomena, Wiley-VCH, Weinheim, Germany 2013.

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30

Section B: Answer any THREE questions (out of 5) 3 x 10 = 30

Section C: Answer any TWO questions (out of 4) 2 x 20 = 40

Total 100

CH1M05: Chemistry of Hydroxyapatite (75 hours)

Learning Objectives:

- To gain insight on the structure and synthetic protocol of Hydroxyapatites
- To comprehend the various characterisation techniques for establishing the structural features.

Unit I – Introduction **15 hours**

Unit cell structure of Hydroxyapatite (HA), resemblance with natural bone and teeth, properties that make hydroxyapatite as biomaterial-non-toxic, biocompatibility, bioactivity, osteointegrative and osteoconductive nature.

Presence of acidic and basic sites in HA, exchange of Ca^{2+} by different cations, different mechanism for the replacement of Ca^{2+} in HA by other ions. Effect of pH on formation of stoichiometric and non-stoichiometric HA.

Unit II - Synthetic methodology **15 hours**

Description of various methods for the synthesis of HA- Chemical precipitation, sol-gel, microemulsion, mechanochemical, organic modifiers assisted routes, hydrothermal, ultrasonic irradiation and microwave irradiation. Significant features and limitations of each of the aforementioned methods.

Unit III – Characterization **15 hours**

Analytical techniques for the characterization of HA: XRD, Calculation of lattice parameter, Crystallite size, Crystallinality using XRD patterns; FTIR analysis, broadening of PO_4^{2-} bands due to B-type substitution of carbonate ion, Temperature programmed desorption(TPD) for quantifying acidic and basic sites in HA, Nitrogen adsorption desorption analysis, elemental analysis, SEM and TEM analysis(instrumentation not required).

Unit IV - Applications

Reactions catalyzed by HA and modified HA: Michael reaction, epoxidation of styrene, oxidation, transesterification, dehydrogenation and racemization of alcohols.
HA as biomaterial, carbon nano tube reinforced HA for orthopedic applications.

HA as adsorbent: adsorption of citric acid, protein, phenol, amine fluorides on HA

HA as drug delivery agent: delivery of anticancer drugs, antibiotics etc.

HA in electrochemical sensing of uric acid, ascorbic acid, dopamine etc.

Unit V– Structure-activity relationship through catalytic studies 15 hours

Proof for the presence of acidic and basic sites in hydroxyapatiteusing various organic reactions; Effect of Ca/P ratio on nature of reaction sites of HA;Correlation between ratio of acidic and basic sites in hydroxyapatite with product distribution in organic conversions.

Learning Outcomes

After completion of the course, the student will be able to

i) Gain understanding on the structure and synthetic methodologies of Hydroxyapatites

ii) Correlate the characterisation of the material with its activity in catalysis, sensing etc.

References:

1. Hydroxyapatite Synthesis and Applications, YoshikiOshida, Momentum Press, LLC, 2015, New York, ISBN-13: 978-1-60650-673-8.

2. Nanocatalysis: Synthesis and Applications, VivekPolshettiewar (Editor), TewodrosAsefa (Editor), ISBN: 978-1-118-14886-0, Wiley Publication 2013.

3. Synthesis methods for nanosized hydroxyapatite indiversestructures,Mehdi Sadat-Shojai, Mohammad-TaghiKhorasani,EhsanDinpanah-Khoshdargi,AhmadJamshidi, ActaBiomater. 9 (8) 2013, 7591-621.

4. Brian L. Cushing, Vladimir L. Kolesnichenko, Charles J. O'Connor, Recent advances in the liquid-phase syntheses of inorganic nanoparticles, Chem. Rev. 104 (2004) 3893-3946.

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30

Section B: Answer any THREE questions (out of 5) 3 x 10 = 30

Section C: Answer any TWO questions (out of 4) 2 x 20 = 40

Total 100

CH1M06: CHEMISTRY OF TITANIUM NANOTUBES(75 hours)

Learning Objectives:

- To acquire knowledge of various TiO_2nanostructuresand their synthetic methods
- To understand the nuances of Anodization techniques and characterisation of TiO_2 nanotubes for various applications.

Unit I - Introduction to Titanium dioxide 15 hours

Chemistry of TiO_2, its forms (amorphous and crystalline).Various nanostructures of TiO_2 – 1D, 2D TiO_2 structures, their electrical (super-capacitor behavior) and optical properties (photoluminescence and photocatalytic behaviour).

Unit II -Approaches to synthesis of TiO_2 Nanotubes 15 hours

Modes of preparation of nanotubes: Electrochemical methods - anodisation, deposition and spinning techniques, Chemical methods: sol-gel technique, hydrothermal/solvothermal techniques.

Unit III- Mechanism of Electrochemical Anodisation of Titanium15 hours

Methodology towards synthesis of nanotubular structures via electrochemical anodisation, stages of nanotube growth. Factors affecting geometry and composition, growth by flow mechanisms. Advanced geometries: tube stacks, bamboo, nanolace and branched tubes.

Unit IV - Physico-chemical properties of TiO_2 Nanotubes/Surface Modification15 hours

TiO_2 nanotubes: crystal structure, optical properties, electrical properties and reactivity;Modification of nanotube properties: heat treatments, introducing other elements, tube wall decoration, Magneli phases and black titania; Sensing properties of doped TiO_2 nanotubes : gas sensor, electrochemical sensor (biosensor, enzymatic and non-enzymatic sensor).

Unit V - Application of TiO_2 Nanotubes 15 hours

Gas sensing and biosensors: Preparation of sensing devices, Sensing Response and performance, effect of temperature in sensing; Photocatalytic degradation: effect of geometry and annealing, water splitting, membranes, dark

photocatalysis, CO_2 reduction. Solar Cells/Dye Sensitized Solar Cells (DSSCs): influence of preparatory parameters and geometry on DSSC, Doped TiO_2 nanotubes for DSSCs. Electrochromic devices. Cell interaction & biomedical coatings – antibacterial behaviour and drug delivery.

References

1. TiO_2 Nanotube Arrays: Synthesis, Properties and Applications by Craig A. Grimes &Gopal K. Mor. Springer 2009 edition.

2. Fabrication of TiO_2 Nanotubes Using Electrochemical Anodization by Marwa Abdul Muhsien Hassan &Haidar H. Hamdan Al-Eqaby. Lap Lambert Academic Publishing GmbH KG, 2012.

3. TiO_2 Nanotubes: Synthesis and Applications - Poulomi Roy, Steffen Berger and PatrikSchmuki. *Angew. Chem. Int. Ed. 2011, 50, 2904 – 2939* (DOI: 10.1002/anie.201001374)

4. One-Dimensional Titanium Dioxide Nanomaterials: Nanotubes - Kiyoung Lee, AncaMazare and PatrikSchmuki. *Chem. Rev., 2014,* 114 *(19), 9385–9454* (DOI: 10.1021/cr500061m)

5. A Review on TiO_2 Nanotubes: Influence of Anodization Parameters, Formation Mechanism, Properties, Corrosion Behavior and Biomedical Applications Indira, K., Mudali, U.K., Nishimura, T. et al. *J Bio TriboCorros (2015) 1: 28* (DOI: 10.1007/s40735-015-0024-x)

Learning Outcome:

After completion of the course, student will be able to

- Gain intellectual expertise on the synthesis of various TiO_2nanostructuresand their synthetic methods
- Understand the nuances of Anodization techniques and characterisation of TiO_2 nanotubes

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30

Section B: Answer any THREE questions (out of 5) 3 x 10 = 30

Section C: Answer any TWO questions (out of 4) 2 x 20 = 40

Total100

CH1M07 - Nanoparticles and Green Nanotechnology (75 hours)

Learning Objectives:

- To know the importance of Green Nanotechnology
- To understand the various analytical tools used for the Characterization and Application studies of Nanoparticles

UNIT – I **15 hours**

Nanoparticles

Definition, Classification: One dimensional, Two dimensional and Three dimensional;Types of Nanoparticles: Silver, Gold, Copper,Alloy, Carbon Dots, Metal Oxide;Properties of nanoparticles (Carbon dots, Metal, Metal Oxide Nanoparticle): Electronic and optical properties, Magnetic property, Mechanical Property,Thermal Property.

UNIT – II **15 hours**

Synthesis of Nanoparticle using Green Nanotechnology:

Definition,Need, Twelve Principles of Green Chemistry; Green routes for synthesis of nanomaterials: using Plant extract, Microorganism, Bacteria, Enzymes and wastes; Green synthesis of nanoparticle: Carbon dots- Functionalization of C-dots, Ag, Au, Pt, Cu, Metal oxide nanoparticles and their composites; Advantages and Disadvantages of Green synthesis.

UNIT – III **15 hours**

Synthesis of Nanoparticle:

Non Biological Method:Physical methods - Plasma arcing, ball milling, thermal evaporate, spray pyrolysis, ultra-thin films, Physical vapour deposition (Evaporation and sputtering)lithographic techniques.

Chemical method:Electrodeposition, sol–gel process, chemical solution deposition, chemical vapour deposition, soft chemical method, Langmuir Blodgett method, co-precipitation method – sonochemical method, Chemical reduction.

UNIT – IV **15 hours**

Characterization Toolsfor Nanoparticles:

Basic Principle and working of the following techniques:Dynamic Light Scattering Technique (DLS),UV- Visible spectroscopy, Photoluminescence Spectroscopy (PL),Fourier TransformInfrared Spectroscopy(FTIR),Raman Spectroscopy(RS),GC- MS,Scanning electron microscopy (SEM) – Atomic Force Microscopy (AFM) – Transmission Electron Microscopy(TEM) - Energy dispersiveSpectroscopy (EDS) – X-ray diffraction (XRD) – X-ray photoelectron spectroscopy(XPS)- Differential Centrifugation -Solvent Extraction.

UNIT – V **15 hours**

Applications ofGreen synthesised Nanoparticle:

As Sensors- Biosensors, Chemical sensors.

As Antibacterial, Antifungal, Anticancer agents;

In Environmental Remediation

Reference

1. C. N. R. Rao, A. Muller, A.K. Cheetam (Eds),*The Chemistry of Nanomaterials*, Vol.1, Wiley – VCH, Weinheim, 2004.
2. T. Pradeep, *A Text Book of Nanoscience and Nanotechnology*Tata McGraw- Hill Education Pvt Ltd,2012
3. T. Pradeep, *Nano: The Essentials*, Tata McGraw- Hill Education Pvt Ltd, 2007 Edition.
4. H.S.Nalwa, *Nanostructured materials and Nanotechnology* Academic Press, Sandiago,2000.
5. Charles P.Poole and frank J. Owens, *Introduction to Nanotechnology*,WileyInterscience 2003.
6. Barbara Karn, and Stanislaus S. Wong,*Ten Years of Green Nanotechnology. Sustainable Nanotechnology and the Environment:Advances and Achievements* ACS Symposium Series; 2013, Vol. 1124, Chapter 1, pp 1–10.

Learning Outcome:

On completion of this course the student will

- Gain knowledge on the use of Green Nanotechnology.
- Be able to synthesize Nanoparticles using Biological and Non Biological Methods.
- Be able to select specific Characterization technique for the research work.

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30

Section B: Answer any THREE questions (out of 5) 3 x 10 = 30

Section C: Answer any TWO questions (out of 4) 2 x 20 = 40

Total100

CH1M08 - Dendrimers – Nanoarchitecture and Photochemistry (75hours)

L earning Objectives

- To provide in-depth knowledge ondendrimers.
- To familiarize the students with the hyper branched polymers and their applications.
- To provide understanding of the characterization of dendrimers.
- To provide the knowledge on the important applications in biomedical field.

Unit – I **(15 hours)**

Dendrimers: General concepts – synthetic approaches – Divergent methods - 1→ 2 branching motifs, 1→ 3 branching motifs; Convergent methods - 1→ 2 and 1→ 3 branched.

Unit – II **(15 hours)**

Metallodendrimers: Introduction – Metal as branching centers – Metal as building block connectors – Metal as cores – Metals as Termination groups – Site specific inclusion – Random metal inclusion

Unit – III **(15 hours)**

Characterization of dendrimers/metallodendrimers:FTIR, NMR, Size exclusion chromatography, Gel Electrophoresis, Small-Angle Neutron Scattering (SANS),Transmission Electron Microscopy (TEM), Surface Electron Microscopy (SEM),MALDI-TOF mass spectrometry.

Unit –IV **(15 hours)**

Dendritic networks: Network formation and classification –ordered vs random – method of formation - Random connectivity –covalently linked dendrimer network – Ordered network- multilayer network – Directed network assembly.

Unit - V **(15 hours)**

Photophysicalandphotochemical properties of metallodendrimers/dendrimers:Applications in Chemical sensors –Electrochemical sensors –Biological sensors.

References

1. Newkome, G. R.; Moorefield, C. R.; Vögtle, F. *Dendrimers and Dendrons Concepts, Syntheses, Applications Dendrimers IV Metal Coordination, Self Assembly, Catalysis* Wiley, **2001.**
2. Fréchet, J. M. J; Tomalia, D. A. *Dendrimers and other Dendritic Polymers*, John Wiley & Sons Ltd, **2001.**
3. Gorman, C. *Metallodendrimers: Structural Diversity and Functional Behavior*, Adv. Mater. **1998**, 10, 295-309.
4. Klajnert, B.; Peng, L.; Cena, V. *Dendrimers in Biomedical Applications*, Royal Society of Chemistry, **2013.**
5. Zeng, F; Zimmerman, S. C. *Dendrimers in Supramolecular Chemistry: From Molecular Recognition to Self-Assembly*,Chem Rev., **1997**, 97, 1681–1712.
6. Franc.G,akkar, A, *Metallodendrimers: Photophysical properties related applications-Photochemistry and Photophysics of Polymer Materials*, Edited by N S. Allen (eds), John Wiley & Sons, Inc, **2010**.
7. Balzani, V.; Juris, A. Photochemistry and photophysics - concepts, research, applications-Wiley-VCHVerlagGmbH ,**2014.**
8. Manen, J. V. N.; Frank C.J.M., van Veggel,; Reinhoudt, D. N. *Non-Covalent Synthesis of Metallodendrimers* - Topics in Current Chemistry, 217, P122-163, Springer Verlag Berlin Heidelberg, **2001.**
9. Nummelin, S.; Skrifvars, M.; Rissanen K. *Dendrimers II Architecture, Nanostructure and SupramolecularChemistry*Vögtle, F eds. Topic in Chemistry, 210, **2000.**
10. Lakowicz, J. R. *Principles of Fluorescence Spectroscopy*, 3rd edition, Springer Publication, **2006**.

Learning Outcome

On completion of this course, the students will

- Gain in-depth knowledge in the dendrimers and related hyper branched polymers.
- Beableto design new dendrimers and characterize using different techniques.
- Be able to correlate the structure of dendrimers and its applications.

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30

Section B: Answer any THREE questions (out of 5) 3 x 10 = 30

Section C: Answer any TWO questions (out of 4) 2 x 20 = 40

Total 100

CH1M09: Applications of Fluorescence Spectroscopy in Chemistry and Biology

(75 hours)

Learning Objectives

- To provide in-depth knowledge in Fluorescence spectroscopy
- To learn various fundamental and advanced measurements in spectrofluorometer.
- To learn steady state and excited state properties of Ru(II)-polypyridine complexes and carbon dots.
- To learn applications of fluorescence techniques in chemistry and in biology.

Unit – I **(15 hours)**

Fluorescence: Introduction, Fluorophores, Carbon dots - Solvent Effects on Fluorescence, Quantum yield, Lifetime, Excited state processes -Localized excited state (LE), Internal Charge Transfer (ICT), Twisted Internal charge transfer (TICT), Excited-State Intramolecular Proton Transfer (ESIPT),Aggregation Induced Emission (AIE); Bimolecular Quenching – Static and Dynamic quenching – Stern Volmer equation – Benesi - Hilderbrand equation.

Unit – II **(15 hours)**

Instrumentation and measurements: Ideal spectrofluorometer – Source – Monochromators – Optical filters – Photomultiplier tubes – Corrected emission spectra –Corrected excitation spectra–Time correlated Single Photon Counting Technique (TCSPC)- Principles and instrumentation - Anisotropy .

Unit- III **(15 hours)**

Photochemistry and photophysics of polypyridineRu(II)-complexes and Carbon dots: Relationships between electrochemistry and photochemistry. Electron-Transfer Kinetics - Marcus Theory - Energy Transfer - Coulombic Mechanism - Exchange Mechanism - Role of Bridge ligands.

Unit – IV **(15 hours)**

Interconversion of light and chemical energy: Conversion of light into chemical energy – Chemiluminescence – Electrochemiluminescence – Light absorption sensitization (LAS) - Light emission Sensitization (LES).

Unit-V **(15 hours)**

Applications of Carbon dots and Ru(II)-polypyridine complexes: pH sensors - glucose sensors – metallo/non-metalloproteins sensors – Biosensors - Immunoassays – Bioimaging.

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Learning Outcome

On completion of this course, the students will

- Gain in-depth knowledge fundamentals in fluorescence spectroscopy.
- Be able to apply various techniques for the study of photophysics and photochemistry of molecules.
- Be able to use fluorescence spectroscopy techniques appropriately.

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30

Section B: Answer any THREE questions (out of 5) 3 x 10 = 30

Section C: Answer any TWO questions (out of 4) 2 x 20 = 40

Total100

CH1M10: Chemistry of Nano Metal Oxides

(75 hours)

Learning Objectives

- To correlate relationship between structure and property of a material.
- To understand how system behaves under nano scale.
- To explain the significance of defects in structure of a material.
- To alter the property of the material by adding impurities.

Unit 1: Introduction to Inorganic materials 15 hours

1.1 Importance of Inorganic solids in materials science research.

1.2 Crystal systems: Rock salt, Rutile and Anatase, Fluorite and Anti-fluorite, Zinc blend and Wurtzite, spinels and perovskites – Description and examples.

1.3 Imperfection in crystals: Point defects – Schottky, Frenkel, Metal excess and metal deficiency defects – Description with examples.

Unit 2: The nano scale 15 hours

2.1 Nanoscale: Fundamental concepts highlighting the effect of size on various properties of the materials.

2.2 Classification of nanoparticles: Metal, metal oxides and chalcogenides – pure, doped and composites – examples.

2.3 Chemical methods of synthesis of nanoparticles: Co-precipitation in aqueous medium, Sol-gel method, Hydrothermal method, sonochemical method, microwave method, Green method using plant extracts and micro-organisms – Principle and examples with reference to metal oxide synthesis.

Unit 3: Characterisation of metal oxides 15 hours

3.1 Structural analysis: Diffraction studies using X-rays – Bragg's law, phase identification, calculation of inter planar distance and size of the particles.

3.2 Morphology: Electron microscopy – Scanning and Transmission Electron Microscopy.

3.3 Elemental composition: X-ray photoelectron spectroscopy (XPS) and Energy Dispersive Spectroscopy (EDS).

3.4 Optical property: UV-Vis- DRS and PL spectroscopic techniques.

Unit 4: Structure property relationship 15 hours

4.1 Effect of defects on thermal and magnetic properties: Thermal properties – Heat capacity of solids and thermal conductivity of materials. Magnetic properties – Ferro- antiferro- and ferri- magnetic materials and super exchange interaction mechanism to explain the magnetic property of the materials.

4.2 Band gap and Photocatalysis: Origin of band gap and Band gap model for intrinsic and extrinsic semiconductors (donor and acceptor levels). Band gap engineering – Generation of additional levels in bandgap of metal oxide either by doping or as composites.Photocatalysis: Mechanism of photocatalytic activity of metal oxides with reference to water splitting and dye degradation.

Unit 5: Application of nano metal oxides 15 hours

5.1 Role of transition metal ions such as Cu(II), Fe(III), Ag(I) in photocatalytic properties.

5.2 Degradation of organic pollutants in presence of TiO_2 and ZnO doped with metals.

5.3 Biomedical applications of zinc oxide nanoparticles: Antibacterial and anticancer activity, Drug delivery and Bio-imaging.

References

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Learning Outcome

At the end of this course, student will be able to

- Correlate relationship between structure and property of a material.
- Explain how system behaves under nano scale.
- Describe the significance of defects in structure of a material.
- Tailor the property of the material by adding impurities

Question paper model for End of Semester Examination

Duration: 3 hours

Total marks: 100

Section A: Answer ALL questions 10 x 3 = 30

Section B: Answer any THREE questions (out of 5) 3 x 10 = 30

Section C: Answer any TWO questions (out of 4) 2 x 20 = 40

Total100