MANONMANIAM SUNDARANAR UNIVERISTY,
TIRUNELVELI-12

SYLLABUS

PG - COURSES – AFFILIATED COLLEGES

Course Structure for M. Sc. Chemistry
(Choice Based Credit System)
(with effect from the academic year 2023-2024 onwards)

Semester-IV				
Part	**Subject Status**	**Subject Title**	**Subject Code**	**Credit**
3	Core	COORDINATION CHEMISTRY-II		5
3	Core	PHYSICAL CHEMISTRY-II		5
3	Core	PROJECT WITH VIVA VOCE		6
3	Elective	CHEMISTRY OF NATURAL PRODUCTS/ POLYMER CHEMISTRY		4
3	SEC 3	SCIENTIFIC RESEARCH METHODOLOGY		2
3	Extension Activity	A REPORT SHOULD BE SUBMITTED AT THE END OF THE IV SEMESTER BY EACH STUDENT		1

Total Marks: 100 Internal Exam: 25 marks + External Exam: 75 marks

A. **Scheme for internal Assessment**:
Maximum marks for written test: **15 marks**
3 internal tests, each of **I hour** duration shall be conducted every semester.
To the average of the **best two** written examinations must be added the marks scored in. The **assignment** for 5 marks and Seminar for 5 marks

The break up for internal assessment shall be:
Written test- 15 marks; Assignment -5 marks; Seminar-5 Marks Total - 25 marks

B. Scheme of External Examination
3 hrs. examination at the end of the semester
A – Part : 1 mark question two - from each unit
B – Part : 5 marks question one - from each unit
C – Part : 8 marks question one - from each unit

- **Conversion of Marks into Grade Points and Letter Grades**

S.No.	Percentage of Marks	Letter Grade	Grade Point	Performance
1	90 - 100	O+	10	Outstanding
2	80 - 89	O	9	Excellent
3	70 - 79	A+	8	Very Good
4	60 - 69	A	7	Good
5	55 - 59	B+	6	Above Average
6	50 - 54	B	5	Pass
7	0 - 49	RA	-	ReAppear
8	Absent	AA	-	Absent

- **Cumulative Grade Point Average (CGPA)**

$$\mathbf{CGPA} = \frac{\mathbf{\Sigma\,(GP \times C)}}{\mathbf{\Sigma C}}$$

- **GP** = Grade point, **C** = Credit
- CGPA is calculated only for Part-III courses
- CGPA for a semester is awarded on cumulative basis

- **Classification**
  a) First Class with Distinction : CGPA $\geq$ 7.5*****
  b) First Class : CGPA $\geq$ 6.0
  c) Second Class : CGPA $\geq$ 5.0 and $<$ 6.0
  d) Third Class : CGPA $<$ 5.0

COORDINATION CHEMISTRY – II

Objectives of the course

- To recognize the fundamental concepts and structural aspects of organometallic compounds.
- To learn reactions of organometallic compounds and their catalytic behaviour.
- To identify or predict the structure of coordination compounds using spectroscopic tools.
- To understand the structure and bonding in coordination complexes.
- To evaluate the spectral characteristics of selected complexes.

UNIT-I: Chemistry of organometallic compounds: 18 and 16 electron rule; Structure and Bonding in Metal – olefin complexes (example: Ziese's salt), metal-acetylene and metal-allyl complexes; Metal-cyclopentadienyl complexes – Examples. Synthesis, Structure bonding and reaction of ferrocenes - structure and bonding of beryllocene-covalent versus ionic bonding of beryllocene ; Metal Carbonyl complexes: Structure, bonding modes - MO approach of M-CO bonding, π-acceptor nature of carbonyl group, synergistic effect (stabilization of lower oxidation states of metals); Carbonyl clusters: Low nuclearity and high nuclearity carbonyl clusters – Structures based on polyhedral skeleton electron pair theory or Wade's rule. Zintl ions.

UNIT-II: Reactions and catalysis of organometallic compounds: Agostic interaction - Oxidative addition, reductive elimination (α and β eliminations), migratory insertion reaction and metathesis reaction. Organometallic catalysis: Hydrogenation of olefins (Wilkinson's catalyst), hydroformylation of olefins using cobalt and rhodium catalysts (oxo process), oxidation of olefin (Wacker process), olefin isomerisation, water gas shift reaction, cyclooligomerisation of acetylenes using Reppe's catalysts and Monsonto's acetic acid process. Fischer Tropsch process and synthetic gasoline - Ziegler-Natta polymerization and mechanism of stereoregular polymer synthesis.
Hybrid Catalysis: Cluster compounds in catalysis - polymer-supported and phase-transfer catalysis-biphasic-systems.

UNIT-III: Inorganic spectroscopy -I: IR spectroscopy: Effect of coordination on the stretching frequency-sulphato, sulphito, aqua, nitro, thiocyanato, cyano, thiourea, Complexes; Determination of the structure of metal carbonyl Complexes.
NMR Spectroscopy: 1H, 19F and 31P – NMR – applications in structural problems based on number of signals, multiplicity, anisotropy (like H3PO3, H3PO2, [HNi(PPh3)4]+, SF4, TiF4, PF5, HPF2, H2PF3, PF3(NH2)2, P4S3, P4N4Cl6(NHC6H5)2, P3N3(CH3)2Cl4, NF3,NF2, NH3 – mer- and fac-

Rh(PPh3)3Cl3. B11 NMR of B3H8 -. Fluxional molecules (including organometallic compounds) and study of fluxionality by NMR technique - NMR of paramagnetic molecules - contact shifts. Evaluation of Rate constants - monitoring the course of reaction using NMR.

UNIT-IV: Inorganic spectroscopy-II: EPR spectroscopy: Hyperfine splitting– Factors affecting magnitude of g-values - Zero field splitting and Kramers' degeneracy - Application of EPR in the study of transition metal complexes based on number of signals, multiplicity, anisotropy [Cu(bpy)3]2+, [Cu(Phen)Cl2], [(NH3)5Co-O2-Co(NH3)5]5+ Co3(CO)9Se, Co3(CO)9Rh, [CoF6]4-, [CrF6]3-, VO(acac)2, [VO(H2O)6]2+, [Fe(CN)5NO]2−, [Ni(H2O]2+, and CuCl2.2H2O. (bis(salicylaldimine)copper(II),[(NH3)5Co-O2-Co(NH3)5]5+. Applications in predicting the covalent character of M-L bond and Jahn-Teller distortion in Cu(II) complexes. EPR spectroscopy of metallo biomolecules: copper and iron proteins.
Mossbauer spectroscopy – Mossbauer effect, Recoil energy, - Mossbauer active nuclei, Doppler shift, Isomer shift, quadrupole splitting and magnetic interactions. Applications of Mössbauer spectra to Fe and Sn compounds/complexes, Structural elucidation and bioinorganic application of iron-sulfur protein.

UNIT-V: Photoelectron Spectroscopy: Theory, Types, origin of fine structures - shapes of vibrational fine structures – adiabatic and vertical transitions, PES of homonuclear diatomic molecules (N2, O2) and heteronuclear diatomic molecules (CO, HCl) and polyatomic molecules (H2O, CO2, CH4, NH3). Koopman's theorem applications and limitations. Shake-up and Shake-off process.
Optical Rotatory Dispersion – Principle of CD, MCD and ORD; Δ and λ isomers in different Cobalt (III) complexes, Assignment of absolute configuration using CD and ORD techniques.

Recommended Text

1. JE Huheey, EA Keiter, RL Keiter and OK Medhi, Inorganic Chemistry – Principles of structure and reactivity, 4th Edition, Pearson Education Inc., 2006
2. GL Meissler and D ATarr, Inorganic Chemistry, 3rd Edition, Pearson Education Inc., 2008
3. D.Bannerjea, Co-ordination Chemistry, TATA Mcgraw Hill, 1993.
4. BD Gupta and A K Elias, Basic Organometallic Chemistry: Concepts, Syntheses and Applications, University Press, 2013.
5. F.A. Cotton, G. Wilkinson.; C. A. Murillo; M. Bochmann, Advanced Inorganic Chemistry, 6thed.; Wiley Inter-science: New York, 1988.
6. H.Kaur Spectroscopy, Pragati Prakashan,8th edition,2023.
7. B.P. Straughan and S. Walker, Spectroscopy, Chapman and Hall Ltd,1st edition 1976.
8. S.F.A. Kettle ,Physical inorganic chemistry A Coordination chemistry

approach, Springer-Verlag Berlin Heidelberg GmbH,1st edition 1996.
9. Asim K Das and Mahua Das, Fundamental concepts of inorganic chemistry,1st eBook edition, Volume 4, 5 & 7, CBS publishers and distributors PVT Ltd,2019.
10. Jagdamba Singh, Mrituanjay D Padey,Jaya Singh, Spectroscopy of Inorganic compounds, New age international publishers,1st edition ,2021.

Reference Books

1. Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals. 3rd ed. New York, NY: John Wiley, 2000.
2. P Gütlich, E Bill, A X Trautwein, Mossbauer Spectroscopy and Transition Metal Chemistry: Fundamentals and Applications, 1st edition, Springer- Verlag Berlin Heidelberg, 2011.
3. B.Douglas, D. McDaniel, J. Alexander, Concepts and Models of Inorganic Chemistry, John Wiley, 1994, 3rd edn.
4. K.F. Purcell, J. C. Kotz, Inorganic Chemistry; Saunders: Philadelphia, 1976.
5. R.S. Drago, PhysicaI Methods in Chemistry; Saunders: Philadelphia, 1977.
6. Ajai Kumar, Coordination chemistry, Aaryush Educations publications, 1st edition, 2014
7. S.K.Agarwal and Keemti Lal, Advanced inorganic chemistry, Pragati Prakashan Educational publication,5th edition,2016.
8. Kazuo Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds Part B: Applications in Coordination, Organometallic, and Bioinorganic Chemistry, A John Wiley & Sons, Inc., Publication,6t edition 2009.
9. R.V.Parish, NMR, NQR. ESR, Mossbauer spectroscopy of inorganic chemistry,Ellis harwood Ltd,1st edition 1990.
10. F.Albert Cotton, Progress in Inorganic chemistry, Interscience Publishers, 1st edition, 1968.

Website and e-learning source

1. https://archive.nptel.ac.in/courses/104/101/104101100/

PHYSICAL CHEMISTRY-II

Objectives of the course

- To understand the essential characteristics of wave functions and need for the quantum mechanics.
- To know the importance of quantum mechanical models of particle in a box, rigid rotor and harmonic oscillator.
- To apply the quantum mechanics to hydrogen and polyelectronic systems.
- To familiarize the symmetry in molecules and predict the point groups.
- To predict the vibrational modes, hybridization using he concepts of group theory.

UNIT-I: Wave particle duality, Uncertainty principle, Particle wave and Schrodinger wave equation, wave function, properties of wave function. Properties of wave function, Normalized, Orthogonal, orthonormal, Eigen values, Eigen functions, Hermitian properties of operators. Introduction to quantum mechanics-black body radiation, photoelectric effect, hydrogen spectrum. Need for quantum

mechanics, Postulates of Quantum Mechanics, Schrodinger wave equation, Time independent and time dependent

UNIT-II: Quantum models: Particle in a box-1D, two dimensional and three-dimensional, degeneracy, application to linear conjugated molecular system, free particles, ring systems. Harmonic Oscillatorwave equation and solution, anharmonicity, force constant and its significance. Rigid Rotor-wave equation and solution, calculation of rotational constants and bond length of diatomic molecules.

UNIT-III: Applications to Hydrogen and Poly electron atoms: Hydrogen atom and hydrogen like ions, Hamiltonian-wave equation and solutions, radial and angular functions, representation of radial distribution functions. Approximation methods – variation methods: trial wave function, variation integral and application to particle in 1D box. Perturbation method - first order applications. Hatrefock self-consistent field method, Hohenberg-Kohn theorem and Kohn-Sham equation, Helium atom-electron spin, Pauli exclusion principle and Slater determination.

UNIT-IV: Group theory: Groups, sub groups, symmetry elements, operations, classification-axial and non-axial. Dihedral point groups- Cn,Cnh, Dn, Dnh, Dnd, Tdand Oh. Matrix representation and classes of symmetry operations, reducible irreducible and direct product representation. The Great orthogonality theorem – irreducible representation and reduction formula, construction of character table for C2v, C2h, C3v and D2h point groups.

UNIT-V: Applications of quantum and group theory: Hydrogen Molecule-Molecular orbital theory and Heitler London (VB) treatment, Energy level diagram, Hydrogen molecule ion; Use of linear variation function and LCAO methods. Electronic conjugated system: Huckel method to Ethylene butadiene, cyclopropenyl, cyclo butadiene and Benzene. Applications of group theory to molecular vibrations, electronic spectra of ethylene.

Recommended Text

1. R.K. Prasad, Quantum Chemistry, New Age International Publishers, New Delhi, 2010, 4th revised edition.
2. F.A. Cotton, Chemical Applications of Group Theory, John Wiley & Sons, 2003, 2nd edition.
3. A.Vincent, Molecular Symmetry and Group Theory. A Programmed Introduction to Chemical Applications, John and Willy & Sons Ltd., 2013, 2nd Edition.
4. T.Engel & Philip Reid, Quantum Chemistry and Spectroscopy, Pearson, New Delhi, 2018, 4th edition.
5. G.K. Vemulapalli, Physical Chemistry, Prentice Hall of India Pvt. Ltd. 2001. 6. D.A. McQuarrie, Quantum Chemistry, Viva Books PW. Ltd, 2013, 2nd edition.

Reference Books

1. N.Levine, Quantum Chemistry, Allyn& Bacon Inc, 1983, 4th edition.
2. D.A. McQuarrie **and** J. D. Simon, Physical Chemistry, A Molecular Approach, Viva Books Pvt. Ltd, New Delhi, 2012.
3. R.P. Rastogi & V. K. Srivastava, An Introduction to Quantum Mechanics of Chemical Systems, Oxford & IBH Publishing Co., New Delhi, 1999.
4. R.L. Flurry. Jr, Symmetry Group Theory and Chemical applications, Prentice Hall. Inc, 1980
5. J.M. Hollas, Symmetry in Molecules, Chapman and Hall, London, 2011, Reprint.

Website and e-learning source

1. https://nptel.ac.in/courses/104101124
2. https://ipc.iisc.ac.in/~kls/teaching.html

CHEMISTRY OF NATURAL PRODUCTS

Objectives of the course

- To learn the basic concepts and biological importance of biomolecules and natural products.
- To understand the functions of alkaloids, terpenoids, annthocyanins, flavones and vitamins
- To elucidate the structure determination of biomolecules and natural products.
- To extract and construct the structure of new alkaloids and terpenoids from different methods.
- To understand the functions natural dyes

UNIT-I: Alkaloids: Introduction, occurrence, classification, isolation and functions of alkaloids. Classification, general methods of structural elucidation. Chemical methods of structure determination of Coniine, Piperine, Nicotine, Atropine, Quinine, Belladine, Cocaine, Heptaphylline, Papaverine and Morphine.

UNIT-II: Terpenoids: Introduction, occurrence, Isoprene rule, classification. General methods of determining structure. Structure determination of Camphor, Abietic acid, Cadinene, Squalene, Zingiberine. Carotenoids: Introduction, geometrical isomerism, Structure, functions and synthesis of β-carotene and vitamin-A.

UNIT-III: Anthocyanines and flavones: Anthocyanines: Introduction to anthocyanines. Structure and general methods of synthesis of anthocyanines. Cyanidine chloride: structure and determination.
Flavones: Biological importance of flavones. Structure and determination of flavone and flavonoids. Quercetin: Structure determination and importance.

UNIT-IV: Vitamins : Water soluble Vitamins - thiamine, riboflavin, niacin, pyridoxine, folic acid, ascorbic acid sources, structure, biochemical functions, deficiency diseases, daily requirements; **Fat soluble Vitamins** - vitamin A, vitamin D2, vitamin E and vitamin K - sources, structure, biochemical functions, deficiency diseases, daily requirements.

UNIT-V: Natural Dyes: Occurrence, classification, isolation, purification, properties, colour and constitution. Structural determination and synthesis of indigoitin and alizarin.

Recommended Text

1. G.K. Chatwal, Organic Chemistry on Natural Products, Vol. 1, Himalaya Publishing House, Mumbai, 2009.
2. G.K. Chatwal, Organic Chemistry on Natural Products, Vol. 2, Himalaya Publishing House, Mumbai,2009.
3. O.P. Agarwal, Chemistry of Organic Natural Products, Vol. 1, Goel Publishing House, Meerut,1997.
4. O.P. Agarwal, Chemistry of Organic Natural Products, Vol. 2, Goel Publishing House, Meerut,1997.
5. I.L. Finar, Organic Chemistry Vol-2, 5thedition,Pearson Education Asia, 1975.

Reference Books

1. I.L. Finar, Organic Chemistry Vol-1, 6thedition, Pearson Education Asia,2004.
2. Pelletier, Chemistry of Alkaloids, Van Nostrand Reinhold Co,2000.
3. Shoppe, Chemistry of the steroids, Butterworthes,1994.
4. I.A. Khan, and A. Khanum. Role of Biotechnology in medicinal & aromatic plants, Vol 1 and Vol 10, Ukkaz Publications, Hyderabad,2004.

Website and e-learning source

1. https://sites.google.com/site/chemistryebookscollection02/home/organicchemistry/organic

POLYMER CHEMISTRY

Objectives of the course

- To learn the basic concepts and bonding in polymers.
- To explain various types of polymerization reactions and kinetics.
- To understand the importance of industrial polymers and their synthetic uses.
- To determine the molecular weight of polymers.
- To predict the degradation of polymers and conductivities.

UNIT-I: Characterization, Molecular weight and its Determination: Primary and secondary bond forces in polymers; cohesiveenergy, molecular structure, chemical tests, thermal methods, Tg, molecular distribution, stability. Determination of Molecular mass of polymers: Number Average molecular mass (Mn)and Weight average molecular mass (Mw) of polymers. Molecular weight determination of high polymers by physical and methods.

UNIT-II: Mechanism and kinetics of Polymerization: Chain growth polymerization: Cationic, anionic, free radical polymerization, Stereo regular polymers: Ziegler Natta polymerization. Reaction kinetics. Step growth polymerization, Degree of polymerization.

UNIT-III: Techniques of Polymerization and Polymer Degradation: Bulk, Solution, Emulsion, Suspension, solid, interfacial and gas phase polymerization. Types of Polymer Degradation, Thermal degradation, mechanical degradation, photodegradation, Photostabilizers, Solid and gas phase polymerization.

UNIT-IV: Industrial Polymers: Preparation and Properties of fibre forming polymers, elastomeric material. Thermoplastics: Polyethylene, polystyrene, Polyacrylonitrile, Polyvinyl Chloride, Poly tetrafluoro ethylene, nylon and polyester. Thermosetting Plastics: Phenol formaldehyde epoxide resin. Elastomers: Natural rubber and synthetic rubber - Buna - N, Buna-S and neoprene. Conducting Polymers: Elementary ideas, polymeric sulphur nitriles and polyacetylene. Polymethyl methacrylate, polyimides, polyamides, polyurethanes, polyurea, and polyethylene

UNIT-V: Polymer Processing: Compounding: Polymer Additives: Fillers, Plasticizers, antioxidants, thermal stabilizers, fire retardants and colourants. Processing Techniques: Calendaring, die casting, compression moulding, injection moulding, blow moulding and reinforcing. Film casting, Foaming, Thermofoaming. Catalysis and catalysts: Polymerization catalysis, catalyst support, clay compounds, basic catalyst, auto-exhaust catalysis, vanadium, heterogeneous catalysis.

Recommended Text

2. V.R. Gowariker, Polymer Science, Wiley Eastern,1995.
3. G.S. Misra, Introductory Polymer Chemistry, New Age International (Pvt) Limited,1996.
4. M.S. Bhatnagar, A Text Book of Polymers, vol-I & II, S.Chand& Company, New Delhi, 2004.

Reference Books

1. F.N. Billmeyer, Textbook of Polymer Science, Wiley Interscience,1971.
2. A.Kumar and S. K. Gupta, Fundamentals and Polymer Science and Engineering, Tata McGraw-Hill,1978.

Website and e-learning source

1. https://archive.nptel.ac.in/courses/104/105/104105039/
2. https://archive.nptel.ac.in/courses/113/105/113105077/

SCIENTIFIC RESEARCH METHODOLOGY

Objectives of the course

- To choose scientific research problems.
- To enable student to comprehend the survey for literature and chemical abstract.
- To teach how to publish scientific writing of research papers, presentations and research proposal .
- To learn Plagiarism and Intellectual Property Rights.
- To introduce the basic principles, working and applications of Instrumental techniques like Surface Probe Microscopy.

UNIT I : TO SCIENTIFIC RESEARCH:

Objectives of research – Types of research – Significance of research. Research methods versus methodology – Research and scientific method – Criteria of good research – Problems encountered by researchers in India. Problem selection – Selection of research problem, sources of research problems, criteria/characteristics of a good research problem, errors in selecting a research problem -project proposal – funding agencies.

UNIT II: LITERATURE SURVEY:

Sources of information, Primary, Secondary, Tertiary sources, Journals, Journal abbreviations, Abstracts – Beilstein - Compendia and tables of information – Reviews –Current titles – Textbooks – Current contents - General treatises – Monographs and

treatises on specific areas - Literature search – Information about a specific compound – Science citation index – Box to locate journals. Introduction to Chemical Abstracts. Online searching, Database, Scifinder, Scopus, Citation Index, Impact Factor.

UNIT III : WRITING OF RESEARCH REPORT:

Format of the research report- style of writing the report- references and bibliography. Research paper writing: Types of research papers – Structure of research papers – Research paper formats - Different formats for referencing – ways of communicating research paper – organizing a poster display, giving an oral presentation in seminars/conferences – Making effective presentations using Power Point and Beamer. Research Proposal: Format of research proposal, individual research proposal and institutional proposal.

UNIT IV: PLAGIARISM AND INTELLECTUAL PROPERTY RIGHTS:

Plagiarism - Introduction, Reason for plagiarism, Types of plagiarism – Plagiarism of words, Patchwork plagiarism, Self-plagiarism, Cyber and Digital plagiarism, Accidental plagiarism, Plagiarism of Authorship, Plagiarism of Ideas. Plagiarism policies - IEEE, Springer, Elsevier. Software used for identifying plagiarism. Techniques to avoid plagiarism - Referencing, Paraphrasing. Significance of Intellectual Property Rights. Forms of IPR - Patents, Copyright, Trademarks, Collective marks, Industrial Design. Valuation of IPR, IPR and licensing.

UNIT V: ADVANCED INSTRUMENTAL TECHNIQUES:

Principles, techniques and applications: Surface probe microscopy: Atomic force microscopy, Scanning tunnelling microscopy, Scanning electron microscopy, Transmission electron microscopy, HRTEM, Energy Dispersive X-ray analysis (EDX), X-ray photo electron spectroscopy. X-ray diffraction techniques - Powder and single crystal XRD, principle, techniques and applications.

Recommended Text:

1. Dr.C.R. Kothari, Research Methodology: Methods and Techniques, New Age International Publishers, 2 nd Edition, New Delhi. 2014.
2. Ranjit kumar, Research Methodology: A Step by Step Guide for Beginners, Pearson Education; 2 nd Edition, 2005.
3. Tanmoy Chakraborty and Lalita Ledwani, Research Methodology in Chemical Sciences: Experimental and Theoretical Approach, Apple Academic Press; 1 st Edition, 2016.
4. Dr. N. Arumugam, Research Methodology, Saras Publication, First Edition, 2016.
5. Vinayak Bairagi and Mousami V. Munot, Research Methodology - A Practical

and Scientific approach, CRC Press, 2019.
6. R.Gopalan, P. S. Subramanian and K. Rengarajan, Elements of Analytical Chemistry, Sultan Chand and Sons, New Delhi, 2005.
7. S.M. Khopkar, Basic concepts of analytical chemistry, New age international, third edition 2008.
8. Douglas A. Skoog, Donald M. West, F. James Holler and Stanley R. Crouch, Fundamentals of Analytical Chemistry, ninth edition, 2013.
9. Gary D. Christian, Purnendu K. Dasgupta and Kevin A. Schug, Analytical Chemistry, John Wiley & Sons, seventh edition, 2013.
10. G.R. Chatwal and S.K. Anand, Instrumental Method of Chemical Analysis, Himalaya Publishing house, fifth Reprint, 2016.

Text Books

1. A.Joseph, Methodology for Research; Theological Publications, Bangalore, 1986.
2. B.E. Cain, The Basis of Technical Communicating, ACS., Washington, D.C., 1988.

Reference Books:

1. M.D. Barbara Gastel and Robert A. Day, How to Write and Publish a Scientific Paper, Greenwood Publishing Group Inc, 8 th Edition, 2016.
2. R. Gopalan, Thesis writing, Vijay Nicole Imprints Private Ltd., 2005.
3. D.G Peters, J.M. Hayes and G.M. Hefige, A brief introduction to Modern chemical analysis, Saunders, 1976.
4. R.A Day and A.L. Underwood, Quantitative analysis, Prentice Hall, 1999.
5. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5 th Edition, Bangalore, 2005.
6. Anthony R. West, Solid state chemistry and its applications, second edition, Aberdeen, March 1994.
7. R. L. Dominoswki, Research Methods, Prentice Hall of India, New Delhi, 1981.
8. Fink, A. Conducting Research Literature reviews: From the internet to the Paper. Sage 2009.

Website and e-learning source

1. https://pubs.acs.org
2. https://link.springer.com
3. https://www.cas.org
4. https://www.chemmethod.com
5. https://science-education-research.com