THE UNIVERSITY OF BURDWAN

SYLLABUS FOR 3-YEAR DEGREE/ 4-YEAR HONS.

IN

CHEMISTRY

Under

Curriculum and Credit Framework for Undergraduate Program (CCFUP), as per N.E.P. 2020

w.e.f 2023 – ’24

Semester wise and Course wise Distribution of Credit & Marks under CCFUP as per NEP, 2020

SEMESTER	Course Type	Code	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
VII	Major/Core Course	CHEM 7011	Inorganic General	6	6 – 0 – 0	75	60 – 00 – 15
	Major/Core Course	CHEM 7012	Nuclear-Analytical General	6	4 – 0 – 2	75	40 – 20 – 15
	Major/Core Course	CHEM 7013	Organic General	6	4 – 0 – 2	75	40 – 20 – 15
	Major/Core Course	CHEM 7014	Physical General	6	4 – 0 – 2	75	40 – 20 – 15
	Minor Course	CHEM 7021	Industrial Chemistry	4	3 – 1 – 0	75	60 – 00 – 15
	Total			**28**		**375**	
VIII Hons. With Research Project/ Dissertation	Major/Core Course	CHEM 8011	Research Methodology	6	6 – 0 – 0	75	40 – 20 – 15
	Minor Course	CHEM 8021	Medicinal Chemistry	4	3 – 1 – 0	75	60 – 00 – 15
	Research Project/ Dissertation	CHEM 8091		12	0 – 0 – 12	225	Seminar Presentation, Preparation & Submission of Research Project/Dissertation-135 + Viva-90
	Total			**22**		**375**	

OR

VIII Hons.	Major/Core Course	CHEM 8011	Research Methodology	6	6 – 0 – 0	75	60 – 00 – 15
	Major/Core Course	CHEM 8012	Inorganic & Nuclear Analytical General	4	4 – 0 – 0	75	60 – 00 – 15
	Major/Core Course	CHEM 8013	Physical & Organic General	4	4 – 0 – 0	75	60 – 00 – 15
	Major/Core Course	CHEM 8014	Practical General	4	0 – 0 – 4	75	00 – 60 – 15
	Minor Course	CHEM 8021	Medicinal Chemistry	4	3 – 1 – 0	75	60– 00– 15
	Total			**22**		**375**	
	Grand total (Sem. I -VIII)			**178**		**3075**	

D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, Fundamentals of analytical chemistry 9/E, Brooks/Cole Pub Co. (2003).

G. D. Christian, Analytical chemistry 6/E, Wiley India (1999).

A. K. Srivastava and P. C. Jain, Chemical Analysis: An Instrumental Approach, S. Chand & Co. (2000).

W. Kemp, Organic spectroscopy 3/E, Palgrave Macmillan (2008)

John R. Dyer, Applications of absorption spectroscopy of organic compounds, PHI learning Pvt. Ltd., New Delhi (1969).

R. M. Silverstein, F. X. Webster and D. L. Bryce, Spectrometric indentifcation of organic compounds 8/E, John Wiley & Sons Inc. (2014).

D. L. Pavia, D.L., Lampman, G.M., Kriz, G.S. and Vyvyan, J.R., Infrared Spectroscopy. In: Introduction to Spectroscopy, Cengage Learning, Washington DC, (2009).

R. K. Das, Industrial chemistry, Asia Publishing House (1967).

S.M. Rao, A.B. Majali, R.G. Deshpande, T.S. Murthy (eds.), Industrial Applications of Radioisotopes and Radiation. A record of the contributions at the International Conference on Applications of Radioisotopes and Radiation in Industrial Development (March 1-3, 1984 Bombay, India), John Wiley & Sons Inc. (1986).

SEMESTER VIII

(Hons. with Research Project/ Dissertation)

Chemistry Major/Core Course

Paper Code: **CHEM 8011**

Paper Title: **Research Methodology**

Credit: 6

Course Objective:

The objective is to impart into the students the theoretical idea and understanding on research and its methodology particularly of reviewing and surveying literature, writing research report with required format; testing of hypotheses and sampling for analysis and quantification research outputs, etc.

Course outcome:

After completion of the course the students will be able to

(i) describe important ideas, concepts, and research styles, such as mixed, qualitative, and quantitative approaches

(ii) create testable hypotheses or research questions, outline research challenges, and identify research gaps

(iii) create a well-thought-out research plan that includes sampling strategies, data gathering procedures, and the right instruments for data processing

(iv) use citing tools correctly, synthesize current research findings, and critically evaluate academic literature

(v) plan and carry out investigations involving human or animal subjects by applying ethical principles and comprehending the ethical issues in research

(vi) evaluate data and interpret the findings in a meaningful way by using fundamental statistical or thematic analysis approaches

(vii) compose well-organized research papers or reports and explain their findings either orally or visually. Students will gain the capacity to evaluate research papers and procedures critically for validity, reliability, and limitations.

Theory **Credit: 6**

Introduction to Research Methodology

Meaning of Research, Objectives of Research, Motivations in Research, Types of Research, Criteria of good Research, What is Research Problem? Basic and Applied research

Review of Literature and Literature survey

Meaning and Purpose of the Literature Review & Literature Survey, Identification of the related Literature.

The Research Report

General format of the Research report, style and formatting of writing, typing of the research report.

Testing of Hypotheses and Sampling design

Definition, Concepts Concerning Testing of Hypotheses, Formulation of hypotheses and related difficulties; Needs of sampling, Sampling for chemical analysis, Random sampling

Quantification of research output

Impact Factor, *h*-index, *i10*-index and *i20*-index, G-index

Recommended books

C R Kothari, Research Methodology: Methods and Techniques, New Age International (P)Ltd. (2010), New Delhi

Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. *An introduction toResearch Methodology*, RBSA Publishers.

Handbook of Communication and Social Interaction Skills by John O. Greene, Brant Raney Burleson.

W.M.K.Trochim, 2005. *Research Methods: the concise knowledge base*, AtomicDog Publishing. 270p.

Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications

Inderpal Singh, Research Methodology and Statistical Methods, Kalyani Publishers, Ludhiana.

G Kanji, 100 statistical tests, Sage Publications.

R.A. Day (1992) How to write and publish a scientific paper. Cambridge Universitypress.London.

Chemistry Minor Course

Paper Code: **CHEM 8021**
Paper Title: **Medicinal Chemistry**

Credit: 6

Course Objective:

The objective is to impart into the students the theoretical idea and understanding on supramolecular photochemistry, medicinal chemistry and drug discovery, radiopharmaceuticals, medicinal inorganic chemistry, pharmacokinetics, photodynamic medicine, and drug targets and drug delivery, etc.

Course outcome:

On completion of the course the students will be able to:

- Comprehend the applicability of supramolecular chemistry in photodynamic therapy as well as in medicinal prospect.
- Acquire idea and understanding on antibacterial, anticancer, antitussive, antiviral agents and structure-activity relationships (SARs).
- Understand the specific radiopharmaceuticals for diagnostic and therapeutic purposes, principle and instrumentation of gamma/PET camera for detection, methods (SPECT, PET, 18FDG etc.)of administration of radionuclides (nuclear medicines).
- Characterize biomolecules in the discovery and development of newer generation anti-tumourand anti-cancer agents
- Get hold of the ideas about drug absorption, drug distribution, drug metabolism, drug excretion, drug administration and drug dosing, etc.
- Grasp basic principle of photodynamic therapy and photochemotherapy and photodynamic medicine with their mode of action, etc.

Theory **Credit: 6**

Supramolecular Photochemistry

Mechanism of energy and/ electron transfer process(es), various supramolecular devices: electronic, ionic and switching devices, application of supramolecular chemistry in photodynamic therapy, some examples of self-assembly in supramolecular chemistry with prospect in medicinal applications

Medicinal Chemistry and Drug Discovery

Antibacterial, Anticancer, Antitussive, and Antiviral agents; Opium analgesics, Antibiotics, New drugs from old poisons; Drug discovery, Structure-Activity Relationships (SARs)

Radiopharmaceuticals

Nuclear pharmacy: concept, pharmaceuticals and radiopharmaceuticals; type of radionuclides, neutral/charged particle emitters, radionuclide generators; ideal radiopharmaceuticals, methods of radiolabeling,

biodistribution, specific radiopharmaceuticals for diagnostic and therapeutic purposes, SPECT, PET, 18FDG etc. method of administration, principle and instrumentation of gamma/PET camera for detection, quality control, Principle, method and application of radioimmuassay(RIA)

Medicinal Inorganic Chemistry

Biomedical significance and inorganic chemistry, Characterization of biomolecules using spectroscopic methods, mechanistic aspects of heavy metal toxicity, platinum anti-cancer drugs (from laboratory to clinic), discovery and development of newer generation anti-tumour and anti-cancer agents

Pharmacokinetics

Drug absorption, drug distribution, drug metabolism, drug excretion, drug administration, drug dosing

Photodynamic medicine

Introduction, early days of photodynamic therapy (PDT), basic principle, photodynamic action, photochemotherapy, photosensitizing molecule, incubation period, light activation, light exposure, total light dose and its fluence rate**,** application of photosensitizer drug

Drug Targets and Drug Delivery

Enzymes, receptors, carrier proteins, structural proteins, nucleic acids, lipids, carbohydrate, targeted drug delivery, novel delivery modalities, Future considerations

Recommended books

Radiopharmaceutical Chemistry, by Jason S. Lewis, Albert D. Windhorst, Brian M. Zeglis, Springer, 2019

Photodynamic Therapy: Basic Principles and Clinical Applications 1st Edition, by B.W. Henderson and T.J. Daugherty, ISBN-13: 978-0824786809, CRC Press; 1 edition (June 19, 1992)

Radiopharmaceuticals for Therapy, by Ashutosh Dash and F. F. (Russ) Knapp, 2016, Springer

The Handbook of Radiopharmaceuticals, by Azuwuike Owunwanne, Mohan Patel and Samy Sadek, Chapman & Hall Medical, 1st Edition, 1995

Handbook of Radiopharmaceuticals: Radiochemistry and Applications, By M.J. Welch and C.S. Redvanly, Wiley, 2005

An Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford (International Student Edition)

Medicinal Inorganic Chemistry, Edited by J.L. Sessler, s.R. Doctrow, T.J. Mcmurry and S.J. Lippard, Americn Chemical Society, Washington, DC

(Instant Notes) Medicinal Chemistry, G. Patrick, Viva Books Pvt. Ltd.

Medicinal Chemistry, Principles and Practice, edited byF.D. King, Royal Society of Chemistry

The practice of Medicinal Chemistry, Edited by C.G. Wermuth, Academic Press

Medicinal Chemistry, D. Sriram & P. Yogeeswari, Pearson

Paper Code: **CHEM 8091**
Paper Title: **Research Project/ Dissertation**

Credit: 12

Course Objective:
The objective is to impart into the students a research oriented logical mind such that they can choose research problem(s) on their own and develop required theoretical methods/theory and/or design experiment with necessary instrumental set up and thereby to achieve the goal (solution).

Course outcome:

On completion of the course the students will be able to:

- Search literatures and choose scientific problems
- Use required tools with necessary modifications/extensions/ for arriving solving solutions
- Design experiment with necessary as per the research problem(s)
- Set up instrument as per experimental requirement
- Analyze and interpret the outcomes of theory/experiments and come to the final conclusions
- Write research papers/articles
- Present and defend the work at the seminar

SEMESTER –VIII (OR)

(Hons.)

Chemistry Major/Core Course

Paper Code: **CHEM 8011**
Paper Title: **Research Methodology**

Credit: 6

Course Objective:
The objective is to impart into the students the theoretical idea and understanding on supramolecular photochemistry, medicinal chemistry and drug discovery, radiopharmaceuticals, medicinal inorganic chemistry, pharmacokinetics, photodynamic medicine, and drug targets and drug delivery, etc.

Course outcome:

On completion of the course the students will be able to:

- Comprehend the applicability of supramolecular chemistry in photodynamic therapy as well as in medicinal prospect.
- Acquire idea and understanding on antibacterial, anticancer, antitussive, antiviral agents and structure-

activity relationships (SARs).

- Understand the specific radiopharmaceuticals for diagnostic and therapeutic purposes, principle and instrumentation of gamma/PET camera for detection, methods (SPECT, PET, 18FDG etc.)of administration of radionuclides (nuclear medicines).
- Characterize biomolecules in the discovery and development of newer generation anti-tumourand anti-cancer agents
- Get hold of the ideas about drug absorption, drug distribution, drug metabolism, drug excretion, drug administration and drug dosing, etc.
- Grasp basic principle of photodynamic therapy and photochemotherapy and photodynamic medicine with their mode of action, etc.

Theory **Credit: 6**

Introduction to Research Methodology

Meaning of Research, Objectives of Research, Motivations in Research, Types of Research, Criteria of good Research, What is Research Problem? Basic and Applied research

Review of Literature and Literature survey

Meaning and Purpose of the Literature Review & Literature Survey, Identification of the related Literature.

The Research Report

General format of the Research report, style and formatting of writing, typing of the research report.

Testing of Hypotheses and Sampling design

Definition, Concepts Concerning Testing of Hypotheses, Formulation of hypotheses and related difficulties; Needs of sampling, Sampling for chemical analysis, Random sampling

Quantification of research output

Impact Factor, *h*-index, *i10*-index and *i20*-index, G-index

Recommended books

C R Kothari, Research Methodology: Methods and Techniques, New Age International (P)Ltd. (2010), New Delhi

Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. *An introduction toResearch Methodology*, RBSA Publishers.

Handbook of Communication and Social Interaction Skills by John O. Greene, Brant Raney Burleson.

W.M.K.Trochim, 2005. *Research Methods: the concise knowledge base*, AtomicDog Publishing. 270p.

Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications
Inderpal Singh, Research Methodology and Statistical Methods, Kalyani Publishers, Ludhiana.
G Kanji, 100 statistical tests, Sage Publications.
R.A. Day (1992) How to write and publish a scientific paper. Cambridge Universitypress.London.

Paper Code: **CHEM 8012**
Paper Title: **Inorganic and Nuclear Analytical General**

Credit: 4

Course Objective:

The objective is to impart into the students the theoretical idea and understanding on cluster compounds, metal-ion promoted reactions, nuclear properties and structure, synthetic elements, circular dichroism (CD) and hetero-NMR spectroscopy, and electroanalytical methods

Course outcome:

On completion of the course the students will be able to:

- Acquire knowledge on cluster compounds and to explain structure-property, electron counts and surface analogies of cluster compounds
- Learn and understand several metal ion promoted reactions with their applications
- Acquire knowledge and understanding on some nuclear models for calculating semi-empirical binding energy, Q-values and cross section of nuclear reaction, fission probability, nuclear magic number, spin, etc.
- Understand the theoretical background for the synthesis and separation of man-made radio isotopes as well elements
- Have preliminary idea and understanding on CD and hetero-NMR spectroscopy
- Learn the electroanalytical methods and there applicability in reversibility test, current-voltage diagram, DC and AC polarography, stripping voltammetry, amperometric titrations.

Theory **Credit: 4**

Unit I

Cluster compounds

Clusters in elemental states, cluster classification, skeletal electron (Elm) counting, higher boron hydrides-structures and reactions, equation of balance, Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT), carboranes, metalloboranes and heteroboranes, metallocarboranes, zintl ions, chevrel compounds, infinite metal chains, multidecker molecules, cluster-surface analogy.

Metal-ion promoted reactions

Fundamentals, simple cycle, catalytic cycle, pliancy of substrates, Tolman catalytic loop, homogeneous/heterogeneous catalysis: Wacker-Smidt synthesis, Monsanto acetic acid process, hydrogenation by Wilkinson's catalyst, water gas shift reaction (WGSR), Fischer-Tropsch synthesis, hydrosilation, hydrophosphilynation, hydroamination, hydrocyanation and hydroboration reactions

Unit II

Nuclear properties and structure II

Nuclear angular momentum, magnetic dipole moment and electronic quadruple moment, parity of nuclear energy states; shell model, nuclear magic number and its derivation from nuclear potential well, calculation of nuclear spin, nuclear isomerism and non-optical transitions

8 Hours

Synthetic elements

Man-made elements: theoretical background, production and separation with special reference to actinoids and super heavy elements, separation chemistry

6 Hours

Preliminary CD and hetero-NMR spectroscopy

Instrumentation, presentation of spectra, Applications of heteronuclear NMR spectroscopy; ^{11}B, ^{14}N, ^{17}O, ^{19}F and ^{31}P-NMR, ^{195}Pt. CD/ORD: molecular dissymmetry and chiroptical properties, Cotton effect, magnetic circular dichroism (MCD), vibrational circular dichroism(VCD)

6 Hours

Electroanalytical methods I

Electrochemical cell, electrodes: reference and indicator electrodes, membrane electrodes, electrode-solution interface layer, gas-sensing probe, electrolytic process, three electrode system; supporting electrolyte, DME; Cottrell equation, Ilkovic equation, Ilkovic-Heyrolsky equation, test of reversibility, current-voltage diagram, DC and AC polarography, stripping voltammetry, amperometric titration

10 Hours

Recommended books

J. D. Lee, *Concise Inorganic Chemistry*, Chapman and Hall, London, 1991.

G. Wulfsberg, *Principles of Descriptive Inorganic Chemistry*, University Science Books, Mill Valley, CA, 1991.

A. F. Holleman and E. Wifrg, *Inorganic Chemistry*, Academic Press, New York, 1995.

N. N. Greenwood and A. Earnshaw, *Chemistry of the Elements*, 2nd Edn, Pergamon, New York, 1997.

F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, *Advanced Inorganic Chemistry*, 6th Edn, John Wiley & Sons, Inc, New York, 1999.

G. Wulfsberg, *Inorganic Chemistry*, Viva Books Pvt Ltd, New Delhi, 2001.

B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn, John Wiley & Sons, Inc, New York, 2001.

P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver & Atkins Inorganic Chemistry,* 4th Edn, Oxford, 2006.

J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorgnic Chemistry: Principles of Structures and Reactivity,* 4th Edn, Pearson, New Delhi, 2006.

R. Xu, W. Pang and Q. Huo (Eds), *Modern Inorganic Synthetic Chemistry*, Elsevier, New York, 2011.

J. Crowe, T. Bradshaw and P. Monk, *Chemistry of Biosciences,* Oxford University Press, Oxford, 2006.

G. L. Miessler and D. A. Tarr, *Inorganic Chemistry*, 3rd Edn, Pearson, New Delhi, 2009.

J. R. Anderson and M. Boudart (Eds), *Catalysis: Science and Technology,* Springer, London, 2012.

G. Cao, *Nanostructures & Nanomaterials, Synthesis, Properties & Applications*, Imperial College Press, London, 2004.

L. Cademartiri and G. A. Ozin, *Concepts of Nanochemistry*, Wiley-VCH, Weinheim, 2009.

D. L. Kepert, *Inorganic Stereochemistry*, Springer, Berlin, 1982.

A. von Zelewsky, *Stereochemistry of Coordination Compounds*, Wiley, New York, 1996.

S. P. Sinha, *Systematics and Properties of Lanthanides*, Riedel, Dordrecht, 1983.

J. J. Katz, G. T. Seaborg and L. R. Morss (Eds), *The Chemistry of the Actinide Elements*, Vols I and II, 2nd Edn, Chapman and Hall, London, 1986.

G. B. Richter-Addo and P. L. Legzdins, *Metal Nitrosyls*, Oxford University Press, New York, 1992.

F. A. Cotton and R. A. Walton, *Multiple Bonds Between Metal Atoms*, 2nd Edn, Clarendon Press, Oxford, UK, 1993.

G. A. Jefferey and W. Saenger, *Hydrogen Bonding in Biological Structures*, Springer, Berlin, 1991.

A. J. Stone, *The Theory of Intermolecular Forces*, Clarendon Press, Oxford, 1996.

G. A. Jeffrey, *An Introduction to Hydrogen Bonding*, Oxford University Press, Oxford, 1997.

J. W. Steed and J. L. Atwood, *Supramolecular Chemistry*, 2nd Edn, John Wiley and Sons, New York, 2009.

P. Powell, *Principles of Organometallic Chemistry*, 2nd Edn, Chapman and Hall, London, 1988.

R. A. van Santen and M. Neurock*Molecular Heterogenous Catalysis,* Wiley-VCH, Weinheim, 2006.

G. O. Spessard and G. L. Miessler, *Organometallic Chemistry*, International 2nd Edn, Oxford University Press, Oxford, 2010.

I. Pelant and J. Valenta, *Luminescence Spectroscopy of Semiconductors, Oxford,* New York, 2012.

D. M. P. Mingos and D. J. Wales, *Introduction to Cluster Chemistry*, Prentice Hall, New York, 1990.

D. F. Shriver, H. D. Kaesz and R. D. Adams (Eds), *The Chemistry of Metal Cluster Complexes*, VCH, New York, 1990.

C. E. Housecroft, *Cluster Molecules of the p-Block Elements,* Oxford University Press, Cambridge, 1994.

K. J. Klabunde, *Free Atoms, Clusters and Nanoscale Particles*, Academic Press, New York, 1994.

D. M. P. Mingos (Ed.), *Structural and Electronic Paradigms in Cluster Chemistry*, Springer, Berlin, 1997.

P. Braunstein, L. A. Oro and P. R. Raithby (Eds), *Metal Clusters in Chemistry*, Wiley-VCH, Weinheim, 1999.
M. Driess and H. Noth (Eds), *Molecular Clusters of the Main Group Elements,* Wiley-VCH, Weinheim, 2004.
T. P. Fehlner, J. -F. Halet and J. -Y. Saillard, *Molecular Clusters - A Bridge to Solid State Chemistry*, Cambridge University Press, Cambridge, 2007.
C. E. Housecraft and A. G. Sharpe, *Inorganic Chemistry*, 3rd Edn, Pearson Education Ltd, Essex, England, 2008.
G. W. Parshall, *Homogeneous Catalysis*, Wiley, New York, 1980.
C. N. Satterfield, *Heterogeneous Catalysis in Practice*, McGraw-Hill, New York, 1980.
O. N. Temkin, *Homogeneous Catalysis with Metal Complexes: Kinetic Aspects and Mechanisms*, John Wiley & Sons, New York, 2012.
M. Beller, A. Renken and R. A. van Santen, *Catalysis,* Wiley, New York, 2012.

R. D. Evans, The Atomic Nucleus, McGraw-Hill, New York, 1979.

G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller, Nuclear and Radiochemistry, 3rd Edn, Jhon Wiley & Sons Inc., New York, 1981.

H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Edn Reprint, New Age International (P) Ltd Publications, New Delhi, 2001.

D. D. Sood, A.V. R Reddy and N. Ramamoorty, Fundumentals of Radiochemistry, Yancas, Mumbai, 2004.

G. R. Choppin, J. O. Liljenjin and J. Rydberg, Radiochemistry and Nuclear Chemistry, Butterworth-Heinmann, Woburu, 2002.

D. G. Peters, J. M. Hayes and G. M. Hieftje, Chemical Separations and Measurements: Theory and Practice of AnalyticalChemistry, Saunders, Wiley Interscience, New York, 1974.

D. A. Skoog, D. M. West and F. J. Holley, Fundamentals in Analytical Chemistry, 5th Edn, Saunders, Philadelphia, 1988.

S. M. Khopkar, Basic Concepts of Analytical Chemistry, Wiley Eastern Ltd., New Delhi, 1998.

D. R. Crow, Polarography of Metal Complexes, Academic Press, London, 1979.
A. J. Bard and L. F. Faulkner, Electrochemical Methods–Fundamentals and Applications, 2nd Edn, Wiley, New York, 1998.

Paper Code: **CHEM 8013**
Paper Title: **Physical and Organic General**

Credit: 4

Course Objective:

The objective is to impart into the students the theoretical idea and understanding on atomic spectra, molecular spectroscopy with its principles, crystal structure, principle and practices in nanotechnology, reaction intermediates, carbohydrate chemistry, and spectroscopy used in organic chemistry.

Course outcome:

On completion of the course the students will be able to:

- Get hold the ideas of origin of atomic spectra, interpret Zeeman and Paschenback effects, Stern- Gerlach experiment, and calculate atomic energy terms and term symbols
- Recollect the idea of molecular spectra of different kinds, explain quantum mechanically their origin, selection rules, effect of several factors on them, and associated effects therein
- Learn and apply molecular spectroscopy in elucidating structures and properties of molecular systems.
- Understand the symmetry operations and the space groups of crystals, realize the electron density and structure factor relationship and hence the band theory that predicts the conducting behaviors of crystals
- Acquire knowledge about the generation, detection, stabilities and reactivities of different organic intermediates
- Learn and understand the structures, synthesis and reactions of carbohydrates and their fragments
- Get hold of the ideas of the ^{1}H NMR and mass spectroscopy and thereby use these tools for identification of different organic compounds, ions, radicals as well as in explaining the structure properties of such species along with the effects of environment on them

Theory **Credit: 4**

Unit I

Atomic spectra

Elliptic orbits and space quantization; principal and azimuthal quantum numbers, total energy; orbital and spin angular momentum of electrons; vector model of atom, quantum numbers, orbital and spin angular momentum of electrons, normal and anomalous Zeeman and Paschenback effects, Stern-Gerlach experiment, Atomic energy terms and term symbols

5 Hours

Principles of molecular spectroscopy

Fundamentals; rotational spectra: intensity distribution, effect of non-rigidity on spectral features; vibrational spectra: potential energy of an oscillator, Harmonic Oscillator approximation, energy levels and selection rules, anharmonicity and its effect on energy levels and spectral features: overtones and hot bands, vibration-rotation spectra of diatomics: origin; selection rules; P, Q and R branches; Raman spectra: origin, selection rules, classical and quantum treatment of rotational and vibrational Raman spectra, resonance Raman spectroscopy; NMR spectra: theory, relaxation process, spin interactions - its origin, equivalent protons, qualitative idea of energy levels of AX,

AX_2 and AX_3 systems, a few representative examples; Electronic spectra: Electronic absorption spectra of molecules, vibrational structures in electronic spectra, vibronic coupling: Herzberg Teller effect, Jahn-Teller effect, and Renner Teller Effect.

15 Hours

Crystal structure

Crystal symmetry, translation, glide plane and screw axis, Bravis lattice, space groups and its determination, stereographic projection, Fourier series, electron density and structure factor, methods for solving the phase problems, B-zones and Fermi level in lattice, concept of particle-hole in conduction process, band theory, theory of conductors, semiconductors and insulators.

5 Hours

Nanotechnology: principles and practices

Density of states – zero dimensional solid, one dimensional quantum wire, thin film and three dimensional box; some special nanomaterials – fullerenes, carbon nanotubes and nanodiamonds; optical properties of metallic and semiconducting nanoparticles; nanolithography

5 Hours

Unit II

Reaction intermediates II

Advanced reactions of carbocations, carbanions, free radicals including radical cations and radical anions, carbenes, arynes and nitrenes

Carbohydrates II

Conformational drawing: Fischer projection, zigzag, chair, half chair, boat, envelop, skew; Reactions of anomeric centers: nucleophilic substitution, oxidation, reduction, reductive elimination, free radical reaction, Wittig/Horner-Emmons reaction;Reactions of hydroxyl groups: protections (cyclic acetal both 5 and 6 membered ring, ether, ester) and deprotections, nucleophilic substitution, oxidation, reduction; Disaccharide formation: chemical and enzymatic; chemical glycobiology

Organic spectroscopy II

^{1}H NMR spectroscopy: FT-NMR; concept of FID signal and signal-to-noise ratio; chemical shift of different functional groups; magnetic anisotropic effect in annulenes and bridge systems; mechanism of spin-spin coupling; geminal couplings in acyclic and cyclic systems; vicinal coupling in open chain molecules, cyclic molecules: cycloalkenes, 3- and 6-membered saturated cyclic molecules, Karplus relationship; homoallylic and allylic couplings; couplings in benzene system; First-order and Non-first-order spectra; tree-diagram analysis; spectra of diastereotopic system; Pople notation; solvents used in NMR; chemical shift reagents

Mass Spectrometry: Instrumentation; Vaporization and Ionization process: EI, CI, ESI, MALDI etc.; Fragmentation process; Mass Analysis; Mass spectral data: Isotope peaks, Mass accuracy; Basic concepts of

hyphenated mass spectral methods: GC-MS, LC-MS, MS-MS

Recommended Books

G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall, India, 1997.

P. W. Atkins, *Physical Chemistry*, Oxford University Press, Oxford, 1998.

R. S. Berry, S. A. Rice and J. Ross, *Physical Chemistry*, Oxford University Press, Oxford, 2000.

H. E. White, *Introduction to Atomic Spectra*, McGraw-Hill Kogakusha Ltd., Tokyo, 1934.

G. M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw-Hill International Book Company, Tokyo, 1982.

C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th Edn, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1994.

J. D. Graybeal, *Molecular Spectroscopy,* McGraw-Hill International Editions, Spectroscopy series, 1998.

C. Kittel, *Introduction to Solid State Physics*, 4thEdn, John Wiley & Sons, New York.

P. A. Cox, *The Electronic Structure & Chemistry of Solids*, Oxford University Press, Oxford, 1987.

M. F. C. Ladd and R. A. Palmer, *Structure Determination by X-ray Crystallography*, 3rdEdn, Plenum Press, New York, 1994.

W. Clegg, *Crystal Structure Determination*, Oxford University Press, Oxford, 2005

J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn, John Wiley, New York, 1999.

S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.

F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn, Plenum Press, New York, 2001.

T. L. Gilchrist and C. W. Rees, Carbenes, Nitrenes and Arynes, Nelson, New York, 1973.

T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn, Harper and Row, New York, 1998.

Robert V. Stick, Carbohydrates: The Sweet Molecules of Life, Academic press, 2001

I. L. Finar, Organic Chemistry, Vol I, 6th Edn, Addison Wesley Longmann, London, 1998.

I. L. Finar, Organic Chemistry, Vol II, 5th Edn, ELBS, London, 1995.

W. J. I. Noble, Highlights of Organic Chemistry, Mercel Dekker, New York, 1974.

W. J. I. Noble, Highlights of Organic Chemistry, Mercel Dekker, New York, 1974.

E. A. Davidson, Carbohydrate Chemistry, Holt, Rinehart and Winston, New York, 1967.

R. D. Guthrie and J. Honeyman, An Introduction of Chemistry of Carbohydrate, 3rd Edn, Clarendon Press, Oxford, 1988.

J. Kennedy, Carbohydrate Chemistry, Clarendon Press, Oxford, 1988.

W. Kemp, Organic Spectroscopy, 3rd Edn, McMillan, Hong Kong, 1991.

R. M. Silverstein and F. Webster, Spectrometric Identification of Organic Compounds, 6th Edn, John Wiley, New York, 1998.

D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 5th Edn, Tata McGraw-Hill, New

Delhi, 2005.

D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Spectroscopy, Brooks/Cole, a part of Cengage Learning, 2008.

K. Biemann, Mass Spectrometry – Application to Organic Chemistry, McGraw-Hill, New York, 1962.

H. Budzikiewicz, C. Djerassi and D.H. Williams, Mass Spectrometry of Organic Compounds, Holden-Day, 1967.

J. Barker, Mass Spectrometry, 2nd Edn, John Wiley, New York, 2000.

C. Dass, An Introduction to Biological Mass Spectrometry, Wiley, New York, 2002.

K. Downard, Mass Spectrometry: A Foundation Course, Royal Society of Chemistry, UK, 2004.

G. Siurdek, The Expanding Role of Mass Spectrometry in Biotechnology, MCC Press, San Diego, 2004.

Paper Code: **CHEM 8014**
Paper Title: **Practical General**

Credit: 4

Course Objective:

The objective is to impart into the students the practical idea and understanding on synthesis and characterization and estimation of components in coordination complexes, photometric estimation of components in mixtures, isolation of natural products, and data processing and elementary numerical techniques used in chemistry.

Course outcome:

On completion of the course the students will be able to:

- Learn and understand the chemistry behind the synthesis and characterization of compounds
- Acquire knowledge and understanding on the chemistry behind the separation and estimation of different compounds using photometric techniques
- Learn and understand the isolation techniques of isolation of natural products
- Acquire knowledge and understanding on data processing and elementary numerical techniques used in chemistry
- Acquire skills with confidence and accuracy in designing experiments and/or their need based extensions

Unit I: Inorganic Practical General

Synthesis and characterization and estimation of several components of copper(I) chloride, manganese(III) phosphate, potash alum, tris(8-hydroxyquinline) aluminium(III) tris(acetylacetonenato)iron(III), potassium tris(oxalate) ferrate(III)

Unit II: Nuclear-Analytical Practical General

Verification of Beer's law using $KMnO_4$ solution and estimation of manganesefrom an unknown sample

Estimation of sugar

Estimation of amino acid

Estimation of phosphate in a supplied sample

Unit III: Organic Practical General

Isolation of natural products: casein from milk, caffeine from tea leaves

Recommended References:

Tetsuo Onami & Hitoshi Kanazawa, *A Simple Method for Isolation of Caffeine from Black Tea Leaves: Use of a Dichloromethane-Alkaline Water Mixture as an Extractant*, Journal of Chemical Education, **73**, 556-557 (1996).

Raquel Galante, Fernando Cunha & Raúl Fangueiro, 'Extraction and properties of casein biopolymer from milk': in *Handbook of Natural Polymers (Vol. 1): Sources, Synthesis, and Characterization (Ch. 19)*, Elsevier, 471-487 (2023).

Unit IV: Physical Practical General

Computer programming for:

Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid, Newton-Raphson method)

Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations)

Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values

Matrix operations: addition, multiplication, transpose, etc.

Curve fitting using supplied data sets

Recommended Books/ Journals

1. Inorganic Experiments, Edited by J. D. Woollins, VCH, Weinheim, Germany, 1994
2. A Collection of General Chemistry Experiments, A. J. Elias, Universities Press, Hyderabad, India
3. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis (5th Edition), 1989.
4. M. S. Dunn, Analytical Methods in the Food Industry, 1950
5. Ajay Kumar Goswami, Spectrophotometric Determination of Vanadium, Chromium and Manganese: Reagents and Methods, 2024
6. J H Tucker, A Manual of Sugar Analysis: Including the Applications in General of Analytical Methods to the Sugar Industry. With an Introduction on the Chemistry of Cane-Sugar, Dextrose, Levulose, and Milk-Sugar, D. Van Nostrand, New York, 2010.

7. D. A. McQuarrie, Mathematics for Physical Chemistry University Science Books (2008).
8. R. Mortimer, Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
9. D. C. Harris, Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
10. P. Yates, Chemical Calculations.2nd Ed. CRC Press (2007).
11. G. W. Collins II, Fundamental Numerical Methods and Data Analysis, Harvard University Press, Harvard (2003)
12. L. R. Scott, Numerical Analysis, Princeton University Press, Princeton (2011)
13. J. H. Noggle, Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).
14. A. I. Vogel, Elementary Practical Organic Chemistry: Qualitative Organic Analysis Part 2, CBS Publishers and Distributors

Chemistry Minor Course

Paper Code: **CHEM 8021**
Paper Title: **Medicinal Chemistry**

Course Objective:

The objective is to impart into the students the theoretical idea and understanding on supramolecular photochemistry, medicinal chemistry and drug discovery, radiopharmaceuticals, medicinal inorganic chemistry, pharmacokinetics, photodynamic medicine, and drug targets and drug delivery, etc.

Course outcome:

On completion of the course the students will be able to:

- Comprehend the applicability of supramolecular chemistry in photodynamic therapy as well as in medicinal prospect.
- Acquire idea and understanding on antibacterial, anticancer, antitussive, antiviral agents and structure-activity relationships (SARs).
- Understand the specific radiopharmaceuticals for diagnostic and therapeutic purposes, principle and instrumentation of gamma/PET camera for detection, methods (SPECT, PET, 18FDG etc.)of administration of radionuclides (nuclear medicines).
- Characterize biomolecules in the discovery and development of newer generation anti-tumourand anti-cancer agents
- Get hold of the ideas about drug absorption, drug distribution, drug metabolism, drug excretion, drug administration and drug dosing, etc.
- Grasp basic principle of photodynamic therapy and photochemotherapy and photodynamic medicine with their mode of action, etc.

Theory **Credit: 6**

Supramolecular Photochemistry

Mechanism of energy and/ electron transfer process(es), various supramolecular devices: electronic, ionic and switching devices, application of supramolecular chemistry in photodynamic therapy, some examples of self-assembly in supramolecular chemistry with prospect in medicinal applications

Medicinal Chemistry and Drug Discovery

Antibacterial, Anticancer, Antitussive, and Antiviral agents; Opium analgesics, Antibiotics, New drugs from old poisons; Drug discovery, Structure-Activity Relationships (SARs)

Radiopharmaceuticals

Nuclear pharmacy: concept, pharmaceuticals and radiopharmaceuticals; type of radionuclides, neutral/charged particle emitters, radionuclide generators; ideal radiopharmaceuticals, methods of radiolabeling, biodistribution, specific radiopharmaceuticals for diagnostic and therapeutic purposes, SPECT, PET, 18FDG etc. method of administration, principle and instrumentation of gamma/PET camera for detection, quality control, Principle, method and application of radioimmuassay (RIA)

Medicinal Inorganic Chemistry

Biomedical significance and inorganic chemistry, Characterization of biomolecules using spectroscopic methods, mechanistic aspects of heavy metal toxicity, platinum anti-cancer drugs (from laboratory to clinic), discovery and development of newer generation anti-tumour and anti-cancer agents

Pharmacokinetics

Drug absorption, drug distribution, drug metabolism, drug excretion, drug administration, drug dosing

Photodynamic medicine

Introduction, early days of photodynamic therapy (PDT), basic principle, photodynamic action, photochemotherapy, photosensitizing molecule, incubation period, light activation, light exposure, total light dose and its fluence rate**,** application of photosensitizer drug

Drug Targets and Drug Delivery

Enzymes, receptors, carrier proteins, structural proteins, nucleic acids, lipids, carbohydrate, targeted drug delivery, novel delivery modalities, Future considerations

Recommended books/Journals

Radiopharmaceutical Chemistry, by Jason S. Lewis, Albert D. Windhorst, Brian M. Zeglis, Springer, 2019

Photodynamic Therapy: Basic Principles and Clinical Applications 1st Edition, by B.W. Henderson and T.J. Daugherty, ISBN-13: 978-0824786809, **CRC Press; 1 edition (June 19, 1992)**

Radiopharmaceuticals for Therapy, by Ashutosh Dash and F. F. (Russ) Knapp, 2016, Springer

The Handbook of Radiopharmaceuticals, by Azuwuike Owunwanne, Mohan Patel and Samy Sadek, Chapman & Hall Medical, 1st Edition, 1995

Handbook of Radiopharmaceuticals: Radiochemistry and Applications, By M.J. Welch and C.S. Redvanly, Wiley, 2005

An Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford (International Student Edition)

Medicinal Inorganic Chemistry, Edited by J.L. Sessler, s.R. Doctrow, T.J. Mcmurry and S.J. Lippard, Americn Chemical Society, Washington, DC

(Instant Notes) Medicinal Chemistry, G. Patrick, Viva Books Pvt. Ltd.

Medicinal Chemistry, Principles and Practice, edited byF.D. King, Royal Society of Chemistry

The practice of Medicinal Chemistry, Edited by C.G. Wermuth, Academic Press

Medicinal Chemistry, D. Sriram & P. Yogeeswari, Pearson