Central University of Himachal Pradesh
Shahpur
Department of Chemistry

Program Specific Outcomes
Program Outcomes
Course Outcomes & Course Contents
Of
Department of Chemistry and Chemical Science

Programme Specific Outcomes of Master of Science in

PSO[1]- To ensure participation of all students in classroom discussions.
PSO[2]- To develop skills for work in various industries.
PSO[3]-To enhance competitive spirit in students.

Programme Outcomes of Master of Science in Chemistry

PO[1] - To develop the basic knowledge of chemistry in four main fields, Organic, inorganic, Physical and Biochemistry.
PO[2]- To enhance close and critical reading of the literary works.
PO[3]- To augment the analytical and interpretative abilities of the students.
PO[4]- Learning of basic skills of practical chemistry (Relevant for job).

CENTRAL UNIVERSITY OF HIMACHAL PRADESH
[Established under the Central Universities Act 2009]
PO Box: 21, Dharamshala, District Kangra - 176215 (HP)
www.cuhimachal.ac.in

Course Code: CCS 511
Course Name: Inorganic Chemistry -I
Course Instructor:
Credits: 2

Course Objectives:

- To understand the significant aspects of Crystal Field theory, splitting of d orbitals and Crystal field stabilization energies.
- To understand the thermodynamic aspects of crystal filed splitting.
- To explain applications of nuclear chemistry as well as radioactive techniques.

Course Outcomes:
The students will be able to
CO[1]Apply the crystal field theory for determining Crystal field stabilization energies.
CO[2]Find out the lattice energy, hydration energy and stability constants of complexes.
CO[3] Explain nuclear chemistry, radioactivity as well as radioactive techniques.
Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

UNIT-I: Theory of Coordination Chemistry
Crystal Field Theory: Splitting of d orbitals in crystal fields of different symmetry for similar and dissimilar ligands (Octahedral, tetrahedral, Linear, trigonal planar, trigonal bipyramidal, square pyramid), crystal field stabilization energies (CFSE), spectrochemical series, octahedral site preference energy (OSPE) and their applications. Tetragonal distortion (Jahn-Teller effect). Thermodynamic aspects of crystal field splitting (variation of ionic radii, lattice energy, hydration enthalpy and stability constants of complexes – Irving Williams order).

UNIT II: Nuclear Chemistry and Radioactive techniques
Nuclear stability, Nuclear cross-sections, Nuclear reactions: types of reactions, Nuclear fission-fission product and fission yields, Tracer technique, (neutron activation analysis), Counting techniques such as G.M. Ionization and proportional counters.

Suggested books:

1. F.A Cotton & G. Wilkinson, Advanced Inorganic Chemistry:,VthEdn. ,Wiley-Interscience, New York

2. B.R.Puri, L.R.Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Company

3. Gurdeep Raj, Advanced Inorganic chemistry, GoelPublishing House.

4. J.E.Huheey, E.A.Keiter and R.L.Keiter, Inorganic Chemistry –4th Edn, Pearson.

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	3	2	3	2		3	2	2
CO2	1	3	3	2		3	2	3
CO3	1	2	2	3		3	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 512
Course Name: Organic Chemistry I
Course Instructor:
Credits:2

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)
Course Objectives:

- To impart knowledge about reaction mechanism
- To impart the knowledge of Structure and Reactivity
- To understand Hammonds postulate, Curtin-Hammett principle.
- To impart knowledge about Methods of determining Reaction mechanisms

- To understand addition reactions which are happening through the nucleophiles and electrophiles
- To understand the reactivity of different carbonyl compounds towards nucleophillic reaction.
- To understand how to write the products of addition reaction to carbonyl compounds.
- To learn the mechanism of addition and elimination reaction
- To understand addition reactions between a hetero atom and double bonded carboncompounds.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1 Distinguish different types of reaction mechanism.
CO^2 Apply their literary knowledge to understand effect of structure on reactivity
CO^3 Understand the importance of Quantitative treatment, linear free energy relationship, Substituent and reaction constants,
CO^4 To learn the addition reactions which are happening through the nucleophiles andelectrophiles
CO^5 To learn about the addition reactions between a hetero atom and double bonded carboncompounds

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in
Evaluation Criteria:
4. Mid Term Examination: 20
5. End Term Examination: 60
6. Continuous Internal Assessment: 20

Course Contents:

Unit I: Reaction Mechanism
Reaction Mechanism: Structure and Reactivity: Thermodynamic and kinetic requirements, Kinetic and Thermodynamic control, Hammonds postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates.
Effect of structure on reactivity: resonance and field effects, steric effect. Quantitative treatment: Hammett equation and linear free energy relationship, Substituent and reaction constants, Taft equation. Methods of determining Reaction mechanisms.

UNIT II: Addition to C-C multiple bonds, C-Hetero Multiple Bonds
Addition to C-C multiple bonds : Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemo selectivity, orientation and reactivity. Hydrogenation of double and triple bonds and aromatic rings.Hydroboration reaction, Sharpless asymmetric epoxidation.**Addition to Carbon-Hetero Multiple Bonds**: Mechanism of metal hydride reaction of substituted and unsubstituted carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organo-Zn and organo-Li reagents to saturated and unsaturated carbonyl compounds. Wittig reaction.Mechanism of condensation involving enolates.

Prescribed Text Books:

R.O.C. Norman, Principles of Organic Synthesis, Chapman and Hall, London, 2nd Edition 1980. 15

Francis A. Carey, Richard J. Sundberg, Advanced Organic Chemistry-Part B Reactions and Synthesis, Plenum Press, 3 rd Edition,1990.

Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.

Suggested Reading:

S.M. Mukherji and S.P. Singh, Organic Reaction Mechanism, Macmillan India Ltd., 1990.

A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.

Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.

Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice Hall.

Course Articulation Matrix of CCS 512; Organic Chemistry I

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	1	3	2		2	3	2
CO2	1	3	1	2		1	1	3
CO3	2	2	1	3		3	3	2
CO4	2	2	2	3		2	3	3
CO5	1	2	3	1		2	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 513
Course Name: PHYSICAL CHEMISTRY I
Course Instructor:
Credits: Total 2 credit

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To study the fundamentals and applications of classical mechanics and quantum chemistry.
- To understand the structure of an atom and different approximation methods.
- Study the classical Maxwell-Boltzman and quantum statistics.
- Know about partition functions and determining thermodynamic properties.
- Understand heat capacity of solids.

- Apply the thermodynamic factors in various organic synthesis processes (how the reaction condition and reaction rate various depend on the thermodynamic factors).

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1Understand about thermodynamics and Non-ideal systems
CO^2 Describe the third law of thermodynamics
CO^3 Study the classical Maxwell-Boltzman and quantum statistics.
CO^4 Explain about partition functions and determining thermodynamic properties.
CO^5Understood heat capacity of solids
CO^6 Apply the thermodynamic factors in various organic synthesis processes (how the reaction condition and reaction rate various depend on the thermodynamic factors).

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):
7. Mid Term Examination: 20
8. End Term Examination: 60
9. Continuous Internal Assessment: 20

Course Contents

UNIT I:

Quantum Mechanics: Time independent Schrödinger equation, probability concept. Linear operators in quantum mechanics, Eigen value equation. Properties of the operators, commutation relations, Applications: Particle-in-a box (1-, 2-, 3- dimensional), different potential functions and barrier problems, degeneracy, density of states. Simple harmonic oscillator, Rigid rotor, Angular momentum operator, Hydrogen atom. Approximate method: Elementary perturbation theory up to second order in energy , Variation theorem, Simple applications. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle.

UNIT-II:

Statistical Thermodynamics: Thermodynamic probability and entropy, Maxwell Boltzman, Partition function: rotational, translational, vibrational and electronic partition functions of diatomic molecules, calculation of thermodynamic functions and equilibrium constants. Theories of heat capacities of solids. Microcanonical ensemble, Canonical ensemble

distribution probability partition function, its relation with different thermodynamic state functions. Gibb's paradox and Sackur- Tetrode equation. Equipartition theorem and its validity. Chemical potential and heat capacity of solids.

SUGGESTED READINGS:

1. Atkins, P., & De Paula, J. (2014). *Atkins Physical Chemistry* (X Edition). Oxford: Oxford University Press.

2. Kapoor, K. L. (2015). *Text Book Physical Chemistry Vol. V*. New Delhi: MacMillan India Ltd.

3. Lavin, I. N. (2002). *Physical Chemistry* (V Edition). New Delhi: Tata-McGraw Hill Publishing Company.

4. Whittakar, A. G. (2001). *Physical Chemistry*. New Delhi: Mount & Heal Viva Books Pvt. Ltd.

Course Articulation Matrix of CCS513- PHYSICAL CHEMISTRY I

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	1	3	2		2	3	2
CO2	3	2	1	1		1	1	3
CO3	3	1	2	3		3	3	2
CO4	2	1	2	3		2	1	3
CO5	1	2	3	3		2	3	1
CO6	3	2	1	2		1	2	3

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 514
Course Name: ADVANCE ANALYTICAL TECHNIQUES
Course Instructor:
Credits: Total 2

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To know about chromatography
- To know about high performance liquid chromatography and gas chromatography
- To know about TEM, SEM, AFM and XPS
- To know basic principle, instrumentation and applications of TEM, SEM, AFM and XPS.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1To know the basic principle of chromatography
CO^2 Basic principle, methodology and application of high-performance liquid chromatography and gas chromatography
CO^3 To know theBasic principle, methodology and application of liquid and gas chromatography – Mass spectrometry
CO^4 To know the basic principle, instrumentation and applications of TEM, SEM, AFM and XPS

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):
10. Mid Term Examination: 20
11. End Term Examination: 60
12. Continuous Internal Assessment: 20

Course Contents

UNIT-I

Introduction to Chromatography: Basic principle of Analytical techniques. Different types of Chromatography techniques and their applications. Thin layer Chromatography – Basic principle, methodology, application. **High Performance Liquid Chromatography:** Basic Principle, Methodology, Application. Discussion with examples, **Gas Chromatography:**Basic Principle, Methodology, Application. Discussion with examples. **Liquid and Gas Chromatography - Mass spectrometry:** Basic Principle, Methodology, Application. Discussion with examples.

UNIT-II

Transmission Electron Microscopy: Basic principle, Instrumentation and Applications, Scanning electron microscopy: Basic principle, Instrumentation and Applications, AFM : Basic principle, Instrumentation and Applications, Light scattering and XPS : Basic principle, Instrumentation and Applications.

Course Articulation Matrix of CCS514

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	2	3	1		1	2	3
CO2	3	2	3	2		1	2	3
CO3	3	1	3	2		2	1	2
CO4	2	2	3	1		1	2	3

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: **CCS 516**
Course Name: **Spectroscopic techniques**
Course Instructor:
Credits: 4

Course Objectives:

- To understand the basic theories of IR and Raman spectroscopyas well as types of vibrations.
- To understand the concept of factors affecting the frequencies and band shapes.
- To understand the Basic principles and Instrumentation of UV spectroscopy.
- To understand the aspects of NMR spectroscopy such as Nuclear overhausser effect, Double resonance, Chemical exchange, Lanthanide shift reagents and NMR spectra of paramagnetic ions.
- To understand basic instrumentation and other techniques of mass spectroscopy.

Course Outcomes:

The students will be able to

CO^1Differentiate various type of vibrations in IR spectroscopy.
CO^2 Explain the different theories of IR absorption as well different scattering phenomenon in Raman spectroscopy.
CO^3 Understand the concepts of Nuclear Quadrupole Resonance, Nuclear electric quadrupole moment, Electric field gradient, Energy levels and NQR frequencies and Effect of magnetic field on spectra.
CO^4 Determine structure by different spectroscopic techniques.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40

2. End Term Examination: 120

3. Continuous Internal Assessment: 40

UNIT-I

Infrared Spectroscopy: Theory of IR absorption, Types of vibrations, observed number of modes of vibrations, Intensity of absorption bands, Theoretical group frequencies, Factors affecting group frequencies and band shapes (Physical state, Vibrational Coupling, Electrical effects, Resonance, Inductive effects, Ring strain). Basic Principle of Raman Spectroscopy, Differences between IR and Raman spectra.

UNIT-II

UV spectroscopy: Basic principles and Instrumentation of UV spectroscopy, Beer lambert law, absorbance, transmittance, Λ_{max} ,$€_{max}$, various fundamental transitions, solvent effect, Chromophores and Auxochromes. Rules for finding Λ_{max} .

UNIT-III

Nuclear Magnetic Resonance Spectroscopy: Introduction to Nuclear Magnetic Resonance, Chemical shift, Mechanism of electron shielding and factors contributing to the magnitude of chemical shift, Nuclear overhausser effect, Double resonance, Chemical exchange, Lanthanide shift reagents and NMR spectra of paramagnetic ions. Contact shifts. Experimental technique (CW and FT). C^{13} NMR, COSY.

UNIT IV: Mass spectrometry

Basic instrumentation, ion production - E1, C1, FD, FAB and MALDI techniques. Mass spectral fragmentation of typical organic compounds, common functional groups.

Suggested books:

1. Paula K Bruice, Organic Chemistry , 8th Edition, Pearson.
2. Jag Mohan, Organic spectroscopy, Narosa Publishing House.
3. Y. R. Sharma, Elementary Organic Chemistry, S. Chand.
4. B.R.Puri, L.R.Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Company
5. Gurdeep R. Chatwal, Sham K. Anand, Instrumental methods of Chemical analysis, Himalya Publishing House.

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	3	2	3	2		2	3	3
CO2	2	3	3	2		3	2	3
CO3	1	2	2	3		3	2	3
CO4	2	2	3	3		2	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 517
Course Name: **Commercial and Green Synthesis**
Course Instructor: Dr. Neeraj Gupta
Credits: 2 credits

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To know about concept of disconnection approach
- To know the inter-conversion of functional groups.
- Knowing the importance and principle of protection of functional groups.
- To know about the green chemistry with their green synthetic approach.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1]To know the disconnection approach
CO[2] Protection of functional groups.
CO[3] Twelve principles of green chemistry.
CO[4] To know aboutgreen synthetic approach.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):
13. Mid Term Examination: 20
14. End Term Examination: 60
15. Continuous Internal Assessment: 20

Course Contents

UNIT-I

Disconnection Approach: Introduction to synthons and synthetic equivalents, disconnection approach (basic concept only), functional group inter-conversions and importance of the order of events in organic synthesis. One group C-X and C-C along with two group C-X disconnections (case studies of representative molecules are required). Reactivity umpolung and importance of functional group protection in organic synthesis. Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

UNIT-II

Green Chemistry: What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry, Twelve principles of Green Chemistry, solvent-free organic reactions. Green solvents– water, super

critical fluids as a solvent for organic reactions, ionic liquids. Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.

Course Articulation Matrix of CCS517- Review of Literature/ Research Proposal

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	3	1	3		1	2	2
CO2	2	1	2	3		1	2	1
CO3	1	3	2	1		3	2	2
CO4	3	2	3	3		1	2	3

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 518
Course Name: Nanoscience
Course Instructor : Dr. Pramod Kumar
Credits: Total 2 credit

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To understand the history and perspectives of Nanotechnology.
- To analyze the various properties and significant nanomaterials.
- To analyzes the various types of nanoparticles and its application.
- To understand about synthesis methods nanomaterials and its properties.
- To apply the biological methods of synthesis and properties of nanomaterials.
- To motivate and lead the student in the field of nanotechnology.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1Explain about the history and perspectives of Nanotechnology.
CO^2 Classify about the various types and significant nanoparticles.
CO^3 Compare the various types of nanoparticles and its application
CO^4 Discuss about synthesis methods nanomaterials and its properties
CO^5Illustrate the biological methods of synthesis and properties of nanomaterials.
6. CO^6 Motivate and lead them in the pathway of nanotechnology.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):
16. Mid Term Examination: 20
17. End Term Examination: 60
18. Continuous Internal Assessment: 20

Course Contents

UNIT I:

Course A: Properties of Nanomaterials

Introduction:Properties of materials & nanomaterials, role of size and shape in nanomaterials.

Electronic Properties:Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, Resistivity.

Magnetic Properties:Superparamagnetism, blocking. Important properties in relation to nanomagnetism.

Optical Properties:Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence. Thermal Properties and Mechanical Properties;

UNIT II:

Course B: Synthesis of Nanomaterials :

Chemical Methods:Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Post-synthetic size-selective processing. Sol-gel, Micelles and microemulsions.

Biological Methods of Synthesis:Use of bacteria, fungi, Actinomycetes for nanoparticles synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.

SUGGESTED READINGS

1. Br'echignac, C., Houdy., & Lahmani, M. (2007). *Nanomaterials and Nanochemistry*. New York: Springer Berlin Heidelberg.

2. Hosokawa, M., Nogi, K., Naito, M., & Yokoyama, T. (2012). *Nanoparticle Technology Handbook* (II Edition). Elsevier.

3. Theodore, L. (2006). *Nanotechnology: Basic Calculations for Engineers and Scientists*. Hoboken: John Wiley & Sons. Inc., Publication.

4. Introduction to Nanoscience, J. Dutta, H.F. Tibbals and G.L. Hornyak, CRC press, Boca Raton, 2008.

5. Sulabha K. Kulkarni , (2014). Nanotechnology: Principles and Practices, Springer Publisher.

Course Articulation Matrix of CCS518 - Nanoscience

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	1	2	2	2		2	3	2
CO2	2	1	2	3		3	1	3
CO3	1	3	3	2		1	3	2
CO4	3	2	1	2		2	1	3
CO5	2	1	1	3		3	3	1
CO6	1	3	2	1		2	2	3

Course Code: **CCS 521**
Course Name: **Inorganic Chemistry -II**
Course Instructor:
Credits: 4

Course Objectives:

1. To understand the significant aspects of Chemical bonding such as Valence band theory, Molecular orbital theory, resonance and hybridization.
2. To be able to describe the concept of spin and orbital moments, stereochemistry of coordination compounds.
3. To be able to understand the different properties and reactions of organometallic compounds.
4. To be able to describe the complex chemistry, electronic configuration and magnetic properties of d and f block elements.

Course Outcomes:

The students will be able to

CO[1]Understand the concept of valence band theory, Molecular orbital theory, hybridisation and resonance.

CO^2 Explain the spin and orbital momentum as well as stereochemistry of coordination compounds.
CO^3 Understand different properties and reactions of organometallic compounds.
CO^4 Explain the complex chemistry, electronic configuration, magnetic properties as well as factor responsible for different properties of d and f block elements.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria:
1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

UNIT-I: Aspects of Chemical Bonding
LCAO-MO and VB treatments on H2+, H2: Valence bond theory (VBT), resonance in VBT, VBT of homonuclear diatomic molecules, sigma and pi bonds, VBT of heteronuclear diatomic molecules, inadequacies of the simple VBT. Hybridization, participation of *d* orbitals in hybridization in polyatomic species.Molecular orbital theory (MOT), linear combination of atomic orbitals (LCAO), criteria for the formation of stable MOs. Sigma, Pi and Delta molecular orbitals.Homonuclear and heteronuclear diatomic molecules and ions.MO theory of polyatomic molecules and ions.MO theory of π bonding and multi-centre bonding.MO concept of metal-ligand bonding (pictorial approach); VSEPR Theory.

UNIT II: Coordination Chemistry I
Labile and inert complexes. Spin and orbital moments, spin-orbit coupling, quenching of only formula, temperature dependence of magnetic moment, Super exchange Dependence of Orbital contribution on the nature of the electronic ground state. Structural, isomerism and stereoisomerism of coordination compounds, optically active coordination compounds.

UNIT III: Organometallic compounds
Organometallic compounds, Classification, Organometallic compounds of various elements, ylides, Organometallic compounds with multicentre bonds, pi bond ligands and their bonding (bonding in alkenyl and alkynyl complexes). Ferrocene and its reactions, Aromaticity of cyclic C_nH_n ligands.Carbene, Carbyne and Carbide complexes.

UNIT-IV: Chemistry of d- and f- Block Elements (Comparative Study)
Electronic configuration, oxidation states; aqueous, redox and complex chemistry,spectral and magnetic properties of compounds in different oxidation states, horizontal and vertical trends in respect of 3d,4d, and 5d elements with references to Ti-Zr- Hf , Cr- Mo- W, Mn Tc-Re and Pt group metals.
Lanthanide and Actinide Elements: Electronic configuration, oxidation states, aqueous, redox and complex- chemistry; electronic spectra and magnetic properties (one example each). Lanthanide and actinide contractions and their consequences, separation of lanthanides and actinides and their applications (with examples).

Suggested Books:

1. J.E.Huheey, E.A.Keiter and R.L.Keiter, Inorganic Chemistry –4th Edn, Pearson.
2. B.R.Puri, L.R.Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Company.
3. J.D.Lee, Concise course in Inorganic Chemistry, Wiley.
4. R.C.Mehrotra, A. Singh, Organometallic Chemistry, New Age International.
5. B D Gupta, A J Elias, Basic Organometallic chemistry, 2nd edition, Universities press.
6. F.A Cotton & G. Wilkinson, Advanced Inorganic Chemistry:,VthEdn., Wiley-Interscience, New York.
7. Ch. Elschenbroich, A. Salzer, Organometallivcs : A concise introduction, 2nd Edition, VCH

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	3	2	3	2		1	2	3
CO2	2	2	3	3		3	3	2
CO3	2	1	3	3		2	2	3
CO4	2	2	3	3		2	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 522
Course Name: Organic Chemistry II
Course Instructor:
Credits: 4

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)
Course Objectives:

- To impart knowledge about organic reagents.
- To impart the knowledge of rearrangements of organic reagents.
- To understand the mechanism of aromatic electrophilic substitution reaction.
- To impart knowledge about Methods of determining reaction mechanisms.
- To understand the Quantitative treatment of reactivity in substrate and electrophiles.
- To understand the mechanism of aromatic nucleophilic substitution reaction.
- To understand how to write the benzyne mechanism.
- To learn the methods for obtaining enantiopure compounds.

- To understand the principle of asymmetric synthesis and different generation methods.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1] Distinguish different types of organic reagents.
CO[2] Apply their literary knowledge to understand the rearrangements of organic reagents.
CO[3] Understand the importance of Quantitative treatment, of reactivity in substrate and electrophile.
CO[4] To learn the effect of substrate, leaving group and attacking nucleophile on aromatic compounds.
CO[5] To learn about the different methods for obtaining enantiopure compounds, understand the principle of asymmetric synthesis and different generation methods.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria:
1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Unit I: Organic Reagents
Reagents in organic synthesis: Willkinson catalyst, Lithium dialkylcuprates (Gilman's reagents), Lithium diisopropylamide (LDA), 1,3-Dithiane (Umpolung) Dicyclohexylcarbobiimide (DCC), and Trimethylsilyliodide, DDQ, SeO_2, Baker yeast, Tri-n-butyltinhydride, Nickel tetracarbonyl, Trimethylchlorosilane. Grubbs Catalysts.**Rearrangements:**General mechanistic considerations-nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Backmann, Witting rearrangement and Stevens rearrangement.
UNIT II:Aromatic Electrophilic Substitution
Arenium ion mechanism, orientation and reactivity, energy profile diagrams, Theortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles, Diazonium coupling, Vilsmeir reaction, Scholl reaction, Amination reaction, Fries rearrangement, Reversal of Friedel Craft alkylation, Decarboxylation of aromatic acids.
UNIT III:Aromatic Nucleophilic Substitution
SNAr, SN1, benzyne and SRN1 mechanism. Reactivity, effect of substrate structure, leaving group and attacking nucleophile, Von Richter, Sommelet- Hauser, and Smiles rearrangements, Ullman reaction, Ziegler alkylation, Schiemann reaction.
UNIT IV: Stereochemistry and Asymmetry synthesis
Asymmetry, Conditions for Asymmetry, Selectivity in organic synthesis, Specificity vs Selectivity, Methods for Obtaining Enantiopure Compounds, Introduction to prochirality, Asymmetric synthesis: principle of assymetrical synthesis, First generation, second generation, third generation and fourth generation Methods, Cram's rule, Felkin-Ahn rule, Sharpless asymmetric epoxidation, Asymmetric hydrogenation, Chiral Pool Synthesis.

Prescribed Text Books:
Jerry March, John Wiley, Advanced Organic Chemistry-Reactions, Mechanism and Structure, 2013.
P.S.Kalsi, Stereochemistry: Conformation and Mechanism, 9th edition, 2017.
Jonathan clayden, Nick Greeves, Stuart warren, Organic chemistry, second edition, 2012.

Suggested Reading:
S.M. Mukherji and S.P. Singh, Organic Reaction Mechanism, Macmillan India Ltd., 1990.
Peter Sykes, Longman, A Guide Book to Mechanism in Organic Chemistry
C.K. Ingold, Structure and Mechanism in Organic Chemistry

Course Articulation Matrix of CCS 522; Organic ChemistryII

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	2	3	2		2	3	2
CO2	1	3	2	1		2	2	3
CO3	2	2	2	3		3	3	2
CO4	2	1	2	3		2	2	3
CO5	2	2	3	2		2	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 523
Course Name: **PHYSICAL CHEMISTRY II**
Course Instructor:
Credits: Total 4 credit

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

1. To provide knowledge on fundamental understanding of chemical kinetics and to establish a relationship between the rate of reaction and the concentration of the reactants (the rate law, or rate equation).
2. To apply the chemical kinetics concept to study the mechanisms.
3. To analyze the various types of reactions in solution and its effects.
4. To determination of molecular weight of polymers and kinetics mechanism.
5. To learn the concept of surface chemistry and their applications.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1]Recall the theories of reaction rates, how reaction rates are measured and represented in rate laws
CO[2] Conclude the applications of chemical kinetics in studying mechanisms
CO[3] Classify the various types of reactions in solution and its effects.
CO[4] Discuss the kinetics of polymerization and kinetics mechanism.
CO[5]Discuss the BET equation and various method in adsorption.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 4 credit theory part):
Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

UNIT-I

Chemcal Dynamics-I : Macroscopic and microscopic kinetics, Review of theories of reaction rate-Collision theory and Transition state theory, Comparison of collision theory with transition state theory, Arrhenious equation- characteristics, Significance of energy of activation, Temperature coefficient and its evaluation. Thermodynamical formulation of reaction rates (Wyne-jones and Eyring treatment), Reaction between ions in solutions – Influence of ionic strength on reaction rates (primary and secondary salt effects).Concept of Steady state kinetics, Chain reactions – chain length and chain inhibition, comparison of photochemical and thermal reactions, Mechanisms of thermal and photochemical reactions between hydrogen-bromine and hydrogen-chlorine. Comparative study of thermal and photochemical hydrogen-halogen reactions. Pyrolysis of acetaldehyde, Decomposition of ethane.Kinetics of fast reactions- Introduction, Study of reactions by relaxation method (Temperature and pressure jump), flow method (Plug flow method and Stopped flow method), Flash photolysis and Shock tube method.

UNIT II:

Chemcal Dynamics-II : Kinetics of homogeneous catalysis-kinetics of auto catalytic reactions, kinetics of acid-base catalysed reactions. Comparison of enzyme catalysed and chemical catalysed reactions, Mechanism (Lock and Key theory), Kinetics of enzyme catalyzed reactions – Henri-MichaelisMenten mechanism, Significance of Michaelis-Menten constant, Lineweaver-Burk plot. Effects of enzyme concentration, pH, Temperature,

Activators and Inhibitors on enzyme activity. Theories of unimoleuclar reactions: Perrin theory, Lindemann theory, and Hinshelwood theory.

UNIT III:

Polymers and Macromolecules:

Determination of molecular weight of polymers (Mn, Mw, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Kinetics of Polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques

UNIT IV:

Surface chemistry:

Surface chemistry- Types of adsorption isotherms, Effect of temperature on adsorption, Mechanical adsorption, Estimation of surface area using BET equation, Gibbs adsorption isotherm and its significance, Surface tension and surface energy, Pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Surface film on liquids (electro-kinetic phenomena), Catalytic activity of surfaces.

SUGGESTED READINGS :

1. Bahl, A., Bahl, B. S., & Tuli, G. D, (2014). Essentials of Physical Chemistry (VEdition). New Delhi: S. Chand & Company.
2. Puri, B.R., Sharma, L.R., & Pathania, M.S. (2015). Elements of Physical Chemistry.
3. Jalandhar: Vishal Publishing House.
4. Laidler, K. J. (2004). Chemical Kinetics (III Edition). New Delhi: Pearson Education Publishing. Indian Branch.
5. Gurdeep Raj, Chemical Kinetics, Goel Publishing House.

A.A.Frost and R.G.Pearson, Kinetics and Mechanism, Wiley Eastern, Pvt. Ltd.

Course Articulation Matrix of CCS523 - PHYSICAL CHEMISTRY II

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	1	2	2		1	3	3
CO2	3	3	2	2		3	2	2
CO3	2	2	3	3		2	3	3
CO4	1	2	1	2		3	3	1
CO5	1	3	1	1		2	2	1

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 524
Course Name: Bio-Chemistry
Course Instructor: Dr. Shiwani Berry
Credits: 2

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The course aims to provide students with a basic understanding of:

- Knowledge about amino acids and proteins.
- The principles of bioenergetics and enzyme catalysis and its functions.
- How the DNA in a genome is organized, replicated and repaired.
- Knowledge about Free energy changes in biological reactions
- Reversible oxygenation in life process O_2-uptake proteins
- Heme protein and non heme protein functions in living cells.
- Metal dependent diseases and Chelation or non-chelation therapy Metal complexes.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1]Demonstrate knowledge and understanding of the molecular machinery of living cells.
CO[2] Demonstrate knowledge and understanding of the principles that govern the structures of macromolecules and their participation in molecular recognition.
CO[3] Demonstrate knowledge and understanding of the principles and basic mechanisms of metabolic control and molecular signalling.
CO[4] Understand detailed information about various diseases caused by toxic metals and their treatment therapy methods.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT I: The primary, secondary, tertiary and quaternary structures of proteins and enzymes. Function of proteins and enzymes. Nucleic acids and nucleotides, polynucleotides,

nucleosides, DNA, RNA, helix-coil transition, A, B and Z conformations. Free energy changes in biological reactions: ATP-ADP inter-conversion.

UNIT II: **Bioinorganic Chemistry**

Reversible oxygenation in life process O_2-uptake proteins, myoglobin, hemoglobin, hemerythin, hemocyanin, electron transport proteins, Fe-S proteins, ferredoxins, ruberodoxin, respiratory electron transport chains: cytochromes, photosynthetic electron transport chain, chlorophyll, PS-I and PS-II, Biological nitrogen fixation (Nitrogenase) and a biological nitrogen fixation; metalloenzymes: superoxide dismutase (SOD), cytochrome P 450, cytochrome C oxidase, carbonic anhydrase, carboxypeptidase; molybdoenzymes.

Metal dependent diseases Wilsons, Alzheimer, vitamin B12 -enzyme, Chelation therapy

Metal complexes in therapeutic use of chelated and non-chelated compounds.

Reference Books:

David L. Nelson, Michael M. Cox, "*Principles of Biochemistry",* 7th edition, W. H. Freeman Publishers.

Dr. J.L. Jain, Dr. Sunjay Jain, Nitin Jain, "*Fundamentals of Biochemistry",* S. Chand Publishing.

Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr. LubertStryer, "*Biochemistry*", 9th edition, MacMillan Publishers**.**

Suggested Readings:

PankajaNaik, "*Essentials of Biochemistry*", 2nd edition, Jaypee Brothers, 2017.

S. P. Singh, "*Textbook of Biochemistry*", 6th edition, CBS Publication, 2015.

Course Articulation Matrix of CCS 524; Bio-Chemistry

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	1	3	2		1	3	2
CO2	2	3	1	1		1	1	3
CO3	1	2	1	3		3	3	2
CO4	2	1	2	3		2	1	3

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 526

Course Name: Medicinal, Supramolecular and Heterocyclic Chemistry

Course Instructor:

Credits: Total 2

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work;

obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To know about drug designing
- To know about supramolecular chemistry
- To know about the heterocyclic chemistry with their synthesis.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1To know the chemistry behind designing of drug
CO^2 To know about the structural activity relationship of various drugs such as penicillin, sulphonamide.
CO^3 Chemistry of supramolecules with their applications
CO^4 Nomenclature and synthesis of heterocyclic compounds.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):
19. Mid Term Examination: 20
20. End Term Examination: 60
21. Continuous Internal Assessment: 20

Course Contents

UNIT-I

Drug Design: Introduction: Drugs: Drug design, Classification of drugs, brief discussion of drug targets, Drugs based on enzyme inhibition: penicillin antibiotics and sulphonamides (Mechanism of drug action). Concepts of antagonist, agonist, prodrugs, pharmacokinetics and pharmacodynamics, concept of structure-activity relationship (SAR) with special reference to penicillin antibiotic and sulphonamides.Synthesis and mechanism of action of (i) fluoroquinolones – norfloxacin, antihypertensive agent – captopril, calcium channel blocker – amlodipine.

UNIT-II

Supramolecular Chemistry: Introduction, Origins and Concept. Molecular recognition. Host-guest complex. Self-assembly, Supramolecular interactions (Bonding other than covalent bond) van der Waal interactions, dipole-dipole, pi-pi interactions. Different types of receptors with special reference of Crown ethers, cryptanes,Cyclodextrins and Calix[4]arene. Applications of supramolecular chemistry.

UNIT-III

Heterocyclic Chemistry: Systematic nomenclature of heterocycles. Principles of heterocyclic synthesis with special reference to aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes, coumarins and chromones.

Course Articulation Matrix of CCS526- Review of Literature/ Research Proposal

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	3	2	1	2		1	2	3
CO2	1	3	2	1		2	3	2
CO3	3	2	3	1		1	2	2
CO4	2	3	1	2		1	2	3

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS527
Course Name: **IKS**
Course Instructor: Dr. Pramod Kumar
Credits: **Total**2 credit

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

On completion of this course, the students will be able to learn:
1. know about the life history of C.V. Raman and P C Ray.
2. Understanding of the Raman effect and its consequences.
3. Will get to know the relation of P C Ray with ancient texts.
4. knowledge about the contribution of two great scientists for the development of science.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1]know about the life history of C.V. Raman and P C Ray.
CO[2] Understanding of the Raman effect and its consequences
CO[3] Will get to know the relation of P C Ray with ancient texts.
CO[4] knowledge about the contribution of two great scientists for the development of science.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):

Mid Term Examination: 20
End Term Examination: 60
Continuous Internal Assessment: 20

Unit 1
Raman spectroscopy: Brief history of C. V Raman, National Science Day, scientific contributions of C.V Raman: musical sounds and blue colour of the sea, Discovery of Raman Effect, Principle, applications and uses of Raman spectroscopy, Research publication-based studies of Raman spectroscopy.

Unit 2
A brief history of P C Ray and his contribution to chemical sciences, the significance of his research work, Father of Indian chemistry, interest in ancient texts, various achievements, History of Hindu Chemistry: P C Ray, the relation of P C Ray with the pharmaceutical sector.

Reference Book(s)
1. Tripathi, V. Ed. Archaeometallurgy in India, (Cambridge University Press, 1998).
2. Singh, M. V. and Shrivastava, B. B. Science and technology in ancient India, (Centrum Press, New Delhi, 2011).
3. Chattopadhyay, D. P. History of Science and technology in Ancient India, (Firma KLM Kolkata, 1986).
4. Ray, P. C. History of Chemistry in ancient and medieval India, (Indian Chemical Society, Kolkata, 1956).

Course Articulation Matrix of CCS527- IKS

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	1	2	2		1	3	3
CO2	3	3	2	2		3	2	2
CO3	2	2	3	3		2	3	3
CO4	1	2	1	2		3	3	1

Course Code: CCS 611
Course Name: Inorganic chemistry Specialization I
Course Instructor:
Credits: 4
Course Objectives:

- To understand the aspects of NMR spectroscopy such as Nuclearoverhausser effect, Double resonance, Chemical exchange, Lanthanide shift reagents and NMR spectra of paramagnetic ions.
- To understand the concepts of Nuclear Quadrupole Resonance, Nuclear electric quadrupole moment, Electric field gradient, Energy levels and NQR frequencies and Effect of magnetic field on spectra.

- To understand the concept of Mössbauer Spectroscopy and application of MB spectroscopy in structural determination.
- To understand the concept of Electron Spin Resonance Spectroscopy such as Hyperfine coupling in methyl, benzene and Naphthalene radicals, Factors affecting the magnitude of g-values. Zero field splitting and Kramer's Degeneracy.

Course Outcomes:

The students will be able to

CO[1]Explain different aspects and processes of NMR spectroscopy.

CO[2]Understand the concepts of Nuclear Quadrupole Resonance, Nuclear electric quadrupole moment, Electric field gradient, Energy levels and NQR frequencies and Effect of magnetic field on spectra.

CO[3]Explain the structure on the basis of Mössbauer Spectroscopy.

CO[4]Explain the concept of hyperfine splitting and structure on the basis of ESR spectroscopy.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

UNIT-I

Nuclear Magnetic Resonance Spectroscopy: Introduction to Nuclear Magnetic Resonance, Chemical shift, Mechanism of electron shielding and factors contributing to the magnitude of chemical shift, Nuclearoverhausser effect, Double resonance, Chemical exchange, Lanthanide shift reagents and NMR spectra of paramagnetic ions. Contact shifts. Experimental technique (CW and FT).

UNIT-II

Nuclear Quadrupole Resonance Spectroscopy: Basic concepts of NQR (Nuclear electric quadrupole moment, Electric field gradient, Energy levels and NQR frequencies), Effect of magnetic field on spectra, Factors affecting the resonance signal (Line shape, position of resonance signal) Relationship between electric field gradient and molecular structure.

UNIT-III

Mössbauer Spectroscopy: Introduction**,** Principle, Conditions for Mössbauer Spectroscopy, parameters from Mössbauer Spectra, Isomer shift, Electric Quadrupole Interactions, Magnetic Interactions MB experiment, Application of MB spectroscopy in structural determination

Photo electron Spectroscopy: Basic Principle of Photo electron Spectroscopy.

UNIT-IV

Electron Spin Resonance Spectroscopy: Introduction, Similarities between ESR and NMR, Behavior of a free electron in an external Magnetic Field, Basic Principle of an Electron Spin Resonance Spectrometer, Presentation of the spectrum, Hyperfine coupling in Isotropic Systems (Hydrogen, methyl, benzene and Naphthalene radicals). Factors affecting the magnitude of g-values. Zero field splitting and Kramer's Degeneracy, Line width in solid state ESR, Double resonance technique in e.s.r. (ENDOR) Applications of ESR

Suggested books:

1. Paula K Bruice, Organic Chemistry, 8th Edition, Pearson.
2. Jag Mohan, Organic spectroscopy, Narosa Publishing House.
3. Y. R. Sharma, Elementary Organic Chemistry, S. Chand.
4. B.R.Puri, L.R.Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing Company
5. Gurdeep R. Chatwal, Sham K. Anand, Instrumental methods of Chemical analysis, Himalaya Publishing House.
6. B.K. Sharma, Instrumental methods of Chemical analysis, GoelPublishing House.

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	2	3	3		2	2	3
CO2	3	2	2	3		3	3	2
CO3	2	2	3	3		3	2	3
CO4	2	2	3	3		2	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: **CCS 612**
Course Name: **Organic Chemistry Specialization I**
Course Instructor:
Credits: Total 4 credits

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To know about terpenoids, alkaloids and steroids
- Making the synthetic schemes for the compounds belonging to this class
- Knowing the properties of these compounds.
- Drawing the retro-synthetic routs for such compounds.
- To know the laboratory synthesis of specific compounds falling in this category.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1 To know the basic properties of terpenoids, alkaloids and steroids
CO^2 Identify the synthetic routes for few specific compounds belonging to this class.
CO^3 Apply the knowledge to draw the synthetic schemes for compounds such as cholesterol, progesterone etc.
CO^4 To know the biosynthesis of these compounds

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 4 credit theory part):
22. Mid Term Examination: 40
23. End Term Examination: 120
24. Continuous Internal Assessment: 40

Course Contents

UNIT-I
Terpenoids and Carotenoids: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination and synthesis of citral, geraniol, camphor, farsenol, santonin, abetic acid.

UNIT-II
Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, general methods of elucidation, degradation, classification based on nitrogen heterocyclic ring, Strucuture and synthesis of epheridine, nicotine, atropine, morphine.

UNIT-III
Steroids: Occurrence, nomenclature, Diel's hydrocarbon and stereochemistry. Isolation, structuredetermination and synthesis of Cholesterol, Androsterone, testosterone, estrone, progesterone.

UNIT-IV
Plant Pigments: Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Anthocyanins (Cyanin and pelargonidin), polyphenols: Flavones (chrysin), Flavonols (quercitin) and isoflavones (daidzein) coumarin, Quinones (lapachol), Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	3	1	3	2		2	3	1
CO2	1	2	1	1		1	1	3
CO3	2	1	2	3		3	3	2
CO4	2	2	2	3		3	1	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS613
Course Name: **PHYSICAL SPECIALIZATION-I**
Course Instructor: Dr. Pramod Kumar
Credits: **Total**4 credit

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course enables the students

- To knowledge about symmetry element and matrices.
- To apply the concept of group theory.
- To learn the concept of Great orthogonality theorem and character table and their applications.
- To understand the various laws in electrochemistry.
- To know about hydrogen fuel cells and other types of fuel cells and other energy storage devices.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1]Describe about symmetry element and matrices
CO[2] Illustrate the concepts in the group theory
CO[3] Describe about the connection of the Great orthogonality theorem and character table.
CO[4] Understand the various laws in electrochemistry.
CO[5]Identify the electronic transition and apply the concept of Jablonski diagram to predict the overpotential properties.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 4 credit theory part):
25. Mid Term Examination: 40
26. End Term Examination: 120
27. Continuous Internal Assessment: 40

UNIT-I *Group Theory-I:*

The concept of group, Symmetry elements and symmetry operations, Symmetry properties of atomic orbital, Elements of group theory: groups, subgroups, classes and characters, classes of symmetry operations, symmetry point groups; representation of groups by matrices, Representation of symmetry operator transformation of basis vector, Symmetry transformation of operators; The Great Orthogonality Theorem (without proof) and its consequences; construction and applications of character tables, representation of cyclic groups. Assignment of point groups to Inorganic molecules, Some general rules for multiplications of symmetry operations, Multiplication tables for water and ammonia, Representations (matrices, matrix representations for C2V and C3V point groups irreducible representations), Character and character tables for C2V and C3V point groups.

UNIT-II *Group Theory-II:*
Applications of group theory to chemical bonding (hybrid orbitals for σ-bonding in different geometries and hybrid orbitals for π-bonding.Symmetries of molecular orbitals in BF3, C2H4 and B2H6.
Application of Group Theory in Vibrational Spectroscopy: A brief idea about Infrared and Raman scattering spectroscopy. Vibrational modes as basis of group representations w.r.t. SO2, POCl3, $PtCl^{2-}4$ and RuO4, Mutual exclusion principle, Classification of vibrational modes (i.e. stretching and angle deformation vibrations w.r.t. SO2, POCl3 and $PtCl^{2-}4$.

UNIT III: *Electrochemistry-I :*
Kohlrausch law of independent migration of ions. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers.

UNIT IV: *Electrochemistry-II :*

Elcetrochemistry of solutions: Ionic atmosphere, Debye-Huckel theory for the problem of activity coefficient, Debye-Huckel limiting Law, Debye-Huckel equation for appreciable concentration, Debye-Huckel Onsagar conductance equation and its extension to ion solvent interations, Debye-Huckel Bjerrum mode, Ion association, triple ions, triple ions and conductance minima. Thermodynamics of electrified interface, derivation of electro capillary Lipmann's equation, surface excess, thermodynamic aspects of surface excess. The method of determination and measurement of interfacial tension as a function of applied potential difference across the interface. Structure of electrified interface: Helmholyz theory, Guoy-Chapman theory, Stern model. Overpotential: Concentration overpotential and activation overpotential, Derivation of Butlervolmer equation. Electrocatalysis: Definition and Influence of various parameters. Polarography: Ilkovic equation, half wave potential and its significance, qualitative and quantitative estimation of metal ions. Semiconductor- solution interface: Theory of double layers at semiconductor- electrolyte interface.

SUGGESTED READINGS :

1. Raman, K.V. (2002). Group Theory and its Applications to Chemistry. New Delhi: Tata McGraw Publishing Company.

2. Cotton, F. A. (2003). Chemical Applications of Group Theory (III Edition). Texas:
A Wiley Inter Science Publication.
3. Veera Reddy, K. (2009). Symmetry and Spectroscopy of Molecules. New Delhi:
New Age International Pvt. Ltd.
4. Bahl, A., Bahl, B. S., & Tuli, G. D, (2014). Essentials of Physical Chemistry (VEdition).
New Delhi: S. Chand & Company.
5. Puri, B.R., Sharma, L.R., & Pathania, M.S. (2015). Elements of Physical Chemistry.
Jalandhar: Vishal Publishing House.
6. Laidler, K. J. (2004). Chemical Kinetics (III Edition). New Delhi: Pearson Education
Publishing. Indian Branch.
7. Gurdeep Raj, Chemical Kinetics, Goel Publishing House.
8. A.A.Frost and R.G.Pearson, Kinetics and Mechanism, Wiley Eastern, Pvt. Ltd.

Course Code: CCS 614
Course Name: Research Methodology
Course Instructor:
Credits: 4

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- Identify and discuss the role and importance of research in the social sciences.
- Identify and discuss the issues and concepts salient to the research process.
- Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project.
- Identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting.
- To understand the format of primary data collection instruments.
- To understand field work problems and techniques.
- To be able to construct basic samples for use in marketing studies and learn how and when to use different sampling techniques.
- To understand and use basic data analysis techniques.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1] Understand some basic concepts of research and its methodologies, identify appropriate research topics
CO[2] Select and define appropriate research problem and parameters
CO[3] Prepare a project proposal (to undertake a project)
CO[4] Organize and conduct research in a more appropriate manner.
CO[5] Build on their knowledge and understanding in tackling more advanced and specialised courses, and more widely to pursue independent, self-directed and critical learning.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
28. Mid Term Examination: 40
29. End Term Examination: 120
30. Continuous Internal Assessment: 40

Course Contents:

Unit–I
Meaning of research; Objectives of Research; Types of Research; Significance of Research, Research and Scientific Method, Research Process, Criteria of good research, Problems encountered by Researchers in India. What is research Problem, Selecting the Problem, Necessity and defining the Problem, Techniques involved in defining the Problem.

Unit–II
Hypothesis: Meaning, Characteristics, and importance of hypothesis in Research, Types and testing of Hypothesis, Problems in Formulating Hypothesis. Research Design: Meaning of Research Design: Need for Research Design, Features of a good Research Design, Types of Research Design: Exploratory, Descriptive, Diagnostic and Experimental.

Unit-III
Sampling Design; Census and Sampling Method, Area of Study, Universe of Study, Sample Design, Steps in Sampling design, Criteria for Selecting a Sampling Procedure; characteristics of a good sample design, Types of Sampling method.

Unit– IV
Techniques of Data collection; collection of Primary data; Questionnaire, Schedule, Interview, Observation, Case Study, Survey Method, Content Analysis, Collection of Secondary Data.Thesis writing, Book review, references and Preparation of Bibliography.

Reference Books:
C R Kothari, GauravGarg, "*Research Methodology: Methods and Techniques*", 4th edition, New Age International Publishers.
A ThangamaniRamalingam, SN Senthil Kumar, *"Essentials of Research Mrthodology*", Jaypee Brothers Publishers, 2019.

Dr. Baidyanath Mishra, Ashok Kumar Stapathy, Sujata Mishra, "*Research Methodology: Methods, Approaches & Techniques*", ChaukhambaOrientalia Publishers, 2018 Edition.

Suggested Readings:

Dr. S. Sachdeva, "*Research Methodology*", LaxminarayanAggarwal Publishers, 2022 Edition.

BL Aggarwal, "*Comprehensive Research Methodology*", 1st edition, New Age International (P) Ltd Publishers, 2015 edition.

Course Articulation Matrix of CCS 614; Research Methodology

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	2	3	2		3	3	2
CO2	2	3	2	1		2	2	3
CO3	1	2	1	3		3	3	2
CO4	2	1	2	3		2	1	3
CO5	3	2	3	1		2	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS615
Course Name: **SOFTWARE BASED DATA ANALYSIS**
Course Instructor: Dr. Pramod Kumar
Credits: **Total**4 credit

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course enables the students

- To provide knowledge about Turnitin
- To understand the Origin
- To impart the knowledge about how to draw the structures in Chem draw
- To provide the fundamental knowledge of laws of Quantum mechanics to predict energies, molecular structures and spectroscopic data by using gaussian software

Course outcomes

CO^1To check the plagiarism by using Turnitin
CO^2 To apply their knowledge to conclude their data into graphical representation.
CO^3 To make chemical structures of compounds by using chem draw..

CO^4 To understand that Guassian is a visualizing tool used to build molecules.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 4 credit theory part):
31. Mid Term Examination: 40
32. End Term Examination: 120
33. Continuous Internal Assessment: 40

UNIT-I

TURNITIN SOFTWARE :web-based plagiarism detection software by the site Turnitin.com., to use Turnitin, to analyze the result after the plagiarism checking.

UNIT II:
ORIGIN :To plot 2D, 3D graphs from Excel sheet.

UNIT III:
CHEM DRAW: To modify images of chemical structures in 2D, 3D structures.

UNIT IV:

GUASSIAN: Utilizes fundamental laws of quantum mechanics to predict energies, molecular structures, spectroscopic data (NMR, IR, UV, etc) and much more advanced calculations

SUGGESTED READINGS :

I. *"Liborigin"*.
II. ^ Review article in Journal of Cheminformatics, Jan 2018
III. ^ *"Origin Viewer"*.
IV. *Halford, Bethany (2014). "Reflections On ChemDraw". C&EN. **92** (33): 26–27. doi:10.1021/cen-09233-scitech1. Retrieved 20 August 2014.*
V. ^ Announcing CambridgeSoft from Perkin Elmer

Course Articulation Matrix of CCS615 - SOFTWARE BASED DATA ANALYSIS

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3

CO1	2	3	3	2		2	3	2
CO2	3	3	2	2		3	2	3
CO3	1	2	1	3		1	3	1
CO4	2	3	2	2		3	2	2

Course Code: CCS 616
Course Name: Review of Literature/ Research Proposal
Course Instructor:
Credits: Total 8 credits (2 Theory+5 Practical Part + 1 presentation in the end)

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To know the importance of literature review.
- To became familiar with different search engines used for scientific literature search.
- To become familiar with the concept of journals, research books and reviews.
- To know what is difference between research proposal and research paper.
- Knowing the strategies to compile the research work in the form of research papers and research proposals.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1 perform the proper literature search.
CO^2 Identify good publishers for publishing their research work.
CO^3 Apply their literary knowledge to formulate a research proposal.
CO^4 Learn the difference between research paper, review article and research proposal.
CO^5 Develop a deep understanding for formulation their research objectives.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):
Mid Term Examination: 20
End Term Examination: 60
Continuous Internal Assessment: 20

Course Contents
1. Theory Part: Review of Literature/ Research Proposal (Credits 2):

UNIT – I: Literature Review

Importance of literature review, Classification of literature into primary and secondary sources, Difference between primary and secondary sources, various tools for doing literature search specifically the Sci finder and Google scholar.

UNIT –II: Research Proposal, Publications and dissertation

Basic information of a research publication. Types of research publications specifically the original research articles and reviews. Basic information of a research proposal. Different components of a research proposal, Difference between publication and proposal. Different components of a student dissertation and critical points to cover in each section.

Prescribed Text Book:

Advanced Organic Chemistry: Reactions, Mechanisms and Structure Paperback – Student Edition, 12 December 2006

- Publisher : Wiley; 4th edition (12 December 2006)
- Language : English
- Paperback : 1512 pages
- ISBN-10 : 8126510463
- ISBN-13 : 978-8126510467

Part-2: Research work (Credits 5)

It will involve the Research work by the student on some specific problem. The outcome of the work has to be submitted in the form of dissertation.

Part-3 Presentation of report after submission (Credit 1)

The students will have to present their work in the form of presentation in the end of semester after the compilation of dissertation.

Course Articulation Matrix of CCS616 - Review of Literature/ Research Proposal

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	1	3	2	2	3	2
CO2	1	2	1	1	1	1	3
CO3	1	2	1	3	3	3	2
CO4	2	1	2	3	2	1	3
CO5	1	2	3	3	2	3	*1*
CO6							

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS 621
Course Name: Inorganic chemistry Specialization II
Course Instructor:
Credits: 4

Course Objectives:

- To understand the nomenclature and shapes of compounds on the basis of electron rule.
- To understand thevarious types of interactions between the molecules.
- To understand different shapes of boranes i.ecloso-, nido-, arachno on the basis of Wade rule.
- To understand the shapes and reactions of cluster compounds.
- To understand the reaction and mechanism of various reactions as well as theories of Trans effect.
- To understand the reaction and mechanism of organometallic compounds by using the concept of catalysis.

Course Outcomes:

The students will be able to

CO[1]Explainnomenclature and shapes of compounds on the basis of electron rule.
CO[2] Understand and explain the concepts the various types of interactions between the molecules
CO[3] Explain the shapes of boranes i.ecloso-, nido-, arachno on the basis of Wade rule..
CO[4] Explain the reaction and mechanism of various reactions as well as theories of Trans effect.
CO[5]Explain thereaction and mechanism of organometallic compounds by using the concept of catalysis.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

UNIT I:Organometallic Chemistry

The 18- electron rule for organometallic compounds of transition metals: Classification based on 18- electron rule: complexes of two, three, four, five six, seven, eight-electron pi-ligands:

nomenclature. Exceptions to 18 electron rule: the 16-electron rule. Agostic interaction, Isolobal and isoelectronic relationship of complexes. Elementary idea about homoleptic and non-homoleptic compounds: oxidative addition and reductive elimination reaction: insertion. Direct combination of carbon monoxide and metal.

UNIT II:Molecular Clusters and cages

Metal-carbonyl clusters, types, structures, the closo-, nido-, arachno-boranes, Wades rule, capping. Clusters having interstitial main group elements, halide type cluster, cubane clusters and naked or Zintl clusters. Molecular clusters in catalysis, boron-carbides and metal borides. Synthesis of heteronuclear metal carbonyls.

UNIT III Inorganic Reactions and Mechanism:

Substitution reactions in octahedral complexes, acid hydrolysis reactions, base hydrolysis and anation reactions, substitution reaction, reactions occurring without rupture of metal-ligand bond. Substitution reactions of square planar complexes. Theories of trans-effect and application, labile and inert complexes. Mechanism of redox reactions.

UNIT IV: Advanced Organometallic Chemistry

Catalysis by organometallic compounds: Tolman Catalytic loop, Hydrogenation, Wilkinson Catalyst, Polymerization -Zieggler Natta catalysis, Phase transfer catalyst (PTC), Synthesis gas-Water gas shift reaction, Hydroformylation (Oxo process), Monsanto Acetic Acid process, Walker process, Synthetic gasoline – Fischer Tropsch process and metatheses reaction.

Suggested books:

8. J.E.Huheey, E.A.Keiter and R.L.Keiter, Inorganic Chemistry –4th Edn, Pearson.
9. B.R.Puri, L.R.Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Company.
10. J.D.Lee, Concise course in Inorganic Chemistry, Wiley.
11. R.C.Mehrotra, A. Singh, Organometallic Chemistry, New Age International.
12. B D Gupta, A J Elias, Basic Organometallic chemistry, 2nd edition, Universities press.
13. F.A Cotton & G. Wilkinson, Advanced Inorganic Chemistry:,VthEdn., Wiley-Interscience, New York

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	3	1	2	3	2	2	3
CO2	3	3	2	3	2	3	2
CO3	2	2	3	3	3	3	2
CO4	2	2	3	3	2	3	2
CO5	3	3	2	2	2	3	3

1. Partially Related
2. Moderately Related
3. Highly Relate

Course Code: CCS 622
Course Name: Organic Chemistry SpecializationII
Course Instructor:
Credits: 4

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

- To impart knowledge about Pericyclic reactions and there classification.
- To understandbasic idea about FMO and PMO approach.
- To impart the knowledge of Cycloaddotion, Sigmatropic and Electrocyclic reactions along with Cope, Claisen, and Aza-cope rearrangement.
- To impart knowledge about Conrotation and Disrotation in 4n and 4n+2 system.
- To understand Jablonski diagram - Norish I &Norish II reaction.
- To understand various rearrangements like Paterno-Buchi reaction, Barton reaction.
- To understand oxidation of Alkenes, Ketones, Allylic system and Alcohols and oxidation by using various oxidizing agents Ruthenium tetroxide, Iodobenzenediacetate, and Thallium (III) nitrate.
- To understand reduction reactions of Alkenes, catalytic reduction, Birch reduction and reduction by using reducing agents ($NaBH_4$, lithiumtrialkoxyaluminium hydride, DIBAL, Sodiumcyanoborodydride, Sodium triacetoxyborodydride, Trialkylborohydrides etc.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1 To form the stereochemically different product.
CO^2 To easily do rearrangements in case of complex structure with 4n and 4n+2 system.
CO^3 Understand the effect of light on various organic compounds like Butadiene, 1, 3, 5 - hexatriene systems
CO^4 To learn oxidation and reduction of alkenes and ketones with different reagents.
CO^5 Apply their literary knowledge to find the desired product by having knowledge about different reagents and effect of rearrangement and light on various reactions.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Course Contents:

UNIT I:Pericyclic Reactions

Molecular orbital symmetry, frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl systems. Classification of pericyclic reactions. Woodward – Hoffmann correlation diagrams. FMO and PMO approach, concept of aromaticity of pericyclic transition states. Selection rules and stereochemical aspects of electrocyclic reactions, cycloaddition and sigmatropic shifts. Electrocyclic reactions: conrotatory and disrotatory motions, 4n, 4n+2. Cycloaddition reactions: antarafacial and suprafacial additions, 4n and 4n+2 systems; 2, 2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements: suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3-sigmatropic rearrangements. Cope, Claisen and aza-Cope rearrangements. Fluxional tautomerism.Ene reaction.

UNIT II Photo chemistry

Photo chemistry – Introduction to photochemistry.cyclisation reaction and ring opening of 1, 3 Butadiene, 1, 3, 5 hexatriene systems.Jablonski diagram - Norish I &Norish II reaction, quantum yield.Primary & Secondary, photochemical reactions, Rearrangement – PaternoBuchi reaction. Barton reaction di-pi methane rearrangement, Photo reduction of ketones, Photo Fries rearrangement

UNIT III:Oxidation reactions

Introduction, Oxidation of hydrocarbons (Oxidation of alkenes: oxidation of carbon-carbon double bonds to epoxides (epoxidation) and diols, Woodward and Prevost Reaction, wacker process, Lemieux reagents, Oxidation of saturated hydrocarbons, Etard reaction, Oxidation at allylic positions, oxidation of alcohols by various reagents and methods, oxidation of ketones. Oxidation with ruthenium tetroxide, iodobenzenediacetate, and thallium (III) nitrate.

UNIT IV:Reduction reactions

Introduction, reduction of hydrocarbons, alkenes, Catalytic hydrogenation, homogeneous, heterogeneous hydrogenation, selectivity of reduction, di-imides, reduction of functional groups, Reduction by dissolving metals-reduction with metal and acid, reduction of carbonyl compounds, Birch reduction. reduction of epoxides, reduction by hydride transfer reagents, LAH and $NaBH_4$, lithiumtrialkoxyaluminium hydride, diisobutylaluminiumhydride (DIBAL), sodiumcyanoborodydride, sodium triacetoxyborodydride, trialkylborohydrides. Other methods-desulphurisation of thio-acetals (mozingo reaction), low-valent titanium species, trialkyltinhydrides.

Prescribed Text Books:

Jonathan clayden, Nick Greeves, Stuart warren, Organic chemistry, second edition, 2012.

P.S.Kalsi, Stereochemistry: Conformation and Mechanism, 9th edition, 2017.

Jerry March, John Wiley, Advanced Organic Chemistry-Reactions, Mechanism and Structure, 2013.

Jagdambasingh and Jaya singh, Photochemistry and pericyclic reactions, 2005.

Suggested Reading:

S.M. Mukherji and S.P. Singh, Organic Reaction Mechanism, Macmillan India Ltd., 1990.

S.P. Singh, Sunil Kumar, and Vinod Kumar, Pericyclic Reactions: A Mechanistic and Problem-Solving Approach, 2015.

Course Articulation Matrix of CCS 622; Organic Chemistry SpecializationII

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	2	3	2		1	3	2
CO2	1	3	1	2		2	1	3
CO3	2	2	2	3		3	3	2
CO4	2	1	2	3		2	1	3
CO5	2	2	3	2		2	3	2

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS623
Course Name: PHYSICAL SPECIALIZATION-II
Course Instructor:
Credits: Total 4

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course enables the students

- To learn knowledge about Nuclear Quadruple Resonance (NQR) spectroscopy.
- To understand about Electron Spin Resonance (ESR) spectroscopy.
- To understand the basic concept of NMR spectroscopy
- To apply the different aspects of NMR spectroscopy to predict the structure of compounds.
- To analyze about the photoelectron spectroscopy and Mossbauer spectroscopy.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1]Recognize the basic concepts of Nuclear Quadruple Resonance (NQR) spectroscopy

CO[2] Understand the valuable concepts in NMR spectroscopy.

CO[3] Discuss the basic knowledge about Electron Spin Resonance (ESR) spectroscopy.

CO[4] Experiment the different aspects of NMR spectroscopy to predict the structure of compounds..

CO[5]Differentiate the photoelectron spectroscopy and Mossbauer spectroscopy.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 4 credit theory part):
Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Principles & Basic Instrumentation of NMR/ESR/NQR/Mossbauer Spectra and Photochemistry

UNIT I: ***Nuclear Magnetic Resonance (NMR) Spectroscopy*****:** Basic instrumentation, nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift, and its measurements, factors influencing chemical sift, deshielding, spin-spin interactions, factors influencing coupling constant `J`. Classification of molecules: (ABX, AMX, ABC, A2B2, etc. types), spin decoupling. FT NMR (qualitative idea) and its advantages, Applications of NMR in medical diagnosis.

UNIT II: ***Electron Spin Resonance (ESR) Spectroscopy*****:** Basic principles, zero field splitting, and Kramer`s degeneracy, factors affecting the `g` value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship.

UNIT IIII: ***Nuclear Quadruple Resonance (NQR) Spectroscopy*****:** Qudrupole nuclei, qudrupole moments, electric field gradient, coupling constant. hyperfine splitting in various systems, factors affecting, hyperfine coupling constants, zero-field splitting and Kramers' degeneracy, nuclear quadrupole interactions, Application.

UNIT IV: ***Mössbauer (MB) Spectroscopy*****:** Gamma ray emission and absorption by nuclei, Mössbauer effect, Isomer shift, quadrupole splitting, Application to the elucidation of structure and bonding of FeIII and FeII, SnIV and SnII compounds, detection of oxidation states and inequivalent MB atoms. Basic principle, instrumentation, spectral parameters and spectrum display, qudrupole and magnetic interactions.
Photoelectron spectroscopy**:** Photo-excitation and photo-ionization. Core level and valence level photo-ionization (XPS, UV-XPS). Detection of atoms in molecules, chemical shift. Applications.

SUGGESTED READINGS :

1. Jag Mohan. (2018). Organic Spectroscopy: Principles and Applications (II Edition).

New Delhi: Narose Publishing House.

2. Kemp, W. (2017). Organic Spectroscopy (III Edition). New York: Palgrave Macmillan.

3. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical Applications (Revised V Edition). New Delhi: S. Chand & Company Limited.

4. Silverstein, R. M., Webster, F. X., & Kiemle, D. (2014). Spectroscopy of Organic Compounds (VIII Edition). New York: John Wiley & Sons.

5. Levine, I. N. (2013). Quantum Chemistry (VII Edition). New Delhi: Pearson Education Pvt. Ltd.

6. Drago, R.S. (2012). Physical Methods in Inorganic Chemistry. New York: East- West Press Pvt. Ltd.

7. Banwell.,(2017). Fundamentals of Molecular & Spectroscopy (IV Edition), McGraw-Hill Education (India) Pvt. Limited.

Course Articulation Matrix of CCS623 - PHYSICAL SPECIALIZATION-II

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	2	3	3	2		2	3	2
CO2	3	3	2	2		3	2	3
CO3	1	2	1	3		1	3	1
CO4	2	3	2	2		3	2	2
CO5	3	2	3	1		2	3	3

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: CCS624
Course Name: **ACADEMIC WRITINGS**
Course Instructor: Dr. Pramod Kumar
Credits: 2 credit

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course enables the students

- To write a research proposal.
- To conduct rigorous academic research and to express your ideas clearly in an academic format
- To use reference tools.

Course Outcomes: After the successful completion of this course, the student will be able to

CO[1]To write research and review papers in proper manner
CO[2] To compile their lab work into thesis or research paper.
CO[3] To provide proper citation in order make their paper plagiarism free.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 2 credit theory part):
Mid Term Examination: 20
End Term Examination: 60
Continuous Internal Assessment: 20

UNIT-I

INTRODUCTION TO RESEARCH: introduction of academic and research writing , structure and components of scientific report:, types of academic writing (descriptive, persuasive and critical)

UNIT II:

ACADEMIC WRITING: different steps in writing: layout, structure and language of typical reports , citation style, illustrations and tables, bibliography, refrencing nad foot notes, importance of effective communication, difference between content writing and academic writings, format of academic writings with proper citation.

SUGGESTED READINGS :

1. Stephen B. Heard. The scientist's Guide to writing: how to write more easily and effectively throughout here scientific career, Princeton University press (2016)
2. John.M Swales, Christine B. Feak. Academic Writing for graduate student: Essential Tasks and Skills, University of Michigan press (2012)

Course Articulation Matrix of CCS624 - ACADEMIC WRITINGS

Course Outcomes	Programme Outcomes	Programme Outcomes	Programme Outcomes	Programme Outcomes		Programme Specific	Programme Specific	Programme Specific

	1	2	3	4		Outcomes 1	Outcomes 2	Outcomes 3
CO1	1	2	3	2		2	3	2
CO2	2	2	3	2		3	2	3
CO3	3	3	2	3		1	3	1

Course Code: CCS626
Course Name: Subject based data analysis and interpretation
Course Instructor:
Credits: 4 credits

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)
Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria (For 4 credit theory part):
Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40