Course Matrix and Syllabus (Semesters I and II)

Five Year Integrated B.Sc.(Hons.)-M.Sc. Program in Chemistry

(under CBCS, *w.e.f.* Academic Session 2020-2021)

Offered By

Department of Chemistry and Chemical Sciences

CENTRAL UNIVERSITY OF JAMMU
Rahya-Suchani (Bagla), District-Samba
Jammu-181143, (J&K) India

Course Matrix for Five Year Integrated B.Sc.(Hons.)-M.Sc. Chemistry
Semesters I to VI
w.e.f. Academic Session 2020-2021

Semester	Core Course (CC)		Ability Enhancement Compulsory Course (AECC)		Ability Enhancement Elective Course (AEEC) (Skill Based)		Discipline Specific Elective (DSE)		Generic Elective (GE)		Total
	Theory	**Lab**	**Theory**	**Lab**	**Theory**	**Lab**	**Theory**	**Lab**	**Theory**	**Lab**	
I	8	4	2	-	-	-	-	-	4	2	20
II	8	4	2	-	-	-	-	-	4	2	20
III	12	6	-	-	2	-	-	-	4	2	26
IV	12	6	-	-	2	-	-	-	4	2	26
V	8	6	-	-	-	-	8	2	-	-	24
VI	8	2	-	-	-	-	8	6	-	-	24
Total (I-VI)	56	28	4	-	4	-	16	8	16	8	140

Course Type	Code
Core Course	CC
Ability Enhancement Compulsory Course	AC
Ability Enhancement Elective Course (Skill Based)	AE
Discipline Specific Elective	DE
Generic Elective	GE

Semester – I

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
ICCHM1C005T	Inorganic Chemistry-I	CC	4	3-1-0
ICCHM1C006T	Organic Chemistry-I	CC	4	3-1-0
ICCHM1C006L	Inorganic Chemistry Lab-I	CC	2	0-0-4
ICCHM1C007L	Organic Chemistry Lab-I	CC	2	0-0-4
ICPHY1E001T	Physics	GE	4	3-1-0
ICPHY1E001L	Physics Lab	GE	2	0-0-4
ICECL1F002T	English	AC	2	2-0-0
	Total		20	

Semester – II

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
ICCHM2C005T	Physical Chemistry-I	CC	4	3-1-0
ICCHM2C006T	Inorganic Chemistry-II	CC	4	3-1-0
ICCHM2C006L	Physical Chemistry Lab-I	CC	2	0-0-4
ICCHM2C007L	Inorganic Chemistry Lab-II	CC	2	0-0-4
ICAMT2E001T	Mathematics	GE	4	3-1-0
ICCHM2E001L	Laboratory Safety and Utility Tools Lab	GE	2	0-0-4
ICEVS2F001T	Environmental Science	AC	2	2-0-0
	Total		20	

Examination Pattern

Course	Credit	CIA	MSE	ESE	Max. Marks
Theory	4	25	25	50	100
Theory	2	12.5	12.5	25	50
Practical	2	25	-	25	50

L	T	P	C
3	1	0	4

Course: Inorganic Chemistry-1
Course Code: ICCHM1C005T

Course Objectives:

This course enables the learners to understand the basic concepts, fundamental principles and theories of atomic structure, quantum numbers and concept of chemical bonding, structure and properties of ionic compounds.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Write the electronic configuration of given atomic number and recognizing the shapes of orbitals.
- Calculate the bond order and draw the geometries of different molecules.
- Describe the periodic table and demonstrate the trends in the physical and chemical properties of elements.
- Explain how chemical elements are arranged in periodic table.
- Design and carry out scientific experiments and quantitatively perform acid-base and Redox titrations.
- Describe the chemical combination of atoms with other atoms forming molecules.

Semester: I
Course Name: Inorganic Chemistry-I
Course Code: ICCHM1C005T **4 Credits (3-1-0)**

UNIT – I **12 hours**

Atomic structure-I: Characteristics of Black-body radiation, Planck's radiation law, Photoelectric effect, Compton effect, Bohr's model of hydrogen atom and its limitations, Rutherford's atomic model, Bohr's theory, Dual nature of electrons, de Broglie hypothesis and its derivation, Heisenberg's uncertainty principle.

UNIT – II **12 hours**

Atomic structure-II: Schrodinger wave equation and its importance, Physical interpretation and significance of Ψ and Ψ^2, Radial and angular wave functions, Probability distribution curves, Quantum numbers and their significance, Atomic orbitals, Shapes of *s*, *p*, *d* and *f* atomic orbitals and their characteristics, Aufbau and Pauli exclusion principles, Hund's multiplicity rule and (*n*+*l*) rule, Electronic configurations of elements (*s*, *p* and 3*d*-block elements), Effective nuclear charge and shielding effect, Slater's rule, Calculation of screening constant.

UNIT – III **12 hours**

Periodic table and periodicity: Periodic table and periodic properties, Long form of periodic table, Classification of elements as main group, transition and inner transition elements, Periodic properties: Atomic radius, Covalent, Ionic and van der Waals radii, Ionization energy, Electron affinity, Electronegativity: Definition, Methods of determination-Pauling's, Mulliken's and Allred-Rochow's scales, Numerical problems, Inert pair effect.

UNIT – IV **12 hours**

Chemical bonding-I: Covalent Bond, Valence bond theory and its limitations, Basic concept of resonance, Bond angles and shapes of molecules and ions, Directional characteristics of covalent bond, Bent's rule, Various types of hybridization and shapes of simple inorganic molecules and ions, Valence shell electron pair repulsion (VSEPR) theory, Application of VSEPR theory to NH_3, H_3O^+, SF_4, ClF_3, ICl_2, and H_2O.

UNIT – V **12 hours**

Chemical bonding-II: Properties of ionic compounds, Unit cell, Types of unit cells, Packing in ionic solids, Madelung constant, Structures of some common ionic solids, AB-type: NaCl, ZnS-zinc blende and wurtzite, CsCl, AB_2 type: CaF_2, A_2B type: Na_2O, Radius ratio effect and Coordination number, Limitation of radius ratio rule, Lattice energy and Born-Haber cycle, Solvation energy and solubility of ionic solids, Polarizing power and polarisability of ions, Fajan's rule.

REFERENCES

1. B. R. Puri, L. R. Sharma and K. K. Kalia, *Principles of Inorganic Chemistry*, 33rd Ed., New Delhi, S. L. N. Chand & Co., 2017.
2. J. D. Lee, *Concise Inorganic Chemistry*, 5th Ed., UK, John Wiley & Sons, 2016.
3. W. U. Malik, G. D. Tuli and R. D. Madan, *Selected Topics in Inorganic Chemistry*, Revised Ed., S. Chand, 2010.
4. N. N. Greenwood and A. Earnshow, *Chemistry of the Elements*, 2nd Ed., Pergamon, 1997.

L	T	P	C
3	1	0	4

Semester: I
Course: Organic Chemistry - I
Course Code: ICCHM1C006T

Course Objectives:
This course enables the learners to understand the basics of organic chemistry, types of organic reactions, reactive intermediates and aromaticity. It aims to confer the learners with a clear insight into the various aromatic electrophilic substitution reactions and their mechanistic aspects. It also aims to provide the learners with a broad understanding of the basic concepts of stereochemistry and conformational analysis.

Learning Outcomes
Upon completion of this course, the learners will be able to:

- Describe the various basic concepts of organic chemistry.
- Demonstrate an understating of various types of organic reaction mechanisms and reactive intermediates.
- Illustrate the significance of aromatic compounds and various aromatic electrophilic substitution reactions.
- Acquire knowledge of the basics of stereochemistry and conformational analysis

Semester: I
Course Name: Organic Chemistry-I
Course Code: ICCHM1C006T **4 Credits (3-1-0)**

UNIT – I **12 hours**

Basics of organic chemistry: Classification and nomenclature of organic compounds, Hybridization, Shapes of molecules, Influence of hybridization on bond lengths, bond angles and bond energy, Inductive effect, Polar covalent bonds and dipole moment, Delocalized bonds and resonance, Drawing resonance structures, Concept of formal charge, Hyperconjugation, Steric effect, Steric inhibition of resonance, Hydrogen bonding, Inter- and intramolecular hydrogen bonding, Effect on boiling point and solubility.

UNIT – II **12 hours**

Introduction to organic reaction mechanism: Addition, elimination, substitution and rearrangement reactions, Homolytic and heterolytic C–C bond fission, Electrophiles and nucleophiles, Generation, structure and stability of reactive intermediates: carbocations, carbanions, free radicals, carbenes and nitrenes, Acids and bases, Factors affecting acid and base strength.

UNIT – III **12 hours**

Aromaticity: Resonance in benzene, Huckel's rule, Aromatic, non-aromatic and anti-aromatic compounds, Aromatic character of arenes, Cyclic carbocations/carbanions and heterocyclic compounds, Electrophilic substitution reactions in aromatic compounds, General mechanisms of nitration, halogenation, sulphonation, Friedel-Craft's acylation and alkylation, *ortho*/*para*/*meta* directive effect of substituents.

UNIT – IV **12 hours**

Stereochemistry I: Concept of isomerism, Optical isomerism, Chirality and elements of symmetry, Classification of stereoisomers, Enantiomersim and diasteroisomerism involving one and two chiral centers, *Meso*/*dl* and *erythro*/*threo* isomers, Relative and absolute configurations, *D-L*, *R-S* systems of nomenclature, Fischer, Newmann and Sawhorse projection formulae and their interconversion.

UNIT – V **12 hours**

Stereochemistry II: Optical isomerism of allenes and biphenyls, *R-S* nomenclature of allenes and biphenyls, Conformational analysis of ethane, *n*-butane and cyclohexane, Preferred conformations of cyclic and acyclic compounds, Ring inversion of cyclohexane, Geometrical isomerism: *cis-trans, syn-anti*, *E-Z* notations, Geometrical isomerism in oximes, cumulenes and alicyclic compounds.

REFERENCES

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011.
2. A. Bahl and B. S. Bahl, *A Text Book of Organic Chemistry*, 22nd Ed., 2016.
3. T. W. G. Solomons, *Fundamentals of Organic Chemistry*, John Wilev, 5th Ed., 1998.
4. L.G. Wade Jr., *Organic Chemistry*, Prentice Hall, 8th Ed., 2016.
5. P. Y. Bruice, *Organic Chemistry*, 8th Ed., 2016.
6. F. A. Carey and R. M. Giuliano, *Organic Chemistry*, *McGraw Hill*, 10th Ed., 2016.

L	T	P	C
0	0	4	2

Course: Inorganic Chemistry Lab-I
Course Code: ICCHM1C006L

Course Objectives:

This course enables the learners to handle chemicals, apparatus and chemical wastes, prepare of different concentration solution and perform volumetric titration.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Learn how to handle chemicals and apparatus in laboratory.
- Handle chemical wastes.
- Learn the disposal methods for damaged glassware.
- Prepare different concentration solution.
- Perform volumetric titrations.
- Learn to maintain laboratory note book.

Semester: I
Course Name: Inorganic Chemistry Lab-I
Course Code: ICCHM1C006L **2 Credits (0-0-4)**

General Instructions: Demonstration and concept of good lab practices including safety, chemical/glassware handling, chemical nature understanding, waste management, notebook maintenance.

Part A

1. Calibration and use of apparatus
2. Preparation of solutions of different Molarity/Normality

Part B: Volumetric Analysis:
Acid-Base Titrations

1. Titration of HCl Vs NaOH (strong acid Vs strong base).
2. Titration of HCl Vs Na_2CO_3 (strong acid Vs weak base).
3. Titration of Oxalic acid Vs NaOH (weak acid Vs strong base).
4. Titration of Acetic acid (commercial vinegar) Vs NaOH (weak acid Vs strong base).
5. Any other related experiments as desired by the course teacher.

Oxidation-Reduction Titrations

1. Estimation of Fe(II) using $KMnO_4$.
2. Estimation of oxalic acid using $KMnO_4$.
3. Estimation of Fe(II) using $K_2Cr_2O_7$.
4. Any other related experiment as desired by the course teacher.

REFERENCES:

1. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denny *Vogel's Text book of Quantitative Chemical Analaysis*, 5/e., LBS.
2. V. K. Ahluwalia, S. Dhingra and A. Gulate, *College Practical Chemistry*, 2008 (reprint), Universities Press (India) Pvt Ltd.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
0	0	4	2

Semester: I
Course: Organic Chemistry Lab - I
Course Code: ICCHM1C007L

Course Objectives:
This laboratory course provides the learners hands-on experience in the purification of organic compounds by recrystallization and determination of melting and boiling points. It also enables learners separating the organic compounds using paper and thin layer chromatography methods.

Learning Outcomes
Upon completion of this course, the learners will be able to:

- Gain hands-on experience in purification of organic compounds using recrystallization technique
- Determine the melting and boiling points of organic compounds
- Demonstrate the separation of organic compounds using paper and thin layer chromatography

Semester: I
Course Name: Organic Chemistry Lab-I
Course Code: ICCHM1C007L **2 Credits (0-0-4)**

1. Purification of organic compounds by crystallization.
   Compounds: Phthalic acid, Acetanilide, Naphthalene, Benzoic acid etc.
   Solvents: Water, Ethanol, Aqueous ethanol.
2. Determination of meting point of at least four organic compounds.
3. Effect of impurities on the melting point: mixed melting point of two unknown organic compounds.
4. Determination of boiling point of liquid compounds (distillation and capillary method).
5. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.
6. Separation of a mixture of compounds by thin layer chromatography (TLC).
7. Any other related experiments as desired by the course teacher.

REFERENCES:

1. F. G. Mann, and B. C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G, Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
3	1	0	4

Course: Physical Chemistry-I
Course Code: ICCHM2C005T
Semester: II

Course Objectives:

This course enables the learners to understand the basics of gaseous and liquid states of matter. This course also sheds some lights on the basics of different laws of thermodynamics and their applications.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Acquire knowledge of the basics of gaseous and liquid states of matter required to understand chemistry and their applications.
- Acquire basic knowledge of the laws of thermodynamics as its application to understand a chemical processes from macroscopic view-point.

Semester: II
Course Name: Physical Chemistry-I
Course Code: ICCHM2C005T **4 Credits (3-1-0)**

UNIT – I **12 hours**

Gaseous state of matter: Postulates of kinetic theory of gases, Gas laws from kinetic equation, Relation between kinetic energy and temperature, Maxwell distribution of molecular velocities and kinetic energies, Effect of temperature, Most probable velocity, Average velocity and root mean square velocity, Evaluation of these velocities using Maxwell equation, Collision theory, Collision frequency and mean free path, Degrees of freedom of gaseous molecule: Translational, rotational and vibrational, Deviation from ideal behaviour, van der Waals equation of state for real gases, Virial equation of state, Critical phenomenon, Critical constants, Law of corresponding states.

UNIT – II **12 hours**

Liquid state and viscosity of fluids: Nature of the liquid state, Vapour pressure, Surface tension, Capillary rise and measurement of surface tension, Work of cohesion and adhesion, Spreading of liquid over other surface, Temperature dependence of surface tension, General features of fluid flow, Reynold number, Nature of viscous drag for streamline motion, Newton' equation, Viscosity coefficient, Poiseuille's equation, Temperature dependence of viscosity, Principle of determination of viscosity coefficient of liquids by falling sphere method.

UNIT – III **12 hours**

Thermodynamics-I: Thermodynamic terms, State functions, path functions and their differentials, Thermodynamic process, Concept of heat and work, First Law of thermodynamics, Internal energy and enthalpy, Heat capacity, Heat capacities at constant volume and pressure and their relationship, Joule's law, Joule-Thomson experiment, Joule-Thomson coefficient and inversion temperature, Calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and adiabatic condition for reversible process, Zeroth law of thermodynamics.

UNIT – IV **12 hours**

Thermochemistry: Hess's law of constant heat summation, Exothermic and endothermic reactions, Standard enthalpy changes, Types of enthalpy changes: reaction, formation, combustion, neutralization, ionization, Enthalpy of physical transformations, Kirchhoff's equation, Bond energy and bond enthalpy, Numerical problems.

UNIT – V **12 hours**

Thermodynamics-II: Second law of thermodynamics, Heat engine, Carnot cycle and its efficiency, Concept of entropy, Physical significance of entropy, Entropy change in an ideal gas, Entropy as a function of temperature, volume and pressure, Entropy change of universe, Combined statement of first and second laws of thermodynamics, Entropy change for isolated systems, Thermodynamic relations based on 2nd law: energy as a function of temperature and volume, enthalpy as a function of temperature and pressure.

REFERENCES

1. P. W. Atkins, *The Elements of Physical Chemistry*, Oxford, 11th Ed., 2019.
2. R. P. Rastogi and R. R. Mishra, *Chemical Thermodynamics*, Vikas Publishing House

Pvt. Ltd., 6th Ed., 2009.
3. K. L. Kapoor, *A Text Book of Physical Chemistry*, McGraw Hill Education (India) Pvt. Ltd., Vol. 3, 5th Ed., 2014.
4. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., 49th Ed., 2019.

Sem-II

L	T	P	C
3	1	0	4

Course: Inorganic Chemistry II
Course Code: ICCHM2C006T

Course Objectives:

The course enables the learners to understand the geometries of molecular orbitals and shapes of different molecules. It provides knowledge about defects in solids, concept of pH and inorganic oxidation-reduction reactions and inorganic analysis.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Describe molecular orbital theory and draw the geometries of different molecules.
- Explain the different types of defects in solids and how does a conductor and semiconductor works.
- Demonstrate basic concept of pH, various definitions of acids and bases and inorganic redox reactions.
- Understand the basic principles of inorganic analysis including qualitative and quantitative analysis.

Semester: II
Course Name: Inorganic Chemistry-II
Course Code: ICCHM2C006T **4 Credits (3-1-0)**

UNIT – I **12 hours**

Chemical bonding-III: Molecular orbital theory, Postulates, Criteria for forming MOs, Construction of MOs by LCAO, Physical picture of bonding and antibonding wave functions, Concept of σ, σ*, π, π* orbitals and their characteristics, Homonuclear (He_2, N_2, O_2, F_2, C_2) and heteronuclear (CO and NO) diatomic molecules, Bond order and bond energy, Calculation of percentage ionic character from dipole moment and electronegativity difference.

UNIT – II **12 hours**

Solid defects: Intrinsic and extrinsic defects, Point defects, Line and plane defects, Schottky and Frenkel defects, Metallic bonding: Insulators and semiconductors, Band theory, Band structure of metals, Intrinsic and extrinsic semiconductors, Doping semiconductors, *p-n* junctions, High temperature super conductors, Metallic bond.

UNIT – III **12 hours**

Basic concepts of *p*H and redox reaction: Concept of *p*H, *p*H scale, Calculation of *p*H of weak/strong acids/base, *p*Ka, determination of *p*H using potentiometric methods, Buffers-Mechanism of buffer action, Henderson-Hazel equation, Application of buffer solution, Hydrolysis of salts, Oxidation and Reduction, Standard Electrode Potential and its application to inorganic reactions, Electrochemical series and its applications.

UNIT – IV **12 hours**

Acids-bases and weak interactions: Various definitions of acids and bases, Arrhenius, Bronsted-Lowry concepts of acid bases, Measurement of acid-base strength, Lewis interactions in non-polar solvents, Lewis acid-base interactions, Bond energies, Steric effects, Solvation effects. van der Waals forces: Dipole-dipole, ion-dipole, dipole-induced dipole, and instantaneous dipole-induced dipole interactions, Hydrogen bonding, Inter- and intramolecular hydrogen bonding and applications.

UNIT – V **12 hours**

Principles of inorganic analysis: Common ion effect, solubility product and their applications in qualitative analysis, Reactions involved in the separation and identification of cations and anions, Spot tests reagents, Aluminon cupferon, DMG, thiourea, magneson, alizarin and Nessler's reagents, Quantitative analysis: Gravimetric and Volumetric analysis.

REFERENCES

1. B. R. Puri, L. R. Sharma and K. K. Kalia, *Principles of Inorganic Chemistry*, 33rd Ed., New Delhi, S. L. N. Chand & Co., 2017.
2. J. D. Lee, *Concise Inorganic Chemistry*, 5th Ed., UK, John Wiley & Sons, 2016.
3. W. U. Malik, G. D. Tuli and R. D. Madan, *Selected Topics in Inorganic Chemistry*, Revised Ed., S. Chand, 2010.
4. P. L. Soni, and M. Katyal, *Text Book of Inorganic Chemistry*, S. Chand & Sons, New Delhi, 2013.
5. J. E. Huheey, E. A. Keiter, R. L .Keiter and O. K. Medhi, *Principles of Structure and Reactivity*, 4th Ed., Pearson Education, 2006.

L	T	P	C
0	0	4	2

Course: Physical Chemistry Lab-I

Course Code: ICCHM2C006L
Semester: II

Course Objectives:

This course enables the students to gain hands-on experience on the thermochemistry. It also provides hands-on experience about the determination of the properties of liquid states.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Gain hand-on experience on different theormochemical processes in chemistry such as heats of neutralization, molecular weight determination, etc.
- Gain hand-on experience on different properties of liquid states like surface tension and viscosity.

Semester: II
Course Name: Physical Chemistry Lab-I
Course Code: ICCHM2C006L **2 Credits (0-0-4)**

PART A: Liquid state

1. Determination of the surface tension of given liquids by stalagmometer method.
2. Determination of the viscosity of a given liquids by Ostwald's viscometer.
3. Determination of viscosity of two pure liquids A and B and hence to find the composition of the two liquid mixtures.
4. Determination of the heat of solutions of given compounds.
5. Determination of solubility of benzoic acid at different temperatures and to determine the enthalpy change of dissolution process.
6. Any other related experiment as desired by the course teacher.

PART B: Thermochemistry

1. Determination of the heat of neutralization of HCl by NaOH.
2. Determination of molecular weight of the given volatile organic liquid by using ideal gas equation.
3. Any other related experiments as desired by the course teacher.

REFERENCES

1. V. K. Ahluwalia, S. Dhingra and A. Gulate, *College Practical Chemistry*, 2008, Universities Press (India) Pvt Ltd.
2. A. Ghoshal, B. Mahapatra and A. K. Nad, *An Advanced Course in Practical Chemistry,* New Central Book Agency Pvt. Ltd., 3rd Ed., 2012.
3. J. B. Yadav, *Advanced Practical Physical chemistry*, Goel Publishing, 1st Ed., 2015.
4. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Sem-II

L	T	P	C
0	0	4	2

Course; Inorganic Chemistry Lab -II
Course Code: ICCHM2C007L

Course Objectives:

The course enables the learners to gain laboratory skills for the estimation of iodine in antiseptic drug, available chlorine in bleaching powder, manganese dioxide in pyrolusite, nitrogen in fertilizer. It also provides knowledge for the determination of iodine and saponification value in oil, percentage composition of a mixture, hardness of water.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Explain the principle of different titration methods.
- Prepare different concentration standard solution.
- Apply their knowledge to determine percentage composition of a mixture.
- Design methods for estimation of metal from the ore.
- Develop innovative methods to determine hardness of water and to produce soft water for industrial use.

Semester: II
Course Name: Inorganic Chemistry Lab-II
Course Code: ICCHM2C007L **2 Credits (0-0-4)**

Qualitative inorganic analysis

Qualitative semi-micro analysis of mixtures of anions and cations
List of anions: CO_3^{2-}, S^{2-}, SO_4^{2-}, NO_3^-, NO_2^-, $(CO_2)_2^{2-}$, F^-, Cl^-, Br^-, I^-, SCN^-, $S_2O_3^{2-}$, BO_3^{3-} etc.
List of Cations: Groups I and II

REFERENCES:

1. V. V. Ramanujam, *Inorganic Semi Micro Qualitative Analysis*, 3rd Ed., National Publishing Company, Chennai.
2. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denny *Vogel's Text book of Quantitative Chemical Analaysis*, 5/e., LBS.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
0	0	4	2

Course: Laboratory Safety and Utility Tools Lab
Course Code: ICCHM2E001L

Course Objectives:

This course enables the learners to understand the nature of different chemicals, handling and storage of toxic and flammable chemicals, disposal of chemical wastes, first aid procedures for various laboratory accidents and usage of basic office tools and chemistry software.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Handle chemicals including toxic and hazardous chemicals
- Give first aid for smaller lab incidents
- Dispose chemical waste and damaged glass wares
- Use different chemistry software available and will apply them for drawing chemical structures and reaction mechanisms
- Use office tools for making presentations, graphs and plots, bar diagrams etc.

Semester: II **GE**
Course Name: Laboratory Safety and Utility Tools Lab
Course Code: ICCHM2E001L **2 Credits (0-0-4)**

Laboratory Safety:
Laboratory hygiene and safety: Storage and handling of corrosive, flammable, explosive, toxic, carcinogenic and poisonous chemicals, Simple first aid procedures for accidents involving acids, alkalies, bromine, burns and cut by glass, Waste disposal, Green chemistry aspects.

Utility Tools for Chemistry and Application Software:
Introduction to the list utility tools and software available and their applications to chemistry, Use of molecular editor software to draw small molecules and simple reaction mechanisms.

Basics of office tools and their usage: Word processor, Presentation tool, Spreadsheet package, Picture manager etc. Use of Spreadsheet package and plotting tools to plot graphs, *pi*-chart, bar diagrams and fitting the plot, Concept of interpolation and extrapolation.

Use of a free web services like Google Classroom, and use of other available utility tools as recommended by the course teacher.

REFERENCES

1. G. D. Christian, *Analytical Chemistry*, 6th Ed., John Wiley & Sons, New York, 2004.
2. J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.
3. H. H. Willard, L. L. Merritt Jr., J. A. Dean and F. A. Settle Jr., *Instrumental Methods of Analysis*, 7th Ed., Wardsworth Publishing Company, 1988.
4. Online contents of office tools
5. In-house manual (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Course Matrix and Syllabus (Semesters III and IV)

Five Year Integrated B.Sc.(Hons.)-M.Sc. Program in Chemistry

(under CBCS, *w.e.f.* Academic Session 2021-2022)

Offered By

Department of Chemistry and Chemical Sciences

CENTRAL UNIVERSITY OF JAMMU
Rahya-Suchani (Bagla), District-Samba
Jammu-181143, (J&K) India

Semester – III

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
ICCHM3C007T	Organic Chemistry-II	CC	4	3-1-0
ICCHM3C008T	Physical Chemistry-II	CC	4	3-1-0
ICCHM3C009T	Inorganic Chemistry-III	CC	4	3-1-0
ICCHM3C007L	Organic Chemistry Lab-II	CC	2	0-0-4
ICCHM3C008L	Physical Chemistry Lab-II	CC	2	0-0-4
ICCHM3C009L	Inorganic Chemistry Lab-III	CC	2	0-0-4
ICBOT3E001T	Botany	GE	4	3-1-0
ICBOT3E001L	Botany Lab	GE	2	0-0-4
ICCHM3F001T	Basic Analytical Chemistry	AEEC	2	2-0-0
	Total		26	

Semester – IV

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
ICCHM4C007T	Organic Chemistry-III	CC	4	3-1-0
ICCHM4C008T	Physical Chemistry-III	CC	4	3-1-0
ICCHM4C009T	Inorganic Chemistry-IV	CC	4	3-1-0
ICCHM4C007L	Organic Chemistry Lab-III	CC	2	0-0-4
ICCHM4C008L	Physical Chemistry Lab-III	CC	2	0-0-4
ICCHM4C009L	Inorganic Chemistry Lab-IV	CC	2	0-0-4
ICZOL4E001T	Applied Zoology	GE	4	3-1-0
ICZOL4E001L	Applied Zoology Lab	GE	2	0-0-4
ICCHM4F002T	Green Methods in Chemistry	AEEC	2	2-0-0
	Total		26	

Examination Pattern

Course	Credit	CIA	MSE	ESE	Max. Marks
Theory	4	25	25	50	100
Theory	2	12.5	12.5	25	50
Practical	2	25	-	25	50

L	T	P	C
3	1	0	4

Semester: III
Course Name: Organic Chemistry-II
Course Code: ICCHM3C007T

Course Objectives:
This course enables the students to understand the basics of organic molecules and reaction mechanisms. It also provides the knowledge about nomenclature of cycloalkanes, cycloalkenes, conformations of cyclohexane, stability of cycloalkanes, methods for the preparation of alkenes and alkynes. It also enables the students to understand reactivity of carbonyl compounds and names reactions of carbonyl compounds.

Learning Outcomes:

Upon completion of this course, the learners will be able to:

- Demonstrate organic reaction mechanisms.
- Demonstrate conformations of cyclohexane and relative stability of cycloalkanes.
- Demonstrate reactivity of carbonyl compounds.
- Demonstrate name reactions of carbonyl compounds.

Semester: III
Course Name: Organic Chemistry-II
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Alkanes: Nomenclature, Formation of alkanes, Corey-House reactions, Decarboxylation of carboxylic acids, Wurtz Reaction, Wurtz-Fittig Reaction, Free-radical halogenation of alkanes-Relative reactivity and selectivity.

Cycloalkanes: Nomenclature, Methods of preparation, Types of cycloalkanes and their relative stability, Bayer's strain theory and its limitations, Ring strain in cyclopropane and cyclobutane, Ring inversion of cyclohexane with energy diagrams, Relative stability of chair, boat and twist boat forms.

UNIT – II **12 hours**

Alkenes: Nomenclature of alkenes, Formation of alkenes by elimination reactions: Dehydration, dehydrohalogenation and dehalogenation reactions, Mechanisms of E1, E2, E1cB reactions, Regioselectivity, Saytzeff rule, Hoffmann elimination, Reactions of alkenes: Electrophilic additions and their mechanisms (Markovnikov/Anti-Markovnikov addition), Mechanism of oxymercuration-demercuration, Hydroboration-oxidation, Epoxidation, Ozonolysis, Hydrogenation, *syn*- and *anti*-Hydroxylation, Polymerization.

UNIT – III **12 hours**

Dienes and Cycloalkenes: Nomenclature and classification of dienes: Isolated, conjugated and cumulated dienes, Structure of allenes and butadiene, Methods of formation, Polymerization, 1,2- and 1,4-Addition reactions of conjugated dienes, Diels-Alder reaction, Methods of formation and chemical reactions of cycloalkenes.

Alkynes: Nomenclature, Structure and bonding in alkynes, Methods of formation, Acidity of alkynes, Chemical reactions of alkynes, Mechanism of electrophilic and nucleophilic addition reactions, Hydration to form carbonyl compounds, Hydroboration-oxidation, Metal-ammonia reductions, Oxidation and polymerization.

UNIT – IV **12 hours**

Carbonyl compounds I: Nomenclature, Structure of the carbonyl group, Synthesis of aldehydes and ketones: Oxidation of alcohols, Oppenauer oxidation, Synthesis from acid chlorides, Rosenmund reduction, Friedel-Crafts reaction, Synthesis of aldehydes and ketones using 1,3-dithianes, Synthesis of ketones from nitriles and from carboxylic acids.

UNIT – V **12 hours**

Carbonyl compounds II: Reaction of carbonyl compounds: Nucleophilic addition to carbonyl group, Mechanism of aldol, Benzoin and Knoevenagel condensations, Perkin, Cannizzaro, Claisen-Schmidt, Wittig reactions, Baeyer-Villiger oxidation, Benzil-Benzilic acid and Beckmann rearrangements, MPV, Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions, Halogenation of enolizable ketones, α-Substitution reactions, Use of acetal as protecting group, Introduction to α,β-unsaturated carbonyl compounds, Michael addition.

REFERENCES

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011.
2. A. Bahl and B. S. Bahl, *A Text Book of Organic Chemistry*, 22nd Ed., 2016.
3. T. W. G. Solomons, *Fundamentals of Organic Chemistry*, John Wilev, 5th Ed., 1998.

4. L.G. Wade Jr., *Organic Chemistry*, Prentice Hall, 8th Ed., 2016.
5. P. Y. Bruice, *Organic Chemistry*, 8th Ed., 2016.
6. F. A. Carey and R. M. Giuliano, *Organic Chemistry*, *McGraw Hill*, 10th Ed., 2016.
7. M. B. Smith, *March's Advanced Organic Chemistry, Reactions, Mechanisms and Structure*, 7th Ed., 2016.

L	T	P	C
3	1	0	4

Course: Physical Chemistry-II
Course Code: ICCHM3C008T

Course Objectives:

This course enables the learners to understand the third law of thermodynamics, concept of entropy and free energy. It also enables the learners to understand the kinetics of different order chemical reactions, effect of temperature and catalyst on the rate of reaction, different types of catalysis and solid state chemistry.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Describe the third law of thermodynamics as well as the concept of entropy and free energy
- Determine the rate and order of different chemical reactions
- Explain the different types of catalysis, effect of catalyst on rate of reactions
- Determine the kinetics of various catalytic reactions
- Draw and explain the structure of different ionic solids

Semester: III
Course Name: Physical Chemistry-II
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Thermodynamics-III: Third law, Nernst heat theorem, Statement and concept of residual entropy, Evaluation of absolute entropy from heat capacity data, Gibbs and Helmholtz functions, *G* and *A* functions as thermodynamic quantities, *G* and *A* as criteria for thermodynamic equilibrium and spontaneity, Their advantage over entropy change, Variation of *G* and *A* with *P, V* and *T*, Maxwell's relation, Thermodynamic equation of state, Temperature dependence of free energy: Gibbs-Duhem, Gibbs-Margules equation, Clausius-Clapeyron equation and its applications.

UNIT – II **12 hours**

Chemical kinetics-I: Introduction to chemical kinetics, Order and molecularity of chemical reaction, Rate expression for first order, second order and third order reactions, Half life, Methods for determining order of reaction, Opposing reactions, Parallel reactions, Consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) and chain reactions.

UNIT – III **12 hours**

Chemical kinetics-II: Effect of temperature and catalyst on rate of reaction, Arrhenius equation, Concept of activation energy, Simple collision theory based on hard sphere model, Lindemann mechanism, Qualitative treatment of the theory of absolute reaction rates, Expression of rate constant based on equilibrium constant and thermodynamic aspects.

UNIT – IV **12 hours**

Catalysis: Characteristic of catalytic reactions, Homogeneous catalysis, Acid-base catalysis and its kinetics, Enzyme catalysis and its mechanism, Effect of temperature on enzyme catalysis, Heterogeneous catalysis, Surface reactions, Kinetics of surface reactions, Unimolecular surface reactions, Bimolecular surface reactions, Effect of temperature on heterogeneous reactions: Unimolecular and Bimolecular.

UNIT – V **12 hours**

Solid state chemistry: Crystal structures, Close packing, Body centered and primitive structures, Symmetry in crystals, Crystallographic point groups, Space groups, Lattices, One, two- and three-dimensional unit cells, Translational symmetry elements, Miller and Weiss indices, Interplanar spacing, Packing diagrams, Atomic packing fraction, Braggs' law, Structures of important ionic solids: Ionic Radii, Ionic solids with formula MX (CsCl, NaCl, zinc blende and wurtzite structures), MX_2 (fluorite and anti-fluorite structures), Crystal defects.

REFERENCES

1. P. W. Atkins, *The Elements of Physical Chemistry*, Oxford, 11th Ed., 2019.
2. R. P. Rastogi and R. R. Mishra, *Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd., 6th Ed., 2009.
3. K. L. Kapoor, *A Text Book of Physical Chemistry*, McGraw Hill Education (India) Pvt. Ltd., Vol. 3, 5th Ed., 2014.
4. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., 48th Ed., 2020.

5. K. J. Laidler, *Chemical Kinetics*, Pearson Education India, 3rd Ed., 2003.
6. P. C. Rakshit, *Physical Chemistry*, Sarat Book House, India, 7th Ed., 2014.
7. A. K. Nag, *Physical Chemistry*, Vol. I and II, McGraw Hill, India, 1st Ed., 2019.
8. A. R. West, *Solid State Chemistry and its Applications*, Wiley, 1990.
9. S. Glasstone, *Thermodynamics For Chemists,* EWP, 2018.

L	T	P	C
3	1	0	4

Course: Inorganic Chemistry III
Course Code: ICCHM3C009T

Course Objectives:

This course enables the learners to understand the general physical and chemical characteristics of s-block elements, p-block elements and noble gases, the concept of coordination chemistry, crystal field theory, crystal field stabilization energy, stability constants and different methods for determination of stability constants.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Describe and compare the general characteristics and properties of s-block elements, p-block elements and noble gases
- Demonstrate the trends in the physical and chemical properties of s-block elements, p-block elements and noble gases.
- Acquire knowledge of the basics of stereochemistry and conformational analysis of coordination compounds.
- Explain the stability of coordination compounds.
- Predict the geometry of coordination compounds.
- Design coordination compounds as catalyst for different chemical reactions.

Semester: III
Course Name: Inorganic Chemistry-III
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Chemistry of *s*-block elements: General characteristics and comparative study of *s*-block elements, Position of hydrogen in the periodic table, Spectral lines of hydrogen atoms, Uses of hydrogen, Diagonal relationships, Salient features of hydrides, Solvation, Complexation tendencies and functions in biosystem, Introduction to alkyls and aryls.

Noble gases: Occurrence and uses, Rationalization of inertness of noble gases, Clathrates: preparation and properties of XeF_2, XeF_4 and XeF_6, VB and MO treatment for XeF_2, Molecular shapes of noble gas compounds (VSEPR theory).

UNIT – II **12 hours**

Chemistry of *p*-block elements-I:

Electronic configuration, Atomic and Ionic size, Metallic/non-metallic character, Melting point, Ionization enthalpy, Electron gain enthalpy, Electronegativity, Allotropy of C, P, S, Inert pair effect, Comparative study (including diagonal relationship) and Anomalous behaviour of first member of each group, Compounds with C–N and C–S bonds, Silane reagents, Synthesis, properties and modifications on polysilanes, silicides, silicone polymers, Oxygen compounds of silicon.

UNIT – III **12 hours**

Chemistry of *p*-block elements-II:

Hydrides of groups 13, 14, 15, 16 and 17, Oxides of phosphorus, sulphur and chlorine**,** Oxoacids of phosphorus and chlorine, Peroxoacids of sulphur, halides of silicon and phosphorus, Interhalogen and pseudohalogen compounds.

UNIT – IV **12 hours**

Coordination chemistry-I: Basic terminologies, Ligands and their classification, Chelates and their uses, IUPAC nomenclature, Isomerism (structural, geometrical and optical), Valence VBT of coordination complexes and its limitations, Werner's coordination theory, Effective atomic number, Electroneutrality principle and back bonding, Stereochemistry of complexes with 4- and 6-coordination numbers, Polynuclear complexes, Labile and inert complexes.

UNIT – V **12 hours**

Coordination chemistry-II: Crystal field theory and crystal field stabilization energy (CFSE), Measurement of CFSE in weak and strong field complexes, Factors affecting CFSE, Pairing energy, Hydration energy, Crystal field splitting in octahedral, tetrahedral and square planar complexes, Jahn-Teller effect.

Stability constants-Stepwise and Overall formation constants and relation between them, Difference between thermodynamic and kinetic stability, Determination of stability constants by Job's method, Bjerrum's method and Polarographic method.

REFERENCES

1. J. D. Lee, *Concise Inorganic Chemistry*, Oxford University Press, 2010.
2. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, John Wiley, 1999.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi *Inorganic Chemistry-Principles of structure and reactivity*, 4th Ed., 2006.

4. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver and Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press, 2009.
5. M. Weller, T. Overton, J. Rourke and F. Armstrong, *Inorganic Chemistry*: 7th Ed., Oxford University Press, 2018.
6. N. N. Greenwood and A. Earnshop, *Chemistry of the Elements*, 2nd Ed., Pergamon, 1997.
7. S. Chandra, *Concise Inorganic Chemistry*, Dreamtech Press, 2020.
8. B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing Co, 2020.
9. R. D. Madan, G. D. Tuli and W. U. Malik, *Selected Topics in Inorganic Chemistry*, S. Chand Publisher, 2010.
10. P. L. Soni, *Text Book of Inorganic Chemistry*, S. Chand and Sons, New Delhi, 2013.
11. G. Wulfsberg, *Inorganic Chemistry*, 2nd Ed., Viva Publisher, 2018.

L	T	P	C
0	0	4	2

Semester: III
Course Name: Organic Chemistry Lab-II
Course Code: ICCHM3C007L

Course Objectives:
This course enables the students to gain hands-on experience about the conventional and green methods for acetylation, benzoylation, bromination, nitration and reduction reactions. It also provides hands-on experience about the separation of binary organic mixtures containing strongly acidic, weakly acidic, basic and neutral compounds.

Learning Outcomes:

Upon completion of this course, the learners will be able to:

- Gain hands-on experience for acetylation, benzoylation, bromination, nitration and reduction reactions.
- Separate organic mixtures containing strongly acidic, weakly acidic, basic and neutral compounds.

Semester: III
Course Name: Organic Chemistry Lab-II
Course Code: **2 Credits (0-0-4)**

Organic preparations (At least 10 experiments)

1. Acetylation of any two of the following compounds: Aniline, Toluidines, Anisidines, Phenols, β-Naphthol, Salicylic acid by (i) using conventional method and (ii) using green approach.
2. Benzolyation of any two of the following compounds: Aniline, Toluidines, Anisidines, Phenols, β-Naphthol, Resorcinol by Schotten-Baumann reaction.
3. Bromination of acetanilide by conventional method and using green approach (Bromate-bromide method).
4. Bromination of aniline and phenol.
5. Nitration of acetanilide and nitrobenzene by conventional method.
6. Nitration of salicylic acid by green approach (using ceric ammonium nitrate).
7. Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline.
8. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
9. Hydrolysis of amides and esters.
10. Semicarbazone of any one of the following compounds: Acetone, Ethyl methyl ketone, Cyclohexanone, Benzaldehyde.
11. Aldol condensation using either conventional or green method.
12. Any other related experiments as desired by the course teacher.

REFERENCES:

1. F. G. Mann and B. C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G, Smith and A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
0	0	4	2

Course: Physical Chemistry Lab-II
Course Code: ICCHM3C008L

Course Objectives:

This course enables the learners to understand the kinetics of various hydrolysis and decomposition reactions, principle of adsorption and Freundlich adsorption isotherm.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Prepare solutions of different concentrations
- Perform the volumetric titrations
- Determine the rate constant of different order reactions
- Perform the adsorption experiments
- Determine the adsorption of acids on activated charcoal
- Test the validity of Freundlich adsorption isotherm

Semester: III
Course Name: Physical Chemistry Lab-II
Course Code: **2 Credits (0-0-4)**

PART A: Kinetics

1. Study the kinetics of hydrolysis of an ester in presence of HCl as catalyst and determine the energy of activation of the reaction.
2. Determination of the velocity constant of hydrolysis of ethyl acetate by NaOH (saponification of an ester).
3. Determination of the relative strength of two acids say, HCl and H_2SO_4, by studying the hydrolysis of ester.
4. Determination of equilibrium constant of the reaction $KI + I_2 \rightleftharpoons KI_3$ by solubility method.
5. Determination of the kinetics of decomposition of H_2O_2.

PART B: Adsorption

1. Determination of adsorption of acetic acid on charcoal - verification of Freundlich's adsorption isotherm.
2. Determination of the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich adsorption isotherms.

Any other related experiments as desired by the course teacher.

REFERENCES

1. A. K. Nad, A. Ghosha and B. Mahapatra, *An Advanced Course in Practical Chemistry,* New Central Book Agency Pvt. Ltd., 3rd Ed., 2012.
2. J. B. Yadav, *Advanced Practical Physical chemistry*, Goel Publishing, 36th Ed., 2015.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
0	0	4	2

Course: Inorganic Chemistry Lab-III
Course Code: ICCHM3C009L

Course Objectives:

This course enables the learners to understand complexometric titration and iodometry, iodimetry redox titration and qualitative estimation of cations and anions.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Design and carry out scientific experiments and quantitatively perform complexometric and redox titrations.
- Qualitatively analysis inorganic salt mixtures and identify cations and anions present in a salt mixture.
- Gain experience in determination of chemical composition of inorganic compound.

Semester: III
Course Name: Inorganic Chemistry Lab-III
Course Code: **2 Credits (0-0-4)**

PART A: Volumetric analysis
Complexometric titrations using disodium salt of EDTA

1. Estimation of Mg^{2+}, Zn^{2+}.
2. Estimation of Ca^{2+} by substitution method.

Iodometry and iodimetry redox titration

1. Determination of the strength of copper sulphate solution iodometrically using iodine solution.
2. Determination of strength of arsenous oxide solution iodimetrically using sodium thiosulphate solution.

PART B: Qualitative inorganic analysis

Qualitative semi-micro analysis of mixture containing three anion radicals and three cation radicals:

Analysis of anions: Acetate, Oxalate, fluoride, Chloride, Bromide, Iodide, Nitrate, Carbonate, Sulphide, Sulphite, Sulphate, Borate and Phosphate.

Analysis of cations: NH_4^+, Pb^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, Mg^{2+}.

Any other related experiments as desired by the course teacher.

REFERENCES

1. V. Venkateswaran, R. Veeraswamy and A. R. Kulandaivelu, *Basic Principles of Practical Chemistry*, 2nd Ed., S. Chand and Sons, 2012.
2. J. Mendham, *Vogel's Textbook of Quantitative Analysis*, 6th Ed., John Wiley and Sons, 2009.
3. G. Raj, *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, 2013.
4. S. Ratnani, S. Agrawal and S. K. Mishra, *Practical Chemistry*, McGraw Hill, 2020.
5. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
2	0	0	2

Course: Basic Analytical Chemistry
Course Code: ICCHM3F001T

Course Objectives:

This course enables the learners to understand the concept of sampling, accuracy, precession, sources of error, representation of experimental data and results, standard deviation of calculated results, the analysis of soil, water and food products and also the basic concept, different techniques and application of chromatography.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Develop sampling methods.
- Represent and analyse experimental data.
- Calculate accuracy, precession, percentage error, standard deviation of experimental data.
- Develop methods for determination of soil and food products composition.
- Develop methods for water purification.
- Understand the basic principle of different chromatographic techniques and develop methods for the separation of the mixture of compounds/ions using various chromatography methods.

Semester: III
Course Name: Basic Analytical Chemistry
Course Code: **2 Credits (2-0-0)**

UNIT – I **10 hours**

Introduction to Analytical Chemistry and its interdisciplinary nature, Concept of sampling, Importance of accuracy, precision and sources of error in analytical measurements, Presentation of experimental data and results, Standard deviations, Standard deviation of calculated results: Sum or difference, Product or quotient, Significant figures, Rounding and expressing results of chemical computations.

UNIT – II **10 hours**

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, Use of indicators.
Analysis of water: Definition of pure water, Sources responsible for contaminating water, Water sampling methods, Water purification methods.
Analysis of food products: Nutritional value of foods, Idea about food processing and food preservations and adulteration.

UNIT – III **10 hours**

Chromatographic techniques: Chromatographic separations: General description and classification of chromatographic methods, Thin layer, Paper and Column chromatographic techniques and their simple applications, Types of adsorbents, R_f-values and their significance, Principle and simple applications of ion exchange separation.

REFERENCES

1. J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.
2. H. H. Willard, L. L. Merritt Jr., J. A. Dean and F. A. Settle Jr., *Instrumental Methods of Analysis*, 7th Ed., Wardsworth Publishing Company, 1988.
3. G. D. Christian, *Analytical Chemistry*, 6th Ed., John Wiley & Sons, New York, 2004.
4. D. C. Harris, *Exploring Chemical Analysis*, 9th Ed., New York, W.H. Freeman, 2016.
5. S. M. Khopkar, *Basic Concepts of Analytical Chemistry*, 3rd Ed., New Age International Publisher, 2008.
6. D. A. Skoog, F. J. Holler and S. R. Crouch, *Principles of Instrumental Analysis*, 7th Ed., 2006.

L	T	P	C
3	1	0	4

Semester: IV
Course: Organic Chemistry - III
Course Code: ICCHM4C007T

Course Objectives:
This course enables the learners to gather knowledge on the preparation of various organic molecules comprising alcohols, phenols, ether, epoxide, alkyl and aryl halides, and active methylene compounds. It also aims to transfer a deep understanding to the learners of the reactivity of the above-mentioned organic functional groups.

Learning Outcomes
Upon completion of this course, the learners will be able to:

- Illustrate the various preparation methods of alcohols, phenols, ether, epoxide, alkyl and aryl halides, and active methylene compounds
- Describe an understating of substitution and elimination reactions of alkyl halides
- Acquire knowledge of the various named reactions and rearrangement reactions which are involving alcohols, phenols, and active methylene compounds
- Describe the physical and chemical properties of ethers and epoxides

Semester: IV
Course Name: Organic Chemistry-III
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Alcohols: Monohydric alcohols: Methods of formation, Reduction of aldehydes, ketones, carboxylic acids and esters, Hydrogen bonding, Acidic nature, Reactions of monohydric alcohols: Substitution, Dehydration, Oxidation and Esterification, Methods to distinguish primary, secondary and tertiary alcohols, Dihydric alcohols: Methods of formation, Chemical reactions of vicinal glycols, Oxidative cleavage by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement, Trihydric alcohols: Methods of formation, chemical reactions of glycerol.

UNIT – II **12 hours**

Phenols: Preparation of phenols, Acidity and factors effecting it, Relative acidity of phenol, alcohol and carboxylic acid, Resonance stabilization of phenoxide ion, Reactions of phenols, Electrophilic aromatic substitution, Mechanisms of Fries rearrangement, Claisen rearrangement, Kolbe's–Schmidt reaction, Gattermann synthesis, Hauben-Hoesch, Lederer-Manasse, Reimer-Tiemann reaction, Schotten-Baumann Reaction.

UNIT – III **12 hours**

Ethers: Nomenclature, Methods of formation, Physical properties, Chemical reactions, Cyclic ethers, Introduction to crown ethers, Structure and applications.

Epoxides: Nomenclature and synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides, Regiochemistry of epoxide ring opening, Reactions of epoxides with alcohols, amines, Grignard and organolithium reagents.

UNIT – IV **12 hours**

Alkyl halides: Methods of formation, Mechanisms of nucleophilic substitution reactions of alkyl halides (S_N1, S_N2, S_Ni), Substitution at the allylic and vinylic positions, Mechanisms of elimination reactions of alkyl halides (E1 and E2), Stereochemical aspects of substitution and elimination reactions, Competition between substitution and elimination, Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides.

Aryl halides: Preparation of aryl halides, Aromatic nucleophilic substitution, Addition-elimination and the elimination-addition mechanisms.

UNIT – V **12 hours**

Active methylene compounds: Acidity of α-hydrogens, Keto-enol tautomerism, Preparation of ethyl acetoacetate, Alkylation of diethyl malonate and ethyl acetoacetate, Synthetic applications of ethyl acetoacetate: Synthesis of ketones, Carboxylic acids and Ketonic acids, Biginelli reaction, Hantzsch dihydropyridine synthesis, Synthetic applications diethyl malonate: Synthesis of disubstituted acetic acid, α-Substituted succinic acids, Ketones and Ketonic acids.

REFERENCES

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011.
2. A. Bahl and B. S. Bahl, *A Text Book of Organic Chemistry*, 22nd Ed., 2016.
3. T. W. G. Solomons, *Fundamentals of Organic Chemistry*, John Wilev, 5th Ed., 1998.
4. I. L. Finar, *Organic Chemistry*, Vol. I and II, 6th Ed., 2002.

5. L.G. Wade Jr., *Organic Chemistry*, Prentice Hall, 8th Ed., 2016.
6. P. Y. Bruice, *Organic Chemistry*, 8th Ed., 2016.
7. F. A. Carey and R. M. Giuliano, *Organic Chemistry*, *McGraw Hill*, 10th Ed., 2016.
8. M. B. Smith, *March's Advanced Organic Chemistry, Reactions, Mechanisms and Structure*, 7th Ed., 2016.

L	T	P	C
3	1	0	4

Course: Physical Chemistry -III
Course Code: ICCHM3C008T
Semester: IV

Course Objectives:

This course enables the learners to understand the different types of equilibrium processes in chemistry and their suitable applications.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Acquire knowledge of different equilibrium processes in chemistry.
- Acquire knowledge of thermodynamical equilibrium to understand a chemical processes from macroscopic view-point.
- Acquire knowledge of phase equilibrium to understand a phase change processes from macroscopic view-point.
- Acquire knowledge of electrochemical equilibrium to understand a electrochemcial change processes and their applications.
- Acquire knowledge of ionic equilibrium to understand the ionic effects and their applications.

Semester: IV
Course Name: Physical Chemistry-III
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Chemical equilibrium: Dynamic nature of Chemical equilibrium, Attainment and characteristics of chemical equilibrium, Law of mass action and its thermodynamic derivation, Relation between K_p, K_c and K_x, Thermodynamic relations for chemical affinity, Homogeneous equilbria, Temperature dependence of equilibrium constant and integrated form of van't Hoff equation, Pressure dependence of equilibrium constant (K_p, K_c and K_x), Heterogeneous equilibria, Le Chatelier's principle and its thermodynamic treatment.

UNIT – II **12 hours**

Electrochemistry-I: Conductance and ionization: Review of electrolytes, Arrhenius theory of electrolytic dissociation, Conductance and its variation with dilution, Ionic mobility, Kohlrausch law and its applications, Migration of Ions: Transport number and its relation with concentration and ionic mobility, Experimental procedures for measuring transport numbers (Hittorf's rule, Moving boundary method), Abnormal transport numbers, Walden's rule. Conductometric titrations.

UNIT – III **12 hours**

Electrochemistry-II: Rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples, Electromotive force (EMF) 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 (i) G, H, S and K (equilibrium constants) of a cell reaction using hydrogen, quinone-hydroquinone and glass electrodes, Determination of *p*H using hydrogen and quinone-hydroquinone electrodes, Concentration cell with and without transference, Liquid junction potential, Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

UNIT – IV **12 hours**

Phase equilibrium: Statement and meaning of the terms-phase, component and degree of freedom, Conditions for equilibrium between phases, Thermodynamic derivation of Gibbs Phase Rule, Phase equilibria of one component system: H_2O, CO_2 and S systems, Phase equilibria of two component systems: Simple eutectic systems, Compound formation with congruent and incongruent m.pt, Three component systems: triangular plots, H_2O-$CHCl_3$-CH_3COOH system, Nernst distribution law: its derivation and applications.

UNIT – V **12 hours**

Ionic equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, Ionization of weak acids and bases, *p*H scale, common ion effect, Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and *p*H for different salts. Buffer solutions, Solubility and solubility product of sparingly soluble salts, applications of solubility product principle, Qualitative treatment of acid–base titration curves (calculation of *p*H at various stages), Theory of acid–base indicators, selection of indicators and their limitations.

REFERENCES

1. P. W. Atkins, *The Elements of Physical Chemistry*, Oxford, 11th Ed., 2019.
2. R. P. Rastogi and R. R. Mishra, *Chemical Thermodynamics*, Vikas Publishing House

Pvt. Ltd., 6th Ed., 2009.
3. K. L. Kapoor, *A Text Book of Physical Chemistry*, McGraw Hill Education (India) Pvt. Ltd., Vol. 3, 5th Ed., 2014.
4. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., 48th Ed., 2020.
5. P. C. Rakshit, *Physical Chemistry*, Sarat Book House, India, 7th Ed., 2014.
6. A. K. Nag, *Physical Chemistry*, Vol. I and II, McGraw Hill, India, 1st Ed., 2019.
7. R. P. Sarkar, *General and Inorganic Chemistry,* Vol. I, New Central Book Agency, 3rd Ed., 2011.
8. S. Glasstone, *An Introduction To Electrochemistry*, East-West Press, 2006.
9. J. Bockris, *Modern Electrochemistry*, Vol. 1 and 2, 2nd Ed., Springer, 2018.

L	T	P	C
0	0	4	2

Semester: IV
Course: Organic Chemistry Lab - III
Course Code: ICCHM4C007L

Course Objectives:
This laboratory course provides the learners hands-on experience in the identification of functional groups by performing a qualitative analysis of organic compounds involving systematic functional group analysis.

Learning Outcomes
Upon completion of this course, the learners will be able to:
- Identify the organic compounds performing systematic functional group analysis
- Demonstrate the confirmatory test for different organic functional groups

Semester: IV
Course Name: Organic Chemistry Lab-III
Course Code: **2 Credits (0-0-4)**

Qualitative analysis of organic compounds (At least 10 compounds)
Identification of organic compounds (aromatic/aliphatic, saturated/unsaturated, elements present, functional groups present etc.) via systematic analysis: Phenols, Carboxylic acids, Aldehydes, Ketones, Carbohydrates, Amines, Esters, Amides etc.

REFERENCES:

1. F. G. Mann and B. C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G, Smith and A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
0	0	4	2

Course: Physical Chemistry Lab-III
Course Code: ICCHM4C008L
Semester: IV

Course Objectives:

This course enables the students to gain hands-on experience on electrochemistry, properties of phase equilibrium and ionic solubility of materials in different solvents.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Gain hand-on experience on different electrochemical processes in chemistry using *p*H measurements, conductometric titrations, etc.
- Gain hand-on experience on different properties of phase equilibrium, partition coefficients and ionic solubility.

Semester: IV
Course Name: Physical Chemistry Lab-III
Course Code: **2 Credits (0-0-4)**

PART A: Electrochemistry

1. Determination of the molar conductivity of weak monobasic acid over a given range of concentration.
2. Determination of the ionization constant of a weak acid conductometrically.
3. Potentiometric titration of an acid with a base.
4. Determination of the pK_a value of the given organic acid by p*H* measurement.
5. Determination of the saponification of ethyl acetate conductometrically.
6. Determination of the strength of the given acid condutometrically and pH-metrically using standard alkali solution: (i) Strong acid - Strong base, (ii) Weak acid - Strong base.

PART B: Phase equilibrium

1. Determination of the distribution coefficient (partition coefficient) of benzoic acid between benzene and water at room temperature.
2. Determination of the distribution coefficient (partition coefficient) of iodine between two immiscible solvents (H_2O-C_6H_6; H_2O-CCl_4).

PART C: Solubility

1. Determination the influence of the ionic strength on the solubility of $CaSO_4$ and hence determination of its thermodynamic solubility product and mean ionic activity.

Any other related experiment as desired by the course teacher.

REFERENCES

1. A. K. Nad, Ghoshal and B. Mahapatra, *An Advanced Course in Practical Chemistry,* New Central Book Agency Pvt. Ltd., 3rd Ed., 2012.
2. J. B. Yadav, *Advanced Practical Physical chemistry*, Goel Publishing, 36th Ed., 2015.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Sem-IV

L	T	P	C
0	0	4	2

Course: Inorganic Chemistry Lab-IV
Course Code: ICCHM4C009L

Course Objectives:

The course enables the learners to gain laboratory skills for the qualitative analysis of anionic radicals containing interfering ions. It also provides knowledge for the preparation of coordination complexes and their separation by some suitable methods like paper and TLC chromatographic techniques etc.

Learning Outcomes

After studying this course and performing the experiments set in it student will be able to:

- Demonstrate the qualitative analysis of salt mixtures.
- Demonstrate the separation of interfering ions in the salt mixtures.
- Demonstrate the methods of synthesis for coordination complexes.
- Demonstrate the procedure of separation and quantative analysis of metal ions in the complexes.
- Develop innovative methods to separate the metal ions in the coordination complexes.

Semester: IV
Course Name: Inorganic Chemistry Lab-IV
Course Code: **2 Credits (0-0-4)**

PART A: Qualitative inorganic analysis

Qualitative semi-micro analysis of mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO^{2-} and NO^{3-}, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO^{3-} and Br^-, NO^{3-} and I^-.

PART B: Inorganic preparations

1. Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.
2. Sodium trioxalato ferrate (III), $Na_3[Fe(C_2O_4)_3]$.
3. Nickel dimethyl glyoxime Ni-DMG complex, $[Ni(DMG)_2]$.
4. Copper tetraammine complex, $[(Cu(NH_3)_4]SO_4$.

PART C: Separation and quantitative estimation of metal ions

1. Estimation of nickel(II) using dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN.
3. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
4. Estimation of Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

Any other related experiment as desired by the course teacher.

REFERENCES

1. V. Venkateswaran, R. Veeraswamy and A. R. Kulandaivelu, *Basic Principles of Practical Chemistry*, 2nd Ed., S. Chand and Sons, 2012.
2. J. Mendham, *Vogel's Textbook of Quantitative Analysis*, 6th Ed., John Wiley and Sons, 2009.
3. A. I. Vogel, *Vogel's Textbook of Quantitative Chemical Analysis*, 5th Ed., John Wiley and Sons, 1989.
4. S. Ratnani, S. Agrawal and S. K. Mishra, *Practical Chemistry*, McGraw Hill, 2020.
5. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
2	0	0	2

Course: Green Methods in Chemistry
Course Code: ICCHM4F002T

Course Objectives:

This course enables the learners to understand the basics of green chemistry, twelve principles of green chemistry, advantages of green chemistry over conventional chemistry, green solvents and future trends in green chemistry.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Demonstrate green chemistry and its principles
- Demonstrate green chemistry as sustainable chemistry
- Develop green synthetic protocols
- Design atom economic chemical reactions using green chemistry principles

Semester: IV
Course Name: Green Methods in Chemistry
Course Code: **2 Credits (2-0-0)**

UNIT – I **12 hours**

Introduction to green chemistry: Definitions of Green Chemistry, Introduction of twelve principles of Green Chemistry with examples, Atom and step economy, Reducing toxicity, Green solvents, Green Chemistry and catalysis, Alternative sources of energy, Green energy and sustainability, Introduction to multicomponent reactions and Domino reactions, Hantzsch synthesis, Ugi reaction.

UNIT – II **18 hours**

Green synthesis: Comparative study of conventional and green protocols of Wittig reaction, and Baeyer-Villiger oxidation, Green synthesis of ibuprofen.

Real world cases in Green Chemistry: Environmentally safe antifoulant, Surfactants for carbon dioxide-replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments, CO_2 as an environmentally friendly blowing agent for the polystyrene foam sheet, Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments, Green synthesis of a compostable and widely applicable plastic (poly-lactic acid) made from corn, Development of a fully recyclable carpet: Cradle-to-cradle carpeting.

REFERENCES

1. P. Tundo, A. Perosa and F. Zucchini, *Methods and Reagents for Green Chemistry*, Wiley, New Jersey, 2007.
2. A. S. Matlack, *Introduction to Green Chemistry*, Marcel Dekker, Inc., New York, 2001.
3. V. K. Ahluwalia, *Green Chemistry: Environmentally benign reaction*, Boca Raton, FL: CRC, Taylor & Francis, 2008.
4. P. T. Anastas and R. H. Crabtree, *Handbook of Green Chemistry, Green Catalysis, Homogeneous Catalysis*, Wiley, 2014.
5. P. T. Anastas and J. K. Warner, *Oxford Green Chemistry-Theory and Practical*, University Press, 1998.
6. R. K. Sharma, I. T. Sidhwani and M. K. Chaudhari, *Green Chemistry Experiments: A monograph*, I. K. International Publishing House Pvt Ltd. New Delhi, Bangalore. 2013.

Syllabus for Semesters V and VI

Five Year Integrated B.Sc.(Hons.)-M.Sc. Program in Chemistry

(under CBCS, *w.e.f.* Academic Session 2022-2023)

Offered By

Department of Chemistry and Chemical Sciences

CENTRAL UNIVERSITY OF JAMMU
Rahya-Suchani (Bagla), District-Samba
Jammu-181143, (J&K) India

Semester – V

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
	Organic Chemistry-IV	CC	4	3-1-0
	Physical Chemistry-IV	CC	4	3-1-0
	Organic Chemistry Lab-IV	CC	2	0-0-4
	Physical Chemistry Lab-IV	CC	2	0-0-4
	Natural Products Chemistry	DSE	4	3-1-0
	Properties of Inorganic Metal Complexes	DSE	4	3-1-0
	Applied Chemistry	DSE	4	3-1-0
	Applied Chemistry Lab	DSE	2	0-0-4
	Total		26	

Semester – VI

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
	Organic Chemistry-V	CC	4	3-1-0
	Physical Chemistry-V	CC	4	3-1-0
	Organic Chemistry Lab-V	CC	2	0-0-4
	Physical Chemistry Lab-V	CC	2	0-0-4
	Selected Topics in Inorganic Chemistry	DSE	4	3-1-0
	Project/Dissertation	DSE	6	0-0-12
	Total		22	

Examination Pattern

Course	Credit	CIA	MSE	ESE	Max. Marks
Theory	4	25	25	50	100
Theory	2	12.5	12.5	25	50
Practical	2	25	-	25	50

Course: Organic Chemistry- IV

Course Code: ICCHM5C003T

Course Objectives:

This course enables the learners to understand the basics of Carboxylic acid and their derivatives, nitro compounds organo sulfur compounds and also basic idea of biomolecules including proteins, nucleic acids, Lipids, enzymes etc.

Learning outcomes:

Upon completion of this course, the learners will be able to:

- Demonstrate the reactivity and importance of carboxylic acids and their derivatives.
- Demonstrate the importance of biomolecules such as proteins lipids enzymes and nucleic acids.
- Develop synthetic protocols

Semester: V
Course Name: Organic Chemistry-IV
Course Code: 4 Credits (3-1-0)

UNIT – I **14 hours**

Carboxylic acids: Nomenclature, Structure and bonding, Preparation of monocarboxylic acids, Physical properties, Acidity of carboxylic acids, Effect of substituents on acid strength, Reactions of carboxylic acids, HVZ reaction, Reduction of carboxylic acids, Mechanism of decarboxylation, Methods of formation and chemical reactions hydroxy acids: Malic, Tartaric and Citric acids, Dicarboxylic acids: Methods of formation and effect of heat and dehydrating agents, Unsaturated acids: Cinnamic, Maleic and Fumaric acids.

Carboxylic acid derivatives: Preparation and reactions of acid chlorides, anhydrides, esters, amides and acid anhydrides, Comparative study of nucleophilic substitution at acyl group, Mechanism of acidic and alkaline hydrolysis of esters, Claisen and Dieckmann condensations, Reformatsky reaction, Hofmann bromamide degradation, Curtius rearrangement.

UNIT – II **12 hours**

Nitro compounds: Preparation of nitroalkanes and nitroarenes, Chemical reactions of nitroalkanes, Mechanism of nucleophilic substitution in nitroarenes, Picric acid.

Amines: Preparation of alkyl and aryl amines *via* reduction of nitro compounds and nitriles, Reductive amination, Hofmann degradation, Gabriel-phthalimide reaction, Hoffmann rearrangement, Separation of a mixture of primary, secondary and tertiary amines (Hinsberg's method), Reactions of amines, Electrophilic aromatic substitution, Basicity of amines and effect of substituents on basicity, Amine salts as phase transfer catalysts

Diazonium salts: Preparation and reactions.

UNIT – III **12 hours**

Organosulfur compounds: Nomenclature, Methods of formation of thiols, thioethers, sulphonic acids, sulphonamides, suphur ylides, thiocyanates, isothiocyanates and sulphaguanidine.

Organophosphorus and organosilicon compounds: Preparation and chemical reactions of organophosphorous and organosilicon compounds, Phosphines, Phosphorous ylides, Wittig reaction, Phophine oxides, Esters of phosphorous acids, Alkyl silanes, Silanols, Siloxanes, Silylamines, Hiyama coupling.

UNIT – IV **10 hours**

Amino acids, peptides and proteins: Classification, Structure and stereochemistry of amino acids, Zwitterions, Isoelectric point, Electrophoresis, Synthesis, ionic properties and reactions of α-amino acids, Classification of proteins, Peptide structure determination: End group analysis and Selective hydrolysis of peptides, Solid-phase peptide synthesis, Primary and secondary structures of proteins.

UNIT – V **12 hours**

Nucleic acids: Components of nucleic acids, Nucleosides and nucleotides, Synthesis of Adenine, Guanine, Cytosine, Uracil and Thymine, Structure of polynucleotides, Ribonucleosides and Ribonucleotides, The double helical structure of DNA.

Lipids: Introduction to oils and fats, Common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, Acid value, Iodine number.

Enzymes: Classification and characteristics of enzymes, Salient features of active site of enzymes, Mechanism of enzyme action (chymotrypsin), Factors affecting enzyme action, Enzyme inhibitors and their importance.

REFERENCES

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011.
2. A. Bahl and B. S. Bahl, *A Text Book of Organic Chemistry*, 22nd Ed., 2016.
3. I. L. Finar, *Organic Chemistry*, Vol. I and II, 6th Ed., 2002.
4. L.G. Wade Jr., *Organic Chemistry*, Prentice Hall, 8th Ed., 2016.
5. P. Y. Bruice, *Organic Chemistry*, 8th Ed., 2016.
6. F. A. Carey and R. M. Giuliano, *Organic Chemistry*, *McGraw Hill*, 10th Ed., 2016.
7. F. A. Carey and R. J. Sundberg, *Advanced Organic Chemistry: Part A: Structure and Mechanisms*, 5th Ed., 2008.
8. M. B. Smith, *March's Advanced Organic Chemistry, Reactions, Mechanisms and Structure*, 7th Ed., 2016.
9. D. L. Nelson and M. M. Cox, *Lehninger's Principles of Biochemistry*, 7th Ed., W. H. Freeman and Company, 2017.
10. J. M. Berg, J. L. Tymoczko, G. J. Gatto Jr. and L. Stryer, *Biochemistry*, 8th Ed., 2015

L	T	P	C
3	1	0	4

Course: Physical Chemistry IV
Course Code: ICCHM6C004T

Course Objectives:

This course enables the learners to understand the basic principles and fundamental theories of quantum mechanics, the Schroedinger equation and its importance, degeneracy and its applications to conjugated systems and application of quantum mechanics. This course also provides the knowledge of surface chemistry and colloidal system, properties of colloidal system and surface active agents.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Understand the concept of quantum mechanics and learn to apply the postulates of quantum mechanics to solve some quantum mechanical systems.
- Design and carry out experiments, data analysis and account for uncertainties and compare results with theoretical predictions.
- Describe adsorption process and its mechanisms on the surfaces.
- Explain colloidal system and the surface active agents.

Semester: V
Course Name: Physical Chemistry-IV
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Quantum mechanics-I: Basic principles of quantum mechanics, Inadequacy of classical mechanics, The concept of quantization, Black–body radiation, Planck's radiation law, Photoelectric effect, Heat capacity of solids, Bohr's model of hydrogen atom and its defects, Compton effect, The wave-particle duality, The Heisenberg's uncertainty principle, Operator formalism: Linear operator, Hermitian operator and angular momentum operator, Commutator, Eigen functions and eigen values, Expectation values.

UNIT – II **12 hours**

Quantum mechanics-II: Hamiltonian operator, Schrödinger wave equation and its importance, Physical interpretation of the wave function, Orthogonal and orthonormal functions, Correspondence principle, Postulates of quantum mechanics and their analysis, Particle in a one, two and three-dimensional box, Degeneracy and its applications to conjugated systems.

UNIT – III **12 hours**

Quantum mechanics-III: Simple harmonic oscillator: Setting up of the Schrodinger stationary equation, Energy expression (without derivation), Expression of wave function for $n = 0$ and $n = 1$ (without derivation) and their characteristic features; Schrödinger wave equation for *H*-atom, Transformation of coordinates: Cartesian to polar (without derivation), Separation into three total differential equations in terms of the variables r, θ, φ; and their significance, Solution of φ equation and emergence of magnetic quantum number '*m*', Concept of orbital.

UNIT – IV **12 hours**

Surface chemistry: Structure of solid surfaces: Adsorption and desorption of molecules, physisorption and chemisorption, Surface reaction kinetics, Langmuir, BET and Freundlich adsorption isotherms, The rates of surface processes, Temperature dependence of adsorption, Structure of heterogeneous surfaces: Langmuir-Hinshelwood and Eley-Rideal mechanism.

UNIT – V **12 hours**

Colloidal state: The colloidal systems, general properties, Tyndall effect, Properties of hydrophobic colloidal systems: Electrical properties (electrical double layer) and electrokinetic properties (electro-osmosis).
Surface active agent, Classification of surface-active agent, Critical micelle concentration (CMC), Factor affecting the CMC of surfactants, Hydrophobic interaction, Thermodynamics approach to CMC and micellization.

REFERENCES

1. D. A. McQuarrie and J. D. Simon, *Physical Chemistry: A Molecular Approach*, Viva Student Ed., 2011.
2. D. A. McQuarrie, *Quantum Chemistry,* Viva Student Ed., 2014.
3. R. K. Prasad, *Quantum Chemistry*, New Age International Publishers Ltd., New Delhi, 4th revised Ed., 2014.
4. A. K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw Hill, 4th Ed., 1998.
5. I. N. Levine, *Quantum Chemistry*, Pearson, 7th Ed., 2013.

6. P. W. Atkins and J. de Paula, *The Elements of Physical Chemistry*, Oxford, 10th Ed., 2014.
7. P. W. Atkins and R. Friedman, *Molecular Quantum Mechanics*, Oxford University Press, 5th Ed., 2012.
8. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., 47th Ed., 2017.

Course: Organic Chemistry Lab IV

Course Code: ICCHM5C002L

Course Objectives:

This course enables the learners to understand the knowledge of Separation oforganic compounds such as Acidic , basic And neutral organic compound Naphthol, aniline, glucose, phenol, ascorbic acid and amino acids, etc. Also learners will be able to understand the application of U.V, I.R and NMR spectra for identification of organic compounds.

Learning Outcomes:

Upon completion of the course, the learners will be able to:

- Demonstrate the estimation of organic compounds such as amines carbohydrates, amino acids, etc.
- Demonstrate the identification of functional groups by IR and UV spectroscopy.
- To determine structure of molecules on the basis of NMR data.

Semester: **V**
Course Name: **Organic Chemistry Lab-IV**
Course Code: **2 Credits (0-0-4)**

Separation of organic mixture (at least 4-6 mixtures)

The given mixture of organic compounds will be separated *via* biphasic extraction method. A binary mixture containing strongly acidic, weakly acidic, basic and neutral compounds will be provided from the following list.

1. Strongly acidic compounds: Carboxylic acids, Sulphonic acids
2. Weakly acidic compounds: Phenols, Naphthols
3. Basic compounds: Amines
4. Neutral compounds: Hydrocarbons, Carbohydrates, Amides, Anilides, Diamides, Esters, Nitro compounds, Halogen compounds, etc.

Any other related experiment as desired by the course teacher.

REFERENCES:

1. F. G. Mannand, B. C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G, Smith and A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
0	0	4	2

Course: Physical Chemistry Lab -IV
Course Code: ICCHM5C003L

Course Objectives:

This course enables the learners to understand the basic principle and application of potentiometer, conductometer, pH-meter, the relationship between the E_{cell} and a spontaneous reaction, the difference between a voltaic and electrolytic cell, quantify the anode and cathode reaction and the concept and preparation of different buffer solution.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Learn the application of potentiometer for the acid-base titration.
- Apply conductometer study of acid hydrolysis of ester and relative acid strength determination.
- Handle pH-meter to measure the pH of different solution.
- Design and construct an electrochemical cell.
- Measure the cell potential and calculate the free energy change for an electrochemical cell
- Control an electrochemical cell to achieve a desired voltage.
- Prepare and study the buffer solution.

Semester: **V**
Course Name: **Physical Chemistry Lab-IV**
Course Code: **2 Credits (0-0-4)**

Electrochemistry

1. Determination of degree of hydrolysis of aniline hydrochloride in 0.001 M solution at room temperature and hence calculate the hydrolysis constant of the salt and dissociation constant of the base.
2. Potentiometric titrations of
   (i) Strong acid with strong base
   (ii) weak acid with strong base
   (iii) dibasic acid with strong base
3. Potentiometric titration of Mohr's salt with potassium dichromate.
4. Determination of the *p*H of a number of buffer solution using quinhydrone electrode
5. Acid hydrolysis of methyl acetate with hydrochloric acid conductometrically.
6. Determine the relative strength of chloroacetic acid and acetic acid by conductance measurement.
7. Determination of the *p*H of different solutions using *p*H-meter
8. Preparation of buffer solutions
   (i) Sodium acetate-acetic acid,
   (ii) Ammonium chloride-ammonium hydroxide

Any other related experiment as desired by the course teacher.

REFERENCES

1. A. Ghoshal, B. Mahapatra and A. K. Nad, *An Advanced Course in Practical Chemistry,* New Central Book Agency Pvt. Ltd., 3rd Ed., 2012
2. B. P. Levitt, *Findley's Practical Physical Chemistry*, Longman Group Limited, 9th Ed., 1954.
3. J. B. Yadav, *Advanced Practical Physical chemistry*, Goel Publishing, 1st Ed., 2015.
4. B. Viswanathan and P. S. Raghavan, *Practical Physical chemistry*, Viva Books Pvt. Ltd., 1st Ed., 2014.

L	T	P	C
3	1	0	4

Semester: V
Course: Natural Products Chemistry
Course Code: ICCHM5E003T

Course Objectives:
This course confers the learners an understanding of the occurrence, classification and structural elucidation of various natural products. It also enables the learners in developing knowledge of synthetic methods of natural products including carbohydrates, terpenoids, alkaloids, steroids etc.

Learning Outcomes
Upon completion of this course, the learners will be able to:
- Describe the significance of natural products in the medicinal field
- Determine the structural elucidation of various naturally occurring molecules
- Design the synthetic schemes of the preparation of different natural products

Semester: V
Course Name: Natural Products Chemistry
Course Code: 4 Credits (3-1-0)

UNIT – I **12 hours**

Carbohydrates: Classification, Chemistry of monosaccharides (glucose and fructose), Mechanism of osazone formation, Interconversion of glucose and fructose, Chain lengthening and chain shortening of aldoses, Configuration of monosaccharides, Erythro and threo diastereomers, Mechanism of mutarotation, Introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination, Industrial applications of starch and cellulose.

UNIT – II **12 hours**

Terpenoids: Classification, Isoprene rule, General methods of structural elucidation, Synthesis and stereochemistry of Citral, Geraniol and Menthol.
Carotenoids: Introduction, Structural elucidation and total synthesis of β-carotene.

UNIT – III **12 hours**

Alkaloids: Natural occurrence, General structural features, Physiological action, Occurrence and isolation, General methods of structural determination, Hoffmann's exhaustive methylation, Emde's modification, Synthesis of Coniine, Nicotine and Piperine.

UNIT – IV **12 hours**

Steroids: Occurrence, Nomenclature, Basic skeleton, Diel's hydrocarbon, Stereochemistry, Isolation, Structural determination and synthesis of Cholesterol and Estrone.

UNIT – V **12 hours**

Plant pigments: Occurrence, General methods of structural determination of Flavones and Isoflavones, Synthesis of Quercetin, Cyanidin and Cyanin, Biosynthesis of flavonoids:Acetate pathway.

REFERENCES

1. J. Mann, R. S. Davidson, J. B. Hobbs, D.V. Banthrope and J. B. Harborne, *Natural Products: Their Chemistry and Biological Significance*, Harlow, Essex, England Longman Scientific & Technical, New York, Wiley, 1stEd., 1994.
2. M. Nogradi, *Stereoselective Synthesis A Practical Approach*, 2ndEd., 2008, VCH.
3. K. Hostettmann, M. P. Gupta and A. Marston, Chemistry, *Biological and Pharmacological Properties of Medicinal Plants From the Americas*, 1997, Harwood Academic Publishers.
4. B. A. Bohm, *Introduction to Flavonoids*, 1998, Harwood Academic Publishers.
5. Atta-ur-Rahman M. I. Choudhary, *New Trends in Natural Product Chemistry*, 1998, Harwood Academic Publishers.
6. S. Dev, Insecticides of Natural Origin, 1997, Routledge; 1st Ed., 2017.
7. I. L. Finar, *Organic Chemistry*, Vol. II, ELBS Publishers, 1985.

Sem-V

L	T	P	C
3	1	0	4

Course: Properties of Inorganic Metal Complexes
Course Code: ICCHM5E004T

Course Outline:

This course is introductory in nature and expected to provide the learners about the transitions in the metal complexes. The course introduces the arrangement of electrons in various orbitals and its behaviour in the presence of magnetic field. The course also introduces the basics concepts of electronic absorption spectroscopy and metal carbonyls. This course is also exploring the understanding to the undergraduate students about the electronic transitions, presence of magnetic field and synthesis of metal carbonyl and its wide applications.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Demonstrate the types of transitions, microstates for the different electronic configurations.
- Demonstrate the methods for the calculation of magnetic moment values.
- Develop the different synthetic methods for the metal carbonyls
- Design the various ligands for the synthesis of metal carbonyl derivatives.

Semester: V
Course Name: Properties of Inorganic Metal Complexes
Course Code: 4 Credits (3-1-0)

UNIT – I 12 hours

Electronic spectra of transition metal complexes-I: Quantum numbers, Types of electronic transitions, Selection rules for *d-d* transitions, Spectroscopic ground states, Term symbols, Microstates, Spectrochemical series of ligands, Orbital and spin magnetic moments, Orbital contribution, Quenching of magnetic moment, Russel-Saunders Coupling: *l-l* coupling, *J-J* coupling, *L-S* coupling, Derivation of Russell-Saunders terms: p^2, d^2 configuration, Orgel diagram (d^1 to d^9 states), Electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion, Nepheleuxatic effect.

UNIT – II 12 hours

Magnetic properties of transition metal complexes-I: Definition of magnetic properties, Types of magnetic bodies (Diamagnetism, Paramagnetism Ferromagnetism, Ferrimagnetism, and Antiferromagnetism), Mechanism of anti-ferromagnetic interaction, Spin-only formula, Spin orbit coupling, Lande interval rule, Energies of *J*-levels, Curie law, Curie-weiss law, Temperature independent paramagnetism (TIP), Derivation and application of Van-Vleck susceptibility equation, Magnetic exchange coupling and spin crossover (Low spin and high spin cross over), Anomalous magnetic moments, Magnetic properties of binuclear and polynuclear complexes.

UNIT – III 12 hours

Magnetic properties of transition metal complexes-II: Magnetic susceptibility-orbital and spin effects, Importance of magnetic susceptibility, Diamagnetism and Pascals's constant, Gouy's method, Faraday method, Vibrating sample magnetometer, SQUID, NMR method for measuring magnetic susceptibility, Correlation of μs and μeff values, Orbital contribution to magnetic moments, Magnetic properties based on crystal field models: Octahedral, Tetrahedral, Trigonal bipyramidal, Square pyramidal and tetragonally distorted octahedral complexes.

UNIT – IV 12 hours

Metal π-complexes–I: Metal carbonyls, Classification of metal carbonyls, Effective atomic number, Preparation and important reactions (substitution, nucleophilic, electrophilic, reduction reactions) of metal carbonyls, Structure and chemical bonding in metal carbonyls, Preparation of anionic metal carbonyl complexes and substituted metal carbonyl complexes, Vibrational spectra of metal carbonyls for bonding and structural elucidation, Application of metal carbonyls complexes.

UNIT – V 12 hours

Structure, Bonding, and important reactions with transition metals, Metal nitrosyls complexes-Preparation, Structure, Bonding and important reactions with transition metals, Ligating behaviour of tertiary phosphines, Isopoly and heteropoly acids-salts of molybdenum and tungsten.

REFERENCES

1. B. R. Puri, L. R. Sharma and K. K. Kalia, *Principles of Inorganic Chemistry*, 33rd Ed., New Delhi, S. L. N. Chand & Co., 2017.
2. J. E. Huhey, Harpes and Row, *Inorganic Chemistry-Principles of structure and reactivity*, 4th Ed., Pubs: Harper Collins 2006.

3. J. D. Lee, *Concise Inorganic Chemistry*, 5th Ed., Oxford University Press, John Wiley & Sons, 2010.
4. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver and Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press, 2009.
5. A. B. P. Lever, *Inorganic Electronic Spectroscopy*, Elsevier Applied Science, 1984.
6. R. D. Madan, G. D. Tuli and W. U. Malik, *Selected Topics in Inorganic Chemistry*, S. Chand & company, New Delhi, 2010.
7. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver and Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press, 2009.
8. A. Earnshaw, *Introduction to Magnetochemistry*, 1st Ed., Academic Press, 2013.
9. R. L. Carlin, *Magnetochemistry*, Springer Verlag, Berlin, 1986.
10. A. Syamal and R. L. Dutta, *Elements of Magnetochemistry*, 2nd Ed., East-West Press Pvt. Ltd, 2004.
11. F. E. Mabbs, D. J. Machin, *Magnetism and Transition Metal Complexes*, Dover Publications, 2008.

L	T	P	C
3	1	0	4

Course: Applied Chemistry
Course Code: ICCHM5E002T

Course Objectives:

This course enables the learners to understand the nature, types and uses of polymers, manufacturing and uses of soaps, detergents, paints and dyes, food additives and food preservatives, manures, fertilizers, properties and types of cement and glass as well as their application.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Describe the polymers and their types as well as the use of polymers in day to day life
- Explain the manufacturing and cleansing action of soaps and detergents
- Demonstrate the methods of preserving food items
- Discuss the role of different fertilizers in plant growth and development
- Describe the manufacturing, properties and uses of cement and glass

Semester: V
Course Name: Applied Chemistry
Course Code: 4 Credits (3-1-0)

UNIT – I **14 hours**

Polymers: Monomers and their functionality, Classification, Degree of polymerization, Type of polymerization, Addition and condensation polymerization, Mechanism of free radical, cationic, anionic and Ziegler-Natta polymerizations, Stereochemistry of polymer, Thermo and thermosetting plastics, Preparation, properties and uses of Polythene, Polystyrene, PVC, Phenol-formaldehydes, Nylons, Kevlar, Terylene, Rubber: natural and synthetic rubbers, Silicone rubber, Functional polymers-Fire retarding polymers and electrically conducting polymers, Biomedical polymers-contact lens, dental polymers artificial heart, kidney, skin and blood cells.

UNIT – II **12 hours**

Dyes and paints: Classification of dyes, Synthetic dyes: Methyl orange, Congo red, Malachite green, Crystal violet, Primary constituents of a paint, Binders and solvents for paints, Oil based paints, Latex paints, Constituents of varnishes.

Soaps and detergents: Soap action, Raw materials for soaps, Classification and manufacture of soaps, Batch process, Continuous process, Difference between soap and detergent, Active ingredients in detergents, Anionic surfactant, Cationic surfactant, Amphoteric surfactant and Nonionic surfactant.

UNIT – III **12 hours**

Food additives: Food additives, Definition, Classification, Functions, Artificial sweeteners, Food flavors, Food colour, Acidulants, Antioxidants, Alkalies, Edible emulsifiers and edible foaming agents, Baking powder, Yeast, Sequesterants, Taste enhancers, Uses and abuses of these substances in food beverages.

Food preservation and processing: Food deterioration, Methods of preservation and processing, Food preservatives, Methods of preservation, Packaging of foods

UNIT – IV **10 hours**

Cement: Type of cements, Raw material for manufacture, Manufacture of Portland cement, Manufacturing processes, Dry process, Wet process, Setting of cement, Hydrolysis, Hydration, Properties of cement, Role of gypsum in cement, Special type cements, High alumina cement, White cement, Mortar, Concrete and RCC, Curing and decay of concrete.

Glass: Physical and chemical properties of glass, Raw materials, Manufacture of glass by potand tank furnaces, Types of glass, Tempered glass, Laminated glass, Water glass, Optical glass, Borosilicate glass, Lead glass, Safety glass, Fibre glass, Insulating glass.

UNIT – V **12 hours**

Fertilizers: Plant nutrients and its role, Classification of fertilizers, Properties of fertilizers, Nitrogenous fertilizers and its manufacture: Ammonium nitrate, Ammonium sulphate, Urea, Calcium cyanamide, Manufacture of phosphate fertilizer: Normal super phosphate, Triple super phosphate, Mono-ammonium phosphate, Diammonium phosphate, Potassium fertilizer, NPK fertilizer, Bio-fertilizers, Formulation and utilization.

Pesticides and insecticides: Classification of pesticides with examples and their modes of action, Organic and inorganic pesticides, Biopesticides, Impact of pesticides on soil, plants and environment.

REFERENCES

1. F. W. Billmeyer, *Textbook of Polymer Science*, John Wiley & Sons, Inc, 3rd Ed., 2007.
2. V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, *Polymer Science*, New Age International (P) Ltd. Pub, 2ndEd., 2015.
3. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2010.
4. G. N. Pandey, *Text Book of Chemical Technology*, Vol. 1 Chand Publishers House, 2018.
5. E. Stocchi, *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK, 1990.
6. R. M. Felder and R. W. Rousseau, *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi, 3rd Ed., 2014.
7. P. C. Jain and M. Jain, *Engineering Chemistry*, 16th Ed., Dhanpat Rai and Sons, Delhi, 2013.
8. T. P. Coultate, *Food-The Chemistry of its components*. Royal Society of Chemistry London, 2009.
9. M. Swaminathan, *Text Book on Food and Nutrition*, Printing and Publishing CO., Ltd., Bangalore. 2018.
10. M. F. Ali, B. M. El Ali and J. G. Speight, *Handbook of Industrial Chemistry: Organic Chemicals*, McGraw-Hill Education, 2005.
11. B. K. Sharma and H. Gaur, *Industrial Chemistry*, 19th Edition, Goel Publishing House, Meerut, 2016.
12. H. R. Alcock and F.R. Lambe, *Contemporary Polymer Chemistry*, Prentice Hall, 3rd Ed., 2003.

L	T	P	C
0	0	4	2

Course: Applied Chemistry Lab
Course Code: ICCHM5E002L

Course Objectives:

This course enables the learners to understand the saponification value, iodine value, and hardness of water as well as the estimation of iodine, chlorine, nitrogen and calcium oxide in the given samples.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Determine the iodine value and saponification value of an oil sample
- Estimate the iodine in drugs through drug analysis
- Determine the hardness of water sample
- Estimate the amount of nitrogen in a given fertilizer
- Determine the concentration of CaO in given sample

Semester: **V**
Course Name: **Applied Chemistry Lab**
Course Code: **2 Credits (0-0-4)**

Technical Analysis (At least eight experiments)

1. Estimation of iodine in antiseptic drug through drug analysis.
2. Estimation of available chlorine in the given bleaching powder sample.
3. Estimation of manganese dioxide in pyrolusite.
4. Determination of CaO in the given sample of commercial lime.
5. Estimation of nitrogen in a given fertilizer (inorganic).
6. Determination of iodine value of an oil sample.
7. Determination of saponification value of an oil sample.
8. Determination of percentage composition of a mixture of sodium hydroxide and sodium chloride.
9. Determination of amount of dissolved oxygen in water.
10. Determination of total, permanent and temporary hardness of water.

Any other related experiments as desired by the course teacher.

REFERENCES

1. V. V. Ramanujam, *Inorganic Semi Micro Qualitative Analysis*, 3rd Ed., 1974, National Publishing Company, Chennai.
2. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denny, *Vogel's Text Book of Inorganic Qualitative Analysis*, 4th Ed., 1974, ELBS, London.
3. V. Venkateswaran, R. Veeraswamy and A. R. Kulandaivelu, *Basic Principles of Practical Chemistry*, 2nd Ed., 2017, Sultan Chand and Sons, New Delhi.

Course: Organic Chemistry- V

Course Code: ICCHM6C003T

Course Objectives:

This course enables the learners to understand the basics of Spectroscopy such as U.V. visible, IR, NMR and mass spectroscopy and also about the basic knowledge of heterocyclic compounds such as five membered and six membered heterocycles.

Learning outcomes:

Upon completion of the course, the learners will be able to

- Demonstrate the application of spectroscopic techniques for structure determination.
- Demonstrate the application of heterocyclic Compounds
- To identify the functional groups by U.V and I.R and to elucidate the structure by Mass spectroscopy.

Semester: **VI**
Course Name: **Organic Chemistry-V**
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

UV-Vis spectroscopy: Introduction, Absorption laws, Instrumentation, Formation of absorption bands, Types of electronic transitions, Chromophores, Auxochromes, Absorption and intensity shifts, Solvent effects, Woodward-Fieser rules for calculating absorption maximum in dienes and α,β-unsaturated carbonyl compounds.

IR spectroscopy: Introduction, Theory of molecular vibrations, Vibrational frequency, Factors influencing vibrational frequencies, Finger print region, Applications of IR spectroscopy in functional group analysis, Effect of hydrogen bonding, conjugation, resonance and ring size on IR absorptions.

UNIT – II **12 hours**

NMR Spectroscopy: Basic principles of proton magnetic resonance, Instrumentation, Number of signals, Position of signals (Chemical shift), Shielding and deshielding effects, Factors influencing chemical shifts: Inductive effect, Anisotropic effect in alkenes, alkynes, aldehydes and aryl compounds, Hydrogen bonding, Splitting of signals, Spin-spin coupling, Coupling constant, Introduction to ^{13}C NMR.

UNIT – III **12 hours**

Introduction to mass spectrometry: Instrumentation, Ionization, Fragmentation, Molecular ion peak, Base peak, Isotopic peaks, Nitrogen rule, McLafferty rearrangement, Retro Diels-Alder reaction.

Applications of spectral techniques: Structural determination of simple organic compounds using UV, IR and NMR spectral data.

UNIT – IV **12 hours**

Heterocyclic compounds-I: Classification and nomenclature, Methods of formation of five membered heterocycles: Furan, Thiophene and Pyrrole, Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis, Aromatic characteristics of pyrrole, furan and thiophene, Chemical reactions, Mechanism of electrophilic substitution.

Six membered heterocycles, Methods of formation of pyridine and pyrimidine, Mechanism of nucleophilic substitution reactions in pyridine derivatives, Comparison of basicity of pyridine, piperidine and pyrrole.

UNIT – V **12 hours**

Heterocyclic compounds-II: Introduction to condensed five- and six-membered heterocycles, Preparation and reactions of indole, quinoline and isoquinoline, Fischer indole synthesis, Madelung synthesis, Skraup synthesis, Friedländer synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski synthesis, Pictet-Spengler reaction, Pomeranz-Fritsch reaction.

REFERENCES

1. R. M. Silverstein, F. X. Webster, D. V. Kiemle and D. L. Bryce, *Spectrometric Identification of Organic Compounds*, 8th Ed., Wiley, 2014.
2. P. S. Kalsi, *Spectroscopy of Organic* Compounds, 8th Ed., New Age International, 2020.
3. W. Kemp, *Organic Spectroscopy*, 2nd Ed., Macillan, 2019.

4. D. H. Williams and I. Fleming, *Spectroscopic Methods in Organic Chemistry*, 6th Ed., McGraw Hill Education, 2011.
5. T. L. Gilchrist, *Heterocyclic Chemistry*, 3rd Ed., Addison Wesley Longman Limited, 1997.
6. R. R. Gupta, M. Kumar and V. Gupta, *Heterocyclic Chemistry, Vol. I, II and III*, Springer Nature, 2011.
7. J. A. Joule, K. Mills and G. F. Smith, *The Chemistry of Heterocycles*, 3rd Ed., Chapman and Hall, 1995.
8. *Comprehensive Heterocyclic Chemistry*, A.R. Katritzky and C.W. Rees (Eds.), Vol I-VIII, Ist Ed., Pergamon Press.
9. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2010.
10. I. L. Finar, *Organic Chemistry*, Vol. I and II, 6th Ed., 2002.

L	T	P	C
3	1	0	4

Course: Physical Chemistry -V
Course Code: ICCHM6C004T
Semester: VI

Course Objectives:

This course enables the learners to understand the basics of theoretical spectroscopy and their applications in chemistry. Additionally, course enables the learners to understand the fundamentals of computational chemistry.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Acquire knowledge of different aspects of theoretical spectroscopy such as rotational, vibrational and electronics transitions.
- Acquire knowledge of the applications of spectroscopic techniques in real time problems.
- Acquire knowledge on the state-of-the-art techniques on computational chemistry and their applications.

Semester: **VI**
Course Name: **Physical Chemistry-V**
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Spectroscopy: Introduction: Electromagnetic radiation, Regions of the spectrum, Basic elements of practical spectroscopy, Lambert-Beer Law, Width and intensity of spectral lines, Statement of Born-Oppenheimer approximation.

Rotational spectroscopy: Diatomic molecules, Energy levels of a rigid rotor (semi-classical principles), Selection rules, Spectral intensity, Distribution using population distribution (Maxell- Boltzmann distribution), Rigid diatomic molecule, Non-rigid rotator, Spectrum of non-rigid rotator, Polyatomic molecules, Determination of bond length, Isotope effect.

UNIT – II **12 hours**

Vibrational spectroscopy: Infrared spectrum: Energy levels of simple harmonic oscillator, Selection rules, Pure vibrational spectrum, Intensity, Determination of force constant and qualitative relation of force constant and bond energies, Effect of anharmonic motion and isotope on the spectrum, Idea of vibrational frequencies of different functional groups, Vibration–rotation spectroscopy, P-branch and R-branch.

Raman spectroscopy: Concept of polarizability, Stokes and Anti-Stokes lines, Pure rotational and pure vibrational Raman spectra of diatomic molecules, Selection rules, Mutual Exclusion.

UNIT – III **12 hours**

Electronic spectroscopy: The characteristics of electronic transitions, Electronic spectroscopy of atoms, Term symbol, Photoelectron spectroscopy, Electronic spectroscopy of molecules, Selection rules, Vibrational structure and Franck-Condon principle, Franck-Condon factor, Concept of HOMO-LUMO transitions, Simple Dissociation energy, Pre-dissociation, Quantum yield and radiative processes, Fluorescence and phosphorescence, Jablonski diagram, Internal conversion and intersystem crossing.

UNIT – IV **12 hours**

Photochemistry: Generation of excited states, Singlet and triplet states, Spin-orbit coupling, Kinetics of photophysical and photochemical processes, Timescales, The primary quantum yield, Mechanism of decay of excited singlet states, Quenching, Stern-Volmer equation and its applications, Flash photolysis, Laser flash photolysis, Lasers and their applications.

UNIT – V **12 hours**

Computers in chemistry: General introduction to computers, Different components of a computer, Hardware and software, Conceptual background of theory, Computations and molecular modeling, Z-matrix, Potential energy surfaces and chemical properties, Cost and efficiency, algorithms, Elementary ideas of molecular mechanics and force fields, Parameterization, Potential energy functional forms, Conceptual ideas of Molecular orbital methods, Concept of equilibrium structures, Transition state structures and harmonic frequency calculations, Born-Oppenheimer approximation, Awareness of computational chemistry software, Introduction to computer languages, Programming and operating systems.

REFERENCES

1. P. W. Atkins and J. de Paula, *The Elements of Physical Chemistry*, Oxford, 10th Ed., 2014.

2. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., 47th Ed., 2017
3. C. Banwell and E. McCash, *An Introduction to Molecular Spectroscopy*, McGraw Hills, 4th Ed., 1994.
4. C. Banwell, C. McCash and H. Chaudhury, *Fundamentals of Molecular Spectroscopy,* McGraw Hill Education, 4th Ed., 2013.
5. J. Michael Hollas, *Modern Spectroscopy*, Wiley, 4th Ed., 2004.
6. K. K. Rohatgi-Mukerjee, *Fundamentals of Photochemistry*, Wiley Eastern Ltd., 1986.
7. C. J. Cramer, *Essentials of Computational Chemistry*, Wiley-Blackwell, 2nd Ed., 2004.
8. F. Jensen, *Introduction to Computational Chemistry*, Wiley, 2nd Ed., 2007.
9. On-line manual of *Gaussian 16* and *GAMESS.* www.gaussian.com and www.msg.ameslab.gov/gamess
10. T. Engel and P. Reid, *Physical Chemistry*, Pearson, 2nd Ed., 2010.

Course: Organic Chemistry Lab – V

Course Code: ICCHM6C00IL

Course Objectives:

This course enables the learners to understand the knowledge of estimation of organic compounds such as aniline, glucose, phenol, ascorbic acid and amino acids, etc. Also learners will be able to understand the application of U.V, I.R and NMR spectra for identification of organic compounds.

Learning Outcomes:

Upon completion of the course, the learners will be able to:

- Demonstrate the estimation of organic compounds such as amines carbohydrates, vitamins, amino acids, etc.
- Demonstrate the identification of functional groups by IR and UV spectroscopy.
- To determine structure of molecules on the basis of NMR data.

Semester: **VI**
Course Name: **Organic Chemistry Lab-V**
Course Code: **2 Credits (0-0-4)**

Part A: Quantitative estimation of organic compounds:

1. Estimation of aniline (Bromate-bromide method)
2. Estimation of glucose (Fehling's method)
3. Estimation of phenol (Bromate-bromide method)
4. Estimation of ascorbic acid in Vitamin C tablets
5. Estimation of amino acid

Part B: Organic Spectroscopy:

1. Record of the UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water and comment on the effect of structure on the UV spectra of organic compounds.
2. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).

Any other related experiment as desired by the course teacher.

REFERENCES:

1. F. G. Mann and B. C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G, Smith and A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

L	T	P	C
0	0	4	2

Course: Physical Chemistry Lab-V
Course Code: ICCHM6C002L
Semester: VI

Course Objectives:

This course enables the students to gain hands-on experience on electrochemistry and experience about spectroscopic properties of chemical processes. It also provides hands-on experiences on the use of computers for a chemist as well as basics of computational chemistry.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Gain hand-on experience on the electrochemistry of different chemical processes.
- Gain hand-on experience on different properties of molecular spectroscopy of chemical processes.
- Gain hand-on experience on aspects of computational chemistry and use of different software tools suitable to learn chemistry in more interactive ways.

Semester: **VI**
Course Name: **Physical Chemistry Lab-V**
Course Code: **2 Credits (0-0-4)**

Part A: Spectroscopy

1. Determination of the specific rotation of a given optically active compound.
2. Determination of the λ_{max} for different colour solutions by colorimetric measurements.
3. Verify Beer- Lambert Law for a coloured solution ($KMnO_4$/$K_2Cr_2O_7$, etc.).
4. Determination of indicators constant (pK_{In}) of methyl red colorimetrically.
5. Study of the formation of a complex between ferric and thiocyanate (or salicylate) ions.

Part B: Electrochemistry

1. Study of titration of a mixture of hydrochloric acid and oxalic acid conductometrically.
2. Determine the concentration of each component in the following solutions:
   a) HCl and NH_4Cl in a solution
   b) NH_4OH and NH_4Cl in a solution

Part C: Computer in Chemistry

1. Study of simple control commands of *vi* editor embedded in a Linux box.
2. Plotting a linear graph using MS excel and Xmgrace from a given set of data set.
3. Plotting a non-linear graph using a given data set.
4. Study of quantum chemistry using computational chemistry software:
   a) Determination of the Z-matrices (Cartesian coordinate) of simple molecules: H_2, H_2O, H_2O_2, H_2CO, etc.
   b) Draw 3D structures of complex molecules using GaussView and determination of Z-matrices.

Any other related experiment as desired by the course teacher.

REFERENCES

1. A. Ghoshal, B. Mahapatra and A. K. Nad, *An Advanced Course in Practical Chemistry,* New Central Book Agency Pvt. Ltd., 3rd Ed., 2012
2. B. P. Levitt, *Findley's Practical Physical Chemistry*, Longman Group Limited, 9th Ed., 1954.
3. J. B. Yadav, *Advanced Practical Physical chemistry*, Goel Publishing, 1st Ed., 2015.
4. B. Viswanathan and P. S. Raghavan, *Practical Physical chemistry*, Viva Books Pvt. Ltd., 1st Ed., 2014.
5. On-line manual of *Gaussian 16 and GauessView,* www.gaussian.com

Sem-VI

L	T	P	C
3	1	0	4

Course: Selected topics in Inorganic Chemistry
Course Code: ICCHM6E003T

Course Objectives:

This course enables the learners to understand the basic concepts of oxidation and reduction and its application, physical and chemical properties of lanthanides and actinides. This course also also provides the knowledge of radioactivity, bioinorganic chemistry, action of metal ions in biological systems, biological and chemical nitrogen fixation and dioxygen storage and transport protein and classification function and storage of protein.

Learning Outcomes

Upon completion of this course, the learners will be able to:

- Determine oxidation no of a molecule, atom or ion.
- Predict the products of an oxidation reduction reaction.
- Demonstrate the trends in the physical and chemical properties of lanthanides and actinides.
- Acquire the knowledge of nuclear chemistry and radioactive decay.
- Have the knowledge of the basics of measurement of radioactivity and the main applications of nuclear chemistry.
- Describe the basic concept of bioinorganic chemistry, action of metal ions in biological systems and structure and function of protein.

Semester: **VI**
Course Name: **Selected Topics in Inorganic Chemistry**
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Oxidation and reduction: Oxidation number, Redox potential, Half-cell reaction, Nernst equation (without derivation), Electrochemical series, Use of redox potential data–Analysis of redox cycle, Redox stability in water, Latimer diagram for oxygen, copper (acidic medium) and for chlorine (acidic/alkaline medium), Calculation of E values for skip-step couples using EMF diagrams, Frost diagrams for oxygen and nitrogen, Pourbiax diagram for iron couple, Applications of redox reactions to the extraction of elements from their ores: Ellingham diagrams.

UNIT – II **10 hours**

Chemistry of lanthanides elements: Position of lanthanides in the periodic table, Occurrence and isolation, Electronic configuration, Oxidation states, Ionic radii, Magnetic and spectral properties, Complex formation, Lanthanide contraction, Application of lanthanides.

UNIT – III **12 hours**

Chemistry of actinides elements: Position of actinides in the periodic table, Occurrence and isolation, Electronic configuration, Oxidation states, Ionic radii, Magnetic and spectral properties, Complex formation, Separation of lanthanides: Ion-exchange method, Principles of separation of Np, Pu and Am from U, Application of actinides, Trans-uranium elements.

UNIT – IV **12 hours**

Nuclear chemistry and radioactivity-II: Introduction to radioactivity: Radioactive decay and equilibrium, Q value, Cross sections, Radioactive techniques, Tracer technique, Neutron activation analysis, Counting techniques such as G.M. ionization and proportional counter, Radioactive disintegration, Half life, Average life, Artificial transmutation, Decay kinetics, Types of decay, α-, β-, γ-emissions, Different radioactive series (natural and artificial), Group displacement law, Chemical reaction pathways and dating techniques, Mass defect and binding energy, Application of radioactivity and radio isotopes as tracers in analysis, in medicines, in biological field, in agriculture and in carbon dating.

UNIT – V **14 hours**

General principles of bioinorganic chemistry: Introduction to bio-inorganic chemistry, Classification of elements (essential and trace) in biological system with special reference to Na^+, K^+ and Mg^{2+} ions, Sodium-potassium pump (Na^+/K^+ pump), Nitrogen fixation-Biological and Chemical, Role of Mg^{2+} ion in energy production and chlorophyll, Hemoglobin and Myoglobin-Electronic and spatial structures, Protein-Classification, Structures, Functions, Role of proteins with reference to bones.

REFERENCES

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver and Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press, 2009.
2. B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Ed., John Wiley & Sons, 2010.
3. B. R. Puri, L. R. Sharma and K. K. Kalia, *Principles of Inorganic Chemistry*, 33rd Ed., New Delhi, S. L. N. Chand & Co., 2017.

4. J. E. Huhey, Harpes and Row, *Inorganic Chemistry-Principles of structure and reactivity*, 4th Ed., Pubs: Harper Collins 2006.
5. J. D. Lee, *Concise Inorganic Chemistry*, 5th Ed., Oxford University Press, John Wiley & Sons, 2010.
6. G. L. Miessler P. J. Fischer, D. A. Tarr, *Inorganic Chemistry*, 5th Ed., Pearson, 2014.
7. R. Gopalan and V. Ramalingam, Concise *Coordination Chemistry*, 1st Ed., S. Chand, 2008.
8. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, *Advanced Inorganic Chemistry*, 6th Ed., , John Wiley & Sons, 2008.
9. R. D. Madan, G. D. Tuli and W. U. Malik, *Selected Topics in Inorganic Chemistry*, S. Chand & company, New Delhi, 2010.
10. H. J. Arnikar, *Essentials of Nuclear Chemistry*, New Age International Private Limited, 4th Ed., 2011.
11. M. Sharon and M. Sharon, *Nuclear Chemistry*, Ane Books, 2nd Ed., 2018.
12. S. J, Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, 1994.
13. R. Crichton, Biological Inorganic Chemistry-A New Introduction to Molecular Structure and Function, 3rd Ed., 2018.

L	T	P	C
0	0	12	6

Semester: VI
Course: Project/Dissertation
Course Code: ICCHM6E001D

Course Objectives:
This course enables the learners to identify a research problem and execute it under the supervision of a faculty member. It also provides a platform the learners to learn literature survey, basic experimental and analytical techniques and carry out the research work. It also provides learners the systematic procedures to document and present the research findings or outcomes.

Learning Outcomes
Upon completion of this course, the learners will be able to:

- Illustrate the possible methods of performing a literature survey
- Design new research problems based on a detailed literature survey
- Demonstrate the experimental and analytical techniques which are involved in the respective field of research
- Deliver a detailed presentation explaining the importance and the experimental outcomes of a particular research topic

Semester: **VI**
Course Name: **Project/Dissertation**
Course Code: **6 Credits (0-0-12)**

The students will identify a research problem and execute it under the supervision of a faculty member. They will learn literature survey, basic experimental and analytical techniques and carry out the research work. The research finding will be documented and a dissertation will be submitted. The students will deliver a power point presentation at the end of semester examination.