BS in Chemistry (4-Years)

FIRST YEAR (SEMESTER-I)

S.NO	Course Code	Course Name	Credit Hours
1	ENG-100	English-I	3+0
2	GEN-100	Cell Biology	3+0
3	GEN-101	Principle of Sociology	3+0
4	Math-100	Mathematics-I	3+0
5	Comp-100	Computer Applications-I	3+0
6	CHEM-151	Inorganic Chemistry	3+1
Total Credit Hours			19

Course Code: ENG-100 **Course Name:** English I (Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents: Basics of Grammar, Parts of speech and use of articles, Sentence structure, active and passive voice, Practice in unified sentence, Analysis of phrase, clause and sentence structure, Transitive and intransitive verbs, Punctuation and spelling

Comprehension: Answers to questions on a given text

Discussion: General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening: To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills: Urdu to English

Paragraph writing: Topics to be chosen at the discretion of the teacher

Presentation skills: Introduction

Note: Extensive reading is required for vocabulary building

Recommended books:

1. **Functional English**

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition Oxford University Press. 1997. ISBN 0194313492 95.

2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition Oxford University Press. 1997. ISBN 0194313506.

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills.Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate.Brain Tomlinson and Rod Ellis.Oxford Supplementary Skills. Third Impression 1992.ISBN 0 19 453402 2.

d) Speaking

Course Code: GEN-100 **Course Name:** Cell Biology

Course Objectives:

To acquaint students with features of eukaryotic cells, functions of different compartments and the overall structure/ultrastructure of cells as visualized by electron microscopy.

Course Contents:

Introduction to cell theory including historical perspective; overview of membrane structure and chemical constituents of the cell; function, isolation and molecular organization of cellular organelles specifically the endoplasmic reticulum, lysosome, micro-bodies, mitochondrial ultra-structure and function, chloroplast ultra-structure and the mechanism of photosynthesis; composition and structure of membranes; membrane receptors and transport mechanisms; cell movement
- structure and function of cytoskeleton, centriole, cilia and flagella; nucleus; structure and function of chromosomes; cell cycle, mitosis and meiosis.

Practical:

Microscopy and staining techniques; study of prokaryotic, eukaryotic, plant and animal cells; cell structure in the staminal hair of *Tradescantia*; study of different types of plastids; cellular reproduction; Mitosis: smear/squash preparation of onion roots.

Recommended Books:

1. Alberts B and Johnson A, 2006. Molecular Biology of the Cell. 4th Edition; Garland Publishers, New York. (available at www.ncbi.nlm.nih.gov)
2. Karp, 2002. Cell and Molecular Biology. 3rd Edition; John Wiley and Sons, New York.
3. Alberts et al., 2009. Essential Cell Biology. 3rd Edition; Garland Publishers, New York.
4. Lodish et al,. 2007. Molecular Cell Biology. 6th Edition; Freeman and Company, New York. (available at www.ncbi.nlm.nih.gov)
5. Cooper GM and Hausman RE, 2009. The Cell, a molecular approach. 5th Edition; Sinauer Associates, Inc.

Course Code: GEN-101 **Course Name:** Principle of Sociology

Course Objectives:

The course is designed to introduce the students with sociological concepts and the discipline. The focus of the course shall be on significant concepts like social systems and structures, socio-economic changes and social processes. The course will provide due foundation for further studies in the field of sociology.

Course Outline:

1. Introduction
    a. Definition, Scope, and Subject Matter
    b. Sociology as a Science
    c. Historical back ground of Sociology
    d. Relationship of sociology with other social sciences
2. Basic Concepts
    a. Group, Community, Society
    b. Associations
        i. Non-Voluntary
        ii. Voluntary
    c. Organization
        i. Informal
        ii. Formal
    d. Social Interaction
        i. Levels of Social Interaction
        ii. Process of Social Interaction
            a) Cooperation
            b) Competition
            c) Conflict
            d) Accommodation
            e) Acculturation and diffusion
            f) Assimilation
            g) Amalgamation

3. Social Groups
    a. Definition and Functions
    b. Types of social groups
        i. In and out groups
        ii. Primary and Secondary group
        iii. Reference groups
        iv. Informal and Formal groups
        v. Pressure groups
4. Culture
    a. Definition, aspects and characteristics of Culture
        i. Material and non material culture
        ii. Ideal and real culture
    b. Elements of culture
        i. Beliefs
        ii. Values
        iii. Norms and social sanctions
    c. Organizations of culture
        i. Traits
        ii. Complexes
        iii. Patterns
        iv. Ethos
        v. Theme
    d. Other related concepts
        i. Cultural Relativism
        ii. Sub Cultures
        iii. Ethnocentrism and Xenocentrism
        iv. Cultural lag

5. Socialization and Personality
    a. Personality, Factors in Personality Formation
    b. Socialization, Agencies of Socialization

   c. Role and Status

6. Deviance and Social Control
   a. Deviance and its types
   b. Social control and its need
   c. Forms of Social control
   d. Methods and Agencies of Social control
7. Collective Behaviour
   a. Collective behaviour, its types
   b. Crowd behaviour
   c. Public opinion
   d. Propaganda
   e. Social movements
   f. Leadership

Suggested Readings:

1. Anderson, Margaret and Howard F. Taylor. 2001. *Sociology the Essentials*. Australia: Wadsworth.
2. Brown, Ken 2004. *Sociology*. UK: Polity Press
3. Gidden, Anthony 2002. *Introduction to Sociology*. UK: Polity Press.
4. Macionis, John J. 2006. 10th Edition *Sociology* New Jersey: Prentice-Hall
5. Tischler, Henry L. 2002. *Introduction to Sociology* 7th ed. New York: The Harcourt Press.
6. Frank N Magill. 2003. *International Encyclopedia of Sociology*. U.S.A: Fitzroy Dearborn Publishers
7. Macionis, John J. 2005. *Sociology* 10th ed. South Asia: Pearson Education
8. Kerbo, Harold R. 1989. *Sociology: Social Structure and Social Conflict.* New York: Macmillan Publishing Company.
9. Koening Samuel. 1957. *Sociology: An Introduction to the Science of Society*. New York: Barnes and Nobel..
10. Lee, Alfred Mclung and Lee, Elizabeth Briant 1961. *Marriage and The family.*New York: Barnes and Noble, Inc.
11. Leslie, Gerald et al. 1973. *Order and Change: Introductory Sociology*Toronto: Oxford University Press.

12. Lenski, Gevbard and Lenski, Jeam. 1982. *Human Societies*. 4th edition New York: McGraw-Hill Book Company.

13. James M. Henslin. 2004. *Sociology: A Down to Earth Approach*. Toronto: Allen and Bacon.

Course Code: Math-100 **Course Name:** Mathematics-I(Algebra)

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.

Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression.

Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices.

Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Recommended Books:

1. Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin.
2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

Course Code: Comp-100 **Course Name:** Computer applications-I

Course Contents:

Fundamental concepts of computer

- ❖ Overview of computers
  - History of computer
  - What is Computer
  - Data and Information
- ❖ **Components of a Computer**
  - Hardware
    - Input Units, System/ Processing Units, Output Units, Storage Units
  - Software
    - System Software
      - Operating System
      - Utility Software
      - Translator Software
    - Application Software
      - Packaged Software
      - Custom Software
      - Shareware Software
      - Freeware and Public Domain Software
  - User
- ❖ Categories of Computers

Digital, Analog, Hybrid Computer

- Super Computer
- Main Frame Computer
- Mini Computer
- Micro Computer

- ❖ **Data Communication**
  - Applications of Data Communication
  - Components of a data communication system
  - Rate of data Transmission
  - Computer Networks, Network Topology, Gateway
  - E-mail/Internet concepts.
  - Browsers, search engines, social websites, databases.
- ❖ **Application Software**
  - Database Software
  - Multimedia software
  - Spreadsheet Software
  - Presentation Software

Books Recommended

1. Using Information Technology Fourth Edition by Brain K Williams.
2. Fundamental Concepts Computer System By Asiya Sultan Ali Amena Nudrat.

3. Computer Science Text Book Grade XI By Muhammad Khalid.
4. Peter Norton: Introduction to Computers 6th Edition.

Course Code: CHEM-100 **Course Name:** Inorganic Chemistry

Course Objectives:

Students will acquire knowledge about the key introductory concepts of chemical bonding, acid-base chemistry, and properties of p-block elements as well as using this knowledge for qualitative and quantitative analysis of inorganic compounds during laboratory work.

Course Content:

Chemical Bonding:

Types of chemical bonding, ionic and covalent bonding, localized bond approach, theories of chemical bonding, valence bond theory (VBT), hybridization and resonance, prediction of molecular shapes using Valence Shell Electron Pair Repulsion (VSEPR) model, molecular orbital theory (MOT) applied to diatomic molecules, delocalized approach to bonding, bonding in electron deficient compounds,hydrogen bonding.

Acids and Bases:

Brief concepts of chemical equilibrium, acids and bases including soft and hard acids and bases (SHAB),concept of relative strength of acids and bases, significance of pH, pKa, pKb and buffer solutions, theory of indicators, solubility, solubility product, common ion effect and their industrial applications.

p-Block Elements:

Physical and chemical properties of p-block elements with emphasis on some representative compounds, inter-halogens, pseudo-halogens and polyhalides.

CHEM-151 Lab:

Lab safety and good laboratory practices, knowledge about material safety data sheets (MSD), disposal of chemical waste and first-aid practices, qualitative analysis of salt mixtures, quantitative analysis, acid- base titrations, preparation and standardization of acid and alkali solutions, redox titrations, preparation and standardization of potassium permanganate solution

and its use for the determination of purity of commercial potassium oxalate or oxalic acid, preparation and standardization of sodium thiosulfate solution and its use in determination of copper in a given sample, gravimetric analysis, determination of barium in a given sample, determination of chloride in a given solution.

Recommended Books:

1. Shriver, D. F., Atkins, P. W., Langford, C. H., *Inorganic Chemistry*, 2nd ed., Oxford University Press, (1994).
2. Cotton, F. A. and Wilkinson, G., *Advanced Inorganic Chemistry*, 6th ed., John-Wiley & Sons, New York, (2007).
3. Huheey, J. E., *Inorganic Chemistry: Principles of Structure and Reactivity*, 3rd ed., Harper International SI Edition, (2006).
4. House, J. E., *Inorganic Chemistry*, Academic Press. USA, (2008).
5. Lee, J. D., *Concise Inorganic Chemistry*, 5th ed., Chapman and Hall, (1996).
6. Miessler, G. L., Tarr, D. A., *Inorganic Chemistry*, 3rd ed., Pearson Education, India, (2008).
7. Huheey, J. E., Kieter E. A., Keiter L. R., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Benjamin-Cummings Pub Co., (1993).
8. Sharpe, A. G., *Inorganic chemistry*, 3rd ed., Pearson Education India, (1981).
9. Chaudhary S. U., *Ilmi Textbook of Inorganic Chemistry*, Ilmi Kitab Khana, Lahore, (2013).
10. Catherine E. House crdft, Alan G. Sharpe, *Inorganic Chemistry*, 3rd ed., Prentice Hall, (2008).
11. Kathleen A. H., James E. H., *Descriptive Inorganic Chemistry*, 2nd ed., Brooks Cole, (2010).
12. Wulfsberg G., *Principles of Descriptive Inorganic Chemistry*, 1st ed., University Science Books, (1991).
13. Hill, R. H. JR and Fister, D. C., *Laboratory Safety for Chemistry Students*, John-Wiley & Sons, Inc., (2010).
14. Mendham, J., Denny, R. C., Barnes, J. D., Thomas, M. and Sivasankar, B., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th ed., Pearson Education, Ltd., (2000).
15. Svehla, G., *Vogel's Qualitative Inorganic Analysis,* 7th ed., (7th imp.), Pearson Education, Ltd., (2009).

FIRST YEAR (SEMESTER-II)

S.NO	Course Code	Course Name	Credit Hours
1	ENG-200	English-II (Functional)	3+0
2	GEN-200	Islamic Studies	2+0
3	GEN-201	Animal diversity-I	3+0
4	MATH-200	Mathematics-II	3+0
5	STAT-100	Statistics	3+0
6	CHEM-161	Organic Chemistry	3+1
Total Credit Hours			18

Course Code: ENG-200 **Course Name:** English II (Functional)

Objectives: Enable the students to meet their real life communication needs.

Course Contents

Paragraph writing: Practice in writing a good, unified and coherent paragraph

Essay writing: Introduction

CV and job application: Translation skills, Urdu to English

Study skills: Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills: Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills: Personality development (emphasis on content, style and pronunciation)

Recommended Books:

Communication Skills

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing

2. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
3. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan.
3. Study Skills by Riachard York.

Course Code: GEN-200 **Course Name:** Islamic Studies

Objectives:

This course is aimed at:

- To provide Basic information about Islamic Studies
- To enhance understanding of the students regarding Islamic Civilization
- To improve Students skill to perform prayers and other worships
- To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses:

Introduction to Quran Studies

1) Basic Concepts of Quran

2) History of Quran

3) Uloom-ul -Quran

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)

2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)

3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)

4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)

5) Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6, 21, 40, 56, 57, 58.)

2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment

3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)

2) Life of Holy Prophet (S.A.W) in Makkah

3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina

2) Important Events of Life of Holy Prophet in Madina

3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To Sunnah

1) Basic Concepts of Hadith

2) History of Hadith

3) Kinds of Hadith

4) Uloom –ul-Hadith

5) Sunnah & Hadith

6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

1) Basic Concepts of Islamic Law & Jurisprudence

2) History & Importance of Islamic Law & Jurisprudence

3) Sources of Islamic Law & Jurisprudence

4) Nature of Differences in Islamic Law

5) Islam and Sectarianism

Islamic Culture & Civilization

1) Basic Concepts of Islamic Culture & Civilization

2) Historical Development of Islamic Culture & Civilization

3) Characteristics of Islamic Culture & Civilization

4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

1) Basic Concepts of Islam & Science

2) Contributions of Muslims in the Development of Science

3) Quran & Science

Islamic Economic System

1) Basic Concepts of Islamic Economic System

2) Means of Distribution of wealth in Islamic Economics

3) Islamic Concept of Riba

4) Islamic Ways of Trade & Commerce

Political System of Islam

1) Basic Concepts of Islamic Political System

2) Islamic Concept of Sovereignty

3) Basic Institutions of Govt. in Islam

Islamic History

1) Period of Khlaft-E-Rashida

2) Period of Ummayyads

3) Period of Abbasids

Social System of Islam

1) Basic Concepts of Social System of Islam

2) Elements of Family

3) Ethical Values of Islam

Reference Books:

1. Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
2. Hameed ullah Muhammad, "Muslim Conduct of State"
3. Hameed ullah Muhammad, 'Introduction to Islam
4. Mulana Muhammad Yousaf Islahi,"
5. Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6. Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
7. Mir Waliullah, "Muslim Jrisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
8. H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
9. Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

Course Code: GEN-201 **Course Name:** Animal Diversity-I

Objectives

The course is designed to provide students with:

1. Taxonomic characteristics and classification of each phylum
2. Concepts of evolutionary relationship of animal kingdom
3. Knowledge about animal kingdom, emphasizing their phylogenetic

relationships and simple to complex mode of animal life

Course Contents

Introduction: Architectural pattern of an animal, taxonomy and phylogeny,major subdivisions of animal kingdom with evolutionary perspective.

Animal-Like Protists: The Protozoa; life within a single plasma membrane;symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and superclasses, wherever applicable). Pseudopodia and amoeboid locomotion; ciliaand other pellicular structures; nutrition; genetic control and reproduction;symbiotic ciliates; further phylogenetic considerations.

Multicellular and Tissue Levels of Organization: origins ofmulticellularity; animal origins. Phylum porifera: cell types, body wall, andskeletons; water currents and body forms; maintenance functions;reproduction. Phylum Cnidaria (coelenterata) the body wall andnematocysts; alternation of generations; maintenance functions;reproduction and classification up to class.Phylum Ctenophora; furtherphylogenetic considerations.

Triploblastics and Acoelomate Body Plan: Phylum Platyhelminthes:classification up to class; the free-living flatworms and the tapeworms;Phylum Nemertea; Phylum Gastrotricha; further phylogeneticconsiderations.

Pseudocoelomate Body Plan: Aschelminths: general characteristics;classification up to phyla with external features; feeding and the digestivesystem; other organ systems; reproduction and development of PhylumRotifera and Phylum Nematoda; Phylum Kinorhyncha. Some importantnematode parasites of humans; further phylogenetic considerations.

Molluscan Success: relationships to other animals; origin of the coelom;molluscan characteristics; classification up to class. The characteristics ofshell and associated structures, feeding, digestion, gas exchange,locomotion, reproduction and development, other maintenance functionsand diversity in gastropods, bivalves and cephalopods; further phylogeneticconsiderations.

Annelida: The Metameric Body Form: relationship to other animals,metamerism and tagmatization; External structure and locomotion, feedingand the digestive system, gas exchange and circulation, nervous andsensory functions, excretion, regeneration, reproduction and developmentin different classes; further phylogenetic considerations.

Arthropods: Blueprint for Success: classification and relationships to otheranimals; metamerism and tagmatization; the exoskeleton; metamorphosis;classification up to class; further phylogenetic considerations; phylogenyand adaptive diversification.

Echinoderms: relationships to other animals; echinoderm characteristics;classification up to class. Maintenance functions, regeneration,reproduction, and development; further phylogenetic considerations.

Lesser Invertebrates: The lophophorates, entoprocts, cycliophores, andchaetognaths.

Books Recommended

1. Hickman, C.P., Roberts, L.S., Larson, A. 2011. Integrated Principles of Zoology, 15th Ed. (International). Singapore: McGraw Hill.
2. Miller, S.A., Harley, J.B. 2011. Zoology, 8th Ed. (International), Singapore: McGraw Hill.
3. Pechenik, J.A. 2010. Biology of Invertebrates, 4th Ed. (International), Singapore: McGraw Hill.
4. Campbell, N.A. 2002. Biology, 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
5. Miller, S.A., 2002. General Zoology Laboratory Manual. 5th Ed. (International). Singapore: McGraw Hill.
6. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

Course Code: Math-200 **Course Name:** Mathematics-II

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.

Limits and Continuity: Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.

Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Recommended Books:

1. Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
   Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston
3. Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

Course Code: Stat-200 **Course Name:** Statistics

Specific Objectives:

This course helps students to understand the basic concepts of statistics, its nature, scope and importance with special focus on its use in social sciences.

Unit 1. What is Statistics?

Definition of Statistics, Population, sample Descriptive and inferential Statistics, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant digits, Rounding of a Number, Collection of primary and secondary data, Sources, Editing of Data. Exercises.

Unit 2. Presentation of Data

Introduction, basic principles of classification and Tabulation, Constructing of a frequency distribution, Relative and Cumulative frequency distribution, Diagrams, Graphs and their Construction, Bar charts, Pie chart, Histogram, Frequency polygon and Frequency curve, Cumulative Frequency Polygon or Ogive, Histogram, Ogive for Discrete Variable. Types of frequency curves.Exercises.

Unit 3. Measures of Central Tendency

Introduction, Different types of Averages, Quantiles, The Mode, Empirical Relation between Mean, Median and mode, Relative Merits and Demerits of various Averages. properties of Good Average, Box and Whisker Plot, Stem and Leaf Display, definition of outliers and their detection. Exercises.

Unit 4. Measures of Dispersion

Introduction, Absolute and relative measures, Range, The semi-Inter-quartile Range, The Mean Deviation, The Variance and standard deviation, Change of origin and scale, Interpretation of the standard Deviation, Coefficient of variation, Properties of variance and standard Deviation, Standardized variables, Moments and Moments ratios. Exercises.

Unit 5. Probability and Probability Distributions.

Discrete and continuous distributions: Binomial, Poisson and Normal Distribution. Exercises

Unit 6. Sampling and Sampling Distributions

Introduction, sample design and sampling frame, bias, sampling and non sampling errors, sampling with and without replacement, probability and non-probability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions.

Unit 7. Hypothesis Testing

Introduction, Statistical problem, null and alternative hypothesis, Type-I and Type-II errors, level of significance, Test statistics, acceptance and rejection regions, general procedure for testing of hypothesis. Exercises.

Unit 8. Testing of Hypothesis- Single Population

Introduction, Testing of hypothesis and confidence interval about the population mean and proportion for small and large samples, Exercises

Unit 9. Testing of Hypotheses-Two or more Populations

Introduction, Testing of hypothesis and confidence intervals about the difference of population means and proportions for small and large samples, Analysis of Variance and ANOVA Table. Exercises

Unit 10. Testing of Hypothesis-Independence of Attributes

Introduction, Contingency Tables, Testing of hypothesis about the Independence of attributes.Exercises.

Unit 11. Regression and Correlation

Introduction, cause and effect relationships, examples, simple linear regression, estimation of parameters and their interpretation.r and R2. Correlation.Coefficient of linear correlation, its estimation and interpretation.Multiple regression and interpretation of its parameters. Examples

Recommended Books:

1. Walpole, R. E. 1982. "Introduction to Statistics", 3rd Ed., Macmillan Publishing Co., Inc. New York.
2. Muhammad, F. 2005. "Statistical Methods and Data Analysis", Kitab Markaz, Bhawana Bazar, Faisalabad.

Course Code: CHEM-161 **Course Name:** Organic Chemistry

Course Objectives:

Students will acquire knowledge about basic concepts of organic chemistry, chemistry of hydrocarbons and functional groups and the mechanism of organic reactions. Such information will be useful for qualitative analysis and synthesis of organic compounds.

Course Content:

Basic Concepts of Organic Chemistry:

Bonding and hybridization, localized and delocalized bonding, structure-aromaticity, inductive effect, dipole moment, resonance and its rules, hyperconjugation, classification and nomenclature of organic compounds including IUPAC system, types of organic reactions (an overview).

Chemistry of Hydrocarbons:

Saturated, unsaturated and aromatic hydrocarbons with emphasis on synthesis and free radical, electrophilic addition and electrophilic substitution reactions.

Chemistry of Functional Groups:

Hydroxyl, ether and amino groups, preparation and properties of alcohols, phenols, ethers, and amines with focus on reaction mechanism and applications, carbonyl compounds, preparations and reaction mechanism of aldehydes and ketones and their applications, carboxylic acids and their derivatives, acidity of carboxylic acids and effect of substituents on their acidity, preparation and reactions of carboxylic acids and their derivatives including esters, amides, acid halides and acid anhydrides.

CHEM-161 Lab.

Qualitative analysis of compounds with different functional groups, synthesis of organic compounds using as a tool for understanding techniques like reflux, distillation, filtration, recrystallization and yield calculation, organic syntheses may include preparation of benzanilide from benzoyl chloride, succinic anhydride from succinic acid, phthalimide from phthalic anhydride, oximes and hydrazones from carbonyl compounds, and an ester from a carboxylic acid and alcohol etc.

Recommended Books:

1. Brown, W. and Poon, T., *Introduction to Organic Chemistry*, 3rd ed., John-Wiley & Sons, Inc., (2005).

2. John, E. M. *Organic Chemistry,* 8th ed., Brooks/Cole Publishing Co, USA, (2012).
3. Robert, T. M. and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).
4. Younus, M., *A Textbook of Organic Chemistry*, Ilmi Kitab Khana, Urdu Bazar, Lahore, Pakistan, (2006).
5. Sykes, P., *A Guide Book to Mechanism in Organic Chemistry*, 6th ed., Pearson Education Limited, England, (1986).
6. Solomons, T. W. G. and Fryhle, C. B., *Organic Chemistry,* 10th ed., John-Wiley & Sons, Inc., (2011).
7. Furniss, B. S., Hannaford , A. J., Smith, P. W. G., Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Longman, UK, (1989).
8. Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., *A Microscale Approach to Organic Laboratory Techniques,* 5th ed., Brooks/ Cole Cengage Learning, (2013).
9. Mayo, D. W., Pike, R. M. and Forbes, D. C., *Microscale Organic to Laboratory with Multistep and Multisacle Syntheses,* 5th ed., John-Wiley & Sons, Inc., (2011).
10. Gilbert, J. C. and Martin, S. F., *Experimental Organic Chemistry: A Miniscale and Microscale Approach,* 5th ed., Brooks/ Cole Cengage Learning, (2010).
11. Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., *Organic Chemistry,* 6th ed., Brooks/ Cole Cengage Learning, (2012).

SECOND YEAR (SEMESTER-III)

S.NO	Course Code	Course Name	Credit Hours
1	ENG-300	English-III (Report Writing)	3+0
2	GEN-300	Pakistan Study	2+0
3	GEN-302	Chordate Zoology	3+0
4	GEN-301	Animal diversity-II	3+0
5	CHEM-141	Environmental Chemistry	3+0
6	CHEM-171	Physical Chemistry	3+1
Total Credit Hours			18

Course Code: ENG-300 **Course Name:** English III (Report Writing)

1. **The Art of listening**
2. **What is good listening?**
3. **Types of Listening**
    - Appreciative
    - Listening for pleasure or enjoyment
    - Empathetic
    - Comprehensive
    - Critical
4. **Tips for good listening**
    - Face the speaker
    - Maintain eye contact
    - Minimize the external distractions
    - Respond appropriately
    - Focus on what the speaker is saying
    - Minimize the internal distractions
    - Keep an open mind
    - Avoid letting the speaker know how you handled a simi situation
    - Even if the speaker is launching a complaint against yoı they finish to defend yourself
    - Engage yourself.
    - Body language
    - Silence
    - Touching
    - Some Audio Listening

5. Ways to become effective Listener

- Setting the stage
- appropriate physical environment
- Removal of distractions
- Be open and accessible
- Maintain relaxed, open posture that shows concentration
- Ensure mutual understanding Reflect feelings
- Offer acknowledgements (say "uh-huh")
- Paraphrase main ideas
- Interrupt to clarify
- Confirm next steps

6. Barriers to listening include:

- worry, fear, anger, grief and depression
- individual bias and prejudice
- semantics and language differences
- noise and verbal "clutter"
- preoccupation, boredom and shrinking attention spans
- Act distracted (look at your watch!)
- Tell your own story without acknowledging theirs
- Give no response
- Invalidate response, be negative
- Interrupt
- Criticize
- Diagnose what was said
- Give advice/solutions quickly
- Change the subject
- Reassure without acknowledgment

7. Communication

- Communication Skill
- Types of Communication
- Importance and Benefits of Effective Communication
- Components of Communication
- Nonverbal Communication
- Barriers to Communication
- Difference between hearing and listening
- Essentials of communication (Dos)
- Essentials of Communication (Don`ts)

8. Barriers to Communication

- Noise
- Inappropriate medium
- Assumptions/Misconceptions
- Emotions
- Language differences
- Poor listening skills
- Distractions

9. Public Speaking

- Talk,conversation,Speech and Rhetoric
- Speaking Opportunities at Work Place,home,daily li

10. PS and conversation

- Organization of thought
- Tailoring the message to the right audience
- Interesting start
- Consideration of audience feedback
- PS is structured
- PS requires formal language
- PS requires delivery method

11. The Speech communication Process

- Speaker
- Message
- Channel
- Listener
- Feedback
- Interference
- Situation

12. Analysis of Audience

- PS is audience centred
- Kind of audience
- Psychology of audience
- Care for Egocentrism of people
- Demographic Analysis of Audience
    - Observable Traits

- Age
- Gender
- Racial, ethnic or cultural Background
- Religion
- Group

13. Situational Audience Analysis

- **Unique Traits of Speaking Situation**
  - Size
  - Physical Setting

14. Disposition toward the Topic

- Interest
- Knowledge
- Attitude

15. Disposition toward the Speaker

16. Disposition towards the Occasion

17. Organization of Speech

18. Connectives

- Transitions
- Internal Previews
- Internal Summaries
- Signposts

19. Supporting Materials

i. Examples
ii. Statistics
iii. Testimony

20. Beginning and Ending of Speech

- Get Attention and Interest
- Reveal the Topic
- Establish Credibility and Goodwill
- Preview the body of the speech
- Signal the End of the speech
- Reinforce the central idea

21. Many more things to remember for effective speech

- Use language accurately
- Use language clearly
- Use Language vividly
  - Imagery
  - Concrete words
  - Simile

- **Rhythm**
- **Parallelism**
- **Repetition**
- **Alliteration**
- **Antithesis**

22. Speech Delivery

Types of Delivery

- Read from manuscript
- Reciting from memory
- Impromptu
- Extemporaneously

23. Vocalization of Speech

- Volume – loudness or softness
- Pitch –Rate speed at which you speak
- Pauses
- Variety
- Pronunciation
- Articulation
- Dialect

24. Interviewing

The Nature and Types of interviews

i. Interview Structure
ii. How to Be Interviewed for a job
iii. How to Be Interviewed for an Information-Gathering Interview
iv. The Responsibilities of an Interviewer

Types of Interviews

- ☐ Information-Gathering Interview
- ☐ Appraisal Interview
- ☐ Problem-Solving Interview
- ☐ Persuasion Interview

Interview Structure

- ☐ Opening
- ☐ Body
- ☐ Conclusion

- Be Aware of Your Skills & Abilities
- Prepare Your Resume
  - **A written, concise, organized description of your qualifications**
  - **Components**
    - Personal Information
    - Career Objective
    - Education
    - Experience
    - Honors & Special Accomplishments
    - Optional Information

- Identify the Needs of Your Employer
- Listen, Respond, and Ask Appropriate Questions
- Follow Up After the Interview

esponsibilities of the Interviewer

- Be Aware of Biases & Prejudices
- Adapt to an Interviewee's Behavior
- Deal with Sensitive Content Wisely
- Listen Effectively
- Record Information
- Ask Appropriate Questions

25. The Right use of Diction

A	AN	ACCEPT	EXCEPT	ADVICE
ADVISE	AFFECT	EFFECT	ALRIGHT	MOST
AMOUNT	BETWEN	AMONG	AMOUNT	NUMBER
AS, AS IF, AS THOUGH	LIKE	BE SURE AND	TRY AND	COULD OF
SHOULD OF	MIGHT OF	WOULD OF	DIFFERENT THAN	DIFFERENT FROM
DUE TO	BECAUSE OF	ENTHUSED/ENTHUSE	FEWER	LESS

HOPEFULLY	IRREGARDLESS	LEAD	LED	LEND
LOAN	LIE	LAY	PRINCIPAL	PRINCIPLE
RISE	RAISE	SIT	SET	SUPPOSED TO
USED TO	THEN	THAN	SENIOR TO	JUNIOR TO

26. SHORT STORIES READING AND THEN PRESENTING THEM IN THEIR OWN WORDS IN THE CLASS.

i. The Gift of Magi (O'Henry)
ii. The Diamond Necklace (Guy De Mauspassant)
iii. Overcoat (Ghulam Abbas)
iv. His First Flight
v. Rustam and Sohrab

27. Common Grammatical Errors

28. Successful Strategies for Group meetings

- Definition of a Group Meeting
- Formation of a Group Meeting
- Background Information on Group Meetings
- Purposes and Kinds of Meetings
- Solving problems in Meeting or Groups
- Leadership Responsibilities in Meetings
- Participant Responsibilities in Meetings

29. Resume (Vita, Qualifications Brief)

- Opening Section
- Education
- Work Experience
- Achievements
- Awards
- Service Activities
- Personal Data
- References
- Sample Resumes

30. Letters, Emails and Memos

31. Watching some Movies or listening materials from IELTS or TOFEL courses based on thematic or important course related issues and then writing an assignment or doing some quiz on them

Text Books:

- Bov'ee D. Philips: Business Communication Today
- Exploring the World of English by Sadat Ali Shah
- Murphy Heart and Hildebrandt Jana : Business Communication
- Himstreet & Btty: Business Communication
- Kitty O Locker: Business & Administrative communication
- Stewart, Zimiber & Clark:Business English & Communication
- Browsing on internet

Course Code: GEN-300 **Course Name:** Pakistan Study

Introduction/Objectives:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.
2. **Government and Politics in Pakistan**

   Political and constitutional phases:

   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Recommended Books:

1. Burki, Shahid Javed. *State and Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots and Development.* Lahore, 1994.
5. Wilcox, Wayne.*The Emergence of Bangladesh.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno -National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson and sons Ltd, 1980.
9. Zahid, Ansar. *History and Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II and III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

Course Code: GEN-302 **Course Name:** Computer Application-II

Course Contents

Course Contents

Protochrodates: Structure, anatomy and organ systems; reproduction; life histories and metamorphosis; phylogenetic relationships; furtherphylogenetic considerations.

Fishes: Vertebrate Success in Water: phylogenetic relationships; Agnathaand Gnathostomata: locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

Amphibians: The first terrestrial vertebrates: phylogenetic relationships;
Caudata, Gymnophiona, and Anura;Structure and locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, temperatureregulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogeneticconsiderations.

Reptiles: The First Amniotes: cladistic interpretation of the amniotic lineage;
Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia; adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

Birds: Feathers, flight and endothermy: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.

Mammals: Specialized teeth, endothermy, hair andviviparity; diversity of mammals; adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation,nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Books Recommended

Course Code: GEN-301 **Course Name:** Animal Diversity-II

Course Contents

Protochrodates: Structure, anatomy and organ systems; reproduction; life histories and metamorphosis; phylogenetic relationships; further phylogenetic considerations.

Fishes: Vertebrate Success in Water: phylogenetic relationships; Agnatha and Gnathostomata: locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

Amphibians: The first terrestrial vertebrates: phylogenetic relationships;

Caudata, Gymnophiona, and Anura;Structure and locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.

Reptiles: The First Amniotes: cladistic interpretation of the amniotic lineage;

Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia; adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

Birds: Feathers, flight and endothermy: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.

Mammals: Specialized teeth, endothermy, hair and viviparity; diversity of mammals; adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Practicals

Museum study of:

1. Protochordates
2. Pisces

3. Amphibia
4. Reptilia
5. Aves
6. Mammalia
7. Field trips to study animal diversity in an ecosystem.

Note: Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.

Books Recommended

1. Hickman, C.P., Roberts, L.S., Larson, A. 2011. Integrated Principles of Zoology, 15th Ed. (International). Singapore: McGraw Hill.

2. Campbell, N.A. Biology, 9th Ed. 2011.Menlo Park, California: Benjamin/Cummings Publishing Company, Inc. Miller, S.A. and Harley, J.B. 2010. Zoology, 8th Edition (International) Singapore: McGraw Hill.

3. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. International), Singapore: McGraw Hill.

4. Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. Latest edition New York: McGraw Hill.

5. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

Course Code: CHEM-141 **Course Name:** Environmental Chemistry

Course Objectives:

Students will be able to acquire knowledge and develop understanding about the fundamental principles of environmental chemistry and different types of pollutions. Such information will be useful in studying and solving pollution related issues and experiments in the laboratory.

Course Contents:

Atmospheric Pollution:

The atmosphere, composition, temperature and pressure profile, role of free radicals in the atmosphere, temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, atmospheric aerosols, acid-rain major sources, mechanism, control measures and effects on buildings and vegetation, global warming, major greenhouse gases, mechanism, control measures and global impact, the stratospheric ozone theozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

Water Pollution:

Water pollution and waste water treatment, municipal, industrial and agricultural sources of pollution, heavy metals contamination of water, eutrophication, detergents and phosphates in water, water quality criteria, water purification: primary, secondary and advanced treatment, removal of nitrogen and phosphorous compounds from polluted water, organic matter in water and its decomposition.

Land pollution:

Soil and mineral resources, general principles of metal extraction, heavy metals contamination of soil, toxicity of heavy metals, bio-accumulation of heavy metals, organic matter in soil, macro and micro-nutrients in soil, ion-exchange in soil, soil pH and nutrients availability.

Green Chemistry:

Atom economy, integrated pests management control (IPMC), ionic liquids, super critical extraction technology, green synthesis, recycling, carbon dioxide sequestering, water based paints.

Recommended Books:

1. Baird, C. and Cann, M., *Environmental Chemistry,* 5th ed., W. H. Freeman & Company, (2012).

2. Dara, S. S. and Mihsra, D. D., *A Text Book of Environmental Chemistry and Pollution Control*, 9th ed., S. Chand & Co. Ltd., (2004).
3. Singhi, R. and Singh, V., *Green Chemistry for Environmental Remediation*, John-Willey & Sons, Inc., (2011).
4. Holloway, A. M. and Wayne, R. P., *Atmospheric Chemistry*, 1st ed., Royal Society of Chemistry, (2010).
5. Vaclavikova, M., Vitale, K., Gallios, G. P. and Ivanicova, L. *Water Treatment Technologies for Removal of High Toxicity Pollutants*, Springerlink, UK, (2010).
6. Manahan, S. E., *Environmental Chemistry*, 9th ed., CRC press, Taylor & Francis group, USA, (2009).
7. Girard, J. E., *Principles of Environmental Chemistry*, 2nd ed., Jones and Bartlett publishers, (2010).
8. Harrison, R. M., Monks, P., Farmer, J. G., Graham, M. C., Mora, S. J., Pulford, I. and Hulsal, C., *Principles of Environmental Chemistry*, 1st ed., Royal Society of Chemistry, (2007).
9. Matalack, A., *Introduction to Green Chemistry*, 2nd ed., CRC press, Taylor & Francis group, USA, (2010).
10. Wright, J., *Environmental Chemistry*, Routledge, (2003).
11. O’Neill, P., *Environmental Chemistry*, 3rd ed., Blackie Academic & Professional, (1998).

Course Code: CHEM-171 **Course Name:** Physical Chemistry

Course Objectives:

Students will acquire knowledge to enable themselves to understand the fundamental principles and laws of thermodynamics and chemical equilibria and to investigate the physical properties of ideal/non-ideal binary solutions. Students will also be able to study the rates of reactions and perform related calculations.

Chemical Thermodynamics:

Equation of states, ideal and real gases, the virial equation and the van der Waals equation for real gases, critical phenomena and critical constants, four laws of thermodynamics and their applications, thermochemistry, calorimetry, heat capacities and their dependence on temperature, pressure and volume, reversible and non-reversible processes, spontaneous and non-spontaneous processes, relations of entropy and Gibbs free energy with equilibrium constant, Gibbs Helmholtz equation, fugacity and activity.

Chemical Equilibrium:

General equilibrium expressions, reaction quotients, examples of equilibrium reactions in solid, liquid and gas phases, extent of reactions and equilibrium constants, Gibbs energies of formation and calculations of equilibrium constants, effect of temperature and pressure on the equilibrium constants/compositions, van't Hoff equation, Le-Chatelier's principle.

Solution Chemistry:

Physical properties of liquids, surface tension, viscosity, refractive index, dipole moment etc. and their applications, brief account of interactions among the molecules in liquids, ideal and non-ideal solutions, Raoult's law and its applications, lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure, vapor pressure of non-ideal solutions and Henry's law, abnormal colligative properties, degrees of association and dissociation of solutes, osmotic pressure and its measurement, fractional distillation and concept of azeotropic mixtures.

Chemical Kinetics:

The rates of reactions, zero, first, second and third order reactions with same and different initial concentrations, half-lives of reactions, experimental techniques for rate determination and methods for determination of order of reaction (integration, half-life, initial rate, and graphical methods), Arrhenius equation.

CHEM-171 Lab.

1. Determination of viscosity and refractive index of liquids.
2. Determination of percent composition of liquid solutions viscometrically.
3. Determination of refractive index and molar refractivity.
4. Determination of percent composition of liquid solutions by refractive index measurements.
5. Determination of molecular weight of a compound by elevation of boiling point (ebullioscopic method).
6. Determination of molecular weight of a compound by lowering of freezing point (cryoscopic method).
7. Determination of heat of solution by solubility method.
8. Determination of heat of neutralization of an acid with a base.
9. Kinetic study of acid catalyzed hydrolysis of ethyl acetate.
10. Determination of partition coefficient of a substance between two immiscible liquids.

Recommended Books:

1. McQuarrie, D. A. and Simon, J. D., Physical Chemistry – A Molecular Approach,1st ed., University Science Books,(1997).
2. Atkins,P. and Paula,J.D., Atkin’s Physical Chemistry, 9th ed., Oxford University Press, (2010).
3. Shoemaker, D., Experiments in Physical Chemistry, 8th ed., McGraw Hill Publishing Company Limited, (2003).
4. Silbey, R., Alberty, R. and Bawendi, M., Physical Chemistry, 4th ed., (2005).
5. Glasstone, S., *Textbook of Physical Chemistry,* Macmillan London (1960*).*
6. James, A. M., Prichard, F. E., Practical Physical Chemistry, 3rd ed., Longman Group Limited, New York, (1974).
7. Chaudhary, S. U., Ilmi Textbook of Physical Chemistry, 2nd ed., Ilmi Kitab Khana, Lahore, (2013).
8. Atkins, P., Jones, L., Chemical Principles: The Quest for Insight, 5th ed., W. H. Freeman, New York, (2010).
9. Linder, B., Elementary Physical Chemistry, World Scientific Publishing Co. Ptv. Ltd., (2011).

SECOND YEAR (SEMESTER-IV)

S.NO	**Course Code**	**Course Name**	**Credit Hours**
1	ENG-400	English-IV	3+0
2	GEN-401	Physics	3+0
3	GEN-401	Research Methodology	3+0
4	CHEM-111	Analytical Chemistry	2+1
5	CHEM-121	Applied Chemistry	2+0
6	CHEM-131	Biochemistry	2+1
Total Credit Hours			17

Course Code: ENG-400 **Course Name:** English IV

Critical Reading

Advanced reading skills and strategies building on Foundations of English I & II courses in semesters I and II of a range of text types e.g. description, argumentation, comparison and contrast.

Advanced Academic Writing

Advanced writing skills and strategies building on English I & II in semesters I and II respectively, Writing summaries of articles, report writing, Analysis and synthesis of academic material in writing Presenting an argument in assignments/term-papers and examination answers

Recommended Readings:

1. Aaron, J. 2003. *The Compact Reader*. New York: Bedford.
2. Axelrod, R. B and Cooper, C. R. 2002. *Reading Critical Writing Well: A Reader and Guide.*
3. Barnet, S. and Bedau, H. 2004. *Critical Thinking, Reading and Writing: A Brief Guide to Writing.* 6th Ed.
4. Behrens & Rosen. 2007. *Reading and Writing Across the Curriculum.*
5. Gardner, P. S. 2005. *New Directions: Reading, Writing and Critical Thinking.*
6. George, D. and Trimbur, J. 2006. *Reading Culture: Context for Critical Reading and Writing*. 6th Ed.
7. Goatly, A. 2000. *Critical Reading and Writing: An Introductory Course*. London: Taylor & Francis.
8. Grellet, F., *Writing for Advanced Learners of English*. CUP.
9. Jordan, K. M. and Plakans, L. 2003. *Reading and Writing for Academic Success.*
10. Jordon, R. R. 1999. *Academic Writing Course*. CUP.
11. Smith, L. C. 2003. *Issues for Today: An Effective Reading Skills Text.*
12. Withrow, J., *Effective Writing*. CUP.

Course Code: GEN-401 **Course Name:** Physics

Course Contents:

Physical Optics: Nature of light, interference of light, Michelson's interferometer, Diffraction of light, Diffraction grating, Diffraction of X-rays by crystal, Bragg's law, Polarization of Light and its application in optical activity.

Thermodynamics: Thermodynamics system, Heat, Temperature and internal energy, First law of thermodynamics and its applications, Specific heat, Second law of thermodynamics, Refrigerator, Entropy.

Spectroscopy: Atomic spectra, Spectrum of H-Atom, Rutherford and Bohar atomic model, X-rays, its production and applications, Laser.

Nuclear physics: Nuclear Compositions, Nuclear Properties, Stable Nuclei, Nuclear Magnetic Resonance, Binding Energy, Isotopes, Mass spectrograph.

Nuclear transformations: Radioactive Decay, Radioactivity and the Earth, Radiation Hazards, Half-Life life of radioactive material, Radiometric Dating, Radioactive Series, Nuclear Fission (Divide and conquer), Nuclear Reactor, Nuclear Fusion, Fusion Reactor.

Recommended Books:

Course Code: GEN-401 **Course Name:** Research Methodology

Course Content:

1. Literature Review

Type of literature, sources of literature, use of modern techniques in literature review. Impact factor.

2. Academic writings

Types, method, design, format, style, language, layout and application of publication. Use of modern techniques in academic writings, preparing synopsis, manuscript, thesis and reports.

3. Plagiarism

Introduction, types of plagiarism, plagiarism policy. Identification and prevention of plagiarism using modern techniques. Use of anti-plagiarism software/website and its application.

4. Laboratory Safety Guidelines: Research ethics, chemical handling, substances with a hazardous nature, exposure limits, common safety symbols, suggested shelf storage pattern for organics and in-organics, recommended safety and emergency equipment for the Laboratory.

5. Use of Computer Based Software in Chemistry

Chem Draw, MS-NIST, DNP, 13C-NMR, 1H-NMR, IUPAC, Chem Bio Office etc.

Recommended Books:

1. Research Methodology, S.C.Sinha & A.K. Dhiman Ess Ess Publication.
2. Research Methodology, Ranjeet Kumar, 3rd Edition, 2011, SAGE Publications Ltd. Landon.
3. Research Methodology for Biological Sciences N.Gurumani, MJP Publisher.
4. Practical Skills in Chemistry, J. R. Dean, A. M.Jones, D. Holmes, R. Reed, J. Weyers and A Jones, Pearson Education Ltd. [Prentice Hall] (2002).
5. Scientific, Social, Surveys and research P.V. Young & C.F. Schmid Prentice-Hall of India Pvt.Ltd. New Delhi.
6. Essentials of computational chemistry by C. J. Cramer.
7. Fundamentals of analytical chemistry by D. A. Skoog, D. M. West & F. J. Hooler.
8. Computers and Their Applications to Chemistry, by Ramesh Kumari, 2002.
9. The Little Book of Plagiarism, Leeds Metropolitan University,2013.
10. School Chemistry Laboratory Safety Guide, CPSC Publication No. 390. (October 2006).

Course Code: CHEM-111 **Course Name:** Analytical Chemistry

Course Objectives:

Students will acquire knowledge about sampling and their handling and preparation and results calculation and data reporting. In addition they will learn and develop understanding about the classical techniques of analytical chemistry and quality control and quality assurance

Course Contents:

Chemometrics:

Sampling, significant figures, stoichiometric calculations, measurement errors, analysis of variance (ANOVA), arithmetic mean, median, mode, standard deviation/relative standard deviation, confidence limits, Gaussian distribution, least square method, tests for significance, outliers

Quality Control and Quality Assurance:

Definitions, seven tools for quality control, the concept of quality assurance, quality assurance techniques, validations based on design qualification (DQ), installation qualification (IQ), operational qualification (OQ) and performance qualification (PQ), calibrations, monitoring and quality reviews, periodical trainings, six sigma concept, ISO standards.

Classical Analytical Methods:

Acid-base, complexometric and redox titrations, gravimetric analysis.

CHEM-111 Lab.

Calibration of volumetric glassware, electronic and analytical equipment, statistical evaluation of analytical data including linear regression analysis, constructing a calibration curve from a given analytical data using spread sheet software, determination of hardness of water using EDTA, determination of chloride in tap water sample, estimation of copper, arsenic, hydrogen peroxide and vitamin C using iodometry, gravimetric analysis, determination of barium in barium nitrate, determination of nickel in a given steel sample, determination of bicarbonates in a clinical sample using back-titration, determination of cation in a mixture by complexometric titration, studying the effect of common ions on solubility of sparingly soluble salts (e. g. AgCl / PbSO4).

Recommended Books:

1. Skoog, D. A., West, P. M., Holler, F. J., Crouch, S. R., *Fundamentals of Analytical Chemistry*, 9th ed., Brooks Cole Publishing Company, (2013).
2. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).

3. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York,USA, (2011).
4. Kealey, D. and Haines, P. J,Instant Notes., *Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).
5. Matthios, Otto, *CHEMOMETRICS-Statistics and Computed applications in Analytical Chemistry*, 2nd ed., Wiley-VCH, Germany, (2007).
6. Mitra A., *Fundamentals of Quality Control and Improvement*, 3rd ed., John-Wiley & Sons, (2008).
7. Miller, J. and Miller, J., *Statistics and Chemometrics for Analytical Chemistry*, 5th ed., Prentice Hall, (2005).

Course Code: CHEM-121 **Course Name:** Applied Chemistry

Course Objectives:

The objectives of the course are to educate the students about the fundamentals of chemical industry, raw materials, manufacturing and industrial processes.

Fundamentals of Chemical Industry:

Basic principles and parameters for industrial plant unit operations and unit processes.

Chemical Industries:

Raw materials, flow sheet diagrams and unit operations and unit processes of sulphuric acid, nitric acid, hydrochloric acid, oxalic acid, formic acid, caustic soda and washing soda, cement industry, petroleum, textile, polymer and fuel industries, applications of these industries.

Recommended Books:

1. Kent, J. A., *Riegel's Handbook of Industrial Chemistry*, 10th ed., Kluwer Academic/ Plenum Publishers, (2003).
2. Vermani, O. P. and Narula, A. K., *Applied Chemistry; Theory and Practice,* New Age International Pvt. Ltd. Publishers, (2008).
3. Hede, P. D., Bier. S.P., *Inorganic and Applied Chemistry,* Ventus publishing app., (2007).
4. Sharma, J., Ndi.,*Applied Industrial Chemistry,* Arise publishers & Distributors, (2012).
5. Heaton, A., *An introduction to Industrial Chemistry,* 3rd ed., Chapman & Hall, (1996).

Course Code: CHEM-131 **Course Name:** Biochemistry

Course Objectives:

Students will gain knowledge about fundamental concepts of biochemistry as well as be able to learn about the structures, properties and functions of amino acids, proteins, carbohydrates, lipids and nucleic acids.

Introduction to Biochemistry:

Brief introduction to the scope and history of Biochemistry, molecular logic of the living organism, cell structures and their functions, origin and nature of biomolecules.

Acid–Base and Electrolyte Chemistry:

Intracellular and extracellular electrolytes, body fluids as electrolyte solutions, pH, Henderson-Hasselbalch equation and buffers, amino acids, peptides and proteins, buffer capacity, buffers of body fluids, haemoglobin as an acid-base system, renal control of acid-base, balance, acid-base disorders: acidosis, alkalosis. haemoglobin and omeostasis, variation of Na^+, K^+, Cl^- in acid-base disturbances.

Carbohydrates, Lipids and Proteins:

Definition and classification, chemistry, physical and chemical properties of various classes of carbohydrates, biological functions of starch, glycogen, cellulose, and cell wall polysaccharides, acid mucopolysaccharides and proteoglycans.

Definition and classification of lipids, chemistry and biological importance of fatty acids, waxes, glycerides, phospholipids, sphingolipids, glycolipids, sterols and prostaglandins.

Significance of lipids in biological membranes and transport mechanism.

Chemistry and classification of amino acids, physical and chemical properties of amino acids, biological significance of amino acids, peptides, proteins, their classification, properties and biological significance, primary, secondary tertiary and quatenary structure of proteins, denaturation of proteins.

Nucleic Acids:

Chemical composition of nucleic acids, structure and biological significance of nucleic acids, chemical synthesis of oligonucleotides, nucleic acids hydrolysis, isolation and separation of nucleic acids, introduction to recombinant DNA technology.

CHEM-131 Lab.

Qualitative and quantitative analysis of carbohydrates, lipids and proteins.

Laboratory work illustrating topics covered in the lecture of Chem.131, Determination of pH, Preparation of buffers.

Enzyme catalysis, Progress curve for enzyme catalyzed reactions, Determination of values. To study the effect of different factors on the rate of enzyme catalyzed reactions.

Recommended Books:

1. R. C. Alkire, D. M. Kolb, J. Lipkowski, *Biselectro chemistry, volume 13*, 13th ed., Publisher: Wiley-VCH Verlag GmbH & Co. ISSN: 0938-5193.
2. Nelson,D.L., *Lehninger's Principles of Biochemistry,* 6th ed., Publisher: Macmillan Higher Education, (2008). ISBN: 149222638, 9781429222631.
3. Voet, D. and Voet, J.D., *Biochemistry*, 4th ed., illustrated. Publisher: John-Wiley & Sons Canada, Limited, (2011). ISBN: 0470917458, 9780470917459.
4. Murray, R.M. and Harper, H.A., *Harper's Biochemistry,* 25th ed., Publisher:Appleton& Lange, (2000). ISBN: 0838536840, 9780838536841.
5. Zubay, G. L., *Biochemistry*, 4th ed., illustrated, Publisher W. M. C. Brown Publishers, (1998), Digitized (2008). ISBN: 0697219003, 9780697219008.
6. Guyton, A. C. & Hall, J. E., *Guyton & Hall Textbook of Medical Physiology,* 12th ed., Publishers: Saunders Elsevier, (2011). ISBN: 978-1-4160-4574-8.
7. Harvey, R. A., Ferrier, DR, Karandish S., *Lippincott's illustrated Reviews: Biochemistry,* 5th ed., *and Biochemistry Map (Med maps)* Bundle. Publisher: Lippincott Williams & Wilkins, (2010). ISBN: 1451116314, 9781451116311.

THIRD YEAR (SEMESTER-V)

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-251	Inorganic Chemistry	3+1
2	CHEM-261	Organic Chemistry	3+1
3	CHEM-271	Physical Chemistry	3+1
4	CHEM-211	Analytical Chemistry	3+1
Total Credit Hours			16

Course Code: CHEM-251 **Course Name:** Inorganic Chemistry

Course Objectives:

Students will acquire knowledge about the physical and chemical properties of d- & f- block elements on the basis of their electronic configurations and will be able to work out structures of coordination compounds through development of understanding of VBT, CFT and MOT.

Course Contents:

Chemistry of d-block elements and coordination complexes:

Back ground of coordination chemistry, nomenclature and structure of coordination complexes with coordination number 2-6, chelates and chelate effect, theories of coordination complexes, Werner's theory, valence bond theory (VBT), crystal field theory (CFT) and molecular orbital theory (MOT), Jahn-Teller theorem, magnetic properties, spectral properties, isomerism, stereochemistry, and stability constants of coordination complexes.

Chemistry of f-block elements:

i.Lanthanides: General characteristics, occurrence, extraction and general principles of separation, electronic structure and position in the periodic table, lanthanides contraction, oxidation states, spectral and magnetic properties and uses.

ii.Actinides: General characteristics, electronic structure, oxidation state and position in the periodic table, half-life and decay law.

CHEM-251 Lab.

Preparations of following Inorganic Complexes;

Tetraamminecopper (II) sulphate.

Potassiumtrioxalatochromate (III).

Potassiumtrioxalatoaluminate (III).

cis-Potassium dioxalatodiaquachromate (III).

Determination of zinc and cadmium by complexometric titration

Chromatographic separations of transition metals;

Separation of Ni2+ & Co2+ ions in a mixture by paper chromatography.

Separation of Ni2+ & Cu2+ ions in a mixture by paper chromatography.

Separation of Cu2+ & Fe2+ ions in a mixture by paper chromatography.

Spectrophotometric determination of iron, manganese and nickel.

Recommended Books:

1. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M., *Advanced Inorganic Chemistry*, 6th ed., Wiley-Interscience, (1999).
2. Housecraft, C. and Sharpe, A. G., *Inorganic Chemistry*, 4th ed., Prentice Hall, (2012).
3. Miessler, G. L. and Tarr, D.A., *Inorganic Chemistry*, 4th ed., Pearson-Prentice Hall International, (2010).
4. Douglas, B., McDanial, D., Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd ed., John-Wiley & Sons, New York, (1994).
5. Shriver, D. and Atkins, P., *Inorganic Chemistry*, 5th ed., W. H. Freeman & Company, (2010).
6. Lee, J. D., *Concise Inorganic Chemistry*, 5th ed., Blackwell Science Ltd., (1996).
7. Atkins, P. and Jones, L., *Chemicals Principles*, 5th ed., W. H. Freeman & Company, (2010).
8. Svehla, G., *Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis*, 5th ed., Longman Group Limited, (1979).
9. Huheey, J. E., Kieter, E. A. and Kieter, R. L., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Prentice Hall, (1997).
10. Pass, G., Sutcliffe, H., *Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods*, 2nd ed., Chapman and Hall (1974).
11. Müller, U., *Inorganic Structural Chemistry*, 2nd ed., John-Wiley & Sons, Ltd., (2006).
12. Marusak R. A., Doan K., Cummings S. D., *Integrated Approach to Coordination Chemistry*, 1st ed., John-Wiley & Sons, (2007).
13. Chaudhary, S. U., *Ilmi Textbook of Inorganic Chemistry*, Ilmi Kitab Khana, Urdu Bazar, Lahore, (2013).

Course Code: CHEM-261 **Course Name:** Organic Chemistry

Course Objectives:

Students will gain knowledge about the stereochemical behavior of organic molecules and acquire an ability to propose mechanism of simple reactions.

Course Contents:

Stereochemistry:

Types of stereoisomers, RS and EZ notation, optical activity, stereoselectivity and stereospecificity, conformational analysis.

Organic Reactions and Mechanism:

Detailed mechanism of aliphatic reactions including addition, substitution, and elimination reactions, concept of energy profile, transition state and intermediate.

CHEM-261 Lab.

Experiments using polarimeter such as to determine optical activity of a sugar solution and to determine sugar concentration by polarimeter, isomerization of maleic acid.

Experiments involving aliphatic addition, elimination and substitution reactions, e.g., synthesis of cyclohexene from cyclohexanol, addition reaction to cyclohexene etc.

Synthesis of a chalcone explaining the concept of condensation and dehydration, *N*-Alkylation of phthalimide, etc.

Recommended Books:

1. Robert, T. M., and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).
2. John, E. M., *Organic Chemistry*, 8th ed., Brooks/Cole Publishing Co, USA, (2012).
3. Younas, M., *A Textbook of Organic Chemistry*, Ilmi Kitab Khana, Urdu Bazar, Lahore, (2006).
4. Morris, D. G., *Stereochemistry (Basic Concepts in Chemistry)*, Wiley-RSC, (2002).
5. Mislow, K., *Introduction to Stereochemistry*, Dover Publications Inc., (2003).
6. David M., *Stereochemistry (Tutorial Chemistry Texts*), Royal Society of Chemistry, (2002).
7. Furniss, B. S, Hannaford, A. J., Smith, P. W. G., Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Longman, UK, (1989).

8. Mohan J., *Organic Analytical Chemistry*, *Theory and Practice*, 1st ed. Alpha Science International, Ltd. (2003).
9. Seiler, J. P., *Good Laboratory Practice*: *The Why and the How*, 2nd ed., Springer, (2005).
10. Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., *Organic Chemistry*, 6th ed., Brooks/ Cole Cengage Learning, (2012).
11. Solomons, T. W. G. and Fryhle, C. B., *Organic Chemistry*, 10th ed., John-Wiley & Sons, Inc., (2011).
12. Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., *A Microscale Approach to Organic Laboratory Techniques*, 5th ed., Brooks/ Cole Cengage Learning, (2013).
13. Eames, J. and Peach, J. M., *Stereochemistry at a Glance*, Blackwell Science, Ltd., (2003).
14. Eliel, E. L., Wilen, S. H. and Doyle, M. P., *Basic Organic Chemistry*, John-Wiley & Sons, Inc., (2001).
15. Eliel, E. L. and Wilen, S. H., *Stereochemistry of Organic Compounds*, John-Wiley & Sons, Inc., (1994).

Course Code: CHEM-271 **Course Name:** Physical Chemistry

Course Objectives:

Students will be able to understand and acquire knowledge about the principles and theoretical background of quantum chemistry, kinetics theory of gases and phase equilibrium. The knowledge gained thus can be applied to study various aspects of quantum mechanics, gas kinetic behavior and thermodynamics and phase equilibrium.

Course Contents:

Quantum Chemistry:

Black body radiation, photoelectric effect, line spectra of elements, Bohr atomic model, wave and particle nature of matter, de Broglie’s equation, Young’s double slit experiment, Heisenberg’s uncertainty principle, wavefunctions and Born interpretation of wavefunctions, probability density, eigenfunctions and eigenvalues, Hamiltonian operator, Schrödinger wave equation, wavefunctions for hydrogen-like atomic orbitals, radial distribution functions, shielding and penetration, effective nuclear charge, orbital energies, periodic trends in the properties of the elements in the periodic table.

Kinetic Theory of Gases:

Probability density for molecular speeds of gas molecules, Maxwell distribution of molecular speeds, average speeds, pressure of an ideal gas, calculation of molecular speeds, binary collisions, effusion and mean free paths, Maxwell-Boltzmann’s law of energy distribution, method for the determination of the Avogadro’s number (NA), statistical probability and entropy.

Phase Equilibrium:

Gibbs phase rule, Phase diagrams of one component and two component systems, Gibbs energy and the phase diagram of a substance, location of phase boundaries, Clausius-Clapeyron equation, vapor-liquid equilibrium of binary liquid mixtures, binary phase diagrams and lever rule.

CHEM-271 Lab.

Equilibrium constant of the KI + I2 = KI3 reaction.

Kinetics of saponification of ethyl acetate.

Acid catalyzed hydrolysis of sucrose.

Study of the adsorption isotherms of acetic acid-charcoal system.

Study of the charge transfer complex formation between iodine and benzene.

Determination of activation energy for the acid catalyzed hydrolysis of ethyl acetate.

Determination of partial molar volumes.

Characterization of the given compound by UV-Vis spectroscopy.

Recommended Books:

1. Silbey, R. J., Alberty, R. A., and Bawendi, M. G., *Physical Chemistry*, 4th ed., Jojn-Wiley & Sons, (2005).
2. McQuarrie, D. A. and Simon, J. D., *Physical Chemistry – A Molecular Approach*, 1st ed., University Science Books, (1997).
3. Atkins, P. and Paula, J. D., *Atkin's Physical Chemistry*, 9th ed., Oxford University Press, (2010).
4. Moore. W. J., *Physical Chemistry*, 4th ed., Longman Publisher (1972).
5. Coulson C. A., *Vanlence*, Oxford University Press (1980).
6. Keeler. J. and Wothers, P., *Chemical Structure and Reactivity: An Integrated Approach*, 1st ed., Oxford University Press, (2008).
7. Helpern, A. M., *Experimental Physical Chemistry: A Laboratory Textbook* 2nd ed., Prentice Hall, (1997).
8. Garland, C. W., Nibler, J. W. and Shoemaker, D., P., *Experiments in Physical Chemistry*, 8th ed., McGraw-Hill, (2003).
9. Born, Max., *Atomic Physics*, 8th ed., Blackie & Son Ltd., (1969).
10. Atkins, P., Jones, L., Chemical Principles: The Quest for Insight, 5th ed., W. H. Freeman, New York, (2010).
11. James, A. M., Prichard, F. E., *Practical Physical Chemistry*, 3rd ed., Longman Group Limited, New York, (1974).

Course Code: CHEM-211 **Course Name:** Analytical Chemistry

Course Objectives:

The main objectives of this course are to introduce the students to the basics principles, instrumental aspects and applications of separation and spectrophotometric analytical methods.

Course Contents:

Separation Methods:

Principle of solvent extraction, solvent extraction of metals, analytical separations, multiple batch extraction, counter current distribution, solid-phase extraction, solvent extraction by flow injection method, principles of chromatography, classification of chromatographic techniques, overview of paper, thin layer, column, ion exchange chromatography and electrophoresis.

Analytical Spectrophotometry:

Properties of light and its interaction with matter, relation between frequency, velocity and wave number, Lambert- Beer's law and its limitations, single beam and double beam spectrophotometers, lamps and lasers as sources of light, monochromators, detectors, photomultiplier tube, photodiode array, charged coupled device, FT-IR spectroscopy, fourier analysis, interferometry, noise and its control.

CHEM-211 Lab.

Separation of phenol from given organic mixture using solvent extraction.

Separation of given mixture of cations using Paper Chromatography.

Analysis of the composition of a mixture of nitro anilines by TLC.

Separation of sugars using paper chromatography.

Separation of amino acids using paper/thin layer chromatography.

Deionization and softening of water using ion exchange chromatography.

Determination of λmax of KMnO4 and K2Cr2O7 solutions and verification of Beer-Lambert's law.

Determination of stoichiometry of a metal complex by visible spectrometry.

Determination of aspirin and caffeine in a proprietary analgesic by double beam UV-Vis. spectrometer.

Quantification of iron in a given sample by using single beam spectrophotometer.

A study of characteristics infrared absorption frequencies.

Recommended Books:

1. Skoog, D. A., West, P. M., Holler, F. J., Crouch, S. R., *Fundamentals of Analytical Chemistry*, 9th ed., Brooks Cole Publishing Company, (2013).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, USA, (2011).
3. Christian, G. D., *Analytical Chemistry*, 6th ed., John Wiley and Sons, New York, (2006).
4. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry,* 1st ed.,Bios Saence Publisher Ltd. Oxford UK. (2002).
5. Pavia, D. L., Lampman, G. M., Kriz, G. S. and Vyvyan, J. A., *Introduction to spectroscopy*, 4th ed., Cengage Learning, (2008).
6. Wall, P. E., *Thin Layer Chromatography: A Modern Approach (RSC Chromatography Monographs),* 1st ed., Royal Society of Chemistry, (2005).
7. Deinstrop, E. H., *Applied Thin Layer Chromatography,* 2nd ed., Wiley-VCH, (2006).
8. Kellener. R, Mermet. J. M., Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry: A Modern Approach to Analytical Science*, Wiley. VCH, (2004).
9. Hollas, J. M., *Modern Spectroscopy*, 4th ed., John-Wiley & Sons, Ltd., England (2004).

THIRD YEAR (SEMESTER-VI)

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-351	Inorganic Chemistry	3+1
2	CHEM-361	Organic Chemistry	3+1
3	CHEM-371	Physical Chemistry	3+1
4	CHEM-321	Applied Chemistry	3+1
Total Credit Hours			16

Course Code: CHEM-351 **Course Name:** Inorganic Chemistry

Course Objectives:

Students will acquire knowledge about various types of inorganic materials, their structure, synthesis, characterization and applications in various fields

Course Contents:

Introduction to inorganic materials, crystalline and amorphous states, bonding in solids, non-stoichiometric compounds, binary solid solutions, mechanical, electrical, magnetic, dielectric, optical, and chemical (corrosion) properties of advanced materials, synthesis (e.g., sol-gel, hydrothermal techniques, etc.) and design of inorganic materials and characterization, doping and purification of silicone, chemical vapour deposition and sputtering, introduction to nano materials.

CHEM-351 Lab

1. Estimation of anions in mixtures:

Chloride-phosphate, chloride-nitrate, oxalate-chloride, sulphate-phosphate, bromide-nitrate, borate-acetate, iodide-nitrate.

2. Iodometric titration with potassium iodate.

3. Gravimetric estimation of oxalate.

4. Precipitation Titrations.

a) Determination of strength of NaCl given solution by AgNO3 using Fluorescein as indicator.

b) Determination of % age purity of KBr using Fluoresceine as indicator.

c) Determination of % composition of mixture of KI & KNO3 using Eoscein as indicator.

5. Spectrophotometric determination of cerium.

6. Separation of heavy metals using solvent extraction technique.

Recommended Books:

1. Xu, R., Pang, W., Huo, Q., *Modern Inorganic Synthetic Chemistry*, 1st ed., Elsevier, (2011).
2. Mendham, J., Denney, R. C., Barnes, J. D. and Thomas, M. J. K., *Vogel's Quantitative Chemical Analysis*, 6th ed., Prentice Hall, (2000).
3. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M., *Advanced Inorganic Chemistry*, 6th ed., Wiley-Interscience, (1999).

4. Huheey, J. E., Keiter, E. A. and Keiter, R. L., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Prentice Hall, (1997).
5. Housecraft, C. and Sharpe, A. G., *Inorganic Chemistry*, 4th ed., Prentice Hall, (2012).
6. Rodgers G. E., *Descriptive Inorganic*, *Coordination*, *and Solid State Chemistry*, 3rd ed., Brooks- Cole, (2012).
7. Smart L. E., Moore E. A., *Solid State Chemistry: An Introduction*, 4th ed., CRC Press, (2012).
8. Müller, U., *Inorganic Structural Chemistry*, 2nd ed., John-Wiley & Sons, (2006).
9. Schwarzenbach D., *Crystallography*, 1st ed., John-Wiley & Sons, (1996).

Course Code: CHEM-361 **Course Name:** Organic Chemistry

Course Objectives:

Students will acquire knowledge and understanding about aromatic substitution reactions and oxidation and reduction as well as pericyclic reactions.

Course Contents:

Aromatic Substitution Reactions:

Mechanisms of aromatic reactions including electrophilic and nucleophilic substitutions, effect of substituents on orientation and reactivity.

Oxidation-reductions Reactions:

Common oxidizing and reducing reagents, reactions involving elimination of H, cleavage of C-C bond, replacement of hydrogen by oxygen, and addition of oxygen to substrates, reaction involving replacement of oxygen by hydrogen, removal of oxygen from the substrates and reduction with cleavage.

Pericyclic Reactions:

Introduction to pericyclic reactions, frontier orbital theory, mechanisms of electrocyclic, cycloaddition and sigmatropic reactions.

CHEM-361 Lab.

Experiments involving aromatic substitution, oxidation/reduction reactions and pericyclic reactions, nitration of nitrobenzene to meta-dinitrobenzene, reduction of meta- dinitrobenzene to meta-nitroaniline, sulphonation of aniline, oxidation of benzaldehyde, oxidation of cyclohexanol to cyclohexanone. Preparation of benzoic acid and benzyl alcohol from benzaldehyde using Cannizzaro’s reaction.

Recommended Books:

1. Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., *A Microscale Approach to Organic Laboratory Techniques*, 5th ed., Brooks/Cole Laboratory Series, Cengage Learning, (2013).
2. Furniss, B. S., Hannaford, A. J., Smith, P. W. G., Tatchell, A. R., *Vogel’s Textbook of Practical Organic Chemistry*, 5th edition, Longman, UK, (1989).
3. Mohan, J., *Organic Analytical Chemistry: Theory and Practice*,1st ed. Alpha Science Int. Ltd.New Delhi, India, (2003).

4. Robert, T. M. and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).
5. Tse-Lok, H., *Symmetry: A Basis for Synthesis Design*, John-Willey & Sons, Inc., New York, (1995).
6. Pine, S. H., *Organic Chemistry*, 5th ed., Tata McGraw-Hill, India, (1987).
7. Sykes, P., *A Guide Book to Mechanism in Organic Chemistry,* 6th ed., Pearson Education, (1986).
8. Mayo, D. W., Pike, R. M. and Forbes, D. C., *Microscale Organic Laboratory with Multistep and Multiscale Syntheses,* 5th ed., John-Wiley & Sons, Inc., (2011).
9. Gilbert, J. C. and Martin, S. F., *Experimental Organic Chemistry: A Miniscale and Microscale Approach,* 5th ed., Brooks/ Cole Cengage Learning, (2010).
10. Solomons, T. W. G. and Fryhle, C. B., *Organic Chemistry,* 10th ed., John-Wiley & Sons, Inc., (2011).
11. Carey, F. A. and Giuliano, R. M., *Organic Chemistry,* 9th ed., McGraw-Hill Education, (2013).
12. 12. Bruice, P. Y., *Organic Chemistry,* 7th ed., Perason Education, Ltd., (2013).
13. Smith, M. B*., March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 7th ed., John-Wiley & Sons, Inc., (2013).
14. Ansari, F. L., Qureshi, R. and Qureshi, M. L., *Electrocyclic Reactions: From Fundamentals to Research,* Wiley-VCH, Germany, (1999).
15. Kürti, L. and Czakó. B., *Strategic Applications of Named Reactions in Organic Synthesis: Background and Detailed Mechanisms,* Elsevier Inc., (2005).

Course Code: CHEM-371 **Course Name:** Physical Chemistry

Course Objectives:

Students will acquire knowledge and understanding about the theoretical and instrumental as well as application related aspects of conductometric, and electrochemical techniques and surface chemistry. They will also acquire information regarding nuclear binding energy, nuclear instabilities and decay mechanisms as well as the fission and fusion processes.

Conductometry:

Ions in solution, measurement of conductance and Kohlrausch's law, mobility of ions and transport number, conductometric titrations, Debye-Hückel theory and activity coefficient, determination of activities, application of conductance measurement.

Electrochemistry:

Redox reactions, spontaneous reactions, electrochemical cells, standard electrode potentials, liquid junction potential, electrochemical series, Nernst's equation, thermodynamic of redox reactions, measurement of pH and pKa, dynamic electrochemistry, Latimer Diagram, Frost Diagram, electrolytic cells, potentiometry, reference and indicator electrodes, voltammetry, fuel cells, corrosion and its prevention, fuel cell and hydrogen economy.

Surface Chemistry:

Interfaces, Gibbs surface excess, curved surfaces, capillary action, adsorption and adsorption isotherms, Freundlich and Langmuir adsorption isotherms, catalysis, colloids, emulsion and their industrial applications.

Nuclear Chemistry:

Atomic nucleus, nuclides, nuclear stability, modes of decay, nuclear energetics, nuclear models (shell + liquid drop model), fusion and fission, non-spontaneous nuclear processes, nuclear reactors, beta decay systematic.

CHEM-371 Lab.

Spectroscopic determination of Cu percentage in the given sample.

Conductometric determination of Cu (II)- EDTA mole ratio in the complex.

To determine the effectiveness of an extraction of I2 solution by using Solvent Extraction method.

Determination of molecular weight of a polymer by viscosity method.

Determination of percentage composition of KMnO4/ K2Cr2O7 in a given solution by spectrophotometry.

Evaluation of pKa value of an indicator by spectrometric method.

Conductometric determination of hydrolysis constant (Kh) of conjugate base of a weak acid.

Recommended Books:

1. Silbey, R. J., Alberty, R. A. and Bawendi, M. G., *Physical Chemistry*, 4th ed., John-Wiley & Sons, (2005).
2. Ball D. W., *Physical Chemistry*, Brooks/Cole Co. Inc., (2003).
3. Vertes, A., Nagy, S. and Klencsar, Z., *Handbook of Nuclear Chemistry. Volume 1: Basics of Nuclear Science, 1st ed.*, Springer, (2003).
4. Choppin, G., Liljenzin, J-. O. and Rydberg, J., *Radiochemistry and Nuclear Chemistry*, 3rd ed., Butterworth- Heinemann, (2002).
5. Loveland, W., Morrisey, D. J. and Seaborg, G. T., *Modern Nuclear Chemistry*, John-Wiley & Sons, Inc., (2006).
6. Atkins, P. and Paula, J. D., *Atkin's Physical Chemistry,* 9th ed., Oxford University Press, (2010).
7. Somorjai, G. A. and Li, Y., *Introduction to Surface Chemistry and Catalysis*, 2nd ed., John-Wiley & Sons, Inc., (2010).
8. Laidler. K. J., "Chemical Kinetics" 3rd ed., Prentice Hall, (1987).
9. Atkins, P., Jones, L., Chemical Principles: The Quest for Insight, 5th ed., W. H. Freeman, New York, (2010).
10. James, A. M., Prichard, F. E., *Practical Physical Chemistry*, 3rd ed., Longman Group Limited, New York, (1974).

Course Code: CHEM-321 **Course Name:** Applied Chemistry

Course Objectives:

Students will gain understanding about the importance of water and its quality requirements for the industrial uses in addition to learning about water treatment techniques. They will also learn about the composite materials.

Course Contents:

Water Treatment, Steam Production and Scale Removal:

Sources of water hardness, water treatment and conditioning for municipal and industrial purposes, steam production and its utilization for power and energy generation, boiler water treatment, chemistry involved in the formation of scale and its prevention.

Distillation:

Vapor liquid equilibrium, methods of getting equilibrium data for binary systems, construction of equilibrium diagram, designing of distillation column, reflux ratio and its importance.

Composite Materials:

Introduction to composite material, classification of composite on the basis of reinforcement (Particle–Reinforced composite, Fibre–Reinforced composite, structural composites) and classification of composites on the basis of matrix phase (Polymer–Matrix composite, Metal–Matrix composite, Ceramics–Matrix composite, Carbon-carbon composite, Hybrid-composite, Laminar composite, Sandwich panels), synthesis, properties and applications of composite materials.

CHEM-322 Lab

Measurement of water hardness with EDTA Titrations.

Estimation of total solids in water.

Estimation of chloride in water.

Estimation of Ferrous and Ferric ions in drinking water by redox titration.

Extraction of capsicum oil (soxhlet extraction).

Extraction of clove oil from cloves.

Preparation of liquid detergents.

Study of the kinetics of dissolution of Magnesium metal in dilute HCl.

Estimation of Manganese in Steel.

Estimation of Ferric Iron in Cement.

Recommended Books:

1. Erwin D. L., *Industrial Chemical Process Design*, McGraw-Hill, (2002).
2. Chawla, K. K., *Composite Materials: Science and Engineering*, 3rd ed., Springer, (2012).
3. Methews, F. L., Rawlings, R. D., *Composite Materials: Engineering and Sciences*, CRC Press, (2003).
4. Deborah, D. L., *Composite Materials: Science and Applications*, 2nd ed., Springer, (2010).
5. Gay, D. and Hoa, S. V., *Composite Materials: Design and Applications*, 2nd ed., CRC Press, LLC, (2007).
6. Kister, H., *Distillation Operation*, 1st ed., McGraw-Hill Professional, (1990).
7. Tchobanoglous, G., Burton, F. L. and Stensel, H. D., *Wastewater Engineering: Treatment and Reuse*, 4th ed., McGraw-Hill, (2003).
8. 9. Callister, W. D. Jr., *Materials Science and Engineering: An Introduction*, 7th ed., John-Wiley & Sons, Inc., (2007).
9. 10. Roussak, O. V. and Gesser, H. D., *Applied Chemistry: A Textbook for Engineers and Technologists*, 2nd ed., Springer, (2013).
10. Mizrahi, J., *Developing an Industrial Chemical Process: An Integrated Approach*, CRC Press, (2002).
11. Prakash, N. B., *Applied Chemistry Lab Manual*, LAP Lambert Academic Publishing, (2013).
12. Vermani, O. P., *Applied Chemistry : Theory And Practice*, 2nd ed., New Age International, (2006).
13. Goostray. S and Schwenck. R. J., *Experiments in Applied Chemistry*, Collier-Macmillan, (1966).

FOURTH YEAR (SEMESTER-VII)

SPECIALIZATION IN ANALYTICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-311	Atomic Spectroscopy	3+0
2	CHEM-313	Electro Analytical Techniques	3+0
3	CHEM-312	Advance Separation Techniques	3+0
4	CHEM-321/ CHEM-231/ CHEM-141	Applied Chemistry/Biochemistry/Fuel Chemistry	3+1
5	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			16

Course Code: CHEM-311 **Course Name:** Atomic Spectroscopy

Course Objectives: Students will acquire knowledge about theoretical aspects and instrumentation of different atomic spectroscopic methods as well as learn about the applications of these techniques in the field of chemical sciences.

Course Contents:

Flame Photometry: Origin and classification of atomic spectroscopic methods, origin of atomic spectrum, position of the signal, intensity of the signal, spectral line width, principle of flame photometry, fate of the sample in the flame, flame and its characteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic fluorescence spectrometry, interferences, merits and limitations.

Atomic Absorption Spectrophotometry: Principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, monochromators, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of the sample, use of organic solvents, microwave, digestion, sample introduction methods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively coupled plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).

4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West., D. M., *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., London, (2008).
6. Ebdon,L., Evaus, E.H, Fischer, A., and Hill, S.J., *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons, England. (1998).
7. Bernhard Welz, Michael Sperling, *Atomic Absorption Spectrometry*, 3rd ed., Wiley-VCH, Germany, (1998).
8. Farrukh, M. A., *Atomic Absorption Spectroscopy*, In Tech, (2012).
9. Kellner, R., Mermet, J. M, Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry A Modern Approach to Analytical Science*, Wiley-VCH,(2004).

Course Code: CHEM-313 **Course Name:** Electro Analytical Techniques

Course Objectives:

Students will acquire sound knowledge regarding the theoretical, instrumental as well as application related aspects of different electroanalytical techniques

Course Contents:

Potentiometry: Electrode potential, Nernst equation and its use for measuring half-cell potential, different kinds of electrodes including glass and calomel electrodes, working of potentiometer and its applications including pH measurements, Ion selective electrode systems, Ion exchange membrane electrode, solid state membrane electrodes, and bio-membrane electrodes, Potentiometric titrations.

Coulometry and Electrogravimetry: Basic electrochemistry, principle, instrumentation of coulometry, principle, instrumentation of electrogravimetry, consequences of electrogravimetry, Ohmic drop, activation over potential, concentration and gas polarization, basic difference and merits/demerits of coulometry and electrogravimetry.

Voltammetry and Polarography: Basic principle, voltammogram, polarizable and non-polarizable electrodes, solid electrodes, their scope and limitations, cyclic voltammetry, anodic stripping voltammetry. voltammetric equation, basic concept of polarography and interpretation of various polarographic curves, measurement of decomposition potential, diffusion and limiting currents, derivation of Ilkovic equation, logarithmic analysis of polarographic wave, advantages and limitation of dropping mercury electrode.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry,* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis 8*th ed.,W.H. Freeman and Company, New York, (2009).
3. Kealey, D. and Haines , P. J., *BIOS Instant Notes in Analytical Chemistry,* Bios Scientific Publishers Limited, Oxford, UK, (2002).
4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West, D. M., *Fundamentals of Analytical Chemistry,* 8th ed., Hot Reinehart Inc., London, (2008).

6. Fritz, Schulz, *Electranalytical Methods: Guide to Experiments and Applications.* 2nd revised, Springer-Verlag Berlin, Germany, (2010).
7. Monk,P.M.S, *Fundamentals of Electroanalytical Chemistry*, John-Wiley & Sons Ltd, England, (2001).

Course Code: CHEM-312 **Course Name:** Advance Separation Techniques

Course Objectives: Students will acquire knowledge about the principles and instrumentation of advanced chromatographic techniques namely GLC, HPLC and capillary electrophoresis along with their applications in different fields such as food, pharmaceuticals, petroleum, environmental and other industrial sectors.

Course Contents:

Introduction: Classifications of chromatographic techniques, the chromatographic processes, rate theory of chromatography, Van-Deemter equation and its significance in evaluating column efficiency. **Gas Liquid Chromatography:** General principle, sample preparation/derivatization, separation process, and instrumental aspects and its applications.

HPLC: General principle, sample preparation, separation process (normal phase and reverse phase separation), instrumentation, method development and applications.

Capillary electrophoresis: Theory and principle of CE, mobility, electro-osmotic flow separation by CE, instrumentation, modes of operation, applications.

Recommended Books:

1. Skoog, D. A., West, P. M., Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry*, 9th ed., Cengage Learning, (2013).
2. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, New York, (2004).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry,* 1st ed., Taylor & Francis, (2002).
4. Sharma, B.K. *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Grob, R. L., Eugene, F. Barry, *Modern Practice of Gas Chromatography,* 4th ed., John-Wiley & Sons, USA, (2004).
6. Kellner, R., Mermet, J-. M., Otto, M., Valcarcel, M. and Widmer, H. M., *Analytical Chemistry: A Modern Approach to Analytical Science*, Wiley-VCH, (2004).
7. Meyer, V. R., *Practical High-Performance Liquid Chromatography,* 5th ed., John-Wiley & Sons, Ltd., (2010).
8. Lindsay, S., *High Performance Liquid Chromatography,* 2nd ed., John-Wiley & Sons, Ltd., (1992).

9. Braitwaite, A. and Smith, F. J., *Chromatographic Methods,* 5th ed., Kluwer Academic Publishers, (1999).
10. Miller, J. M., *Chromatography: Concepts and Contrasts,* 2nd ed., John-Wiley & Sons, Inc., (2005).
11. Camilleri, P., *Capillary Electrophoresis: Theory and Practice,* 2nd ed., CRC Press, (1998).

Course Code: CHEM-321 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge and technical know-how about sugar manufacturing industry, starch production industry and leather tanneries.

Sugar Industry:

Scope of sugar industry, Manufacture of raw sugar from cane and beet, Refining of raw sugar, Methods of clarification of cane juice and chemistry involved in the clarification processes, Defecation Remelt Carbonation (DRC), Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation (DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of by-products of sugar industry.

Starch Industry:

Scope of starch industry, Raw materials for starch production, Manufacture of starch from various raw materials such as corn, rice, wheat, potatoes, Industrial applications of starch, Chemistry involved in the conversion of starch, Synthesis of d-glucose and dextrin from starch.

Leather Industry: Leather, Gelatin and adhesives preparations of hides, methods of tanning vegetable and chrome tanning processing of leather, production of glue and gelatin.

Recommended Books:

1. Rao, G. P., Mogarey, R. C., Solomn, S., Rewal, S. S. and Li,Y-., *SugarCane: Production Managemnet and Agro-Industrial Imperatives*, IbdcPublisher, (2005).

2. Covington, A. D., *Tanning Chemistry: The Science of Leather*, Royal Society of Chemistry, (2009).

3. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10th ed., Kluwer Academic/ Plenum Publishers, (2003).

Course Code: CHEM-231 **Course Name:** Biochemistry

Course Objectives:

Students will acquire knowledge about the fundamental biochemical and molecular aspects of endocrinology and chemistry of blood and other extracellular fluids.

Course Contents:

Endocrinology: General introduction, chemical nature of hormones, common characteristics, mode of action of hormones, hormones receptors, chemistry, biosynthesis, metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid, pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids: General composition of blood, function of blood plasma, plasma protein, composition and functions, composition, development and functions of red blood cells, white blood cells and platelets, Hemoglobin, chemistry properties, synthesis, functions and derivatives, degradation of hemoglobin, respiration and gas transport, blood coagulation and clotting of blood, blood pressure, blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended books:

1. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry,* 6th ed., W. H. Freeman, (2012).
2. Voet, D. and Voet, J. D, *Biochemistry,* 4th ed., illustrated. John Wiley & Sons, (2011).
3. Hall, J. E., *Guyton & Hall Textbook of Medical Physiology,* 12th ed., Elsvier Health Sciences,(2011).
4. Orten, James. M. and Neuhaus, O. W., *Human Biochemistry,* 10th ed., Mosby, Incorporated, (1982).
5. Devlin, T. M., *Textbook of Biochemistry with Clinical Correlations, 7*th ed., Wiley, (2010).
6. Frisell, W. R., *Human Biochemistry*, 1st ed., Macmillan Publication Company, (1982).
7. Hadley, M. and Levine, J. E., *Endocrinology,* 6th ed., pearson, (2006).

Course Code: CHEM-141 **Course Name:** Fuel Chemistry

Course Objectives:

The students will acquire knowledge about environmentally friendly utilization of coal and how to extract maximum energy and convert coal in to a variety of highly demanding chemicals used as feed stock in a number of Industries.

Course Contents: Coal: Composition, structure, coalification and classification of coal, ASTM international and coal Standards. Use of coal in different industries like power generation, steel and other metallurgical operations.Coal exploration, mining and mining risk handling, pretreatment and preparation of coals.Innovations in coal using industry.

Environmental Aspects: Pollution problems associated with coal combustion, mining and flue gases.

Gasification: Thermodynamics, kinetics and catalytic aspects of coal gasification, fixed bed gasifier, fluidized bed gasifier, transport reactor, liquid medium gasifier and underground gasification. Gas upgrading by carbon monoxide shift, gas purification, methanation and dehydration, properties and processing of gaseous fuels, environmental consideration.

Recommended Books:

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).

2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).

3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).

4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).

5. Berkowitz, N. *The Chemistry of Coal,* Elsevier Amsterdam. (1985).

FOURTH YEAR (SEMESTER-VII)

SPECIALIZATION IN APPLIED CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-322	Common Industries-I	3+0
2	CHEM-321	Agro Based Industries & PollutionControl	3+0
3	CHEM-323	Agro Based Industries & Pollution	3+0
4	CHEM-311/ CHEM-231/ CHEM-141	Analytical Chemistry/Biochemistry/Fuel Chemistry	3+1
5	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			16

Course Code: CHEM-322 **Course Name:** Common Industries-I

Course Objectives:

Students will acquire knowledge and technical know-how about sugar manufacturing industry, starch production industry and leather tanneries.

Sugar Industry:

Scope of sugar industry, Manufacture of raw sugar from cane and beet, Refining of raw sugar, Methods of clarification of cane juice and chemistry involved in the clarification processes, Defecation Remelt Carbonation (DRC), Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation (DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of by-products of sugar industry.

Starch Industry:

Scope of starch industry, Raw materials for starch production, Manufacture of starch from various raw materials such as corn, rice, wheat, potatoes, Industrial applications of starch, Chemistry involved in the conversion of starch, Synthesis of d-glucose and dextrin from starch.

Leather Industry:

Leather, gelatin and adhesives, Preparation of hides, Methods of tanning, vegetable and chrome tanning processing of leather, Production of glue and gelatin.

Recommended Books:

1. Rao, G. P., Mogarey, R. C., Solomn, S., Rewal, S. S. and Li,Y-., *Sugar Cane: Production Managemnet and Agro-Industrial Imperatives*, Ibdc Publisher, (2005).
2. Covington, A. D., *Tanning Chemistry: The Science of Leather,* Royal Society of Chemistry, (2009).
3. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10th ed., Kluwer Academic/ Plenum Publishers, (2003).

Course Code: CHEM-321 **Course Name:** Agro Based Industries & Pollution Control

Course Objectives: Students will acquire knowledge about various fertilizers, pesticides and herbicides used in agriculture sector as well as know about the environmental pollution and its protection.

Fertilizers: Importance of chemical fertilizers, classification of chemical fertilizers, manufacture and chemistry involved in the production of various fertilizers i.e. Urea, Single Super phosphate (SSP), Triple superphosphate (TSP), Nitrophos (NP), Diammonium phosphate (DAP), Calcium ammonium nitrate (CAN), Ammonium nitrate (AN), Ammonium sulphate (AS), Zinc sulphate (ZS) and Complex fertilizers.

Agrochemicals: Classification of pesticides, formulation and toxicity of pesticides, future trends of pest control, control of weeds, household agrochemicals, plant growth regulators and background chemistry, hazards associated with the use of agrochemicals and environmental aspects.

Industrial Pollution and Its Abatement: Sources of air, water and soil pollution, Industrial waste control for the protection of environment, modern trends of waste management.

Recommended Books:

1. Afonso, C. A. M. Crespo, J. P. G. and Anastas, P. T., *Green Separation Process: Fundamentals and Applications,* Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, (2005).
2. Manahan, S. E., *Fundamentals of Environmental Chemistry*, 2nd ed., CRC Press, (2001).
3. Lister, J. and Ennis, B., *The Science and Engineering of Granulation Processes,* Kluwer Academic Publishers, (2004).
4. Park, M., *The Fertilizer Industry,* Woodhead Publishing Limited, (2001).
5. Anastas, P. T. and Warmer, J. C., *Green Chemistry: Theory and Practice,* Oxford University Press, (2000).
6. Kumar, A., *Industrial Pollution: Problems and Solution,* Daya Publishing House, India, (2006).
7. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10th ed., Kluwer Academic/ Plenum Publishers, (2003).

Course Code: CHEM-323 **Course Name:** Common Industries-II

Course Objectives: Students will acquire knowledge for extraction, production and processing oil, fats and waxes. They will also gain knowledge about soap and detergent industries as well as surface coating industries.

Oils and Fats: Oils, Fats and Waxes, extraction of oils such as soya bean and cotton seed oils, purification and refining of oils, chemistry involved in the production of vegetable ghee, selective hydrogenation of oil and fats during the manufacture of vegetable ghee, inter-esterification of crude fats.

Soaps and Detergents: Raw materials for the manufacture of soap and detergents, chemistry involved in the production of soap and detergents, action of builders, additives brighteners and surfactants, cleansing action of soaps, effect of acidic species and hard water on soap, Production of transparent soap.

Paints: Raw materials for paints and pigments, classification and properties of surface-coating constituents, classification and manufacture of pigments, production of paints, varnishes, distempers, enamels and lacquers, chemistry involved in the drying phenomena of paints, drying oils for paint and classification of drying oils.

Recommended Books:

1. Vermani, O. P, Narula, A.K, *Applied Chemistry, Theory and Practice*, 2nd ed., New Age International. Publisher, India, (1995).
2. Balasaraf, V. M, *Applied Chemistry*, I. K. International House Pvt. Ltd, India, (2009).
3. P. K. Chattopadyay, *Modern Technology of Soaps, Detergents and Toilries: with formulae and project profile, 2nd ed.,* National Institute of Industrial Research, India, (2003).
4. Bockisch M., *Fats and Oils Handbook*, American oil Chemists and Society, (1998).
5. Gunstone F., *Oils and Fats in Food Industry,* Wiley Black Well, (2008).
6. Gunstone F., *Vegetable Oil in Food Technology: Composition, Properties and Uses,* John-Wiley & Sons, (2011).
7. Lambourme, R., Strivens, T.A., *Paint and Surface Coatings: Theory and Practice, 2nd ed.,* Woodhead Publishing Limited, (1999).
8. Board. B, *Paint, Pigment, Solvent, Coating, Emulsion, Paint additives and formulations*, Engineers India Research Incorporation, (2008).

9. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10th ed., Kluwer Academic/Plenum Publishers, (2003).

Course Code: CHEM-311 **Course Name:** Analytical Chemistry

Course Objectives: Students will acquire knowledge about theoretical aspects and instrumentation of different atomic spectroscopic methods as well as learn about the applications of these techniques in the field of chemical sciences.

Course Contents:

Flame Photometry: Origin and classification of atomic spectroscopic methods, origin of atomic spectrum, position of the signal, intensity of the signal, spectral line width, principle of flame photometry, fate of the sample in the flame, flame and its characteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic fluorescence spectrometry, interferences, merits and limitations.

Atomic Absorption Spectrophotometry: Principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, monochromators, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of the sample, use of organic solvents, microwave, digestion, sample introduction methods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively coupled plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).

4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West., D. M., *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., London, (2008).
6. Ebdon,L., Evaus, E.H, Fischer, A., and Hill, S.J., *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons, England. (1998).
7. Bernhard Welz, Michael Sperling, *Atomic Absorption Spectrometry*, 3rd ed., Wiley-VCH, Germany, (1998).
8. Farrukh, M. A., *Atomic Absorption Spectroscopy*, In Tech, (2012).
9. Kellner, R., Mermet, J. M, Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry A Modern Approach to Analytical Science*, Wiley-VCH,(2004).

Course Code: CHEM-231 **Course Name:** Biochemistry

Course Objectives:

Students will acquire knowledge about the fundamental biochemical and molecular aspects of endocrinology and chemistry of blood and other extracellular fluids.

Course Contents:

Endocrinology: General introduction, chemical nature of hormones, common characteristics, mode of action of hormones, hormones receptors, chemistry, biosynthesis, metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid, pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids: General composition of blood, function of blood plasma, plasma protein, composition and functions, composition, development and functions of red blood cells, white blood cells and platelets, Hemoglobin, chemistry properties, synthesis, functions and derivatives, degradation of hemoglobin, respiration and gas transport, blood coagulation and clotting of blood, blood pressure, blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended books:

8. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry*, 6th ed., W. H. Freeman, (2012).
9. Voet, D. and Voet, J. D, *Biochemistry,* 4th ed., illustrated. John Wiley & Sons, (2011).
10. Hall, J. E., *Guyton & Hall Textbook of Medical Physiology,* 12th ed., Elsvier Health Sciences,(2011).
11. Orten, James. M. and Neuhaus, O. W., *Human Biochemistry,* 10th ed., Mosby, Incorporated, (1982).
12. Devlin, T. M., *Textbook of Biochemistry with Clinical Correlations, 7*th ed., Wiley, (2010).
13. Frisell, W. R., *Human Biochemistry*, 1st ed., Macmillan Publication Company, (1982).
14. Hadley, M. and Levine, J. E., *Endocrinology,* 6th ed., pearson, (2006).

Course Code: CHEM-141 **Course Name:** Fuel Chemistry

Course Objectives:

The students will acquire knowledge about environmentally friendly utilization of coal and how to extract maximum energy and convert coal in to a variety of highly demanding chemicals used as feed stock in a number of Industries.

Course Contents: Coal: Composition, structure, coalification and classification of coal, ASTM international and coal Standards. Use of coal in different industries like power generation, steel and other metallurgical operations.Coal exploration, mining and mining risk handling, pretreatment and preparation of coals.Innovations in coal using industry.

Environmental Aspects: Pollution problems associated with coal combustion, mining and flue gases.

Gasification: Thermodynamics, kinetics and catalytic aspects of coal gasification, fixed bed gasifier, fluidized bed gasifier, transport reactor, liquid medium gasifier and underground gasification. Gas upgrading by carbon monoxide shift, gas purification, methanation and dehydration, properties and processing of gaseous fuels, environmental consideration.

Recommended Books:

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).
2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).
3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).
4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).
5. Berkowitz, N. *The Chemistry of Coal,* Elsevier Amsterdam. (1985).

FOURTH YEAR (SEMESTER-VII)

SPECIALIZATION IN BIOCHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-231	Biomedical Chemistry	3+0
2	CHEM-232	Molecular Biology	3+0
3	CHEM-233	Physical Techniques in Biochemistry	3+0
4	CHEM-311/ CHEM-321/ CHEM-141	Analytical Chemistry/ Fuel Chemistry/ Applied Chemistry	3+1
5	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			16

Course Code: CHEM-231 **Course Name:** Biomedical Chemistry

Course Objectives:

Students will acquire knowledge about the fundamental biochemical and molecular aspects of endocrinology and chemistry of blood and other extracellular fluids.

Course Contents:

Endocrinology: General introduction, chemical nature of hormones, common characteristics, mode of action of hormones, hormones receptors, chemistry, biosynthesis, metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid, pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids: General composition of blood, function of blood plasma, plasma protein, composition and functions, composition, development and functions of red blood cells, white blood cells and platelets, Hemoglobin, chemistry properties, synthesis, functions and derivatives, degradation of hemoglobin, respiration and gas transport, blood coagulation and clotting of blood, blood pressure, blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended books:

15. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry,* 6th ed., W. H. Freeman, (2012).
16. Voet, D. and Voet, J. D, *Biochemistry,* 4th ed., illustrated. John Wiley & Sons, (2011).
17. Hall, J. E., *Guyton & Hall Textbook of Medical Physiology,* 12th ed., Elsvier Health Sciences,(2011).
18. Orten, James. M. and Neuhaus, O. W., *Human Biochemistry,* 10th ed., Mosby, Incorporated, (1982).
19. Devlin, T. M., *Textbook of Biochemistry with Clinical Correlations, 7*th ed., Wiley, (2010).
20. Frisell, W. R., *Human Biochemistry*, 1st ed., Macmillan Publication Company, (1982).
21. Hadley, M. and Levine, J. E., *Endocrinology,* 6th ed., pearson, (2006).

Course Code: CHEM-232 **Course Name:** Molecular Biology

Course Objectives:

Students will acquire knowledge about the structural and functional features of DNA and RNA.

Course Contents:

DNA: the primary genetic material, structure, replication in prokaryotes and comparison with eukaryotes, DNA sequencing, chemical synthesis of polynucleotides, DNA repair and recombination. Different types of RNA and their role in protein synthesis, transcription and its regulation, genetic code, post transcriptional processing, structure of transfer RNA, protein synthesis inhibitors, control of translation, post translational modification, plasmids, bacteriophage and cosmids, *invitro* mutagenesis, deletion, insertion and substitution, recombinant DNA and genetic diseases.

Recommended Books:

1. Watson, J. D., Baker, A. T., Bell, S. P., Gann A., Levine, M. and Losick, M. R., *Molecular Biology of the Gene,* 7th ed., Benjamin Cummings, (2013).
2. Watson, J. D., Myers, R. M., Caudy A. A., and Witkowski, J. A., *Recombinant DNA: Genes and Genome. A Short Course,* 3rd ed., W. H. Freeman, (2006).
3. Krabs, J., *Genes X* 10th ed., Jones and Bartlett Learning, (2011).
4. Alberts, B., *Molecular Biology of the Cell,* 5th ed., Publisher: Garland Science, (2008). ISBN: 0815341113, 9780815341116.
5. Brown, T.A., *Genomes 3,* 3rd ed., Publisher: Garland Science Publishing, (2007). ISBN: 0815341385, 9780815341383.

Course Code: CHEM-233 **Course Name:** Physical Techniques in Biochemistry

Course Objectives:

Students will gain knowledge and in depth understanding about the fundamental biochemical techniques such as extraction, purification, fractionation and centrifugation being applicable for macromolecules separation as well as those techniques which are used for characterization of biomolecules.

Course Contents:

Extraction, Fractionation and Purification of Macrobiomolecules:

Homogenization, solubilization and concentration including ultrasonication, lyophilization and ultradecantation, purification based on differential solubility techniques, ion-exchange chromatography, gel chromatography, affinity chromatography, paper & thin layer chromatography and HPLC.

Electrophoresis: Paper and gel electrophoresis, two-dimensional electrophoresis, capillary electrophoresis.

Electrofocusing: Preparative and analytical electrofocusing.

Centrifugation: Principle, preparative centrifugation, application of density gradient and differential centrifugation, ultracentrifugation sedimentation equilibrium and sedimentation velocity methods, application of analytical centrifugation.

Tracer techniques: Detection and measurement of radioactivity, application of radioisotopes in biological system.

U.V. and Visible Spectroscopy: Basic principles, instrumentation and applications.

Enzyme linked immunosorbent assay (ELISA): Basic principle, instrumentation and applications.

Recommended Books:

1. Cooper, T. C., *The Tools of Biochemistry,* 2nd ed., John Wiley, (2007).
2. Wilson, K. and Golding, K. H., *A Biologist's Guide to Principles and Techniques of Practical Biochemistry*, 3rd ed., Edward Arnold, (1986).
3. Dawes, E. A., *Quantitative Problems in Biochemistry,* 5th ed., Williams & Wilkins, (1972).
4. Morris, J. G., *A Biologist's Physical Chemistry,* 2nd ed., Addison-Wesley, (1974).
5. Scopes, R. K., *Protein Purification: Principles and Practice,* 3rd ed., Springer (1994).

Course Code: CHEM-311 **Course Name:** Analytical Chemistry

Course Objectives: Students will acquire knowledge about theoretical aspects and instrumentation of different atomic spectroscopic methods as well as learn about the applications of these techniques in the field of chemical sciences.

Course Contents:

Flame Photometry: Origin and classification of atomic spectroscopic methods, origin of atomic spectrum, position of the signal, intensity of the signal, spectral line width, principle of flame photometry, fate of the sample in the flame, flame and its characteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic fluorescence spectrometry, interferences, merits and limitations.

Atomic Absorption Spectrophotometry: Principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, monochromators, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of the sample, use of organic solvents, microwave, digestion, sample introduction methods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively coupled plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).

4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West., D. M., *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., London, (2008).
6. Ebdon,L., Evaus, E.H, Fischer, A., and Hill, S.J., *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons, England. (1998).
7. Bernhard Welz, Michael Sperling, *Atomic Absorption Spectrometry*, 3rd ed., Wiley-VCH, Germany, (1998).
8. Farrukh, M. A., *Atomic Absorption Spectroscopy*, In Tech, (2012).
9. Kellner, R., Mermet, J. M, Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry A Modern Approach to Analytical Science*, Wiley-VCH,(2004).

Course Code: CHEM-141 **Course Name:** Fuel Chemistry

Course Objectives:

The students will acquire knowledge about environmentally friendly utilization of coal and how to extract maximum energy and convert coal in to a variety of highly demanding chemicals used as feed stock in a number of Industries.

Course Contents: Coal: Composition, structure, coalification and classification of coal, ASTM international and coal Standards. Use of coal in different industries like power generation, steel and other metallurgical operations.Coal exploration, mining and mining risk handling, pretreatment and preparation of coals.Innovations in coal using industry.

Environmental Aspects: Pollution problems associated with coal combustion, mining and flue gases.

Gasification: Thermodynamics, kinetics and catalytic aspects of coal gasification, fixed bed gasifier, fluidized bed gasifier, transport reactor, liquid medium gasifier and underground gasification. Gas upgrading by carbon monoxide shift, gas purification, methanation and dehydration, properties and processing of gaseous fuels, environmental consideration.

Recommended Books:

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).
2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).
3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).
4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).
5. Berkowitz, N. *The Chemistry of Coal,* Elsevier Amsterdam. (1985).

Course Code: CHEM-321 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge and technical know-how about sugar manufacturing industry, starch production industry and leather tanneries.

Sugar Industry:

Scope of sugar industry, Manufacture of raw sugar from cane and beet, Refining of raw sugar, Methods of clarification of cane juice and chemistry involved in the clarification processes, Defecation Remelt Carbonation (DRC), Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation (DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of by-products of sugar industry.

Starch Industry:

Scope of starch industry, Raw materials for starch production, Manufacture of starch from various raw materials such as corn, rice, wheat, potatoes, Industrial applications of starch, Chemistry involved in the conversion of starch, Synthesis of d-glucose and dextrin from starch.

Leather Industry: Leather, Gelatin and adhesives preparations of hides, methods of tanning vegetable and chrome tanning processing of leather, production of glue and gelatin.

Recommended Books:

4. Rao, G. P., Mogarey, R. C., Solomn, S., Rewal, S. S. and Li,Y-., *SugarCane: Production Managemnet and Agro-Industrial Imperatives*, IbdcPublisher, (2005).

5. Covington, A. D., *Tanning Chemistry: The Science of Leather,* Royal Society of Chemistry, (2009).

6. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10^{th} ed., Kluwer Academic/ Plenum Publishers, (2003).

FOURTH YEAR (SEMESTER-VII)

SPECIALIZATION IN FUEL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-141	Chemistry of Coal Conversion Process-I	3+0
2	CHEM-143	Petroleum & Petrochemicals-I	3+0
3	CHEM-142	Characterization of fossil fuels	3+0
4	CHEM-311/ CHEM-321/ CHEM-231	Analytical Chemistry/Applied Chemistry/Biochemistry	3+1
5	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			16

Course Code: CHEM-141 **Course Name:** Chemistry of Coal Conversion Process-I

Course Objectives:

The students will acquire knowledge about environmentally friendly utilization of coal and how to extract maximum energy and convert coal in to a variety of highly demanding chemicals used as feed stock in a number of Industries.

Course Contents: Coal: Composition, structure, coalification and classification of coal, ASTM international and coal Standards. Use of coal in different industries like power generation, steel and other metallurgical operations.Coal exploration, mining and mining risk handling, pretreatment and preparation of coals.Innovations in coal using industry.

Environmental Aspects: Pollution problems associated with coal combustion, mining and flue gases.

Gasification: Thermodynamics, kinetics and catalytic aspects of coal gasification, fixed bed gasifier, fluidized bed gasifier, transport reactor, liquid medium gasifier and underground gasification. Gas upgrading by carbon monoxide shift, gas purification, methanation and dehydration, properties and processing of gaseous fuels, environmental consideration.

Recommended Books:

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).
2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).
3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).
4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).
5. Berkowitz, N. *The Chemistry of Coal,* Elsevier Amsterdam. (1985).

Course Code: CHEM-143 **Course Name:** Petroleum & Petrochemicals-I

Course Objectives:

The students will acquire knowledge about the modern refining operations for maximum recovery of petroleum products and to get knowledge using crude petroleum and its distillate products in commercial manufacture of highly demanding petrochemicals.

Course Contents:

Petroleum: Composition, properties and classification of crude oils, oil shale and tar sands. Preparation, structure and properties of cracking and reforming catalysts.Mechanism of cracking and reforming.Effect of operating conditions on cracking and reforming products.Hydroforming and desulphurization of petroleum products.

Petrochemicals:

Ethylene production by thermal cracking from ethane.Propane and naphtha.Petrochemicals from oxidation processes. Production of petrochemicals from halogenation processes. Hydrogenation of benzene, fats, and adiponitrite, nitration of benzene and toluene, sulphonation of benzene and toluene, alkylation of aromatics.

Recommended Books:

1. Hobson, G.D. *Modern Petroleum Technology*, Part 2, John Wiley and Sons, New York. (1984).
2. Gates, B.C, Katzer, J.R and Schuit, G.C.A. *Chemistry of Catalytic Processes*, McGraw Hill Book company, London (1979).
3. List, H.L. *Petrochemical Technology*, Printice-Hall Englewood Cliffs, New Jersey. (1986).
4. Goodger, E.M. *Hydrocarbon Fuels*, Union Brothers Ltd, London. (1975).
5. Maleev, V.L. *Internal Combustion Engines*, McGraw Hill Book Company London, (1985).
6. Hughes, J.R., and Swindells, N.S. *Storage and Handling of Petroleum Liquids*, Charless Griffin and Company Ltd, London. (1987).
7. Wiseman, P. *An Introduction to Industrial Organic Chemistry*, Wiley Interscience, New York (2001).

Course Code: CHEM-142 **Course Name:** Characterization of fossil fuels

Course Objectives:

The students will acquire knowledge of the physicochemical and instrumental analysis of fuels

Course Contents:

Physicochemical: Determination and data interpretation using ASTM methods of API Gravity, Flash Point, Pour Point, Analine Point, Distillation behaviors, Octane no. Cetane number and RVP.

Analytical Methods: Analytical methods in the production of analytes and quality assurance of fuels using GC-FID, GC-MS, Calorimetry, Atomic absorption, ICP.

Recommended Books:

1. Ewing, G.W. *Instrumental Methods of Chemical Analysis*, McGraw Hill, London. (1985).
2. Chrisition, G.D. *Instrumental Analysis,* Allyn and Bacon, Inc, Boston, London. (1986).
3. Kagler, S.H. *Spectroscopic and Chromatographic Analysis of Mineral Oils,* John, Wiley and Sons, New York. (1983).
4. Karr. C. *Analytical Methods for Coal and Coal Products,* Academic Press, New York. (1978).
5. Harker, J.H. and Backurst, J.R. *Fuel and Energy,* Academic Press, London and New York (1988).
6. Skooge, D.A.*Instrumental Analysis,* Sanat Printer, Indian Edition, 2009.

Course Code: CHEM-311 **Course Name:** Analytical Chemistry

Course Objectives: Students will acquire knowledge about theoretical aspects and instrumentation of different atomic spectroscopic methods as well as learn about the applications of these techniques in the field of chemical sciences.

Course Contents:

Flame Photometry: Origin and classification of atomic spectroscopic methods, origin of atomic spectrum, position of the signal, intensity of the signal, spectral line width, principle of flame photometry, fate of the sample in the flame, flame and its characteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic fluorescence spectrometry, interferences, merits and limitations.

Atomic Absorption Spectrophotometry: Principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, monochromators, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of the sample, use of organic solvents, microwave, digestion, sample introduction methods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively coupled plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).

4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West., D. M., *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., London, (2008).
6. Ebdon,L., Evaus, E.H, Fischer, A., and Hill, S.J., *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons, England. (1998).
7. Bernhard Welz, Michael Sperling, *Atomic Absorption Spectrometry*, 3rd ed., Wiley-VCH, Germany, (1998).
8. Farrukh, M. A., *Atomic Absorption Spectroscopy*, In Tech, (2012).
9. Kellner, R., Mermet, J. M, Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry A Modern Approach to Analytical Science*, Wiley-VCH,(2004).

Course Code: CHEM-321 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge and technical know-how about sugar manufacturing industry, starch production industry and leather tanneries.

Sugar Industry:

Scope of sugar industry, Manufacture of raw sugar from cane and beet, Refining of raw sugar, Methods of clarification of cane juice and chemistry involved in the clarification processes, Defecation Remelt Carbonation (DRC), Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation (DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of by-products of sugar industry.

Starch Industry:

Scope of starch industry, Raw materials for starch production, Manufacture of starch from various raw materials such as corn, rice, wheat, potatoes, Industrial applications of starch, Chemistry involved in the conversion of starch, Synthesis of d-glucose and dextrin from starch.

Leather Industry: Leather, Gelatin and adhesives preparations of hides, methods of tanning vegetable and chrome tanning processing of leather, production of glue and gelatin.

Recommended Books:

7. Rao, G. P., Mogarey, R. C., Solomn, S., Rewal, S. S. and Li,Y-., *SugarCane: Production Managemnet and Agro-Industrial Imperatives*, IbdcPublisher, (2005).

8. Covington, A. D., *Tanning Chemistry: The Science of Leather,* Royal Society of Chemistry, (2009).

9. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10th ed., Kluwer Academic/ Plenum Publishers, (2003).

Course Code: CHEM-231 **Course Name:** Biochemistry

Course Objectives:

Students will acquire knowledge about the fundamental biochemical and molecular aspects of endocrinology and chemistry of blood and other extracellular fluids.

Course Contents:

Endocrinology: General introduction, chemical nature of hormones, common characteristics, mode of action of hormones, hormones receptors, chemistry, biosynthesis, metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid, pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids: General composition of blood, function of blood plasma, plasma protein, composition and functions, composition, development and functions of red blood cells, white blood cells and platelets, Hemoglobin, chemistry properties, synthesis, functions and derivatives, degradation of hemoglobin, respiration and gas transport, blood coagulation and clotting of blood, blood pressure, blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended books:

1. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry,* 6th ed., W. H. Freeman, (2012).
2. Voet, D. and Voet, J. D, *Biochemistry,* 4th ed., illustrated. John Wiley & Sons, (2011).
3. Hall, J. E., *Guyton & Hall Textbook of Medical Physiology,* 12th ed., Elsvier Health Sciences,(2011).
4. Orten, James. M. and Neuhaus, O. W., *Human Biochemistry,* 10th ed., Mosby, Incorporated, (1982).
5. Devlin, T. M., *Textbook of Biochemistry with Clinical Correlations, 7*th ed., Wiley, (2010).
6. Frisell, W. R., *Human Biochemistry,* 1st ed., Macmillan Publication Company, (1982).

   Hadley, M. and Levine, J. E., *Endocrinology,* 6th ed., pearson, (2006).

FOURTH YEAR (SEMESTER-VII)

SPECIALIZATION IN INORGANIC CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-452	Inorganic Reaction Mechanism	3+0
2	CHEM-451	Π- Aceptor Ligands And Inorganic Polymers	3+0
3	CHEM-453	Inorganic Spectroscopy	3+0
4	CHEM-311/ CHEM/321/ CHEM-231/ CHEM-141	Analytical Chemistry/Applied Chemistry/Biochemistry/Fuel Chemistry	3+1
5	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			16

Course Code: CHEM-452 **Course Name:** Inorganic Reaction Mechanism

Course Objective: Students will acquire know-how and understanding about different mechanisms of inorganic reactions and their applications towards understanding different types of complexes.

Course Contents: Classification of reaction mechanisms; rate laws; steady state approximation; inert and labile complexes; substitution reactions in octahedral complexes and square planar complexes, acid hydrolysis, base hydrolysis, steric effects of inert ligands, nucleophilic reactivity, trans-effect, *cis*-effect, racemization reactions. Mechanism of electron transfer reactions, oxidation reduction reactions of metal ions, outer and inner sphere mechanisms, factors affecting rate of electron transfer reactions, two electrons transfer reactions, complementary or non-complementary electron transfer reactions, oxidative addition, addition of oxygen, hydrogen, HX, organic halides and bimetallic species, Reductive Elimination Reactions.

Recommended Books:

1. Huheey, J. E., Keiter, E. A., Keiter, R. L., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Prentice Hall, (1997).
2. Shriver, D. F., Atkins, P. W., *Inorganic Chemistry*, 3rd ed., Oxford University Press, (2001).
3. Wilkins, R. G., *Kinetics and Mechanism of Reactions of Transition Metal Complex*, 2nd ed., (Rev.), Wiley-VCH, (1991).
4. Jolly, W. L., *Modern Inorganic Chemistry*, 2nd ed., McGraw-Hill Company, (1991).
5. Jordan, R. B., *Reaction Mechanisms of Inorganic and Organomettalic Systems*, 2nd ed., Oxford University Press, New York, (1998).
6. Atwood, J. D., *Inorganic and Organometallic Reaction Mechanisms,* 2nd ed., Wiley-VCH, Inc., (1997).
7. Sharma, S. K., *Inorganic Reaction Mechanisms,* Discovery Publishing House, (2007).

Course Code: CHEM-451 **Course Name:** Π- Aceptor Ligands And Inorganic Polymers

Course Objective: Student will acquire sound knowledge about π--acceptor ligands and different types of inorganic polymers.

Course Contents:

π-Acceptor Ligands:

Introduction to π-acceptor ligands, effective atomic number (EAN) rule and chemistry of metal carbonyls, nitrosyls, and isocyanides, structure elucidation based on spectroscopic evidences, applications and uses of metal carbonyls and their derivatives for catalysis and organic synthesis.

Inorganic Polymers:

Introduction to homoatomic and heteroatomic inorganic polymers, chains and cages of boron, silicon, nitrogen, phosphorous and sulphur, synthesis and applications, Polyionic species, Isopoly and heteropoly, anions of transition metals, silicates, borates, condensed phosphates, zeolites.

Recommended Books:

1. Brady, J. E., and Sense, F., *Chemistry-The Study of Matter and Its Changes*, 5th ed., Wiley Plus, (2009).
2. Miessler, G. L.,Tarr, D. A., *Inorganic Chemistry*, 4th ed., Prentice-Hall International, New Jersey, USA, (2010).
3. Douglas, B., McDanial, D., Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd ed., John-Wiley & Sons, New York, (1994).
4. Huheey, J. E., Keiter, E. A., Keiter, R. L., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Prentice Hall, (1997).
5. Shriver, D. F., Atkins, P. W., Langford, C. H., *Inorganic Chemistry*, 2nd ed., Oxford University Press, (1994).
6. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M., *Advanced Inorganic Chemistry*, 6th ed., Wiley-Interscience, (1999).
7. Atkins, P. and Jones, L., *Chemicals Principles: The Quest for Insight*, 5th ed., W. H. Freeman, (2010).
8. Mandelkern, L., *An Introduction to Macromolecules*, 2nd ed., Springer Verlag, New York, (1983).
9. Ravve, A., *Principles of Polymer Chemistry*, 2nd ed., Plenum Publishers, (2000).

10. Crabtree, R. H., *The Organometallic Chemistry of the Transition Metals,* 5th ed., John-Wiley and Sons, New Jersey, (2011).
11. Yamamoto, A., *Organotransition Metal Chemistry,* Prentice Hall, (1992).
12. Billmeyer, F. W., *A Text Book of Polymer Science*, 3rd, John-Wiley and Sons, (2003).
13. Malmcoim, P.S., *Polymer Chemistry: An Introduction*, 3rd ed.,Oxford University Press, (2005).

Course Code: CHEM-453 **Course Name:** Inorganic Spectroscopy

Course Objectives: Students will acquire understanding about various types of transitions (e. g. d-d transition, charge transfer) occurring in transition metal compounds and to characterize new compounds by application of electronic spectroscopy.

Course Contents: Electronic States of transition metal complexes, Russel-Sander's coupling scheme, derivation of term symbols for d1-d10 systems, d-d transitions, connecting atomic states and molecular states, correlation diagrams, Tanabe -Sugano diagrams, calculation of 10Dq values, High-spin and low-spin molecules, Jahn-Teller effect, applications of subgroups, selection rules for electronic transitions in molecules, LMCT and MLCT transitions, some examples involving different geometries.

Recommended Books:

1. Yarwood, J., Bazin, P., and Douthwaite, R., *Spectroscopic Properties of Inorganic and Organometallic Compounds*, Volume 42, The Royal Society of Chemistry, UK, (2011).
2. Lever, A. B. P., *Inorganic Electronic Spectroscopy,* 2nd ed., Elsevier, UK, (1984).
3. Brisdon, A. K., *Inorganic Spectroscopic Methods*, Oxford University Press, UK, (1998).
4. Solomon, E.I., *Inorganic Electronic Structure and Spectroscopy: Methodology*, Volume 2, Wiley, New York, (1999).

Course Code: CHEM-311 **Course Name:** Analytical Chemistry

Course Objectives: Students will acquire knowledge about theoretical aspects and instrumentation of different atomic spectroscopic methods as well as learn about the applications of these techniques in the field of chemical sciences.

Course Contents:

Flame Photometry: Origin and classification of atomic spectroscopic methods, origin of atomic spectrum, position of the signal, intensity of the signal, spectral line width, principle of flame photometry, fate of the sample in the flame, flame and its characteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic fluorescence spectrometry, interferences, merits and limitations.

Atomic Absorption Spectrophotometry: Principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, monochromators, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of the sample, use of organic solvents, microwave, digestion, sample introduction methods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively coupled plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry,* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).

4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West., D. M., *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., London, (2008).
6. Ebdon,L., Evaus, E.H, Fischer, A., and Hill, S.J., *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons, England. (1998).
7. Bernhard Welz, Michael Sperling, *Atomic Absorption Spectrometry*, 3rd ed., Wiley-VCH, Germany, (1998).
8. Farrukh, M. A., *Atomic Absorption Spectroscopy*, In Tech, (2012).
9. Kellner, R., Mermet, J. M, Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry A Modern Approach to Analytical Science*, Wiley-VCH,(2004).

Course Code: CHEM-321 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge and technical know-how about sugar manufacturing industry, starch production industry and leather tanneries.

Sugar Industry:

Scope of sugar industry, Manufacture of raw sugar from cane and beet, Refining of raw sugar, Methods of clarification of cane juice and chemistry involved in the clarification processes, Defecation Remelt Carbonation (DRC), Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation (DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of by-products of sugar industry.

Starch Industry:

Scope of starch industry, Raw materials for starch production, Manufacture of starch from various raw materials such as corn, rice, wheat, potatoes, Industrial applications of starch, Chemistry involved in the conversion of starch, Synthesis of d-glucose and dextrin from starch.

Leather Industry: Leather, Gelatin and adhesives preparations of hides, methods of tanning vegetable and chrome tanning processing of leather, production of glue and gelatin.

Recommended Books:

10. Rao, G. P., Mogarey, R. C., Solomn, S., Rewal, S. S. and Li,Y-., *SugarCane: Production Managemnet and Agro-Industrial Imperatives*, IbdcPublisher, (2005).

11. Covington, A. D., *Tanning Chemistry: The Science of Leather,* Royal Society of Chemistry, (2009).

12. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10th ed., Kluwer Academic/ Plenum Publishers, (2003).

Course Code: CHEM-231 **Course Name:** Biochemistry

Course Objectives:

Students will acquire knowledge about the fundamental biochemical and molecular aspects of endocrinology and chemistry of blood and other extracellular fluids.

Course Contents:

Endocrinology: General introduction, chemical nature of hormones, common characteristics, mode of action of hormones, hormones receptors, chemistry, biosynthesis, metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid, pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids: General composition of blood, function of blood plasma, plasma protein, composition and functions, composition, development and functions of red blood cells, white blood cells and platelets, Hemoglobin, chemistry properties, synthesis, functions and derivatives, degradation of hemoglobin, respiration and gas transport, blood coagulation and clotting of blood, blood pressure, blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended books:

1. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry,* 6th ed., W. H. Freeman, (2012).
2. Voet, D. and Voet, J. D, *Biochemistry,* 4th ed., illustrated. John Wiley & Sons, (2011).
3. Hall, J. E., *Guyton & Hall Textbook of Medical Physiology*, 12th ed., Elsvier Health Sciences,(2011).
4. Orten, James. M. and Neuhaus, O. W., *Human Biochemistry*, 10th ed., Mosby, Incorporated, (1982).
5. Devlin, T. M., *Textbook of Biochemistry with Clinical Correlations, 7*th ed., Wiley, (2010).
6. Frisell, W. R., *Human Biochemistry*, 1st ed., Macmillan Publication Company, (1982).

   Hadley, M. and Levine, J. E., *Endocrinology,* 6th ed., pearson, (2006).

Course Code: CHEM-141 **Course Name:** Fuel Chemistry

Course Objectives:

The students will acquire knowledge about environmentally friendly utilization of coal and how to extract maximum energy and convert coal in to a variety of highly demanding chemicals used as feed stock in a number of Industries.

Course Contents: Coal: Composition, structure, coalification and classification of coal, ASTM international and coal Standards. Use of coal in different industries like power generation, steel and other metallurgical operations.Coal exploration, mining and mining risk handling, pretreatment and preparation of coals.Innovations in coal using industry.

Environmental Aspects: Pollution problems associated with coal combustion, mining and flue gases.

Gasification: Thermodynamics, kinetics and catalytic aspects of coal gasification, fixed bed gasifier, fluidized bed gasifier, transport reactor, liquid medium gasifier and underground gasification. Gas upgrading by carbon monoxide shift, gas purification, methanation and dehydration, properties and processing of gaseous fuels, environmental consideration.

Recommended Books:

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).
2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).
3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).
4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).
5. Berkowitz, N. *The Chemistry of Coal,* Elsevier Amsterdam. (1985).

FOURTH YEAR (SEMESTER-VII)

SPECIALIZATION IN ORGANIC CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-461	Heterocyclic & Organometallic Compounds	3+0
2	CHEM-464	Organic Spectroscopy	3+0
3	CHEM-466	Reactive Intermediates	3+0
4	CHEM-311/ CHEM-321/ CHEM-231/ CHEM-141	Analytical Chemistry/Applied Chemistry/Biochemistry/ Fuel Chemistry	3+1
5	CHEM-690	Special Paper-I/Research (Lab Work/Literature Review)	3
Total Credit Hours			16

Course Code: CHEM-461 **Course Name:** Heterocyclic & Organometallic ompounds.

Course Objectives:

Students will acquire knowledge about C-Hetero atom bond with emphasis on how it is formed and how it reacts. The importance and applications of compounds containing hetero atom should also be discussed.

Course Contents:

Aromatic Heterocycles:

Structure, classification and nomenclature; aromaticity; basicity and acidity of the nitrogen heterocycles; synthesis and reactions, chemistry of furan, pyrrole and thiophene, pyridine;

Organometallic Compounds:

Principles, organomagnesium, organolithium, organocopper, organocadmium, organomercury and organozinc compounds: their structure and reactivity, methods of preparation and synthetic applications.

Chemistry of organic compounds containing sulfur, phosphorus, boron and silicon: synthesis, reactions and application.

Recommended Books:

1. Claydem, J., Greeves,N. and Warren, S., *Organic Chemistry,* 2nd ed., Oxford University Press, (2012).
2. Coxon, J. M. Norman, R. O. C., *Principles of Organic Synthesis*, 3rd ed., CRC Press, (1993).
3. Joule, J. A., Mills, K., *Heterocyclic Chemistry*, 5th ed., John-Wiley & Sons, UK, (2010).
4. Crabtree, R. H., *The Organometallic Chemistry of the Transition Metals,* 5th ed., John-Wiley & Sons, New Jersey, (2009).

Course Code: CHEM-464 **Course Name:** Organic Spectroscopy

Course Objectives:

Students will acquire an adequate knowledge about fundamental and instrumental aspects of different spectroscopic techniques and will be able to perform structural elucidation of organic compounds using spectral data.

Course Contents:

UV-Visible:

Basic concepts, electronic transitions, Lambert-Beer's law, factors influencing the lambda max (λmax) values, Woodward rules for calculation of wavelength values.

IR spectroscopy:

Basic concepts, absorption mechanisms, functional group determination and factors affecting the absorption frequencies.

1H-NMR and 13C-NMR:

Chemical shift, factors affecting chemical shift, spin relaxation, spin-spin coupling, coupling constants, nuclear overhauser effect, 2-D NMR, COSY and HETCOR.

Mass Spectrometry:

Basic concepts; mass spectrometers, ionization techniques, different fragmentation patterns and structure elucidation, combined usage of IR, UV, NMR and Mass spectrometric data for structure elucidation of organic compounds having medium complexity.

Recommended Books:

1. Mohan, J., *Organic Analytical Chemistry: Theory and Practice*, 1st ed., Alpha Science Int. Ltd., (2003).
2. Kalsi, P. S., *Spectroscopy of Organic Compounds,* 6th ed., New Age International, New Delhi, India, (2007).
3. Yadav, L. D. S., *Organic Spectroscopy*, Springer, UK, (2005).
4. Kemp, W., *Organic Spectroscopy*, 3rd ed., W. H. Freeman & Company, New York, USA, (1991).
5. Younas, M., *Organic Spectroscopy*, Ilmi Kitab Khana, Urdu Bazar Lahore, Pakistan, (2006).
6. Hollas, J. M., *Modern Spectroscopy,* 4th ed., John-Wiley & Sons, Inc., (2004).

7. Pavia, D. L., Lampman, G. M., Kriz, G. S. and Vyvyan, J. R., *Introduction to Spectroscopy*, 4th ed., Brooks/ Cole Cengage Learning, (2009).
8. 8. Silverstein, R. M., Webster, F. X. and Kiemle, D., *Spectrometric Identification of Organic Compounds*, 7th ed., John-Wiley & Sons, Inc., (2005).
9. 9. Williams, D. H. and Flemming, I., *Spectroscopic Methods in Organic Chemistry*, 6th ed., McGraw-Hill Higher Education, (2008).

Course Code: CHEM-466 **Course Name:** Reactive Intermediates

Course Objectives:

Students will acquire knowledge regarding the rearrangement reactions and their types including some name reactions, and different intermediates involved in organic reactions. Students are expected to learn the underlying concepts and synthetic applications.

Course Contents:

Reactive Intermediates:

Carbocations, carbanions, free radicals, carbenes, nitrenes, and arynes, their generation, stability, reactions and synthetic applications. Chemistry of Enolates and Enols: Acidity of carbonyl compounds, enolization of carbonyl compounds, α-halogenation of carbonyl compounds; aldol-addition and aldol-condensation, condensation reactions involving ester enolate ions, alkylation of ester enolate ions.

Rearrangement Reactions:

Types of rearrangements, general mechanisms of nucleophilic, free radical and electrophilic rearrangements, hydrogen and/or carbon migration to electron-deficient carbon, nitrogen and oxygen, carbon migration to electron-rich carbon, aromatic rearrangements, inter- and intra-molecular carbon migration from oxygen to carbon.

Recommended Books:

1. Clayden, J., Greeves, N. and Warren, S., *Organic Chemistry*, 2nd ed., Oxford University Press, (2012).
2. Coxon, J. M. and Norman, R.O.C., *Principles of Organic Synthesis*, 3rd ed., Chapman and Hall, UK, (1993).
3. Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., *Organic Chemistry*, 6th ed., Brooks/Cole Learning, (2012).
4. John, E. M., *Organic Chemistry,* 8th ed., Brooks/Cole Publishing Co., USA, (2012).
5. Robert, T. M. and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).

Course Code: CHEM-311 **Course Name:** Analytical Chemistry

Course Objectives: Students will acquire knowledge about theoretical aspects and instrumentation of different atomic spectroscopic methods as well as learn about the applications of these techniques in the field of chemical sciences.

Course Contents:

Flame Photometry: Origin and classification of atomic spectroscopic methods, origin of atomic spectrum, position of the signal, intensity of the signal, spectral line width, principle of flame photometry, fate of the sample in the flame, flame and its characteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic fluorescence spectrometry, interferences, merits and limitations.

Atomic Absorption Spectrophotometry: Principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, monochromators, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of the sample, use of organic solvents, microwave, digestion, sample introduction methods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively coupled plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).

4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West., D. M., *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., London, (2008).
6. Ebdon,L., Evaus, E.H, Fischer, A., and Hill, S.J., *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons, England. (1998).
7. Bernhard Welz, Michael Sperling, *Atomic Absorption Spectrometry*, 3rd ed., Wiley-VCH, Germany, (1998).
8. Farrukh, M. A., *Atomic Absorption Spectroscopy*, In Tech, (2012).
9. Kellner, R., Mermet, J. M, Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry A Modern Approach to Analytical Science*, Wiley-VCH,(2004).

Course Code: CHEM-321 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge and technical know-how about sugar manufacturing industry, starch production industry and leather tanneries.

Sugar Industry:

Scope of sugar industry, Manufacture of raw sugar from cane and beet, Refining of raw sugar, Methods of clarification of cane juice and chemistry involved in the clarification processes, Defecation Remelt Carbonation (DRC), Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation (DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of by-products of sugar industry.

Starch Industry:

Scope of starch industry, Raw materials for starch production, Manufacture of starch from various raw materials such as corn, rice, wheat, potatoes, Industrial applications of starch, Chemistry involved in the conversion of starch, Synthesis of d-glucose and dextrin from starch.

Leather Industry: Leather, Gelatin and adhesives preparations of hides, methods of tanning vegetable and chrome tanning processing of leather, production of glue and gelatin.

Recommended Books:

13. Rao, G. P., Mogarey, R. C., Solomn, S., Rewal, S. S. and Li,Y-., *SugarCane: Production Managemnet and Agro-Industrial Imperatives,* IbdcPublisher, (2005).

14. Covington, A. D., *Tanning Chemistry: The Science of Leather,* Royal Society of Chemistry, (2009).

15. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10th ed., Kluwer Academic/ Plenum Publishers, (2003).

Course Code: CHEM-231 **Course Name:** Biochemistry

Course Objectives:

Students will acquire knowledge about the fundamental biochemical and molecular aspects of endocrinology and chemistry of blood and other extracellular fluids.

Course Contents:

Endocrinology: General introduction, chemical nature of hormones, common characteristics, mode of action of hormones, hormones receptors, chemistry, biosynthesis, metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid, pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids: General composition of blood, function of blood plasma, plasma protein, composition and functions, composition, development and functions of red blood cells, white blood cells and platelets, Hemoglobin, chemistry properties, synthesis, functions and derivatives, degradation of hemoglobin, respiration and gas transport, blood coagulation and clotting of blood, blood pressure, blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended books:

1. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry,* 6th ed., W. H. Freeman, (2012).
2. Voet, D. and Voet, J. D, *Biochemistry,* 4th ed., illustrated. John Wiley & Sons, (2011).
3. Hall, J. E., *Guyton & Hall Textbook of Medical Physiology,* 12th ed., Elsvier Health Sciences,(2011).
4. Orten, James. M. and Neuhaus, O. W., *Human Biochemistry,* 10th ed., Mosby, Incorporated, (1982).
5. Devlin, T. M., *Textbook of Biochemistry with Clinical Correlations, 7*th ed., Wiley, (2010).
6. Frisell, W. R., *Human Biochemistry*, 1st ed., Macmillan Publication Company, (1982).
7. Hadley, M. and Levine, J. E., *Endocrinology,* 6th ed., pearson, (2006).

Course Code: CHEM-141 **Course Name:** Fuel Chemistry

Course Objectives:

The students will acquire knowledge about environmentally friendly utilization of coal and how to extract maximum energy and convert coal in to a variety of highly demanding chemicals used as feed stock in a number of Industries.

Course Contents: Coal: Composition, structure, coalification and classification of coal, ASTM international and coal Standards. Use of coal in different industries like power generation, steel and other metallurgical operations.Coal exploration, mining and mining risk handling, pretreatment and preparation of coals.Innovations in coal using industry.

Environmental Aspects: Pollution problems associated with coal combustion, mining and flue gases.

Gasification: Thermodynamics, kinetics and catalytic aspects of coal gasification, fixed bed gasifier, fluidized bed gasifier, transport reactor, liquid medium gasifier and underground gasification. Gas upgrading by carbon monoxide shift, gas purification, methanation and dehydration, properties and processing of gaseous fuels, environmental consideration.

Recommended Books:

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).
2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).
3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).
4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).
5. Berkowitz, N. *The Chemistry of Coal,* Elsevier Amsterdam. (1985).

Course Title: Reaction mechanism and Rearrangements **Code: CHEM-690**

Credit Hours: (3+0) **Marks: 100**

Course Objectives:

Students will acquire knowledge about determination of reaction mechanism with emphasis on how it is determined using various method. The importance and applications some reaarangment reactions.

Course contents

Reaction Mechanism: Introduction to reaction mechanism, methods of determination of the reaction mechanism and comprehensive study on the mechanism of different types of substitution addition and elimination reaction with emphasis on their determination.

Rearrangements: Baker-Venkataraman rearrangement, Benzilic acid rearrangement, Claisen rearrangement, Favorski rearrangement, Pinacol-Pinacolon rearrangement, Wagner Meerwin rearrangement.

Recommended Books:

1. Claydem, J., Greeves,N. and Warren, S., *Organic Chemistry,* 2nd ed., Oxford University Press, (2012).
2. Coxon, J. M. Norman, R. O. C., *Principles of Organic Synthesis,* 3rd ed., CRC Press, (1993).
3. Furniss, B. S., Hannaford, A. J., Smith, P. W. G., Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th edition, Longman, UK, (1989).
4. Mohan, J., *Organic Analytical Chemistry: Theory and Practice*,1st ed. Alpha Science Int. Ltd.New Delhi, India, (2003).
5. Robert, T. M. and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).
6. Tse-Lok, H., *Symmetry: A Basis for Synthesis Design*, John-Willey & Sons, Inc., New York, (1995).
7. Pine, S. H., *Organic Chemistry*, 5th ed., Tata McGraw-Hill, India, (1987).
8. Sykes, P., *A Guide Book to Mechanism in Organic Chemistry,* 6th ed., Pearson Education, (1986).
9. Mayo, D. W., Pike, R. M. and Forbes, D. C., *Microscale Organic Laboratory with Multistep and Multiscale Syntheses,* 5th ed., John-Wiley & Sons, Inc., (2011).
10. Gilbert, J. C. and Martin, S. F., *Experimental Organic Chemistry: A Miniscale and Microscale Approach*, 5th ed., Brooks/ Cole Cengage Learning, (2010).
11. Solomons, T. W. G. and Fryhle, C. B., *Organic Chemistry,* 10th ed., John-Wiley & Sons, Inc., (2011).
12. Carey, F. A. and Giuliano, R. M., *Organic Chemistry,* 9th ed., McGraw-Hill Education, (2013).
13. 12. Bruice, P. Y., *Organic Chemistry,* 7th ed., Perason Education, Ltd., (2013).

14. Smith, M. B.*, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 7th ed., John-Wiley & Sons, Inc., (2013).

FOURTH YEAR (SEMESTER-VII)

SPECIALIZATION IN PHYSICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-471	Electrochemistry & Statistical Thermodynamics	3+0
2	CHEM-472	Polymer Chemistry	3+0
3	CHEM-473	Quantum Chemistry & Molecular Spectroscopy	3+0
4	CHEM-311/ CHEM-321/ CHEM-231/ CHEm-141	Analytical Chemistry/Applied Chemistry/Biochemistry/ Fuel Chemistry	3+1
5	CHEM-690	Special Paper-I/Research (Lab Work/Literature Review)	3
Total Credit Hours			16

Course Code: CHEM-471 **Course Name:** Electrochemistry & Statistical Thermodynamics

Course Objectives:

Students will develop understanding of the electrochemical processes, thermodynamic principles and mechanisms involved in aqueous salt solutions as well as colloidal solutions. In the second part of the course, students will acquire knowledge about the molecular level treatment of the thermodynamic functions/properties using partition functions and Boltzmann statistics.

Electrochemistry:

Electrical double layer, interface, a look into the interface, OHP (Outer Helmholttz Plane) and IHP (Inner Helmholttz Plane) , contact adsorption, Gibbs Surface Excess, potential differences across metal solution interfaces, outer and surface potential differences, galvanic potential difference, electrochemical potential difference, interfacial tension, electro-capillary thermodynamics, Lippmann's equation, Helmholtz-perrin model, Gouy-Chapmann model, Stern model of electrical double layer, and BDM (Bockris-Devanathan-Muller) model, charge density, differential capacitance, shape of capacitance-charge curve, the Capacitance hump.

Electrochemical devices, charge transfer processes in the absence and presence of electrical field, the over potential, Butler-Volmer's equation,the idea of equilibrium exchange current density, the symmetry factor, high field and low field approximation, Tafel's equation, cyclic voltammetry and its applications, Fuel cell, corrosion and its prevention, electrochemical impedance spectroscopy.

Statistical Thermodynamics:

Description of various systems, Concepts of states, accessible states and distribution, Probability concepts, Maxwell-Boltzmann's statistics for the systems of independent particles, Partition functions, The relationship of partition function to the various thermodynamic functions, Transitional, vibrational and rotational partitional functions and equilibrium constant, Statistical thermodynamics, Applications to equilibrium and chemical kinetics, Bose-Einstein's and Fermi-Dirac's statistics.

Recommended Books:

1. Gasser, R. P. H., *Entropy and Energy Level*, Rev. ed., Oxford University Press, New York, (1986).

2. Wayatt, P. A. H., *The Molecular Basis of Entropy and Chemical Equilibrium,* Royal Institute of Chemistry London, UK, (1971).
3. Bockris J. O. M., and Reddy, A. K. N., *Modern Electrochemistry: Ionics*, Vol. I, 2nd ed., Plenum Press, London, (1998).
4. Seddon, J. M. and Gale, J. D., *Thermodynamics and Statistical Mechanics,* Royal Society of Chemistry, (2001).
5. Engel, T., Reid, P., *Thermodynamics, Statistical Thermodynamics, and Kinetics,* 3rd ed., Prentice Hall, (2012).
6. Bard, A. J. and Faulkner, L. R., *Electrochemical Method*: *Fundamentals and Applications* 2nd ed., John-Wiley & Sons, New York, (2001).
7. Kondepudi D., *Introduction to Modern Thermodynamics,* John-Wiley & Sons, (2008).
8. Hamann, C. H., Hamnett, A. and Veilstich, W., *Electrochemistry,* 2nd ed., Wiley-VCH Verla Gnb H and Co. KGaA, (2007).
9. Braun R. D. and Walters F., *Application of Chemical Analysis*, McGraw-Hill, (1982).
10. McQuarrie, D. A., *Statistical Mechanics*, Viva Books Private Ltd. (2008).

Course Code: CHEM-472 **Course Name:** Polymer Chemistry

Course Objectives: Students will learn the fundamental principles of polymerization, synthesis methods and reaction mechanisms, thermodynamic and kinetic aspects of the polymerization, and physical and mechanical properties of polymers. Students will also know about the polymer characterization techniques and various applications of polymers.

Polymer Chemistry: Introduction to Polymers, step-growth polymerization, polymer chain growth, kinetics of polymer chain growth, co-polymerization, emulsion polymerization, natural and inorganic polymers, physical aspects of polymers, molecular weight of polymers, distribution, averages, and methods of determination, viscosity, osmometry, light scattering method, diffusion, sedimentation, optical rotation method, structure of polymer chain, introduction to chain isomerism, stereochemistry, configurations, and conformations (not in Hiemenz), amorphous state of polymers, in-depth examination of polymer conformation, microstructure, and dynamics in the amorphous state, polymer viscoelasticity, stress relaxation, mechanical models of polymer behavior, time-temperature superposition, polymer rheology, crystalline state of polymers, crystallization and kinetics, crystalline structures, experimental methods, polymer solutions and blends.

Recommended Books:

1. Sperling, L. H. *Introduction to Physical Polymer Science*, 4th ed., Wiley-Interscience, New York, USA, (2006).
2. Boyd, R. H. and Phillips, P. J., *The Science of Polymer Molecules*, Cambridge, UK, (1993).
3. Odian, G., *Principles of Polymerization,* 4th ed., Wiley Interscience, (2004).
4. Carraher Jr, C. E., *Carraher's, Polymer Chemistry,* 8th ed., CRC Press, Inc., (2010).
5. Ravve, A., *Principles of Polymer Chemistry,* 3rd ed., Springer, (2012).
6. Stevens, M. P., *Polymer Chemistry: An Introduction,* 3rd ed., Oxford University Press, (1998).
7. Allcock, H., Lampe, F. and Mark, J., *Contemporary Polymer Chemistry,* 3rd ed., Prentice Hall, (2003).
8. Flory, J., *Principles of Polymer Chemistry*, Cornell University Pres (1953).

Course Code: CHEM-473 **Course Name:** Quantum Chemistry & Molecular Spectroscopy

Course Objectives: Students will acquire knowledge about quantum chemistry including Schrödinger wave equation and its applications to define the behavior and properties of different systems. In addition they will learn about different molecular spectroscopic techniques.

Course Contents:

Quantum Chemistry:

Operators and their properties, Schrödinger wave equation, particle in a box and a ring, quantum mechanical tunneling, angular momentum, postulates of quantum mechanics, central field problem, approximate methods, perturbation methods and variation principle, many electron systems, treatment of simple harmonic oscillator, diatomic rigid rotor, valence bond and molecular orbital theories, Hũckel method for pi-electron approximation in aromatic compounds.

Molecular Spectroscopy:

Interaction of electromagnetic radiation with matter, symmetry properties of molecules, microwave and infrared spectroscopy, rotational, vibrational and rotational-vibrational spectra of diatomic and polyatomic molecules, electronic spectra of simple molecules, nuclear magnetic resonance spectroscopy.

Recommended Books:

1. Fayer, M. D., *Elements of Quantum Mechanics*, Oxford University Press, London, UK, (2001).
2. Becker, E. D., *High Resolution NMR; Theory & Chemical Application*, 3rd ed., Academic Press, New York, USA, (2000).
3. Graybeal, J. D., *Molecular Spectroscopy*, 1st ed., McGraw-Hill, New York, (1988).
4. Hayward, D. O., *Quantum Mechanics for Chemists*, Royal Society Of Chemistry, (2002).
5. House, J. E., *Fundamentals of Quantum Mechanics* 2nd ed., Elsevier-Academic Press, New York, USA, (2004).
6. Kirsten, H. J. W. M., *Introduction to Quantum Mechanics: Schrodinger Equation and Path Integral* 1st ed., World Scientific Publishing Co. Pvt. Ltd., (2006).
7. Barrow, G. M., *Physical Chemistry*, 6th ed., McGraw-Hill Book Company, (1996).
8. Straughan, B. P., and Walker, S., *Spectroscopy*, Vol. 1 and 2., Chapman and Hall Ltd., (1976).

9. Coulson C. A., *Vanlence*, Oxford University Press (1980).
10. Sathyanarayana, D. N., *Vibrational Spectroscopy, Theory and Applications*, New Age International Publishers (2004).

Course Code: CHEM-311 **Course Name:** Analytical Chemistry

Course Objectives: Students will acquire knowledge about theoretical aspects and instrumentation of different atomic spectroscopic methods as well as learn about the applications of these techniques in the field of chemical sciences.

Course Contents:

Flame Photometry: Origin and classification of atomic spectroscopic methods, origin of atomic spectrum, position of the signal, intensity of the signal, spectral line width, principle of flame photometry, fate of the sample in the flame, flame and its characteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic fluorescence spectrometry, interferences, merits and limitations.

Atomic Absorption Spectrophotometry: Principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, monochromators, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of the sample, use of organic solvents, microwave, digestion, sample introduction methods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively coupled plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Kealey, D. and Haines, P. J., *BIOS Instant Notes in Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK, (2002).

4. Sharma, B. K., *Instrumental Methods of Chemical Analysis*, 24th ed., Goel Publishing House, Meerut, India, (2005).
5. Skoog, D. A. and West., D. M., *Fundamentals of Analytical Chemistry*, 8th ed., Hot Reinehart Inc., London, (2008).
6. Ebdon,L., Evaus, E.H, Fischer, A., and Hill, S.J., *An Introduction to Analytical Atomic Spectrometry*, John Wiley & Sons, England. (1998).
7. Bernhard Welz, Michael Sperling, *Atomic Absorption Spectrometry*, 3rd ed., Wiley-VCH, Germany, (1998).
8. Farrukh, M. A., *Atomic Absorption Spectroscopy*, In Tech, (2012).
9. Kellner, R., Mermet, J. M, Otto, M., Valcarcel, M., Widmer, H.M., *Analytical Chemistry A Modern Approach to Analytical Science*, Wiley-VCH,(2004).

Course Code: CHEM-321 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge and technical know-how about sugar manufacturing industry, starch production industry and leather tanneries.

Sugar Industry:

Scope of sugar industry, Manufacture of raw sugar from cane and beet, Refining of raw sugar, Methods of clarification of cane juice and chemistry involved in the clarification processes, Defecation Remelt Carbonation (DRC), Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation (DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of by-products of sugar industry.

Starch Industry:

Scope of starch industry, Raw materials for starch production, Manufacture of starch from various raw materials such as corn, rice, wheat, potatoes, Industrial applications of starch, Chemistry involved in the conversion of starch, Synthesis of d-glucose and dextrin from starch.

Leather Industry: Leather, Gelatin and adhesives preparations of hides, methods of tanning vegetable and chrome tanning processing of leather, production of glue and gelatin.

Recommended Books:

16. Rao, G. P., Mogarey, R. C., Solomn, S., Rewal, S. S. and Li,Y-., *SugarCane: Production Managemnet and Agro-Industrial Imperatives*, IbdcPublisher, (2005).

17. Covington, A. D., *Tanning Chemistry: The Science of Leather,* Royal Society of Chemistry, (2009).

18. Kent, J. A., *Riegel's Handbook of Industrial Chemistry,* 10^{th} ed., Kluwer Academic/ Plenum Publishers, (2003).

Course Code: CHEM-231 **Course Name:** Biochemistry

Course Objectives:

Students will acquire knowledge about the fundamental biochemical and molecular aspects of endocrinology and chemistry of blood and other extracellular fluids.

Course Contents:

Endocrinology: General introduction, chemical nature of hormones, common characteristics, mode of action of hormones, hormones receptors, chemistry, biosynthesis, metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid, pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids: General composition of blood, function of blood plasma, plasma protein, composition and functions, composition, development and functions of red blood cells, white blood cells and platelets, Hemoglobin, chemistry properties, synthesis, functions and derivatives, degradation of hemoglobin, respiration and gas transport, blood coagulation and clotting of blood, blood pressure, blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended books:

1. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry*, 6th ed., W. H. Freeman, (2012).
2. Voet, D. and Voet, J. D, *Biochemistry,* 4th ed., illustrated. John Wiley & Sons, (2011).
3. Hall, J. E., *Guyton & Hall Textbook of Medical Physiology*, 12th ed., Elsvier Health Sciences,(2011).
4. Orten, James. M. and Neuhaus, O. W., *Human Biochemistry*, 10th ed., Mosby, Incorporated, (1982).
5. Devlin, T. M., *Textbook of Biochemistry with Clinical Correlations, 7*th ed., Wiley, (2010).
6. Frisell, W. R., *Human Biochemistry*, 1st ed., Macmillan Publication Company, (1982).
7. Hadley, M. and Levine, J. E., *Endocrinology,* 6th ed., pearson, (2006).

Course Code: CHEM-141 **Course Name:** Fuel Chemistry

Course Objectives:

The students will acquire knowledge about environmentally friendly utilization of coal and how to extract maximum energy and convert coal in to a variety of highly demanding chemicals used as feed stock in a number of Industries.

Course Contents: Coal: Composition, structure, coalification and classification of coal, ASTM international and coal Standards. Use of coal in different industries like power generation, steel and other metallurgical operations.Coal exploration, mining and mining risk handling, pretreatment and preparation of coals.Innovations in coal using industry.

Environmental Aspects: Pollution problems associated with coal combustion, mining and flue gases.

Gasification: Thermodynamics, kinetics and catalytic aspects of coal gasification, fixed bed gasifier, fluidized bed gasifier, transport reactor, liquid medium gasifier and underground gasification. Gas upgrading by carbon monoxide shift, gas purification, methanation and dehydration, properties and processing of gaseous fuels, environmental consideration.

Recommended Books:

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).
2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).
3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).
4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).
5. Berkowitz, N. *The Chemistry of Coal,* Elsevier Amsterdam. (1985).

FOURTH YEAR (SEMESTER-VIII)

SPECIALIZATION IN ANALYTICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-414	Luminescence Spectroscopy & Thermal Analysis	3+0
2	CHEM-416	Nuclear Analytical Techniques	3+0
3	CHEM-415	Food & Drug Analysis	3+0
4	CHEM-424/ CHEM-334/ CHEM-244	Applied Chemistry/Biochemistry/Fuel Chemistry	3+1
5	CHEM-690	Research (Thesis Write up)	3
Total Credit Hours			16

Course Code: CHEM-414 **Course Name:** Luminescence Spectroscopy & Thermal Analysis

Course Objectives:

Students will acquire knowledge about the theoretical and instrumental aspects of luminescence spectroscopy and thermal techniques of analysis in addition to learning about their applications.

Course Contents:

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Thermal Methods of Analysis: Introduction, instrumentation, sources of errors, interpretation of data, Factors affecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., *Thermal Methods of Analysis Principles, Applications and Problems,* 1st ed., Springer, (1995).
5. Lakowicz, J. R., *Principles of Fluorescence Spectroscopy,* 3rd ed., Springer (2006).
6. Gabbot, P., *Principles & Applications of Thermal Analysis,* Wiley-Blackwell, (2007).
7. Brown, M. E., *Introduction to Thermal Analysis: Techniques and Applications,* 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry,* 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., *Spectrophotometry, Luminescence and Colour; Science and Compliance,* Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-416 **Course Name:** Nuclear Analytical Techniques

Course Objectives:

Students will acquire knowledge about different nuclear analytical techniques with special emphasis on the theoretical, instrumental and applications

Course Contents:

Radiotracer techniques, choice of radiotracers, factors affecting choice of radiotracers, isotope dilution analysis (IDA), principle and equation, instrumentation, applications, advantages and limitations, sub-stoichiometric isotope dilution analysis (SIDA), activation analysis (AA), principle of NAA, neutron sources, interferences, sensitivity and detection limits, classification, instrumentation, applications, advantages and limitations, comparison of NAA and IDA with other methods, radiometric titrations (RT), procedure, advantages and limitations, radio chromatography and radioimmunoassay.

Recommended Books:

1. Friedlander, G., Kennedy, J. W., Macias, E. S. and Miller. M. J., *Nuclear and Radiochemistry,* 3rd ed., Wiley, New York, (1981).
2. Arnikan, H. J., *Essentials of Nuclear Chemistry*, 4th ed., New Age International Pvt. Ltd.(1995).
3. Harvey, B. G., *Nuclear Physics and Chemistry,* 2nd ed., Prentice Hall Inc., (1969).
4. Naqvi, I. I., Farrukh, M. A, *Radiotracers in Chemical Applications: Radiochemistry, VDM* Verlog Dr. Muller, (2010).

Course Code: CHEM-415 **Course Name:** Food & Drug Analysis

Course Objectives:

Students will acquire knowledge about sample preparation, derivations and analysis of different types of foods, pharmaceuticals and forensics.

Course Contents:

Food Products: Introduction to food analysis, sampling of food, general methods of analysis. Analysis of milk, butter, wheat flour, meat, beverages, tea, coca, honey and soft drinks.

Pharmaceuticals: Classification of drugs, tests for analysis of different pharmaceuticals, introduction to US and British pharmacopeia.

Forensics: History and scope of Forensic Science, Forensic Ethics, Forensic Toxicology. Classification and analysis of narcotics & dangerous drugs, examination of crime scene evidences, fingerprinting, skeletal material to provide scientific opinion for legal.

Recommended Books:

1. Skoog, D. A., West, D. M. and Holler, F. J., *Fundamentals of Analytical Chemistry*, 7th ed., Saunders College Publishing, (1995).
2. Christian, G. D., *Analytical Chemistry*, John-Wiley & Sons, Inc., 6th ed., (2004).
3. Eckert, W. G., *Introduction to Forensic Science*, 2nd ed., CRC Press, (1997).
4. Nielsen, S. S., *Food Analysis*, 4th ed., Springer, (2010).
5. Thomas, G., *Medicinal Chemistry: An Introduction*, 2nd ed., John-Wiley & Sons, (2007).
6. Kobilinsky, L. F., *Forensic Chemistry Handbook, 1st ed.,* John-Wiley & Sons, USA, (2012).
7. Watson, D. G., *Pharmaceutical Analysis: A Textbook for Pharmacy Students and Pharmaceutical Chemists,* Elsevier, (2012).
8. Stuart H. Barbara, *"Forensic Analytical Techniques",* 1st ed., John-Wiley & Sons, (2013).
9. Jackson, A. R. W. and Jackson, J. M., *Forensic Science,* 2nd ed., Pearson Education, (2008).

Course Code: CHEM-424 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge to understand the structure, mechanism, properties and synthesis of various polymers. The course will also provide technical know- how about perfumes and cosmetics and surface coating industries.

Course Contents:

Paper and Pulp: Raw materials for pulp and paper industries, classification of paper products, chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers: General classification and characterization of polymers, mechanism and chemistry of polymerization, thermoplastic and thermosetting polymerization, A brief outline for the production and applications of polymers i.e. polyethylene, polystyrene, polyurethanes, polyesters and urea phenol formaldehyde resins, and production of drug delivery polymers.

Cosmetics and Perfumes: Chemistry and production of hair products and shampoos, chemistry involved in hair curling and styling products, hair tonics and depilatory products, production of cold cream, vanishing cream, bleach cream and shaving creams, tooth paste and face powders, production of nail polish, lipsticks and mascaras.

Recommended Books:

1. Odian, G., *Principles of Polymerization*, 4th ed., John-Wiley & Sons, Inc., (2004).
2. Carraher, C. E. Jr., *Polymer Chemistry,* 6th ed., Marcel Dekker Incorporation, New York, (2003).
3. Roussak, D. V., Gesser, H. D., *Applied Chemistry; A Textbook of Engineers and Technologists,* 2nd ed., Springer, (2013).
4. Bajpai, P., *Environmentally Friendly Production of Pulp and Paper*, John-Wiley & Sons, Inc., (2010).
5. Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,* 3rd ed., Allured Publishing Corporation, (2009).
6. Barel, A. O., Paye, M. and Maibach, H. I., *Handbook of Cosmetic Science and Technology,* 3rd ed., Informa Healthcare, (2009).

Course Code: CHEM-334 **Course Name:** Biochemistry

Course Objectives:

The aim of the course is to acquire knowledge about bionanotechnology in general and its potential applications in particular. Bionanotechnology aims to exploit attributes of new materials like biosensors for medical applications. Understanding of the structure and assembly of nanoparticles opens some exciting possibilities to construct artificial structures in applied nanotechnology, which will mimic the functions of the biological systems.

Course Contents: Introduction to nanoparticles, overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, bionanotechnology systems, protein based nanostructures, nanobiosensors, challenges and opportunities associated with biology on the nanoscale, green nanoparticle production, self-assembly and templating, surface patterning and functionalization, characterization techniques of nanostructures.

Recommended Books:

1. Ratner, M.A. and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Prentice Hall Professional, upper saddle river, New Jersey (2003).

2. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., Hoboken, New Jersey (2004).

3. Papazoglou, E. S., *Bionanotechnology*, Morgan & Claypool Publishers, California, USA (2007).

4. Renugopalakrishnan V., Lewis, R. V., *Bionanotechnology: Proteins to Nanodevices*, Springer (2006).

5. Iqbal, S., *Bionanosensors*, Morgan & Claypool Publishers, California USA (2008).

6. Kotov, N. A., *Nanoparticle Assemblies and Superstructures*, CRC press, USA (2006).

7. Dinh, T.V., *Nanotechnology in Biology and Medicine: Methods, Devices and Application* CRC press, USA (2007).

8. Kumar, C., *Nanomaterials for Biosensors*, Wiley-VCH, Germany (2007).

9. Niemeyer, C.M., and Mirkin, C.A., *Nanobiotechnology: Concepts, Applications and Perspectives*, Wiley-VCH, Germany(2004).

Course Code: CHEM-244 **Course Name:** Fuel Chemistry

Course objectives:

This course will enable students to know about the challenging sources of alternate sources of energy. The students will also be able to learn about the safe uses of natural resources.

Course Contents:

Biomass Resources: Biomass conversion processes, bio gas technology. Various traditional methods of alcohol production.Alcohols and its uses as alternative fuel.

Biofuels: Production of Bio-ethanol and biodiesel, uses of bioethanol as supplement with petroleum gasoline as E10 and E20 etc

Hydrogen: Hydrogen production, storage, handling and its uses as alternative fuel. Fuel cells: Fuel Cells and its application,

Solar Energy: Photovoltaic power conversion & solar energy collectors.

Nuclear fuels: Nuclear fuels processing, fission and fusion, nuclear reactors.

Hydel Energy: introduction to Hydel energy. Prospecting of hydel powers in Pakistan.

Recommended Books:

1. Gyngell, E. bS. *Applied Chemistry for Engineers*.Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.b .and Backurst, J.R. *Fuel and Energy*. Academic Press, London and New York (1988).

3. Goodger E. M. *Alternative fuels (chemical energy resources)*. The Macmillan press Ltd, London, (1980).

4. Twidell, J. and Weir, T. *Renewable Energy Resources*. John Wiley and Sons, London, New York, (1986).

Course Title: **Special Paper-I**

Code: **CHEM- 690**

Credit Hours: **3+0**

Course Objectives:

Students will acquire knowledge to enable themselves to understand the fundamental principles and laws of thermodynamics and chemical kinetics and to investigate the methods for determining the order of reaction. Students will also be able to study the rates of reactions and perform related calculations.

Chemical Kinetics:

Rate of Chemical reaction & rate law, order of reaction, First and second order reaction.Methods of determination of order of reaction.Energy of activation.Effect of temperature on the reaction rate.Lindeman's theory of unimolecular reactions.Bimolecular collision theory.

Chemical Thermodynamics:

Definition, important thermodynamic terms i.e. system, surrounding & boundary. Properties of system, laws of thermodynamics and their applications, Enthalpy, entropy, heat capacities, types of heat capacities and their dependence on temperature, pressure and volume, reversible and non-reversible processes, spontaneous and non-spontaneous processes, relations of entropy and Gibbs free energy with equilibrium constant, Gibbs Helmholtz equation etc.

Recommended Books:

1. McQuarrie, D. A. and Simon, J. D., Physical Chemistry – A Molecular Approach,1st ed., University Science Books,(1997).
2. Atkins,P. and Paula,J.D., Atkin’s Physical Chemistry, 9th ed., Oxford University Press, (2010).
3. Shoemaker, D., Experiments in Physical Chemistry, 8th ed., McGraw Hill Publishing Company Limited, (2003).
4. Silbey, R., Alberty, R. and Bawendi, M., Physical Chemistry, 4th ed., (2005).
5. Glasstone, S., *Textbook of Physical Chemistry*, Macmillan London (1960).
6. James, A. M., Prichard, F. E., Practical Physical Chemistry, 3rd ed., Longman Group Limited, New York, (1974).
7. Chaudhary, S. U., Ilmi Textbook of Physical Chemistry, 2nd ed., IlmiKitabKhana, Lahore, (2013).
8. Linder, B., Elementary Physical Chemistry, World Scientific Publishing Co. Ptv. Ltd., (2011).

9. R.A. Alberty, J.S. Robert, G.B. Moungi Physical Chemistry, 4thed, John Wiley and Sons (2004).
10. D.W. Ball, Physical Chemistry, 1st ed., Brooks/Cole Co. Inc. (2003).
11. Engel, Thomas, P.Reid, Thermodynamics, Statistical Thermodynamics,and Kinetics 1st ed., Benjamin Cummings (2006).
12. K. James, P. Wothers, Why Chemical Reactions Happen. Oxford University Press (2003).
13. B. R. Stephen, S. A. Rice, J. Roses, Physical Chemistry, 2nd ed., Oxford University Press (2000).
14. J.H. Espenson, Chemical Kinetics and Reaction Mechanism, 2nd ed., McGraw Hill (2002).
15. R.S. Berry, A.R. Stuart, J. Roses, Physical and Chemical Kinetics, 2nd ed., Oxford University Press (2000).
16. M. Helpern Arthur, Experimental Physical Chemistry: A Laboratory Textbook2nd ed., Prentice Hall (1997).
17. D. Shoemaker, Experimental Physical Chemistry, McGraw Hill (1989)

FOURTH YEAR (SEMESTER-VIII)

SPECIALIZATION IN APPLIED CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours

1	CHEM-424	Organic Based Industries	3+0
2	CHEM-425	Industrial Processes	3+0
3	CHEM-426	Metallurgy & Explosives	3+0
4	CHEM-414/ CHEM-334/ CHEM-244	Analytical Chemistry/Biochemistry/Fuel Chemistry	3+1
5	CHEM-690	Research (Thesis Write up)	3
Total Credit Hours			16

Course Code: CHEM-424 **Course Name:** Organic Based Industries

Course Objectives:

Students will acquire knowledge to understand the structure, mechanism, properties and synthesis of various polymers. The course will also provide technical know- how about perfumes and cosmetics and surface coating industries.

Course Contents:

Paper and Pulp: Raw materials for pulp and paper industries, classification of paper products, chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers: General classification and characterization of polymers, mechanism and chemistry of polymerization, thermoplastic and thermosetting polymerization, A brief outline for the production and applications of polymers i.e. polyethylene, polystyrene, polyurethanes, polyesters and urea phenol formaldehyde resins, and production of drug delivery polymers.

Cosmetics and Perfumes: Chemistry and production of hair products and shampoos, chemistry involved in hair curling and styling products, hair tonics and depilatory products, production of cold cream, vanishing cream, bleach cream and shaving creams, tooth paste and face powders, production of nail polish, lipsticks and mascaras.

Recommended Books:

7. Odian, G., *Principles of Polymerization*, 4th ed., John-Wiley & Sons, Inc., (2004).
8. Carraher, C. E. Jr., *Polymer Chemistry*, 6th ed., Marcel Dekker Incorporation, New York, (2003).
9. Roussak, D. V., Gesser, H. D., *Applied Chemistry; A Textbook of Engineers and Technologists*, 2nd ed., Springer, (2013).
10. Bajpai, P., *Environmentally Friendly Production of Pulp and Paper*, John-Wiley & Sons, Inc., (2010).
11. Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,* 3rd ed., Allured Publishing Corporation, (2009).
12. Barel, A. O., Paye, M. and Maibach, H. I., *Handbook of Cosmetic Science and Technology,* 3rd ed., Informa Healthcare, (2009).

Course Code: CHEM-425 **Course Name:** Industrial Processes

Course Objectives:

Students will acquire knowledge about pharmaceutical industries and nuclear industry as well as about oil refinery and production of various petrochemicals.

Course Contents:

Pharmaceuticals: Classification of pharmaceutical products and pharmaceutical processing, manufacture of paracetamol and aspirin, chemistry involved in the production and manufacture of various antibiotics such as streptomycin, erythromycin, penicillin etc.

Petroleum and Petrochemicals: Origin of petroleum, constituents and classification of petroleum, cracking and distillation of various fractions in distillation towers, control of distillation tower in refinery, manufacture of monomers such as acetylene, ethylene, propylene, separation and purification of benzene, toluene and xylene.

Recommended Books:

1. Austin, G. T., Nelson, W. L., *Petroleum Refinery Engineering*, 4th ed., Aukland. Mcgraw Hill, (1985).
2. Shreve, R. M., George, T. A., *Shreve's Chemical Process Industries*, 5th ed., McGraw-Hill Book Company Inc., New York, (1984).
3. Kent, J. A., *Riegel's Handbook of Industrial Chemistry*, 10h ed., Kluwer Academic/Plenum publishers, (2003).
4. Vermani, O. P., Narula. A. K, *Applied Chemistry*, Theory and Practice, 2nd ed., New Age International Publisher, India, (1995).
5. D. G. Watson, *Pharmaceutical Chemistry, Churchill Living Stone,* (2007).
6. Cairms, D., *Essentials of Pharmaceutical Chemistry*, Pharmaceutical Press, (2003).
7. Loveland, W. D., Morrisey, D. J, *Modern Nuclear Chemistry,* Wiley Interscience, (2005).
8. Speight, J. G., *The Chemistry and Technology of Petroleum, 3*rd ed., Taylor & Francis, (2013).

Course Code: CHEM-426 **Course Name:** Metallurgy & Explosives

Course Objectives:

The course is designed to give sufficient knowledge about iron, steel and its alloys. The course also provides the knowledge about corrosion and its preventions. The course will also give the knowledge about organic Dyes industries, different lubricants used in industrial processes.

Course Contents:

Iron, Steel and Alloys: Iron ores, constituents and their classification, manufacture of iron and steel, types of iron and steel, metal extractions and production of Alloys.

Explosives and Propellants:

Raw materials, manufacture of industrial explosives and propellants, types of explosives and their safety measures, chemistry involved in production of military explosives.

Nuclear Materials: Extraction of uranium from rocks, importance of nuclear technology, nuclear energy and its peaceful applications, production of nuclear energy and control of nuclear reactors, chemistry of fission and fusion reactions, reprocessing of nuclear spent fuel, industrial application of nuclear radiations.

Recommended Books:

1. Akhawan, J., *The Chemistry of Explosives,* 2nd ed., Royal Chemical Society, (2004).

2. Campball, F. C., *Elements of Metallurgy and Engineering Alloys,* ASM. International, (2008).

3. Davis, T. L., *The Chemistry of Powder and Explosives,* Angriff Press, (2012).

4. Reddy, L. K., *Principles of Engineering Metallurgy,* 2nd ed., New Age Publishers, (2009).

5. Loveland, W., Morrissey, D. J. and Seaborg, G. T., *Modern Nuclear Chemistry,* John-Wiley & Sons, Inc., (2006).

6. Choppin, G., Liijenzin, J-O. and Rydberg, J., *Radiochemistry and Nuclear Chemistry,* 3rd ed., Butterworth-Heinemann, (2002).

7. Vermani, O. P, Narula, A. K, *Applied Chemistry, Theory and Practice*, 2nd ed., New Age Publishing House,India, (1995).

8. Balsaral, V. M, *Applied Chemistry*, I.K. International House Pvt. Ltd., India, (2009).

Course Code: CHEM-414 **Course Name:** Analytical Chemistry

Course Objectives:

Students will acquire knowledge about the theoretical and instrumental aspects of luminescence spectroscopy and thermal techniques of analysis in addition to learning about their applications.

Course Contents:

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Thermal Methods of Analysis: Introduction, instrumentation, sources of errors, interpretation of data, Factors affecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., *Thermal Methods of Analysis Principles, Applications and Problems*, 1st ed., Springer, (1995).
5. Lakowicz, J. R., *Principles of Fluorescence Spectroscopy*, 3rd ed., Springer (2006).
6. Gabbot, P., *Principles & Applications of Thermal Analysis*, Wiley-Blackwell, (2007).
7. Brown, M. E., *Introduction to Thermal Analysis: Techniques and Applications,* 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry,* 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., *Spectrophotometry, Luminescence and Colour; Science and Compliance,* Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-334 **Course Name:** Biochemistry

Course Objectives:

The aim of the course is to acquire knowledge about bionanotechnology in general and its potential applications in particular. Bionanotechnology aims to exploit attributes of new materials like biosensors for medical applications. Understanding of the structure and assembly of nanoparticles opens some exciting possibilities to construct artificial structures in applied nanotechnology, which will mimic the functions of the biological systems.

Course Contents: Introduction to nanoparticles, overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, bionanotechnology systems, protein based nanostructures, nanobiosensors, challenges and opportunities associated with biology on the nanoscale, green nanoparticle production, self-assembly and templating, surface patterning and functionalization, characterization techniques of nanostructures.

Recommended Books:

1. Ratner, M.A. and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Prentice Hall Professional, upper saddle river, New Jersey (2003).

2. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., Hoboken, New Jersey (2004).

3. Papazoglou, E. S., *Bionanotechnology*, Morgan & Claypool Publishers, California, USA (2007).

4. Renugopalakrishnan V., Lewis, R. V., *Bionanotechnology: Proteins to Nanodevices*, Springer (2006).

5. Iqbal, S., *Bionanosensors*, Morgan & Claypool Publishers, California USA (2008).

6. Kotov, N. A., *Nanoparticle Assemblies and Superstructures*, CRC press, USA (2006).

7. Dinh, T.V., *Nanotechnology in Biology and Medicine: Methods, Devices and Application* CRC press, USA (2007).

8. Kumar, C., *Nanomaterials for Biosensors,* Wiley-VCH, Germany (2007).

9. Niemeyer, C.M., and Mirkin, C.A., *Nanobiotechnology: Concepts, Applications and Perspectives,* Wiley-VCH, Germany(2004).

Course Code: CHEM-244 **Course Name:** Fuel Chemistry

Course objectives:

This course will enable students to know about the challenging sources of alternate sources of energy. The students will also be able to learn about the safe uses of natural resources.

Course Contents:

Biomass Resources: Biomass conversion processes, bio gas technology. Various traditional methods of alcohol production.Alcohols and its uses as alternative fuel.

Biofuels: Production of Bio-ethanol and biodiesel, uses of bioethanol as supplement with petroleum gasoline as E10 and E20 etc

Hydrogen: Hydrogen production, storage, handling and its uses as alternative fuel. Fuel cells: Fuel Cells and its application,

Solar Energy: Photovoltaic power conversion & solar energy collectors.

Nuclear fuels: Nuclear fuels processing, fission and fusion, nuclear reactors.

Hydel Energy: introduction to Hydel energy. Prospecting of hydel powers in Pakistan.

Recommended Books:

1. Gyngell, E. bS. *Applied Chemistry for Engineers*.Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.b .and Backurst, J.R. *Fuel and Energy*. Academic Press, London and New York (1988).

3. Goodger E. M. *Alternative fuels (chemical energy resources)*. The Macmillan press Ltd, London, (1980).

4. Twidell, J. and Weir, T. *Renewable Energy Resources*. John Wiley and Sons, London, New York, (1986).

FOURTH YEAR (SEMESTER-VIII)

SPECIALIZATION IN BIOCHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-335	Microbiology & Immunology	3+0
2	CHEM-334	Biotechnology	3+0
3	CHEM-336	Nutritional Chemistry	3+0
4	CHEM-414/ CHEM-424/ CHEM-244	Analytical Chemistry/Applied Chemistry/ Fuel Chemistry	3+1
5	CHEM-690	Research (Thesis Write up)	3
Total Credit Hours			16

Course Code: CHEM-335 **Course Name:** Microbiology & Immunology
Course Objectives:

Students will learn about fundamentals of microbiology and immunology as well as the related disorders such as microbial borne infectious diseases, allergy, inflammation, and hypertension and their control.

Course Contents:

Fundamentals of Microbiology: Prokaryotic cell structure and function, Prokaryotic growth and nutrition, prokaryotic genetics. Virus and eukaryotic microorganisms, virus, bacteria, fungi and parasites.Bacterial diseases, airborne, foodborne and waterborne bacterial diseases.Industrial microbiology and biotechnology, microorganism in industry, alcoholic beverages, other important microbial products.

Immunology: Chemistry of immunoglobulins, myeloma and hybridoma immunoglobulins, immune system and its abnormalities, allergy and inflammation, complement system, Peripheral leucocytes and macrophages, Type I lgE-mediated hypersensitivity, other types of hypersensitivity autoimmune disorders, immunodeficiency disorders.

Recommended Books:

1. Nester, E., Nester, M., Anderson, D. and Roberts, C. E. Tr., *Microbiology: A Human Perspective*, 7th ed., McGraw-Hill, (2011).

2. Duan, T., Melvold, R., Viselli, S. and Waltenbaugh, C., *Lippincott's Illustrated Reviews, Immunology*, 2nd ed., Lippincott William & Wilkins, (2012).

3. Harvey, R. A., Cornelissen, C. N. and Fischer, B. D., *Lippincott's Illustrated Reviews: Microbiology*, 3rd ed., Lippincott William & Wilkins, (2012).

4. Wiley, J. M., Sherwood, L. M. and Woolnerton, C. J., *Prescott's Microbiology,* 7th ed., McGraw-Hill Education, (2011).

5. Male, D., Brostoff, J., Roth, D. B. and Roitt, I. M., *Immunology*, 8th ed., Elsevier, (2012).

Course Code: CHEM-334 **Course Name:** Biotechnology

Course Objectives:

The aim of the course is to acquire knowledge about bionanotechnology in general and its potential applications in particular. Bionanotechnology aims to exploit attributes of new materials like biosensors for medical applications. Understanding of the structure and assembly of nanoparticles opens some exciting possibilities to construct artificial structures in applied nanotechnology, which will mimic the functions of the biological systems.

Course Contents: Introduction to nanoparticles, overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, bionanotechnology systems, protein based nanostructures, nanobiosensors, challenges and opportunities associated with biology on the nanoscale, green nanoparticle production, self-assembly and templating, surface patterning and functionalization, characterization techniques of nanostructures.

Recommended Books:

1. Ratner, M.A. and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Prentice Hall Professional, upper saddle river, New Jersey (2003).

2. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., Hoboken, New Jersey (2004).

3. Papazoglou, E. S., *Bionanotechnology*, Morgan & Claypool Publishers, California, USA (2007).

4. Renugopalakrishnan V., Lewis, R. V., *Bionanotechnology: Proteins to Nanodevices*, Springer (2006).

5. Iqbal, S., *Bionanosensors*, Morgan & Claypool Publishers, California USA (2008).

6. Kotov, N. A., *Nanoparticle Assemblies and Superstructures*, CRC press, USA (2006).

7. Dinh, T.V., *Nanotechnology in Biology and Medicine: Methods, Devices and Application* CRC press, USA (2007).

8. Kumar, C., *Nanomaterials for Biosensors,* Wiley-VCH, Germany (2007).

9. Niemeyer, C.M., and Mirkin, C.A., *Nanobiotechnology: Concepts, Applications and Perspectives,* Wiley-VCH, Germany(2004).

Course Code: CHEM-336 **Course Name:** Nutritional Chemistry

Course Objectives:

Students will acquire knowledge about dietary components; energy needs based nutritional requirements of different age groups as well as the importance of minerals and vitamins.

Course Contents:

Major Dietary Constituents: Nutritional importance of carbohydrates, proteins and amino acids, lipids, and dietary fiber.

Energy Needs: Assessment and requirement of energy in different age groups nutrition in growth and aging, nutritional requirement during infancy and childhood, diet, nutrition and adolescence, nutrition in the elderly minerals, biochemical role of Calcium, Chromium, Copper, Iron, Iodine, Magnesium, Phosphorous, Selenium and Zinc, their dietary source daily requirements and deficiency diseases.

Vitamins: Role of vitamins as coenzymes structure, physiological functions, deficiency diseases and recommended dietary allowances of the following vitamins, fat soluble vitamins: A, D, E, and K, water soluble vitamins: Thiamine, Riboflavin, Niacin, Pantothenic acid, Folic acid, Blotin and Ascorbic acid.

Recommended Text Books:

1. Wilson, K. and Walker, J., *Principles and Techniques of Biochemistry,* 5th ed., Cambridge University Press, (2000)

2. Belitz, H. D., Grosch, W. and Schieberle, P., *Food Chemistry,* 4th ed., Springer-Verlag Berlin, Germany, (2009).

3. Spallholz, J. E., Boylan, L. M. and Driskell, J. A., *Nutrition: Chemistry & Biology,* 2nd ed., CRC Press Inc., USA, (1999).

4. Ross, A. C., Caballero, B., Cousins, R. J., Tucker, K. L. and Ziegler, T. R., *Modern Nutrition in Health and Disease,* 11th ed., Lippincott Williams & Wilkins, (2012).

5. McDowell, L. R., *Vitamins in Animal and Human Nutrition,* 2nd ed., Iowa State University Press, (2000).

6. Zempleni, J., Rucker, R. B., McCormick, D. B. and Suttie, J. W., *Handbook of Vitamins,* 4th ed., CRC Press, (2007).

Course Code: CHEM-414 **Course Name:** Analytical Chemistry

Course Objectives:

Students will acquire knowledge about the theoretical and instrumental aspects of luminescence spectroscopy and thermal techniques of analysis in addition to learning about their applications.

Course Contents:

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Thermal Methods of Analysis: Introduction, instrumentation, sources of errors, interpretation of data, Factors affecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., *Thermal Methods of Analysis Principles, Applications and Problems*, 1st ed., Springer, (1995).
5. Lakowicz, J. R., *Principles of Fluorescence Spectroscopy*, 3rd ed., Springer (2006).
6. Gabbot, P., *Principles & Applications of Thermal Analysis*, Wiley-Blackwell, (2007).
7. Brown, M. E., *Introduction to Thermal Analysis: Techniques and Applications,* 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry,* 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., *Spectrophotometry, Luminescence and Colour; Science and Compliance,* Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-424 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge to understand the structure, mechanism, properties and synthesis of various polymers. The course will also provide technical know- how about perfumes and cosmetics and surface coating industries.

Course Contents:

Paper and Pulp: Raw materials for pulp and paper industries, classification of paper products, chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers: General classification and characterization of polymers, mechanism and chemistry of polymerization, thermoplastic and thermosetting polymerization, A brief outline for the production and applications of polymers i.e. polyethylene, polystyrene, polyurethanes, polyesters and urea phenol formaldehyde resins, and production of drug delivery polymers.

Cosmetics and Perfumes: Chemistry and production of hair products and shampoos, chemistry involved in hair curling and styling products, hair tonics and depilatory products, production of cold cream, vanishing cream, bleach cream and shaving creams, tooth paste and face powders, production of nail polish, lipsticks and mascaras.

Recommended Books:

1. Odian, G., *Principles of Polymerization*, 4th ed., John-Wiley & Sons, Inc., (2004).
2. Carraher, C. E. Jr., *Polymer Chemistry,* 6th ed., Marcel Dekker Incorporation, New York, (2003).
3. Roussak, D. V., Gesser, H. D., *Applied Chemistry; A Textbook of Engineers and Technologists,* 2nd ed., Springer, (2013).
4. Bajpai, P., *Environmentally Friendly Production of Pulp and Paper,* John-Wiley & Sons, Inc., (2010).
5. Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,* 3rd ed., Allured Publishing Corporation, (2009).
6. Barel, A. O., Paye, M. and Maibach, H. I., *Handbook of Cosmetic Science and Technology,* 3rd ed., Informa Healthcare, (2009).

Course Code: CHEM-244 **Course Name:** Fuel Chemistry

Course objectives:

This course will enable students to know about the challenging sources of alternate sources of energy. The students will also be able to learn about the safe uses of natural resources.

Course Contents:

Biomass Resources: Biomass conversion processes, bio gas technology. Various traditional methods of alcohol production.Alcohols and its uses as alternative fuel.

Biofuels: Production of Bio-ethanol and biodiesel, uses of bioethanol as supplement with petroleum gasoline as E10 and E20 etc

Hydrogen: Hydrogen production, storage, handling and its uses as alternative fuel. Fuel cells: Fuel Cells and its application,

Solar Energy: Photovoltaic power conversion & solar energy collectors.

Nuclear fuels: Nuclear fuels processing, fission and fusion, nuclear reactors.

Hydel Energy: introduction to Hydel energy. Prospecting of hydel powers in Pakistan.

Recommended Books:

1. Gyngell, E. bS. *Applied Chemistry for Engineers*.Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.b .and Backurst, J.R. *Fuel and Energy*. Academic Press, London and New York (1988).

3. Goodger E. M. *Alternative fuels (chemical energy resources)*. The Macmillan press Ltd, London, (1980).

4. Twidell, J. and Weir, T. *Renewable Energy Resources*. John Wiley and Sons, London, New York, (1986).

FOURTH YEAR (SEMESTER-VIII)

SPECIALIZATION IN FUEL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-245	Chemistry of Coal Conversion Processes-II	3+0
2	CHEM-246	Petroleum & Petrochemicals-II	3+0
3	CHEM-244	Alternate Energy Sources	3+0
4	CHEM-414/ CHEM-424/ CHEM-334	Analytical Chemistry/Applied Chemistry/Biochemistry	3+1
5	CHEM-690	Research (Thesis Write up)	3
Total Credit Hours			16

Course Code: CHEM-245 **Course Name:** Chemistry of Coal Conversion Processes-II
Course Objectives:

The students will acquire knowledge about the coal conversion processes like solvent extraction, hydrogenation, and importance of catalysis in such reactions, product up gradation and analysis and environmental problems relating to synthetic fuels obtained from coal.

Course Contents:

Liquefaction of Coal

Historical Developments: Historical developments of coal liquefaction, earlier coal liquefaction processes; (a) Pott and Broch Process (b) Bergius process.

Solvent Extraction: Solvent extraction of coal, some experiments on solvent extraction, mechanism of solvent extraction, types of solvent extraction, solvent systems, super critical gas extraction, commercial processes of solvent extraction like SRC-I, SRC-II, EDS, Super critical gas extraction.

Direct Liquefaction: Direct liquefaction of coal through catalytic hydrogenation, mechanism, catalysts' system, catalyst poisoning, catalytic role of coal minerals, commercial processes of catalytic hydrogenation like H-coal and Synthoil process.

Indirect Liquefaction: Indirect liquefaction through Fischer Tropsch synthesis, methanol synthesis and MTG (Methanol to Gasoline) processes.

Effect of Parameters: Effect of coal properties, catalyst and solvent on liquefaction behaviour of coal, effect of coal properties like rank, maceral components and mineral matter on liquefaction, effect of operating condition like temperature, pressure, residence time, solvent, catalyst, etc.

Processing of Coal Liquids: Purification of liquefaction products, solid-separation, fractionation, upgrading and characterization of coal derived liquids, properties of coal derived liquids.

Liquefaction Reactor: Description of high pressure coal liquefaction reactor and auxiliary devices, ebulated bed reactor, fluidization.

Environmental Aspects: Environmental consideration, aerial emissions, water effluents, solid waste disposal.

Recommended Books:

1. Wen, C. Y. and Stanley, E. *Coal Conversion Technology*. Addison-Wesley, New York. (1979).

2. Probstein, R. F and Hicks, R. E. *Synthetic Fuels.* McGraw Hill, New York. (1982).

3. Francis, W. *Fuels and Fuel Technology.* Pergamon Press, London (1980).

4. Merick, D. *Coal Combustion and Conversion Technology.* McMillan Ltd., London (1984).

5. Berkowitz, N. *The chemistry of Coal.*Elsevier Amsterdam (1985).

Course Code: CHEM-246 **Course Name:** Petroleum & Petrochemicals-II

Course objectives:

The students will acquire knowledge about the modern thermodynamics and combustion of hydrocarbons fuels. The students will also be able to learn about the safe storage and transportation of hydrocarbons fuels.

Course Contents:

Thermo chemistry and Combustion of Hydrocarbon Fuels: Basic thermodynamics principles, standard enthalpy of formation, standard enthalpy of reaction, enthalpy of combustion products, mechanism of combustion of gaseous and liquid hydrocarbon, theory of flame propagation, method of measuring flame speed, fuel performances in reciprocating piston engines, environmental pollution from hydrocarbon fuel utilization.

Storage and Handling of Hydrocarbon Fuels: Various types of storage tanks, different methods of transportation of crude and refined petroleum products. Health hazards associated with petroleum handling, volatility losses, fire hazards and its prevention. Extinguishing of oil fire methods.

Recommended Books:

1. Hobson, G. D. *Modern Petroleum Technology*. Part 2, John Wiley and Sons, New York. (1984).

2. Gates, B. C, Katzer, J. R, and Schuit, G. C. A. *Chemistry of Catalytic Processes*.. McGraw Hill Book company, London (1979).

3. List, H. L. *Petrochemical Technology*. Printice-Hall Englewood Cliffs, New Jersey. (1986).

4. Goodger, E. M. *Hydrocarbon Fuels*. Union Brothers Ltd, London. (1975).

5. Maleev, V. L. Internal Combustion Engines. McGraw Hill Book Company London, (1985).

6. Hughes, J.R., and Swindells, N. S. *Storage and Handling of Petroleum Liquids*. Charless Griffin and Company Ltd, London (1987).

Course Code: CHEM-244 **Course Name:** Alternate Energy Sources

Course objectives:

This course will enable students to know about the challenging sources of alternate sources of energy. The students will also be able to learn about the safe uses of natural resources.

Course Contents:

Biomass Resources: Biomass conversion processes, bio gas technology. Various traditional methods of alcohol production.Alcohols and its uses as alternative fuel.

Biofuels: Production of Bio-ethanol and biodiesel, uses of bioethanol as supplement with petroleum gasoline as E10 and E20 etc

Hydrogen: Hydrogen production, storage, handling and its uses as alternative fuel. Fuel cells: Fuel Cells and its application,

Solar Energy: Photovoltaic power conversion & solar energy collectors.

Nuclear fuels: Nuclear fuels processing, fission and fusion, nuclear reactors.

Hydel Energy: introduction to Hydel energy. Prospecting of hydel powers in Pakistan.

Recommended Books:

1. Gyngell, E. bS. *Applied Chemistry for Engineers*.Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.b .and Backurst, J.R. *Fuel and Energy*. Academic Press, London and New York (1988).

3. Goodger E. M. *Alternative fuels (chemical energy resources)*. The Macmillan press Ltd, London, (1980).

4. Twidell, J. and Weir, T. *Renewable Energy Resources*. John Wiley and Sons, London, New York, (1986).

Course Code: CHEM-414 **Course Name:** Analytical Chemistry

Course Objectives:

Students will acquire knowledge about the theoretical and instrumental aspects of luminescence spectroscopy and thermal techniques of analysis in addition to learning about their applications.

Course Contents:

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Thermal Methods of Analysis: Introduction, instrumentation, sources of errors, interpretation of data, Factors affecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., *Thermal Methods of Analysis Principles, Applications and Problems*, 1st ed., Springer, (1995).
5. Lakowicz, J. R., *Principles of Fluorescence Spectroscopy*, 3rd ed., Springer (2006).
6. Gabbot, P., *Principles & Applications of Thermal Analysis*, Wiley-Blackwell, (2007).
7. Brown, M. E., *Introduction to Thermal Analysis: Techniques and Applications,* 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry,* 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., *Spectrophotometry, Luminescence and Colour; Science and Compliance,* Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-424 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge to understand the structure, mechanism, properties and synthesis of various polymers. The course will also provide technical know- how about perfumes and cosmetics and surface coating industries.

Course Contents:

Paper and Pulp: Raw materials for pulp and paper industries, classification of paper products, chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers: General classification and characterization of polymers, mechanism and chemistry of polymerization, thermoplastic and thermosetting polymerization, A brief outline for the production and applications of polymers i.e. polyethylene, polystyrene, polyurethanes, polyesters and urea phenol formaldehyde resins, and production of drug delivery polymers.

Cosmetics and Perfumes: Chemistry and production of hair products and shampoos, chemistry involved in hair curling and styling products, hair tonics and depilatory products, production of cold cream, vanishing cream, bleach cream and shaving creams, tooth paste and face powders, production of nail polish, lipsticks and mascaras.

Recommended Books:

1. Odian, G., *Principles of Polymerization*, 4th ed., John-Wiley & Sons, Inc., (2004).
2. Carraher, C. E. Jr., *Polymer Chemistry,* 6th ed., Marcel Dekker Incorporation, New York, (2003).
3. Roussak, D. V., Gesser, H. D., *Applied Chemistry; A Textbook of Engineers and Technologists,* 2nd ed., Springer, (2013).
4. Bajpai, P., *Environmentally Friendly Production of Pulp and Paper,* John-Wiley & Sons, Inc., (2010).
5. Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,* 3rd ed., Allured Publishing Corporation, (2009).
6. Barel, A. O., Paye, M. and Maibach, H. I., *Handbook of Cosmetic Science and Technology,* 3rd ed., Informa Healthcare, (2009).

Course Code: CHEM-334 **Course Name:** Biochemistry

Course Objectives:

The aim of the course is to acquire knowledge about bionanotechnology in general and its potential applications in particular. Bionanotechnology aims to exploit attributes of new materials like biosensors for medical applications. Understanding of the structure and assembly of nanoparticles opens some exciting possibilities to construct artificial structures in applied nanotechnology, which will mimic the functions of the biological systems.

Course Contents: Introduction to nanoparticles, overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, bionanotechnology systems, protein based nanostructures, nanobiosensors, challenges and opportunities associated with biology on the nanoscale, green nanoparticle production, self-assembly and templating, surface patterning and functionalization, characterization techniques of nanostructures.

Recommended Books:

1. Ratner, M.A. and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Prentice Hall Professional, upper saddle river, New Jersey (2003).

2. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., Hoboken, New Jersey (2004).

3. Papazoglou, E. S., *Bionanotechnology*, Morgan & Claypool Publishers, California, USA (2007).

4. Renugopalakrishnan V., Lewis, R. V., *Bionanotechnology: Proteins to Nanodevices*, Springer (2006).

5. Iqbal, S., *Bionanosensors*, Morgan & Claypool Publishers, California USA (2008).

6. Kotov, N. A., *Nanoparticle Assemblies and Superstructures*, CRC press, USA (2006).

7. Dinh, T.V., *Nanotechnology in Biology and Medicine: Methods, Devices and Application* CRC press, USA (2007).

8. Kumar, C., *Nanomaterials for Biosensors,* Wiley-VCH, Germany (2007).

9. Niemeyer, C.M., and Mirkin, C.A., *Nanobiotechnology: Concepts, Applications and Perspectives*, Wiley-VCH, Germany(2004).

FOURTH YEAR (SEMESTER-VIII)

SPECIALIZATION IN INORGANIC CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-554	Organometallics	3+0
2	CHEM-556	Symmetry & Magnetochemistry	3+0
3	CHEM-555	Radio & Nuclear Chemistry	3+0
4	CHEM-414/ CHEM-424/ CHEM-334/ CHEM-244	Analytical Chemistry/Applied Chemistry/Biochemistry/ Fuel Chemistry	3+1
5	CHEM-690	Research (Thesis Write up)	3
Total Credit Hours			16

Course Code: CHEM-554 **Course Name:** Organometallics
Course Objectives:

Students will acquire knowledge about chemistry of organometallics especially with reference to their types and bonding, and reactivity of organometallic compounds in homogeneous catalysis.

Course Contents:

Fundamentals of organometallic compounds, types of bonding in organometallics, single, double and triple bonds to carbon (compound types, acyls, alkylidene complexes and alkylidyne complexes), delocalized hydrocarbon systems (alkenes, olefins, allyl and butadienes), alkyne complexes, cyclic π-complexes (five and six membered rings). Homogeneous catalytic hydrogenation, dimerization, oligomerization, polymerization, hydroformylation of olefins, catalytic polymerization of acetylenes.Insertion reactions and uses of organometallic compounds in organic synthesis.

Recommended Books:

1. Powell, P., *Principles of Organometallics Chemistry*, 2nd ed., Springer, (1998).
2. Yamamoto A., *Organotransition Metal Chemistry*: *Fundamental Concepts and Applications*, 1st ed., John-Wiley & Sons, Inc., (1986).
3. Cotton, F. A., Wilkinson, G., Murillo, C. A., Bochmann M., *Advanced Inorganic Chemistry*, 6th ed., Wiley-Intersceince, New York, (1999).
4. Miessler, G. L., Fisher, P. J. and Tar, D, A., *Inorganic Chemistry*, 5th ed., Prentice Hall, (2013). 5. Douglas, B., McDaniel, D. and Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd ed., John-Wiley & Sons, Inc., (1994).
5. Haiduc, I. and Zuckerman, J. J., *Basic Organometallic Chemistry*, Walter De Gruyter Inc., (1985).
6. Jolly, W. L., *Modern Inorganic Chemistry*, 2nd ed., McGraw-Hill Company, (1991).
7. Porterfield, W. W., *Inorganic Chemistry: A Unified Approach*, 2nd ed., Academic Press, (1993).
8. Vincet, A., *Molecular Symmetry and Group Theory:* 2nd ed., John-Wiley & Sons, Ltd., (2001).
9. Malik, W. U., Tuli, G. D., Madan, R. D., *Selected Topics in Inorganic Chemistry, S. Chand and Co. Ltd.*, (2010).

Course Code: CHEM-556 **Course Name:** Symmetry & Magnetochemistry

Course Objectives:

Students will acquire knowledge about magnetic properties from chemistry point of view and group theory.

Course Contents:

Symmetry and Group Theory: Symmetry and group theory, point groups, multiplication tables, group representation and development of character tables. Introduction to the interpretation of spectra and structure elucidation.

Magnetochemistry: Theory of magnetism, diamagnetism, paramagnetism, ferro, ferri and antiferromagnetism, magnetic susceptibility, magnetic moments, Faraday's & Gouy's methods, effect of temperature on magnetic properties of complexes. Electron spin resonance spectroscopy, Magnetic moment of lanthanides.

Recommended Books:

1. Douglas, B., McDaniel, D., Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd ed., John-Wiley & Sons Inc., (1997).
2. Huheey, J. E, Keiter, E. A., Keiter, R. L., *Inorganic Chemistry: Principles of Structure and Reactivity*", 4th ed., Prentice Hall, (1997).
3. Mackay, K. M., Mackay, R. A. and Henderson, W., *Introduction to Modern Inorganic Chemistry*, 6th ed., CRC Press, (2002).
4. Miessler, G. L., Fisher, P. J. and Tar, D, A., *Inorganic Chemistry*, 5th ed., Prentice Hall, (2013).
5. Purcell, K. F., Kotz, J. C., *An Introduction to Inorganic Chemistry*, W. B. Saunders, Company Holt-Saunders, International ed., (1980).
6. Cotton, F. A., Wilkinson, G., Murillo, C. A., Bochmann, M., *Advanced Inorganic Chemistry*, 6th ed., Wiley-Intersceince, New York, (1999).
7. Jolly, W. L., *Modern Inorganic Chemistry*, 2nd ed., McGraw-Hill Company, (1991).
8. Carter, R. L., *Molecular Symmetry and Group Theory*, 1st ed., John-Wiley & Sons, Inc., New York, (1997).
9. Orchin, M., Jaffe, H. H., *Symmetry, Orbitals, and Spectra*, John-Wiley & Sons, Inc., New York, (1971).
10. McWeeny, R., *Symmetry: An Introduction to Group Theory and its Applications,* Dover Publications, Inc., (2002).

11. Vincet, A., *Molecular Symmetry and Group Theory*, 2nd ed., John Wiley & sons Ltd, (2001).

Course Code: CHEM-555 **Course Name:** Radio & Nuclear Chemistry
Course Objectives:

Students will acquire knowledge about radio and nuclear chemistry and nuclear reactions.

Course Contents:

Fundamentals and applied aspects of radioactivity and nuclear chemistry. types and characteristics of nuclear radiation, structure of nucleus, half-life, nuclear binding energy, and artificial radioactivity, fission and fusion reactions, acceleration of charged particles and applications of radioisotopes.

Recommended Books:

1. Friedlander, G., Kennedy, J. W., Miller, J. M. and Maciuas, E. S., *Nuclear and Radiochemistry*, 3rd ed., John-Wiley & Sons, Inc., (1981).
2. Choppin, G. R., Rydberg, J., Liljenzin, J., *Radiochemistry and Nuclear Chemistry*, 3rd ed., Butterworth-Heinemann Ltd., (2002).
3. Arnikar, H. J., *Essentials of Nuclear Chemistry*, 4th ed., New Age International Pvt. Ltd. Publishers, (1996).
4. Naqvi, I. I. and Farrukh, M. A., *Radiotracers in Chemical Applications* VDM Verlag Dr. Müller, Germany, (2010).
5. Loveland,W., Morrissey, D. J. and Seaborg, J. T., *Modern Nuclear Chemistry*, John Wiley and Sons, Inc.,(2006).

Course Code: CHEM-414 **Course Name:** Analytical Chemistry

Course Objectives:

Students will acquire knowledge about the theoretical and instrumental aspects of luminescence spectroscopy and thermal techniques of analysis in addition to learning about their applications.

Course Contents:

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Thermal Methods of Analysis: Introduction, instrumentation, sources of errors, interpretation of data, Factors affecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., *Thermal Methods of Analysis Principles, Applications and Problems*, 1st ed., Springer, (1995).
5. Lakowicz, J. R., *Principles of Fluorescence Spectroscopy*, 3rd ed., Springer (2006).
6. Gabbot, P., *Principles & Applications of Thermal Analysis*, Wiley-Blackwell, (2007).
7. Brown, M. E., *Introduction to Thermal Analysis: Techniques and Applications,* 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry,* 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., *Spectrophotometry, Luminescence and Colour; Science and Compliance,* Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-424 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge to understand the structure, mechanism, properties and synthesis of various polymers. The course will also provide technical know- how about perfumes and cosmetics and surface coating industries.

Course Contents:

Paper and Pulp: Raw materials for pulp and paper industries, classification of paper products, chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers: General classification and characterization of polymers, mechanism and chemistry of polymerization, thermoplastic and thermosetting polymerization, A brief outline for the production and applications of polymers i.e. polyethylene, polystyrene, polyurethanes, polyesters and urea phenol formaldehyde resins, and production of drug delivery polymers.

Cosmetics and Perfumes: Chemistry and production of hair products and shampoos, chemistry involved in hair curling and styling products, hair tonics and depilatory products, production of cold cream, vanishing cream, bleach cream and shaving creams, tooth paste and face powders, production of nail polish, lipsticks and mascaras.

Recommended Books:

1. Odian, G., *Principles of Polymerization*, 4th ed., John-Wiley & Sons, Inc., (2004).
2. Carraher, C. E. Jr., *Polymer Chemistry,* 6th ed., Marcel Dekker Incorporation, New York, (2003).
3. Roussak, D. V., Gesser, H. D., *Applied Chemistry; A Textbook of Engineers and Technologists,* 2nd ed., Springer, (2013).
4. Bajpai, P., *Environmentally Friendly Production of Pulp and Paper,* John-Wiley & Sons, Inc., (2010).
5. Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,* 3rd ed., Allured Publishing Corporation, (2009).
6. Barel, A. O., Paye, M. and Maibach, H. I., *Handbook of Cosmetic Science and Technology,* 3rd ed., Informa Healthcare, (2009).

Course Code: CHEM-334 **Course Name:** Biochemistry

Course Objectives:

The aim of the course is to acquire knowledge about bionanotechnology in general and its potential applications in particular. Bionanotechnology aims to exploit attributes of new materials like biosensors for medical applications. Understanding of the structure and assembly of nanoparticles opens some exciting possibilities to construct artificial structures in applied nanotechnology, which will mimic the functions of the biological systems.

Course Contents: Introduction to nanoparticles, overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, bionanotechnology systems, protein based nanostructures, nanobiosensors, challenges and opportunities associated with biology on the nanoscale, green nanoparticle production, self-assembly and templating, surface patterning and functionalization, characterization techniques of nanostructures.

Recommended Books:

1. Ratner, M.A. and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Prentice Hall Professional, upper saddle river, New Jersey (2003).

2. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., Hoboken, New Jersey (2004).

3. Papazoglou, E. S., *Bionanotechnology*, Morgan & Claypool Publishers, California, USA (2007).

4. Renugopalakrishnan V., Lewis, R. V., *Bionanotechnology: Proteins to Nanodevices*, Springer (2006).

5. Iqbal, S., *Bionanosensors*, Morgan & Claypool Publishers, California USA (2008).

6. Kotov, N. A., *Nanoparticle Assemblies and Superstructures*, CRC press, USA (2006).

7. Dinh, T.V., *Nanotechnology in Biology and Medicine: Methods, Devices and Application* CRC press, USA (2007).

8. Kumar, C., *Nanomaterials for Biosensors,* Wiley-VCH, Germany (2007).

9. Niemeyer, C.M., and Mirkin, C.A., *Nanobiotechnology: Concepts, Applications and Perspectives,* Wiley-VCH, Germany(2004).

Course Code: CHEM-244 **Course Name:** Fuel Chemistry

Course objectives:

This course will enable students to know about the challenging sources of alternate sources of energy. The students will also be able to learn about the safe uses of natural resources.

Course Contents:

Biomass Resources: Biomass conversion processes, bio gas technology. Various traditional methods of alcohol production.Alcohols and its uses as alternative fuel.

Biofuels: Production of Bio-ethanol and biodiesel, uses of bioethanol as supplement with petroleum gasoline as E10 and E20 etc

Hydrogen: Hydrogen production, storage, handling and its uses as alternative fuel. Fuel cells: Fuel Cells and its application,

Solar Energy: Photovoltaic power conversion & solar energy collectors.

Nuclear fuels: Nuclear fuels processing, fission and fusion, nuclear reactors.

Hydel Energy: introduction to Hydel energy. Prospecting of hydel powers in Pakistan.

Recommended Books:

1. Gyngell, E. bS. *Applied Chemistry for Engineers*.Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.b .and Backurst, J.R. *Fuel and Energy*. Academic Press, London and New York (1988).

3. Goodger E. M. *Alternative fuels (chemical energy resources)*. The Macmillan press Ltd, London, (1980).

4. Twidell, J. and Weir, T. *Renewable Energy Resources*. John Wiley and Sons, London, New York, (1986).

FOURTH YEAR (SEMESTER-VIII)

SPECIALIZATION IN ORGANIC CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-563	Natural Products	3+0
2	CHEM-565	Organic Synthesis	3+0
3	CHEM-562	Medicinal Chemistry	3+0
4	CHEM-414/ CHEM-424/ CHEM-334/ CHEM-244	Analytical Chemistry/Applied Chemistry/Biochemistry/ Fuel Chemistry	3+1
5	CHEM-690	Special Paper-II/Research (Thesis Write up)	3
Total Credit Hours			16

Course Code: CHEM-563 **Course Name:** Natural Products

Course Objectives:

Students will acquire knowledge about different types of natural products with emphasis on their structure, synthesis and applications.

Course Contents:

Alkaloids: Introduction, classification, isolation methods, structure elucidation and discussion with particular reference to structure and synthesis and biosynthesis of typical alkaloids such as ephedrine, nicotine, atropine, quinine, papaverine and morphine.

Terpenoids: Introduction, classification, isolation techniques and discussion with particular reference to structure and synthesis and biosynthesis of typical terpenoids such as citral, α-terpineol, α-pinene, camphor and α-cadinene.

Steroids: Study of cholesterol and steroidal hormones with emphasis on their structure and biosynthesis.

Flavonoids: Introduction and classification of flavonoids, general biosynthetic pathway, synthesis of flavone, flavonol and cyanidin.

Recommended Books:

1. Dewick, P. M., *Medicinal Natural Products: A Biosynthetic Approach*, 3rd ed., Medicinal Natural Products, John-Wiley & Sons, Ltd., (2009).
2. Sell, C. S., A *Fragrant Introduction to Terpenoid Chemistry*, The Royal Society of Chemistry, UK, (2003).
3. De la Rosa, L. A., Parrilla, E. A. and Aguitar, G. A. G., *Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability*, Wiley-Blackwell, (2009).
4. Shahidi, F. and Naczk M., *Phenolics in Food and Nutraceuticals*, CRC Press, (2004).
5. Oyvind, M. A., and Kenneth, R. M., *Flavonoids: Chemistry, Biochemistry and Applications*, CRC, Taylor & Francis, New York, (2010).
6. Finar, I. L., Organic Chemistry, Vol. 2, *Stereochemistry and the Chemistry of Natural Products,* 5th ed., Pearson Education Ltd., Delhi, (2008).
7. Hesse, M., *Alkaloid Chemistry,* John-Wiley & Sons, New York, (1981).
8. Bhat, S. V., Nagasampagi, B. A. and Sivakumar, M., *Chemistry of Natural Products,* Narosa Publishing House, (2005).

Course Code: CHEM-565 **Course Name:** Organic Synthesis

Course Objectives:

Students will acquire knowledge and understanding to design protocols for synthesis of small to medium sized organic compounds and be able to carry out retrosynthetic analysis, and propose alternative reactions to synthesize a compound.

Course Contents:

Principles and importance of organic synthesis, Introduction to reterosynthesis and disconnection approach, synthesis of aromatic compounds; one and two group carbon C-X disconnections, donor and acceptor synthons, C-C disconnections and 1,2-, 1,3-, 1,4-, 1,5- and 1,6-difunctionalized compounds, synthesis of cyclic compounds (3-6 membered), chemo-, regio- and stereoselectivity.

Synthetic strategies:

Functional group protection: hydroxyl, amino, carbonyl, carboxylic, sulfanyl, C=C, solid phase synthesis, phase-transfer catalysis.

Recommended Books:

1. Warren, S. and Wyatt, P., *Workbook for Organic Synthesis: The Disconnection Approach*, 2nd ed., John-Wiley & Sons, Inc., (2010).
2. Fox, M. A. and Whitsell, J. K., *Organic Chemistry*, 3rd ed., Jones & Bartlett Publishers (1997).
3. Clayden, J., Greeves, N., and Warren, S., *Organic Chemistry*, 2nd ed., Oxford University Press, New York, (2012).
4. Loudon, M., *Organic Chemistry*, 5th ed., Roberts Company Publishers, (2009).
5. Smith, J. G., *Organic Chemistry*, 3rd ed., McGraw-Hill, (2010).
6. Norman, R. O. C. and Coxon, J. M., *Principles of Organic Synthesis*, 3rd ed., CRC Press, (1993).

Course Code: CHEM-562 **Course Name:** Medicinal Chemistry

Course Objectives:

Students will acquire knowledge and learn about the nature, types and properties of drugs and medicines, and the role of an organic chemist in drug designing and drug discovery.

Course Contents:

Chemistry of biomolecules; introduction to drugs and drug discovery, sources of therapeutic agents, structure activity relationship (SAR), drug-receptor interaction, , drug formulation and its methods, different types of drugs; chemistry and modes of action of some common drugs.

Recommended Books:

1. Paul, M. D., *Medicinal Natural Products: A Biosynthetic Approach*, 3rd ed., Medicinal Natural Products, John-Wiley & Sons, Ltd, (2009).
2. Wolff, M. E., *Burger's Medicinal Chemistry,* 4th ed., Part III, John-Wiley & Sons, New York, (2006).
3. Williams, D. A. and Lemke, T. L., *Foye's Principles of Medicinal Chemistry*, 6th ed., Lippincott Williams & Wilkins, New York, (2008).
4. D. Sriram, P. Vogeeswari, *Medicinal Chemistry,* 2nd ed., BITS Pilani, Pearson, Publisher: Darling Kindernley, India, (2010).
5. Carins D., *Essential of Pharmaceutical Chemistry,* 3rd ed., Pharmaceutical Press, London, (2008)

Course Code: CHEM-414 **Course Name:** Analytical Chemistry
Course Objectives:

Students will acquire knowledge about the theoretical and instrumental aspects of luminescence spectroscopy and thermal techniques of analysis in addition to learning about their applications.

Course Contents:

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Thermal Methods of Analysis: Introduction, instrumentation, sources of errors, interpretation of data, Factors affecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., *Thermal Methods of Analysis Principles, Applications and Problems,* 1st ed., Springer, (1995).
5. Lakowicz, J. R., *Principles of Fluorescence Spectroscopy,* 3rd ed., Springer (2006).
6. Gabbot, P., *Principles & Applications of Thermal Analysis,* Wiley-Blackwell, (2007).
7. Brown, M. E., *Introduction to Thermal Analysis: Techniques and Applications*, 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry*, 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., *Spectrophotometry, Luminescence and Colour; Science and Compliance,* Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-424 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge to understand the structure, mechanism, properties and synthesis of various polymers. The course will also provide technical know- how about perfumes and cosmetics and surface coating industries.

Course Contents:

Paper and Pulp: Raw materials for pulp and paper industries, classification of paper products, chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers: General classification and characterization of polymers, mechanism and chemistry of polymerization, thermoplastic and thermosetting polymerization, A brief outline for the production and applications of polymers i.e. polyethylene, polystyrene, polyurethanes, polyesters and urea phenol formaldehyde resins, and production of drug delivery polymers.

Cosmetics and Perfumes: Chemistry and production of hair products and shampoos, chemistry involved in hair curling and styling products, hair tonics and depilatory products, production of cold cream, vanishing cream, bleach cream and shaving creams, tooth paste and face powders, production of nail polish, lipsticks and mascaras.

Recommended Books:

1. Odian, G., *Principles of Polymerization*, 4th ed., John-Wiley & Sons, Inc., (2004).
2. Carraher, C. E. Jr., *Polymer Chemistry,* 6th ed., Marcel Dekker Incorporation, New York, (2003).
3. Roussak, D. V., Gesser, H. D., *Applied Chemistry; A Textbook of Engineers and Technologists,* 2nd ed., Springer, (2013).
4. Bajpai, P., *Environmentally Friendly Production of Pulp and Paper*, John-Wiley & Sons, Inc., (2010).
5. Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,* 3rd ed., Allured Publishing Corporation, (2009).
6. Barel, A. O., Paye, M. and Maibach, H. I., *Handbook of Cosmetic Science and Technology,* 3rd ed., Informa Healthcare, (2009).

Course Code: CHEM-334 **Course Name:** Biochemistry

Course Objectives:

The aim of the course is to acquire knowledge about bionanotechnology in general and its potential applications in particular. Bionanotechnology aims to exploit attributes of new materials like biosensors for medical applications. Understanding of the structure and assembly of nanoparticles opens some exciting possibilities to construct artificial structures in applied nanotechnology, which will mimic the functions of the biological systems.

Course Contents: Introduction to nanoparticles, overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, bionanotechnology systems, protein based nanostructures, nanobiosensors, challenges and opportunities associated with biology on the nanoscale, green nanoparticle production, self-assembly and templating, surface patterning and functionalization, characterization techniques of nanostructures.

Recommended Books:

1. Ratner, M.A. and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Prentice Hall Professional, upper saddle river, New Jersey (2003).

2. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., Hoboken, New Jersey (2004).

3. Papazoglou, E. S., *Bionanotechnology*, Morgan & Claypool Publishers, California, USA (2007).

4. Renugopalakrishnan V., Lewis, R. V., *Bionanotechnology: Proteins to Nanodevices*, Springer (2006).

5. Iqbal, S., *Bionanosensors*, Morgan & Claypool Publishers, California USA (2008).

6. Kotov, N. A., *Nanoparticle Assemblies and Superstructures*, CRC press, USA (2006).

7. Dinh, T.V., *Nanotechnology in Biology and Medicine: Methods, Devices and Application* CRC press, USA (2007).

8. Kumar, C., *Nanomaterials for Biosensors,* Wiley-VCH, Germany (2007).

9. Niemeyer, C.M., and Mirkin, C.A., *Nanobiotechnology: Concepts, Applications and Perspectives,* Wiley-VCH, Germany(2004).

Course Code: CHEM-244 **Course Name:** Fuel Chemistry
Course objectives:

This course will enable students to know about the challenging sources of alternate sources of energy. The students will also be able to learn about the safe uses of natural resources.

Course Contents:

Biomass Resources: Biomass conversion processes, bio gas technology. Various traditional methods of alcohol production.Alcohols and its uses as alternative fuel.

Biofuels: Production of Bio-ethanol and biodiesel, uses of bioethanol as supplement with petroleum gasoline as E10 and E20 etc

Hydrogen: Hydrogen production, storage, handling and its uses as alternative fuel. Fuel cells: Fuel Cells and its application,

Solar Energy: Photovoltaic power conversion & solar energy collectors.

Nuclear fuels: Nuclear fuels processing, fission and fusion, nuclear reactors.

Hydel Energy: introduction to Hydel energy. Prospecting of hydel powers in Pakistan.

Recommended Books:

1. Gyngell, E. bS. *Applied Chemistry for Engineers*.Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.b .and Backurst, J.R. *Fuel and Energy*. Academic Press, London and New York (1988).

3. Goodger E. M. *Alternative fuels (chemical energy resources)*. The Macmillan press Ltd, London, (1980).

4. Twidell, J. and Weir, T. *Renewable Energy Resources*. John Wiley and Sons, London, New York, (1986).

Course name: Special paper-2 (Organic)
Course code: CHEM-690
Credit hours: 3+0

Title: Separation and analysis of organic compounds

Introduction: The course is aimed in training of final year students in the separation and systematic identification of organic compounds using chemical tests as well as spectral analysis. The course forms basis for the graduates of organic chemistry, medicinal chemistry, natural products, material chemistry etc. The course is buildup on the knowledge acquired by MSc/BS students in other subjects including natural products, medicinal chemistry, spectroscopy, chromatography, organic synthesis etc. The course is relative.

Objectives:

1. Give authority to plan organic chemical laboratory work.
2. Provide skills in identification of organic compounds.
3. Provide skills and knowledge about the methods of separation of organic compounds.
4. Providing skills in performing chemical synthesis on a small scale.
5. Provide knowledge about the handling of the security aspects in an organic chemistry lab.

Contents:

Separation of mixtures: Distillation, sublimation, extraction (polar/nonpolar), crystallization, recrystallization, chromatography (CC, TLC, GC, HPLC).
Identification/classification tests: physical properties, solubility, chemical tests for classification (Functional groups), derivative preparation.
Spectral analysis: Infrared, NMR, Mass spectroscopic data and characteristics of Organic compounds.

Recommended books:

Shriner, Hermann, Morrill, Curtin and Fusan (2004)*The systematic identification of organic compounds* (8^{th} edition). John Wiley & Sons, Inco.

Finar, I. L. (1959). *Organic Chemistry: The Fundamental Principles*(Volume 1) 3^{rd} or 4^{th} edition. Longmans, Green and Company.

John D. Robert and Marjorie C. Caserio (1977) *Basic Principles of Organic Chemistry, second edition.* W. A. Benjamin, Inc., Menlo Park, CA.

FOURTH YEAR (SEMESTER-VIII)

SPECIALIZATION IN PHYSICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-575	Reaction Dynamics	3+0
2	CHEM-576	Radiation & Photochemistry	3+0
3	CHEM-574	Colloid & Surface Chemistry	3+0
4	CHEM-414/ CHEM-424/ CHEM-334/ CHEM-244	Analytical Chemistry/Applied Chemistry/Biochemistry/ Fuel Chemistry	3+1
5	CHEM-690	Special Paper-II/Research (Thesis Write up)	3
Total Credit Hours			16

Course Code: CHEM-575 **Course Name:** Reaction Dynamics

Course Objectives:

Students will acquire knowledge and learning about reaction dynamics and kinetic theories. They will also know about the factors which can influence the rates of reactions under different reaction conditions.

Reaction Dynamics: Correlation between physical properties and concentration, Kinetics of the complex reactions, reversible, parallel, consecutive bimolecular reactions, Theory of absolute reaction rate, Lindemann's theory of unimolecular reactions, bimolecular collision theory, transition state theory, comparison of collision and absolute reaction theories, Potential energy surfaces, Thermodynamic formulation of reaction rates, Calculation of entropy and enthalpy changes, Thermal decomposition of nitrogen pentaoxide.

Reactions in solutions: Influence of ionic strength on the reaction rate, effect of dielectric constant of the medium on the rate of the reaction, single sphere activated complex model, double sphere activated complex model, complex reactions, chain reactions, single chain carrier with second order breaking, one chain carrier with first order breaking, two chain carrier with second order breaking, experimental techniques for fast reactions.

Recommended Books:

1. Espenson, J. H., *Chemical Kinetics and Reaction Mechanism* 2nd ed., McGraw-Hill, London (2002).
2. Connors, K. A., *Chemical Kinetics: The Study of Reaction Rates in Solution*, VCH Publishers, Inc., (1990).
3. Silbey, R. J., Alberty, R. A. and Bawendi, M. G., *Physical Chemistry,* 4th ed., John-Wiley & Sons, (2005).
4. Atkins, P. and Paula, J. D., *Atkin's Physical Chemistry,* 9th ed., Oxford University Press, (2010).
5. Houston, P. L., *Chemical Kinetics and Reaction Dynamics,* Dover Publications, (2006).
6. Levine, R., *Molecular Reaction Dynamics*, Cambridge University Press, (2005).
7. Laidler, K. J., *Chemical Kinetics*, 3rd Edition, Prentice Hall, (1987).
8. Frost, A. A., and Pearson, R. G., *Reaction Mechanism*, 2nd Edition John Wiley and sons, Inc; (1961).
9. Benson, S. W., *Foundation of Chemical Kinetics*, Krieger Publication Co. (1980).

Course Code: CHEM-576 **Course Name:** Radiation & Photochemistry

Course Objectives:

Students will learn about the mechanisms of radiation induced chemical changes in molecules, radiation dosimetery and applications of the radiation chemistry. They will also learn about radioactive decays, and how radioisotopes are produced and applied in Mössbauer spectroscopy. Students will be able to understand the principles of fluorescence, phosphorescence and other photochemical processes, and their applications.

Course Contents:

Radiation Chemistry: Development and advancement in radiation chemistry, radiation dosimetry, Fricke dosimeter, dosimetry in pulse radiolysis, energy states in radiation chemistry, excited states, fragmentation, pre-dissociation, photochemical decay, ions and electrons, radiolysis of gases, liquids, solids, frozen liquids and ions in radiation chemistry, recent application of radiation chemistry.

Photochemistry: Principles of photochemistry, laws of photochemistry, Einstein's law of photochemical equivalence, rates of intramolecular processes, chemical reactions and quantum yields with examples, energy transfer in photochemical reaction, quantum yield of emission process radiation and nonradiation process, kinetics and quantum yields of radiative and nonradiative process (fluorescence, phosphorescence, inter-system crossing, internal conversion, quenching) and Stern-Volmer reactions, photosensitized reactions.

Recommended Books:

1. Spinks, J. W. T. and Woods, R. J., *An introduction to Radiation Chemistry*, 3rd ed., Wiley Inter Si. Pub., USA, (1990).
2. Aziz, F. and Rodgers, M. A. J., *Radiation Chemistry Principles and Applications*, 1st ed., VCH Publishers, Inc., (1987).
3. Choppin, G., Liljenzin, J-O., Rydberg, J., *Radiochemistry and Nuclear Chemistry*, 3rd ed., Butterworth-Heinemann, (2002).
4. Mostafavi, M., Douki, T., *Radiation Chemistry: From Basic to Applications in Material and Life Sciences*, EDP Science, (2008).
5. Dunkin, I., *Photochemistry*, Vol. 36, RSC Publishing, (2007).
6. Dickson, D. P. E., Berry, F. J., *Mossbauer Spectroscopy*, Cambridge University Press, (1986).

7. Scaglia, B., *The Fundamentals: An Understanding of Photochemistry, B*iblio Bazaar, (2011).
8. Konya, J. and Nagy, N. M., *Nuclear and Radiochemistry,* 1st ed., Elsevier, (2012).

Course Code: CHEM-574 **Course Name:** Colloid & Surface Chemistry

Course Objectives:

Students will acquire knowledge about the important physical and chemical aspects of nano and colloidal systems and the basics of thermodynamically and kinetically stabilized nanoparticles and colloidal solutions. They will also learn about the surfactant chemistry, characterization methods and applications of nanoparticles and colloidal solutions.

Course Contents:

Colloid and Surface Chemistry:

Colloidal solutions, catalyst preparation methods, industrial catalysts, emulsion, surfactant, nanoscale chemistry, nanomaterials and their applications, dimensional control in nanostructures, macromolecular surface films, charged films and Langmuir-Blodgett layers, characterization methods and applications.

Solid surfaces, surface structures, clean surface structures, gas solid interface, thermodynamics of adsorption, heterogeneous catalysis, kinetic and mechanisms of catalyzed reactions, adsorption at liquid surfaces, chemisorption, physiosorption and dynamics, enzymatic catalysis, organized molecular assemblies, experimental probes for surface and adsorbent structures, scanning probe techniques, low energy electron diffraction (LEED), electron spectroscopy, and other surface analysis techniques.

Recommended Books:

1. Hunter, R. J., *Introduction to Modern Colloid Science*, Oxford University Press, Oxford, (1994).
2. Poole, C. P. and Owens, F. J., *Introduction to Nanotechnology*, 1st ed., Wiley-Interscience, (2003).
3. Klabunde, K. J., *Nanoscale Materials in Chemistry*, John-Wiley & Sons, Inc., (2003).
4. Kolunsiki, K. W., *Surface Science: Foundations of Catalysis and Nanoscience*, 3rd ed., John-Wiley & Sons, Ltd., (2012).
5. Adamson, A. W. and Gast, A. P., *Physical chemistry of Surfaces*, 6th ed., Wiley-Interscience, (1997).
6. Atkins, P. and Paula, J. D., *Atkin's Physical Chemistry,* 8th ed., Oxford University Press, (2006).
7. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, (2004).

Course Code: CHEM-414 **Course Name:** Analytical Chemistry

Course Objectives:

Students will acquire knowledge about the theoretical and instrumental aspects of luminescence spectroscopy and thermal techniques of analysis in addition to learning about their applications.

Course Contents:

Luminescence Spectrophotometry: Introduction, origin of fluorescence and phosphorescence spectra, Jablonski diagram, activation, deactivation, fluorescence spectrum, fluorescent and phosphorescent species; photoluminescence and structure, factors affecting fluorescence and phosphorescence, fluorescence quenching, quantum yield, instrumentation for fluorescence measurement, sources, wavelength selectors, sampling, detectors, read out devices, instrumentation for phosphorescence measurement, sampling, recording procedure, applications of fluorescence and phosphorescence.

Thermal Methods of Analysis: Introduction, instrumentation, sources of errors, interpretation of data, Factors affecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., *Analytical Chemistry.* 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., *Introduction to Chemical Analysis*, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., *Thermal Methods of Analysis Principles, Applications and Problems,* 1st ed., Springer, (1995).
5. Lakowicz, J. R., *Principles of Fluorescence Spectroscopy,* 3rd ed., Springer (2006).
6. Gabbot, P., *Principles & Applications of Thermal Analysis,* Wiley-Blackwell, (2007).
7. Brown, M. E., *Introduction to Thermal Analysis: Techniques and Applications*, 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., *Fundamentals of Analytical Chemistry*, 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., *Spectrophotometry, Luminescence and Colour; Science and Compliance,* Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-424 **Course Name:** Applied Chemistry

Course Objectives:

Students will acquire knowledge to understand the structure, mechanism, properties and synthesis of various polymers. The course will also provide technical know- how about perfumes and cosmetics and surface coating industries.

Course Contents:

Paper and Pulp: Raw materials for pulp and paper industries, classification of paper products, chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers: General classification and characterization of polymers, mechanism and chemistry of polymerization, thermoplastic and thermosetting polymerization, A brief outline for the production and applications of polymers i.e. polyethylene, polystyrene, polyurethanes, polyesters and urea phenol formaldehyde resins, and production of drug delivery polymers.

Cosmetics and Perfumes: Chemistry and production of hair products and shampoos, chemistry involved in hair curling and styling products, hair tonics and depilatory products, production of cold cream, vanishing cream, bleach cream and shaving creams, tooth paste and face powders, production of nail polish, lipsticks and mascaras.

Recommended Books:

1. Odian, G., *Principles of Polymerization*, 4th ed., John-Wiley & Sons, Inc., (2004).
2. Carraher, C. E. Jr., *Polymer Chemistry,* 6th ed., Marcel Dekker Incorporation, New York, (2003).
3. Roussak, D. V., Gesser, H. D., *Applied Chemistry; A Textbook of Engineers and Technologists,* 2nd ed., Springer, (2013).
4. Bajpai, P., *Environmentally Friendly Production of Pulp and Paper*, John-Wiley & Sons, Inc., (2010).
5. Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry*, 3rd ed., Allured Publishing Corporation, (2009).
6. Barel, A. O., Paye, M. and Maibach, H. I., *Handbook of Cosmetic Science and Technology,* 3rd ed., Informa Healthcare, (2009).

Course Code: CHEM-334 **Course Name:** Biochemistry

Course Objectives:

The aim of the course is to acquire knowledge about bionanotechnology in general and its potential applications in particular. Bionanotechnology aims to exploit attributes of new materials like biosensors for medical applications. Understanding of the structure and assembly of nanoparticles opens some exciting possibilities to construct artificial structures in applied nanotechnology, which will mimic the functions of the biological systems.

Course Contents: Introduction to nanoparticles, overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, bionanotechnology systems, protein based nanostructures, nanobiosensors, challenges and opportunities associated with biology on the nanoscale, green nanoparticle production, self-assembly and templating, surface patterning and functionalization, characterization techniques of nanostructures.

Recommended Books:

1. Ratner, M.A. and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Prentice Hall Professional, upper saddle river, New Jersey (2003).

2. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., Hoboken, New Jersey (2004).

3. Papazoglou, E. S., *Bionanotechnology*, Morgan & Claypool Publishers, California, USA (2007).

4. Renugopalakrishnan V., Lewis, R. V., *Bionanotechnology: Proteins to Nanodevices*, Springer (2006).

5. Iqbal, S., *Bionanosensors*, Morgan & Claypool Publishers, California USA (2008).

6. Kotov, N. A., *Nanoparticle Assemblies and Superstructures*, CRC press, USA (2006).

7. Dinh, T.V., *Nanotechnology in Biology and Medicine: Methods, Devices and Application* CRC press, USA (2007).

8. Kumar, C., *Nanomaterials for Biosensors,* Wiley-VCH, Germany (2007).

9. Niemeyer, C.M., and Mirkin, C.A., *Nanobiotechnology: Concepts, Applications and Perspectives,* Wiley-VCH, Germany(2004).

Course Code: CHEM-244 **Course Name:** Fuel Chemistry

Course objectives:

This course will enable students to know about the challenging sources of alternate sources of energy. The students will also be able to learn about the safe uses of natural resources.

Course Contents:

Biomass Resources: Biomass conversion processes, bio gas technology. Various traditional methods of alcohol production.Alcohols and its uses as alternative fuel.

Biofuels: Production of Bio-ethanol and biodiesel, uses of bioethanol as supplement with petroleum gasoline as E10 and E20 etc

Hydrogen: Hydrogen production, storage, handling and its uses as alternative fuel. Fuel cells: Fuel Cells and its application,

Solar Energy: Photovoltaic power conversion & solar energy collectors.

Nuclear fuels: Nuclear fuels processing, fission and fusion, nuclear reactors.

Hydel Energy: introduction to Hydel energy. Prospecting of hydel powers in Pakistan.

Recommended Books:

1. Gyngell, E. bS. *Applied Chemistry for Engineers*.Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.b .and Backurst, J.R. *Fuel and Energy*. Academic Press, London and New York (1988).

3. Goodger E. M. *Alternative fuels (chemical energy resources)*. The Macmillan press Ltd, London, (1980).

4. Twidell, J. and Weir, T. *Renewable Energy Resources*. John Wiley and Sons, London, New York, (1986).

Course Title: **Special Paper-II**

Code: **CHEM- 690**

Credit Hours: **3+0**

Course Objectives:

Students will acquire knowledge to enable themselves to understand the fundamental concepts of liquids, and to investigate the physical properties of ideal/non-ideal binary solutions. Students will also able how to prepare different types of solution and their calculations.

Solution Chemistry:

Liquids,their characteristics and properties.Surface tension, viscosity, refractive index, and their measurement and applications, Solution, Types of solution, concentration units and their measurements. Brief account of interactions among the molecules in liquids, ideal and non-ideal solutions, Raoult's law and its applications, Colligative properties,lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure, vapor pressure of non-ideal solutions. Henry's law, abnormal colligative properties, degrees of association and dissociation of solutes, osmotic pressure and its measurement, fractional distillation etc.

Recommended Books:

1. Atkins, P. and Paula, J. D., Atkin's Physical Chemistry,9th ed., Oxford University Press, (2010).
2. Albert R.A., Robert J.S. and Moungi G.B. "Physical Chemistry". 4th ed., John Wiley and Sons (2004).
3. Chaudhary, S. U.,Ilmi Textbook of Physical Chemistry, 2nd ed., IlmiKitabKhana, Lahore, (2013)..
4. R. A. alberty, J.s. Robert and G. B. moungi physical chemistry, 4th edition, jhonwilley& sons(2004).
5. Levine, Physical Chemistry 6Th Ed (2015).

MSc in Chemistry (2-Years)

FIRST YEAR (SEMESTER-I)

S.NO	Course Code	Course Name	Credit Hours
1	CHEM- 511/ CHEM- 521/ CHEM- 531/ CHEM-541	Analytical Chemistry paper-I/Applied Chemistry paper-I/ Biochemistry Chemistry paper-I/Fuel Chemistry-I	3+1
2	CHEM- 551	Inorganic Chemistry paper-I	3+1
3	CHEM- 561	Organic Chemistry paper-I	3+1
4	CHEM- 571	Physical Chemistry paper-I	3+1
5	MATH- 590	Mathematics	2+0
Total Credit Hours			18

Course Code: CHEM-511 **Course Name:** Analytical Chemistry-I

Course Contents

Classical analytical techniques:

Introduction to fundamental concepts of Analytical Chemistry, Introduction to classical methods of analysis; Chemical units and stoichiometric relations, Gravimetric, Volumetric, Complexation methods of analysis.Stoichiometric calculations, various types of titrations, basic theory, indicators and applications.

Separation Methods:

Principle of solvent extraction, solvent extraction of metals, analytical separations, multiple batch extraction, counter current distribution, solid-phase extraction, solvent extraction by flow injection method, principles of chromatography, classification of chromatographic techniques, overview of paper, thin layer, column, ion exchange chromatography and electrophoresis.

Analytical Spectrophotometry:

Properties of light and its interaction with matter, relation between frequency, velocity and wave number, Lambert- Beer's law and its limitations, single beam and double beam spectrophotometers, lamps and lasers as sources of light, monochromators, detectors, photomultiplier tube, photodiode array, charged coupled device, FT-IR spectroscopy, fourier analysis, interferometry, noise and its control.

Analytical Chemistry Practical **Credit Hours:01**

1. Separation of organic components by paper and thin layer chromatography.
2. To determine the solubility product of Cadmium iodate titrimetrically.
3. To estimate Ca^{2+} concentration in drinking water by EDTA complexometric titration.
4. Separation of phenol from given organic mixture using solvent extraction.
5. Separation of given mixture of cations using Paper Chromatography.
6. Analysis of the composition of a mixture of nitro anilines by TLC.
7. Separation of sugars using paper chromatography.
8. Separation of amino acids using paper/thin layer chromatography.
9. Deionization and softening of water using ion exchange chromatography.
10. Determination of λ_{max} of $KMnO_4$ and $K_2Cr_2O_7$ solutions and verification of Beer-Lambert's law.

11. Determination of stoichiometry of a metal complex by visible spectrometry.
12. Determination of aspirin and caffeine in a proprietary analgesic by double beam UV-Vis. spectrometer.
13. Quantification of iron in a given sample by using single beam spectrophotometer.
14. A study of characteristics infrared absorption frequencies.

Books Recommended

1. G.D. Christian, Analytical Chemistry, 6^{th} ed., New York (2006), John Wiley and Sons.
2. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, Reinhote, New York.
3. R. D. Braun, Introduction to Chemical Analysis,
4. I.M. Kolthoff, Sandell, Text Book of Quantitative Inorganic Analysis, Macmillan and Co. New York.
5. D. Harvey, Modern Analytical Chemistry.
6. J.G. Dick, Analytical Chemistry, Mc-Graw-Hill, Tokyo.
7. S.M. Koapkar, Basic concept of Analytical Chemistry, Willey New Delhi
8. D.C. Harris, Quantitative Chemical Analysis, 8th ed., W. H. Freeman and
9. Company, New York, USA, (2011).
10. Kealey, D. and Haines, P. J., BIOS Instant Notes in Analytical Chemistry, 1st ed.,Bios Saence Publisher Ltd. Oxford UK. (2002)
11. D.L. Pavia, G.M. Lampman, G. S. Kriz, J.A. Vyvyan, Introduction to spectroscopy, 4^{th} ed., Cengage Learning, (2008).
12. P.E. Wall, Thin Layer Chromatography: A Modern Approach (RSC Chromatography Monographs), 1^{st} ed., Royal Society of Chemistry, (2005).
13. Deinstrop, E. H., Applied Thin Layer Chromatography, 2^{nd} ed., Wiley-VCH, (2006).
14. R. Kellener. J.M. Mermet. M. Otto, M. Valcarcel, H.M. Widmer, Analytical Chemistry: A Modern Approach to Analytical Science, Wiley.VCH, (2004)
15. J. M. Hollas, Modern Spectroscopy, 4^{th} ed., John-Wiley & Sons, Ltd.,England (2004).

Course Code: CHEM-521 **Course Name:** Applied Chemistry-I
Course Contents
Chemical Industrial Unit Operations and Processes:

Brief introduction to Chemical Industry with reference to Pakistan, Elementary treatment of general unit operations commonly used in Industry such as heat transfer; Evaporation; size Reduction; Screening; Filtration and Distillation. Chemical; Unit processes, Nitration; Sulphonation; Halogenations; Hydration; Oxidation and Hydrogenation.

Basic Chemical Industries:

Raw materials; Chemical processes involved; flow sheet diagrams with all the important parameters concerned with the manufacturing of Sulphuric acid; Hydrochloric acid; caustic Soda; Washing soda; Oxalic Acid, Formic acid, Phthalic anhydride. Applications of these chemicals in industry.

Cement Industries:

Cement raw materials used for cement manufacturing, dry process, wet process, semi wet process, special cement, chemistry involved in hydration of cement, setting of cement, setting time.

Applied Chemistry Practical Credit Hours: 01

Preparations:

Detergent and cosmetics (Cold cream, shampoo and vanishing cream), Dentifrice, Thermosetting and thermoplastic resins (alkyd and urea formaldehyde)

Titrimetry:

Estimation of water hardness by complexometery Estimation ofacetic acid contents in the vinegar sample Determine the acidity of the sulphuric acid and its normality. Determination of acidity, alkalinity, Free CO_2 in water Assay of bleaching powder by free chlorine method. Determine the %age purity of the Commercial sample of sodium chloride. Determination of Residual Chlorine in water.%age of reducing sugars. Soap analysis for free and combined alkali. Determining the %age purity of sodium bicarbonate and sodium carbonate.

Flame photometry:

Estimation of Potassium in the tap water.Estimation of Sodium in the Commercial Sodium Chloride.Estimation of Calcium in milk.

Books Recommended

1. Industrial Organic Chemicals, by H.A.Witcoff, B.J.Reuben, John Wiley & Sons Inc. New York.
2. Water Supply and Sewerage, T.J.McGhee,McGraw Hill Book Co. New York.
3. Unit operations in Chemical Engineering, Chattopadhyay, Khanna Publishers, Delhi-6.
4. Chemical Process Design, Robin Smith, McGraw Hill Book Co. New York.
5. Hand Book of Industrial Chemicals, By SIRI Board of Consultants and Engineers, Small Industries Research Institute, New Delhi.
6. Small Medium and large Scale Industries, A.K. Sirivastawa, Small Industries Research Institute, New Delhi.
7. The Chemistry of Cement, H.F.W. Taylor, Academic Press, London.
8. Shereve's Chemical Process Industries, 5th Ed.1975, By G.T.Austin, McGraw Hill Book Co. New York.
9. Industrial chemistry, B. K. Sharma, Krishna Prakashan Media (P) Ltd.
10. Perfumes Cosmetics and Soaps, W.A. Poucher, chapmann and Hall 7th Ed.
11. Applied Chemistry Theory and Practice,O.P. Vermani& A.K. Narula,WileyEastern Limited

Course Code: CHEM-531 **Course Name:** Biochemistry-I
Course Contents

Introduction to Biochemistry:
Introduction, Importance and the scope of Biochemistry.Forms, functions and brief classification of prokaryotes.Cellular architecture and diversity of eukaryotes.

Physical aspects of biochemistry:
Water, ionization of water, pH, Acid-base reactions, Buffers and their application in biological systems.

Biomolecules:
Overview of Biomolecules and their structures including Proteins, Carbohydrates, Lipids and Nucleic acids, Nucleosides and Nucleotides, Purines and Pyrimidines.Introduction to DNA, RNA.

Evolution of life:
Prebiotic molecular evolution and rise of living systems. Review of the variety and ecology of the living world. Use and significance of Radioisotopes in Biochemistry.

Books Recommended

1. D. Voet, J.G. Voet, Biochemistry, John Wiley and Sons, New York (2001).
2. Text Book of Biochemistry (1970) by E. West & W. Todd Macmillan.
3. Biochemistry. (1999) 3rd Ed. by C.K. Mathews, K.E. Van Holde, K.G. Ahern. Prentice Hall.
4. Harper's Illustrated Biochemistry, 27th Ed. by R.K. Murray, D.K. Grannar, V.W. Rodwell. McGraw Hill.
5. Lehninger Principles of Biochemistry (2008) 5th Ed. by D.L. Nelson, M.M. Cox. W. H. Freeman Publishers
6. Wilson, A. Practical Biochemistry: Principle and techniques (2000).
7. Swotzer, Experiment Biochemistry theory and exercises in fundamental method
8. (2000).
9. Dryer, R. L. and G. F. Lata, Experimental Biochemistry, Oxford University Press.
10. Plummer, D. T., Introduction to Practical Biochemistry, McGraw Hill Book Co., New York (1986).
11. R.R. Alexander, J.M. Griggiths, M.L. Wikinson, Basic Biochemical Methods, John Wiley& Sons.

12. I.D.P. Wooton, Microanalysis in Medical Biochemistry, J&A Churchill.

Course Title: Fuel Chemistry-I
CHEM=541
Credit Hours: 3+1
Marks=100

Course Objectives:

Able the students about the chemistry of fossil fuels like coal, petroleum and natural gas and their conversion processes to get useful chemical products. Improve their understanding about alternative fuels to be used in case of no availability of petroleum-based oils.

Course Contents:

Introduction Classification and Chemistry of fossil fuels. Origin of coal, petroleum and natural gas. Petrology of fossil fuels Worldwide use and environmental problems related to fossil fuel consumption.
Origin and theory of coal, classification of coal, physical and mechanical properties of coal. Chemical composition and properties of coal. Use of coal as energy source in different industries like power generation, steel and other metallurgical operations.
Origin and nature of petroleum and natural gas. Physical and chemical properties of petroleum. Preliminary treatment of crude petroleum and fractional distillation. Cracking, reforming and classification of petroleum products.
alternative fuels. Bio-fuels, alcohol and alternate fuels, liquid fuels from oil shale and tar. Nitogen hydride as alternative fuel.

Lab:
Determination of moisture contents of coal mined in different parts of Pakistan.
Determination of Ash contents of coal mined in different parts of Pakistan.
Determination of Volatile matter of coal.
Determination of fixed carbon contents of coal.
Determination of various forms of sulfur in coal.
Determination of specific and API gravity of petroleum fractions.
Estimation of carbon residue in petroleum products (Conradson method).
Determination of ash content in petroleum products.
Determination of cloud and pour point of Lube-oil.
Estimation of asphalt in road samples.

Recommended Books:

1. Gyngell, E.S. *Applied Chemistry for Engineers,* Edward Arnold Publisher, Ltd. London. (1989).

2. Harker, J.H. and Backurst, J.R. *Fuel and Energy,* Academic Press, London and New York (1988).
3. Wilson, P.J. and Wells, J.H. *Coal Coke and Coal Chemicals,* McGraw-Hill Book Company, London, (1980).
4. Hobson, G.D. *Modren Petroleum Technology,* part-I. John Wily & Sons, Toronto, (1984).
5. Goodger E.M. *Alternative Fuels (chemical energy resources),* The Macmillan press Ltd, London, (1980).

Course Code: CHEM-551 **Course Name:** Inorganic Chemistry-I

Course Contents

Coordination Compounds:

Study of coordination compounds regarding their historical back ground, nomenclature, geometry, theories i.e. Jorgensen theory, Werner's theory, valence bond theory, crystal field theory and molecular orbital theory. Properties of coordination compound i.e. magnetic properties, stability and stereochemistry. Techniques for studying coordination compounds and their applications.

Chemistry of f-block elements:

- **(a) Lanthanides:** General characteristics, occurrence, extraction and general principles of separation, electronic structure and position in the periodic table, lanthanides contraction, oxidation states, spectral and magnetic properties and uses.
- **(b) Actinides:** General characteristics, electronic structure, oxidation state and position in the periodic table, half-life and decay law.

Books Recommended

1. J.E. Huheey, E.A Keiter, R.L. Keiter. Inorganic Chemistry: Principles of Structure and Reactivity, 4^{th} Ed., Harper and Row, New York, 2001
2. F.A. Cotton., G. Wilkinson, P.L. Gaus. Basic Inorganic Chemistry, 3^{rd} Ed., Wiley, New York, 1995.
3. F. Basolo, R.C Johnson. Coordination Chemistry, Tallahassee, Florida, 1962.
4. F.A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, “Advanced Inorganic Chemistry”, 6^{th} Ed., Wiley-Inter-sceince, New York, 1999.
5. E.M. Larsen. “Transition Elements”, W.A. Benjamin Inc., 1995
6. J. Bassette., G.H. Denney, J. Mendham. “Vogel’s Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis” English Language Book Society, 4^{th} Edition, 1981.
7. A.I. Vogel, A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis, Longman Green & Co. 1995.

8. C. Housecraft, A.G. Sharpe, Inorganic Chemistry, 4th ed., PrenticeHall, (2012).
9. G.L. Miessler, D.A. Tarr, Inorganic Chemistry, 4th ed., Pearson-Prentice Hall International, (2010).
10. B. Douglas, D. McDanial, J. Alexander, Concepts and Models ofInorganic Chemistry, 3rd ed., John-Wiley & Sons, New York, (1994).
11. D. Shriver, P. Atkins, Inorganic Chemistry, 5th ed., W. H. Freeman &Company, (2010).
12. U. Müller, Inorganic Structural Chemistry, 2nd ed., John-Wiley & Sons,Ltd., (2006).
13. R.A. Marusak K. Doan, S.D. Cummings, Integrated Approach toCoordination Chemistry, 1st ed., John-Wiley & Sons, (2007).
14. S.U. Chaudhary, Ilmi Textbook of Inorganic Chemistry, Ilmi Kitab Khana,Urdu Bazar, Lahore, (2013).

Inorganic Chemistry Practical **Credit Hours: 01**

1. Analysis of salts mixtures for anions and cations
2. Determination of Zn and Cd by Complexometric titrations
3. Spectrophotometric determination of iron, manganese and nickel.
4. Preparations of following Inorganic Complexes;
   (a)Tetraamminecopper(II)sulphate
   (b) Potassiumtrioxalatochromate(III)
   (c)Potassiumtrioxalatoaluminate(III)
   (d) *cis*-Potassium dioxalatodiaquachromate(III)
5. Chromatographic separations of Ni^{2+}& Co^{2+} ions in a mixture by paper chromatography.

Course Code: CHEM-561 **Course Name:** Organic Chemistry-I

Course Contents

Introduction to Organic Chemistry:

Classification of organic compounds; development of systematic nomenclature of organic compounds; IUPAC nomenclature of hydrocarbons and heteroatom functional groups. Localized and delocalized chemical bonding; concept of hybridization leading to bond angles, bond lengths, bond energies and shape of organic molecules; dipole moment; inductive and field effects; resonance; aromaticity; tautomerism; hyper conjugation; hydrogen bonding.

Stereochemistry:

Introduction to Stereochemistry, stereoisomerism, geometrical isomerism, E/Z notations, chirality, enantiomers and diastereomers, *meso*-compounds, optical isomerism, optical activity and specific rotation, R/S nomenclature, conformations and conformational analysis of ethane and cyclo-hexane.

Organic Reactions and Mechanism:

Detailed mechanism of aliphatic reactions including addition, substitution, andelimination reactions, concept of energy profile, transition state andintermediate.

Recommended Books

1. Clayden, J., Greeves, N., Warren, S. and Wothers, P., "Organic Chemistry", Oxford University Press, New York.
2. Loudon, G. M., "Organic Chemistry", Oxford University Press, New York
3. Sorrell, T. N., "Organic Chemistry", Viva Books Private Ltd., New Delhi.
4. Finar, I. L., "Organic Chemistry", Vol. 1, Pearson Education, Delhi.
5. Carey, F. A., "Organic Chemistry", McGraw-Hill, New York.
6. Ahluwalia, V. K. and Goyal, M., "A Text Book of Organic Chemistry", Narosa Publishing House, New Delhi
7. March, J., "Advanced Organic Chemistry", John Wiley & Sons, New York.
8. Bansal, R. K., "Organic Reaction Mechanisms", Tata McGraw-Hill Publishing Company Ltd., New Delhi.
9. Pine, S. H., "Organic Chemistry", National Book Foundation, Islamabad.

10. Bailey Jr., P. S. and Bailey, C. A., “Organic Chemistry-A Brief Survey of Concepts and Applications”, Prentice-Hall, New Jersey.

Organic Chemistry Practical **CreditHours: 01**

1. Laboratory Ethics and safety measures
2. Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations.
3. Experiments using polarimeter such as to determine optical activity of a sugar solution and to determine sugar concentration by polarimeter, isomerization ofmaleic acid.
4. Experiments involving aliphatic addition, elimination and substitution reactions,e.g., synthesis of cyclohexene from cyclohexanol, addition reaction tocyclohexene etc.
5. Synthesis of a chalcone explaining the concept of condensation and dehydration, *N*-Alkylation of phthalimide.

Course Code: CHEM-571 **Course Name:** Physical Chemistry-I
Course Contents

Kinetic Molecular Theory of Gases:
KMT assumption & KM equation, Binary collisions & molecular velocities, Maxwell’s law of molecular velocities.Calculation of molecular velocities, Maxwell-Boltzmann’s law of energy distribution.

Quantum Chemistry:
Black body radiation, photoelectric effect, line spectra of elements, Bohratomic model, wave and particle nature of matter, de Broglie’s equation,Young’s double slit experiment, Heisenberg’s uncertainty principle,wavefunctions and Born interpretation of wavefunctions, probability density,eigenfunctions and eigenvalues, Hamiltonian operator, Schrödinger waveequation, wavefunctions for hydrogen-like atomic orbitals, radial distributionfunctions, shielding and penetration, effective nuclear charge, orbital energies,periodic trends in the properties of the elements in the periodic table.

Phase Equilibrium:
Gibbs phase rule, Phase diagrams of one component and two componentsystems, Gibbs energy and the phase diagram of a substance, location ofphase boundaries, Clausius-Clapeyron equation, vapor-liquid equilibrium ofbinary liquid mixtures, binary phase diagrams and lever rule.

Chemical Kinetics:
Rate of Chemical reaction & rate law, integrated rate laws of 1st& 2nd order reactions with same and different initial concentrations of reactants.Effect of temperature on the reaction rate.Lindeman's theory of unimolecular reactions.Bimolecular collision theory.

Chemical Equilibrium:
Types of equilibrium, Characteristic of chemical equilibrium, Law of mass action, Le Chatelier's principle, Equilibrium constant and the effect of variable e.g. temperature, concentration and pressure on equilibrium constant,Relationship between Kc,Kp,Kx and Kn, Temperature and chemical equilibrium-The Vant Hoff equation.

Books Recommended

1. R.A. Alberty, J.S. Robert, G.B. Moungi Physical Chemistry, 4thed, John Wiley and Sons (2004).
2. D.W. Ball, Physical Chemistry, 1st ed., Brooks/Cole Co. Inc. (2003).

3. Engel, Thomas, P.Reid, Thermodynamics, Statistical Thermodynamics,and Kinetics 1st ed., Benjamin Cummings (2006).
4. K. James, P. Wothers, Why Chemical Reactions Happen. Oxford University Press (2003).
5. E. Smith, E. Brain, Basic Chemical Thermodynamics 5th ed., Imperial College Press (2004).
6. B. R. Stephen, S. A. Rice, J. Roses, Physical Chemistry, 2nd ed., Oxford University Press (2000).
7. W. Jurg, Basic Chemical Thermodynamics,W. A. Banjamin (1969).
8. I. Chorkendorff, I. J.W. NiemantsverdrietConcept of Modern Catalysis and Kinetics, 1st ed., John Wiley and Sons (2003).
9. J.H. Espenson, Chemical Kinetics and Reaction Mechanism, 2nd ed., McGraw Hill (2002).
10. R.S. Berry, A.R. Stuart, J. Roses, Physical and Chemical Kinetics, 2nd ed., Oxford University Press (2000).
11. M. Helpern Arthur, Experimental Physical Chemistry: A Laboratory Textbook 2nd ed., Prentice Hall (1997).
12. J. Bassette, C. Denney,G.H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society.4th ed. (1978).
13. F. Daniel, Experimental Physical Chemistry, McGraw Hill (1962).
14. D. Shoemaker, Experimental Physical Chemistry, McGraw Hill (1989)

Physical Chemistry Practical **Credit Hours: 01**

1. Equilibrium constant of the reaction.
2. Kinetics of saponification of ethyl acetate.
3. Determination of partial molar volumes.
4. Characterization of the given compound by UV-Vis spectroscopy.
5. Equilibrium constant of the $KI + I_2 = KI_3$ reaction.
6. Acid catalyzed hydrolysis of sucrose.
7. Study of the adsorption isotherms of acetic acid-charcoal system.
8. Study of the charge transfer complex formation between iodine and benzene.
9. Determination of activation energy for the acid catalyzed hydrolysis of ethylacetate.

Course Code: MATH-590 **Course Name:** Mathematics

Course contents

Large and small numbers, exponents and radicals, function and their graphs,permutation and combinations, binomial theorem, trigonometric functions,graph of logarithmic and trigonometric functions.

Differential calculus:

Rules for differentiation, graphical significance of differentiation, successive differentiation, partial differentiation, solution of the problems of differential calculus.

Integral calculus:

Theory, rules, integration between limits, integration by partial fractions, solutions of the problem of integration with reference to physical chemistry.Infinite series, McLaurin series, Taylor series, Fourier series.

Books recommended

1. Anton H, Bevens I, Davis S, Calculus: A New Horizon (8th edition), 2005, John Wiley, New York
2. Stewart J., Calculus (3rd edition), 1995, Brooks/Cole (suggested text)
3. Swokowski E.W. Calculus and Analytic Geometry, 1983, PWS-Kent Company, Boston
4. Thomas G.B, Finney AR, Calculus (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

FIRST YEAR (SEMESTER-II)

S.NO	Course Code	Course Name	Credit Hours
1	CHEM- 512/ CHEM- 522/ CHEM- 532/ CHEM-542	Analytical Chemistry paper-II/Applied Chemistry paper-II/ Biochemistry Chemistry paper-II/Fuel Chemistry-II	3+1
2	CHEM- 552	Inorganic Chemistry paper-II	3+1
3	CHEM- 562	Organic Chemistry paper-II	3+1
4	CHEM- 572	Physical Chemistry paper-II	3+1
5	ENG-502/ COMP-503	Computer/English	2+0
Total Credit Hours			18

Course Code: CHEM-512 **Course Name:** Analytical Chemistry-II
Course Contents

Chemical Equilibrium:
Types of equilibrium, Characteristic of chemical equilibrium, Law of mass action, Le-Chatelier's principle, Equilibrium constant and the effect of variable e.g. temperature, concentration and pressure and catalysis on equilibrium constant.

Electroanalytical techniques:
The electrochemical cell. Oxidation and reductions potentiometric methods, various types of electrodes and their use, Redox reactions, spontaneous reactions, electrochemical cells, standardelectrode potentials, liquid junction potential, electrochemical series, Nernst'sequation, some well-known redox reactions of analytical importance, ion selective electrodes.

Books Recommended

1. Gary D. Christian, Analytical Chemistry, John Wiley and Sons.
2. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Fundamentals of Analytical Chemistry, Reinhote, New York.
3. Robert D. Braun, Introduction to Chemical Analysis,
4. I.M. Kolthoff, Sandell, Text Book of Quantitative Inorganic Analysis, Macmillan and Co. New York.
5. David Harvey, Modern Analytical Chemistry.
6. J. Bassette., G. H Denney, and J. Mendham,. Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, English Language Book Society, 4th Edition, 1981.
7. A.I. Vogel, A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis, Longman Green & Co. 1995.

Analytical Chemistry Practical **Credit Hours: 01**

1. To verify Beer's Law and to evaluate molar extinction coefficient.
2. Spectrophotometric determination of Ammonia.

3. To determine Iron by spectroscopic method using phenonthroline.
4. To determine the distribution coefficient of a given solute between an aqueous/non aqueous system.
5. To determine Calcium by indirect volumetric method.
6. To determine Zinc by direct titration with EDTA.
7. To estimate Lead amperometrically through titration with Potassium dichromate.

Course Code: CHEM-522 **Course Name:** Applied Chemistry-II
Course Contents

Water Softening and Scale Removing:
Water hardness; its measurement and removal; methods used for water softening including ion-exchange and reverse osmosis, distillation and precipitation. Types of boiler scales.Chemical and mechanical methods to eliminate the scaling.

Glass Industries:
History of glass, raw materials used for glass, methods of manufacturing, various types of furnaces and crucibles used for the manufacture of glass, special types of glass, their manufacture and properties.

Soap and Detergent Industries:
Processes involved in soap manufacturing, methods used for manufacture of laundry soap, typical soaps. Recovery of glycerin.Detergents or surface active agents, cationic, anionic and non-ionic agents.

Distillation:
Vapor liquid equilibrium, methods of getting equilibrium data for binarysystems, construction of equilibrium diagram, designing of distillation column,reflux ratio and its importance.

Composite Materials:
Introduction to composite material, classification of composite on the basis ofreinforcement (Particle–Reinforced composite, Fibre–Reinforced composite,structural composites) and classification of composites on the basis of matrixphase (Polymer–Matrix composite, Metal–Matrix composite, Ceramics–Matrixcomposite, Carbon-carbon composite, Hybrid-composite, Laminar composite,Sandwich panels), synthesis, properties and applications of compositematerials.

<u>Books Recommended</u>

1. Industrial Organic Chemicals, by H.A.Witcoff and B.J.Reuben, John Wiley & Sons Inc. New York.
2. Water Supply and Sewerage, T.J.McGhee,McGraw Hill Book Co. New York.
3. Unit operations in Chemical Engineering, Chattopadhyay, Khanna Publishers, Delhi-6.
4. Chemical Process Design, Robin Smith, McGraw Hill Book Co. New York.
5. Hand Book of Industrial Chemicals, By SIRI Board of Consultants and Engineers,

Small Industries Research Institute, New Delhi.

6. Small Medium and large Scale Industries, A.K. Sirivastawa, Small Industries Research Institute, New Delhi.
7. Chemistry of glass manufacturing, F.W.Hunter, Dower Publications, New York.
8. Shereve's Chemical Process Industries, 5th Ed.1975, By G.T.Austin, McGraw Hill Book Co. New York.
9. Industrial chemistry, B. K. Sharma, Krishna Prakashan Media (P) Ltd.
10. Applied Chemistry Theory and Practice,O.P. Vermani& A.K. Narula,WileyEastern Limited
11. T. B. of Quantitative Inorganic Analysis, Vogal's Ed-4th, Longman Group Limited.

Applied Chemistry Practical Credit Hours: 01

1. Spectrophotometric determination of $KMnO_4$, $K_2Cr_2O_7$ and $CoCl_4$ Estimation of nickel in vanaspati ghee. Estimation of chloride in the tannery effluent. Estimation of Iron in Pharmaceutical Products. Estimation of Phosphates in fertilizers.
2. Chromatographic separation of mixture of ink by circular paper chromatography, separation of mixture of metal ions by paper chromatography, coating of TLC plates and separation of mixture of dyes,separation of different pigments of plant extract by TLC chromatography.
3. Estimation of total solids in water.
4. Estimation of chloride in water.
5. Extraction of capsicum oil (soxhlet extraction).
6. Extraction of clove oil from cloves.
7. Estimation of Manganese in Steel.
8. Estimation of Ferric Iron in Cement.
9. Preparation of liquid detergents.
10. Measurement of water hardness with EDTA Titrations.
11. Estimation of Ferrous and Ferric ions in drinking water by redox titration.
12. Study of the kinetics of dissolution of Magnesium metal in dilute HCl.

Course Code: CHEM-532 **Course Name:** Biochemistry-II

Intermediary Metabolism and Bioenergetics:
Biological oxidation-Reduction including respiratory carriers, cell bioenergetics,Oxidative phosphorylation, free energy change and redox system.

Enzymes:
Enzyme-substrate interactions and nature of active site, mechanism ofenzyme action with specific reference to chymotrypsin and ribonuclease,kinetics of single substrate reactions, enzyme inhibition, regulatory enzymes,Allosteric enzymes, Multienzyme system, zymogens, and isozymes, enzymaticcontrol of metabolic pathways, immobilized enzymes, synthesis, propertiesand uses.

Metabolism of Carbohydrates:
Digestion, Absorption and Transport of sugars into cell, Glycolysis, Citric AcidCycle, HMP pathway and its significance, Uronic acid pathway,Gluconeogenesis, Glycogenesis, Glycogenolysis, Photosynthesis.

Metabolism of Lipids:
Digestion of Lipids, absorption and transport of lipids and fatty Acids, Oxidationsaturated and unsaturated, odd chain and branched chain fatty acids,Biosynthesis of fatty acids and eicosanoids, Biosynthesis of triglycerides,phosphides, steroid and Bitter acids, Biosynthesis and utilization of Ketonebodies.

Metabolism of Proteins:
Digestion of proteins, absorption and transport of amino acids to the cell,Biochemical reaction of amino acids: decarboxylation, deamination,transamination and transmethylation etc., metabolism of essential aminoacids, metabolic disorders, urea cycle, Creatine and uric acid synthesis, interrelationshipbetween carbohydrate, lipid and protein metabolism.

Metabolism of Nucleic Acids:
Biosynthesis and catabolism of purines and pyrimidines and their regulation,synthesis, catabolism of nucleosides, DNA polymerases and other enzymesinvolves in metabolism.

<u>Books Recommended</u>

1. Essentials of Carbohydrate Chemistry (1998) by John F. Robyt. Springer verlag
2. Text book of Biochemistry (2008) by S.P. Singh. CBS Publishers
3. Text book of Biochemistry (2007) by K. Rambabu.
4. Fundamentals of Biochemistry (2008) 3rd Ed. by D. J. Voet, G.J. Voet and C. W. Pratt.

5. J. Wiley & Sons Inc.
6. Lehninger Principles of Biochemistry (2008) 5th Ed. D. L. Nelson, M. M. Cox. W. H.
7. Freeman Publishers.
8. Fundamentals of Biochemistry by J. I. Jain. (2008) S. Chand & Co. India
9. Biochemistry. (1999) 3rd Ed. by C. K. Mathews, K. E. Van Holde, & K.G. Ahern.
10. Prentice Hall.
11. Text book of Biochemistry & Human Biology (2006) 3rd Ed. by G.P. Talwar& L.M.
12. Srivastava. Prentice Hall India.
13. Text book of Biochemistry 3rd edition (2009) by Satyanarayana.
14. Biochemistry 3rd Ed. (1999) by C. K. Mathews, K. E.vanHolde and K.G. Ahern.
15. Prentice Hall.

Biochemistry Practical **Credit Hours: 01**

1. Qualitative analysis of carbohydrates lipids and proteins with different tests.
2. Counting WBC, RBC and platelet.
3. Analysis of blood glucose level
4. Blood grouping
5. Electrophoresis

Course Title: Fuel Chemistry-II
CHEM-542
Credit Hours: 3+1
Marks=100

Course Objectives:

Able the students about the processes involving purification/separation of fossil fuels,their high yielding and environmentally friendly utilization as well as conversion into a variety of highly demanding chemicals. To under alternative fuels especially renewable energy sources in detail.

Course Contents:

Cleaning of coal by various methods (gravity, float and sink, froth flotation methods). Storage of coal. Carbonization of coal. Coking and non-coking coals, ASTM international and coal Standards. Separation of tar, ammonia, light oil, hydrogen sulfide and Sulphur compounds from coke oven gas. coal gasification,methanation and dehydration. Innovations in coal using industry.

Chemistry of petroleum products; CNG, LPG, Diesel, gasoline, kerosene oil, fuel oil, lubricating oil and greases. Preparation, structure and properties of cracking and reforming.Mechanism of cracking and reforming catalysts. Effect of operating conditions on cracking and reforming products. Hydroforming and desulphurization of petroleum products. Petrochemicals from various processes (oxidation halogenation, alkylation etc).
Modern methods of petroleum conversion.

Introduction to alternate sources of energy: Biomass, Biogas technology. Alcohols. Hydrogen production, storage, handling and its uses as alternative fuel. FuelCells and its application, Solar Energy: Solar energy collectors. Geothermal powers, Nuclear fuels:fission and fusion, nuclear reactors and introduction to Hydel energy.

1. Wen, C.Y. and Stanley, E. *Coal conversion Technology,* Addison-Wesley, New York. (1979).
2. Probstein, R.F and Hicks, R.E. *Synthetic Fuels,* McGraw Hill, New York. (1982).

3. Francis, W. *Fuels and Fuel Technology,* Pergamon Press, London. (1980).
4. Merick, D. *Coal Combustion and Conversion Technology,* McMillan Ltd., London (1984).
5. Hobson, G.D. *Modern Petroleum Technology,* Part 2, John Wiley and Sons, New York. (1984).
6. Gates, B.C, Katzer, J.R and Schuit, G.C.A. *Chemistry of Catalytic Processes,* McGraw Hill Book company, London (1979).
7. List, H.L. *Petrochemical Technology,* Printice-Hall Englewood Cliffs, New Jersey. (1986).

8. Matar, S. and Hatch, L.W. *Chemistry of Petrochemical Processes,* 2nd Ed. Gulf Publishing Company. Houston, Texas, USA (2002).

9. Twidell, J. and Weir, T. *Renewable Energy Resources,* Sopn London, New York, (1986).

Lab:

Determination of hydrogen and nitrogen contents of the coal.
Determination of chlorine and oxygen in coal.
Determination of sulfated ash in lube oil.
Estimation of water, sediments and oil in crude oil by centrifuge method.
Determination of the total base number of petroleum products by potentiometric titration.
Determination of total salt content in crude petroleum by conductivity method.
Determination of the kinematic viscosity of asphalt (bitumen).
of liquid hydrocarbon fuels. Determination of neutralization number of lubricating oils by potentiometric titration.
Determination of total sulfur in coal by bomb calorimeter.
Determination of chlorine in coal by bomb calorimeter.
Determination of the distillation behavior of petroleum fractions.
Determination of sulfur in petroleum products by bomb calorimeter method.
Determination of sulfur in petroleum products by lamp method.

Course Code: CHEM-552 **Course Name:** Inorganic Chemistry-II

Course contents

Introduction to inorganic materials, crystalline and amorphous states, bonding in solids, non-stoichiometric compounds, binary solid solutions, mechanical, electrical, magnetic, dielectric, optical, and chemical (corrosion) properties of advanced materials, synthesis (e.g., sol-gel, hydrothermal techniques, etc.) and design of inorganic materials and characterization, doping and purification of silicone, chemical vapour deposition and sputtering, introduction to nano-materials.

Books recommended

1. J. E. Huheey., E.A. Keiter., and R.L. Keiter,., “Inorganic Chemistry: Principles of Structure and Reactivity”, 4th Ed., Harper & Row, New York, 2001.
2. F.A. Cotton., G. Wilkinson., C.A.Murillo, and M.Bochmann.,“Advanced Inorganic Chemistry”, 6th Ed., Wiley-Intersceince, New York, 1999.
3. N.N. Greenwood., and AEarnshaw. “Chemistry of the Elements”, 2nd Ed., Pergamon Press, New York, 1992.
4. W. Willium. Porterfield. Inorganic chemistry, Unified approach, Elsevier Company, Delhi, (2005)
5. K.M. Mackay., R.A., Mackay. and W. Henderson,., “Introduction to Modern Inorganic Chemistry”, 5th Edition, Stanley Thomas Publisher Ltd. 1996
6. J. Bassette., G.H Denney., and J. Mendham, “Vogel’s Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis” English Language Book Society, 4th Edition, 1981.
7. A.I. Vogel. “A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis” Longman Green & Co. 1995.
8. Kumar, A text Book of Inorganic Chemistry, Jhon Wiley, New Delhi.
9. Zafar Iqbal, Pi acceptors Ligands University Grants communication, Islamabad.

Inorganic Practical Credit Hours: 01

1. Separation of cations and anions in a mixture by paper chromatography.
2. Gravimetric estimation of Ba^{2+} and Fe^{3+} ions
3. Preparation of at least four inorganic compounds using various synthetic techniques
4. Estimation of Ca^{2+} and Mg^{2+}; $Fe^{3+}$and Al^{3+} volumetrically.

5. Estimation of anions in mixtures:
6. Chloride-phosphate, chloride-nitrate, oxalate-chloride, sulphatephosphate, bromide-nitrate, borate-acetate, iodide-nitrate.
7. Spectrophotometric determination of cerium.
8. Separation of heavy metals using solvent extraction technique.
9. Iodometric titration with potassium iodate.
10. Gravimetric estimation of oxalate.
11. Precipitation Titrations.
    (a) Determination of strength of NaCl given solution by $AgNO_3$ usingFluorescein as indicator.
    (b) Determination of % age purity of KBr using Fluorescein as indicator.
    (c) Determination of % composition of mixture of KI & KNO_3 usingEoscein as indicator.

Course Code: CHEM-562 **Course Name:** Organic Chemistry-II

Course contents

Introductory Organic Spectroscopy:
Introduction to UV-Visible, IR, ^{1}HNMR and mass spectrometric methods and their uses for the structure determination of simple organic compounds.

Aromatic Substitution Reactions:
Mechanisms of aromatic reactions including electrophilic and nucleophilicsubstitutions, effect of substituents on orientation and reactivity.

Oxidation-reductions Reactions:
Common oxidizing and reducing reagents, reactions involving elimination of H,cleavage of C-C bond, replacement of hydrogen by oxygen, and addition ofoxygen to substrates, reaction involving replacement of oxygen by hydrogen,removal of oxygen from the substrates and reduction with cleavage.

Pericyclic Reactions:
Introduction to pericyclic reactions, frontier orbital theory, mechanisms ofelectro-cyclic, cyclo-addition and sigma tropic reactions.

Recommended Books

1 March, J., "Advanced Organic Chemistry", John Wiley & Sons, New York.

2 Loudon, G. M., "Organic Chemistry", Oxford University Press, New York.

3 Brown, W. H., "Introduction to Organic Chemistry", Saunders College Publishing, Tokyo.

4 Sykes, P., "A Guide Book to Mechanism in Organic Chemistry", Longman, London.

5 Pine, S. H., "Organic Chemistry", National Book Foundation, Islamabad.

6 McMurry, J., "Organic Chemistry", Brooks/Cole Publishing Company, California.

7 Carey, F. A., "Organic Chemistry", McGraw-Hill, New York.

8 Kalsi, P.S. "Spectroscopy of Organic Compounds", Wiley Eastern Ltd., New Delhi.

9 Pavia, D. L., Lampman, G. M. and Kriz, G. S., "Introduction to Spectroscopy: A Guide for Students of Organic Chemistry", Saunders Golden Sunburst Series, London.

10 Furniss, B. S., Hannaford, A. J., Smith, P. W. G. and Tatchell, A. R., "Vogel's Text Book of Practical Organic Chemistry", National Book Foundation, Islamabad.

11 Shriner, R. L., Hermann, C. K. F., Morrill, T. C., Curtin, D. Y. and Fuson, R. C., "The Systematic Identification of Organic Compounds", John Wiley & Sons, New York.

12 Mendham, J., Denney, R. C., Barnes, J. D. and Thomas, M. J. K., "Vogel's Text Book of Quantitative Chemical Analysis", Pearson Education, New Delhi.

Organic Chemistry Practical Credit Hours: 01

1. Separation of amino acids by TLC.
2. Determination off boiling point of organic liquids by sublimation
3. Re-crystallization of crude organic compounds
4. Determination of melting point of organic compound
5. Separation of ink pigments by ascending chromatography
6. Separation of ink pigments by descending chromatography
7. Preparation of benzoic acid and benzyl alcohol from benzaldehyde usingCannizzaro's reaction.
8. Experiments involving aromatic substitution, oxidation/reduction reactions andpericyclic reactions, nitration of nitrobenzene to meta-dinitrobenzene, reduction of meta-dinitrobenzene to meta-nitroaniline, sulphonation of aniline,Oxidation of benzaldehyde, oxidation of cyclohexanol to cyclohexanone.

Course Code: CHEM-572 **Course Name:** Physical Chemistry-II

Course Contents

Conductometry:
Ions in solution, measurement of conductance and Kohlrausch's law, mobilityof ions and transport number, conductometric titrations, Debye-Hückel theoryand activity coefficient, determination of activities, application of conductancemeasurement.

Electrochemistry:
Redox reactions, spontaneous reactions, electrochemical cells, standardelectrode potentials, liquid junction potential, electrochemical series, Nernst'sequation, thermodynamic of redox reactions, measurement of pH and pKa,dynamic electrochemistry, Latimer Diagram, Frost Diagram, electrolytic cells,potentiometry, reference and indicator electrodes, voltammetry, fuel cells,corrosion and its prevention, fuel cell and hydrogen economy.

Surface Chemistry:
Interfaces, Gibbs surface excess, curved surfaces, capillary action, adsorptionand adsorption isotherms, Freundlich and Langmuir adsorption isotherms,catalysis, colloids, emulsion and their industrial applications.

Nuclear Chemistry:
Atomic nucleus, nuclides, nuclear stability, modes of decay, nuclearenergetics, nuclear models (shell + liquid drop model), fusion and fission, nonspontaneousnuclear processes, nuclear reactors, beta decay systematic.

Chemical Thermodynamics:
1^{st} law of thermodynamics, Pressure-volume work & enthalpy of a system, heat capacity of gas at constant volume & constant pressure, 2^{nd} law of thermodynamics & entropy, Free energy Change, dependence of free energy on temperature and volume. Relation of free energy with equilibrium constant, Clausius-Clapeyron's equation.Partial molar quantities & Chemical potential.

<u>Books Recommended</u>

6. Albert R.A., Robert J.S. and Moungi G.B. "Physical Chemistry". 4^{th} ed., John Wiley and Sons (2004).
7. Ball D.W. "Physical Chemistry" 1^{st} ed., Brooks/Cole Co. Inc. (2003).
8. Bassetts J., Denney C., Jeffery G.H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4^{th} ed. (1978).
9. Hatch R.C. "Experimental Chemistry" van Nostrand Reinhold Company (1972).

10. Halpern, Arthur M. “Experimental Physical Chemistry: A Laboratory Textbook” 2nd ed.,Prentice Hall (1962).
11. Silbey, R. J., Alberty, R. A. and Bawendi, M. G., Physical Chemistry, 4th ed., John-Wiley & Sons, (2005).
12. Vertes, A., Nagy, S. and Klencsar, Z., Handbook of Nuclear Chemistry. Volume 1: Basics of Nuclear Science, 1st ed., Springer, (2003).
13. Choppin, G., Liljenzin, J-. O. and Rydberg, J., Radiochemistry and Nuclear Chemistry, 3rd ed., Butterworth- Heinemann, (2002).
14. Loveland, W., Morrisey, D. J. and Seaborg, G. T., Modern Nuclear Chemistry, John-Wiley & Sons, Inc., (2006).
15. Atkins, P. and Paula, J. D., Atkin’s Physical Chemistry, 9th ed., Oxford University Press, (2010).
16. Somorjai, G. A. and Li, Y., Introduction to Surface Chemistry and Catalysis, 2nd ed., John-Wiley & Sons, Inc., (2010).
17. Laidler. K. J., “Chemical Kinetics” 3rd ed., Prentice Hall, (1987).
18. James, A. M., Prichard, F. E., Practical Physical Chemistry, 3rd ed., Longman Group Limited, New York, (1974).

Physical Chemistry Practical **Credit Hours: 01**

1. Spectroscopic determination of Cu % in the given sample.
2. Conductometric determination of Cu (II)- EDTA mole ratio in the complex.
3. To determine the effectiveness of an extraction of I_2 solution by using Solvent Extraction method.
4. Determination of molecular weight of a polymer by viscosity method.
5. Determination of percentage composition of $KMnO_4$/$K_2Cr_2O_7$ in a given solution by spectrophotometry.
6. Evaluation of pK_a value of an indicator by spectrometric method.
7. Conductometric determination of hydrolysis constant (K_h) of conjugate base of a weak acid.

Course Code: ENG-502 **Course Name:** English

Course Contents

Essay writing:

Descriptive, narrative, discursive, argumentative

Academic writing:

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Presentation skills

Recommended Books

1. Technical Writing and Presentation Skills
2. Essay Writing and Academic Writing
3. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
4. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
5. Patterns of College Writing (4^{th} edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
6. The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Course Code: COMP-503 **Course Name:** Computer
Course Contents

Fundamentals basic concept of computers:

History of Data Processing, Types of Computers, Components of a Computer, Computer System and Business Computer System, Backing, Storage Devices, Unit of Memory, Viruses and Anti-viruses Issues.

System Analysis and Design:
What is a System? Steps in system life cycle, Data Gathering and DataAnalysis, Designing a New System, Development and Implementation ofNew System, Documentation.
E-mail: browsers, search engines, social websites, databases.

Data Communication:
Applications of Data Communication, Components of a datacommunication system, Rate of data Transmission, Computer Networks,Network Topology, Gateway, E-mail/Internet concepts.

Books Recommended

5. Elias M System Analysis. Award Galgotia Publications, New Delhi,1989.112
6. Peter Norton, Inside IBM PC. Brady Computer Books, New York, 1988.
7. Dennis N, MS-DOS. Jump Practice Hall Press, New York, 1987.
8. Peter Norton, PC-DOS. Brady Computer Books, New York, 1985.

SECOND YEAR (SEMESTER-III)

SPECIALIZATION IN ANALYTICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-641	Environmental Chemistry Paper-I	2+1
2	CHEM-611	Elementary Analytical Chemistry	3+0
3	CHEM-612	Advance Separation Techniques	3+0
4	CHEM-613	Spectroscopy& AdvancedInstrumentation	3+0
5	CHEM-614	Advanced Analytical Chemistry	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-641 **Course Name:** Environmental Chemistry-I
Course Content

The atmosphere and air pollution:
Structure and properties of the atmosphere, temperature inversion and air pollution, atmosphere photochemistry, possible depletion of stratospheric ozone, natural vs polluted air, particulate matter, analysis and control of particulations, sulphur oxides, effects of sulphur dioxides and particulates, other industryial air pollutants, carbon monoxide, oxides of nitrogen photochemicals smog, airborne load, control of automobile emissions.

Water and water treatment:
Unique physical and chemical properties of water, criteria of water quality, natural water-eutrophiction, detergents and phosphates, importance of micro-organisms in water purification, primary and secondary treatment of water, advanced waste water treatment, removal of nitrogen and phosphorus, sources of industrial water pollution, heavy metals and mercury.

The green revolution:
Pest control, pesticides, toxicity of pesticides, pest management.

Books Recommended

1. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi
2. J. W. Moore & E. A. Moore, Environmental chemistry, Academic Press, New York.
3. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.
4. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.
5. Staneley E. Manahan, Environmental chemistry, Brooks, California

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipment.

1. Determination of caffeine in tea leaves by HPLC.
2. Determination of fluoride in water samples by spectrophotometric method
3. Determination of lead in polluted water sample by spectrophotometric method
4. Analysis of water; to determine various parameters of the given water sample.
5. Determination of phenol contents in the given sample by spectrophotometric method
6. Analysis of the rain water using potentiometric and conductometric techniques.

Course Code: CHEM-611 **Course Name:** Elementary Analytical Chemistry
Course Contents

Sampling:
Theory of sampling, Preparation of sample for the analysis, various factors involved in sampling process, significant of sampling in analytical chemistry

Precipitation:
Solubility and solubility product.Effects of salt, solvents, hydration, hydrolysis, pH changes, beginnings surface exchange, adsorption etc, on precipitates. Gravimetric analysis, steps involved, Co-precipitation, Heterogeneous precipitates, Determination of error in gravimetric analysis, thermogravimetric methods for testing of thermal stability.

Complexation:
Chelate formation; competing reactions in complexation.The computation of stability constant from various experimental data.The use of complexes in analytical chemistry as reagents.Masking agents. Indicators and metal ion buffers. Complexometric titrations.

Automation:
Automation in analytical chemistry: Instrumental parameters for automated instrument, automated process and instruments in process control and clinical laboratory.

Books Recommended

1. Gary D. Christian, Analytical Chemistry, John Wiley and Sons, New York.
2. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Fundamentals of Analytical Chemistry, Reinholt, New York.
3. Robert D. Braun, Introduction to Chemical Analysis, McGraw Hill Book Co. New York.
4. I.M. Kolthoff, Sandell, Text Book of Quantitative Inorganic Analysis, Macmillan and Co. New York.
5. J.G. Dick, Analytical Chemistry, McGraw Hill Book Co. New York.
6. David Harvey, Modern Analytical Chemistry.

Course Code: CHEM-612 **Course Name:** Advance Separation Techniques

Chromatographic Techniques:

Adsorption and distribution laws applied to chromatography, the displacement, frontal method of analysis and elution techniques: Column, paper and thin-layer chromatography, suitable systems for analysis of some simple organic substances, reversed phase chromatography

Gas Chromatography:

GSC and GLC parameters governing gas phase separation, simple instrumentation for gas chromatography, suitable systems for analysis high temperature programmed analysis.

High Performance Chromatography:

Introduction, Basic Principles, Instrumentation, sample preparation (Normal Phase and reverse phase separation) and applications

Capillary Electrophoresis:

Theory and principle of CE, mobility, electro-osmotic flow separation by CE, instrumentation, mode of operation and applications.

Books Recommended

1. Gary D. Christian, Analytical Chemistry, John Wiley and Sons.
2. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Fundamentals of Analytical Chemistry, Reinholt, New York.
3. Robert D. Braun, Introduction to Chemical Analysis, McGraw Hill Book Co. New York.
4. I.M. Kolthoff, Sandell, Text Book of Quantitative Inorganic Analysis, Macmillan and Co. New York.

Course Code: CHEM-613 **Course Name:** Atomic Spectroscopy

Flame Photometry:

Origin and classification of atomic spectroscopic methods, origin of atomicspectrum, position of the signal, intensity of the signal, spectral line width,principle of flame photometry, fate of the sample in the flame, flame and itscharacteristics,instrumentation for flame photometry, merits and limitations.

Atomic Fluorescence Spectrometry:

Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomicfluorescence transitions, principle of atomic fluorescence spectrometry,fluorescence intensity and analyte concentration, instrumentation for atomicfluorescence spectrometry, applications of atomic fluorescence spectrometry,interferences, merits and limitations.

Atomic Absorption Spectrophotometry:

Principle of atomic absorption spectrophotometry, concentration dependenceof absorption, quantitative methodology, instrumentation for atomic absorptionspectrophotometry, radiation sources, atomizers, flames, graphite furnacesand electrochemical atomizers, monochromators, detectors, handlingbackground absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, preparation of thesample, use of organic solvents, microwave, digestion, sample introductionmethods, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry:

Introduction, principle of atomic emission spectrometry, atomic emissionspectrometry using plasma sources, plasma and its characteristics, inductivelycoupled plasma, direct current plasma, microwave induced plasma, choice ofargon as plasma gas, instrumentation for ICP-MS.

Books Recommended

1. Robert D. Braun, Introduction to Instrumental Analysis McGraw Hill Book Co. New York.
2. Gary D. Christian, James E. O’Reilly, Instrumental Analysis, Allyn and Bacon Inc. New York.
3. Douglas A. Skoog, Stanley R. Crouch, Instrumental Analysis, Reinholt, New York.
4. F.W. Fifield and D. Kealy, Principles and Practice of Analytical Chemistry I.T.B, London.
5. Willard, Meritte and Dean, Instrumental Analysis, D. Van Nostrand, New York.
6. Bernhard Wetz, Atomic Absorption Spectroscopy, Verlay Chemie, New York.

Course Code: CHEM-614 **Course Name:** Advance Analytical Chemistry

Course Contents

Potentiometry:

Electrode potential, Nernst equation and its use for measuring half-cellpotential, different kinds of electrodes including glass and calomel electrodes,working of potentiometer and its applications including pH measurements, Ionselective electrode systems, Ion exchange membrane electrode, solid statemembrane electrodes, and bio-membrane electrodes, Potentiometric titrations.

Coulometry and Electrogravimetry:

Basic electrochemistry, principle, instrumentation of coulometry, principle, instrumentation of electrogravimetry, consequences of electrogravimetry, Ohmic drop, activation over potential, concentration and gas polarization, basic difference and merits/demerits of coulometry and electrogravimetry.

Voltammetry and Polarography:

Basic principle, voltammogram, polarizable and non-polarizable electrodes, solid electrodes, their scope and limitations, cyclic voltammetry, anodic stripping voltammetry. voltammetric equation, basic concept of polarography and interpretation of various polarographic curves, measurement of decomposition potential, diffusion and limiting currents, derivation of Ilkovic equation, logarithmic analysis of polarographic wave, advantages and limitation of dropping mercury electrode.

Books Recommended

1. Robert D. Braun, Introduction to Instrumental Analysis McGraw Hill Book Co. New York.
2. D.A. Skoog, an D.M. West, Principles of Instrumental Analysis, Reinholt, New York.
3. Gary D. Christian, James E. O’Reilly, Instrumental Analysis, John Wiley and Sons.
4. Douglas A. Skoog, Stanley R. Crouch, Instrumental Analysis, Reinholt, New York.
5. I.M. Kolthoff, Sandell, Text Book of Quantitative Inorganic Analysis, Macmillan and Co. New York.
6. F.W. Fifield and D. Kealy, Principles and Practice of Analytical Chemistry I.T.B, London.

SECOND YEAR (SEMESTER-III)

SPECIALIZATION IN APPLIED CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-641	Environmental Chemistry Paper-I	2+1
2	CHEM-621	Petrochemical Industry	3+0
3	CHEM-622	Leather and Paper Industry	3+0
4	CHEM-623	Fertilizer Industry	3+0
5	CHEM-624	Polymers	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-641 **Course Name:** Environmental Chemistry-I
Course Content

The atmosphere and air pollution:
Structure and properties of the atmosphere, temperature inversion and air pollution, atmosphere photochemistry, possible depletion of stratospheric ozone, natural vs polluted air, particulate matter, analysis and control of particulations, sulphur oxides, effects of sulphur dioxides and particulates, other industryial air pollutants, carbon monoxide, oxides of nitrogen photochemicals smog, airborne load, control of automobile emissions.

Water and water treatment:
Unique physical and chemical properties of water, criteria of water quality, natural water-eutrophiction, detergents and phosphates, importance of micro-organisms in water purification, primary and secondary treatment of water, advanced waste water treatment, removal of nitrogen and phosphorus, sources of industrial water pollution, heavy metals and mercury.

The green revolution:
Pest control, pesticides, toxicity of pesticides, pest management.

Books Recommended

6. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi
7. J. W. Moore & E. A. Moore, Environmental chemistry, Academic Press, New York.
8. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.
9. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.
10. Staneley E. Manahan, Environmental chemistry, Brooks, California

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipment.

7. Determination of caffeine in tea leaves by HPLC.
8. Determination of fluoride in water samples by spectrophotometric method
9. Determination of lead in polluted water sample by spectrophotometric method
10. Analysis of water; to determine various parameters of the given water sample.
11. Determination of phenol contents in the given sample by spectrophotometric method
12. Analysis of the rain water using potentiometric and conductometric techniques.

Course Code: CHEM-621 **Course Name:** Common Industry-I
Course Contents

Leather Tanning Industries:
Introduction, important steps in leather manufacturing, theory of leather tanning, waste disposal and pollution aspects involved in tanning industries.

Paper and Pulp Industries:
History and back ground, survey of raw materials, production of pulp by soda process, sulphite process and Kraft (sulphate) process, Manufacture of paper environmental aspects of paper industry.

Sugar Industry:
Scope of sugar industry, Manufacture of raw sugar from cane and beet,Refining of raw sugar, Methods of clarification of cane juice and chemistryinvolved in the clarification processes, Defecation Remelt Carbonation (DRC),Defecation Remelt Sulphitation (DRS), Defecation Remelt Phosphitation(DRP) and Double Carbonation Double Sulphitation (DCDS), Utilization of byproductsof sugar industry.

Starch Industry:
Scope of starch industry, Raw materials for starch production, Manufacture ofstarch from various raw materials such as corn, rice, wheat, potatoes,Industrial applications of starch, Chemistry involved in the conversion ofstarch, Synthesis of d-glucose and dextrin from starch.

Books Recommended

1. Pulp and Paper Technology, Testing and Applications, K.P. Rao (2003), CBS Publishers.
2. Chemistry of Pulp and Paper making, Edwin Sutermeister, Ed-3rd (1946).
3. Fertilizers and Soil Fertility, U.S.Jones, Reston Publishing Co. Virginia,1979.
4. Petroleum Refining Technology, Ram Parsad (2002).
5. Industrial chemistry, B. K. Sharma, Krishna Prakashan Media (P) Ltd., Ed-15 (2006).
6. Shereve’s Chemical Process Industries, 5th Ed.1975, By G.T.Austin, Mc-Graw Hill Book Co. New York.
7. Food Oils and Fats, H.Lawson, CBS Publishers and Distributors, New Delhi.(1997).
8. Leather in life art and industry, John W. Waterer, 1927. Faber and Faber Ltd.
9. A Text on Petrochemicals, Bhaskararsao, 2002.
10. An Introduction to Polymer Chemistry, W.R.Moor, London Press, London.
11. Principles of Polymer Systems, Rodri-Guez, McGraw Hill Book Co. New York.
12. Modern Technology of Plastics and Polymer Processing Industries, NIIR Board
13. Petroleum Refining Technology, Ram Parsad (2002).

Course Code: CHEM-622 **Course Name:** Common Industry-II
Course Contents

Oils and Fats:
Oils, Fats and Waxes, extraction of oils such as soya bean and cotton seedoils, purification and refining of oils, chemistry involved in the production ofvegetable ghee, selective hydrogenation of oil and fats during the manufactureof vegetable ghee, inter-esterification of crude fats.

Soaps and Detergents:
Raw materials for the manufacture of soap and detergents, chemistry involvedin the production of soap and detergents, action of builders, additivesbrighteners and surfactants, cleansing action of soaps, effect of acidic speciesand hard water on soap, Production of transparent soap.

Paints:
Raw materials for paints and pigments, classification and properties ofsurface-coating constituents, classification and manufacture of pigments,production of paints, varnishes, distempers, enamels and lacquers, chemistryinvolved in the drying phenomena of paints, drying oils for paint and classification of drying oils.

Books Recommended

1. Vermani, O. P, Narula, A.K, Applied Chemistry, Theory and Practice, 2nd ed., New Age International. Publisher, India, (1995).
2. Balasaraf, V. M, Applied Chemistry, I. K. International House Pvt. Ltd, India,(2009).
3. P. K. Chattopadyay, Modern Technology of Soaps, Detergents and Toilries: with formulae and project profile, 2nd ed., National Institute of Industrial Research, India, (2003).
4. Bockisch M., Fats and Oils Handbook, American oil Chemists and Society, (1998).
5. Gunstone F., Oils and Fats in Food Industry, Wiley Black Well, (2008).
6. Gunstone F., Vegetable Oil in Food Technology: Composition, Properties and Uses, John-Wiley & Sons, (2011).
7. Lambourme, R., Strivens, T.A., Paint and Surface Coatings: Theory and Practice, 2nd ed., Woodhead Publishing Limited, (1999).
8. Board. B, Paint, Pigment, Solvent, Coating, Emulsion, Paint additives and formulations, Engineers India Research Incorporation, (2008).
9. Kent, J. A., Riegel’s Handbook of Industrial Chemistry, 10th ed., Kluwer Academic/Plenum Publishers, (2003).

Course Code: CHEM-623 **Course Name:** Agro Based Industries & Pollution Control

Course Contents

Fertilizer Industries (Ammonia, Urea and other Fertilizers):
Ammonia: Raw materials, various sources of hydrogen and nitrogen, manufacture of ammonia (Haber's process), its use as fertilizer and other applications.
Urea: Raw materials, manufacture of urea, assimilation in soil.
Calcium ammonium nitrate, calcium Cyanamid, calcium super phosphate and triple super phosphate,
and manufacture and use of potash fertilizers.

Agrochemicals:
Classification of pesticides, formulation and toxicity of pesticides, future trends of pest control, control of weeds, household agrochemicals, plant growth regulators and background chemistry, hazards associated with the use of agrochemicals and environmental aspects.

Industrial Pollution and Its Abatement:
Sources of air, water and soil pollution, Industrial waste control for the protection of environment, modern trends of waste management.

Books Recommended

1. Fertilizers and Soil Fertility, U.S.Jones, Reston Publishing Co. Virginia,1979.
2. Petroleum Refining Technology, Ram Parsad (2002).
3. Industrial chemistry, B. K. Sharma, Krishna Prakashan Media (P) Ltd., Ed-15 (2006).
4. Shereve's Chemical Process Industries, 5th Ed.1975, By G.T.Austin, Mc-Graw Hill Book Co. New York.
5. Food Oils and Fats, H.Lawson, CBS Publishers and Distributors, New Delhi.(1997).

Leather in life art and industry, John W. Waterer, 1927.Faber and Faber Ltd.

Course Code: CHEM-624 **Course Name:** Polymers

Polymers:

General classification of polymers, characteristics and significance of polymers, various mechanisms of polymerization process, Polymer processing like extrusion, injection, modeling and blow molding of plastics.

Brief description and uses of the following polymers:

Polyethylene, polystyrene, epoxy resins, polyethylene tetrapthalate.

Books Recommended

1. An Introduction to Polymer Chemistry, W.R.Moor, London Press, London.
2. Principles of Polymer Systems, Rodri-Guez, McGraw Hill Book Co. New York.
3. Modern Technology of Plastics and Polymer Processing Industries, NIIR Board
4. Petroleum Refining Technology, Ram Parsad (2002).
5. Metallurgical Analysis, Lord (1893).
6. Applied Chemistry Theory and Practice, O.P. Vermani& A.K. Narula, Wiley Eastern Limited (1989).
7. T. B. of Quantitative Inorganic Analysis, Vogal's Ed-4th, Longman Group Limited (1978).
8. Practical Statistics for the Analytical Scientist, A Bench Guide, RSC Publishing LGC Ltd 2009.
9. Dyes and Dyeing, C. E. Pellew, Abhishek Publishers (1998).

SECOND YEAR (SEMESTER-III)

SPECIALIZATION IN BIOCHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-641	Environmental Chemistry Paper-I	2+1
2	CHEM-631	Clinical Biochemistry	3+0
3	CHEM-632	Molecular biology	3+0
4	CHEM-633	Physical techniques in Biochemistry	3+0
5	CHEM-634	Biomedical Chemistry	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-641 **Course Name:** Environmental Chemistry-I
Course Content

The atmosphere and air pollution:
Structure and properties of the atmosphere, temperature inversion and air pollution, atmosphere photochemistry, possible depletion of stratospheric ozone, natural vs polluted air, particulate matter, analysis and control of particulations, sulphur oxides, effects of sulphur dioxides and particulates, other industryial air pollutants, carbon monoxide, oxides of nitrogen photochemicals smog, airborne load, control of automobile emissions.

Water and water treatment:
Unique physical and chemical properties of water, criteria of water quality, natural water-eutrophiction, detergents and phosphates, importance of micro-organisms in water purification, primary and secondary treatment of water, advanced waste water treatment, removal of nitrogen and phosphorus, sources of industrial water pollution, heavy metals and mercury.

The green revolution:
Pest control, pesticides, toxicity of pesticides, pest management.

Books Recommended

11. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi

12. J. W. Moore & E. A. Moore, Environmental chemistry, Academic Press, New York.

13. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

14. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

15. Staneley E. Manahan, Environmental chemistry, Brooks, California

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipment.

13. Determination of caffeine in tea leaves by HPLC.

14. Determination of fluoride in water samples by spectrophotometric method

15. Determination of lead in polluted water sample by spectrophotometric method

16. Analysis of water; to determine various parameters of the given water sample.

17. Determination of phenol contents in the given sample by spectrophotometric method

18. Analysis of the rain water using potentiometric and conductometric techniques.

Course Code: CHEM-631 **Course Name:** Clinical Biochemistry

Course Contents

Common clinical chemistry tests:

Electrolytes:
Sodium, Potassium, Chloride, Bicarbonate.

Renal (Kidney) Function Tests:
Creatinine, Blood urea nitrogen.

Liver Function Tests:
Total protein (serum):Albumin, Globulins, A/G ratio (albumin-globulin), Protein electrophoresis, Urine protein, Bilirubin; direct; indirect; total, Aspartate transaminase (AST), Alanine transaminase (ALT), Gamma-glutamyltranspeptidase (GGT), Alkaline phosphatase (ALP).

Cardiac Markers:
Troponin, Myoglobin, CK-MB, B-type natriuretic peptide (BNP).

Minerals:
Calcium, Magnesium, Phosphate, Potassium , sodium.

Blood Disorders:
Iron, Transferrin, TIBC ,Vitamin B12, Folic acid

Miscellaneous:
Glucose, C-reactive protein, Glycated hemoglobin (HbA1c), Uric acid, Arterial blood gases ($[H^+]$, PCO_2, PO_2), Adrenocorticotropic hormone (ACTH), Toxicological screening and forensic toxicology (drugs and toxins), Neuron-specific enolase (NSE), fecal occult blood test (FOBT), Panel tests, hematology, urine analysis. Description of body fluids,Use of different diagnostic kits.

<u>RecommendedBooks</u>:

1. Burtis, Carl A.; Ashwood, Edward R.; Bruns, David E. (2006). Tietz textbook of clinical chemistry (4th ed.). Saunders. ISBN 978-0-7216-0189-2.
2. Stephen K. Bangert MA MB BChir MSc MBA FRCPath; William J. Marshall MA MSc PhD MBBS FRCP FRCPathFRCPEdinFIBiol; Marshall, William Leonard (2008). Clinical biochemistry: metabolic and clinical aspects. Philadelphia: Churchill Livingstone/Elsevier. ISBN 0-443-10186-8.
3. Medical toxicology By Richard C. Dart Edition: 3, illustrated Published by Lippincott Williams & Wilkins, 2004 ISBN 0-7817-2845-2.
4. Walter F., PhD. Boron (2005). Medical Physiology: A Cellular and Molecular Approach. Elsevier/Saunders. ISBN 1-4160-2328-3.

Course Code: CHEM-632 **Course Name:** Molecular biology

Course Contents

Gene theory, Gene, Allele, Structure of DNA, Chromosome, DNA replication, Transcription, Translation and post translational modification. DNA repair, Recombination, Gene expression and regulation, Genotype and Phenotype, Mutation and Types of mutation, DNA Sequencing.
Different types of RNA and their role in protein synthesis. Transcription and its regulation.Genetic code. Post transcriptional processing. Structure of transfer RNA.Protein synthesis inhibitors.Control of translation. Post translational modification. Plasmids, bacteriophage and cosmids. In vitro mutagenesis: Deletion, Insertion and Substitution. Recombinant DNA and genetic diseases.

Recommended Books:

1. Molecular Cell Biology (2007) 6th Edition H.Lodish, C.A. Kaiser, M.Krieger. M.P.Scott, A Bretscher, H Ploegh, & P. Matsudaira, W.H. Freeman
2. Biochemistry 6th edition by J.M. Berg, J.L.Tymoczko& L. Stryer (2007) W.H. Freeman & Co.
3. Lehninger Principles of Biochemistry 5th Ed. by D. L. Nelson, M. M. Cox. W. H. Freeman Publishers
4. Modern Genetic Analysis: Integrating Genes and Genomes (2002) 2nd Edition by A. J. F. Griffiths, J.H.Miller, D.T.Suzuki, R. C. Lewontin and W. M. Gelbart W. H.

Freeman.

Course Code: CHEM-633 **Course Name:** Physical Techniques in Biochemistry

Course Contents

Extraction, Fractionation and Purification of Macro-biomolecules:
Homogenization, solubilization and concentration including ultrasonication,lyophilization and ultradecantation, purification based on differential solubilitytechniques, ion-exchange chromatography, gel chromatography, affinitychromatography, paper & thin layer chromatography and HPLC.

Electrophoresis:
Paper and gel electrophoresis, two-dimensional electrophoresis, capillaryelectrophoresis.

Electrofocusing:
Preparative and analytical electrofocusing.

Centrifugation:
Principle, preparative centrifugation, application of density gradient anddifferential centrifugation, ultracentrifugation sedimentation equilibrium andsedimentation velocity methods, application of analytical centrifugation.

Tracer techniques:
Detection and measurement of radioactivity, application of radioisotopes inbiological system.

U.V. and Visible Spectroscopy:
Basic principles, instrumentation and applications.

Enzyme linked immunosorbent assay (ELISA):
Basic principle, instrumentation and applications.

Recommended Books:

1. Cooper, T. C., The Tools of Biochemistry, 2nd ed., John Wiley, (2007).
2. Wilson, K. and Golding, K. H., A Biologist's Guide to Principles and Techniques of Practical Biochemistry, 3rd ed., Edward Arnold, (1986).
3. Dawes, E. A., Quantitative Problems in Biochemistry, 5th ed., Williams &Wilkins, (1972).
4. Morris, J. G., A Biologist's Physical Chemistry, 2nd ed., Addison-Wesley,(1974).
5. Scopes, R. K., Protein Purification: Principles and Practice, 3rd ed., Springer(1994).

Course Code: CHEM-634 **Course Name:** Biomedical Chemistry

Course Contents:

Endocrinology:
General introduction, chemical nature of hormones, common characteristics,mode of action of hormones, hormones receptors, chemistry, biosynthesis,metabolism and biological functions of pituitary, adrenal, thyroid, parathyroid,pancreatic and gonadal hormones, hormones of GIT, renal and pineal Glands.

Blood and Other Body Fluids:
General composition of blood, function of blood plasma, plasma protein,composition and functions, composition, development and functions of redblood cells, white blood cells and platelets, Hemoglobin, chemistry properties,synthesis, functions and derivatives, degradation of hemoglobin, respirationand gas transport, blood coagulation and clotting of blood, blood pressure,blood groups, composition of urine, extracellular fluids like: cerebrospinal fluid, lymph, sweat, tears, synovial and interstitial fluid.

Recommended Books:

1. Nelson, D. L. and Cox, M. M., Lehninger's Principles of Biochemistry, 6^{th} ed., W. H. Freeman, (2012).
2. Voet, D. and Voet, J. D, Biochemistry, 4th ed., illustrated. John Wiley & Sons, (2011).
3. Hall, J. E., Guyton & Hall Textbook of Medical Physiology, 12th ed., Elsvier Health Sciences,(2011).
4. Orten, James. M. and Neuhaus, O. W., Human Biochemistry, 10th ed., Mosby, Incorporated, (1982),
5. Devlin, T. M., Textbook of Biochemistry with Clinical Correlations, 7th ed., Wiley, (2010).
6. Frisell, W. R., Human Biochemistry, 1st ed., Macmillan Publication Company, (1982).
7. Hadley, M. and Levine, J. E., Endocrinology, 6th ed., pearson, (2006).

SECOND YEAR (SEMESTER-III)

SPECIALIZATION IN INORGANIC CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-641	Environmental Chemistry Paper-I	2+1
2	CHEM-651	π-Acceptor Ligands and Inorganic Polymers	3+0
3	CHEM-652	Inorganic Reaction Mechanism	3+0
4	CHEM-653	Bio-Inorganic Chemistry	3+0
5	CHEM-654	Spectro. Methods of analysis	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-641 **Course Name:** Environmental Chemistry-I

Course Content

The atmosphere and air pollution:

Structure and properties of the atmosphere, temperature inversion and air pollution, atmosphere photochemistry, possible depletion of stratospheric ozone, natural vs polluted air, particulate matter, analysis and control of particulations, sulphur oxides, effects of sulphur dioxides and particulates, other industryial air pollutants, carbon monoxide, oxides of nitrogen photochemicals smog, airborne load, control of automobile emissions.

Water and water treatment:

Unique physical and chemical properties of water, criteria of water quality, natural water-eutrophiction, detergents and phosphates, importance of micro-organisms in water purification, primary and secondary treatment of water, advanced waste water treatment, removal of nitrogen and phosphorus, sources of industrial water pollution, heavy metals and mercury.

The green revolution:

Pest control, pesticides, toxicity of pesticides, pest management.

Books Recommended

16. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi

17. J. W. Moore & E. A. Moore, Environmental chemistry, Academic Press, New York.

18. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

19. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

20. Staneley E. Manahan, Environmental chemistry, Brooks, California

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipment.

19. Determination of caffeine in tea leaves by HPLC.
20. Determination of fluoride in water samples by spectrophotometric method
21. Determination of lead in polluted water sample by spectrophotometric method
22. Analysis of water; to determine various parameters of the given water sample.
23. Determination of phenol contents in the given sample by spectrophotometric method
24. Analysis of the rain water using potentiometric and conductometric techniques.

Course Code: CHEM-651 **Course Name:** π-Acceptor Ligands and Inorganic Polymers

Course contents

π-Acceptor Ligands:
Introduction to π-acceptor ligands, effective atomic number (EAN) rule andchemistry of metal carbonyls, nitrosyls, and isocyanides, structure elucidationbased on spectroscopic evidences, applications and uses of metal carbonylsand their derivatives for catalysis and organic synthesis.

Inorganic Polymers:
Introduction to homoatomic and heteroatomic inorganic polymers, chains andcages of boron, silicon, nitrogen, phosphorous and sulphur, synthesis andapplications, Polyionic species, Isopoly and heteropoly, anions of transitionmetals, silicates, borates, condensed phosphates, zeolites.

Recommended Books:

1. Brady, J. E., and Sense, F., Chemistry-The Study of Matter and ItsChanges, 5th ed., Wiley Plus, (2009).
2. Miessler, G. L.,Tarr, D. A., Inorganic Chemistry, 4th ed., Prentice-HallInternational, New Jersey, USA, (2010).
3. Douglas, B., McDanial, D., Alexander, J., Concepts and Models ofInorganic Chemistry, 3rd ed., John-Wiley & Sons, New York, (1994).
4. Huheey, J. E., Keiter, E. A., Keiter, R. L., Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed., Prentice Hall, (1997).
5. Shriver, D. F., Atkins, P. W., Langford, C. H., Inorganic Chemistry, 2nd ed.,Oxford University Press, (1994).
6. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M., Advanced Inorganic Chemistry, 6th ed., Wiley-Interscience, (1999).
7. Atkins, P. and Jones, L., Chemicals Principles: The Quest for Insight, 5thed., W. H. Freeman, (2010).
8. Mandelkern, L., An Introduction to Macromolecules, 2nd ed., SpringerVerlag, New York, (1983).
9. Ravve, A., Principles of Polymer Chemistry, 2nd ed., Plenum Publishers,(2000).
10. Crabtree, R. H., The Organometallic Chemistry of the Transition Metals,5th ed., John-Wiley and Sons, New Jersey, (2011).
11. Yamamoto, A., Organotransition Metal Chemistry, Prentice Hall, (1992).

12. Billmeyer, F. W., A Text Book of Polymer Science, 3rd, John-Wiley andSons, (2003).
13. Malmcoim, P.S., Polymer Chemistry: An Introduction, 3rd ed.,OxfordUniversity Press, (2005).

Course Code: CHEM-652 **Course Name:** Inorganic Reaction Mechanism

Course Contents

Classification of reaction mechanisms; rate laws; steady state approximation;inert and labile complexes; substitution reactions in octahedral complexes andsquare planar complexes, acid hydrolysis, base hydrolysis, steric effects ofinert ligands, nucleophilic reactivity, trans-effect, *cis*-effect, racemizationreactions. Mechanism of electron transfer reactions, oxidation reductionreactions of metal ions, outer and inner sphere mechanisms, factors affectingrate of electron transfer reactions, two electrons transfer reactions,complementary or non-complementary electron transfer reactions, oxidativeaddition, addition of oxygen, hydrogen, HX, organic halides and bimetallicspecies, Reductive Elimination Reactions.

RecommendedBooks:

1. Huheey, J. E., Keiter, E. A., Keiter, R. L., Inorganic Chemistry: Principlesof Structure and Reactivity, 4th ed., Prentice Hall, (1997).
2. Shriver, D. F., Atkins, P. W., Inorganic Chemistry, 3rd ed., OxfordUniversity Press, (2001).
3. Wilkins, R. G., Kinetics and Mechanism of Reactions of Transition MetalComplex, 2nd ed., (Rev.), Wiley-VCH, (1991).
4. Jolly, W. L., Modern Inorganic Chemistry, 2nd ed., McGraw-Hill Company,(1991).
5. Jordan, R. B., Reaction Mechanisms of Inorganic and OrganomettalicSystems, 2nd ed., Oxford University Press, New York, (1998).
6. Atwood, J. D., Inorganic and Organometallic Reaction Mechanisms, 2nded., Wiley-VCH, Inc., (1997).
7. Sharma, S. K., Inorganic Reaction Mechanisms, Discovery PublishingHouse, (2007).

Course Code: CHEM-653 **Course Name:** Bio-Inorganic Chemistry

Course contents

Biochemistry of selenium, Bio-Chemistry of Organo selenium Compounds, Antioxidant Activity of Organo-selenium Compounds, Toxicology of Organo-selenium Compounds; The biochemistry of iron, Iron storage and transfer in bacteria, ion transport, hemoglobinand myoglobin, nature of haemo-dioxygen, Model systems, cyto chromes, P/450 enzymes, iron sulphur protein , ferrodoxins, haemoerthrins, the biochemistry of Zn, Cu. Co, Mg, F_2, I_2 and Alkaline earth metals.

RecommendedBooks:

1. F.A. Cotton, and S.W, Advanced inorganic chemistry, John Wiley and sons, New York.
2. F. Basolo and R. Johnson, Mechanism of inorganic reactions, John Wiley and sons, New York.
3. F. Basalo and R. Johnson, Coordination chemistry, W.A. Benjamen, Row Publishers, New York.
4. J. E. Huheey, Inorganic Harper and Row Publisher, New York.
5. D. Jonson, Mechanism of inorganic reaction in solutions, McGraw-Hill, London.
6. Nicolaou, K. C.; Petasi, N. A. Selenium in Natural Products Synthesis; CIS: Philadelphia, PA, 1984.
7. Paulmier, C. SeleniumReagents and Intermediates in Organic Synthesis; Pergamon: Oxford, U.K., 1986.
8. Patai, S.; Rappoport, Z. The Chemistry of Organic Selenium and Tellurium Compounds;Wiley: New York, 1986; Vol. 1.

Course Code: CHEM-654 **Course Name:** Inorganic Spectroscopy

Course contents

Electronic States of transition metal complexes, Russel-Sander's couplingscheme, derivation of term symbols for d1-d10 systems, d-d transitions,connecting atomic states and molecular states, correlation diagrams, Tanabe -Sugano diagrams, calculation of 10Dq values, High-spin and low-spinmolecules, Jahn-Teller effect, applications of subgroups, selection rules forelectronic transitions in molecules, LMCT and MLCT transitions, someexamples involving different geometries.

Recommended Books:

1. Yarwood, J., Bazin, P., and Douthwaite, R., Spectroscopic Properties of Inorganic and Organometallic Compounds, Volume 42, The Royal Society of Chemistry, UK, (2011).
2. Lever, A. B. P., Inorganic Electronic Spectroscopy, 2nd ed., Elsevier, UK, (1984).
3. Brisdon, A. K., Inorganic Spectroscopic Methods, Oxford University Press, UK, (1998).

Solomon, E.I., Inorganic Electronic Structure and Spectroscopy:Methodology, Volume 2, Wiley, New York, (1999).

SECOND YEAR (SEMESTER-III)

SPECIALIZATION IN ORGANIC CHEMISTRY

S.NO	**Course Code**	**Course Name**	**Credit Hours**
1	CHEM-641	Environmental Chemistry Paper-I	2+1
2	CHEM-661	Heterocyclic & Organometallic Compounds	3+0
3	CHEM-662	Organic Spectroscopy	3+0
4	CHEM-663	Reactive Intermediates	3+0
5	CHEM-664	Stereochemistry	3+0
6	CHEM-690	Special Paper-I/Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-641 **Course Name:** Environmental Chemistry-I

Course Content

The atmosphere and air pollution:

Structure and properties of the atmosphere, temperature inversion and air pollution, atmosphere photochemistry, possible depletion of stratospheric ozone, natural vs polluted air, particulate matter, analysis and control of particulations, sulphur oxides, effects of sulphur dioxides and particulates, other industryial air pollutants, carbon monoxide, oxides of nitrogen photochemicals smog, airborne load, control of automobile emissions.

Water and water treatment:

Unique physical and chemical properties of water, criteria of water quality, natural water-eutrophiction, detergents and phosphates, importance of micro-organisms in water purification, primary and secondary treatment of water, advanced waste water treatment, removal of nitrogen and phosphorus, sources of industrial water pollution, heavy metals and mercury.

The green revolution:

Pest control, pesticides, toxicity of pesticides, pest management.

Books Recommended

21. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi

22. J. W. Moore & E. A. Moore, Environmental chemistry, Academic Press, New York.

23. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

24. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

25. Staneley E. Manahan, Environmental chemistry, Brooks, California

Environmental Chemistry Practical **Credit Hours: 01**

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipment.

25. Determination of caffeine in tea leaves by HPLC.

26. Determination of fluoride in water samples by spectrophotometric method

27. Determination of lead in polluted water sample by spectrophotometric method

28. Analysis of water; to determine various parameters of the given water sample.

29. Determination of phenol contents in the given sample by spectrophotometric method

30. Analysis of the rain water using potentiometric and conductometric techniques.

Course Code: CHEM-661 **Course Name:** Heterocyclic & Organometallic Compounds

Course contents

Aromatic Heterocycles:
Structure, classification and nomenclature; aromaticity; basicity and acidity ofthe nitrogen heterocycles; synthesis and reactions, chemistry of furan, pyrroleand thiophene, pyridine;

Organometallic Compounds:
Principles, organomagnesium, organolithium, organocopper, organocadmium,organomercury and organozinc compounds: their structure and reactivity,methods of preparation and synthetic applications.Chemistry of organic compounds containing sulfur, phosphorus, boron andsilicon: synthesis, reactions and application.

Recommended Books:

1. Claydem, J., Greeves,N. and Warren, S., Organic Chemistry, 2nd ed., Oxford University Press, (2012).
2. Coxon, J. M. Norman, R. O. C., Principles of Organic Synthesis, 3rd ed. CRC Press, (1993).
3. Joule, J. A., Mills, K., Heterocyclic Chemistry, 5th ed., John-Wiley & Sons, UK, (2010).
4. Crabtree, R. H., The Organometallic Chemistry of the Transition Metals, 5th ed., John-Wiley & Sons, New Jersey, (2009).

Course Code: CHEM-662 **Course Name:** Organic Spectroscopy

Course Contents:

UV-Visible:
Basic concepts, electronic transitions, Lambert-Beer's law, factors influencing the lambda max (λmax) values, Woodward rules for calculation of wavelength values.

IR spectroscopy:
Basic concepts, absorption mechanisms, functional group determination and factors affecting the absorption frequencies.

^{1}H-NMR and ^{13}C-NMR:
Chemical shift, factors affecting chemical shift, spin relaxation, spin-spin coupling, coupling constants, nuclear overhauser effect, 2-D NMR, COSY and HETCOR.

Mass Spectrometry:
Basic concepts; mass spectrometers, ionization techniques, different fragmentation patterns and structure elucidation, combined usage of IR, UV, NMR and Mass spectrometric data for structure elucidation of organic compounds having medium complexity.

Recommended Books:

1. Pavia, D. L., Lampman, G.M. and Kriz, G.S., Introduction to spectroscopy: a Guide for Students of Organic Chemistry, Thomson Learning, Australia (2001).
2. Silverstein, R. M. Webster F.X. and Kiemle, D.J. Spectrometeric Identification of Organic Compounds, John Wiley and Sons Inc., USA (2005).
3. Brown, D.W., Floyed, A.J. and Sainsury, M. Organic spectroscopy, 1. Wiley and Sons, Chichester (1998).
4. Willians, D. H. and Fleming, I. Spectroscopic methods in organic Chemistry, 4th ed., McGraw-Hill Book. Co., Lodon (1987).
5. Younas, M. Organic Spectroscopy, IlmiKitabKhana, Lahore (2004).
6. Kalsi, P.S. "Spectroscopy of Organic Compounds", Wiley Eastern Ltd., New Delhi.
7. Lambert, J. B, Shurvell, H. F., Lightner, D. A. and Cooks, R. G., "Introduction to Organic Spectroscopy", Macmillan Publishing Company, New York.
8. Williams D. H. and Fleming, I., "Spectroscopic Methods in Organic Chemistry", Athlone Press, London.
9. Atta-ur-Rehman, "Nuclear Magnetic Resonance Spectroscopy", UGC, Islamabad.
10. Davis, R. and Freason, M., "Mass Spectrometry", John Wiley & Sons, New York.

Course Code: CHEM-664 **Course Name:** Reactive Intermediates

Reactive Intermediates:
Carbocations, carbanions, free radicals, carbenes, nitrenes, and arynes, theirgeneration, stability, reactions and synthetic applications. Chemistry ofEnolates and Enols: Acidity of carbonyl compounds, enolization of carbonylcompounds, α-halogenation of carbonyl compounds; aldol-addition and aldolcondensation,condensation reactions involving ester enolate ions, alkylationof ester enolate ions.

Rearrangement Reactions:
Types of rearrangements, general mechanisms of nucleophilic, free radicaland electrophilic rearrangements, hydrogen and/or carbon migration toelectron-deficient carbon, nitrogen and oxygen, carbon migration to electronrichcarbon, aromatic rearrangements, inter- and intra-molecular carbonmigration from oxygen to carbon.

Recommended Books:

1. Clayden, J., Greeves, N. and Warren, S., Organic Chemistry, 2nd ed., Oxford University Press, (2012).
2. Coxon, J. M. and Norman, R.O.C., Principles of Organic Synthesis, 3rd ed., Chapman and Hall, UK, (1993).
3. Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., Organic Chemistry, 6th ed., Brooks/Cole Learning, (2012).
4. John, E. M., Organic Chemistry, 8th ed., Brooks/Cole Publishing Co., USA, (2012).
5. Robert, T. M. and Robert, N. B., Organic Chemistry, 6th ed., Prentice Hall, New Jersey, (1992).

Course Title: Stereochemistry **Code: CHEM-664**

Credit Hours: 03 **Marks: 100**

Course contents

Stereochemistry:

Introduction History and Significance. Static Stereochemistry: Structure and Symmetry, configurations and conformations, methods for determination of relative and absolute configuration, stereochemical nomenclature. Types of Chirlity: Central, Axial and planar chiral compounds, atropisomerism, molecular overcrowding and cyclostereisomereism.

Dynamic stereochemistry; steereochemical reactions, stereoselectivity and stereospeciticity, prostereoisomerism and prochirility. Analytical methods: determination of enantiomers and distereomers composition. Resolution:
Diasteroisomers formation, mechanical and enzymetic resolutions, preferential crystallization.

Books Recommended

1. Eliel, E. L.; Wilen, S. H Doyle, M.P. and Michael, P. Basic Organic Stereochemistry, Willey Inter Science, New York (2003).
2. Kalsi, P. S. Sterochemistry and mechanism through Solved problems, new age international publishers, New Delhi, India (2001).
3. Mislow, K. Introduction to stereochemistry, W.A. Benjamin, New York (1966).
4. Morris, D.G. Stereochemistry, Royal Society of Chemistry, UK. (2001).
5. M. North. Principles and application of stereochemistry, StanelyThornes: Cheltenham, UK (1998).
6. Morrison, R. T. and Boyd, R. N., "Organic Chemistry", Prentice-Hall of India, New Delhi

Course Title: Reaction mechanism and Rearrangements **Code: CHEM-690**

Credit Hours: (3+0) **Marks: 100**

Course Objectives:

Students will acquire knowledge about determination of reaction mechanism with emphasis on how it is determined using various method. The importance and applications some reaarangment reactions.

Course contents

Reaction Mechanism: Introduction to reaction mechanism, methods of determination of the reaction mechanism and comprehensive study on the mechanism of different types of substitution addition and elimination reaction with emphasis on their determination.

Rearrangements: Baker-Venkataraman rearrangement, Benzilic acid rearrangement, Claisen rearrangement, Favorski rearrangement, Pinacol-Pinacolon rearrangement, Wagner Meerwin rearrangement.

Recommended Books:

1. Claydem, J., Greeves,N. and Warren, S., *Organic Chemistry,* 2nd ed., Oxford University Press, (2012).
2. Coxon, J. M. Norman, R. O. C., *Principles of Organic Synthesis,* 3rd ed., CRC Press, (1993).
3. Furniss, B. S., Hannaford, A. J., Smith, P. W. G., Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th edition, Longman, UK, (1989).
4. Mohan, J., *Organic Analytical Chemistry: Theory and Practice*,1st ed. Alpha Science Int. Ltd.New Delhi, India, (2003).
5. Robert, T. M. and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).
6. Tse-Lok, H., *Symmetry: A Basis for Synthesis Design*, John-Willey & Sons, Inc., New York, (1995).
7. Pine, S. H., *Organic Chemistry*, 5th ed., Tata McGraw-Hill, India, (1987).
8. Sykes, P., *A Guide Book to Mechanism in Organic Chemistry,* 6th ed., Pearson Education, (1986).
9. Mayo, D. W., Pike, R. M. and Forbes, D. C., *Microscale Organic Laboratory with Multistep and Multiscale Syntheses,* 5th ed., John-Wiley & Sons, Inc., (2011).
10. Gilbert, J. C. and Martin, S. F., *Experimental Organic Chemistry: A Miniscale and Microscale Approach*, 5th ed., Brooks/ Cole Cengage Learning, (2010).
11. Solomons, T. W. G. and Fryhle, C. B., *Organic Chemistry,* 10th ed., John-Wiley & Sons, Inc., (2011).
12. Carey, F. A. and Giuliano, R. M., *Organic Chemistry,* 9th ed., McGraw-Hill Education, (2013).
13. 12. Bruice, P. Y., *Organic Chemistry,* 7th ed., Perason Education, Ltd., (2013).
14. Smith, M. B., *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure,* 7th ed., John-Wiley & Sons, Inc., (2013).

SECOND YEAR (SEMESTER-III)

SPECIALIZATION IN PHYSICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-641	Environmental Chemistry Paper-I	2+1
2	CHEM-671	Electrochemistry &Statistical Thermodynamics	3+0
3	CHEM-672	Polymer Chemistry	3+0
4	CHEM-673	Quantum Chemistry& Molecular Spectroscopy	3+0
5	CHEM-674	Nuclear Chemistry	3+0

6	CHEM-690	Special Paper-I/Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-641 **Course Name:** Environmental Chemistry-I
Course Content

The atmosphere and air pollution:
Structure and properties of the atmosphere, temperature inversion and air pollution, atmosphere photochemistry, possible depletion of stratospheric ozone, natural vs polluted air, particulate matter, analysis and control of particulations, sulphur oxides, effects of sulphur dioxides and particulates, other industryial air pollutants, carbon monoxide, oxides of nitrogen photochemicals smog, airborne load, control of automobile emissions.

Water and water treatment:
Unique physical and chemical properties of water, criteria of water quality, natural water-eutrophiction, detergents and phosphates, importance of micro-organisms in water purification, primary and secondary treatment of water, advanced waste water treatment, removal of nitrogen and phosphorus, sources of industrial water pollution, heavy metals and mercury.

The green revolution:
Pest control, pesticides, toxicity of pesticides, pest management.

Books Recommended

26. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi

27. J. W. Moore & E. A. Moore, Environmental chemistry, Academic Press, New York.

28. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

29. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

30. Staneley E. Manahan, Environmental chemistry, Brooks, California

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipment.

31. Determination of caffeine in tea leaves by HPLC.
32. Determination of fluoride in water samples by spectrophotometric method
33. Determination of lead in polluted water sample by spectrophotometric method
34. Analysis of water; to determine various parameters of the given water sample.
35. Determination of phenol contents in the given sample by spectrophotometric method
36. Analysis of the rain water using potentiometric and conductometric techniques.

Course Code: CHEM-671 **Course Name:** Electrochemistry & Statistical Thermodynamics

Course Contents

Electrochemistry:
Electrical double layer, interface, a look into the interface, OHP (OuterHelmholttz Plane) and IHP (Inner Helmholttz Plane) , contact adsorption,Gibbs Surface Excess, potential differences across metal solution interfaces,outer and surface potential differences, galvanic potential difference,electrochemical potential difference, interfacial tension, electro-capillarythermodynamics, Lippmann's equation, Helmholtz-perrin model, Gouy-Chapmann model, Stern model of electrical double layer, and BDM (Bockris-Devanathan-Muller) model, charge density, differential capacitance, shape ofcapacitance-charge curve, the Capacitance hump.
Electrochemical devices, charge transfer processes in the absence andpresence of electrical field, the over potential, Butler-Volmer's equation,theidea of equilibrium exchange current density, the symmetry factor, high fieldand low field approximation, Tafel's equation, cyclic voltammetry and itsapplications, Fuel cell, corrosion and its prevention, electrochemical impedance spectroscopy.

Statistical Thermodynamics:
Description of various systems, Concepts of states, accessible states anddistribution, Probability concepts, Maxwell-Boltzmann's statistics for thesystems of independent particles, Partition functions, The relationship ofpartition function to the various thermodynamic functions, Transitional,vibrational and rotational partitional functions and equilibrium constant,Statistical thermodynamics, Applications to equilibrium and chemical kinetics,
Bose-Einstein's and Fermi-Dirac's statistics.

<u>RecommendedBooks</u>:

1. Gasser, R. P. H., Entropy and Energy Level, Rev. ed., Oxford University Press, New York, (1986).

2. Wayatt, P. A. H., The Molecular Basis of Entropy and Chemical Equilibrium, Royal Institute of Chemistry London, UK, (1971).
3. Bockris J. O. M., and Reddy, A. K. N., Modern Electrochemistry: Ionics, Vol. I, 2nd ed., Plenum Press, London, (1998).
4. Seddon, J. M. and Gale, J. D., Thermodynamics and Statistical Mechanics, Royal Society of Chemistry, (2001).
5. Engel, T., Reid, P., Thermodynamics, Statistical Thermodynamics, and Kinetics, 3rd ed., Prentice Hall, (2012).
6. Bard, A. J. and Faulkner, L. R., Electrochemical Method: Fundamentals and Applications 2nd ed., John-Wiley & Sons, New York, (2001).
7. Kondepudi D., Introduction to Modern Thermodynamics, John-Wiley & Sons, (2008).
8. Hamann, C. H., Hamnett, A. and Veilstich, W., Electrochemistry, 2nd ed., Wiley-VCH Verla Gnb H and Co. KGaA, (2007).
9. Braun R. D. and Walters F., Application of Chemical Analysis, McGraw- Hill, (1982)
10. McQuarrie, D. A., Statistical Mechanics, Viva Books Private Ltd. (2008).

Course Code: CHEM-672 **Course Name:** Polymer Chemistry
Course Contents

Physical aspects of Polymers:

Introduction to Polymers.Step-growth Polymerizations.Polymer chain growth.Kinetics of polymer chain growth.Copolymerization. Emulsion Polymerization. Natural and Inorganic Polymers.Physical Aspects of polymers. Molecular Weight of Polymers: Distribution, averages, and methods of determination. Viscosity.Osmometry. Light scattering method. Diffusion, sedimentation.Optical rotation method. Structure of Polymer Chain: Introduction to chain isomerism, stereochemistry, configurations, and conformations (not in Hiemenz). Amorphous State of Polymers: In depth examination of polymer conformation, microstructure, and dynamics in the amorphous state. Polymer viscoelasticity: Stress relaxation, mechanical models of polymer behavior, time-temperature superposition, perhaps rheology. Crystalline State of Polymers: crystallization and kinetics, crystalline structures, experimental methods. Polymer Solutions and Blends:

Recommended Books:

1. Hiemenz P.C. “Polymer Chemistry: The Basic Concepts” Marcel Dekker (1984).
2. Stevens M.P. “Polymer Chemistry: An Introduction” Oxford University Press (1999).
1. Allcock H.R. and Lampe F.W. “Contemporary Polymer Chemistry” Prentice-Hall (1990).
3. Rudin “The Element of Polymer Science and Engineering” Academic Press (1990).
4. Sperling L.H. “Introduction to Physical Polymer Science” Wiley Interscience (1992).
5. Boyd R.H. and Phillips P.J. “The Science of Polymer Molecules” Cambridge (1993).
6. Malcolm P.S. “Polymer Chemistry” Oxford University Press (2005).
7. Ravue, “Principles of Polymer Chemistry” 2nd ed. Plenum Publishers (2000).

Course Code: CHEM-673 **Course Name:** Quantum Chemistry & Molecular Spectroscopy

Course Contents

Quantum Chemistry:
Limitation of classical mechanics, wave and particle nature of matter, de-Broglie's equation, Heisenberg's uncertainty principle, concept of quantization of energy, Operators and their properties. Types of operators, Hemaltonian operator, Hermition operator, Angular momentum. Postulates of quantum chemistry, Eigen function and Eigen values, general wave equation, Schrödinger wave equation (Time dependent + Time independent). Particle in one dimensional box, three dimensional box, hydrogen atom and harmonic oscillator, comparison between general wave equation and Schrödinger wave equation, Central field problem. Approximate methods.Perturbation methods.Many electron systems.Treatment of simple harmonic oscillator, diatomic rigid rotor.Valence bond and molecular orbital theories.Pi-electron calculations.

Molecular Spectroscopy:
Interaction of electromagnetic radiation with matter, symmetry properties ofmolecules, microwave and infrared spectroscopy, rotational, vibrational androtational-vibrational spectra of diatomic and polyatomic molecules, electronicspectra of simple molecules, nuclear magnetic resonance spectroscopy.

Recommended Books:

1. Fayer, M. D., Elements of Quantum Mechanics, Oxford University Press, London, UK, (2001).
2. Becker, E. D., High Resolution NMR; Theory & Chemical Application, 3rd ed., Academic Press, New York, USA, (2000).
3. Graybeal, J. D., Molecular Spectroscopy, 1st ed., McGraw-Hill, New York, (1988).
4. Hayward, D. O., Quantum Mechanics for Chemists, Royal Society of Chemistry, (2002).
5. House, J. E., Fundamentals of Quantum Mechanics 2nd ed., Elsevier-Academic Press, New York, USA, (2004).
6. Kirsten, H. J. W. M., Introduction to Quantum Mechanics: Schrodinger Equation and Path Integral 1st ed., World Scientific Publishing Co. Pvt.Ltd., (2006).
7. Barrow, G. M., Physical Chemistry, 6th ed., McGraw-Hill Book Company,(1996).
8. Straughan, B. P., and Walker, S., Spectroscopy, Vol. 1 and 2.,Chapmanand Hall Ltd., (1976).
9. Coulson C. A., Vanlence, Oxford University Press (1980).
10. Sathyanarayana, D. N., Vibrational Spectroscopy, Theory and Applications, New Age International Publishers (2004).

Course Code: CHEM-674 **Course Name:** Nuclear Chemistry

Course Contents

Radioactivity, elemental particles, isotopes, isobars, isotones, transmutation and artificial radioactivity, Bohar's theory of nuclear reaction, classification of nuclear reactions, nuclear reactions vs chemicals reactions, mass defect and binding energy, nuclear fusion and nuclear fission, Q.value of nuclear reaction. Atomic nucleus, nuclides, nuclear stability, nuclear energetic, nuclear models (shell + liquid drop model), non-spontaneous nuclear processes, nuclear reactors, beta decay systematic, nuclear spins.Atomic bomb, hydrogen bomb, uses of radioisotopes in reaction mechanism, in diagnosis of diseases, in industry, in agriculture.Determination of the age of the earth by rock dating method, determination of the age of recent objects by radioactive carbon dating method.

Recommended Books:

1. Albert R.A., Robert J.S. and Moungi G.B. "Physical Chemistry". 4^{th} ed., John Wiley and Sons (2004).
2. Ball D.W. "Physical Chemistry" 1^{st} ed., Brooks/Cole Co. Inc. (2003).
3. Vertes A. "Basics of Nuclear Science" Kluwer Academic Publisher London (2003).

Friedlander G. and Kennedy J.W. "Nuclear and Radiochemistry" 3^{rd} ed., Wiley, New York (1981).

Course Title:	**Special Paper-I**
Code:	**CHEM- 690**
Credit Hours:	**3+0**

Course Objectives:

Students will acquire knowledge to enable themselves to understand the fundamental principles and laws of thermodynamics and chemical kinetics and to investigate the methods for determining the order of reaction. Students will also be able to study the rates of reactions and perform related calculations.

Chemical Kinetics:

Rate of Chemical reaction & rate law, order of reaction, First and second order reaction.Methods of determination of order of reaction.Energy of activation.Effect of temperature on the reaction rate.Lindeman's theory of unimolecular reactions.Bimolecular collision theory.

Chemical Thermodynamics:

Definition, important thermodynamic terms i.e. system, surrounding & boundary. Properties of system, laws of thermodynamics and their applications, Enthalpy, entropy, heat capacities, types of heat capacities and their dependence on temperature, pressure and volume, reversible and non-reversible processes, spontaneous and non-spontaneous processes, relations of entropy and Gibbs free energy with equilibrium constant, Gibbs Helmholtz equation etc.

Recommended Books:

1. McQuarrie, D. A. and Simon, J. D., Physical Chemistry – A Molecular Approach,1st ed., University Science Books,(1997).
2. Atkins,P. and Paula,J.D., Atkin's Physical Chemistry, 9th ed., Oxford University Press, (2010).
3. Shoemaker, D., Experiments in Physical Chemistry, 8th ed., McGraw Hill Publishing Company Limited, (2003).
4. Silbey, R., Alberty, R. and Bawendi, M., Physical Chemistry, 4th ed., (2005).
5. Glasstone, S., *Textbook of Physical Chemistry*, Macmillan London (1960).
6. James, A. M., Prichard, F. E., Practical Physical Chemistry, 3rd ed., Longman Group Limited, New York, (1974).
7. Chaudhary, S. U., Ilmi Textbook of Physical Chemistry, 2nd ed., IlmiKitabKhana, Lahore, (2013).

8. Linder, B., Elementary Physical Chemistry, World Scientific Publishing Co. Ptv. Ltd., (2011).
9. R.A. Alberty, J.S. Robert, G.B. Moungi Physical Chemistry, 4thed, John Wiley and Sons (2004).
10. D.W. Ball, Physical Chemistry, 1st ed., Brooks/Cole Co. Inc. (2003).
11. Engel, Thomas, P.Reid, Thermodynamics, Statistical Thermodynamics,and Kinetics 1st ed., Benjamin Cummings (2006).
12. K. James, P. Wothers, Why Chemical Reactions Happen. Oxford University Press (2003).

13. B. R. Stephen, S. A. Rice, J. Roses, Physical Chemistry, 2nd ed., Oxford University Press (2000).

14. J.H. Espenson, Chemical Kinetics and Reaction Mechanism, 2nd ed., McGraw Hill (2002).
15. R.S. Berry, A.R. Stuart, J. Roses, Physical and Chemical Kinetics, 2nd ed., Oxford University Press (2000).
16. M. Helpern Arthur, Experimental Physical Chemistry: A Laboratory Textbook 2nd ed., Prentice Hall (1997).

SECOND YEAR (SEMESTER-IV)

SPECIALIZATION IN ANALYTICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-642	Environmental Chemistry Paper-II	2+1
2	CHEM-615	Advanced Analytical Chemistry	3+0
3	CHEM-616	Food & Drug Analysis	3+0
4	CHEM-617	Luminescence Spectroscopy &Thermal Analysis	3+0
5	CHEM-618	Nuclear Analytical Techniques	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-642 **Course Name:** Environmental Chemistry-II
Course Contents

Fossil fuels and energy sources:
Origin and development of coal: Origin and reserves of petroleum and natural gas, composition and classification of petroleum, refining, and environmental problems associated with petroleum, nuclear fission reactors, solar energy, power synthesis, tidal and geothermal energy, synthetic chemical fuels, the H economy, electrochemical energy conversion, conservation of free energy, the energy balance of the earth.

Soils and mineral resources:
Estimating reserves of mineral resources of earth, extraction of metal-general principles, iron, steel, aluminum, copper and other metals, sulphur and nitrogen.Organic matter in soil, soil nutrients, ion exchange in soils, solid pH and nutrients availability.

RecommendedBooks:

1. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi J. W. Moore & E.

2. A. Moore, Environmental chemistry, Academic Press, New York.

3. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

4. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

5. Staneley E. Manahan, Environmental chemistry, Brooks, California.

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipments.

Course Code: CHEM-615 **Course Name:** Advance Analytical Chemistry
Course Contents

Nanomaterials:
Introduction to Nanoparticles, Nanomaterials and Nanotechnology, properties ofNanomaterials, Synthesis and characterization of Nanomaterials, Applications of Nanomaterials. Analytical Techniques for Nanomaterials

Molecular Imprinted Polymers:
Introduction to Molecularly Imprinted polymers (MIPs), Applications of MIPs

Conducting Polymers:
Introduction to Conducting Polymers, Applications of Conducting polymers

RecommendedBooks:

1. Robert D. Braun, Introduction to Instrumental Analysis McGraw Hill Book Co. New York.
2. Gary D. Christian, James E. O'Reilly, Instrumental Analysis, John Wiley and Sons.
3. Douglas A. Skoog, Stanley R. Crouch, Instrumental Analysis, Reinholt, New York.
4. I.M. Kolthoff, Sandell, Text Book of Quantitative Inorganic Analysis, Macmillan and Co. New York.
5. F.W. Fifield and D. Kealy, Principles and Practice of Analytical Chemistry I.T.B, London.
6. Prasanna Chandrasekhar, Conducting Polymers, Fundamentals and Applications: a practical approach, Springer.
7. Kenneth J. Klabunde, Nanomaterials in Chemistry, John Wiley and Sons, Inc.
8. BorjeSellergren, Molecularly Imprinted Polymers, Elsevier, Amsterdam-Lausanne-New York-Oxford-Shannon-Singapore-Tokyo

Course Code: CHEM-616 **Course Name:** Food & Drug Analysis
Course Contents

Food Products:
Introduction to food analysis, sampling of food, general methods of analysis.Analysis of milk, butter, wheat flour, meat, beverages, tea, coca, honey andsoft drinks.
Pharmaceuticals:
Classification of drugs, tests for analysis of different pharmaceuticals,introduction to US and British pharmacopeia.

Forensics:
History and scope of Forensic Science, Forensic Ethics, Forensic Toxicology.Classification and analysis of narcotics & dangerous drugs, examination ofcrime scene evidences, fingerprinting, skeletal material to provide scientificopinion for legal.

Recommended Books:

1. Skoog, D. A., West, D. M. and Holler, F. J., Fundamentals of AnalyticalChemistry, 7th ed., Saunders College Publishing, (1995).
2. Christian, G. D., Analytical Chemistry, John-Wiley & Sons, Inc., 6th ed.,(2004).
3. Eckert, W. G., Introduction to Forensic Science, 2nd ed., CRC Press,(1997).
4. Nielsen, S. S., Food Analysis, 4th ed., Springer, (2010).
5. Thomas, G., Medicinal Chemistry: An Introduction, 2nd ed., John-Wiley &Sons, (2007).
6. Kobilinsky, L. F., Forensic Chemistry Handbook, 1st ed., John-Wiley &Sons, USA, (2012).
7. Watson, D. G., Pharmaceutical Analysis: A Textbook for PharmacyStudents and Pharmaceutical Chemists, Elsevier, (2012).
8. Stuart H. Barbara, “Forensic Analytical Techniques”, 1st ed., John-Wiley &Sons, (2013).
9. Jackson, A. R. W. and Jackson, J. M., Forensic Science, 2nd ed., PearsonEducation, (2008).

Course Code: CHEM-617 **Course Name:** Luminescence Spectroscopy & Thermal Analysis

Course Contents

Luminescence Spectrophotometry:
Introduction, origin of fluorescence and phosphorescence spectra, Jablonskidiagram, activation, deactivation, fluorescence spectrum, fluorescent andphosphorescent species; photoluminescence and structure, factors affectingfluorescence and phosphorescence, fluorescence quenching, quantum yield,instrumentation for fluorescence measurement, sources, wavelength selectors,sampling, detectors, read out devices, instrumentation for phosphorescencemeasurement, sampling, recording procedure, applications of fluorescenceand phosphorescence.

Thermal Methods of Analysis:
Introduction, instrumentation, sources of errors, interpretation of data, Factorsaffecting curve, applications of TGA, DTA and DSC.

Recommended Books:

1. Christian, G. D., Analytical Chemistry. 6th ed., John-Wiley & Sons, New York, (2006).
2. Harris, D. C., Quantitative Chemical Analysis, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Braun, R. D., Introduction to Chemical Analysis, International Student Edition, (1985).
4. Haines, P. J., Whitby, On Canada Mcgraw Hill Ltd., Thermal Methods of Analysis Principles, Applications and Problems, 1st ed., Springer, (1995).
5. Lakowicz, J. R., Principles of Fluorescence Spectroscopy, 3rd ed., Springer (2006).
6. Gabbot, P., Principles & Applications of Thermal Analysis, Wiley-Blackwell, (2007).
7. Brown, M. E., Introduction to Thermal Analysis: Techniques and Applications, 2nd ed., Kluwer Academic Publishers, (2001).
8. Skoog, D. A., West, D. M. and Holler, F. J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 8th ed., (Int.), Cengage Learning, (2004).
9. Burgess, C. and Jones, D. G., Spectrophotometry, Luminescence and Colour; Science and Compliance, Vol. 6, Elsevier Science, (1995).

Course Code: CHEM-618 **Course Name:** Nuclear Analytical Techniques
Course Contents

Radiotracer techniques, choice of radiotracers, factors affecting choice ofradiotracers, isotope dilution analysis (IDA), principle and equation,instrumentation, applications, advantages and limitations, sub-stoichiometricisotope dilution analysis (SIDA), activation analysis (AA), principle of NAA,neutron sources, interferences, sensitivity and detection limits, classification,instrumentation, applications, advantages and limitations, comparison of NAA and IDA with other methods, radiometric titrations (RT), procedure,advantages and limitations, radio chromatography and radioimmunoassay.

Recommended Books:

1. Robert D. Braun, Instrumental Analysis, McGraw Hill Book Co. New York.
2. Robert D. Braun, Introduction to Chemical Analysis, McGraw Hill Book Co. New York.
3. S. M. .Khopkar, Basic Concepts of Analytical Chemistry, New Age International.
4. Bern Kahn, Radio analyticalChemistry, Springer.

SECOND YEAR (SEMESTER-IV)

SPECIALIZATION IN APPLIED CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-642	Environmental Chemistry Paper-II	2+1
2	CHEM-625	Metallurgical & Explosives	3+0
3	CHEM-626	Industrial Processes	3+0
4	CHEM-627	Analytical Techniques in Industry	3+0
5	CHEM-628	Textile and Cosmetic Industry	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-642 **Course Name:** Environmental Chemistry-II

Course Contents

Fossil fuels and energy sources:

Origin and development of coal: Origin and reserves of petroleum and natural gas, composition and classification of petroleum, refining, and environmental problems associated with petroleum, nuclear fission reactors, solar energy, power synthesis, tidal and geothermal energy, synthetic chemical fuels, the H economy, electrochemical energy conversion, conservation of free energy, the energy balance of the earth.

Soils and mineral resources:

Estimating reserves of mineral resources of earth, extraction of metal-general principles, iron, steel, aluminum, copper and other metals, sulphur and nitrogen.Organic matter in soil, soil nutrients, ion exchange in soils, solid pH and nutrients availability.

RecommendedBooks:

6. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi J. W. Moore & E.

7. A. Moore, Environmental chemistry, Academic Press, New York.

8. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

9. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

10. Staneley E. Manahan, Environmental chemistry, Brooks, California.

Environmental Chemistry Practical **Credit Hours: 01**

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipments.

Code: CHEM-625 **Course Title:** Metallurgy and Explosives

Course Contents

Steel and Metallurgical Products:

Manufacture of cast iron and steel, wrought iron, formation of alloys, heat treatment of steel, classification of steel, passivity, different theories of rusting of iron and its prevention.

Electroplating:

Principle of electroplating, purpose of electroplating, different processes involved in electroplating, chrome plating, nickel plating and electroplating of plastics.

Explosives and Propellants:

Raw materials, manufacture of industrial explosives and propellants, types ofexplosives and their safety measures, chemistry involved in production ofmilitary explosives.

Nuclear Materials:

Extraction of uranium from rocks, importance of nuclear technology, nuclearenergy and its peaceful applications, production of nuclear energy and controlof nuclear reactors, chemistry of fission and fusion reactions, reprocessing ofnuclear spent fuel, industrial application of nuclear radiations.

Recommended Books:

1. Metallurgical Analysis, Lord (1893).
2. Applied Chemistry Theory and Practice, O.P. Vermani& A.K. Narula, Wiley Eastern Limited (1989).
3. T. B. of Quantitative Inorganic Analysis, Vogal's Ed-4th, Longman Group Limited (1978).
4. Practical Statistics for the Analytical Scientist, A Bench Guide, RSC Publishing, LGC Ltd 2009.
5. Dyes and Dyeing, C. E. Pellew, Abhishek Publishers (1998).
6. Experiments in Physical Chemistry, David P. Shoe Maker, McGraw Hill International (1996)
7. Pulp and Paper Technology, Testing and Applications, K.P. Rao (2003), CBS Publishers.
8. Chemistry of Pulp and Paper making, Edwin Sutermeister, Ed-3rd (1946).
9. Fertilizers and Soil Fertility, U.S.Jones, Reston Publishing Co. Virginia,1979.
10. Petroleum Refining Technology, Ram Parsad (2002).
11. Industrial chemistry, B. K. Sharma, Krishna Prakashan Media (P) Ltd., Ed-15 (2006).

12. Shereve's Chemical Process Industries, 5th Ed.1975, By G.T.Austin, Mc-Graw Hill Book Co. New York.

Course Code: CHEM-626 **Course Title:** Industrial Processes

Course Contents

Pharmaceuticals:

Classification of pharmaceutical products and pharmaceutical processing,manufacture of paracetamol and aspirin, chemistry involved in the productionand manufacture of various antibiotics such as streptomycin, erythromycin,penicillin etc.

Petroleum and Petrochemicals:

Origin of petroleum, constituents and classification of petroleum, cracking anddistillation of various fractions in distillation towers, control of distillation towerin refinery, manufacture of monomers such as acetylene, ethylene, propylene,separation and purification of benzene, toluene and xylene.

Sugar Industry and Related Chemicals:

Extraction of juice from sugar cane, purification of juice, clarification, concentration, refining and crystallization.Beet sugar. Glucose and hydrogenated glucose syrups.

Coal Chemicals fuel Gases:

The destructive distillation of coal, coking of coal distillation of coal tar; Liquid Fuels: Hydrogenelysis Natural gas; Coal Gas: Water Gas; Liquefied Petroleum Gases.

<u>RecommendedBooks</u>:

1. Petroleum Refining Technology, Ram Parsad (2002).
2. Industrial chemistry, B. K. Sharma, Krishna Prakashan Media (P) Ltd., Ed-15 (2006).
3. Shereve's Chemical Process Industries, 5th Ed.1975, By G.T.Austin, Mc-Graw Hill Book Co. New York.
4. Food Oils and Fats, H.Lawson, CBS Publishers and Distributors, New Delhi.(1997).
5. Leather in life art and industry, John W. Waterer, 1927. Faber and Faber Ltd.
6. A Text on Petrochemicals, Bhaskararsao, 2002.
7. An Introduction to Polymer Chemistry, W.R.Moor, London Press, London.
8. Principles of Polymer Systems, Rodri-Guez, McGraw Hill Book Co. New York.
9. Modern Technology of Plastics and Polymer Processing Industries, NIIR Board
10. Petroleum Refining Technology, Ram Parsad (2002).

Course Title: Analytical Techniques in Industry **Code:** CHEM-627
Credit Hours: 03
Course Contents
Spectroscopy:
Use of different spectroscopic techniques like FES, AAS and Spectrophotometry for the quality control of raw materials, intermediates and final products in various industries.

Chromatography:
Use of Thin layer chromatography, gas chromatography and HPLC in pharmaceutical and other industries.

On-Line Analysis and Automation:
Significance of on-line analysis and automation of analytical techniques in industry; Classification of techniques w.r.t. automation, Use of microprocessor in conjugation with automation and on-line analysis, different types of automatic analyzers.

RecommendedBooks:

1. Austin, G. T., Nelson, W. L., Petroleum Refinery Engineering, 4th ed., Aukland. Mcgraw Hill, (1985).
2. Shreve, R. M., George, T. A., Shreve's Chemical Process Industries, 5th ed., McGraw-Hill Book Company Inc., New York, (1984).
3. Kent, J. A., Riegel’s Handbook of Industrial Chemistry, 10h ed., Kluwer Academic/Plenum publishers, (2003).
4. Vermani, O. P., Narula. A. K, Applied Chemistry, Theory and Practice, 2nd ed., New Age International Publisher, India, (1995).
5. D. G. Watson, Pharmaceutical Chemistry, Churchill Living Stone, (2007).
6. Cairms, D., Essentials of Pharmaceutical Chemistry, Pharmaceutical Press, (2003).
7. Loveland, W. D., Morrisey, D. J, Modern Nuclear Chemistry, Wiley Interscience, (2005).
8. Speight, J. G., The Chemistry and Technology of Petroleum, 3rd ed., Taylor & Francis, (2013).

Course Title: Textile and Cosmetic Industry **Course Code:** CHEM-628
Credit Hours: 03
Course Contents
Textile Dyeing:
Color and chemical constitution, Important classes of chromogens, Classification and nomenclature of dyes, manufacturing of dye intermediates and dyes, Selection of dyes for wool, cellulosic and synthetic fibers, Theory of Coloration, Coloration of wool, cellulosic and synthetic fibers.

Textile Fibers:
Classification of synthetic fibers, chemistry and manufacturing of viscose rayon, true synthetic fibers including nylons and polyester fibers. Finishing processes for 100% cotton fabrics such as singeing, desizing, scouring, mercerizing and bleaching.

Cosmetics and Perfumes:
Chemistry and production of hair products and shampoos, chemistry involvedin hair curling and styling products, hair tonics and depilatory products,production of cold cream, vanishing cream, bleach cream and shaving creams,tooth paste and face powders, production of nail polish, lipsticks andmascaras.

RecommendedBooks:

1. Dyes and Dyeing, C.E. Pellow, Abhishek Publishers, 1998.
2. Textile Dyes and Pigments, H. Panda, NIIR Publishers.
3. The Chemistry of Synthetic Dyes and Pigments, H.A. Lubs, Reinhold Publishing Corporation, 1955.
4. Fibre to fabric, 4th Ed, Potter &Corban, McGraw Hill book Company, 1959.
5. Industrial chemistry, B. K. Sharma, Krishna Prakashan Media (P) Ltd., Ed-15 (2006).
6. Shereve's Chemical Process Industries, 5th Ed.1975, G.T. Austin, McGraw Hill Book Co. New York.
7. Sugar: Science and Technology, G. G. Birch and K. J. Parker, Applied Science Publishers Ltd., 1979.
8. Schueller, R. and Romanowski, P., Beginning Cosmetic Chemistry:Practical Knowledge for the Cosmetic Industry, 3rd ed., Allured Publishing Corporation, (2009).

Barel, A. O., Paye, M. and Maibach, H. I., Handbook of Cosmetic Scienceand Technology, 3rd ed., Informa Healthcare, (2009).

SECOND YEAR (SEMESTER-IV)

SPECIALIZATION IN BIOCHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-642	Environmental Chemistry Paper-II	2+1
2	CHEM-635	Microbiology and Immunology	3+0
3	CHEM-636	Nutritional Chemistry	3+0
4	CHEM-637	Bio-nanotechnology	3+0
5	CHEM-638	Pharmacology	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-642 **Course Name:** Environmental Chemistry-II

Course Contents

Fossil fuels and energy sources:

Origin and development of coal: Origin and reserves of petroleum and natural gas, composition and classification of petroleum, refining, and environmental problems associated with petroleum, nuclear fission reactors, solar energy, power synthesis, tidal and geothermal energy, synthetic chemical fuels, the H economy, electrochemical energy conversion, conservation of free energy, the energy balance of the earth.

Soils and mineral resources:

Estimating reserves of mineral resources of earth, extraction of metal-general principles, iron, steel, aluminum, copper and other metals, sulphur and nitrogen.Organic matter in soil, soil nutrients, ion exchange in soils, solid pH and nutrients availability.

RecommendedBooks:

11. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi J. W. Moore & E.

12. A. Moore, Environmental chemistry, Academic Press, New York.

13. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

14. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

15. Staneley E. Manahan, Environmental chemistry, Brooks, California.

Environmental Chemistry Practical **Credit Hours: 01**

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipments.

Course Title: Microbiology and Immunology **Code:** CHEM-635

Course Contents:

Fundamentals of Microbiology:
Prokaryotic cell structure and function, Prokaryotic growth and nutrition,prokaryotic genetics.Virus and eukaryotic microorganisms, virus, bacteria,fungi and parasites.Bacterial diseases, airborne, foodborne and waterbornebacterial diseases.Industrial microbiology and biotechnology, microorganismin industry, alcoholic beverages, other important microbial products.

Immunology:
Chemistry of immunoglobulins, myeloma and hybridoma immunoglobulins,immune system and its abnormalities, allergy and inflammation, complementsystem, Peripheral leucocytes and macrophages, Type I lgE-mediatedhypersensitivity, other types of hypersensitivity autoimmune disorders,immunodeficiency disorders.

Recommended Books:

1. Nester, E., Nester, M., Anderson, D. and Roberts, C. E. Tr., Microbiology: A Human Perspective, 7th ed., McGraw-Hill, (2011).
2. Duan, T., Melvold, R., Viselli, S. and Waltenbaugh, C., Lippincott's Illustrated Reviews, Immunology, 2nd ed., Lippincott William & Wilkins, (2012).
3. Harvey, R. A., Cornelissen, C. N. and Fischer, B. D., Lippincott's Illustrated Reviews: Microbiology, 3rd ed., Lippincott William & Wilkins, (2012).
4. Wiley, J. M., Sherwood, L. M. and Woolnerton, C. J., Prescott's Microbiology, 7th ed., McGraw-Hill Education, (2011).
5. Male, D., Brostoff, J., Roth, D. B. and Roitt, I. M., Immunology, 8th ed., Elsevier, (2012).

Course Title: Nutritional Chemistry **Course Code:** CHEM- 636

Course Contents

Major Dietary Constituents:

Nutritional importance of carbohydrates, proteins and amino acids, lipids, anddietary fiber.

Energy Needs:

Assessment and requirement of energy in different age groups nutrition ingrowth and aging, nutritional requirement during infancy and childhood, diet,nutrition and adolescence, nutrition in the elderly minerals, biochemical role ofCalcium, Chromium, Copper, Iron, Iodine, Magnesium, Phosphorous,Selenium and Zinc, their dietary source daily requirements and deficiencydiseases.

Vitamins:

Role of vitamins as coenzymes structure, physiological functions, deficiencydiseases and recommended dietary allowances of the following vitamins, fatsoluble vitamins: A, D, E, and K, water soluble vitamins: Thiamine, Riboflavin,Niacin, Pantothenic acid, Folic acid, Blotin and Ascorbic acid.

Recommended Books:

1. Wilson, K. and Walker, J., Principles and Techniques of Biochemistry, 5^{th} ed., Cambridge University Press, (2000).
2. Belitz, H. D., Grosch, W. and Schieberle, P., Food Chemistry, 4th ed., Springer-Verlag Berlin, Germany, (2009).
3. Spallholz, J. E., Boylan, L. M. and Driskell, J. A., Nutrition: Chemistry & Biology, 2nd ed., CRC Press Inc., USA, (1999).
4. Ross, A. C., Caballero, B., Cousins, R. J., Tucker, K. L. and Ziegler, T. R., Modern Nutrition in Health and Disease, 11th ed., Lippincott Williams &Wilkins, (2012).
5. McDowell, L. R., Vitamins in Animal and Human Nutrition, 2nd ed., Iowa State University Press, (2000).
6. Zempleni, J., Rucker, R. B., McCormick, D. B. and Suttie, J. W., Handbook of Vitamins, 4^{th} ed., CRC Press, (2007).
7. Nelson, D. L. and Cox, M. M., Lehninger's Principles of Biochemistry, 6^{th} ed., W. H. Freeman, (2012).

Course Title: Bio-nanotechnology **Course Code:** CHEM- 637

Course Contents:
Introduction to nanoparticles, overview of nanoscale materials, effect of lengthscale on properties, introduction to bio-nanotechnology, bio-nanotechnologysystems, and protein based nanostructures, nano-biosensors, challenges andopportunities associated with biology on the nanoscale, green nanoparticleproduction, self-assembly and templating, surface patterning andfunctionalization, characterization techniques of nanostructures.

Recommended Books:

1. Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc.,Hoboken, New Jersey (2004).
2. Ratner, M.A. and Ratner, D., Nanotechnology: A Gentle Introduction to the Next Big Idea, Prentice Hall Professional, upper saddle river, New Jersey (2003).
3. Papazoglou, E. S., Bionanotechnology, Morgan & Claypool Publishers, California, USA (2007).
4. Renugopalakrishnan V., Lewis, R. V., Bionanotechnology: Proteins to Nano devices, Springer (2006).
5. Iqbal, S., Bionanosensors, Morgan & Claypool Publishers, California USA (2008).
6. Kotov, N. A., Nanoparticle Assemblies and Superstructures, CRC press, USA (2006).
7. Dinh, T.V., Nanotechnology in Biology and Medicine: Methods, Devices and Application CRC press, USA (2007).
8. Kumar, C., Nanomaterials for Biosensors, Wiley-VCH, Germany (2007).
9. Niemeyer, C.M., and Mirkin, C.A., Nanobiotechnology: Concepts, Applications and Perspectives, Wiley-VCH, Germany(2004).

Course Title: Pharmacology **Course Code:** CHEM- 638

Course Contents

Chemotherapy:
Structure and mode of action of antipyretics analgesic, antimalarial, sulpha-drugs, antibiotics with special reference to pencillin, sulphanilamides.Mechanism of drugs action and resistance.Modes of drug delivery. Pharmacokinetics and pharmacodynamics

Recommended Books:

1. Principles of Biochemistry by White Hundler and Smith.
2. Biochemistry by Lehninger.
3. Review of Physiological Chemistry by H.A.Harper.
4. Text Book of Biochemistry by West Todd/Mason/Von Brugge.
5. Text Book of Biochemistry by Mazur/Harrow.
6. The Phermacological basis of Therapeutics edited by L.S.Goodman and A.Gilman (Macmillan).

SECOND YEAR (SEMESTER-IV)

SPECIALIZATION IN INORGANIC CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-642	Environmental Chemistry Paper-II	2+1
2	CHEM-655	Radio and Nuclear Chemistry	3+0
3	CHEM-656	Symmetry and Magnetochemistry	3+0
4	CHEM-657	Elementary Group Theory	3+0
5	CHEM-658	Organometallics and Catalysis	3+0
6	CHEM-690	Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-642 **Course Name:** Environmental Chemistry-II
Course Contents

Fossil fuels and energy sources:
Origin and development of coal: Origin and reserves of petroleum and natural gas, composition and classification of petroleum, refining, and environmental problems associated with petroleum, nuclear fission reactors, solar energy, power synthesis, tidal and geothermal energy, synthetic chemical fuels, the H economy, electrochemical energy conversion, conservation of free energy, the energy balance of the earth.

Soils and mineral resources:
Estimating reserves of mineral resources of earth, extraction of metal-general principles, iron, steel, aluminum, copper and other metals, sulphur and nitrogen.Organic matter in soil, soil nutrients, ion exchange in soils, solid pH and nutrients availability.

RecommendedBooks:

16. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi J. W. Moore & E.

17. A. Moore, Environmental chemistry, Academic Press, New York.

18. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

19. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

20. Staneley E. Manahan, Environmental chemistry, Brooks, California.

Environmental Chemistry Practical **Credit Hours: 01**

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipments.

Course Title: Radio and Nuclear Chemistry**Course Code:** CHEM-655

Course contents

Fundamentals and applied aspects of radioactivity and nuclear chemistry, types and characteristics of nuclear radiation, structure of nucleus, half-life,nuclear binding energy, and artificial radioactivity, fission and fusion reactions,acceleration of charged particles and applications of radioisotopes.

Recommended Books:

1. Friedlander, G., Kennedy, J. W., Miller, J. M. and Maciuas, E. S., Nuclearand Radiochemistry, 3rd ed., John-Wiley & Sons, Inc., (1981).
2. Choppin, G. R., Rydberg, J., Liljenzin, J., Radiochemistry and NuclearChemistry, 3rd ed., Butterworth-Heinemann Ltd., (2002).
3. Arnikar, H. J., Essentials of Nuclear Chemistry, 4th ed., New AgeInternational Pvt. Ltd. Publishers, (1996).
4. Naqvi, I. I. and Farrukh, M. A., Radiotracers in Chemical Applications VDMVerlag Dr. Müller, Germany, (2010).
5. Loveland,W., Morrissey, D. J. and Seaborg, J. T., Modern NuclearChemistry, John Wiley and Sons, Inc.,(2006).

Course Title: Symmetry and Magnetochemistry **Course Code:** CHEM-656

Course Contents:

Symmetry and Group Theory:
Symmetry and group theory, point groups, multiplication tables, grouprepresentation and development of character tables. Introduction to theinterpretation of spectra and structure elucidation.

Magneto-chemistry:
Theory of magnetism, diamagnetism, paramagnetism, ferro, ferri andantiferromagnetism, magnetic susceptibility, magnetic moments, Faraday's &Gouy's methods, effect of temperature on magnetic properties of complexes.Electron spin resonance spectroscopy, Magnetic moment of lanthanides.

Recommended Books:

1. Douglas, B., McDaniel, D., Alexander, J., Concepts and Models of Inorganic Chemistry, 3rd ed., John-Wiley & Sons Inc., (1997).
2. Huheey, J. E, Keiter, E. A., Keiter, R. L., Inorganic Chemistry: Principles of Structure and Reactivity", 4^{th} ed., Prentice Hall, (1997).
3. Mackay, K. M., Mackay, R. A. and Henderson, W., Introduction to Modern Inorganic Chemistry, 6th ed., CRC Press, (2002).
4. Miessler, G. L., Fisher, P. J. and Tar, D, A., Inorganic Chemistry, 5^{th} ed., Prentice Hall, (2013).

Course Title: Elementary Group Theory **CourseCode:** CHEM-657

Course contents

Symmetry elements and symmetry operations, point groups, properties of groups, matrices, transformation of matrices, character tables and their applications in hybridization, IR and Raman spectroscopy.

Books recommended

1. Cotton F.A. "Chemical Applications of Groups Theory" Interscience Publishers (1963).
2. Lowell Hall H. "Group Theory and Symmetry in Chemistry" McGraw Hill Book Company (1969).
3. Vincent A. "Molecular symmetry and Group Theory", John Wiley &sons, London, (1977)

Course Title: Organometallics and Catalysis **Course Code:** CHEM-658

Course contents

Fundamentals of organometallic compounds, types of bonding inorganometallics, single, double and triple bonds to carbon (compound types,acyls, alkylidene complexes and alkylidyne complexes), delocalizedhydrocarbon systems (alkenes, olefins, allyl and butadienes), alkynecomplexes, cyclic π-complexes (five and six membered rings). Homogeneouscatalytic hydrogenation, dimerization, oligomerization, polymerization,Hydro-formylation of olefins, catalytic polymerization of acetylenes.Insertionreactions and uses of organometallic compounds in organic synthesis.

<u>Recommended Books</u>

1. Powell, P., Principles of Organometallics Chemistry, 2nd ed., Springer, (1998).
2. Yamamoto A., Organotransition Metal Chemistry: Fundamental Conceptsand Applications, 1st ed., John-Wiley & Sons, Inc., (1986).
3. Cotton, F. A., Wilkinson, G., Murillo, C. A., Bochmann M., AdvancedInorganic Chemistry, 6th ed., Wiley-Intersceince, New York, (1999).
4. Miessler, G. L., Fisher, P. J. and Tar, D, A., Inorganic Chemistry, 5th ed.,Prentice Hall, (2013).
5. Douglas, B., McDaniel, D. and Alexander, J., Concepts and Models ofInorganic Chemistry, 3rd ed., John-Wiley & Sons, Inc., (1994).
6. Haiduc, I. and Zuckerman, J. J., Basic Organometallic Chemistry, WalterDe Gruyter Inc., (1985).
7. Jolly, W. L., Modern Inorganic Chemistry, 2nd ed., McGraw-Hill Company,(1991).
8. Porterfield, W. W., Inorganic Chemistry: A Unified Approach, 2nd ed.,Academic Press, (1993).
9. Vincet, A., Molecular Symmetry and Group Theory: 2nd ed., John-Wiley Sons, Ltd., (2001).
10. Malik, W. U., Tuli, G. D., Madan, R. D., Selected Topics in InorganicChemistry, S. Chand and Co. Ltd., (2010).

SECOND YEAR (SEMESTER-IV)

SPECIALIZATION IN ORGANIC CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-642	Environmental Chemistry Paper-II	2+1
2	CHEM-665	Natural Products	3+0
3	CHEM-666	Organic Synthesis	3+0
4	CHEM-667	Reaction mechanism	3+0
5	CHEM-668	Medicinal Chemistry	3+0
6	CHEM-690	Special Paper-II/Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-642 **Course Name:** Environmental Chemistry-II
Course Contents

Fossil fuels and energy sources:
Origin and development of coal: Origin and reserves of petroleum and natural gas, composition and classification of petroleum, refining, and environmental problems associated with petroleum, nuclear fission reactors, solar energy, power synthesis, tidal and geothermal energy, synthetic chemical fuels, the H economy, electrochemical energy conversion, conservation of free energy, the energy balance of the earth.

Soils and mineral resources:
Estimating reserves of mineral resources of earth, extraction of metal-general principles, iron, steel, aluminum, copper and other metals, sulphur and nitrogen.Organic matter in soil, soil nutrients, ion exchange in soils, solid pH and nutrients availability.

RecommendedBooks:

21. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi J. W. Moore & E.

22. A. Moore, Environmental chemistry, Academic Press, New York.

23. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

24. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

25. Staneley E. Manahan, Environmental chemistry, Brooks, California.

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipments.

Course Title: Natural Products **Course Code:** CHEM-665

Course contents

Anthocyanins:
General nature and occurrence of anthocyanins, structure, Flavons, isoflavones, Depsides and tannins.

Saponins:
Introduction, nomenclature and classification.Structural studies, isolation and total synthesis of latest isolated saponins.

Chemotherapy:
Introduction, Sulphonamids, Antimalerial, Arsenic drugs, Antibiotics, Penicillin, Streptomycin, Auromycin and teramysin, Patulin, Chloramphenicol.

Extraction and isolation:
General methods of extraction and isolation of natural products.Common chromatographic techniques, CC, TLC, HPLC etc. phytochemical tests for various classes of natural products.

Reference books:

1. Organic chemistry Vol. II, I by I. Finar.
2. The chemistry of Natural Products, by P. D. B. Mayo.
3. Chemistry of Natural products by 8.P. W. Bently.

Course Title: Organic Synthesis **Course Code:** CHEM-666

Course Contents

Principles and importance of organic synthesis, Introduction to retero-synthesisand disconnection approach, synthesis of aromatic compounds; one and twogroup carbon C-X disconnections, donor and acceptor synthons, C-Cdisconnections and 1,2-, 1,3-, 1,4-, 1,5- and 1,6-difunctionalized compounds,synthesis of cyclic compounds (3-6 membered), chemo-, regio-andstereoselectivity.

Synthetic strategies:
Functional group protection: hydroxyl, amino, carbonyl, carboxylic, sulfanyl,C=C, solid phase synthesis, phase-transfer catalysis.

Recommended Books:

1. Warren, S. and Wyatt, P., Workbook for Organic Synthesis: The Disconnection Approach, 2nd ed., John-Wiley & Sons, Inc., (2010).
2. Fox, M. A. and Whitsell, J. K., Organic Chemistry, 3rd ed., Jones & Bartlett Publishers (1997).
3. Clayden, J., Greeves, N., and Warren, S., Organic Chemistry, 2nd ed., Oxford University Press, New York, (2012).
4. Loudon, M., Organic Chemistry, 5th ed., Roberts Company Publishers, (2009).
5. Smith, J. G., Organic Chemistry, 3rd ed., McGraw-Hill, (2010).
6. Norman, R. O. C. and Coxon, J. M., Principles of Organic Synthesis, 3rd ed., CRC Press, (1993).

Course Title: Reaction mechanism **Course Code:** CHEM-667

Course Contents

Name Organic Reactions: Recent developments, mechanistic, stereochemical aspects and synthetic applications of various Name reactions: Aldol Condensation, Diels-alder reaction, Michael Addition, Robinson annulations, Knoevenagal Condensation, Clasien Condensation, Dickmann Condensation, Mannich Reaction, Wittig reaction, Peterson reaction, Heck Reaction, Husdiecker reaction and fischerindole synthesis, Birgmann,s cyclisation, Corey Kim oxidation, Cannizzaro reaction, Dakin oxidation, Kolbe Schmitt oxidation.

Recommended Books

1. Mundy, B.P. Ellerd, M.G. Favalozo F.G. and Favalozo, Jr. Name Reactions and Reagents in Organic Synthesis, john Wiley, New York (2005).
2. Smith, M. B. and Marks, Advanced Organic Chemistry, Reactions, Mechanism and Structure, 5^{th} ed., John Wiley, New York (2001).
3. R.O.S. Norman, Principles of organic synthesis, 3^{rd} ed., Chapman-Hall, London (1993).
4. Gilchrist, T.L. and Rees, C. W., "Carbenes, Nitrenes and Arynes' Nelson, London.
5. Clayden, J., Greeves, N., Warren, S. and Wothers, P., "Organic Chemistry", Oxford University press New York.
6. Sykes, P.,"A guide book to Mechanism in organic Chemistry" longmann, London.
7. Carry, F. A. and Sundberg, R.J., "Advanced Organic Chemistry" Part A:" Structure and Mechanisms" oxford university press.
8. Bruchner, R., Advance Organic Chemistry-Reaction Mechanism" Harcourt Science and Technology company, New York.

Course Title: Medicinal Chemistry **Course Code:** CHEM-668

Course contents

Chemistry of biomolecules; introduction to drugs and drug discovery, sourcesof therapeutic agents, structure activity relationship (SAR), drug-receptorinteraction, , drug formulation and its methods, different types of drugs;chemistry and modes of action of some common drugs.

Recommended Books:

1. Paul, M. D., Medicinal Natural Products: A Biosynthetic Approach, 3rd ed.,Medicinal Natural Products, John-Wiley & Sons, Ltd, (2009).
2. Wolff, M. E., Burger's Medicinal Chemistry, 4th ed., Part III, John-Wiley &Sons, New York, (2006).
3. Williams, D. A. and Lemke, T. L., Foye's Principles of Medicinal Chemistry,6th ed., Lippincott Williams & Wilkins, New York, (2008).
4. D. Sriram, P. Vogeeswari, Medicinal Chemistry, 2nd ed., BITS Pilani,Pearson, Publisher: Darling Kindernley, India, (2010).
5. Carins D., Essential of Pharmaceutical Chemistry, 3rd ed., PharmaceuticalPress, London, (2008)

Course name: Special paper-2 (Organic)
Course code: CHEM-690
Credit hours: 3+0

Title: Separation and analysis of organic compounds

Introduction: The course is aimed in training of final year students in the separation and systematic identification of organic compounds using chemical tests as well as spectral analysis. The course forms basis for the graduates of organic chemistry, medicinal chemistry, natural products, material chemistry etc. The course is buildup on the knowledge acquired by MSc/BS students in other subjects including natural products, medicinal chemistry, spectroscopy, chromatography, organic synthesis etc. The course is relative.

Objectives:

1. Give authority to plan organic chemical laboratory work.
2. Provide skills in identification of organic compounds.
3. Provide skills and knowledge about the methods of separation of organic compounds.
4. Providing skills in performing chemical synthesis on a small scale.
5. Provide knowledge about the handling of the security aspects in an organic chemistry lab.

Contents:
Separation of mixtures: Distillation, sublimation, extraction (polar/nonpolar), crystallization, recrystallization, chromatography (CC, TLC, GC, HPLC).
Identification/classification tests: physical properties, solubility, chemical tests for classification (Functional groups), derivative preparation.
Spectral analysis: Infrared, NMR, Mass spectroscopic data and characteristics of Organic compounds.

Recommended books:
Shriner, Hermann, Morrill, Curtin and Fusan (2004)*The systematic identification of organic compounds* (8th edition). John Wiley & Sons, Inco.

Finar, I. L. (1959). *Organic Chemistry: The Fundamental Principles*(Volume 1) 3rd or 4th edition. Longmans, Green and Company.

John D. Robert and Marjorie C. Caserio (1977) *Basic Principles of Organic Chemistry, second edition.* W. A. Benjamin, Inc., Menlo Park, CA.

SECOND YEAR (SEMESTER-IV)

SPECIALIZATION IN PHYSICAL CHEMISTRY

S.NO	Course Code	Course Name	Credit Hours
1	CHEM-642	Environmental Chemistry Paper-II	2+1
2	CHEM-675	Reaction Dynamics	3+0
3	CHEM-676	Colloid and Surface Chemistry	3+0
4	CHEM-677	Radiation and Photochemistry	3+0
5	CHEM-678	Special topics in physical chemistry	3+0
6	CHEM-690	Special Paper-II/Research (Lab Work/Literature Review)	3
Total Credit Hours			18

Course Code: CHEM-642 **Course Name:** Environmental Chemistry-II
Course Contents

Fossil fuels and energy sources:
Origin and development of coal: Origin and reserves of petroleum and natural gas, composition and classification of petroleum, refining, and environmental problems associated with petroleum, nuclear fission reactors, solar energy, power synthesis, tidal and geothermal energy, synthetic chemical fuels, the H economy, electrochemical energy conversion, conservation of free energy, the energy balance of the earth.

Soils and mineral resources:
Estimating reserves of mineral resources of earth, extraction of metal-general principles, iron, steel, aluminum, copper and other metals, sulphur and nitrogen.Organic matter in soil, soil nutrients, ion exchange in soils, solid pH and nutrients availability.

RecommendedBooks:

26. Anil Kumar, Environmental chemistry, Wiley Eastern, New Delhi J. W. Moore & E.

27. A. Moore, Environmental chemistry, Academic Press, New York.

28. S. K. Banerji, Environmental chemistry, Prentice Hall, Delhi.

29. S. K. Banerji, Environmental chemistry, Tata Publisher, Delhi.

30. Staneley E. Manahan, Environmental chemistry, Brooks, California.

Environmental Chemistry Practical Credit Hours: 01

The Environmental Chemistry Particles will be designed and carried out by the teacher depending upon the availability of the chemicals and equipments.

Course Title: Reaction Dynamics **Course Code:** CHEM-675

Reaction Dynamics:
Correlation between physical properties and concentration, Kinetics of thecomplex reactions, reversible, parallel, consecutive bimolecular reactions,Theory of absolute reaction rate, Lindemann's theory of unimolecularreactions, bimolecular collision theory, transition state theory, comparison ofcollision and absolute reaction theories, Potential energysurfaces,Thermodynamic formulation of reaction rates, Calculation of entropy andenthalpy changes, Thermal decomposition of nitrogen pentaoxide.

Reactions in solutions:
Influence of ionic strength on the reaction rate, effect of dielectric constant ofthe medium on the rate of the reaction, single sphere activated complexmodel, double sphere activated complex model, complex reactions, chainreactions, single chain carrier with second order breaking, one chain carrierwith first order breaking, two chain carrier with second order breaking,experimental techniques for fast reactions.

Recommended Books:

1. Espenson, J. H., Chemical Kinetics and Reaction Mechanism 2nd ed., McGraw-Hill, London (2002).
2. Connors, K. A., Chemical Kinetics: The Study of Reaction Rates in Solution, VCH Publishers, Inc., (1990).
3. Silbey, R. J., Alberty, R. A. and Bawendi, M. G., Physical Chemistry, 4th ed., John-Wiley & Sons, (2005).
4. Atkins, P. and Paula, J. D., Atkin's Physical Chemistry, 9th ed., Oxford University Press, (2010).
5. Houston, P. L., Chemical Kinetics and Reaction Dynamics, Dover Publications, (2006).
6. Levine, R., Molecular Reaction Dynamics, Cambridge University Press, (2005).
7. Laidler, K. J., Chemical Kinetics, 3rd Edition, Prentice Hall, (1987).
8. Frost, A. A., and Pearson, R. G., Reaction Mechanism, 2nd Edition John Wiley and sons, Inc; (1961).
9. Benson, S. W., Foundation of Chemical Kinetics, Krieger Publication Co. (1980).

Course Title: Colloid and Surface Chemistry **Course Code:** CHEM-676

Course Contents

Colloid and Surface Chemistry:
Colloidal solutions, catalyst preparation methods, industrial catalysts,emulsion, surfactant, nanoscale chemistry, nanomaterials and theirapplications, dimensional control in nanostructures, macromolecular surfacefilms, charged films and Langmuir-Blodgett layers, characterization methodsand applications.Solid surfaces, surface structures, clean surface structures, gas solid interface,thermodynamics of adsorption, heterogeneous catalysis, kinetic andmechanisms of catalyzed reactions, adsorption at liquid surfaces,chemisorption, physiosorption and dynamics, enzymatic catalysis, organizedmolecular assemblies, experimental probes for surface and adsorbent structures, scanning probe techniques, low energy electron diffraction (LEED),electron spectroscopy, and other surface analysis techniques.

Recommended Books:

1. Hunter, R. J., Introduction to Modern Colloid Science, Oxford UniversityPress, Oxford, (1994).
2. Poole, C. P. and Owens, F. J., Introduction to Nanotechnology, 1st ed.,Wiley-Interscience, (2003).
3. Klabunde, K. J., Nanoscale Materials in Chemistry, John-Wiley & Sons,Inc., (2003).
4. Kolunsiki, K. W., Surface Science: Foundations of Catalysis andNanoscience, 3rd ed., John-Wiley & Sons, Ltd., (2012).
5. Adamson, A. W. and Gast, A. P., Physical chemistry of Surfaces, 6th ed.,Wiley-Interscience, (1997).
6. Atkins, P. and Paula, J. D., Atkin’s Physical Chemistry, 8th ed., OxfordUniversity Press, (2006).
7. Christian, G. D., Analytical Chemistry, 6th ed., John-Wiley & Sons, (2004).

Course Title: Radiation and Photochemistry **Course Code:** CHEM-677

Course Contents

Radiation Chemistry:
Development and advancement in radiation chemistry, radiation dosimetry, Fricke dosimeter, dosimetry in pulse radiolysis, energy states in radiation chemistry, excited states, fragmentation, pre-dissociation, photochemical decay, ions and electrons, radiolysis of gases, liquids, solids, frozen liquids and ions in radiation chemistry, recent application of radiation chemistry.

Photochemistry:
Principles of photochemistry, laws of photochemistry, Einstein's law ofphotochemical equivalence, rates of intramolecular processes, chemicalreactions and quantum yields with examples, energy transfer in photochemicalreaction, quantum yield of emission process radiation and nonradiationprocess, kinetics and quantum yields of radiative and nonradiative process(fluorescence, phosphorescence, inter-system crossing, internal conversion,quenching) and Stern-Volmer reactions, photosensitized reactions.

Recommended Books:

1. Spinks, J. W. T. and Woods, R. J., An introduction to Radiation Chemistry, 3rd ed., Wiley Inter Si. Pub., USA, (1990).
2. Aziz, F. and Rodgers, M. A. J., Radiation Chemistry Principles and Applications, 1st ed., VCH Publishers, Inc., (1987).
3. Choppin, G., Liljenzin, J-O., Rydberg, J., Radiochemistry and Nuclear Chemistry, 3rd ed., Butterworth-Heinemann, (2002).
4. Mostafavi, M., Douki, T., Radiation Chemistry: From Basic to Applications in Material and Life Sciences, EDP Science, (2008).
5. Dunkin, I., Photochemistry, Vol. 36, RSC Publishing, (2007).
6. Dickson, D. P. E., Berry, F. J., Mossbauer Spectroscopy, Cambridge University Press, (1986).
7. Scaglia, B., The Fundamentals: An Understanding of Photochemistry, Biblio Bazaar, (2011).
8. Konya, J. and Nagy, N. M., Nuclear and Radiochemistry, 1st ed., Elsevier, (2012).

Course Title: **Special topics in Physical Chemistry**

Code: **CHEM- 678**

Credit Hours: **03**

Course Objectives:

Students will acquire knowledge to enable themselves to understand the fundamental concepts about the important physical and chemical aspects of surfactant chemistry, characterization methods and applications of surfactant nanoparticles and colloidal solutions.

Course Contents:

Lignocellulosic materials, sources of lignocellulosic materials, General methods of extraction and isolation of cellulose and nanocellulose their applications and characterization through (SEM),transmission electron spectroscopy (TEM) and other surface analysis techniques .

Surface Chemistry, Interfaces, adsorption, Types of adsorption and adsorption isotherms, Freundlich and Langmuir adsorption isotherms, surfactant chemistry, adsorption at liquid surfaces, micellization, factors affecting micellization, organized molecular assemblies, characterization methods and applications of surfactant nanoparticles and colloidal solutions.

experimental techniques for surface and adsorbent structures, scanning electron spectroscopy (SEM),transmission electron spectroscopy (TEM) and other surface analysis techniques.

Recommended Books:

1. Poole, C. P. and Owens, F. J., *Introduction to Nanotechnology*, 1st ed., Wiley-Interscience, (2003).
2. Klabunde, K. J., *Nanoscale Materials in Chemistry*, John-Wiley & Sons, Inc., (2003).
3. Kolunsiki, K. W., *Surface Science: Foundations of Catalysis and Nanoscience*, 3rd ed., John-Wiley & Sons, Ltd., (2012).
4. Adamson, A. W. and Gast, A. P., *Physical chemistry of Surfaces,* 6th ed., Wiley-Interscience, (1997).

5. Atkins, P. and Paula, J. D., *Atkin's Physical Chemistry,* 8th ed., Oxford University Press, (2006).
6. Christian, G. D., *Analytical Chemistry*, 6th ed., John-Wiley & Sons, (2004).
7. Somorjai, G. A. and Li, Y., Introduction to Surface Chemistry and Catalysis, 2nd ed., John-Wiley & Sons, Inc., (2010).
8. Atkins, P. and Paula, J. D., Atkin's Physical Chemistry, 9th ed., Oxford University Press, (2010).
9. Albert R.A., Robert J.S. and Moungi G.B. "Physical Chemistry". 4th ed., John Wiley and Sons (2004).
10. Surface Science: Foundations of Catalysis and Nanoscience, 3rd ed., John-Wiley & Sons, Ltd., (2012).

Course Title:	**Special Paper-II**
Code:	**CHEM- 690**
Credit Hours:	**3+0**

Course Objectives:

Students will acquire knowledge to enable themselves to understand the fundamental concepts of liquids, and to investigate the physical properties of ideal/non-ideal binary solutions. Students will also able how to prepare different types of solution and their calculations.

Solution Chemistry:

Liquids,their characteristics and properties.Surface tension, viscosity, refractive index, and their measurement and applications, Solution, Types of solution, concentration units and their measurements. Brief account of interactions among the molecules in liquids, ideal and non-ideal solutions, Raoult's law and its applications, Colligative properties,lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure, vapor pressure of non-ideal solutions. Henry's law, abnormal colligative properties, degrees of association and dissociation of solutes, osmotic pressure and its measurement, fractional distillation etc.

Recommended Books:

19. Atkins, P. and Paula, J. D., Atkin's Physical Chemistry,9th ed., Oxford University Press, (2010).
20. Albert R.A., Robert J.S. and Moungi G.B. "Physical Chemistry". 4th ed., John Wiley and Sons (2004).
21. Chaudhary, S. U.,Ilmi Textbook of Physical Chemistry, 2nd ed., IlmiKitabKhana, Lahore, (2013)..
22. R. A. alberty, J.s. Robert and G. B. moungi physical chemistry, 4th edition, jhonwilley& sons(2004).
23. Levine, Physical Chemistry 6Th Ed (2015).

Special paper-I **Cr.Hrs: (3+0)**

Course objective: The course is aimed to:

- To understand reaction mechanism and methods of their determination with reference to different organic reactions.
- To study different states of matter along with their physical properties.
- To study material chemistry and characterization of these material using advance techniques.

Course Outlines:

Introduction to reaction mechanism, how determine mechanism of a reaction, comprehensive study on the mechanism of different types of substitution, addition and elimination reactions.

Introduction to liquids, characteristics & Properties of liquids, Surface tension, conductance, viscosity, Refractive index and their measurement. Nanomaterials and applications their measurement through SEM, XRD.

Basic Principles and instrumentation of Flame photometry and Spectrofluorimetry. Introduction to thermogravimetric analysis. ATR (FT-IR) and spectral interpretation. Biodegradable polymers and its significance in environmental pollution control.

Recommended Books:

1. Claydem, J., Greeves,N. and Warren, S., *Organic Chemistry*, 2nd ed., Oxford University Press, (2012).

2. Coxon, J. M. Norman, R. O. C., *Principles of Organic Synthesis*, 3rd ed., CRC Press, (1993).

3. Furniss, B. S., Hannaford, A. J., Smith, P. W. G., Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th edition, Longman, UK, (1989).

4. Mohan, J., *Organic Analytical Chemistry: Theory and Practice*,1st ed. Alpha Science Int. Ltd.New Delhi, India, (2003).

5. Robert, T. M. and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).

6. Tse-Lok, H., *Symmetry: A Basis for Synthesis Design*, John-Willey & Sons, Inc., New York, (1995).

7. Pine, S. H., *Organic Chemistry*, 5th ed., Tata McGraw-Hill, India, (1987).

8. Sykes, P., *A Guide Book to Mechanism in Organic Chemistry*, 6th ed., Pearson Education, (1986).

9. Mayo, D. W., Pike, R. M. and Forbes, D. C., *Microscale Organic Laboratory with Multistep and Multiscale Syntheses*, 5th ed., John-Wiley & Sons, Inc., (2011).

10. Gilbert, J. C. and Martin, S. F., *Experimental Organic Chemistry: A Miniscale and Microscale Approach*, 5th ed., Brooks/ Cole Cengage Learning, (2010).

11. Solomons, T. W. G. and Fryhle, C. B., *Organic Chemistry,* 10th ed., John-Wiley & Sons, Inc., (2011).

12. Carey, F. A. and Giuliano, R. M., *Organic Chemistry*, 9th ed., McGraw-Hill Education, (2013).

13. 12. Bruice, P. Y., *Organic Chemistry,* 7th ed., Perason Education, Ltd., (2013).

14. Smith, M. B*., March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure,* 7th ed., John-Wiley & Sons, Inc., (2013).

Course name: Special paper-II
Course code: CHEM-690 **Credit hours: 3+0**

Objectives:

1. Give authority to plan organic chemical laboratory work.
2. Provide skills in identification of organic compounds.
3. Provide skills and knowledge about the methods of separation of organic compounds.
4. Providing skills in performing chemical synthesis on a small scale.
5. Provide knowledge about the handling of the security aspects in an organic chemistry lab.

Contents:

Separation of mixtures: Distillation, sublimation, extraction (polar/nonpolar), crystallization, recrystallization, chromatography (CC, TLC, GC, HPLC).
Identification/classification tests: physical properties, solubility, chemical tests for classification (Functional groups), derivative preparation.
Rate of Chemical reaction & rate law, order of reaction, First and second order reaction. Methods of determination of order of reaction. Energy of activation. Effect of temperature on the reaction rate. Lindeman's theory of unimolecular reactions. Bimolecular collision theory.
Basic principle of Electroplating and its significance. Rechargeable and solar
batteries and their application. Introduction to forensic science and finger printing. Study of Physico-chemical parameters for water analysis. Toxic chemicals associated with cosmetics and perfumes and their health concerns.

Recommended books:

Shriner, Hermann, Morrill, Curtin and Fusan (2004)*The systematic identification of organic compounds* (8^{th} edition). John Wiley & Sons, Inco.

Finar, I. L. (1959). *Organic Chemistry: The Fundamental Principles*(Volume 1) 3^{rd} or 4^{th} edition. Longmans, Green and Company.

John D. Robert and Marjorie C. Caserio (1977) *Basic Principles of Organic Chemistry, second edition.* W. A. Benjamin, Inc., Menlo Park, CA.

Christian, G. D., Analytical Chemistry, 6^{th} ed., John-Wiley & Sons, New York, (2006).

Harris, D. C., Quantitative Chemical Analysis, 8^{th} ed., W. H. Freeman and Company, New York, (2011).

Pavia, D. L., Lampman, G. M., Kriz, G. S. and Vyvyan, J. R., Introduction to Spectroscopy, 4^{th} ed., Brooks/ Cole Cengage Learning, (2009).

Crabtree,R. H., The Organometallic Chemistry of Transition Metals, 5^{th} ed., John-Wiley & Sons, New York, (2011).

Chiellini, E., Solaro, R., Biodegradable Polymers and Plastics, 2^{nd} ed., Springer Science & Business Media, New York, (2018).

Sharma, S. K., Hand Book of Material Characterization, Springer,(2018).

McQuarrie, D. A. and Simon, J. D., Physical Chemistry – A Molecular Approach,1st ed., University Science Books,(1997).

Atkins,P. and Paula,J.D., Atkin‟s Physical Chemistry, 9th ed., Oxford University Press, (2010).

Shoemaker, D., Experiments in Physical Chemistry, 8th ed., McGraw Hill Publishing Company Limited, (2003).

Silbey, R., Alberty, R. and Bawendi, M., Physical Chemistry, 4th ed., (2005).

Glasstone, S., *Textbook of Physical Chemistry,* Macmillan London (1960*).*

James, A. M., Prichard, F. E., Practical Physical Chemistry, 3rd ed., Longman Group Limited, New York, (1974).

Chaudhary, S. U., Ilmi Textbook of Physical Chemistry, 2nd ed., IlmiKitabKhana, Lahore, (2013).