SYLLABUS OF CHEMISTRY
BS (4 -Year) Degree Program

(Revised 2019)

Department of Chemistry
University of Balochistan
Quetta

BS (4-YEAR) DEGREE PROGRAM IN CHEMISTRY
SCHEME OF STUDIES

YEAR – I

SEMESTER – I

COURSE CODE	COURSE TITLE	CREDIT HOURS
ENG–601	ENGLISH–I (FUNCTIONAL)	3(3–0)
BOT–601/ECO–601/PSY–601	BOTANY–I/ECONOMICS–I/PSYCHOLOGY	3(3–0)
PHY–601	PHYSICS–I	3(3–0)
MATH–601	MATHEMATICS–I	3(3–0)
COMP–601	COMPUTER APPLICATIONS	3(2–1)
CHEM–601	INORGANIC CHEMISTRY-I	4(3–1)
Total Credit Hours		**19**

SEMESTER – II

COURSE CODE	COURSE TITLE	CREDIT HOURS
ENG–602	ENGLISH–II (COMMUNICATION SKILLS)	3(3–0)
ISL–601	ISLAMIC STUDIES/ETHICS	2(2–0)
BOT–602/ECO–602/SOC–601	BOTANY–II/ECONOMICS–II/SOCIOLOGY	3(3–0)
MATH–602	MATHEMATICS–II	3(3–0)
PHY–602	PHYSICS–II	3(3–0)
CHEM–602	ORGANIC CHEMISTRY–I	4(3–1)
Total Credit Hours		**18**

YEAR – II

SEMESTER–III

COURSE CODE	COURSE TITLE	CREDIT HOURS
ENG–603	ENGLISH–III (REPORT WRITING)	3(3–0)
PAK–601	PAKISTAN STUDIES	2(2–0)
ZOO–601/GEOL–601	ZOOLOGY–I/GEOLOGY–I	3(3–0)
GEOG–601	GEOGRAPHY–I	3(3–0)
CHEM–603	ENVIRONMENTAL CHEMISTRY–I	3(3–0)
CHEM–604	PHYSICAL CHEMISTRY–I	4(3–1)
Total Credit Hours		**18**

SEMESTER–IV

COURSE CODE	COURSE TITLE	CREDIT HOURS
STAT–601	STATISTICS	3(3–0)
ZOO–602/GEOL–602	ZOOLOGY–II/GEOLOGY–II	3(3–0)
GEOG–602	GEOGRAPHY–II	3(3–0)
CHEM–605	ANALYTICAL CHEMISTRY–I	3(2–1)
CHEM–606	APPLIED CHEMISTRY	2(2–0)
CHEM–607	BIOCHEMISTRY–I	3(2–1)
Total Credit Hours		**17**

YEAR – III

SEMESTER – V

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–608	INORGANIC CHEMISTRY–II	4(3–1)
CHEM–609	ORGANIC CHEMISTRY–II	4(3–1)
CHEM–610	PHYSICAL CHEMISTRY–II	4(3–1)
CHEM–611 / CHEM–612	ANALYTICAL CHEMISTRY–II / BIOCHEMISTRY–II	4(3–1)
Total Credit Hours		**16**

SEMESTER – VI

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–613	INORGANIC CHEMISTRY–III	4(3–1)
CHEM–614	ORGANIC CHEMISTRY–III	4(3–1)
CHEM–615	PHYSICAL CHEMISTRY–III	4(3–1)
CHEM–616 / CHEM–617	ANALYTICALCHEMISTRY–III/ BIOCHEMISTRY–III	4(3–1)
Total Credit Hours		**16**

YEAR – IV

FIELD OF SPECIALIZATION

Every student shall opt any one of the following specializations.

i. Inorganic Chemistry
ii. Organic Chemistry
iii. Physical Chemistry
iv. Analytical Chemistry
iv. Biochemistry

SEMESTER – VII

INORGANIC CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–618	INORGANIC CHEMISTRY–IV	3(3–0)
CHEM–619	INORGANIC CHEMISTRY–V	3(3–0)
CHEM–620	INORGANIC CHEMISTRY–VI	3(3–0)
CHEM–621	INORGANIC CHEMISTRY LAB–I	1(0–1)
CHEM–622	RESEARCH METHODOLOGY	3(3–0)
CHEM–623	RESEARCH PROJECT–I	3(0–3)
Total Credit Hours		**16**

ORGANIC CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–624	ORGANIC CHEMISTRY–IV	3(3–0)
CHEM–625	ORGANIC CHEMISTRY–V	3(3–0)
CHEM–626	ORGANIC CHEMISTRY–VI	3(3–0)
CHEM–627	ORGANIC CHEMISTRY LAB–I	1(0–1)
CHEM–622	RESEARCH METHODOLOGY	3(3–0)
CHEM–623	RESEARCH PROJECT–I	3(0–3)
Total Credit Hours		**16**

PHYSICAL CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–628	PHYSICAL CHEMISTRY–IV	3(3–0)
CHEM–629	PHYSICAL CHEMISTRY–V	3(3–0)
CHEM–630	PHYSICAL CHEMISTRY–VI	3(3–0)
CHEM–631	PHYSICAL CHEMISTRY LAB–I	1(0–1)
CHEM–622	RESEARCH METHODOLOGY	3(3–0)
CHEM–623	RESEARCH PROJECT–I	3(0–3)
Total Credit Hours		**16**

ANALYTICAL CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–632	ANALYTICAL CHEMISTRY–IV	3(3–0)
CHEM–633	ANALYTICAL CHEMISTRY–V	3(3–0)
CHEM–634	ANALYTICAL CHEMISTRY–VI	3(3–0)
CHEM–635	ANALYTICAL CHEMISTRY LAB–I	1(0–1)
CHEM–622	RESEARCH METHODOLOGY	3(3–0)
CHEM–623	RESEARCH PROJECT–I	3(0-3)
Total Credit Hours		**16**

BIOCHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–636	BIOCHEMISTRY–IV	3(3–0)
CHEM–637	BIOCHEMISTRY–V	3(3–0)
CHEM–638	BIOCHEMISTRY–VI	3(3–0)
CHEM–639	BIOCHEMISTRY LAB–I	1(0–1)
CHEM–622	RESEARCH METHODOLOGY	3(3–0)
CHEM–623	RESEARCH PROJECT–I	3(0–3)
Total Credit Hours		**16**

SEMESTER – VIII

INORGANIC CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–640	INORGANIC CHEMISTRY–VII	3(3–0)
CHEM–641	INORGANIC CHEMISTRY–VIII	3(3–0)
CHEM–642	INORGANIC CHEMISTRY–IX	3(3–0)
CHEM–643	INORGANIC CHEMISTRY LAB–II	1(0–1)
CHEM–644	ENVIRONMENTAL CHEMISTRY–II	3(3–0)
CHEM–645	RESEARCH PROJECT–II	3(0–3)
Total Credit Hours		**16**

ORGANIC CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–646	ORGANIC CHEMISTRY–VII	3(3–0)
CHEM–647	ORGANIC CHEMISTRY–VIII	3(3–0)
CHEM–648	ORGANIC CHEMISTRY–IX	3(3–0)
CHEM–649	ORGANIC CHEMISTRY LAB–II	1(0–1)
CHEM–644	ENVIRONMENTAL CHEMISTRY–II	3(3–0)
CHEM–645	RESEARCH PROJECT–II	3(0–3)
Total Credit Hours		**16**

PHYSICAL CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–650	PHYSICAL CHEMISTRY–VII	3(3–0)
CHEM–651	PHYSICAL CHEMISTRY–VIII	3(3–0)
CHEM–652	PHYSICAL CHEMISTRY–IX	3(3–0)
CHEM–653	PHYSICAL CHEMISTRY LAB–II	1(0–1)
CHEM–644	ENVIRONMENTAL CHEMISTRY–II	3(3–0)
CHEM–645	RESEARCH PROJECT–II	3(0–3)
Total Credit Hours		**16**

ANALYTICAL CHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–654	ANALYTICAL CHEMISTRY–VII	3(3–0)
CHEM–655	ANALYTICAL CHEMISTRY–VIII	3(3–0)
CHEM–656	ANALYTICAL CHEMISTRY–IX	3(3–0)
CHEM–657	ANALYTICAL CHEMISTRY LAB–II	1(0–1)
CHEM–644	ENVIRONMENTAL CHEMISTRY–II	3(3–0)
CHEM–645	RESEARCH PROJECT–II	3(0–3)
Total Credit Hours		**16**

BIOCHEMISTRY

COURSE CODE	COURSE TITLE	CREDIT HOURS
CHEM–658	BIOCHEMISTRY–VII	3(3–0)
CHEM–659	BIOCHEMISTRY–VIII	3(3–0)
CHEM–660	BIOCHEMISTRY–IX	3(3–0)
CHEM–661	BIOCHEMISTRY LAB–II	1(0–1)
CHEM–644	ENVIRONMENTAL CHEMISTRY–II	3(3–0)
CHEM–645	RESEARCH PROJECT–II	3(0–3)
Total Credit Hours		**16**

Total Credit Hours = 136

Code Key

BOT: **Botany**
CHEM: **Chemistry**
COMP: **Computer**
ECO: **Economics**
ENG: **English**
GEOG: **Geography**
GEOL: **Geology**
ISL: **Islamic Studies / Ethics**
MATH: **Mathematics**
PAK: **Pakistan Studies**
PHY: **Physics**
PSY: **Psychology**
SOC: **Sociology**
STAT: **Statistics**
ZOO: **Zoology**

SEMESTER – I

ENG-601	English-I (Functional)	Credit Hours: 3(3-0)

Course 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, discussion (general topics and every-day conversation), translation skills (Urdu to English), paragraph writing, presentation skills.

Recommended books

1. Thomson A. J. And Martinet A. V., Practical English Grammar, Exercises 1, 3rd ed., Oxford University Press, (1997).
2. Thomson A. J. And Martinet A. V., Practical English Grammar, Exercises 2. 3rd ed., Oxford University Press, (1997).
3. Boutin M. C., Brinand S. and Grellet, F., Intermediate Oxford Supplementary Skills. Fourth Impression, (1993).
4. Tomlinson, B. and Ellis, R., Upper Intermediate, 3rd Impression, Oxford Supplementary Skills, (1992)

BOT-601	Botany-I	Credit Hours: 3(3-0)

Course Objectives

To introduce the students to the diversity of plants and their structures and significance.

Course Contents

Comparative study of life form, structure, reproduction and economic significance of: a) Viruses (RNA and DNA types) with special reference to TMV; b) Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance; c) Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia) d) Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications. e) Lichens (Physcia) f) Bryophytes i. Riccia ii. Anthoceros iii. Funaria g) Pteridophytes. i. Psilopsida (Psilotum) ii. Lycopsida (Selaginella) iii. Sphenopsida (Equisetum) iv. Pteropsida (Marsilea) h) Gymnosperms i. Cycas ii. Pinus iii. Ephedra i) Angiosperms i. Monocot (Poaceae) ii. Dicot (Solanaceae)

Recommended Books

1. Alexopoulos, C. J., Mims, C. W. and Blackwell, M. Introductory Mycology, 4th ed., John Wiley and Sons Publishers, (1996).
2. Agrios, G. N., Plant pathology, 8th ed., Academic Press London, (2004).
3. Vashishta, B. R., Botany for degree students (all volumes), S. Chand and Company Ltd., New Delhi, (1991).
4. Andrew, H. N., Studies in Paleobotany, John Willey and Sons, (1961).
5. Ingrouille, M., Diversity and Evolution of Land Plants, Chapman & Hall, (1992).
6. Mauseth, J. D., Botany: An Introduction to Plant Biology 3rd ed., Jones and Bartlett Pub. UK, (2003).

7. Marti. J., Ingrouille & Plant: Diversity and Evolution. CUP, (2006).
8. Taylor, T. N. and Taylor, E. D., Biology and Evolution of Fossil Plants. Prentice Hall. N. Y. (2000).
9. Hussain, F. A., Text Book of Botany and Biodiversity, Pak Book Empire, (2012).

ECO-601	Economics-I	Credit Hours: 3(3-0)

Course Objectives

The main focus will be on theories of consumption, production, distribution and role of the government. Topics include demand, supply, household behavior and consumer choice, the cost structure of the firms.

Introduction to Economics

Studying Choice in a World of Scarcity: The No-Free-Lunch Principle, The Cost-Benefit Principle, Reservation Prices, Economic Surplus, Opportunity Cost, The Role of Economic Models, To What Extent should an Activity be Perused, Micro Economic Versus Macro Economics, Economic Naturalism, Positive Versus Normative Economics, Some common Pitfalls for Decision Makers, Conclusion.

Consumer Behaviour

Cardinal Approach/Utility Analysis, Marginal Utility, Law of Diminishing Marginal Utility, Law of Equi-Marginal Utility, Consumer Equilibrium Ordinal Approach of Consumer Behavior, Indifference Curves, Features of Indifference Curves, Budget Line, Consumer Equilibrium, Comparison between two approaches Conclusion.

Demand & Supply

Demand Function, Law of Demand, Shift in Demand, Change in Demand Factors Affecting Demand, Supply Function, Law of Supply, Changes in Supply Price Equilibrium, Market Equilibrium.

Elasticity of Demand & Supply

Price Elasticity of Demand & Supply, Point Elasticity of Demand & Supply Arc Elasticity of demand & Supply, Income Elasticity of Demand & Supply, Cross Elasticity of demand & Supply, Conclusion.

Efficiency and Exchange

Market Equilibrium and Efficiency, Economic Surplus, the Cost of Preventing Price Adjustments, Taxes and Efficiency, Conclusion.

The Theory of Production & Theory of Cost

The Production Function, Total, average and marginal product, Laws of Returns to Scale , Short run Theory of Cost, Seven family cost curves, Relationship between Production and Cost Curves . Long-run Theory of Cost: Graphical Representation of Long Run Cost Economies, Diseconomies and Constant Returns to Scale.

Recommended Books

1. Mankiw, “Principles of Economics” 7th Edition, Southwest Publishers (2008).

2. Miller, R. L –EconomicsToday-14th Edition Addison Wesley (2005).

PSY-601	Psychology	Credit Hours: 3(3-0)

Course Objectives

The main aim is to familiarize students with history, main concepts, methods, and theoretical frameworks in psychology. The course will help students appreciate the human nature and its related concepts, thereby will gain insight into human behavior and human relationships.

Course Contents

Understanding Psychology
Psychology: Scientific perspective, Historical perspective, Schools of psychology, Methods of psychology, Ethical issues, Fields of psychology and their application

Biological Basis of Behaviour
Neuron and its function, Central nervous system, Peripheral nervous system, Endocrine system

Sensation and Perception
Senses: Vision, audition, smell, taste and kinesthetic, Introduction to perception, Gestalt principles, Binocular and monocular cues, Illusions and extra sensory perception

Learning
Definition of learning, Types of learning: Classical and operant conditioning, Punishment and its effects, Latent and observational learning

Memory
Definition and types of memory, Processes and techniques of improving memory, Forgetting: Nature and causes

Cognition and Language
Concept of cognition, Problem solving, Judgment and decision making, Language development, Language and cognition, Language and culture

Intelligence and Creativity
Concept of intelligence, Theories of intelligence, Assessment of intelligence, Mental retardation, Concept of creativity and its stages

Motivation and Emotion
Introduction to motivation, Factors affecting motivation
Introduction to emotions, Types of emotions, Physiology and emotion, Theories of emotion

Personality
Defining personality, Theories of personality, Personality assessment

Social Thinking and Social Influence
Social facilitation, Attribution theory, Crowd behavior, Conformity, Obedience, Helping behavior

Recommended Books

1. Atkinson R. C., & Smith, E. E. (2000).Introduction to psychology (13th ed.). NY: Harcourt Brace College Publishers.
2. Coon, D., &Mutterer, J. (2008).Introduction to psychology: Gateways to mind and behavior (12th ed.). USA: Wadsworth Cengage Learning.
3. Fernald, L. D., & Fernald, P.S (2005).Introduction to psychology.USA; WMC Brown Publishers.
4. Fredrickson, B., Nolen-Hoeksema, S., Loftus, G., & Wagenaar, W. (2009). Atkinson & Hilgard's introduction to psychology (15th ed.). USA: Wadsworth.
5. Glassman, W.E. (2000). Approaches to psychology.Open University Press.
6. Hayes, N. (2000). Foundation of psychology (3rd ed.). UK: Thomson Learning.
7. Kalat, J. W. (2010). Introduction to psychology.USA: Cengage Learning, Inc.
8. Lahey, B. B. (2004). Psychology: An introduction (8th ed.). UK: McGraw-Hill Companies,Inc.

9. Leahey,T. H. (1992). A history of psychology: Main currents in psychological thought. New Jersey: Prentice-Hall International, Inc.
10. Myers, D. G. (2011).Psychology (10th ed.). USA: Wadsworth Publishers.
11. Ormord, J. E. (1995). Educational psychology: Developing learners. USA: Prentice Hall, Inc.
12. Rathus, S. (2011). Psychology: Concepts and connections (10th ed.). USA: Wadsworth CengageLearning.

PHY-601	Physics-I	Credit Hours: 3(3-0)

Course Objectives

The main objective of this course is to understand the different motions of objects on a macroscopic scale and to develop simple mathematical formalisms to analyze such motions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Course contents

Basic Concepts

Units and dimensions, SI Units, changing units, scalars and sectors, adding vectors: graphical as well as component method, multiplying vectors: dot and cross products.

Motion in One, Two and Three Dimensions

Position & displacement, velocity and acceleration, motion under constant acceleration, projectile motion, uniform circular motion, relative velocity and acceleration in one and two dimensions, inertial and non-inertial reference frames.

Newton's Laws

Newton's laws of motion and their applications involving some particular forces including weight, normal force, tension, friction, and centripetal force, newton's law of gravitation, gravitational potential energy, escape velocity, kepler's laws, satellite orbits & energy.

Work and Kinetic Energy

Work done by constant and variable forces: gravitational and spring forces, power, conservative and non-conservative forces, work and potential energy, isolated systems and conservation of mechanical energy, work done by external forces including friction and conservation of energy.

System of Particles

Motion of a system of particles and extended rigid bodies, center of mass and Newton's Laws for a system of particles, linear momentum, impulse, momentum & kinetic energy in one and two dimensional elastic and inelastic collisions.

Recommended Books

1. Halliday, D., Resnick R. and Walker, J., Fundamentals of Physics, 9th ed., John Wiley & Sons, (2010).
2. Serway R. A. and Jewett, J. W., Physics for Scientists and Engineers, 8th ed., Golden Sunburst Series, (2010).

3. Freedman, R. A., Young, H. D. and Ford A. L., (Sears and Zeemansky), University Physics with Modern Physics, 13th ed., Addison-Wesley-Longman, (2010).
4. Keller, F. J., Gettys W. E. and Skove, M. J., Physics: Classical and Modern, 2nd ed., McGraw Hill, (1992).
5. Giancoli, D. C., Physics for Scientists and Engineers, with Modern Physics, 4th ed. Addison-Wesley, (2008).

MATH-601	Mathematics-I	Credit Hours: 3(3-0)

Course Objectives

To prepare the students with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Contents

Preliminaries

Real-number system, complex numbers, introduction to sets, set operations, functions, types of fun

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, M. P., Wooton, W., Beckenback E. F., Sharron. S., Algebra 2 and Trigonometry, Houghton & Mifflin,(1978).
2. Kaufmann, J. E., College Algebra and Trigonometry, PWS-Kent Company, Boston, (1987).
3. Swokowski, E. W., Fundamentals of Algebra and Trigonometry,6th ed.,PWS-Kent Company, Boston,(1986).

COMP-601	Computer Applications	Credit Hours: 3(2-1)

Course Objectives

To familiarize the student with basics of computer systems, hardware, software, networking and programming languages.

Course Contents

Introduction to computers, types of computers, types of software, hardware, types of hardware (input devices, output devices, and storage devices), communication and networks, introduction to internet and World Wide Web, software, operating systems, utility programs, programming languages, types of programming languages, introduction to windows operating system and office applications.

Recommended Books

1. Shelly, G. B., Cashman, Vermaat, M. E., Discovering Computers, Thomson Course Technology, (2013).
2. Shelly, G. B. And Vermaat, M. E., Microsoft® Office 2013: Brief: Brief.(2013).

CHEM-601	Inorganic Chemistry-I	Credit Hours: 4(3-1)

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 analysis of inorganic compounds during laboratory work.

Course Contents

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.

Practicals

1. Laboratory ethics and safety measures
2. Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations.
3. Qualitative analysis: Analysis of four ions (two anions and two cations) from mixture of salts.

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, 6thed., 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, 5thed., Chapman and Hall, (1996).
6. Miessler, G. L., Tarr, D. A., Inorganic Chemistry, 3rded., 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, 3rded., 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, 3rded.,Prentice Hall, (2008).
11. Hill, R. H. JR and Fister, D. C., Laboratory Safety for Chemistry Students, John-Wiley & Sons, Inc., (2010).
12. Mendham, J., Denny, R. C., Barnes, J. D., Thomas, M. and Sivasankar, B., Vogel's Textbook of Quantitative Chemical Analysis, 6thed., Pearson Education, Ltd., (2000).
13. Svehla, G., Vogel's Qualitative Inorganic Analysis, 7th ed., Pearson Education, Ltd., (2009).

SEMESTER – II

ENG-602	English-II (Communication Skills)	Credit Hours: 3(3-0)

Course 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 with emphasis on content, style and pronunciation).

Recommended Books

1. Thomson, A.J. and Martinet, A.V., Practical English Grammar Exercises 2, 3rd ed., Oxford University Press, (1986).
2. Boutin, M. C., Brinand, S. and Grellet, F.,Intermediate, 4thImpression, Oxford Supplementary Skills. (1993).
3. Nolasco, R., Upper-Intermediate,4thImpression,Oxford Supplementary Skills, (1992).
4. Tomlinson, B. and Ellis, R., Advanced, 3rd Impression, Oxford Supplementary Skills,(1991).

ISL-601	Islamic Studies	Credit Hours: 2(2-0)

Course Objectives

To impart an understanding of the fundamental principles and teachings of Islam through study of selected verses of the Quran and Prophetic Sayings. Important facts of the Prophet's life and salient, features of Islamic Civilization. To provide appreciation of other prominent religions, systems of ethics and cultures to prepare students to survive in international and multicultural work place.

Course Contents

Fundamentals of islam (aqaid, ibadat, islamic dawah etc.), ethical values of islam, serah of the Holy Prophet (PBUH), islamic civilization and its effects on humanity, study of other prominent world religions and ethical systems in comparison with Islamic viewpoint, multicultural societies.

Recommended Books

1. Muhammad, H., Emergence of Islam, Adam Publishers, New Dehli, (2007).
2. Muhammad, H., Muslim Conduct of State, (1953).
3. Hassan, H. H., An Introduction to the Study of Islamic Law, Adam Publishers, New Dehli, (2007).
4. Hasan, A., Principles of Islamic Jurisprudence, Islamic Research Institute, International Islamic University, Islamabad (1993).
5. Waliullah, M., Muslim Jurisprudence and the Quranic Law of Crimes, Islamic Book Service, (1982).
6. Bhatia, H.S., Studies in Islamic Law, Religion and Society, Deep & Deep Publications New Delhi, (1989).
7. Zia-ul-Haq, M., Introduction to Al Sharia Al Islamia, Allama Iqbal Open University, Islamabad, (2001).

BOT-602	Botany-II	Credit Hours: 3(3-0)

Course Objectives

To understand: 1) various systems of classification, identification and nomenclature of Angiosperms, 2) Structures and functions of tissues and organs at embryonic level.

Course Contents

a) Plant systematics

1. Introduction to Plant Systematics: aims, objectives and importance.
2. Classification: brief history of various systems of classification with emphasis on Takhtajan.
3. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to International Code of Botanical Nomenclature (ICBN).Vienna code.
4. Morphology: a detailed account of various morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
5. Diagnostic characters, economic importance and distribution pattern of the following families:

i. Ranunculaceae ii. Brassicaceae (Cruciferae) iii. Fabaceae (Leguminosae) iv. Rosaceae v. Euphorbiaceae vi Cucurbitaceae vii. Lamiaceae (Labiatae) viii. Apiaceae (Umbelliferae) ix. Asteraceae (Compositae) x. Liliaceae (Sen. Lato)

b) Anatomy

1. Cell wall: structure and chemical composition
2. Concept, structure and function of various tissues like: i. Parenchyma ii. Collenchyma iii. Sclerenchyma iv. Phloem Epidermis (including stomata and trichomes) v. Xylem
3. Meristem: types, stem and root apices
4. Vascular cambium
5. Structure and development of root, stem and leaf. Primary and secondary growth of dicot stem, periderm
6. Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.

c) Development/Embryology

1. Early development of plant body:
2. Capsella bursa-pastoris
3. Structure and development of Anther Microsporogenesis, Microgametophyte
4. Structure of Ovule Megasporogenesis Megagametophyte
5. Endosperm formation
6. Parthenocarpy
7. Polyembryony

Recommended Books

1. Mauseth, J. D. An Introduction to Plant Biology: Multimedia Enhanced, Jones and Bartlett Pub. UK, (1998).
2. Moore, R. C., W. D. Clarke and Vodopich, D. S. Botany, McGraw Hill Company, U.S.A, (1998).
3. Raven, P. H., Evert, R. E. and Eichhorn, S. E., Biology of Plants. W. H. Freeman and Company Worth Publishers, (1999).
4. Stuessy, T. F., Plant Taxonomy, Columbia University Press, USA, (1990).
5. Lawrence, G. H. M., Taxonomy of Vascular Plants, MacMillan & Co. New York, (1951).
6. Panday, B. P., A Textbook of Botany (Angiosperms), S. Chand and Co. New Delhi. (2004).
7. Raymond E., Eichhorn, S. E., Esau's Plant Anatomy, Meristems cells and tissues of the plant body, 3rd ed., John Wiley & Sons. Inc. (2005).
8. Fahn, A., Plant Anatomy. Pergamon Press, Oxford, (1990).
9. Esau, K., Anatomy of Seed Plants, John Wiley, New York, (1960).
10. Maheshwari, P., Embryology of Angiosperms, McGraw-Hill. New York (1971).

11. Eames A. J. and Mac Daniels, L. H., An Introduction to Plant Anatomy. Tata-Mac Graw-Hill Publishing Company, Limited, New Delhi, (2002).
12. Pullaiah, T. Taxonomy of Angiosperms, 3rd ed., Regency Publications, New Delhi, (2007).
13. Naik, V. N., Taxonomy of Angiosperms. 20th Reprint. TataMacGraw-Hill Publishing Company, Limited New Delhi. (2005).
14. Rajput, M. T., Hassney, S. S. and Khan, K. M., Plant Taxonomy, New Trends Computer Service, Hyderabad, Sindh, Pakistan, (1996).

ECO-602	Economics-II	Credit Hours: 3(3-0)

Course Objectives

The course is designed for the beginners with no formal background or little acquaintance with economics. The objective is to give the students with a clear understanding of the basic concepts, tools of analysis and terminologies used in macroeconomics. The teacher is expected to draw examples from the surrounding world to clarify the concepts.

Course Contents

Introduction

The economy in aggregate, Complexities of the world of business, Scope of macroeconomics, Brief account of classical and the development of macro- economic after the World War-II, Concept of business cycles: Boom and Depression, three concerns of macroeconomics, Inflation, GDP growth and unemployment, Macroeconomic variables and their mutual relationship, Macro-models as abstraction from the real economy. **National Income** Definition and concept of national income, Measures of national income: Gross Domestic Product (GDP) and Gross National Product (GNP), GDP at factor cost and at market prices, Computation of national income: Product, Income and Expenditure approaches, Circular flow of income, Nominal versus Real income, Per capita income and the standard of living.

Components of Aggregate Demand

The Concept of Open and closed economy models, Concept of aggregate markets: Product, Money, Labor and Capital markets, Components of aggregate demand: Consumption, Investment and Government spending, Income and expenditure identities. Money and Monterey policy, Fiscal Policy.

Recommended Books

1. Mankiw,G–Principles of Economics- latest edition.
2. Samulson and Nordrons - Economics –latest edition
3. Parkin, Michael - Macroeconomics, latest edition
4. Miller, R.L.– Economics Today – latest edition

SOC-601	Sociology	Credit Hours: 3(3-0)

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 Contents

1. **Introduction**
    a. Definition, Scope, and Subject Matter
    b. Sociology as a Science
    c. Historical back ground of Sociology
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 & 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 & Personality**
    a. Personality, Factors in Personality Formation
    b. Socialization, Agencies of Socialization
    c. Role & Status
6. **Deviance and Social Control**
    a. Deviance and its types
    b. Social control and its need
    c. Forms of Social control
    d. Methods & 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

Recommended Books:

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.

MATH-602	Mathematics-II	Credit Hours: 3(3-0)

Course Objectives

To prepare the students with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course contents

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 ed., John Wiley, New York, (2005).
2. Stewart, J., Calculus,3rd ed., Brooks/Cole,(1995).
3. Swokowski, E. W., Calculus and Analytic Geometry, PWS-Kent Company, Boston,(1983).
4. Thomas, G. B., Finney, A. R., Calculus,11th ed., Addison-Wesley, Reading, Ma, USA,(2005).

PHY-602	Physics-II	Credit Hours: 3(3-0)

Course Objectives

The main objective of this course is to understand the rotational motion, angular momentum, simple harmonic motion and special theory of relativity.

Course Contents

Rotational Motion

Rotation about a Fixed Axis, Angular Position, Angular Displacement, Angular Velocity and Angular Acceleration, Rotation under Constant Angular Acceleration, relationship between Linear and Angular Variables, Rotational Inertia, Parallel-axis Theorem, Torque and Newton's Law for Rotation, Work and Rotational Kinetic Energy, Power, Rolling Motion, Angular Momentum for a single Particle and a System of Particles, Conservation of Angular Momentum, Precession of a Gyroscope, Static Equilibrium involving Forces and Torques, Determination of moment of inertia of various shapes i.e. for disc, bar and solid sphere.

Angular Momentum

Angular Velocity, Conservation of angular momentum, effects of Torque and its relation with angular momentum.

Simple Harmonic Motion (SHM)

Amplitude, Phase, Angular Frequency, Velocity and Acceleration in SHM, Linear and Angular Simple Harmonic Oscillators, Energy in SHM, Simple Pendulum, Physical Pendulum, SHM and Uniform Circular Motion, Damped Harmonic Oscillator.

Special Theory of Relativity

Inertial and non-inertial frame, Postulates of Relativity, The Lorentz Transformation, Derivation, Assumptions on which inverse transformation is derived, Consequences of Lorentz transformation, Relativity of time, Relativity of length, Relativity of mass, Transformation of velocity, variation of mass with velocity, mass energy relation and its importance, relativistic momentum and Relativistic energy, (Lorentz invariants) $E^2=c^2\,p^2+m^2{}_oc^4$

Recommended Books

1. Halliday, D., Resnick, R. and Walker, J., Fundamentals of Physics, 9th ed., John Wiley & Sons, (2010).
2. Serway, R. A. and Jewett, J. W., Physics for Scientists and Engineers, 8th ed., Golden Sunburst Series, (2010).
3. Freedman, R. A., Young, H. D. and Ford A. L. (Sears and Zeemansky), University Physics with Modern Physics, 13th ed., Addison-Wesley-Longman, (2010).
4. Keller, F. J., Gettys, W. E. and Skove, M. J., Physics: Classical and Modern, 2nd ed., McGraw Hill, (1992).
5. Giancoli, D. C., Physics for Scientists and Engineers, with Modern Physics, 4th ed., Addison-Wesley, (2008).

CHEM-602	Organic Chemistry-I	Credit Hours: 4(3-1)

Course Objectives

Students will acquire knowledge about basic concepts of organic chemistry, chemistry of hydrocarbons and functional groups.

Course Content

Basic Concepts

Introduction of organic chemistry, localized and delocalized bonding, concept of hybridization leading to bond angles, bond energies and geometry of simple organic molecules, structural formulas, hybridization, dipole moment, inductive effect, hyperconjugation, hydrogen bonding, resonance and tautomerism.

Hydrocarbons

Open Chain: Preparation, properties and reactions of alkanes, alkenes and alkynes.
Closed Chain: Synthesis, reactions and relative stability of small and medium sized cycloalkanes.
Aromatic Compounds: Structure of benzene, concept of aromaticity.

Nomenclature

Nomenclature of organic compounds according to IUPAC system: alkanes, alkenes, alkynes, alcohols, phenols, aldehydes, ketones, carboxylic acids and their derivatives.

Practicals

Qualitative organic analysis: Systematic identification of organic compounds containing groups like COOH, RCOR (amide), phenol (any 8 organic compounds).

Recommended Books

1. Wade, L.G., Organic Chemistry, 8th ed., Pearson Education, Inc. USA, (2013).
2. Jones, M. A., and Fleming S. A., Organic Chemistry, 5th ed., W.W. Norton & Company, Inc., New York, USA, (2014).
3. Brown, W. and Poon, T., Introduction to Organic Chemistry, 3rd ed., John- Wiley & Sons, Inc., (2005).
4. Loudon, G. M., Organic chemistry, 6th ed., W. H. Freeman and Company, New York, USA, (2016).
5. Younus, M., A Textbook of Organic Chemistry, Ilmi Kitab Khana, Urdu Bazar, Lahore, Pakistan, (2006).
6. Solomons, T. W. G. and Fryhle, C. B., Organic Chemistry, 10thed., 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, 5thed., Longman, UK, (1989).
8. Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., A Microscale Approach to Organic Laboratory Techniques, 5thed., Brooks/ ColeCengage Learning, (2013).

SEMESTER – III

ENG-603	English–III (Report Writing)	Credit Hours: 3(3-0)

Course Objectives

Enhance language skills and develop critical thinking

Course Contents

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative.

Academic writing

How to write a proposal for research paper/term paper and how to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency), technical report writing, progress report writing.

Recommended Books

1. White, R., Advanced, 3rd Impression, Oxford Supplementary Skills, (1992).
2. Langan, J., College Writing Skills, Mc Graw-Hill Higher Education, (2004).
3. Kirszner L. G. and Mandell S. R., Patterns of College Writing, 12th ed.,St. Martin's Press, (2012).

PAK-601	Pakistan Studies	Credit Hours: 2(2-0)

Course Objectives

To take an analytical view in the history and development of muslim society and culture in the sub-continent, emergence of Pakistan and its constitutional development. To develop an appreciation of the issues and challenges currently being faced in Pakistan.The strengths of its people and strategies to deal with the impediments to progress and international relations of Pakistan.

Course contents

Historical background of Pakistan: Muslim society in Indo-Pakistan, the movement led by the societies, the downfall of Islamic society, the establishment of British Raj- Causes and consequences, political evolution of muslims in the twentieth century: Sir Syed Ahmed Khan, Muslim League, Nehru, Allama Iqbal, independence movement, Lahore resolution, Pakistan culture and society, constitutional and administrative issues, Pakistan and its geo-political dimension, Pakistan and international affairs, Pakistan and the challenges ahead.

Recommended Books

1. Burki, S. J., State & Society in Pakistan, The Macmillan Press Ltd, (1980).
2. Zaidi, A. S., Issue in Pakistan's Economy. Karachi: Oxford University Press, (2000).
3. Burke, S.M. and Ziring, L., Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, (1993).
4. Mehmood, S., Pakistan Political Roots & Development. Lahore, (1994).

5. Wilcox, W., The Emergence of Banglades., Washington: American Enterprise, Institute of Public Policy Research, (1972).
6. Ziring, L., Enigma of Political Development, Kent England: WmDawson & sons Ltd, (1980).
7. Zahid, A., History & Culture of Sindh. Karachi: Royal Book Company, (1980).
8. Afzal, M. R., Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, (1998).
9. Sayeed, K. B., The Political System of Pakistan. Boston: Houghton Mifflin, (1967).
10. Aziz, K.K., Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research, (1976).
11. Waseem, M., Pakistan Under Martial Law, Lahore: Vanguard, (1987).
12. Haq, N., Making of Pakistan: The Military Perspective. Islamabad: National Commission on Historical and Cultural Research, (1993).

ZOO-601	Zoology-I	Credit Hours: 3(3-0)

1. **Introduction**
   A one-world view: genetic unity, the fundamental unit of life, evolutionary oneness and the diversity of life, environment and world resources; what is zoology? The classification of animals; the scientific method.
2. **The Chemical Basis of Animal Life**
   Atoms and elements: building blocks of all matter; compounds and molecules: aggregates of atoms; acids, bases, and buffers; the molecules of animals: fractional account of carbohydrates, lipids.
3. **Cells, Tissues, Organs, and Organ System of Animals**
   Structure and functions of cell membranes; various movements across membranes; cytoplasm, organelles, and cellular components: functional account of ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, and vacuoles based on their structural aspects. The nucleus: nuclear envelope, chromosomes and nucleolus. Tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue to perform various functions. Structural integrations for functions in organs and organ systems.
4. **Energy and Enzymes: Life's Driving and Controlling Forces**
   Energy and the laws of energy transformation; activation energy; enzymes: structure, function and factors affecting their activity; cofactors and coenzymes; ATP: how cells convert energy? An overview.
5. **How Animals Harvest Energy Stored in Nutrients**
   Glycolysis: the first phase of nutrient metabolism; fermentation: "life without oxygen"; aerobic respiration: the major source of ATP; metabolism of fats and proteins; control of metabolism; the metabolic pool.
6. **Ecology I: Individuals and Populations**
   Animals and their abiotic environment; populations; interspecific interactions.
7. **Ecology II: Communities and Ecosystems**
   Community structure and diversity; ecosystems; ecosystems of the earth; ecological problems; human population growth, pollution, resource depletion and biodiversity.

Recommended Books

1. Hickman, C.P., Roberts, L.S. And Larson, A. Integrated Principles of Zoology, 12th Edition (International), 2004. Singapore: McGraw-Hill.
2. Miller, S.A. And Harley, J.B. Zoology, 6th Edition (International), 2005. Singapore: McGraw-Hill.
3. Pechenik, J.A. Biology of Invertebrates, 5th Edition (International), 2000. Singapore: McGraw-Hill.
4. Kent, G.C. And Miller, S. Comparative Anatomy of Vertebrates, 2001. New York: McGraw-Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
6. Miller, S.A. General Zoology Laboratory Manual. 5th edition (International), 2002. Singapore: McGraw-Hill.

7. Hickman, C.P. And Kats, H.L., Laboratory Studies In Integrated Principles Of Zoology. 2000. Singapore: McGraw Hill.
8. Molles, M.C. Ecology: Concepts and Applications. 6th edition, 2005. McGraw-Hill, New York, USA.
9. Odum, E. P. Fundamentals of Ecology. 3rd Edition, 1994. W.B. Saunders. Philadelphia.
10. Slingby, D. And Cook, C., Practical Ecology. 1986. McMillan Education Ltd. UK.

GEOL-601	Geology-I	Credit Hours: 3(3-0)

Course Objectives

This course is designed to acquire the knowledge about the basic concepts of geology. This will help the students to get knowledge about various types of rocks and minerals and the processes of their formation.

Course Contents

Introduction and scope of geology; importance and relationship with other sciences; history and philosophy of geology; Earth as a member of the solar system; its origin, age, composition and internal structure; introduction to plate tectonics, Isostasy; mountain building processes; earthquakes and volcanoes; weathering and erosion; introduction, identification and classification of rocks and minerals; sedimentary, igneous and metamorphic structures; introduction to fossils in sedimentary rocks; introduction to folds, faults, joints, cleavage, foliation, lineation and unconformities; Geological Time Scale; Law of Superposition, present is key to the past and Law of Faunal Succession; concept and techniques of geological dating, relative and absolute dating; evolution of life on earth; use of Brunton Compass and GPS, etc.

Recommended Books

1. Physical Geology (13th Edition) by Charles Plummer, David Mc Geary, Diane Carlson, Lisa Hammersley, 2009, McGraw-Hill
2. Laboratory Manual in Physical Geology (9th Edition) , Richard M. Busch, 2011, American Geological Institute, Pearson Education
3. Physical Geology, By Plummer, (14th Edition), Charles (Carlos) Plummer, Diane Carlson, Lisa Hammersley, 2012 McGraw-Hill
4. Principles of Physical Geology by Holmes, A., 1978, Nelson.
5. Foundation of Structural Geology by Park, R. G., 1983, Blackie.
6. Elementary Exercises upon Geological Maps by Platt, J. I., 1961, Thomas Murby and Co.
7. An Introduction of Geological Structures and Maps by Bennison, G.M., 1997, Edward Arnold.
8. Physical Geology by Plummer, McGeay and Carlson, 2005.
9. Lab Manual for Physical Geology by Jones, Norris. W., Johns and Charles E., 2005, McGraw-Hill.
10. How Does Earth Work: Physical Geology and Process of Science by Smith, G. and Pun, A., 2006, Prentice Hall.
11. The Mapping of Geological Structures by McClay, K.R., 1987, Open University Press.

GEOG-601	Geography-I	Credit Hours: 3(3-0)

Courses Objectives

To make students understand about the basics of the subject of Geography. The students will be able to understand and differentiate between the various themes of Geography easily.

Course Outline

a) Introduction
Nature and scope, the evolution of geography from ancient to modern times, branches of Geography and their relations with other disciplines

b) Five Major Themes of Geography
Location: Absolute and relative, Place: Physical and anthropogenic characteristics, Man-environment relationship, Movement, Region

c) Earth as a planet
Shape, size and movements, Earth's Satellite-Moon, Lunar and Solar Eclipses

d) Location on Map and Globe
Directions and scales, Geographical coordinates and their characteristics, World time zones: standard and local time

e) Distribution of Land and Water
Proportion of land and water on the planet earth, Fresh water; glaciers, rivers, lakes, swamps and underground water, Ocean water

f) Elements of Geo-system
Lithosphere, Atmosphere o Hydrosphere, Biosphere

Recommended Books

1. Strahlar, A.N., Strahlar, A.H. Physical Environment, John Wiley. New York (2004).
2. Stringer, E.T. "Modern Physical Geography," New York: John Wiley (2004).
3. Christopherson, R.W. "Geo-systems," Prentice-Hall, Inc, USA (2000).
4. Gabler, R.E, Sager, R.J and Wise, D.L. "Essentials of Physical Geography", Saunders College Publishing, New York (1997)
5. Thurman, H.V. & Mexrill "Essentials of Oceanography", Menson, London (1996).
6. Fraser,C. "Unlocking Five Themes of Geography", Globe Book Co. New Jersey (1993).
7. Taylor, J. "Integral Physical Geography", Longman, London (1993).
8. Mcliveen, J.F.R. "Fundamentals of Weather and Climate," Prentice Hall (1992).
9. Thompson, R.D. et al. "Process in Physical Geography", London, Longman (1986).

CHEM-603	Environmental Chemistry-I	Credit Hours: 3(3-0)

Course Objectives

This course is designed to provide the knowledge that what type of chemicals hazard the environment and how we protect the environment from the detrimental chemicals.

Course Contents

Introduction

Introduction to environmental chemistry, components of environment, history and significance of environmental degradation, environmental pollutants, impact of the modern life style on environmental quality, resource depletion, environmental conservation and sustainability, poverty and environmental degradation, environmental education, institutions for the protection of environment, energy resources and their environmental consequences, fossil fuels nuclear energy, synthetic chemical fuel, emission from thermal units, nuclear waste and its disposal.

Atmospheric Pollution

Introduction to atmospheric pollution, components of atmosphere, temperature and pressure profiles of different components of atmosphere, air pollutants and their types, effect of air pollutants on atmosphere (acid rain, ozone depletion, greenhouse effect), photochemical smog, biogeochemical cycles and importance of atmosphere.

Water Pollution and Water Treatment

Introduction to water, properties of water, methods for determining the quality of water (BOD, COD), water pollutants and sources of water pollutants (industrial, agricultural, municipal and natural sources, primary, secondary and advanced treatment of water.

Recommended Books

1. Manahan, S. E., Environmental Chemistry, 9th ed., CRC Press, New York, (2010).
2. Neil, P. O., Environmental Chemistry, 2nd ed., Chapman & Hall, New York, (1993).
3. De, A. K., Environmental Chemistry, 4th ed., Wiley Eastern Ltd., New Delhi, (1996).
4. vanLoon G. W. and Duffy, S. J., Environmental Chemistry, A global perspectives, 3rd ed., Oxford University Press, (2011).
5. Dara, S., Textbook of Environmental Chemistry and Pollution Control, 7th ed., S Chand & Co Ltd. (2004).
6. Yen, T. F., Environmental Chemistry, Prentice Hall, (1999).
7. Buell, P. and Girard, J., Chemistry, an environmental perspective, Prentice Hall, (1994).
8. Baird C. and Cann, M., Environmental Chemistry, 5th ed., W.H. Freeman, New York, (2012).
9. Connell, D. W., Basic Concepts of Environmental Chemistry, 2nd ed., CRC Press, (2005).

CHEM-604	Physical Chemistry-I	Credit Hours: 4(3-1)

Course Objectives

In this course students acquire the deep concepts of physical states of matter, solution, kinetic theory of gases and chemical kinetics.

Course Contents

Physical States of Matter

Ideal and real gases, equations of state, critical phenomenon and critical constants, molecules in motion: collision diameter and mean free path, virtual equations, Maxwell's law of molecular velocities, calculation of molecular velocities and binary collisions, Maxwell-Boltzmann's law of energy distribution, method for the determination of the Avogadro number, physical properties of liquids: surface tension, viscosity, refractive index etc. and their applications, brief account of interactions among the molecules in liquids, packing of atoms in solids, unit cells and crystal systems, method of crystal structure analysis, brief account of polymers and composite materials with special emphasis on superconductors, semi-conductors and introduction to plasma.

Chemical Kinetics

Introduction to chemical kinetics, use of kinetics to fundamental and applied sciences, time scales of chemical reactions, reaction rates and rate laws and their relation to stoichiometry. Order of reaction and molecularity, zero, first and second order reactions,various methods (differential, integral, and half-life), to determine order of reaction, Arrhenius equation for the temperature dependence of the rate of simple reactions, basic collision theory and transition state theory for reaction rate, activation energy, catalysis, principle of catalyst, heterogeneous and homogeneous catalysis and their industrial applications, reaction mechanism.

Practicals

1. To determine the solution surface of the given single by stalagmometer.
2. To determine the composition of the liquid by surface tension method by stalagmometer.
3. Determination of percent composition of liquid solution viscometrically/refractive index measurement.
4. Determination of refractive index and molar refractivity.
5. Determination of molecular weight of a compound by elevation of boiling point and lowering of freezing point.
6. To determine relative viscosity of liquid at room temperature by viscometer.
7. Determination of the composition of the given liquid by viscosity method using Oswald viscometer.
8. To determine hydrolysis constant of methyl acetate in acidic medium
9. To determine the velocity of saponification of ethyl acetate by NaOH.
10. Preparation of different molar and normal solution.

Recommended Books

1. Alberty, R., Physical Chemistry, 17thed., John Wiley and Sons, (1987).
2. Atkins, P., Jones, L., Chemical Principles: The Quest for Insight, 5thed., W. H. Freeman, New York, (2010).
3. Atkins, P.W. Physical Chemistry, 6thed., W.H. Freeman and Co., NewYork, (1998).
4. Barrow, G.M., Physical Chemistry, 5thed., McGraw Hill, (1992).
5. Davis, W. M., Dykstra, C. E., Physical Chemistry: A Modern Introduction, 2nded., CRC Press, (2011).
6. Laidler, K. J., The World of Physical Chemistry, 1sted., Oxford University Press, (1993).

7. Laidler K.J., John H.M. and Bryan C.S., Physical Chemistry, 4thed., Houghton Mifflin Publishing Company Inc., (2003).
8. Linder, B., Elementary Physical Chemistry, World Scientific Publishing Co., Ltd., (2011).
9. Brain, S.E., Basic Chemical Thermodynamics, 4thed., E.L.B.S. Publishers, (1990).

SEMESTER – IV

STAT-601	Statistics	Credit Hours: 3(3-0)

Course Objectives

To introduce the concept of statistics, randomness, probability and build on these concepts to develop tools and techniques to work with random variables.

Course Contents

Introduction to statistics, descriptive statistics, statistics indecision making, graphical representation of data stem-and lead plot, box-cox plots, histograms and O give, measures of central tendencies, dispersion for grouped and ungrouped data, moments of frequency distribution; examples with real life, use of elementary statistical packages for explanatory data analysis, counting techniques, definition of probability with classical and relative frequency and subjective approaches, sample space, events, laws of probability, general probability distributions, conditional probability and bayes theorem with application to random variable (discrete and continuous) binomial, poisson, geometric, negative binomial distributions; exponential gamma and normal distributions, regression and correlation.

Recommended Books

1. Walpole, R. E., Introduction to Statistics, 3rd ed., Macmillan Publishing Co., Inc. New York,(1982).
2. Muhammad, F., Statistical Methods and Data Analysis, Kitab Markaz, Bhawana Bazar, Faisalabad,(2005).
3. Mariano, R., Advances in Statistical Analysis and Statistical Computing, JAI Press, Greenwich, Conn., (1993).
4. Cowan, G., Statistical Data Analysis, Clarendon, Oxford, (1998).

ZOO-602	Zoology-II	Credit Hours: 3(3-0)

1. **Protection, Support, and Movement**
   Protection: the integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of invertebrates and vertebrates; movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates.
2. **Communication**
   a) **Nerves**
   Neurons: structure and function; neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential between cells; invertebrate and vertebrate nervous systems: the spinal cord, spinal nerves, the brain, cranial nerves and the autonomic nervous system.
   b) **Senses**
   Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, photoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates; lateral-line system and electrical sensing, lateral-line system and mechanoreceptor, hearing and equilibrium in air, hearing and equilibrium in water, skin sensors of damaging stimuli, skin sensors of heat and cold, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.
   c) **The Endocrine System and Chemical Messengers**
   Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; some hormones of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals.

5. **Circulation, Immunity, and Gas Exchange**

Internal transport and circulatory systems in invertebrates: characteristics of invertebrate coelomic fluid, hemolymph, and blood cells; transport systems in vertebrates; characteristics of vertebrate blood, blood cells and vessels; the hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; the human heart: blood pressure and the lymphatic system; immunity: nonspecific defenses, the immune response; gas exchange: respiratory surfaces; invertebrate and vertebrate respiratory systems: cutaneous exchange, gills, lungs, and lung ventilation; human respiratory system: gas transport.

Recommended Books

1. Hickman, C.P., Roberts, L.S. And Larson, A. Integrated Principles of Zoology, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. Zoology, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. Biology of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. Comparative Anatomy of Vertebrates. 2001. New York: McGraw Hill.
5. Campbell, N.A. Biology, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

GEOL-602	Geology-II	Credit Hours: 3(3-0)

Course Objectives

This course is designed to acquire the knowledge about the formation of various landforms on the surface of the earth. This will help the students to understand the processes by which the various types of structures developed on the earth surface due to erosional and depositional processes.

Course Contents

Geomorphological processes; weathering and erosion; glaciers and their erosional and depositional landforms; geological work of wind and associated features; erosional and depositional work of surface and subsurf ace water; valley and base-level development and its types; drainage pattern, stream meandering and development of flood plains; the erosional and depositional work of sea; development of coastal landforms; geomorphic cycles and associated landforms produced by tectonics and volcanic activity; introduction to tectonic geomorphology; introduction to topographic maps; aerial photographs and satellite imageries.

Recommended Books

1. Geomorphology: The Mechanics and Chemistry of Landscapes, Robert S. Anderson, Suzanne P. Anderson, 2010, Cambridge University Press
2. Landscapes and Geomorphology: A Very Short Introduction, Andrew Goudie, Heather Viles, 2010, Oxford University Press.
3. Process Geomorphology by Ritter, Kochel and Miller, 2002, the McGraw-Hill Company.
4. Tectonic Geomorphology, Douglas W. Burbank, Robert S. Anderson, 2000, John Wiley and Sons.
5. Principles of Geomorphology by Thornbury, W.D., 1991, John Wiley and Sons.
6. Geomorphology of Earth Surface Processes and Form by Aharma, V.K., 1986, McGraw-Hill.
7. Geomorphology by Chorley, R.J., 1984, Methuen.
8. Image Interpretation in Geology by Drury, S.A., 1986, Allen and Unwin.
9. Remote Sensing and Image Interpretation by Lillis, T.M. and Kiefer, R.W., 1987, John Wiley and Sons.

GEOG-602	Geography-II	Credit Hours: 3(3-0)

Course objectives

To create an understanding about the characteristics of four spheres of the earth, and the processes which are bringing changes in these spheres. On completion of this course, students will be able; i) to know the scope and branches of physical geography ii) to identify the earth's basic spheres such as lithosphere, atmosphere, hydrosphere and biosphere and their characteristics.

Course Contents

a) Introduction

Physical geography, scope and major branches, Realms of the physical environment

b) Lithosphere

Internal structure of earth, Rocks–origin, formation and types: Igneous, Sedimentary and Metamorphic Rocks, Plate tectonics: epeirogenic and orogenic forces, Geomorphic processes– endogenic and exogenic processes and their main functions, Earthquakes and volcanic activity, folding and faulting, Weathering, mass wasting, erosion and deposition, cycle of erosion, Landforms produced by surface streams, ground water, winds and glaciers

c) Atmosphere

Composition and structure of atmosphere, Atmospheric temperature and pressure, Global circulation and wind systems, Cyclones and other disturbances, Atmospheric moisture and precipitation, Air masses and fronts

d) Hydrosphere

Hydrological cycle, Marine landforms Temperature, salinity and other characteristics of ocean water, Movements of the ocean water; waves, currents and tides

e) Biosphere

Eco-systems, Formation and types of soils

Recommended Books

1. Thurman, H. V. & Trujillo, A. "Essentials of Oceanography", Prentice-Hall, Inc, N. York. (2013)
2. Strahler, A. "Introduction to Physical Geography", John Wiley & Sons, New Jersey. (2013)
3. Peterson, J. F., Sack, D. & Gabler, R. E. "Physical Geography", Brooks Cole. (2011)
4. Strahlar, A. N., Strahlar, A. H. "Physical Environment", John Wiley, New York. (2004)
5. Stringer, E. T. "Modern Physical Geography", John Wiley, New York. (2004)
6. Thornbury, W. D. "Principles of Geomorphology", John Willy & Sons, New York. (2004)
7. Monkhouse, F. J. "Principles of Physical Geography", Hodder & Stoughton, London. (1996)
8. Scott, R. C. "Introduction to Physical Geography", West Publishing Co, New York. (1996)
9. McLaren,J.F.R. "Fundamentals of Weather and Climate", Prentice Hall,New Jersey, USA. (1992)
10. Small, R. J. "Geomorphology and Hydrology", Longman, London. (1989)

CHEM-605	Analytical Chemistry-I	Credit Hours: 3(2-1)

Course Objectives

Students will acquire knowledge about basic concepts of analytical chemistry, fundamental of quantitative chemical analysis, sampling and their handling, preparation, results calculation, 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

Analytical Chemistry and its Basic Tools

Introduction to analytical chemistry, the analytical perspective, common analytical problems, numbers in analytical chemistry (fundamental units of measure, significant numbers), units for expressing concentration, stoichiometric calculations, basic equipment and instrumentation, preparing solutions, analysis, determination, and measurement techniques, methods, procedures, and protocols, classifying analytical techniques, selecting an analytical method, developing the procedure and the importance of analytical methodology.

Fundamental of Quantitative Chemical Analysis

Introduction to chemical analysis, applications of chemicals analysis, the basis of sampling, sampling procedure, sampling statistics, sampling and physical state, crushing and grinding, hazardous in sampling, types of analysis, use of literature, factors affecting the choice of analytical methods, interferences, data acquisition and treatment, titrimetric analysis, classification of reactions with examples.

Quality Assurance in Analytical Chemistry and Good Laboratory Practice

Introduction to quality assurance in analytical chemistry, definitions associated with analytical quality assurance, quality management system, quality assurance and quality control, different standards and their main features, good laboratory practice, validation of analytical methods, laboratory accreditation, some official organizations.

Practicals

1. Calibration of glass ware (pipette, burette and flask) used for volumetric analysis.
2. Use of analytical balance and calculation of standard deviation.
3. Preparation of substances for analysis.
4. Estimation of hygroscopic water.
5 Methods of determining the equivalence point.
6. Preparation of approximately 0.1 M sodium hydroxide solution and its standardization.
7. Preparation of approximately 0.1 M hydrochloric acid and its standardization.
8. Titration of weak acid with weak base.
9. Determination of bicarbonates using back-titration.
10. Determination of chloride as silver chloride.

Recommended Books

1. Christian, G. D., Dasgupta P. K. and Schug, K. A., Analytical Chemistry, 7th ed., John Wiley & Sons, Inc., USA, (2014).
2. Jaffery, G. F., Bassett, J., Mandham J. and Denney, R. C., Text Book of Quantitative Chemical Analysis, 5th ed., Longman Scientific and Technical John Wiley & Sons, Inc. New York, (1989).
3. Harvey, D., Modern Analytical Chemistry, The McGraw-Hill Companies, Inc, USA, (2000).

4. Prichard E. and Barwick,V., Quality Assurance in Analytical Chemistry, John Wiley & Sons, Ltd. Chichester, England, (2007).
5. Funk, W., Dammann V. and Donnevert, G., Quality Assurance in Analytical Chemistry, Wiley-VCH Verlag GmbH & Co. Weinheim, Germany, (2007).
6. Skoog, D. A., West, P. M., Holler, F. J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 9th ed., Brooks Cole Publishing Company, (2013).

CHEM-606	Applied Chemistry	Credit Hours: 2(2-0)

Course Objectives

This course provides the knowledge of introduction to applied chemistry, soaps and detergents, pesticides and explosives.

Course Contents

Introduction

Introduction to industrial chemistry and its importance, flowcharts, material balance, cost and yield, functions of chemist, chemical process control; in process and finished products control.

Soaps and Detergents

Introduction of soap, Batch Kettle process, flow diagram and details, Monas Avon process, Delaval process, sharpness process, introduction to detergent, classification, examples of cationic, anionic, nonionic and amphoteric detergents and their action with water, binders, opacifying agents, flavors, moisturizers of soap industry.

Pesticides

Introduction, classification of insecticides (chlorinated hydrocarbons, carbamates, organophosphates), classification and examples of herbicides (contact herbicides, systematic herbicide sand soil sterilants), rodenticides, fungicides (inorganic and organic fungicides) and germicides.

RecommendedBooks

1. Austin, G. T., Shreve's Chemical Process Industries, 5th ed., McGraw Hill, United Kingdom, (1984).
2. Kent, J. A., Riegel's Handbooks of Industrial chemistry, 9th ed., Chapman &Hall, United Kingdom, (1992).
3. Shreve, N., Chemical Process Industries, John Wiley, New York, (1982).
4. Vogel, A. I., Quantitative Organic Analysis, 5th ed., Longman Group, (1994).

CHEM-607	Biochemistry-I	Credit Hours: 3(2-1)

Course Objectives

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

Course Contents

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

Classification, structure of monosaccharides, disacchrides (sucrose, maltose, lactose, oligosaccharide (maltotriose) and polysaccharide (starch, amylase, amylopectin, cellulose, glycogen, dextrins, dextrans, chitin, hayaluronic acid, chondroitin sulfate, heparin), conformation of pyranose and furanose ring, glycosidic bond, biological significances of carbohydrates.

Practicals

1. Qualitative and quantitative analysis of carbohydrates, lipids and proteins.
2. Determination of pH, Preparation of buffers.
3. Enzyme catalysis, Progress curve for enzyme catalyzed reactions,
4. 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, Biselectrochemistry, 13th ed., Publisher: Wiley-VCH Verlag GmbH & Co.
2. Nelson, D. L., Lehninger's Principles of Biochemistry, 6th ed., Publisher: Macmillan Higher Education, (2008).
3. Voet, D. and Voet, J.D., Biochemistry, 4th ed., illustrated. Publisher: John-Wiley & Sons Canada, Limited, (2011).
4. Murray, R.M. and Harper, H.A., Harper's Biochemistry, 25th ed., Publisher:Appleton& Lange, (2000).
5. Zubay, G. L., Biochemistry, 4th ed., illustrated, Publisher W. M. C. Brown Publishers, (1998), Digitized (2008).
6. Guyton, A. C. & Hall, J. E., Guyton & Hall Textbook of Medical Physiology, 12th ed., Publishers: Saunders Elsevier, (2011).
7. Harvey, R. A., Ferrier, D. R., Karandish S., Lippincott's illustrated Reviews: Biochemistry, 5th ed., and Biochemistry Map (Med maps) Bundle. Publisher: Lippincott Williams & Wilkins, (2010).

SEMESTER – V

CHEM-608	Inorganic Chemistry-II	Credit Hours: 4(3-1)

Course Objectives

In this subject students will learn about the shapes of inorganic molecules, S and P block elements, transition molecules and chemistry of f-block elements.

Course Contents

The Chemistry of Hydrogen

Introduction, hydrogen bonding and hydrates, hydrogen-ion and acids, oxyacids, characteristics of some common strong acids, hydrides: classification and types of hydrides.

Metal of 1st transitionseries

Definition and position in the periodic table, general characteristics of 1st transition series, electronic configuration of the atoms and ions, electronic structure and magnetic properties of chemical substances.

Chemistry of f-block elements

Introduction of lanthanoids and actinoids, occurance, position in the periodic table, electronic configuration, oxidation states, complex formation, extraction and separation of lanthanoids and actinoids.

Chromatography

Introduction, principle and types of chromatography, thin layer chromatography (TLC): adsorbents, preparation of plates, application of sample, R_f values, developments, location of substances and application, column chromatography: introduction, practical aspects, elution procedure, applications, ion-exchange chromatography: basic principle, ion-exchangers and applications

Practicals

1. Separation of metal ions by paper chromatography and their identification with the help of locating agents and comparison of R_f values.
2. Separation of anions by paper chromatography and their identification.
3. Estimation of SO_2 and SO_3 in air and discharged from an industrial process.
4. Estimation of CO_2.
5. Estimation of oxalic acid and sulphuric acid in a mixture.
6. Estimation of H_3BO_3 and NaH_2BO_3 in a mixture.
7. Determination of %age composition of a mixture containing H_3BO_3 and CH_3COOH.
8. Estimation of following anions with the help of adsorption indicators (chloride, bromide, sulphate and iodide in a mixture

Recommended Books

1. Miessler, G. L. and Tarr, D. A., Inorganic Chemistry, 4th ed., Pearson Prentice Hall International, (2010).
2. Douglas B., McDanial, D., Alexander, J., Concepts and Models of Inorganic Chemistry, 3rd ed., John Wiley & Sons, New York, (1994).
3. Shriver, D. and Atkins, P., Inorganic Chemistry, 5th ed., W. H. Freewell, & Company, (2010).

4. Lee, J. D., Concise Inorganic Chemistry, 5th ed., Blackwell Science Ltd., (1996).
5. Atkins, P. and Jones, L., Chemical Principles, 5th ed., W. H. Freewell, & Company, (2010).
6. Svehla, G., Vogel's Textbook of Macro and Semi micro Qualitative Inorganic Analysis, 5th ed., Longman Group Ltd., (1979).
7. Huheey, J. E., Kieter, E. A., and Kieter, R. L., Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed., Prentice Hall, (1997).
8. Pass, G. and Sutecliffe, H., Practical Inorganic Chemistry, Preparation, Reactions and Instrumental Methods, 2nd ed., Chapman and Hall, (1974).
9. Skoog, D. A., West, P. M., Holler, F. J., Crouch, S. R., Fundamental of Analytical Chemistry, 9th ed., Brooks Cole Publishing Company, (2013).
10. Harris, D. C., Quantitative Chemical Analysis, 8th ed., W. H. Freewell, & Company, New York, (2011).
11. Christian, G. D., Analytical Chemistry, 6th ed., John Wiley & Sons, New York, (2006).
12. Kealey, D. and Haines, P. J., BIOS Instant Notes in Analytical Chemistry, 1st ed., BIOS Saence Publisher Ltd., Oxford, (2002).
13. Pavia, D. L., Lampman, G. M., Kriz, G. S. and Vyvyan, J. A., Introduction to spectroscopy, 4th ed., Cengage Learning, (2008).
14. Wall, P. E., Thin Layer Chromatography: A Modern Approach (RSC Chromatography Monographs), 1st ed., Royal Society of Chemistry, (2005).
15. Deinstrop, E. H., Applied Thin Layer Chromatography, 2nd ed., Wiley-VCH, (2006).

CHEM-609	Organic Chemistry-II	Credit Hours: 4(3-1)

Course Objectives

The objective of this course is to introduce the concepts of acids and bases, different functional groups chemistry and stereochemistry of organic compounds.

Course Contents

Acids and Bases

Concepts of acids and bases; scale of acidity and basicity; pK_avalues; predicting acid/base reactions from pK_avalues; the effect of structure on the strengths of acids and bases, inductive effects, resonance effects, steric effects, hydrogen bonding effects and hybridization effects; the effect of the medium on the strengths of acids and bases; the Hammett and Taft's equations- applications and limitations.

Chemistry of Functional Groups

Introduction, preparation, physical and chemical properties of alcohols, phenols, ethers, amines, aldehydes, ketones, carboxylic acids and their derivatives including esters, amides, acid halides and acid anhydrides.

Stereochemistry

Introduction, Geometrical isomerism/cis and trans isomers, E-Z convention, determination of configuration of the isomers, inter-conversion of geometrical isomers, geometrical isomerism in cyclic compounds.

Conformational isomerism: conformational analysis of alkanes (ethane, propane, butane), Conformational analysis of monosubstituted cyclohexanes, disubstituted cyclohexanes and decalin systems.

Optical isomerism: optical activity, symmetry elements and optical inactivity, enantiomers, diastereomers, R, S nomenclature, racemic modification and resolution of racemic modification.

Practicals

Qualitative organic analysis: systematic identification of organic compounds containing groups like COOH, RCOR (amide), phenol (any 8 organic compounds).

Recommended Books

1. Wade, L.G., Organic Chemistry, 8th ed., Pearson Education, Inc. USA, (2013).
2. Eliel, E. L. and Wilen, S. H., Stereochemistry of Organic Compounds, John Wiley & Sons, Singapore, (1994).
3. Jones, M. A., and Fleming S. A., Organic Chemistry, 5th ed., W.W. Norton & Company, Inc., New York, USA, (2014).
4. Solomons, T. W. G. and Fryhle, C. B., Organic Chemistry, 11thed., John Wiley & Sons, New York, (2013).
5. Morrison, R. T. and Boyd, R. N., Organic Chemistry, 6th ed., Prentice-Hall of India, New Delhi, (2005).
6. Sykes, P., A Guide Book to Mechanism in Organic Chemistry, 6thed., Longman, London, (1986).
7. Loudon, G. M., Organic Chemistry, 6thed.,W. H. Freeman and Company, New York, USA, (2016).
8. Vogel, A. I., A Text Book of Practical Organic Chemistry, 5thed., Longman Scientific, (1989).

CHEM-610	Physical Chemistry-II	Credit Hours: 4(3-1)

Course Objectives

In this course kinetic theory of gases, chemical thermodynamics and chemical kinetics are taught to the students.

Course Contents

Kinetic theory of gases

Laws of gases, kinetic molecular theory and non-ideal behaviour of gases, van der waal's equation and the critical point, van der waal's equation and the law of corresponding states, maxwell boltzmann distribution law of molecular velocities and its significance, maxwell boltzmann distribution law for molecular energies and its application, mean free path and its determination, collision frequency, calculation of molecular velocities of gases, velocities of gases, its measurement and effect of temperature, avogadro's number and its determination.

Chemical thermodynamics

The first law of thermodynamics and their applications, partial molar quantities and their determinations, heat capacity and adiabatic processes, prove that Cp-Cv = R, isothermal processes in ideal gases, carnot cycle for any substance, carnot cycle for ideal gases, the efficiency of an engine, second law of thermodynamics, entropy, entropy change in isolated system, third law of thermodynamics, Helmhotz free energy, the Gibbs free energy, Gibbs Helmhotz equation, the relation of free energy with equilibrium constant, the Clausics Calpeyron equation and its simple applications.

Chemical Kinetics

Order of reaction, first, second and third order rate laws, kinetics of simultaneous reactions (opposing, consecutive and side reactions), energy of activation, collision and absolute theories of reaction rate and their comparison, Lindemann's mechanism with few examples.

Practicals

1. To determine the heat of neutralization of strong acid (HCl) and strong base (NaOH).
2. To determine the heat of solution by solubility method.
3. To determine the heat of solution of (KNO_3) salt.
4. To determine hydrolysis constant of methyl acetate in acidic medium
5. To determine the velocity of saponification of ethyl acetate by NaOH.
6. Preparation of solution.

Recommended Books

1. Bahl, A., Bahl, B. S. and Tuli, G. D., Essential of Physical Chemistry, S. Chand & Co. Ram Nagar, New Delhi, (2008).
2. Atkins, P. and Paula, J. D., Atkin's Physical Chemistry, 9th ed., Oxford University Press, (2010).
3. Atkins, P., Jones, L., Chemical Principles: The Quest for Insight, 5th ed., W. H. Freeman, New York, (2010).
4. Ball D. W., Physical Chemistry, Brooks/Cole Co. Inc., (2003).
5. Chaudhary, S. U., Ilmi Textbook of Physical Chemistry, 2nd ed., Ilmi Kitab Khana, Lahore, (2013).
6. Choppin, G., Liljenzin, J. O. and Rydberg, J., Radiochemistry and Nuclear Chemistry, 3rd ed., Butterworth-Heinemann, (2002).
7. Brennan, D. and Tipper, C. F. H., A Laboratory Manual for Experiments in Physical Chemistry, McGraw-Hill, (1967).
8. Jaffar, M., Experimental Physical Chemistry, University Grants Commission Islamabad, (1983).
9. Linder, B., Elementary Physical Chemistry, World Scientific Publishing Co Inc., (2012).
10. Loveland, W., Morrisey, D. J. and Seaborg, G. T., Modern Nuclear Chemistry, John-Wiley & Sons, Inc., (2006).
11. Findlay, A., Practical Physical Chemistry, 7th ed., Longman's Green & Co. London, (1949).
12. Silbey, R. J., Alberty, R. A. and Bawendi, M. G.,Physical Chemistry,4th ed., John-Wiley & Sons, (2005).
13. Somorjai, G. A. and Li, Y., Introduction to Surface Chemistry and Catalysis, 2nd ed., John-Wiley & Sons, Inc., (2010).
14. Vertes, A., Nagy, S. and Klencsar, Z., Handbook of Nuclear Chemistry, Vol 1: Basics of Nuclear Science, 1st ed., Springer, (2003).

CHEM-611	Analytical Chemistry-II	Credit Hours: 4(3-1)

Course Objectives

The students will learn about the basic concepts of analysis, error and data handling, gravimetric analysis and basic concepts of electro-analytical techniques.

Course Contents

Basic Concept of Analysis

Introduction to analytical chemistry, analytical process: Defining the problem, sampling, handling the sample, performing necessary chemical separations, performing the measurement, calculation and interpretation of the measurement.

Errors and Data Handling

Determinate and indeterminate errors, significant figures, rounding off, accuracy and precision, arithmetic means, medians, average deviation, standard deviation, confidence limit, testing for significance, Q-test, T-test, correlation coefficient.

Gravimetric Analysis

General principle, steps of gravimetric analysis: solution preparation, precipitation, digestion, washing, filtration, drying and ignition of precipitates, calculation, applications of gravimetric analysis.

Basic Concepts of Electro-analytical Techniques

Principle, instrumentation and applications of potentiometry and polarography.

Practicals

1. Determination of sulphate in the given sample gravimetrically.
2. Estimation of calcium as calcium oxalate gravimetrically.
3. Determination of chloride in water volumetrically
4. Quantitative analysis of calcium and magnesium in the given sample with EDTA volumetrically.
5. Preparation and standardization of sodium thiosulphate solution with a primary standard reagent.
6. Analysis of commercial hypochlorite solution iodometrically.
7. Analysis of hydrogen peroxide iodometrically.
8. Preparation of standard potassium permanganate solution.
9. Titrimetric determination of iron by potassium permanganate solution.
10. Conductometric titration of strong acid-base.

Recommended Books

1. Christian,G. D., Analytical chemistry, 6th& 7th ed., John Wiley & Sons, New York, (2004 & 2013).
2. Christian,G. D., Analytical Chemistry, Student Solutions Manual, 6thed.,Publisher: Wiley, (2004).
3. Christian, G. D. and O'Reilley, J. E, Instrumental analysis, 2nded., Allyn and Bacon, Boston, (1986).
4. Skoog,D. A., West, D. M., Holler, F. J. and Crouch,S. R, Fundamentals of analytical 5. chemistry, 8thed., Thomson Brooks/Cole, USA, (2004).
5. Skoog,D. A., Holler F. J. and NiemanT. A., Principles of instrumental analysis, 5thed., Saunders College Publishing, New York, (1997).
6. Skoog,D. A., Holler F. J. and Crouch,S. R., Principles of instrumental analysis, 6th ed., Thomson, USA, (2007).
7. Harris, D. C., Quantitative chemical analysis, 7thed., Freeman, New York, (2007).
8. Day, R. A. and Underwood,A. L., Quantitative Analysis, 6thed., Prentice Hall Inc. (2004).
9. Harvey,D., Modern Analytical Chemistry, McGraw-Hill Companies, Inc. New York, (2000).
10. Bard, A. J. and Faulkner,L. R., Electrochemical methods, fundamentals and applications, 2nded., John Wiley & Sons, New York, (2001).

CHEM-612	Biochemistry-II	Credit Hours: 4(3-1)

Course Objectives

In this course, students will acquire knowledge about the amino acids, proteins, lipids, nucleic acids and vitamins.

Course Contents

Amino acids and Proteins

Classification of amino acids on the basis of R-chain, acid-base properties of amino acids, di-peptide structure, essential and non-essential amino acids, classification of proteins simple proteins, compound proteins, derived proteins, primary, secondary, tertiary and quaternary structures of proteins.

Lipids and Nucleic acids

Classification of lipids, simple lipids, compound lipids, structure of phospholipids (phosphatidic acid, phosphatidylglycerol, phosphatidylcholine, phosphatidyl-ethanolamine, phosphatidylinositol, phosphatidylserine, lysophospholipids, plasmalogens, sphingomyelins), biological significances of lipids, classification of nucleic acids with structures of purines, pyrimidines, nucleosides and nucleotides.

Vitamins

Occurrence, chemistry, physiological functions, deficiency symptoms and requirements of fat soluble and water soluble vitamins (A, B, C, D and K).

Practicals

Qualitative and Quantitative analysis of;

1. Lipids
2. Protein and
3. Vitamin tests

Recommended Books

1. Voet, D., Voet, J.G., and Pratt, C.W., Fundamentals of Biochemistry, John Wiley & Sons New York (1999).
2. Lehninger, A. L., Nelson, D. L. And Cox, M. M., Principles of Biochemistry, 6th ed., Worth Publishers, New York, (2012).
3. Norton, H. R., Moran, L. A., Ochs, R. S., Pawan, J. D. And Scrogmeour, G., Biochemistry, 2nd ed., Prentice Hall, (1994).
4. Rodwell, V., Bander, D. and Bothman, K. M., Harper's Illustrated Biochemistry, 30th ed., Rpbert K. Murray, (2015).
5. Plummer, D. T., An Introduction to Practical Biochemistry, TATA McGraw-Hill Publishing Company Ltd., (1988).
6. Sawhney, S. K. and Sing, R., Introductory Practical Biochemistry, Narosa Publishing House, New Dehli, (2005).

SEMESTER – VI

CHEM-613	Inorganic Chemistry-III	Credit Hours: 4(3-1)

Course Objectives

In this semester students will learn in detail the different types of chemical reactions, electron transfer reaction and π-acceptor ligands.

Course Contents

Types of Chemical Reactions

Reaction among similar atoms and molecules, reactions among different kinds of atoms and molecules, miscellaneous reactions, electrophilic and nucleophilic reactions.

Electron Transfer Reactions

Electron transfer reactions in co-ordination compounds, mechanism of electron transfer reactions, outer sphere or tunnelling mechanism, inner sphere or ligand bridge mechanism, factors effecting the rate of electron transfer reactions, two electrons transfer reactions.

Chemistry of d-Block Elements and Coordination Complexes

Background 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.

Practicals

1. Estimation of Mg^{2+}, Zn^{2+} with EDTA (Direct titration).
2. Estimation of Ni^{2+} with EDTA (Back titration).
3. Determination of Ca^{2+} and Zn^{2+} in a mixture (Masking).
4. Determination of Cd^{2+} and Zn^{2+} in a mixture (Demasking).
5. Determination of SO_4^{2-} and PO_4^{3-} with EDTA (Indirect titration).
6. Use of ceric sulphate solution for the estimation of the following:
   i) Determination of iron in an iron ore.
   ii) Determination of nitrites
7. Use of potassium iodate for the determination of the followings:
   i) Copper ii) Hydrogen peroxide iii) Commercial hypochlorite

Recommended Books

1. Muller, U., Inorganic Structural Chemistry, 2nd ed., John Wiley & Sons, Ltd.,New York, (2006).
2. Marusak, R. A., Doan, K. and Cummings S. D., Integrated Approach to Coordination Chemistry, 1st ed., John Wiley &Sons Ltd., New York, (2007).
3. Chaudhary, S. U., Ilmi Textbook of Inorganic Chemistry, Ilmi Kitab Khana, Urdu Bazar, Lahore, (2013).
4. Catherine E. H. and Alan G. S., Inorganic Chemistry, 3rd ed., Prentice Hall, (2008).
5. Kathleen, A. H., James, E. H., Descriptive Inorganic Chemistry, 2nd ed., Brooks Cole, (2010).

CHEM-614	Organic Chemistry-III	Credit Hours: 4(3-1)

Course Objectives

In this course, students will acquire knowledge about addition, substitution and elimination reactions.

Course Content

Addition Reactions

Mechanism, kinetics, orientation, and stereochemistry of electrophilic additions to C=C; addition of halogen and halogen acids, hydration, hydrogenation, addition to conjugated dienes, mechanism, kinetics and stereochemistry of following nucleophilic additions to C=O double bond; stereoselectivity of addition reactions.

Nucleophilic Substitution at Saturated Carbon

Introduction and types of nucleophilic substitutions, mechanism kinetics and stereochemical characterization of SN_1 and SN_2 reactions, the effect of solvent, nature of nucleophile, leaving group and structure of substrate on mechanism and rates of SN_1 and SN_2, neighboring group participation.

Elimination Reactions

Introduction of elimination, β-eliminations (E_1 and E_2), E1cb mechanism, kinetics, Saytzeff and Hoffman rules, elimination versus substitution.

Practicals

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 benzoic acid, benzanilide, phenyl benzoate and acetyl salicylic acid etc.

Recommended Books

1. Jones, M. A., and Fleming S. A., Organic Chemistry, 5th ed., W.W. Norton & Company, Inc., New York, USA, (2014).
2. Solomons, T. W. G. and Fryhle, C. B., Organic chemistry, 11thed., John Wiley &Sons, New York, (2013).
3. Morrison, R. T. and Boyd, R. N., Organic chemistry, 6thed., Prentice-Hall, New Delhi, (2005).
4. Loudon, G. M.,Organic chemistry, 6thed.,W. H. Freeman and Company, New York, USA, (2016).
5. Vogel, A. I., A text book of practical organic chemistry, 5thed., Longman Scientific, (1989).
6. Furniss, B. S., Hannaford , A. J., Smith, P. W. G., Tatchell, A. R., Vogel's Textbook of Practical Organic Chemistry, 5thed., Longman, UK, (1989).

CHEM-615	Physical Chemistry-III	Credit Hours: 4(3-1)

Course Objectives

In this course of study students will learn about electrochemistry, quantum chemistry and nuclear Chemistry.

Course Contents

Electrochemistry

Idea of various fundamental concepts, Arrhenius theory of electrolytic dissociation and conductance (equivalent conductance at infinite dilution and calculations), Kohlrausch's law and its applications, Debye-Huckel theory of strong electrolytes and its importance, Debye-Huckel limiting law, transport number and its determination, activity, activity co-efficient and its determination, thermodynamics of cells and their applications, measurement of pH by different electrodes.

Quantum Chemistry

Basic concepts, schrodinger wave equation, physical significance of the wave function, eigen-function, eigen-values, orthogonal and normalized wave functions, derivation of quantum numbers from wave equation particle in a box tunnel effect, the solution of schrodinger wave equation for hydrogen atom, the hydrogen molecule, ion and the molecular orbital treatment of diatomic molecules, the H_2 molecule and its valence bond treatment, concept of molecular orbital (MO) and valance bond (VB) approaches for diatomic and polyatomic molecules.

Nuclear Chemistry

Introduction, inter-conversion of mass and energy, nuclear binding energy, alpha, beta, gamma and positron decay processes, group displacement law, nuclear reactions, induced radioactivity, nuclear forces, radioactive decay rates, half-life and average life, nuclear fission, atomic bomb, nuclear fusion, hydrogen bomb, various types of nuclear reactors, radioactive isotopes and their applications (including numerical relating to the above cited topics).

Practicals

1. To determine the percentage composition of the given solution by means of polarimeter.
2. To prepare solution of As_2S_3 and to study the precipitation value of NaCl and $AlCl_3$.
3. Conductometric determination of hydrolysis constant of conjugate base of a weak acid.
4. Conductomeric determination of Cu^{2+}–EDTA mole ratio in the complex.
5. Determination of %age composition of $KMnO_4$ in a solution by spectrophotometry.
6. Spectroscopic determination of Cu in the given sample.

Recommended Books

1. Aziz, F. and Rodgers, M. A. J., Radiation Chemistry Principles and Applications, 1st ed., VCH Publishers, Inc. (1987).
2. Barrow, G. M., Physical Chemistry, 6th ed., McGraw-Hill Book Company (1996).
3. Choppin, G., Liljenzin, J. O. Rydberg, J., Radiochemistry and Nuclear Chemistry, 3rd ed., Butterworth-Heinemann, (2002).
4. Dunkin, I., Photochemistry, Vol. 36, RSC Publishing, (2007).
5. Brennan, D. and Tipper, C. F. H., A Laboratory Manual for Experiments in Physical Chemistry, McGraw-Hill, (1967).
6. Findlay, A., Practical Physical Chemistry, 7th ed., Longman's Green & Co. London, (1949).

7. Jaffar, M., Experimental Physical Chemistry, University Grants Commission Islamabad, (1983).
8. Fayer M. D., Elements of Quantum Mechanics, Oxford University Press, London, UK, (2001).
9. Hayward, D. O., Quantum Mechanics for Chemists, Royal Society of Chemistry, (2002).
10. House, J. E. Fundamentals of Quantum Mechanics, 2nd ed., Elsevier-Academic Press, New York, USA, (2004).
11. Kirsten, H. J. W. M., Introduction to Quantum Mechanics: Schrodinger Equation and Path Integral, 1st ed., World Scientific Publishing Co. Pvt. Ltd., (2006).
12. Konya, J. and Nagy, N. M., Nuclear and Radiochemistry, 1st ed., Elsevier, (2012).
13. Mostafavi, M. Douki, T., Radiation Chemistry from Basic to Applications in Material and Life Sciences, EDP Science, (2008).
14. Scaglia, B., The Fundamentals, An Understanding of Photochemistry, Biblio Bazaar, (2011).

CHEM-616	Analytical Chemistry-III	Credit Hours: 4(3-1)

Course Objectives

The students will learn about the different separation techniques, physico-chemical basis of reactions in aqueous solutions and introduction to spectroscopic methods of analysis.

Course Contents

Separation Techniques

a) Solvent Extraction

General principle and terminology of solvent extraction, experimental techniques (batch, continuous and counter-current extraction techniques), important experimental variables, and metal extraction system.

b) Chromatography

Principles of chromatography, classification, techniques of chromatography (paper, thin layer,column, ion exchange and size exclusion chromatography) and their analytical applications.

Physico-chemical Basis of Reactions in Aqueous Solutions

Introduction, types of chemical reactions, chemical equilibrium, equilibrium constants, factors effecting equilibrium constants, law of mass action, Le-Chatelier principle and its applications.

a) Acid-base Equilibria

Ionization, ionization constants, activity coefficient, pH measurements and calculations, pH of an acid and base, strong and weak acid base titration's, common ion effect, indicators, titration curves, buffer solution and buffer capacity.

b) Redox-Equilibria

Theory of oxidation and reduction, redox titration's, indicators, titration curves.

c) Complexation Equilibria

Theory, complex-forming reagents, complex formation constants, cheletes, EDTA equilibria, EDTA titration

curves, indicators.

d) Precipitation Equilibria

Solubility, factors effecting solubility, solubility product constant, precipitation titration's, Indicators.

Introduction to Spectroscopic Methods of Analysis

Electromagnetic radiation and spectrum, Beer's and Lambert laws, deviations from Beer's law, instrumentation and applications of UV-Vis spectroscopy.

Practicals

1. Determination of potassium permanganate in the given sample by spectrophotometry.
2. Determination of nitrate-nitrogen in water sample by spectrophotometry.
3. Determination of lead spectrophotometrically using solvent extraction.
4. Coating of thin layer chromatography plates.
5. Separation of metal ions (Nickel, Copper, Zinc and Cobalt) and determination of *Rf*values by thin layer chromatography.
6. Separation and identification of metal ions by paper chromatography.
7. Separation and identification of amino acids by paper chromatography.
8. Preparation of column packing.
9. Separation of dyes by column chromatography.
10. Separation of metal ions by ion exchange chromatography followed by EDTA titration.

Recommended Books

1. Christian,G. D., Analytical chemistry, 6th and 7thed., John Wiley & Sons, New York, (2004 and 2013).
2. Christian, G. D., Analytical Chemistry, Student Solutions Manual, 6thed., Publisher: Wiley, (2004).
3. Christian, G. D. and O'Reilley,J. E., Instrumental analysis, 2nded., Allyn and Bacon, Boston, (1986).
4. Skoog, D. A., West, D. M., Holler, F. J. and Crouch, S. R., Fundamentals of analytical chemistry, 8th ed., Thomson Brooks/Cole, USA, (2004).
5. Skoog, D. A., Holler, F. J. and Nieman, T. A., Principles of instrumental analysis, 5thed., Saunders College Publishing, New York, (1997).
6. Skoog, D. A., Holler, F. J. and Crouch, S. R., Principles of instrumental analysis, 6th ed., Thomson, USA, (2007).
7. Harris, D. C., Quantitative chemical analysis, 7thed., Freeman, New York, (2007).
8. Day, R. A. and Underwood, A. L., Quantitative Analysis, 6thed., Prentice Hall Inc., (2004).
9. Harvey, D., Modern Analytical Chemistry, McGraw-Hill Companies, Inc. New York, (2000).
10. Bard, A. J. and Faulkner, L. R., Electrochemical methods, fundamentals and applications, 2nded., John Wiley & Sons, New York, (2001).

CHEM-617	Biochemistry-III	Credit Hours: 4(3-1)

Course Objectives

In this course, students will learn about intermediary metabolism, bioenergetics, metabolism of carbohydrates, lipids, proteins, minerals and trace elements.

Course Contents

Intermediary Metabolism and Bioenergetics

A brief introduction on the nature of enzymes and coenzymes, biological oxidation reaction including respiratory carriers, oxidative phosphorylation, energy metabolism including caloric values of foods, respiratory quotient RQ and basal metabolic rate BMR.

Metabolism of Carbohydrates

Glycolysis, citric acid cycle, HMP pathway, digestion and absorption of carbohydrates.

Metabolism of Lipids

Fatty acid oxidation, biosynthesis of fatty acids, biosynthesis of triglycerides, biosynthesis of cholesterol, biosynthesis of phospholipids, sterols, bile acids and ketone bodies, biosynthesis of ketone bodies, digestion and absorption of lipids.

Metabolism of Proteins

Protein biosynthesis, decarboxylation, transamination, deamination reaction, urea cycle, creatinine and uric acid synthesis, absorption of proteins.

Metabolism of Minerals and Trace Elements

A brief introduction to minerals, trace elements, electrolytes, sources, requirements, biological functions and deficiency disorders of minerals and trace elements.

Practicals

1. Thin layer chromatography
2. Nitropruside test
3. Isolation of casein from milk

Recommended Books

1. Lehninger, A. L., Nelson, D. L. And Cox, M. M., Principles of Biochemistry, 6th ed., Worth Publishers, New York, (2012).
2. Voet, D., Voet, J. G. and Pratt, C. W., Biochemistry, John Wiley & Sons, New York, (2012).
3. Rodwell, V., Bander, D. and Bothman, K. M., Harper's Illustrated Biochemistry, 30th ed., Robert K. Murray, (2015).
4. West, E. S., Text Book of Biochemistry, 4th ed., (2008).
5. Zubay, G., Biochemistry, 4th ed., Macmillan Publishing Co., (1999).
6. Bhagavan, N. V., Biochemistry, 2nd ed., J. B. Lippincorr Co. (1978).
7. Horton, H. R., Moran, L. A., Ochs, R. S., Pawn, J. D. and Scrigmeour, G., Boichemistry, 2nd ed., Prentice Hall Inc., New Jersey, (1994).
8. Devlin, T. M., Textbook of Biochemistry with Clinical Corrections, 6th ed., Wiley-Liss, New York, 2011.

SEMESTER – VII

Specialization in Inorganic Chemistry

CHEM-618	Inorganic Chemistry-IV	Credit Hours: 3(3-0)

Course Objectives

In this course students will learn detail about the chemistry of pi-acceptor complexes, magnetochemistry and crystallography.

Course Contents

Pi-acceptor Complexes

Introduction, classification, chemistry and structure of carbonyls (moni & polynuclear carbonyls), preparation of metal carbonyls, reactions of carbonyls, general chemistry of cyclopentadienyl, reaction and structure of cyclopentadienyls with reference to theories of bonding and salt formation (Ferrocene).

Magnetochemistry

Theory of magnetism, diamagnetism, paramagnetism, ferro-, ferri- and antiferromegnetism, magneticmoments, Faraday's and Gouy's methods, effect of temperature on magnetic properties of complexes, electron spin resonance spectroscopy, magnetic moment of lanthanides.

Crystallography

Crystalline and amorphous solids, crystal systems, points group, methods of characterizing crystal structure powder diffraction, electron and neutron diffraction, types of close packing, radius ratio, structures of some simple salts, bonding forces in ionic crystals, crystal energies, types of crystals: molecular, covalent, ionic, metallic and intermediate types of crystals.

Recommended Books

1. Miessler, G. L. and Tarr, D. A., Inorganic Chemistry, 4th ed., Pearson Prentice Hall International, (2010).
2. Douglas B., McDanial, D., Alexander, J., Concepts and Models of Inorganic Chemistry, 3rd ed., John Wiley & Sons, New York, (1994).
3. Huheey, J. E., Kieter, E. A., and Kieter, R. L., Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed., Prentice Hall, (1997).
4. Shriver, D. F., Atkins, P. W., Langford, C. H., Inorganic Chemistry, 2nded., Oxford University Press, (1994).

CHEM-619	Inorganic Chemistry-V	Credit Hours: 3(3-0)

Course Objectives

In this course students learn about stereochemistry, kinetics and reaction mechanism of inorganic reactions.

Course Contents

Stereochemistry

Introduction to stereochemistry with structural elucidation of complexes of 6,4 co-ordination on the basis of different theories including, chain theory, Werner theory, stereochemistry of co-ordination compounds with special reference to coordination number 4 & 6, concept of isomerism, its different branches, methods of measurement of optical activity and introduction about rotatory dispersion curve, substitution reactions, stereochemical changes in substitution nucleophilic reactions, VSEPRT and its applications.

Kinetics and Reaction Mechanism of Inorganic Reactions

Classification of reaction mechanisms, rate laws, steady state approximation, inert and labile complexes, substitution reactions, octahedral complexes, acid hydrolysis, acid catalyzed equation, anation reactions, base hydrolysis, attack on ligands, steric effects of inert ligands, square planar complexes, nucleophillic reactivity, trans-effect, cis-effect, effect of leaving group, mechanism of substitution and racemization reactions.

Recommended Books

1. Cotton, F. A. and Wilkineon, G., Advanced Inorganic Chemistry 6th ed., Interscience, Publishers, London, (2001).
2. Billmeyer, F. W., A Text Book of Polymer Science, 3rd ed., John-Wiley and Sons, (2003).
3. Gray H. B., Chemical Bonds and Introduction to Atomic and Molecular Structure,W.A. Benjamin, Inc., London,(1973).
4. Kettle, S. F. A., Coordination Compounds, Nelson, Kenya, (1999).
5. Crabtree, R. H., The Organometallic Chemistry of the Transition Metals, 5th ed., John-Wiley and Sons, New Jersey, (2011).
6. Huheey, J. H., Inorganic Chemistry - Principles, Structure and Reactivity, Harper and Row Publisher, Inc. New York, (2008).
7. Malmcoim, P.S., Polymer Chemistry: An Introduction, 3rded.,Oxford University Press, (2005).
8. Ravve, A., Principles of Polymer Chemistry, 2nd ed., Plenum Publishers, (2000).
9. Yamamoto, A., Organotransition Metal Chemistry, Prentice Hall, (1992).

CHEM-620	Inorganic Chemistry-VI	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the basic concepts of spectroscopy, instrumentation and inorganic applications.

Course Contents

Infrared Spectroscopy

Theoretical basis, kinds of vibration, absorption of various functional groups, instrumentation: sources, diffraction grating, detector, and its types, interpretation of IR-spectrum, inorganic applications.

Nuclear Magnetic Resonance Spectroscopy

Theoretical basis, spin-spin flipping, chemical shift, shielding effect, spin-spin coupling, factors affecting, inorganic applications.

Ultraviolet Spectroscopy

Introduction, nature of electronic excitation, principles of absorption spectroscopy, instrumentation (single and double beam spectrophotometers), chromophore, conjugated systems, applications.

Flame Photometry

Introduction, Instrumentation: burners, fuel and oxidants, monochromator, detectors, limitations of flame photometry and applications.

Mass Spectroscopy

Introduction, instrumentation: sample inlet system, magnetic analyser, detector, electro impact ionization, types of peaks, inorganic applications.

Recommended Books

1. Mohan, J., Organic Analytical Chemistry: Theory and Practice, 1st ed., Alpha Science International 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, (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 Ltd., (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. Silverstein, R. M., Webster, F. X., and Kiemle, D., Spectrometric Identification of Organic Compounds, 7th ed., John Wiley & Sons, Ltd., (2005).
9. Williams, D. H. and Flemming, I., Spectroscopic Methods in Organic Chemistry, 6th ed., McGraw-Hill Higher Education, (2008).

CHEM–621	Inorganic Chemistry Lab–I	Credit Hours: 1(0-1)

The resolution of *cis*-dichlorobis(ethylenediamine)chromium(III) chloride into its optical isomers. The preparation and resolution of the tris(ethylenediamine)cobalt(III) ion into its optical antipode.

Determine

- Photometric determination of potassium.
- Photometric determination of calcium.
- Spectrophotometric determination of iron.
- Spectrophotometric analysis of potassium permanganate.
- Estimation of Al(III) and Fe(III) using 8-hydroxyquinoline.
- Estimation of Ni(II) in the presence of Cu(II).
- Determination of chloride in the presence of iodide and evaluation of Ksp of AgI and AgCl.
- Titration of strong acid and weak acid with a strong base
- Precipitation titration involving $AgNO_3$ and KCl

Recommended Books

1. Bassett, J., Denny, P. C., Jeffery, G H., Mendham, J., Vogel's textbook of Quantitative Inorganic Analysis, 4th ed. English Language Book Society, (1978).
2. Pass, G., Sutcliffe, H., Practical Inorganic Chemistry: Preparation Reactions and Instrumental Methods, 2nd ed., Chapman and Hall, UK, (1974).

CHEM–622	Research Methodology	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the basics of research, types of research, how to devise research experiments and it will enhance the students capabilities to write research proposal and report writing.

Course Content

Scientific Processand Research Process

Introduction, scientific methods, research: research motivation, objectives, methodology, method, and approaches, criteria of good research, types and significance of research, steps in research,

Research Problems and Design

Introduction to research problem and steps in its formulation, introduction to research design, criteria of a good research design, types of research design.

Variables, Measurement, and Scaling Technique and sampling design

Introduction, variable and types variables, measurement and levels of measurement, scaling technique and errors,design of experiments and its principles, sampling, types of sampling and selection of sampling technique.

Data Collection and its Analysis, Research Proposal and Research Report Writing

Introduction, literature review, methods of collection of primary and secondary data, instrumentation and computation, research proposal and research report writing.

Recommended Books:

1. Sahu, P. K., Research Methodology: A guide for researchers in agricultural science, social science and other related fields, Springer New Delhi, (2013).
2. Kothari,C. R., Research Methodology: Method and techniques, New Age International Ltd. New Dehli, (2004).
3. Kumar, R., Research Methodology, A step-by-step guide for beginners, 3rd ed., SAGE, New Dehli, (2011).
4. Marczyk, G., DeMatteo D. and Festinger, D., Essentials of research design and methodology, John Wiley & Sons, Inc.New Jersey, (2005).
5. Pruzan, P., Research Methodology: The aims, practices and ethics of science, Springer International Publishing, Switzerland, (2016).

CHEM– 623	Research Project–I	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VII

Specialization in Organic Chemistry

CHEM–624	Organic Chemistry-IV	Credit Hours: 3(3-0)

Course Objectives

Students will acquire knowledge regarding the aromatic substitutions and different intermediates involved in organic reactions. Students are expected to learn the underlying concepts and synthetic applications.

Course Content

Aromatic Substitutions

Electrophilic aromatic substitution substitution, mechanism of electrophilic aromatic substitution reaction, nitration, halogenation, sulphonation, Friedel Crafts alkylation and acylation, orientation and reactivity in case of monosubstituted and polysubstituted reactions, nucleophilic aromatic substitution**;** mechanism of nucleophilic unimolecular mechanism, benzyne and benzonium ion mechanism.

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.

Recommended Books

1. March, J., Advanced organic chemistry, 6thed., John Wiley & Sons, New York, (2007).
2. Jones, M. A., and Fleming S. A., Organic Chemistry, 5th ed., W.W. Norton & Company, Inc., New York, USA, (2014).
3. Solomons T. W. G. and Fryhle, C. B., Organic chemistry, 11thed., John Wiley & Sons, New York, (2013).
4. Morrison, R. T., and Boyd, R. N., Organic chemistry, 6thed., Prentice-Hall of India, New Delhi, (2005).
5. Sykes, P., A guide book to mechanism in organic chemistry, 6thed., Longman, London, (1986).
6. Loudon, G. M.,Organic chemistry, 6thed.,W. H. Freeman and Company, New York, USA, (2016).
7. Wade, L.G., Organic Chemistry, 8th ed., Pearson Education, Inc. USA, (2013).
8. Carey, F. A. and Sundberg R. J., Advanced Organic Chemistry: Part A Structure and Mechanism, 4th ed., Kluwer Academic/Plenum Publishers, New York, USA, (2000).
9. Clayden, J., Greeves,N. and Warren, S., Organic Chemistry, 2nded., Oxford University Press, (2012).

CHEM–625	Organic Chemistry-V	Credit Hours: 3(3-0)

Course Objectives

Students will acquire knowledge about different types of natural products with emphasis on their structure, synthesis and applications.

Course Contents

Alkaloids

Introduction, general properties, classification, extraction, isolation, techniques, general method of structure determination, preparation, physical and chemical properties of following alkaloids: ephedrine, nicotine, atropine, quinine, papaverine and morphine.

Steroids

Introduction, Diel's hydrocarbon and its chemistry, sterols, chemistry of cholesterol and steroid hormones with emphasis on their structure and biosynthesis.

Terpenoids

Introduction, classification, isoprene and special isoprene rule. Physical and chemical properties of citral, α-terpeniol, α-pinene, camphor, α-cadenine

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, 3rded., Medicinal Natural Products, John-Wiley & Sons, Ltd., (2009).
2. Sell, C. S., A Fragrant Introduction to Terpenoid Chemistry, The RoyalSociety of Chemistry, UK, (2003).
3. De la Rosa, L. A., Parrilla, E. A. and Aguitar, G. A. G., Fruit and VegetablePhytochemicals: Chemistry, Nutritional Value and Stability, Wiley-Blackwell,(2009).
4. Shahidi, F. and Naczk M., Phenolics in Food and Nutraceuticals, CRCPress, (2004).
5. Oyvind, M. A., and Kenneth, R. M., Flavonoids: Chemistry, Biochemistryand Applications, CRC, Taylor & Francis, New York, (2010).
6. Finar, I. L., Organic Chemistry, Vol. 2, Stereochemistry and the Chemistryof 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 NaturalProducts, Narosa Publishing House, (2005).

CHEM–620	Organic Chemistry-VI	Credit Hours: 3(3-0)

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 Content

Ultraviolet Spectroscopy

Theoretical basis, Beer's Lambert's law, electronic transitions, characteristic absorption of compounds containing, O and N extended conjugated systems, Woodward rules for calculation of wavelength values and applications of UV-Vis Spectroscopy.

Infrared Spectroscopy

Theoretical basis, kinds of vibration, functional group determination (C-H, C-C, C=C, C-N, O-H, N-H, C-X etc.) and factors effecting the absorption frequencies, applications of IR spectroscopy.

Nuclear Magnetic Resonance Spectroscopy (^{1}H-NMR and ^{13}C-NMR)

Chemical shift, factors effecting chemical shift, integration curve, spin-spin splitting and coupling constant, structure elucidation of small molecules and introduction of 2-D NMR spectroscopy.

Mass Spectrometry

Introduction, principle, instrumentation, ionization techniques, types of peaks, different fragmentation patterns and interpretation of mass spectra of simple molecules.

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. Silverstein, R. M., Webster, F. X. and Kiemle, D., Spectrometric Identification of Organic Compounds, 7th ed., John-Wiley & Sons, Inc.,(2005).
9. Williams, D. H. and Flemming, I., Spectroscopic Methods in OrganicChemistry, 6th ed., McGraw-Hill Higher Education, (2008).

CHEM–627	Organic Chemistry Lab-I	Credit Hours: 1(0-1)

Experiments involving aromatic substitution reactions (Nitration of benzene, Bromination of phenol and Sulphonation of aniline).

Isolation of at least 5 natural products: Trimyristine from nutmeg, Caffeine from tea leaves, Nicotine from tobacco, Lecithin from egg yolk, Cholesterol from gall bladder, Limonene from Orange peels, piperine from black pepper, carvone from mint etc.

Recommended Books

1. Vogel, A. I., A text book of practical organic chemistry, 5th ed. Longman Scientific, (1989).
2. 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).
3. Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., A Microscale Approach to Organic Laboratory Techniques, 5th ed., Brooks/ ColeCengage Learning, (2013).
4. 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).
5. Gilbert, J. C. and Martin, S. F., Experimental Organic Chemistry: A Miniscale and Microscale Approach, 5th ed., Brooks/ Cole Cengage Learning, (2010).

CHEM–622	Research Methodology	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the basics of research, types of research, how to devise research experiments and it will enhance the students capabilities to write research proposal and report writing.

Course Content

Scientific Process and Research Process

Introduction, scientific methods, research: research motivation, objectives, methodology, method, and approaches, criteria of good research, types and significance of research, steps in research,

Research Problems and Design

Introduction to research problem and steps in its formulation, introduction to research design, criteria of a good research design, types of research design.

Variables, Measurement, and Scaling Technique and sampling design

Introduction, variable and types variables, measurement and levels of measurement, scaling technique and errors,design of experiments and its principles, sampling, types of sampling and selection of sampling technique.

Data Collection and its Analysis, Research Proposal and Research Report Writing

Introduction, literature review, methods of collection of primary and secondary data, instrumentation and computation, research proposal and research report writing.

Recommended Books

1. Sahu, P. K., Research Methodology: A guide for researchers in agricultural science, social science and other related fields, Springer New Delhi, (2013).
2. Kothari,C. R., Research Methodology: Method and techniques, New Age International Ltd. New Dehli, (2004).
3. Kumar, R., Research Methodology, A step-by-step guide for beginners, 3rd Ed. SAGE, New Dehli, (2011).
4. Marczyk, G., DeMatteo D. and Festinger, D., Essentials of research design and methodology, John Wiley & Sons, Inc.New Jersey, (2005).
5. Pruzan, P., Research Methodology: The aims, practices and ethics of science, Springer International Publishing, Switzerland, (2016).

CHEM– 623	Research Project-I	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VII

Specialization in Physical Chemistry

CHEM–628	Physical Chemistry-IV	Credit Hours: 3(3-0)

Course Objectives

Students will acquire knowledge and learning about crystalline solids and reaction dynamics.

Course Contents

Crystalline solids

Crystal lattice (crystal morphology, lattice and unit cells, the miller indices), crystal systems, symmetry of crystal, the line of symmetry, the axis of symmetry, the centre of symmetry, generation of x-ray, x-ray crystallography, Bragg's equation (Crystal, Debye and Scherrer method).

Reaction Dynamics

Correlation 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. Atkins, P. and Paula, J. D., Atkin's Physical Chemistry, 9thed., Oxford University Press, (2010).
2. Connors, K. A., Chemical Kinetics: The Study of Reaction Rates in Solution, VCH Publishers, Inc., (1990).
3. Espenson, J. H., Chemical Kinetics and Reaction Mechanism, 2nded., McGraw-Hill, London, (2002).
4. Houston, P. L., Chemical Kinetics and Reaction Dynamics, Dover Publications, (2006).
5. Levine, R., Molecular Reaction Dynamics, Cambridge University Press, (2005).
6. Silbey, R. J., Alberty, R. A. and Bawendi, M. G., Physical Chemistry, 4thed., John-Wiley & Sons, (2005).

CHEM–629	Physical Chemistry-V	Credit Hours: 3(3-0)

Course Objectives

Students will learn about the gel and emulsions, radiation chemistry and photochemistry.

Course Contents

Gels and Emulsions

Introduction, methods of preparation, emulsifiers, breaking of emulsions, orientation, theory, emulsification, wetting, and significance.

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 (Grothus-Draper law and Einstein's law), rates of intramolecular processes, chemical reactions and quantum yields with examples, energy transfer in photochemical reaction, kinetics and quantum yields of radiative and nonradiative process, fluorescence, phosphorescence, chemiluminescence, 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. Choppin, G., Liljenzin, J-O., Rydberg, J., Radiochemistry and Nuclear Chemistry, 3rd ed., Butterworth-Heinemann, (2002).
3. Mostafavi, M., Douki, T., Radiation Chemistry: From Basic to Applications in Material and Life Sciences, EDP Science, (2008).
4. Dunkin, I., Photochemistry, Vol. 36, RSC Publishing, (2007).
5. Scaglia, B., The Fundamentals: An Understanding of Photochemistry, Biblio Bazaar, (2011).
6. Konya, J. and Nagy, N. M., Nuclear and Radiochemistry, 1sted., Elsevier, (2012).

CHEM–630	Physical Chemistry-VI	Credit Hours: 3(3-0)

Course Objectives

In this course students will learn modern technique of spectroscopy including IR, NMR and Mass spectrometry.

Course Contents

Spectroscopy

Introduction theory of rotational, vibrational, electronic, and molecular systems, microwave spectroscopy, E.S.R. and E.P.R. spectra, microwave region, rotational line spectra, linear and asymmetric systems, selection rule, energy and angular momentum, magetic quantum numbers, summation method, term symbols, instrumentation, nuclear spin, zeeman effect, vibrational spectroscopy, vibrational spectra, morse curves, rotational fine structures, P branch, R branch and Q branch.

Infrared Spectroscopy

Introduction, theory of molecular vibration, factors influencing vibrational frequencies, sampling techniques, applications of infrared spectroscopy, identification by finger printing, identification of functional groups.

Nuclear Magnetic Resonance Spectroscopy

Introduction, nuclear spin states, nuclear magnetic moments, effect of external magnetic field, precessional motion and precessional frequency, energy transition, chemical environment and number of signal, chemical shift, internal standard, factors influencing chemical shift, correction data, choice of solvent, solvent shift, concentration and temperature effects, signal splitting, coupling, constant, ^{1}H-NMR, spectra of carbocation and^{13}C-NMR spectroscopy.

Mass Spectrometry

Introduction, experimental, source, analyser, detector, classification of mass analysers, resolution, sensitivity, valley definition, signal to noise ratio, electron impact phenomenon, application of mass spectrometer, ionization/acceleration, ion collection/amplifiers, magnetic field deflection, quadrupole mass spectrometer, double focusing, time of flight.

Recommended Books

1. Bahl, A., Bahl, B. S., Tuli, G. D., Essential of Physical Chemistry, S. Chand & Co. Ram Nagar, New Delhi, (2008).
2. Banwell, C. N., Fundamentals of Molecular spectroscopy, McFGaw Hill Co, India (1978).
3. Kemp, W., NMR in Chemistry: A Multinuclear Introduction, The Macmillan Press Ltd., (1992).
4. Silverstein, R. M., Terence, G. C. B. and Morrill, C., Spectrometric Identification of Organic Compounds, John Wiley and Sons Inc., (1991).

CHEM–631	Physical Chemistry Lab-I	Credit Hours: 1(0-1)

1. Determination of partial molar properties.
2. Determination of free energy changes, standard free energies.

3. Verification of Kohlrausch's law.
4. Study of temperature dependence of electrode potentials.
5. Determination of heat of solution, ionic reactions and other experiments from thermochemistry.
6. Determination of molecular weight of a polymer by viscosity method.
7. Measurement of cyclic voltammogram of an organic compound and its interpretation.
8. Determination of dipole moment of an organic liquid.
9. Determination of percentage composition of $KMnO_4$-$K_2Cr_2O_7$ in given solution by spectrometry.
10. Evaluation of pKa value of an indicator by spectrometric method.

Recommended Books

1. Garland, C. W., Shoemaker, D. P., and Nibler, J. W., Experiments in Physical Chemistry, 8th ed., McGraw-Hills, New York, (2003).
2. James, A. M., Prichard, F. E., Practical Physical Chemistry, 3rd ed., Prentice Hall Press, (1974).
3. Halpern, A., McBane, G., Experimental Physical Chemistry: A Laboratory Textbook, 3rd ed., W. H. Freeman, (2006).

CHEM–622	Research Methodology	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the basics of research, types of research, how to devise research experiments and it will enhance the students capabilities to write research proposal and report writing.

Course Contents

Scientific Processand Research Process

Introduction, scientific methods, research:research motivation, objectives, methodology, method, and approaches, criteria of good research, types and significance of research, steps in research.

Research Problems and Design

Introduction to research problem and steps in its formulation, introduction to research design, criteria of a good research design, types of research design.

Variables, Measurement, and Scaling Technique and sampling design

Introduction, variable and types variables, measurement and levels of measurement, scaling technique and errors,design of experiments and its principles, sampling, types of sampling and selection of sampling technique.

Data Collection and its Analysis, Research Proposal and Research Report Writing

Introduction, literature review, methods of collection of primary and secondary data, instrumentation and computation, research proposal and research report writing.

Recommended Books

1. Sahu, P. K., Research Methodology: A guide for researchers in agricultural science, social science and other related fields, Springer New Delhi, (2013).
2. Kothari,C. R., Research Methodology: Method and techniques, New Age International Ltd., New Dehli, (2004).

3. Kumar, R., Research Methodology, A step-by-step guide for beginners, 3rd Ed. SAGE, New Dehli, (2011).
4. Marczyk, G., DeMatteo D. and Festinger, D., Essentials of research design and methodology, John Wiley & Sons, Inc.New Jersey, (2005).
5. Pruzan, P., Research Methodology: The aims, practices and ethics of science, Springer International Publishing, Switzerland, (2016).

CHEM– 623	Research Project-I	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VII

Specialization in Analytical Chemistry

CHEM–632	Analytical Chemistry-IV	Credit Hours: 3(3-0)

Course Objectives

In this course, students will acquire knowledge about electro-analytical methods.

Course Contents

Electro-Analytical Methods

a) Potentiometry

Introduction, electrochemical cells, electrode potentials, liquid junction potential, ohmic potential, polarization, Nernst equation, standard hydrogen electrode, glass electrode, reference electrodes: calomel and silver-silver chloride electrode, indicator electrodes, solid-state electrode (fluoride electrode), potentiometric titrations.

b) Polarography

Introduction, dropping mercury electrode (DME), polarogram, diffusion current, residual current, half wave potential, limitations, differential pulse polarography, analytical applications.

c) Amperometry

Introduction and amperometric titrations.

d) Conductometry

Introduction, definition, units, theory, instrumentation, conductometric titrations and analytical applications.

e) Electrogravimetry

Introduction, Current voltage relationship during electrolysis: Decomposition potential, electrolysis at controlled / fixed potential, constant-current electrolysis, constant cathode potential electrolysis, physical properties of electrolytic precipitate, chemical factors of importance in electrode deposition.

CHEM–633	Analytical Chemistry-V	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the basic concepts of spectroscopy including UV-VIS, IR and X-ray spectroscopy and their analytical applications.

Course Contents

Spectroscopic Methods of Analysis

Introduction: Nature of electromagnetic radiation as waves (general nature, diffraction, dispersion, refraction, reflection, scattering, polarization), quantum mechanical properties (photoelectric effect, absorption and

emission of radiation by atoms and molecules) and electromagnetic spectrum, Beer's and Lambert laws, deviations from Beer's law.

a) **UV-Visible Spectroscopy**

Introduction: Electronic excitation, absorption by molecules, effect of solution on absorption wavelength (bathochromic and hypsochromic shift), interpretation of UV spectra, instrumentation (single and double beam spectrophotometers) and applications.

b) **Infra-red Spectroscopy**

Introduction: Theory of IR, types of vibration, intensity of absorption bands, theoretical group frequencies and factor effecting of absorption bands, group frequencies, instrumentation and applications.

c) **X-ray Spectroscopy**

Introduction, detail studies of emission, X-ray absorption, diffraction and fluorescence methods, instrumentation and applications.

CHEM–634	Analytical Chemistry-VI	Credit Hours: 3(3-0)

Course Objectives

In this course, students will learn about the automated, thermal methods of analysis and their analytical applications.

Course Contents

Automated Methods of Analysis

Principles of automation, automated instruments: Processes control with special clinical and environmental aspects, semiautomatic instruments, auto analyser, centrifugal analyser, computers in analytical chemistry and flow injection analysis.

Thermal Methods of Analysis

General characteristics of thermal analysis, thermo-gravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermometric titrations (TT & DIE) and applications.

CHEM–635	Analytical Chemistry Lab-I	Credit Hours: 1(0-1)

1. Determination of absorption curve and concentration of potassium nitrate by spectrophotometry.
2. Determination of copper(II) by spectrophotometric titration with EDTA (sodium salt) solution.
3. Determination of unknown concentration of $KMnO_4$ in the given sample by spectrophotometry.
4. Determination of λ_{max} of *p*-nitrophenol by spectrophotometry and draw calibration graph.
5. Determination of calcium and magnesium by spectrophotometry.
6. Determination of iron(III) by spectrophotometric titration with EDTA solution.
7. Determination of the pH of various solutions.
8. Potentiometric titration of strong acid with strong base.
9. Potentiometric titration of weak acid with weak base.
10. Potentiometric analysis of fluoride in tap water using a fluoride ion-selective electrode.
11. Amperometric titration of lead and dichromate.
12. Conductometric titration of strong acid with strong base.

Recommended Books

1. Christian, G. D., Analytical chemistry, 6th and 7th ed., John Wiley & Sons, New York, (2004 & 2013).
2. Christian, G. D., Analytical Chemistry, Student Solutions Manual, 6th ed., Publisher: Wiley, (2004).
3. Christian G. D. and O'Reilley, J. E., Instrumental analysis, 2nd ed., Allyn and Bacon, Boston, (1986).
4. Skoog, D. A., West, D. M., Holler, F. J. and Crouch, S. R., Fundamentals of analytical chemistry, 8th ed., Thomson Brooks/Cole, USA, (2004).
5. Skoog, D. A., Holler, F. J. and Nieman, T. A., Principles of instrumental analysis, 5th ed., Saunders College Publishing, New York, (1997).
6. Skoog, D. A., Holler, F. J., and Crouch, S. R., Principles of instrumental analysis, 6th ed., Thomson, USA, (2007).
7. Harris, D. C., Quantitative chemical analysis, 7th ed., Freeman, New York, (2007).
8. Day, R. A. and Underwood, A. L., Quantitative analysis, 6th ed., Prentice Hall Inc., (2004).
9. Harvey, D., Modern analytical chemistry, McGraw-Hill Companies, Inc. New York, (2000).
10. Bard, A. J. and Faulkner, L. R., Electrochemical methods, fundamentals and applications, 2nd ed., John Wiley & Sons, New York, (2001).
11. Ewing, G. W., Instrumental methods of chemical analysis, 5th ed., McGraw Hill, New York, (1985).
12. Willard, H., Merritt, L., Dean, J. and Settle, F., Instrumental methods of analysis, 7th ed., vanNostrand Co., New York, (1992).
13. Ingle, J. D. and Crouch, S. R., Spectro-chemical methods of analysis, Prentice Hall, New Jersey, (1988).
14. Ruzicka, J. and Hansen, E. H., Flow injection analysis, 2nd ed., John Wiley & Sons, New York, (1988).
15. Trojanowicz, M., Advances in flow analysis, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, (2008).
16. Robinson, J. W., Frame, E. M. S. and Frame, G. M. II, Undergraduate Instrumental Analysis, 6th ed., Marcel Dekker, New York, (2005).
17. Plummer, D. T., An introduction to practical biochemistry, 3rd ed., Tata, McGraw Hill, New Delhi, India, (1988).
18. Thomspon, K. C. and Reynold, R. J., Atomic absorption, fluorescence and flame emission spectroscopy, 2nd ed., John Wiley & Sons, New York, (1978).
19. Ebdon, L., Evans, E. H., Fisher, A. and Hill, S. J., An introduction to analytical atomic spectroscopy, John Wiley & Sons, New York, (1998).
20. Jenkins, R., Gould, R. W. and Gedcke, D., Quantitative X-ray spectrometry: Practical spectroscopy, 2nd ed., Marcel-Dekker, New York, (1995).
21. Braithwaite A. and Smith, F. J., Chromatographic methods, 4th ed., Chapman and Hall, New York, (1985).
22. Miller J. C. and Miller, J. N., Statistics and chemometrics for analytical chemistry, 5th ed., Prentice Hall, New York, (2005.
23. Mendham, J., Vogel's text book of quantitative analysis, 6th ed., AdisonWisley Publishers, (2004).
24. Campana, A. M. G. and Baeyens, W. R. G., Chemiluminescence in Analytical Chemistry, Marcel Dekker, New York, (2001).

CHEM–622	Research Methodology	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the basics of research, types of research, how to devise research experiments and it will enhance the students capabilities to write research proposal and report writing.

Course Content

Scientific Processand Research Process

Introduction, scientific methods, research:research motivation, objectives, methodology, method, and approaches, criteria of good research, types and significance of research, steps in research.

Research Problems and Design

Introduction to research problem and steps in its formulation, introduction to research design, criteria of a good research design, types of research design.

Variables, Measurement, and Scaling Technique and sampling design

Introduction, variable and types variables, measurement and levels of measurement, scaling technique and errors,design of experiments and its principles, sampling, types of sampling and selection of sampling technique.

Data Collection and its Analysis, Research Proposal and Research Report Writing

Introduction, literature review, methods of collection of primary and secondary data, instrumentation and computation, research proposal and research report writing.

Recommended Books

1. Sahu, P. K., Research Methodology: A guide for researchers in agricultural science, social science and other related fields, Springer New Delhi, (2013).
2. Kothari,C. R., Research Methodology: Method and techniques, New Age International Ltd. New Dehli, (2004).
3. Kumar, R., Research Methodology, A step-by-step guide for beginners, 3rd Ed. SAGE, New Dehli, (2011).
4. Marczyk, G., DeMatteo D. and Festinger, D., Essentials of research design and methodology, John Wiley & Sons, Inc.New Jersey, (2005).
5. Pruzan, P., Research Methodology: The aims, practices and ethics of science, Springer International Publishing, Switzerland, (2016).

CHEM– 623	Research Project-I	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VII

Specialization in Biochemistry

CHEM–636	Biochemistry-IV	Credit Hours: 3(3–0)

Course Objectives

In this course, students will acquire knowledge about physiological chemistry, endocrinology and composition and functions of the blood.

Course Contents

Physiological Chemistry

Structure and functions of specialized tissues and organ of the body including elementary canal, liver, gallbladder, muscle and its construction, Kidney, heart and blood circulation.

Endocrinology

A discussion of the chemistry, synthesis and biological functions of gonadal, adrenal, thyroid, parathyroid hormones, outlines of steroid hormones action at biochemical level.

Blood

General composition and functions of blood, blood plasma, plasma proteins, red blood cells, haemoglobin, white blood cells, platelets, biomedical importance of blood cells, mechanisms of blood coagulation, blood pressure,hypertension, hypotension, factors affecting blood pressure.

CHEM–637	Biochemistry-V	Credit Hours: 3(3–0)

Course Objectives

In this course students will get knowledge about the regulation and metabolism of carbohydrates, lipids and chemistry of glycoconjugates.

Course Contents

Regulation of Carbohydrates Metabolism

General principles of regulation of metabolic pathways and metabolic control of an enzyme catalyzed reaction, regulation of (Glycolysis, Citric acid cycle, Gluconeogenesis), regulation of blood glucose, diabetes mellitus and its types, hyperglycemia and hypoglycemia.

Regulation of Lipids Metabolism

Regulation of β-oxidation of fatty acids, ketogenesis, fatty acids biosynthesis, and cholesterol biosynthesis.

Glycoconjugates

Introduction of glycoproteins, classification of glycoproteins (o-linked glycoproteins, N-linked glycoproteins), proteoglycans and glycosaminoglycans, blood group antigens, enzymatic degradation of glycoproteins, biosynthesis of glycoproteins.

CHEM–638	Biochemistry-VI	Credit Hours: 3(3–0)

Course Objectives

In this course, students will learn about the molecular biology and use of UV-VIS spectroscopy in biochemistry for the analysis of biochemically important analytes.

Course Contents

Molecular biology

Nucleic acids structure, introduction to DNA as genetic material, eukaryotic chromosomes, mutation, process of replication, transcription, translation, regulation of gene expression and operon model.

Spectroscopy

Spectroscopy in biochemistry, Interaction of radiation with matter, region of spectrum, introduction to ultraviolet & visible spectroscopy, Beer and Lambert's law, spectrophotometer, applications of spectrophotometer in biochemistry.

CHEM–639	Biochemistry Lab-I	Credit Hours: 1(0–1)

1. Identification of the unknown sample of sugar / amino acid by thin layer chromatography.
2. Identification of the unknown sample of amino acid by paper chromatography.
3. Determination of concentration of given protein samples by spectrophotometer.
4. Determination of concentration of Na^+ and K^+ in a given sample by flame photometer.
5. Analysis of organic and inorganic constituents of blood.

Recommended Books

1. Hall J. E. and Guyton, A. C., Textbook of Medical Physiology, 13th ed., Elsevier, (2015).
2. Ganong, W. F., Review of medical physiology, 21st ed., McGraw-Hill Professional, (2003).
3. Rodwell, V., Bander, D. and Bothman, K. M., Harper's Illustrated Biochemistry, 30th ed., Robert K. Murray, (2015).
4. Smith, E. L., Hill, R. L., Lehman, I. R., and White, A., Principles of Biochemistry, 7th ed., McGraw-Hill Publishing Company Ltd., (1983).
5. Robinson, K. and Robinson, J. F., Contemporary Instrumental Analysis, Prentice Hall, (2000).
6. Settle, F. A., Handbook of Instrumental Techniques for Analytical Chemistry, Prentice Hall, (1997).
7. Skoog, D. A., Fundamental of Analytical Chemistry, Prentice Hall, (1997).
8. Ewing, G. W., Instrumental Methods of Chemical Analysis, McGraw Hill, (1988).
9. Alper, N. L., Keiser, W. E. and Szymanski, H. A., IR Theory and Practice of Infrared Spectroscopy, 2nd ed., Plenum Press, New York, (1964).
10. Nakanishi, K., Infrared Absorption Spectroscopy, Holden-Day Inc., San Francisco, (1977).
11. Lehninger, A. L., Nelson, D. L. and Cox, M. M., Principles of Biochemistry, 6th ed., Worth Publishers, New York, (2012).
12. Voet, D., Voet, J. G. and Pratt, C.W., Biochemistry, 30th ed., John Wiley & Sons, New York, (2012).

13. Glick, B. R. and Pasternak, J. J., Molecular Biotechnology: Principles and applications, 3rd ed., AS M Press, (2003).
14. Sperelakis, N., Cell Physiology: A molecular approach, 3rd ed., Academic Press, (2001).
15. Lodish, H., Berk, A. and Zipursky, S., Molecular Cell Biology, 4th ed., W.H. Freeman, (2000).
16. Karp, G., Cell and Molecular Biology, 3rd ed., John Wiley & Sons, (2002).
17. Manahan, S. E., Environmental Chemistry, 9th ed., CRC Press, New York, (2010).
18. Neil, P. O., Environmental Chemistry, 2nd ed., Chapman & Hall, New York, (1993).
19. De, A. K., Environmental Chemistry, 4th ed., Wiley Eastern Ltd., New Delhi, (1996).
20. VanLoon G. W., and Duffy, S. J., Environmental Chemistry, A global perspectives, 3rd ed., Oxford University Press, (2011).
21. Dara, S., Textbook of Environmental Chemistry and Pollution Control, 7th ed., S Chand & Co Ltd., (2004).
22. Yen, T. F., Environmental Chemistry, Prentice Hall, (1999).
23. Baird C. and Cann, M., Environmental Chemistry, 5th ed., W.H. Freeman, New York, (2012).
24. Elsom, D. M., Atmospheric Pollution, 2nd ed., Blackwell Publishers, Oxford, (1992).
25. Connell, D. W., Basic Concepts of Environmental Chemistry, 2nd ed., CRC Press, (2005).
26. Lean, G., Hinrichsen, D. and Markham, A., Atlas of the Environment, Helicon Publishing Ltd. Oxford, (1992).
27. Sahu, P. K., Research Methodology: A guide for researchers in agricultural science, social science and other related fields, Springer New Delhi, (2013).
28. Kothari, C. R., Research Methodology: Method and techniques, New Age International Ltd. New Dehli, (2004).
29. Kumar, R., Research Methodology, A step-by-step guide for beginners, 3rd ed., SAGE, New Dehli, (2011).
30. Marczyk, G., DeMatteo, D. and Festinger, D., Essentials of Research Design and Methodology, John Wiley & Sons, Inc., New Jersey, (2005).
31. Pruzan, P., Research Methodology: The aims, practices and ethics of science, Springer International Publishing, Switzerland, (2016).

CHEM–622	Research Methodology	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the basics of research, types of research, how to devise research experiments and it will enhance the students capabilities to write research proposal and report writing.

Course Content

Scientific Processand Research Process

Introduction, scientific methods, research:research motivation, objectives, methodology, method, and approaches, criteria of good research, types and significance of research, steps in research.

Research Problems and Design

Introduction to research problem and steps in its formulation, introduction to research design, criteria of a good research design, types of research design.

Variables, Measurement, and Scaling Technique and sampling design

Introduction, variable and types variables, measurement and levels of measurement, scaling technique and errors,design of experiments and its principles, sampling, types of sampling and selection of sampling technique.

Data Collection and its Analysis, Research Proposal and Research Report Writing

Introduction, literature review, methods of collection of primary and secondary data, instrumentation and computation, research proposal and research report writing.

Recommended Books

1. Sahu, P. K., Research Methodology: A guide for researchers in agricultural science, social science and other related fields, Springer New Delhi, (2013).
2. Kothari, C. R., Research Methodology: Method and techniques, New Age International Ltd. New Dehli, (2004).
3. Kumar, R., Research Methodology, A step-by-step guide for beginners, 3rd ed., SAGE, New Dehli, (2011).
4. Marczyk, G., DeMatteo D. and Festinger, D., Essentials of research design and methodology, John Wiley & Sons, Inc. New Jersey, (2005).
5. Pruzan, P., Research Methodology: The aims, practices and ethics of science, Springer International Publishing, Switzerland, (2016).

CHEM– 623	Research Project-I	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VIII

Specialization in Inorganic Chemistry

CHEM–640	Inorganic Chemistry-VII	Credit Hours: 3(3-0)

Course Objectives

In this course students will learn about organometallic compounds, zero group elements and reactions in aqueous and non-aqueous solvents.

Course Contents

Organometallic Compounds

Introduction, classification and preparation of organometallic compounds of transition metals, their derivatives of different donors from 1 electron to 8 electron donors with examples, 18-electron rule, preparation, properties and uses of simple organozinc, organocopper and organoiron compounds.

Zero Group Elements

Introduction and general properties of the group, chemical and physical properties, occurance, isolation of noble gases by chemical methods, recovery of radon, possibility of compounds of noble gases, Xe compounds, clathrate compounds of noble gases, structure of compounds based upon theories, uses.

Reactions in Aqueous and Non-aqueous Solvents

Classification of solvents, types of reactions, the dielectric constant, solubilities, electrode potential and electromotive forces, reactions in water and molten salts, reaction in non-aqueous solvents, i.e., ammonia, sulphur dioxide, bromine trifluoride and hydrofluoric acid.

Recommended Books

1. Satya, P., Advanced Inorganic Chemistry, Vol 1, S. Chand Ltd., (2000).
2. Cotton, F. A. and Wilkinson, G., Advanced Inorganic Chemistry, 3rd ed., Interscience, New York, (1972).
3. Claydem, J., Greeves N. and Warren, S., Organic Chemistry, 2nd ed., Oxford University Press, (2012).
4. Coxon, J. M. and Norman, R. O. C., Principles of Organic Synthesis, 3rd ed., CRC Press, (1993).
5. Joule, J. A. and Mills, K., Heterocyclic Chemistry, 5th ed., John Wiley & Sons, UK, (2010).
6. Crabtree, R. H., The Organometallic Chemistry of the Transition Metals, 5th ed., John Wiley & Sons, New Jersey, (2009).

CHEM–641	Inorganic Chemistry-VIII	Credit Hours: 3(3-0)

Course Objectives

The students will learn about the metallurgy, periodic anomalies, chemistry of oxides and nuclear chemistry.

Course Contents

Metallurgy

Introduction to ores, minerals and metallurgy, ores of copper and irons, principles of metallurgical operations, metallurgy of iron, steel, copper and aluminium, purification of metals.

Periodic Anomalies and Bonding in Electron deficient Compounds

First and second- row anomalies, the use of d-orbitals by non-metals, reactivity and d-orbital participation, pπ – dπ bonds, the use of p-orbitals in π-bonding, periodic anomalies of non-metals and post-transition metals,multicenter bonding in electron deficient molecules, three centre two electron bond (3c–2e) and three-center, four-electron (3c–4e) bond model.

Chemistry of Oxide

Physical state and structure of oxide of the elements, covalent oxide, periodic trend in structure and physical state, acidity, solubility, practical uses, environmental chemistry of volatile oxide, closed packed anions, metal oxides, electrical conductivity of solid ionic compound, spinels, perovskites, high temperature superconductor and magnetic properties in mixed metal oxides.

Nuclear Chemistry

Introduction, theory of disintegrations, positive ray analysis, mass spectrograph, structure of the nucleus, half-life nuclear binding energy, artificial disintegration, fission and fusion reactions, accelerators of charged particles, applications of radio isotopes.

Recommended Books

1. Cotton, F. A. and Wilkinson, G., Advanced Inorganic Chemistry, 6th ed., Interscience, Publishers, London, (2001).
2. Kettle, S. F. A., Coordination Compounds, Nelson, (Nauohi Kenya), (1999).
3. Addison, A. W. and Cullen, W. R., Biological Aspect of Inorganic Chemistry, Krieger Pub Company, (1977).
4. Huheey, J. H., Inorganic Chemistry: Principles, Structure and Reactivity, Harper & Row Publisher Inc., New York, (2008).

CHEM–642	Inorganic Chemistry-IX	Credit Hours: 3(3-0)

Course Objectives

In this course students will learn about inorganic chemistry in biological systems and chemistry of inorganic polymers.

Course Contents

Inorganic Chemistry in Biological Systems

Development and importance of bio-inorganic chemistry, introduction to metals of biological importance, role of different metals in biological system, metal deficiencies and metal overload in biological system, metalloproteins, transferrin and ferritin, iron sulphur proteins, iron transport mechanism, protein peptides, metallo-enzymes and metal activated enzymes, carbonic anhydrase, carboxy peptidase, alkaline phosphatase, chlorine and porphyrin metal complexes, cytochrome, myoglobin and haemoglobin, haemocyanin, vitamin B12, oxygen carrier, nitrogen fixation, chelation therapy and metallotherapy, photosynthesis.

Inorganic Polymers

Introduction to homoatomic and heteroatomic inorganic polymers, chains and cages of boron,silicon, nitrogen, phosphorus and sulphur, synthesis and applications, polyionic species, isopoly and heteropoly, anions of transition metals, silicates, borates, condensed phosphates and zeolites, introduction to inorganic materials, crystalline and amorphous states, bonding in solids, non-stoichiometric compounds, binary solid solutions, mechanical, electrical, megnatic, 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.

Recommended Books

1. Cotton, F. A. and Wilkinson, G., Advanced Inorganic Chemistry, 6th ed., Interscience, Publishers, London, (2001).
2. Christian, G. D., Analytical Chemistry, 6th ed., John Wiley & Sons, New York, (2006).
3. Anil, K., A textbook of Inorganic Chemistry, John Wiley, New Delhi, (2004).
4. Addison, A. W. and Cullen, W. R., Biological Aspect of Inorganic Chemistry, Krieger Pub Company, (1977).
5. Zafar, I., Pi-acceptor ligands, University Grants Commission, Islamabad, (1993).
6. Huheey, J. H., Inorganic Chemistry: Principles, Structure and Reactivity, Harper & Row Publisher Inc., New York, (2008).
7. Younas, M., Organic Spectroscopy and Chromatography, Ilmi Kotab Khana, Lahore, Pakistan, (2007).
8. Bertini, I., Gray, H. B., Stiefel, E. I. and Valentine, J. S., Biological Inorganic Chemistry: Stracture and reactivity, University Science Books, California, (2007).

CHEM–643	Inorganic Chemistry Lab-II	Credit Hours: 1(0-1)

Course Contents

1. Synthesis of ferrocene and acetyl ferrocene.
2. Synthesis of triarylphosphines.
3. Reduction of anisoñe by lithium-Brich-reduction.
4. Preparation of zinc-porphyrin complexes.
5. Synthesis of zinc-phthalocyanine.
6. Synthesis of coordination polymers of transition metals.

Recommended Books

1. J. Bassett, R. C. Denny, G. H. Jeffery and J. Mendham, Vogel´s Textbook of Qualitative Inorganic Analysis, the English Language Book Society and Longman, New York (2008).
2. J. S. Pritz, G. H. Schenk, Quantitative Analysis Chemistry, Alby and Becon Inc. London (2001).
3. J. T. McNeese and K. A. Ezbiansky, Photochemical preparation and reactivity of *cis*-$Cr(CO)_4(CH_3CN)_2$, J. Chem. Edu., 73, 548-550 (1996).
4. G. O. Spessard and G. L. Miessler, Organometallic Chemistry, Upper Saddle River, New Jersey, Prentice Hall (1996).

CHEM– 644	Environmental Chemistry–II	Credit Hours: 3(0-3)

Course Objectives

This course of advanced Environmental Chemistry will provide knowledge about the environment and toxicological chemistry of chemical substances.

Course Contents

Introduction

Biotic and abiotic factors, concept of eco systems, atmosphere (composition, temperature, pressure, air pollutants, greenhouse effect and global warming, ozone and ozone depletion, CFCs, acid rain, photochemical smog, vehicular and industrial emissions and role of hydroxyl radicals), water (properties, water quality, eutrophication water pollution and water treatment), land (composition, pH, soil erosion and soil pollutants).

Toxicological Chemistry of Chemical Substances

Toxic elements and elemental forms, toxic inorganic and organic compounds, environmental chemical analysis, classical methods vs instrumental methods, analysis of water samples, air monitoring and analysis.

Green Revolution

Pest control, pesticides, toxicity of pesticides, integrated pests management.

Renewable Energy

Nuclear energy, solar energy, geothermal and tidal energy.

Recommended Books

1. Manahan, S. E., Environmental Chemistry, 9th ed., CRC Press, New York, (2010).
2. Neil, P. O., Environmental Chemistry, 2nd ed., Chapman & Hall, New York, (1993).
3. De, A. K., Environmental Chemistry, 4th ed., Wiley Eastern Ltd., New Delhi, (1996).
4. vanLoon G. W. and Duffy, S. J., Environmental Chemistry, A global perspectives, 3rd ed., Oxford University Press, (2011).
5. Dara, S., Textbook of Environmental Chemistry and Pollution Control, 7th ed., S Chand & Co Ltd. (2004).
6. Yen, T. F., Environmental Chemistry, Prentice Hall, (1999).
7. Buell, P. and Girard, J., Chemistry, an environmental perspective, Prentice Hall, (1994).
8. Baird C. and Cann, M., Environmental Chemistry, 5th ed., W.H. Freeman, New York, (2012).
9. Connell, D. W., Basic Concepts of Environmental Chemistry, 2nd ed., CRC Press, (2005).

CHEM– 645	Research Project–II	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VIII

Specialization in Organic Chemistry

CHEM–646	Organic Chemistry-VII	Credit Hours: 3(3-0)

Course Objectives

Students will acquire knowledge about oxidation- reduction, rearrangement and pericyclic reactions.

Course Content

Oxidation – Reduction Reactions

Introduction of organic oxidation and reduction reactions, common oxidizing and reducing reagents, general mechanism and application of oxidation involving: Elimination of hydrogen, cleavage of C-C bond, replacement of hydrogen by oxygen and addition of oxygen to substrates.

General mechanism and applications of reductions involving: replacement of oxygen by hydrogen, removal of oxygen from the substrate and reduction with cleavage.

Molecular Rearrangement

Mechanism and applications of following rearrangements: Arndt-Eistert, Beckman, Benzidine, Benzilic acid, Curtius, Fries, Hoffman, Schmidt, Pinacol-Pinacolone, Wagner and Witting rearrangements.

Pericyclic Reactions

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

Recommended Books

1. Carey, F. A. and Sundberg R. J., Advanced Organic Chemistry: Part A Structure and Mechanism, 4th ed., Kluwer Academic/Plenum Publishers, New York, USA, (2000).
2. Tse-Lok, H., Symmetry: A Basis for Synthesis Design, John-Willey & Sons, Inc., New York, (1995).
3. Jones, M. A., and Fleming S. A., Organic Chemistry, 5th ed., W.W. Norton & Company, Inc., New York, USA, (2014).
4. Loudon, G. M.,Organic chemistry, 6thed.,W. H. Freeman and Company, New York, USA, (2016).
5. Solomons, T. W. G. and Fryhle, C. B., Organic Chemistry, 10th ed., John- Wiley & Sons, Inc., (2011).
6. Carey, F. A. and Giuliano, R. M., Organic Chemistry, 9th ed., McGraw-Hill Education, (2013).
7. Bruice, P. Y., Organic Chemistry, 7th ed., Perason Education, Ltd., (2013).
8. Smith, M. B., March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th ed., John-Wiley & Sons, Inc., (2013)

CHEM–647	Organic Chemistry-VIII	Credit Hours: 3(3-0)

Course Objectives

Students will acquire knowledge about chemistry heterocyclic and organometallic compounds and chemistry of polymers.

Course Content

Heterocycles

Introduction, classification and nomenclature of heterocycles; Introduction, structure, physical and chemical properties (electrophilic and nucleophilic substitution) and synthetic methods of pyrrole, furan, thiophene, pyridine and quinoline.

Organometallic Compounds

Introduction, preparation, reactions and synthetic applications and of organomagnesium compounds, limitation of organomagnesium compounds to carbonyl compounds, organozinc, organomercury, organosodium and organolithium compounds.

Polymer Chemistry

Introduction and scope of polymers, classification and general methods for the preparation of polymers, polymerization techniques, polymer structure.

Recommended Books

1. Clayden, 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).
5. Loudon, G. M.,Organic chemistry, 6thed.,W. H. Freeman and Company, New York, USA, (2016).
6. Jones, M. A., and Fleming S. A., Organic Chemistry, 5th ed., W.W. Norton & Company, Inc., New York, USA, (2014).

CHEM–648	Organic Chemistry-IX	Credit Hours: 3(3-0)

Course Objectives

Students will acquire knowledge and understanding to major organic reactions, retro-synthesis and synthetic strategies.

Course Content

Major Organic Reactions

Mechanism and scope of the following named organic reactions:Stobe condensation, Perkin, Cannizaro, Claisen-Schmidt reaction, Mannich, Claisen, Wittig, Michael, Diels-Alder, Knoevenagel and Reformatsky reaction.

Retro-synthesis

Introduction to retero-synthesis,retro-synthetic analysis, functional group inter-conversion(FG1), C – C, C – N and C – O bond formation, applications to the synthesis of various target molecules and difunctionalized compounds.

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, 2nded., John-Wiley & Sons, Inc., (2010).
2. Fox, M. A. and Whitsell, J. K., Organic Chemistry, 3rded., Jones & Bartlett Publishers (1997).
3. Clayden, J., Greeves, N., and Warren, S., Organic Chemistry, 2nded., Oxford University Press, New York, (2012).
4. Loudon, G. M.,Organic chemistry, 6thed.,W. H. Freeman and Company, New York, USA, (2016).
5. Smith, J. G., Organic Chemistry, 3rded., McGraw-Hill, (2010).
6. Norman, R. O. C. and Coxon, J. M., Principles of Organic Synthesis, 3rded., CRC Press, (1993).
7. Jones, M. A., and Fleming S. A., Organic Chemistry, 5th ed., W.W. Norton & Company, Inc., New York, USA, (2014).

CHEM-649	Organic Chemistry Lab-II	Credit Hours: 1(0-1)

Experiments involving multi-step synthesis (any three).

Determination of functional groups in alcohols, acids, aldehydes, ketones, esters, amides, amine, etc. by using FTIR spectrophotometer.

Recommended Books

1. 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).
2. Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., A Microscale Approach to Organic Laboratory Techniques, 5th ed., Brooks/ ColeCengage Learning, (2013).
3. 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).
4. Gilbert, J. C. and Martin, S. F., Experimental Organic Chemistry: A Miniscale and Microscale Approach, 5thed., Brooks/ Cole Cengage Learning, (2010).

CHEM– 644	Environmental Chemistry–II	Credit Hours: 3(0-3)

Course Objectives

This course of advanced environmental chemistry will provide knowledge about the environment and toxicological chemistry of chemical substances.

Course Contents

Introduction

Biotic and abiotic factors, concept of eco systems, atmosphere (composition, temperature, pressure, air pollutants, greenhouse effect and global warming, ozone and ozone depletion, CFCs, acid rain, photochemical smog, vehicular and industrial emissions and role of hydroxyl radicals), water (properties, water quality, eutrophication water pollution and water treatment), land (composition, pH, soil erosion and soil pollutants).

Toxicological Chemistry of Chemical Substances

Toxic elements and elemental forms, toxic inorganic and organic compounds, environmental chemical analysis, classical methods vs instrumental methods, analysis of water samples, air monitoring and analysis.

Green Revolution

Pest control, pesticides, toxicity of pesticides, integrated pests management.

Renewable Energy

Nuclear energy, solar energy, geothermal and tidal energy.

Recommended Books

1. Manahan, S. E., Environmental Chemistry, 9th ed., CRC Press, New York, (2010).
2. Neil, P. O., Environmental Chemistry, 2nd ed., Chapman & Hall, New York, (1993).
3. De, A. K., Environmental Chemistry, 4th ed., Wiley Eastern Ltd., New Delhi, (1996).
4. vanLoon G. W. and Duffy, S. J., Environmental Chemistry, A global perspectives, 3rd ed., Oxford University Press, (2011).
5. Dara, S., Textbook of Environmental Chemistry and Pollution Control, 7th ed., S Chand & Co Ltd. (2004).
6. Yen, T. F., Environmental Chemistry, Prentice Hall, (1999).
7. Buell, P. and Girard, J., Chemistry, an environmental perspective, Prentice Hall, (1994).
8. Baird C. and Cann, M., Environmental Chemistry, 5th ed., W.H. Freeman, New York, (2012).
9. Connell, D. W., Basic Concepts of Environmental Chemistry, 2nd ed., CRC Press, (2005).

CHEM– 645	Research Project–II	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VIII

Specialization in Physical Chemistry

CHEM– 650	Physical Chemistry-VII	Credit Hours: 3(3-0)

Course Objectives

In this paper student will learn about macromolecules and their polymerization.

Course Contents

Macromolecules

Polymerization in homogenous and heterogeneous phases - kinetics of polymerization (ionic and addition), kinetics of copolymerization, mechanism of polymerization, chain initiation, propagation, termination-transfer-inhibition and retardation-properties of polymers, semi permeable membranes, the cause of semi-permeability, mechanism of osmotic pressure, dilute solutions and the gas laws, the bombardment theory, objections to the bombardment theory, review of the theories, determination of the molecular weight by osmometry (polymers-Mw, Mn), light scattering, viscosity, ultra centrifuge-gel permeation chromatography-crystallinity of polymers-glass transition temperature-polymer technology moulding, extrusion and calendering.

Recommended Books

1. Bahl, A., Bahl, B. S., and Tuli, G. D., Essentials of Organic Chemistry, S. Chand & Co. Ram Nagar, New Delhi, (2008).
2. Cox, P. A., Introduction to Quantum Theory and Atomic Structure,Oxford University Press, Oxford, (1996).
3. Hunter, R. J., Introduction to Modern Colloid Science, Oxford University Press, Oxford, (1994).
4. Klabunde, K. J., Nano scale Materials in Chemistry, John-Wiley & Sons, Inc., (2003).
5. Kolunsiki, K. W., Surface Science: Foundations of Catalysis and Nano science, 3rd ed., John-Wiley & Sons, Ltd., (2012).
6. Poole, C. P. and Owens, F. J., Introduction to Nanotechnology, 1st ed., Wiley-Interscience, (2003).

CHEM– 651	Physical Chemistry-VIII	Credit Hours: 3(3-0)

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 and surface chemistry.

Course Contents

Colloid and Surface Chemistry

Colloidal solutions, catalyst preparation methods, industrial catalysts, emulsion, surfactant, petroleum, catalysis in atmospheric pollution control nano-scale 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, physisorption, chemisorption, types of adsorption therms, adsorption on covalent

and ionic solids, adsorbed state of molecules, potential energy curves for adsorption, measurement of heat of adsorption and chemisorptions, adsorption equations (Gibbs, Langmuir, Freundlich, BET, Temkin and Flower), 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. Bahl, A., Bahl, B. S., and Tuli, G. D., Essentials of Organic Chemistry, S. Chand & Co. Ram Nagar, New Delhi, (2008).
2. Hunter, R. J., Introduction to Modern Colloid Science, Oxford University Press, Oxford, (1994).
3. Poole, C. P. and Owens, F. J., Introduction to Nanotechnology, 1st ed., Wiley-Interscience, (2003).
4. Klabunde, K. J., Nano scale Materials in Chemistry, John-Wiley & Sons, Inc., (2003).
5. Kolunsiki, K. W., Surface Science: Foundations of Catalysis and Nano science, 3rd ed., John-Wiley & Sons, Ltd., (2012).
6. Adamson, A. W. and Gast, A. P., Physical Chemistry of Surfaces, 6th ed., Wiley-Interscience, (1997).

CHEM– 652	Physical Chemistry-IX	Credit Hours: 3(3-0)

Course Objectives

In this course students will learn some advance approach of statistical mechanics, thermodynamics, surface chemistry and chemical kinetics.

Course Contents

Statistical Mechanics, Thermodynamics and Solution Thermodynamics

Statistical distribution permutations, probability, distribution of molecules in energy states, most probable distribution, partition function factorisability of partition functions, transnational, vibrational, rotational, electronic and nuclear partition functions, statistical thermodynamics, the statistical formulation of the functions of thermodynamics, work, heat, enthalpy, heat capacity, entropy and free energy, the equilibrium constant, some applications of statistical thermodynamics, the entropy of mixing ortho and para hydrogen, the entropy of hydrogen, the heat capacity of gases, the heat capacity of solids, solution thermodynamics, Roult's law, heat of mixing, solubility of solid and gases, Henry's law, colligative properties of solutions, activities and activity co-efficient and their measurement, statistical mechanics of non-ideal solutions.

Surface Chemistry and Advanced Chemical Kinetics

Surface chemistry different forms of adsorption isotherms, gas adsorption, Henry's equation, gibbs adsorption equation and its applications, change in free energy in adsorption, energy of adsorption, hydrogen bond in adsorption, adsorption from solutions on the surface of solids, influence of chemical nature of surface, dimension of adsorbent pores, temperature, solubility and properties on solutions of adsorption from solutions, advanced chemical kinetics, a review of common experimental methods and treatment of kinetic data, temperature dependence of the rates of reactions, opposing reactions, consecutive reactions, parallel reactions, chain reactions, different theories for finding reactionary rates (collision and transition state theories) and their comparison, primary salt effect in ionic reactions.

Recommended Books

1. Bahl, A., Bahl, B. S., and Tuli, G. D., Essentials of Organic Chemistry, S. Chand & Co. Ram Nagar, New Delhi, (2008).
2. Gerasimov, Y.A, Physical Chemistry, Vol l, Mir Publishers, Moscow, (1974).
3. Maron, S. and Prutton, C., Principles of Physical Chemistry, MacMillan, New York, (1970).
4. Kaufman, E. D., Advanced Concepts in Physical Chemistry, McGraw Hill, New York, (1966).
5. Moelwyn-Hughs, E. A., Physical Chemistry, Pergamon Press, London New York, (1957).
6. Wall, F. T, Chemical Thermodynamics, W. H. Freemann, San Francisco, (1974).

CHEM– 653	Physical Chemistry Lab-II	Credit Hours: 1(0-1)

1. Determination of energy of activation of the reaction between similar charged ions.
2. Kinetics of autocatalytic reaction between permanganate and oxalate ions.
3. Kinetics of fading of phenolphthalein in alkaline solution.
4. Kinetics of the reaction between methyl orange and peroxodisulphate ions in presence of bromide ions.
5. Stoichiometry of a complex in solution by Job's method using spectroscopic methods.
6. Study of isotherms and experiments of surface chemistry.
7. Study of the effect of pH on the rate constant of the reaction between iodide and persulphate ions.
8. Study of the salt effect on the rate constant of the reaction between similar charges of ions.
9. Sugar analysis and inversion studies by polarimetry.

Recommended Books

1. Halpern, A., McBane, G., Experimental Physical Chemistry: A Laboratory Textbook, 3rd ed., W. H. Freeman, (2006).
2. Palmer, W. G., Experimental Physical Chemistry, 2nd ed., Cambridge University Press, (2009).
3. Athawale, V. D., and Mathur. P., Experimental Physical Chemistry, New Age International (2001).
4. Farrington, D., Experimental Physical Chemistry, BiblioBazaar, (2011).
5. James, A. M., Prichard, F. E., Practical Physical Chemistry, 3rd ed., Prentice Hall Press, (1974).

CHEM– 644	Environmental Chemistry–II	Credit Hours: 3(0-3)

Course Objectives

This course of advanced Environmental Chemistry will provide knowledge about the environment and toxicological chemistry of chemical substances.

Course Contents

Introduction

Biotic and abiotic factors, concept of eco systems, atmosphere (composition, temperature, pressure, air pollutants, greenhouse effect and global warming, ozone and ozone depletion, CFCs, acid rain, photochemical smog, vehicular and industrial emissions and role of hydroxyl radicals), water (properties, water quality, eutrophication water pollution and water treatment), land (composition, pH, soil erosion and soil pollutants).

Toxicological Chemistry of Chemical Substances

Toxic elements and elemental forms, toxic inorganic and organic compounds, environmental chemical analysis, classical methods vs instrumental methods, analysis of water samples, air monitoring and analysis.

Green Revolution

Pest control, pesticides, toxicity of pesticides, integrated pests management.

Renewable Energy

Nuclear energy, solar energy, geothermal and tidal energy.

Recommended Books

1. Manahan, S. E., Environmental Chemistry, 9th ed., CRC Press, New York, (2010).
2. Neil, P. O., Environmental Chemistry, 2nd ed., Chapman & Hall, New York, (1993).
3. De, A. K., Environmental Chemistry, 4th ed., Wiley Eastern Ltd., New Delhi, (1996).
4. vanLoon G. W. and Duffy, S. J., Environmental Chemistry, A global perspectives, 3rd ed., Oxford University Press, (2011).
5. Dara, S., Textbook of Environmental Chemistry and Pollution Control, 7th ed., S Chand & Co Ltd. (2004).
6. Yen, T. F., Environmental Chemistry, Prentice Hall, (1999).
7. Buell, P. and Girard, J., Chemistry, an environmental perspective, Prentice Hall, (1994).
8. Baird C. and Cann, M., Environmental Chemistry, 5th ed., W.H. Freeman, New York, (2012).
9. Connell, D. W., Basic Concepts of Environmental Chemistry, 2nd ed., CRC Press, (2005).

CHEM– 645	Research Project–II	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VIII

Specialization in Analytical Chemistry

CHEM–654	Analytical Chemistry-VII	Credit Hours: 3(3-0)

Course Objectives

In this course, students will acquire knowledge about kinetic method of analysis, radio-analytical and clinical chemistry.

Course Contents

Kinetic Methods of Analysis

Introduction, measurement of catalytic reactions, order of reaction, rate equations for single species, enzyme catalysis, the Michaelis constant, monitoring techniques for enzyme catalyzed reactions and applications.

Radio-Analytical Chemistry

Introduction, units of radioactivity, basic modes of decay, measurement of radioactivity, scintillation counters, neutron activation analysis, isotope dilution analysis.

Clinical Chemistry

Introduction, blood composition, samples collection and preservation, clinical analysis, immunoassay, principles of radioimmunoassay and its applications, Fluorescence and enzyme immunoassays, blood gas analyzer, trace elements in the body.

CHEM–655	Analytical Chemistry-VIII	Credit Hours: 3(3-0)

Course Objectives

In this course, the students will get knowledge about atomic absorption, atomic emission spectroscopy and mass spectrometry.

Course Contents

Atomic Absorption and Emission Spectroscopy

a) **Flame Photometry**

Introduction, principles of flame photometry, instrumentation (source, burner types, monochromators, detector, readout devices) and analytical applications.

b) **Atomic Absorption Spectroscopy**

Introduction, principles of atomic absorption spectroscopy,, flame chemistry, types of flame, interferences (spectral, ionization, chemical and physical interferences),instrumentation (light sources, atomization units, detector, read out devices) and analytical applications.

Mass Spectroscopy

Introduction, instrumentation, mass spectrum, interpretation of mass spectra: assignment of molecular ion peak, elemental composition of molecular ions, fragments ions from simple cleavage reactions (aliphatic and aromatic hydrocarbons), MacLafferty's rearrangement, meta stable ions or peaks, mass spectra of hydrocarbons e.g. Alkanes, alkenes, cycloalkanes, alkynes, aromatic compounds, alcohols, amines, phenols, aldehydes and ketones, aliphatic acids, aromatic acids, halogens compounds and esters.

CHEM–656	Analytical Chemistry-IX	Credit Hours: 3(3-0)

Course Objectives

In this course, students will acquire knowledge about chromatography, types of chromatography, molecular fluorescence and chemiluminescence.

Course Contents

Chromatography

Introduction and classification, adsorption and distribution laws applied to chromatography, displacement, frontal and elution techniques, migration rate of species, band broadening and column efficiency and applications.

a) Gas-Liquid Chromatography (GLC)

Principle, instrumentation (components of A GC installation, carrier gas and flow regulation, sample introduction and the injection chamber, thermostatically controlled oven, columns, stationary phases, principal GC detectors), interfacing GC with MS and analytical applications.

b) High Performance Liquid Chromatography (HPLC)

Introduction, general concept of an HPLC system, instrumentation (pumps and gradient elution, injectors, columns, stationary and mobile phases, principal detectors), modes of HPLC (partition, adsorption, ion exchange and size exclusion chromatography) and their analytical applications.

c) Thin Layer Chromatography (TLC)

Principle of TLC, characteristics of TLC, stationary phases, separation and retention parameters and quantitative TLC, analytical applications.

Molecular Fluorescence and Chemiluminescence

Theory of Fluorescence and phosphorescence, instruments for measuring fluorescence and phosphorescence, application and photoluminescence methods and chemiluminescence.

CHEM–657	Analytical Chemistry Lab-II	Credit Hours: 1(0-1)

1. Quantitative analysis of phosphate by spectrophotometry.
2. Determination of iron in vitamin tablets by spectrophotometry.
3. Estimation of lead in aqueous/non aqueous system by spectrophotometry.
4. Quantitative analysis of protein by biuret method.
5. Sodium and potassium determination in environmental samples by flame photometry.
6. Determination of potassium in fertilizers.

7. Determination of sodium and potassium in fruit juices.
8. Determination of calcium by atomic absorption spectrophotometry.
9. Analysis of analgesics using high performance liquid chromatography.
10. Gas chromatographic analysis of a pesticides mixture.
11. Chemiluminescence determination of iron and cobalt.
12. Fluorometric analysis of vitamin A, vitamin E and riboflavin.

Recommended Books

1. Christian, G. D., Analytical chemistry, 6th and 7th ed., John Wiley & Sons, New York, (2004 & 2013).
2. Christian, G. D., Analytical Chemistry, Student Solutions Manual, 6th ed., Publisher: Wiley, (2004).
3. Christian G. D. and O'Reilley, J. E., Instrumental analysis, 2nd ed., Allyn and Bacon, Boston, (1986).
4. Skoog, D. A., West, D. M., Holler, F. J. and Crouch, S. R., Fundamentals of analytical chemistry, 8th ed., Thomson Brooks/Cole, USA, (2004).
5. Skoog, D. A., Holler, F. J. and Nieman, T. A., Principles of instrumental analysis, 5th ed., Saunders College Publishing, New York, (1997).
6. Skoog, D. A., Holler, F. J., and Crouch, S. R., Principles of instrumental analysis, 6th ed., Thomson, USA, (2007).
7. Harris, D. C., Quantitative chemical analysis, 7th ed., Freeman, New York, (2007).
8. Day, R. A. and Underwood, A. L., Quantitative analysis, 6th ed., Prentice Hall Inc., (2004).
9. Harvey, D., Modern analytical chemistry, McGraw-Hill Companies, Inc. New York, (2000).
10. Bard, A. J. and Faulkner, L. R., Electrochemical methods, fundamentals and applications, 2nd ed., John Wiley & Sons, New York, (2001).
11. Ewing, G. W., Instrumental methods of chemical analysis, 5th ed., McGraw Hill, New York, (1985).
12. Willard, H., Merritt, L., Dean, J. and Settle, F., Instrumental methods of analysis, 7th ed., vanNostrand Co., New York, (1992).
13. Ingle, J. D. and Crouch, S. R., Spectro-chemical methods of analysis, Prentice Hall, New Jersey, (1988).
14. Ruzicka, J. and Hansen, E. H., Flow injection analysis, 2nd ed., John Wiley & Sons, New York, (1988).
15. Trojanowicz, M., Advances in flow analysis, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, (2008).
16. Robinson, J. W., Frame, E. M. S. and Frame, G. M. II, Undergraduate Instrumental Analysis, 6th ed., Marcel Dekker, New York, (2005).
17. Plummer, D. T., An introduction to practical biochemistry, 3rd ed., Tata, McGraw Hill, New Delhi, India, (1988).
18. Thomspon, K. C. and Reynold, R. J., Atomic absorption, fluorescence and flame emission spectroscopy, 2nd ed., John Wiley & Sons, New York, (1978).
19. Ebdon, L., Evans, E. H., Fisher, A. and Hill, S. J., An introduction to analytical atomic spectroscopy, John Wiley & Sons, New York, (1998).
20. Jenkins, R., Gould, R. W. and Gedcke, D., Quantitative X-ray spectrometry: Practical spectroscopy, 2nd ed., Marcel-Dekker, New York, (1995).
21. Braithwaite A. and Smith, F. J., Chromatographic methods, 4th ed., Chapman and Hall, New York, (1985).
22. Miller J. C. and Miller, J. N., Statistics and chemometrics for analytical chemistry, 5th ed., Prentice Hall, New York, (2005.
23. Mendham, J., Vogel's text book of quantitative analysis, 6th ed., AdisonWisley Publishers, (2004).
24. Campana, A. M. G. and Baeyens, W. R. G., Chemiluminescence in Analytical Chemistry, Marcel Dekker, New York, (2001).

CHEM– 644	Environmental Chemistry–II	Credit Hours: 3(0-3)

Course Objectives

This course of advanced Environmental Chemistry will provide knowledge about the environment and toxicological chemistry of chemical substances.

Course Contents

Introduction

Biotic and abiotic factors, concept of eco systems, atmosphere (composition, temperature, pressure, air pollutants, greenhouse effect and global warming, ozone and ozone depletion, CFCs, acid rain, photochemical smog, vehicular and industrial emissions and role of hydroxyl radicals), water (properties, water quality, eutrophication water pollution and water treatment), land (composition, pH, soil erosion and soil pollutants).

Toxicological Chemistry of Chemical Substances

Toxic elements and elemental forms, toxic inorganic and organic compounds, environmental chemical analysis, classical methods vs instrumental methods, analysis of water samples, air monitoring and analysis.

Green Revolution

Pest control, pesticides, toxicity of pesticides, integrated pests management.

Renewable Energy

Nuclear energy, solar energy, geothermal and tidal energy.

Recommended Books

1. Manahan, S. E., Environmental Chemistry, 9th ed., CRC Press, New York, (2010).
2. Neil, P. O., Environmental Chemistry, 2nd ed., Chapman & Hall, New York, (1993).
3. De, A. K., Environmental Chemistry, 4th ed., Wiley Eastern Ltd., New Delhi, (1996).
4. vanLoon G. W. and Duffy, S. J., Environmental Chemistry, A global perspectives, 3rd ed., Oxford University Press, (2011).
5. Dara, S., Textbook of Environmental Chemistry and Pollution Control, 7th ed., S Chand & Co Ltd. (2004).
6. Yen, T. F., Environmental Chemistry, Prentice Hall, (1999).
7. Buell, P. and Girard, J., Chemistry, an environmental perspective, Prentice Hall, (1994).
8. Baird C. and Cann, M., Environmental Chemistry, 5th ed., W.H. Freeman, New York, (2012).
9. Connell, D. W., Basic Concepts of Environmental Chemistry, 2nd ed., CRC Press, (2005).

CHEM– 645	Research Project–II	Credit Hours: 3(0-3)

The student will search literature related to his/her assigned topic according to specialization and to write a review article consisting on the following format and deliver a presentation.
Abstract, Introduction, Description of recent literature related to his/her topic, Conclusion, Future suggestions and References.

SEMESTER-VIII

Specialization in Biochemistry

CHEM–658	Biochemistry-VII	Credit Hours: 3(3–0)

Course Objectives

In this course students will get knowledge about the chemistry of enzymes, urine and immunology.

Course Contents

Enzymes

Enzymes, proenzyme, antienzymes, holoenzymes, co-factors and coenzymes, chemical nature, nomenclature and classification, mode of enzyme action, effects of different factors on enzyme activity, kinetics, derivation of Michaelismenten equation, Km, nature of the active site, mechanism of enzyme catalysis, enzyme specificity, multienzyme systems, enzyme purification, structure and mechanism of chymotrypsin and ribonuclease, inhibition (competitive, non-competitive, uncompetitive), regulatory enzymes, immobilized enzymes

Urine

Characteristics of urine,inorganic and organic constituents of urine, pathological constituents of urine, different tests for the analysis of normal urine, different tests for the analysis of pathological samples such as jaundice, diabetes, kidney stones urinary sediments.

Immunology

Principles of immunology, antigens, antibodies, characteristics of antigens and antibodies reactions, allergy, hypersensitivity, introduction to tumor immunology.

CHEM–659	Biochemistry-VIII	Credit Hours: 3(3–0)

Course Objectives

In this course the students will learn about structure and functions of cell membrane and chemotherapy.

Course Contents

Structure and Functions of Cell Membrane

Structure, composition and functions of cell membrane, Bacterial cell membrane, diffusion, active and passive transport across the membrane, movement of Na^+, K^+ and Ca^{++} ions across the membrane.

Chemotherapy

Structural activity relationship and mode of action of anti (Penicillin) antimalarial, sulfa drugs, antipyretics and analgesics, mechanism of drug resistance, structure activity.

CHEM–660	Biochemistry-IX	Credit Hours: 3(3–0)

Course Objectives

In this course students will acquire knowledge about the physical techniques in biochemistry and oncogenic viruses.

Course Contents

Physical Techniques in Biochemistry

Basic introduction to gel filtration chromatography, ion exchange and affinity chromatography, gel Electrophoresis, isoelectric focusing, ultracentrifugation, flame photometry.

Oncogenic Viruses

Structure of a typical virus, replication and genetics of DNA and RNA tumor viruses, Virus cell interaction and transformation, endogenous RNA tumor virus cell related genes in uninfected cell.

CHEM–661	Biochemistry Lab-II	Credit Hours: 1(0–1)

1. Qualitative milk analysis.
2. Determination of clotting time of human blood.
3. Determination of human blood groups.
4. Introduction to column chromatography.
5. Separation of biomolecules by electrophoresis.
6. Dialysis of proteins glucose

Recommended Books

1. Lehninger, A. L., Nelson, D. L. and Cox, M. M., Principles of Biochemistry, 6th ed., Worth Publishers, New York, (2012).
2. Voet, D., Voet J. G., and Pratt, C.W., Biochemistry, 30th ed., John Wiley & Sons, New York, (2012).
3. Rodwell, V., Bander, D. and Bothman, K. M., Harper's illustrated biochemistry, 30th ed., Robert K. Murray, (2015).
4. John E. H., Guyton and Hall Textbook of Medical Physiology, 13th ed., Saunders, (2015).
5. Ganong, W. F., Review of Medical Physiology, 21st ed., McGraw-Hill Professional, (2003).
6. Stryer, L., Biochemistry, 5th ed., W.H. Freeman and Co. (2002).
7. Braithwaite A. and Smith, F. J., Chromatographic Methods, 4th ed., Chapman and Hall, New York, (1985).
8. Skoog, D. A., Holler, F. J. and Crouch, S. R., Principles of Instrumental Analysis, 6th ed., Thomson, New York, (2007).
9. Dilts, R. V., Analytical Chemistry: Methods of Separation, Van Nostrand, New York, (1974).
10. Scott, R. P. W., Techniques and Practices of Chromatography, Marcel Dekker, (1995).
11. Smith, E. L., Hill, R. L., Lehman, I. R. and White, A., Principles of Biochemistry, 7th ed., McGraw-Hill Publishing Company Ltd., (1983).

CHEM– 644	Environmental Chemistry–II	Credit Hours: 3(0-3)

Course Objective

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7. Buell, P. and Girard, J., Chemistry, an environmental perspective, Prentice Hall, (1994).
8. Baird C. and Cann, M., Environmental Chemistry, 5th ed., W.H. Freeman, New York, (2012).
9. Connell, D. W., Basic Concepts of Environmental Chemistry, 2nd ed., CRC Press, (2005).

CHEM– 645	Research Project–II	Credit Hours: 3(0-3)

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