Courses of Study

For

BACHELOR OF SCIENCE IN CHEMISTRY

(BS Chemistry)

Four-Year Degree Program

DEPARTMENT OF CHEMISTRY

UNIVERSITY OF ENGINEERING and TECHNOLOGY
LAHORE

DEPARTMENT OF CHEMISTRY,
UNIVERSITY OF ENGINEERING and TECHNOLOGY, LAHORE

Title of Degree:

4 YEARS BS (CHEMISTRY) DEGREE PROGRAMME

INTRODUCTION

Aims and Objectives

The general objective of the BS 4 year program in the Department of Chemistry is to bring the basic degree at par to international standards i.e. 16 years of education. The purpose is also to harvest the nursery for the M.Phil. and Ph.D. Program. The curriculum of BS 4 year program in Chemistry balances many important dimensions of both general and Applied Chemistry employing conceptual and Technical approaches. The program will provide the students with a solid base of general skills through core courses and then enrich that knowledge through specialized advanced electives, laboratory work and research in various fields of Chemistry. The students are expected to undergo research projects with the guidance and supervision of a highly qualified faculty. This degree will equip the student with modern trends in the Chemistry and will prepare them to continue with Chemistry for higher degrees in a much better manner.

Eligibility for Admission

Only those candidates will be eligible for admission in BS 4 Years Program who have secured 60% marks in F.Sc. Pre-Engineering, Pre-Medical, or equivalent certificate with Chemistry. The admission will be given as per university rules.

Total Number of Seats: **50 - 29 (A1), 15 (A2), 1 (DAE), 5 (S)**

Expected date to start programme: **September 2019**

Duration of the programme: **4 Years** (minimum) and **6 Years** (maximum)

System: **Semester**

VISION & MISSION

VISION

To generate knowledge for global competitive advantage and become a leading world class research University

MISSION

To produce graduates capable to solve problems related to industry and environment, to provide opportunity to focus on the education and research, create direct linkages with industry at national and international level for technological and socio-economic development.

PEOs

- Graduates will have successful professional careers in industry, government, and academia and as progressive chemists.
- Graduates will be active members ready to serve the society with ethical norms locally and internationally. Graduates will be able to achieve life objectives will excellent communication and managerial skills.

PLOs 4 Years BS-Chemistry

Title	Type	Description
PLO1	Theory and Knowledge	Able to apply the fundamentals of mathematics and physics, and core knowledge of chemistry to solve problems at an advanced level.
PLO2	Problem Analysis	Apply quantitative or qualitative theories related to chemistry to a broad variety of chemical problems.
PLO3	Quantitative skills	Competently perform a broad variety of analytical and synthetic procedures, instrumental analysis and data handling with critical evaluation of scientific investigations.
PLO4	Environment and Industry	Will be able to understand the impact of chemicals in industrial and environmental contexts and provide environment friendly industrial solutions.
PLO5	Communication Skills and Professional Ethics	Graduate will communicate effectively, orally as well as in writing, on current scientific issues with professional and ethical principles.

SCHEME OF COURSES/SYLLABI FOR BS (4 YEAR) PROGRAM IN CHEMISTRY

	Year – I: Semester I	Cr. Hrs 18	
Code	**Title**	**Theory**	**LAB**
HU-111	Communication Skills		1
IS-101	Islamic Studies/Pak studies I	3	
Math-101	Calculus I	3	
CS-101L	Computing Fundamentals		1
Phys-101	Mechanics	3	
Phys-101L	Mechanics Lab		1
CY- 151	Introduction to Physical Chemistry	2	
CY-151L	Introduction to Physical Chemistry Lab		1
CY-121	Introduction to Inorganic Chemistry	2	
HU-204	Foreign Languages (Any)	1	
	Total	14	4

	Year – I: Semester II	Cr. Hrs 18	
Code	**Title**	**Theory**	**LAB**
HU-221	Technical Writing and Presentation Skills	3	
IS-201	Islamic Studies/Pak studies II	3	
Math-105	Statistics	3	
CY-141	Biochemistry and Biotechnology	3	
MGT-100	Introduction to Business	3	
CY-111	Introduction to Analytical Chemistry	2	
CY-111L	Introduction to Analytical Chemistry Lab		1
	Total	17	1

	Year – 2: Semester III	Cr. Hrs 18	
Code	**Title**	**Theory**	**LAB**
Math-203 & 203L	Scientific Programming	2	1
CY-252	Physical Chemistry – I	2	1
CY-222	Inorganic Chemistry – I	2	1
CY-261	Organic Chemistry-I	2	1
CY-201	Environmental Sciences	3	
CY-212	Analytical Chemistry 1	2	1
	Total	13	5

	Year – 2: Semester IV	Cr. Hrs. 19	
Code	**Title**	**Theory**	**LAB**
CY-253	Physical Chemistry – II	2	1
CY-213	Analytical Chemistry II	2	1
CY-223	Inorganic Chemistry-II	2	1
CY-262	Organic Chemistry-II	2	1
CY-203	Work place hazardous materials information	2	
CY-204	Energy Resources of Pakistan and its Management	2	
Math-205	Ordinary Differential Equations	3	
	Total	15	4

	Year – 3: Semester V	Cr. Hrs. 16	
Code	**Title**	**Theory**	**LAB**
CY-314	Analytical Chemistry-III	3	1
CY-324	Inorganic Chemistry-III	3	1
CY-363	Organic Chemistry-III	3	1
CY-354	Physical Chemistry-III	3	1
	Total	12	4

	Year – 3: Semester VI	Cr. Hrs 16	
Code	**Title**		
CY-315 /CY 331	Analytical Chemistry-IV/ Applied Chemistry	3	1
CY-325	Inorganic Chemistry-IV	3	1
CY-364	Organic Chemistry-IV	3	1
CY-355	Physical Chemistry-IV	3	1
	Total	12	4

Year 4

	Year – 4: Semester VII	Cr. Hrs 15	
Code	**Title**		
CY-4--*	Advanced Paper I	3	
CY-4--*	Advanced Paper II	3	
CY-4--*	Experimental Methods	3	
CY-491	Scientific Report Writing	3	
CY-492	Research Project/Internship and Report Writing /Additional Paper (3 credit)		3
	Total	12	3

***Three Courses from the field of specialization (Two Theory and one Experimental Methods)**

CY-491 Scientific Report Writing (Common to all) **(3 Cr Hrs.)**
CY- 492 Research Project/Internship and Report Writing /Additional Paper (3 credit)
Total (12 credit hours + 3 credit hour research = 15) 600 Marks

8th Semester

	Year – 4: Semester VIII	Cr. Hrs. 15	
Code	**Title**		
CY-4--*	Advanced Paper IV	3	
CY-4--*	Advanced Paper V	3	
CY-4--*	Experimental Methods	3	
CY-4--*	Elective Course (Other than the field of specialization)	3	
CY-492	Research Project/Social Services and Report Writing /Additional Paper (3 credit)		3
	Total	12	3

***Three Courses from the field of specialization (Two theory and one experimental) (9 Cr Hrs.)**

Elective Course I (Other than the field of specialization **(3 Cr Hrs.)**
CY- 492 Research Project/Internship and Report Writing /Additional Paper (3 credit)
Total (12 Credit hrs. + 3 Cr hrs. Research) 600 Marks

Total Credit hrs. 15
Total Credit Hours 135

Final Year Subject Specialization

Code	Specialization
1 & 2	Inorganic and Analytical Chemistry
3, 7 & 8	Industrial, Environmental and Polymer Chemistry
4 & 0	Biochemistry and Microbiology
5	Physical and Electrochemistry
6	Organic Chemistry (Organic, Food and Biochemistry)

Specialization in Inorganic & Analytical Chemistry

Course Codes	Subjects
CY-411	Spectroscopic Techniques
CY-412	Thermal Analysis
CY-413	Electroanalytical Techniques
CY-414	Statistical Data Handling and Spreadsheets
CY-415	Vacuum Techniques In Analytical Chemistry
CY-416	Physicochemical Methods of Analysis
CY-418	Experimental Methods in Analytical Chemistry I
CY-419	Experimental Methods in Analytical Chemistry II
CY-421	Introduction to Organometallic Chemistry
CY-422	Inorganic Catalysis
CY-423	Principles of Bioinorganic Chemistry
CY-424	Inorganic Chemistry of Main Group Elements
CY-425	Special Topics in Inorganic Chemistry
CY-426	Experimental Methods in Inorganic Chemistry I
CY-427	Experimental Methods in Inorganic Chemistry II

Specialization in Industrial, Environmental & Polymer Chemistry

Course Codes	Subjects
CY-431	Organic Based Industries
CY-432	Agro Based Industries and Pollution Control
CY-433	Industrial Process
CY-434	Projects of Applied Chemistry
CY-435	Experimental Methods in Industrial Chemistry I
CY-436	Experimental Methods in Industrial Chemistry II
CY-481	Fundamentals of Environmental Chemistry
CY-482	Environmental Toxicology
CY-483	Green Chemistry
CY-484	Environmental Chemistry
CY-485	Environmental Law
CY-486	Projects of energy resources of Pakistan and its management
CY-487	Experimental Methods in Environmental Chemistry
CY-471	Polymer Chemistry
CY-472	Polymer Blends and Composites
CY-473	Degradable Polymeric Materials
CY-474	Polymer Analysis and Characterization
CY-475	Functional Polymeric Materials
CY-476	Experimental Methods in Polymer Chemistry

Specialization in Organic and Food Chemistry

Course Codes	Subjects
CY-461	Organic Spectroscopy
CY-462	Heterocyclic and Organometallic Compounds
CY-463	Reaction Mechanism And Reactive Intermediates
CY-464	Natural Products
CY-465	Advance Food Chemistry and Technology
CY-466	Food Laws and Regulations
CY-467	Food Technology in Dairy
CY-468	Experimental Methods in Organic Chemistry
CY-469	Experimental Methods in Food Chemistry
CY-401	Essentials of Microbiology
CY-402	Introduction to Microbiology
CY-403	Chemical Microbiology
CY-441	Structural Biochemistry
CY-442	Biochemistry of Metabolism
CY-443	Informational Macromolecules
CY-444	Bioenergetics
CY-445	Nutritional Biochemistry
CY-446	Advance Protein Chemistry
CY447	Enzymes and Enzymology
CY-448	Metabolism and Related Diseases
CY-449	Experimental Methods in Biochemistry
CY-404	Experimental Methods in Microbiology

Specialization in Physical & Electrochemistry

Course Codes	Subjects
CY-451	Solid State and Material Chemistry
CY-452	Thermodynamics
CY-453	Electrochemistry and Clean Energy
CY-454	Applied Electrochemistry
CY-455	Electro-Kinetics Phenomenon
CY-456	Electrochemical Industrial Processes
CY-457	Quantum Chemistry
CY-458	Physical and Electrochemistry Chemistry Lab I
CY-459	Physical and Electrochemistry Chemistry Lab II

CURRICULUM
OF
CHEMISTRY
BS (4-YEAR)

UNIVERSITY OF ENGINEERING AND TECHNOLOGY, LAHORE

BS 1st Year
SEMESTER I

HU-111: Communication Skills

Course Contents:

CLOs	PLOs
Developing fluency, accuracy and self-confidence	10
Polishing their argumentative and debating skills proving critical thinking environment	6
Developing presentation skills and polishing the use of multimedia	5

Main Topics	Lecture contents
Introduction to Communication Skills	Communication Principles Process of communication. Importance of good communication skills in business environments
Introduction to Communication Skills	Communication in business organizations Internal-operational External-operational Personal Challenge of communication in the global market.
Study Skills	Brain storming Time-management Effective reading strategies Note-taking Organization Summarizing
Components of Communication	Context Sender-Encoder Message Medium Receiver-decoder Feedback
Non-Verbal Communication	Appearance and dress codes Body language Silence, time and space Importance of listening in communication
Functional English	B . Role-play/Speaking activities
Assessment week	No lectures of communication skills shall take place during the mind-term exam week of the university
Public Speaking	Difference between speaking and writing. Reading texts of good public speeches and analysis of their components.
Public Speaking	Listening to famous public speeches. Exercise in public speaking.
Formal Presentations	Difference between informal and formal presentations Modes of formal presentation Extemporaneous Prepared Reading out form a written text Combination of the above mentioned methods.
Formal Presentations	Purpose of oral presentations Entertain Persuade Inform Sell Mechanics of Presentations Organisation Preparation (including A V As) Rehearsals Presentations Teacher shall mode presentations both, with and without A V As
Resume/CV Writing	Cover Letters, Resumes, CVs
Interview Skills	Practice/Viva
Formal Presentations	Students Presentation

Reference books:

1. Effective Business Communications by Murphy, Hildebrandt and Thomas. 7th Edition.
2. Basic Communication Skills for Technology by A.j. Rutherfoord. 2nd Edition.
3. Basic Business Communications by Lasiker. 8th Edition.
4. A Practical English Grammar by Thomson and Martinet.
5. English for Undergraduates by Howe and Kirkpatrick.

IS- 101 ISLAMIC STUDIES/PAKISTAN STUDIES-I

CLOs	PLOs
CLO1 Comprehend the basic teachings of Islam in the light of Qur'an and Sunnah and ethical and moral teachings of contemporary religions.	PLO08 Cognitive 2. Understand
CLO2 Identify the ethical and social ways of life and evaluate un-social values and extremism.	PLO08 Psychomotor 4. Analyze
CLO3 Describe the ideology of Pakistan and its historical emergence that culminated in the formation of Pakistan	PLO12 Psychomotor 1

Islam and basic beliefs: Qualities of believers, Tawheed Fundamentals and types, Prophet-hood and its finality, The Day of Judgment, Characteristics of *Ibad-ur-Rehman,*(Slaves of Allah)
Ideology of Pakistan: Definition and Explanation
Islam and basic beliefs: Importance of intention (Niyya) in human actions, Islam, Iman (belief), Ihsan (excellence) and the Hour, Sincerity to Allah, His Books, His Messengers, leaders of the Muslims and common people
Ideology of Pakistan: With reference to Allama Iqbal and Quaid-i-Azam
Islamic teachings regarding social behavior: Etiquettes regarding seeking knowledge, Importance of good talk and silence, Prevention from inventing a lie
Ideology of Pakistan: Aims and Objectives of the creation of Pakistan
Islamic teachings regarding social behavior: Brotherhood, Efforts to compose the quarrels of
groups and reconciliation between them, Elimination of social evils such as to laugh at people in contempt, calling others by offensive nick names and suspicion etc. Backbiting
Muslim Rule in South Asia: Arrival of Muhammad bin Qasim and Successors
Islamic teachings regarding social behavior: Importance of modesty (*Al-Haya*), Good behavior towards people, Fair speaking to the people, To control anger, *Ihsan* (excellence) with regards to every thing
Muslim Rule in South Asia: Tolerance, Religious Freedom and kind treatment towards Non-Muslims
Prophetic life as a role model: Life of The Holy Prophet (Peace be upon him) from prophet-hood to *Hijra,* Difficulties in preaching Islam in *Makka* and opposition of Quresh, Reasons of *hijra* (migration) to *Madina* and impact of this migration
Historical Background of Ideology of Pakistan: Services of Mujadid Alf Sani
History of the Holy Qur'ān: Revelation, Compilation, Significance
Reformative movement: Social and religious services of Shah Waliullah, Efforts for sectarian harmony
Importance of hadith: Definition, Importance, Authenticity
Reformative movement: Syed Ahmad Shaheed, Biography, Creation of Islamic State, Opposition from Local tribes and Martydom at Balakot

Prophetic ethical behaviours: Significance of moral values in the light of the life of the Holy Prophet peace be upon him: -Tolerance –Patience, -Endurance, Generosity, Honesty
Sir Syed Ahmad Khan: Educational and Social services, Political aspect of Aligarh movement
Islamic teachings regarding social behavior: Stress on fulfillment of *uqud* (obligations), Sanctity of religious symbol
Arise of Political consciousness among Muslims: Establishment of All India Muslim League (AIML): Objective and achievement
Islam and *Halal* and*haram:* Concept of *Halal* (lawful) and *haram* (forbidden) in Islam, *Halal* and *haram* animals and food, Rules of hunting the animals for food, Lawful, unlawful and doubtful matters, Importance of lawful food, drink, clothing and nourishing
Pakistan Movement: Muslim Nationalism, Khilafat Movement, Non cooperation Movement
Islamic rules of purity and cleanliness: Importance of purity and cleanliness in the life, Rules of purity and cleanliness
Non cooperation movement: Role of Ali Brothers, Role of Mr.Ghandi, Failure and affects of Khilafat movement
Relationship with other religions: Respect of other religions and their believers, Relationship with *Ah'l Al-Kitab* (people of the Book), Social relationships with non-Muslims, The Covenant of *Bani-Israel* (The children of *Isreal*) with Allah, Address of prophet Moses (peace be upon him) to his people
Pakistan Movement: Allahabad Address of Allama Iqbal, Idea of independent Muslim State
Islam and ethics: Definition, importance and significance of Ethics, Concept of Ethics in the light of Qur'ān and Hadith
Pakistan Movement: Provincial Elections 1937, Establishment of Congress Ministries, Behaviour towards Muslims
Islam and ethics: Comparative Religious Morals Hinduism, Buddhism, Judaism, Christianity, Islam, Philosophy of Ethics in revealed and non revealed religions: an analysis
Pakistan Movement: Lahore/ Pakistan Resolution of 23rd March 1940
Islam and Modern Science: The Holy *Qur'ān* as s guide for the modern scientific development, Importance of science education in the modern age, Introduction of Muslim scientists, Contribution of Muslim Scholars towards science
Pakistan Movement: Establishment of Pakistan

Recommended/ Books and Suggested Readings

1. Ma'arif Al-Qur'an
2. Tafheem Al-Qur'an
3. Tafseer Namoona
4. Tayasir Al-Qur'an
5. Zia Al-Qur'an
6. Imam Nawawi, Al-Arbaeen
7. Harun Yahya, "Ilahi Bulandshehri Ashiq, Quick Grasp of Faith
8. Prof. Sharif Al Mujahid, "Ideology of Pakistan"
9. M. Ikram Rabbani, "Comprehensivebook of Pakistan Studies"
10. Shibli Nomani, "Seerat un Nabi"
11. Salman Mansoorpuri Rehmatulilalameen
12. Muharakpuri, "Al-Raheeq Al-Makhtoom"
13. Sheikh Muhammad Ikram, "Muslim Rule in India and Pakistan"
14. Taqi Usmani, "Uloom ul Qur'an"
15. SubhiSaleh, "Mubahis fi Uloomul Qur'an"
16. Dr. Muhammad Hameedullah, "Khutbat-e- Bahawalpur"

17. Dr. Mehmood Ahmad Ghazi, “Muhazarat-e-Qur’ani”
18. G.N Jalbani, “Life of Shah Waliullah”
19. Syed Maudoodi, “Sunnat ki Aini Hesiat”
20. Peer Karam Shah, “Sunnat Kairul Anaam Peer Karam Shah”
21. Dr. Muhammad Hameedullah, “Peghamber-e-Aman”
22. Dr. Mehmood Ahmad Ghazi, Muhazarat-e-Hadith
23. Muharakpuri, “Al-Raheeq Al-Makhtoom”
24. K.B Sayeed, “Pakistan: The Formative Phase”
25. I. H Qureshi, “Struggle for Pakistan”
26. Sharif Al Mujahid, “Ideological Foundation of Pakistan”
27. Hifz ur Rehman syoharwi, “Ikhlaq and FalsafaIkhlaq”
28. Dr. Mazhar ud Din Siddiqi, “Islam ka nazriya e Ikhlaq”
29. K. K. Aziz, “The Making of Pakistan”
30. Dr. Mazhar ud Din Siddiqi, “Islam aur Mazahib e Alam”
31. Ammad ul Hasan Farooqi, “Dunya ky bary mazahib”
32. Murice Bucaile, “The The Qur’an and Modern Science”
33. Harun Yahya, “Concept of Science based on the Qur’an”
34. Azeem Musalman Sciencedan by Urdu Science Board

Module Code: **MATH-101** **Module Title:** **Calculus-I**
Module Rating: **3 Credit Hours**

CLOs	PLOs
Apply derivatives to find tangents and normals, carry out optimization, graphical analysis, and concavity of a function, curvature of a function and asymptotes of functions.	
Evaluate integrals by substitutions, tabular form, reduction formulae, improper forms, and definite integrals	
Use integrals to compute area, volume, arc length, surface area, moments and center of mass.	

Contents:

Review of functions, Limit, Continuity, Derivatives, Slopes and tangent lines, Differentiation of trig functions, Product and quotient rules Chain rule, Implicit differentiation and related rates, Inverse functions and their derivatives, Application of derivatives: Linear Approximation, Extrema, Applied optimization problems, Mean Value Theorem, L'Hopital's rule, Intervals where functions are increasing and decreasing, Intervals where functions are concave up and concave down, and points of inflection, Limits at infinity and horizontal and slant asymptotes, Intermediate value theorem and Mean value theorem , Differentials Indefinite integrals, Approximating area using rectangles, Definite integrals, Evaluating integrals by substitution, Fundamental theorem of calculus, Derivatives and Integrals of Logarithmic, exponential and other transcendental functions, Integration by parts, Trigonometric integrals, Integration by trigonometric substitution Integration by partial fractions, Improper integrals. Area enclosed between curves; Arc length, The Mean-Value Theorem for Integrals and the average value of a function.

Text Book:

Thomas Jr, Thomas, *Calculus*, 14th Ed., Addison Wesley Publishing Company, **(2019)**

Reference Books:

- H. Anton, I. Bevens and S. Davis, *Calculus*, 10th Ed., JohnWiley &Sons, Inc. **(2012)**
- C. H. Edward and E.D. Penney, *Calculus and Analytics Geometry*, Prentice Hall, Inc. **(1988)**
- E. W. Swokowski, Calculus and analytic Geometry, 3rd Ed,, PWS Publishers, Boston, Massachosetts, **(1983)**

CS-101L COMPUTING FUNDAMENTALS

Course Learning Outcomes (CLOs)

The students will be able to:

- identify computer hardware and peripheral devices
- to familiar with software applications
- Accomplish creating basic documents, worksheets, presentations and databases
- Incorporate effective and relevant internet and multimedia resources in their learning process to broaden their knowledge base
- Identify computer risks and safety

Course Content:

The history and evolution of computers, central processing unit, data storage, input/output devices, multimedia, operating systems, programming languages, networking, the internet, systems analysis and design, management information systems, electronic commerce, security and privacy issues, ethical issues and the computing profession. Students will become familiar with popular operating systems, software applications and tools, development of web pages.

Text Books

1. H. L. Capron, "Computers: Tools for an information age" 8th Ed, Adison Weisely 2003

Phys-101 MECHANICS

Course learning outcomes (CLOs)

The students will be able to:

- Verify the Newton's laws of motion and apply them for the measurement of different forces, acceleration due to gravity, linear and angular momentum.
- Measure different parameters related to rolling motion along inclined planes, simple harmonic motion, masses attached to spring using Hooke's law.
- Explain simple harmonic motion by performing simple pendulum and spring mass systems

Units and Dimensions, SI Units, Changing Units; Scalars and Vectors, Adding Vectors: Graphical as well as Component Method, Multiplying Vectors: Dot and Cross Products. Position and 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 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 and 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. 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 and Kinetic Energy in One and Two Dimensional Elastic and Inelastic Collisions. 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; Rotational inertia of various shapes i.e. for disc, bar and solid sphere; Elasticity; Stress; Strain and Properties of Materials. Angular Velocity; Conservation of angular momentum; effects of Torque and its relation with angular momentum. 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. Static Fluids and Pressure; Archimedes' Principle; Fluid Dynamics; Equation of Continuity and Bernoulli's Principle

PHYS-101L MECHANICS LAB

Contents:

Experiments with pendulums, stop watches, one-dimensional motion and verification of Newton's laws of motion, measurement of forces, speed, acceleration and linear momentum, collisions and conservation of momentum, impacts, free fall and acceleration due to gravity, gyroscopes, rotational motion, conservation of angular momentum, friction, static and dynamic equilibrium, compound pendulum, rolling motion along inclined planes, simple harmonic motion, masses attached to springs and Hooke's law, damped motion and the regimes of damping (overdamped, underdamped and critically damped).

Note: See APPENDIX A (Suggested Experiments)

Recommended Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley and Sons, 10th ed., 2016.
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed., 2010.
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed., 2010.
4. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed., 2008.

CY-151: Introduction to Physical Chemistry (THEORY)

CLOs	PLOs
To apply the kinetic theory of gases, including properties of ideal gases and interactions that lead to non-ideal behavior.	2
To develop an understanding about basics of thermodynamics.	1
To describe the adsorption phenomena occurring upon the surface and behavior of solutions by using various laws.	3

Course contents:

1. Laws of thermodynamics, applications, internal energy; enthalpy; entropy; Van't Hoff's equation.

2. States of Matter

Kinetic theory of gases, ideal gas laws and kinetic theory, Surface tension of liquids, capillary action, surface tension and temperature, interfacial tension, surface active agents,

3. Surface Chemistry

Concept of interfaces. Adsorption and adsorption isotherms: Freundlich and Langmuir adsorption isotherms. Catalysis, colloids, emulsion and their industrial applications.

4. Solution Chemistry

Ideal and non-ideal solutions. Raoult's law and its applications. Molecular interactions in solutions. Colligative properties. Distillation and concept of azeotropic mixture. Phase rule and its applications.

Text Book:

1. Introduction to physical chemistry, Andreas Hofman, National library of Australia, **(2015)**

Recommended Books:

1. Inorganic Chemistry: Principles of Structure and Reactivity 4th Ed.,Huheey, J. E., Keiter, E. A.,Keiter, R. L., Harper and Row, New York **(2001)**
2. Physical Chemistry 10th Ed, Atkins, S., Oxford University Press **(2014)**
3. Introduction to Spectroscopy 5th Ed, Pavia, D. L.,George S. K., James A. Vyvyan, J. A.,**(2015)**
4. Basic Inorganic Chemistry 3rd Ed., Cotton, F. A., Wilkinson, G. and Gaus, P. L., Wiley, New York **(1995)**

CY-105L: Introduction to Physical Chemistry (Lab)

CLOs	PLOS
To be able to identify various compounds on the basis of their physical properties	3
To learn how to use certain instruments and equipment for analysis	5

Course Contents

Classical redox titrations
Instrumental redox titrations
Acid-Base titrations using pH meter
Acid-Base titrations using conductivity meter
Determination of Heat of solution
Determination of Heat of neutralization

Determination of depression in the freezing point of the given compound
Determination of molecular mass of the given compound
Determination of refractive index of given compound

Text Book:

1. Experimental Physical Chemistry: A Laboratory Textbook, A. Halpern and G. McGane, 3rd Ed, W. H. Freeman, **(2006)**
2. Introduction to physical chemistry, Andreas Hofman, National library of Australia, 2015

Recommended Books:

1 Atkins' Physical Chemistry, Atkins, P and Paula, J.D., OUP Oxford, **(2014)**
2 Chemical Kinetics and Reaction Mechanism, 2nd Ed, Espenson, J. H., McGraw Hill **(2002)**
3 Physical Chemistry, 4th Ed, Laidler K.J., John, H.M. and Bryan C.S., Houghton Mifflin Publishing Company Inc.**(2003)**

CY-121 Introduction to Inorganic Chemistry

CLOs	PLOs
Students will be able to define the periodicity of elements	1
Students will be able to illustrate the knowledge of chemical Forces and bonding	3

Course contents:

1. The Periodic Law and Periodicity Development of Periodic Table; Classification of elements based on *s, p, d* and *f* orbitals, group trends and periodic properties in *s, p, d* and *f* block elements, i.e., atomic radii, ionic radii, ionization potential, electron affinities, electro negativities and redox potential.

2. Principles of Chemical Bonding

Types of chemical bonding: Theories of Bonding; the delocalized approach to bonding: three center bonds; bonding in electron deficient compounds; Kössel-Lewis approach, Valence Shell Electron Pair Repulsion (VSEPR) Theory, Valence Bond (VB) Theory and Molecular Orbital (MO) Theory

3. Four Intermolecular Forces: Ionic Bonding, Hydrogen Bonding, Van Der Waals Dipole-Dipole Interactions, Dispersion Forces or London Forces.

Text Book:

1. Inorganic Chemistry: Principles of Structure and Reactivity,Huheey, J. E., Ellen A. Keiter,R. L.,Medhi, O. K., Pearson Education India **(2006)**

Recommended Books:

1 Inorganic Chemistry, 5th Ed, Miessler, G. L., Fischer, P. J. and Tarr, D. A., Harlow : Pearson Education Limited, **(2014)**
2 Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed, Huheey, J. E., Keiter, E. A. and Keiter, R. L., Harper and Row, New York, **(2001)**
3 Chemicals Principles, Atkins, P. and Jones, L., Freeman and Company, **(2002)**
4 New Materials, Process and Methods Technology, Schwartz,M.,, CRC Press, New York **(2006)**
5 Basic Inorganic Chemistry, 3rd Ed, Cotton, F. A., Wilkinson, G. and Gaus, P. L., Wiley, New York**(1995)**
6 A New Concise Inorganic Chemistry, 5th Ed, Lee, J. D., Chapman and Hall, London**(1996)**

7 Modern Inorganic Chemistry, Aggarwal, R. C., Kitab Mahal, Allahabad**(1987)**
8 Basic Inorganic Chemistry, 3rd Ed,Cotton, F. A., Wilkinson, G. and Paul L. Gaus, John Wiley and Sons, New York.**(1995)**
9 A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis, Vogel, A. I., Longman Green and Co. **(1995)**
10 Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, 4th Ed, Bassette, J., Denney, G. H. and Mendham, J., English Language Book Society, **(1981)**

BS 1st Year
SEMESTER II

HU-221: Technical Writing and Presentation Skills

Technical Writing and Presentation Skills

CLOs	PLOS
Learn principles of effective technical writing	10
Recognize and adapt writing for a variety of audiences and situations	6
Apply effective writing strategies in order to produce concise, clear and meaningful documents ranging from technical definitions to technical proposals and reports	5

Main Topic	Lecture Contents
Introduction Technical Communication	A. What is technical communication? B. Factors to consider in technical communication C. Examining your purpose. D. Determining how to provide content.
The Writing Process	A. Writing effective paragraphs for technology. B. Developing a clear pattern of organization.
Getting started with technical writing	A. Recognizing different audiences B. Involving the audience.
Making writing effective	A. Achieving parallelism in writing B. Constructing effective sentences.
Memos	
Assessment Week	
Letter Writing	E-Mails
Parts of a Formal/Technical Report	Title Abstract Outline/contents Introduction Body/procedures Conclusion Appendices Use of illustrations (Tables and Figures)
Parts of a Research Report	Title Abstract Contents Introduction Literature review Methodology Analysis/Results Discussion/interpretation

	Conclusion Recommendations References
Report Defence	Presentation of Reports.

Reference books:

1) Anderson. V. Paul Technical Communication. A Reader-Centered Approach.5th edition. 2003. Thomson Wadsworth.
2) Gerson and Gerson. Technical Writing. Process and Product. 5th edition 2006. Pearson Education Inc.
3) Huckin and Olsen. English for science and Technology. 1983, McGraw-Hill Inc.
4) McMurrey. D. Power Tools for Technical Communication. Wadsworth Publishing Company 2001.

IS-201 ISLAMIC/PAKISTAN STUDIES II

CLOs	PLOs
CLO1 Explain doctrines of Islam with reference to Islamic primary sources.	PLO08 Cognitive 2. Understand
CLO2 Deduce ethical and social values from the life of the Holy Prophet (PBUH) and identify criminal behavior in the light of Islamic penal law.	PLO08 Psychomotor 4. Analyze
CLO3 Recognize the geography, resources and foreign policy of Pakistan which emphasizes on progression and peaceful co-existence.	PLO12 Psychomotor 4. Analyze

Characteristics of the righteous people: *Al-Mohsineen* and their reward, Explanation of *Lahw al-Hadith* and torment for its buyer, Stress on fear of Allah the Lord and the Judgment Day

National Integration: Role of Ulema and Mashaikh in Pakistan Movement, Role of Students, Women and
Journalists in Pakistan Movement

Advices of Luqman a wise man: Not to associate anyone with Allah, To establish *Salat* (prayer), To enjoin good, To forbid evil, To bear the difficulties, Not to speak to others with your face turned away, Not to walk proudly and lower your voice

National Integration: Initiatives of Muhammad Ali Jinnah to strengthen the State

Scientific study of the universe: Universal arguments on Allah as the Creator, Conquering the Universe

Initial Problems of Pakistan and Efforts to Resolve: Refugee Crisis, Water Disputes, Kashmir Issue, Distribution of Asserts

Pillars of Islam: *Shahada, Salat,Saum, Zakāt, Hajj*

Striving in the cause of *Allah* (*Jihad*): Importance and significance, Kinds: Against one's soul: to control its ego and desires (The greatest Jihad),Against ignorance, Against *Satan,* Against the enemy, Against disbelievers by the Holy *Qur'an* etc

Land of Pakistan: Geographical Importance of Pakistan, China-Pakistan Economic Corridor (CPEC), TAPI Gas Pipeline Project

Social manners: Obligations on a Muslim for a Muslim, Golden principal to and lead a satisfied life and to control one's greed, What is righteousness? What is sin?, Emphasis on the respect of human sentiments, Awareness of a meal blessed with auspiciousness

Resources of Pakistan: Agriculture: Potential and Performance

Social manners: Manners of *salam* and greeting Muslims and non-Muslims, Manners regarding sneeze, eating, drinking, wearing cloths, putting on and off shoes and walking with shoes, Restriction of trailing garments arrogantly, Restriction of overspending
Resources of Pakistan: Industry: Problems and viable solutions
Qur'ān sciences: Miracles of the Holy Qur'an,Usul-e-Tafseer
State and Constitution of Pakistan: Objectives Resolution 1949
History of Hadith: Compilation of Hadith, A Brief Introduction of *Sihah Settah* and its compilers
State and constitution of Pakistan: Fundamental Rights in the Constitution of 1956 and 1962, Islamic Provisions of 1973 Constitution
Human Rights: Human rights, Rights of parents, Rights of relatives, Rights of neighbours, Women rights, Privacy
Foreign Policy of Pakistan: Definition and Concept of Foreign Policy, Determinants and Objectives of Foreign Policy
Islamic criminal law: Introduction to the criminal law of Islam, Concept of crime and punishment, Role of Islamic criminal law in eliminate crimes in the society, Classification of crimes in Islamic, Criminal Law: *Hudood* and *Tazirat, Qad'f* (false accusation), *Li'ān* (accusation of a wife of *zina*) , Zina (adultery, fornication), Drinking intoxicating liquors and narcotics, Theft, Dacoity androbbery, Rebellion, Murder, Retaliation, Apostasy
Relations with Neighbouring Countries: India, China, Afghanistan, Iran
Relations with Muslim World: Pakistan and Saudi Arabia, Pakistan and Turky,
Pakistan and Contemporary World: United Nations, America, Russia, Europe
Prophetic life as a role model: The Holy Prophet peace be upon him, as a role model, Life of the Holy Prophet (peace be upon him), after migration
Principles of Foreign Policy: Bilateralism, Non-Alignment, Peaceful Co-Existence, Nuclear Non-Proliferation
Islam and ethics: Ethical behavior of the Prophets, Impact of belief on Ethics, Concept of worship and manners/social relations in religion and their impact on ethics, Ethics and character building, significance of moral values Charity, Tolerance, Simplicity, Respect of mankind Social Etiquettes of meetings, eating and drinking and conversation, Right of people
Pakistan and Regional Organizations: SAARC, OIC, ECO, SCO

Recommended Books and Suggested Reading

1. Ma'arif Al-Qur'an
2. Tafheem Al-Qur'an
3. Tafseer Namoona
4. Tayasir Al-Qur'an
5. Zia Al-Qur'an
6. Dr. Ishtiaq Hussain Qureishi "Ulema in Politics"
7. Dr. Sarfraz Hussain Mirza, "Tahreek-i-Pakistan main Khawateen ka Kirdar"
8. Stanley Wolpert, "Jinnah of Pakistan"
9. M Hanif Shahid, "Quaid-i-Azam aur Akliyatain"
10. Murice Bucaile, "The Qur'an and Modern Science"
11. Harun Yahya, "Concept of Science based on the Qur'an"
12. Chaudhari, "Muhammad Ali Emergence of Pakistan"
13. Qudrat Ullah Shahab, "Shahab Nama"
14. Ibn-e-Qayyam, "Zad-ul-Muad"
15. Prof. Khurshid Ahmad, "Islami Nazriya-e-Hiyat"
16. Syed Maudoodi, "Al-Jihad Fil Islam"
17. Harun Yahya, "Quick Grasp of Faith"
18. Fazal-i-Karim Khan, "Pakistan Geography, Economy and People"

19. Safi ur Rehman, “Bulug Al-Maram: Chapter: *Al-Adab* Hadith 1 to 9”
20. Abdussalam bn Muhammad, “English commentary of Bulug Al-Maram”
21. Prof. Masood A Qureishi,”Pakistan Agricultural Management and Development”
22. Murice Bucaile, “The Bible, the Qur’an and Science”
23. Numan Ali Khan, “Ijaz ul Qur’an”
24. Ghulam Ahmad Hareri, “Tareekh Tafseer wa Mufassireen”
25. Taqi Usmani, “Uloom ul Qur’an”
26. Subhi Saleh, “Mubahis fi Uloom ul Qur’an”
27. G.W.Chaudhari,”Political and Constitutional Development of Pakistan”
28. Dr. Muhammad Hameedullah, “History of Hadith”
29. Dr. Mehmood Ahmad Ghazi, “Muhazarat-e-Hadith”
30. Abdurshid Nomani, “Tareekh Tadweene-Hadith “
31. Dr.Muhammad Hameedullah, “Khutabat-e-Bahawalpur”
32. Syed Maududi, “Human Rights in Islam”
33. Salah ud Din, “Bunyadi Huqooq”
34. Dr.Safadar Mahmood, “Constitutional Foundation of Pakistan”
35. S.M.Burke and Lawrence Ziring, “Pakistan’s Foreign Policy: An Historical Analyses”
36. Dr. Anwarullah, “The Criminal Law of Islam”
37. Abdul Qadir Uda, “Islam ka Fojdari Qanun”
38. Zafeer ud Din, “Islam ka Nazam-e-Iffat wa Asmat”
39. Dr. Safdar Mahmood, “International Affairs”
40. Hifz ur Rehman syoharwi, Ikhlaq and Falsafa Ikhlaq”

MATH-105 : Statistics 3 Credit Hours

CLOs

- Understand the techniques to interpret descriptive statistics numerically and graphically.
- Develop a relationship between two or more data sets, their strength of relation and their variation over time for prediction and forecasting.

Contents:

Introduction to Statistics, Variables, different types of variables, Data and its types, Numeric presentation of Quantitative and Qualitative variables, Frequency Distribution, Graphic Presentation of Quantitative and Qualitative Variables: Charts and Histograms. Basic Measures of Location: Mean, Median and mode, Basic Measures of Dispersion: Variance, Standard Deviation, Coefficient of Variation, The Chebyshev’s Result and its use. Simple Linear Regression. Coefficient of determination, Correlation, Rank of Correlation and its use. The Multiple Linear Regression, Multiple and Partial Correlations.

Text Book:

Devore J. L. and Kenneth N.B. (2012) "Modern Mathematical Statistics with Applications", (Second Edition) McGraw-Hill.

Reference Books:

- Introduction to Probability and Statistics for Engineers and Scientists, by Sheldon Ross, 8th Ed., AP, 2013.
- Probability, Random Variables and Stochastic Processes, by A. Popoulis and S. Unnikrishna Pillai, 4th Edition, McGraw Hill. 2002.
- Probability and Statistics for Engineers and Scientists, by Ronald E. Walpole, Raymond H. Myers and Sharon L. Myers, 9th Edition, AP, 2011.
- Freedman, Pissani and Purves, Statistics, 4th Ed., W.W. Norton & Co., 2007.

MGT100: INTRODUCTION TO BUSINESS

Course Objectives

- To build on the understanding of contemporary business and its environment; management, organization, marketing, and financing the organization. Coverage of the basic FSM laws and regulations in business ate also included.
- Explain what a business is and how it operates in a free market system. Discus the concept of social responsibility in business.
- Discuss inflation and unemployment and how monetary and fiscal policy are used to combat them. Differentiate between macroeconomics and microeconomics.
- Identify and explain the three basic forms of business ownership. Identify the levels of management and skills required for managerial success.
- List the major functions of marketing. Discuss how marketing's role in the exchange process creates utility.
- Explain the objectives of promotion and the concept of a promotional mix.
- Describe the functions of accounting and its importance to the firm's management and to outside parties such as investors, creditors, and government agencies.
- Identify the major categories of financial institutions and the sources and uses of those funds.

Course Learning Outcomes (CLOs)

The students will be able to:

- build on the understanding of contemporary business and its environment; management, organization, marketing, and financing the organization. Coverage of the basic FSM laws and regulations in business ate also included.
- Explain what a business is and how it operates in a free market system. Discus the concept of social responsibility in business.
- Discuss inflation and unemployment and how monetary and fiscal policy are used to combat them. Differentiate between macroeconomics and microeconomics.
- Identify and explain the three basic forms of business ownership. Identify the levels of management and skills required for managerial success.
- Describe the concept of human resource planning and outline the major steps involved in the process. Explain how each step in the recruitment and selection process contributes to finding the right person for the job.
- List the major functions of marketing. Discuss how marketing's role in the exchange process creates utility.
- List the components of the total product concept. Identify the types of consumer goods, industrial goods, and services.
- Explain the objectives of promotion and the concept of a promotional mix.
- Describe the functions of accounting and its importance to the firm's management and to outside parties such as investors, creditors, and government agencies.
- Identify the major categories of financial institutions and the sources and uses of those funds.

Course contents

- Contemporary business and its environment
- The structure of business
- Management and organization
- The human resource
- Marketing management
- Information for decision making
- Financing the enterprise

Reference books:

- Louis boone and david kurtz; contemporary business.dreden press 15th edition, 2013

Cy-111 Introduction to Analytical Chemistry

Sr. No.	CLOs	PLO
1.	The students will be able to understand various analytical process with respect to chemical reagents, standards, sampling and chemical measurements.	1
2.	The students will solve and study equilibrium conditions and various titrations and methods.	2

CONTENTS

Introduction: The Analytical Process, Chemicals and reagents, Use and handling of standards, sampling, chemical measurements.

Chemical Equilibrium: Fundamentals, Acids, and Bases, Activity and the Systematic Treatment of Equilibrium.

Monoprotic Acid-Base Equilibria, Polyprotic Acid-Base Equilibria, Acid-Base Titrations, (Complexation, Precipitation). EDTA Titrations, Gravimetric Analysis, Precipitation Titrations, and Combustion Analysis.

Introduction to Analytical Chemistry Lab:

1. Calibration of provided lab glassware such as pipette, burette, etc.
2. Calibration of lab instruments such as analytical balance, etc.
3. Determination of the strength of provided acid using acid-base titration.
4. Determination of Al^{3+} ions by gravimetric analysis.
5. Find out the molarity of provided acid/base and also calculate SD and RSD in accordance to the reference values.
6. Quantitative determination of silver in the provided solution using gravimetric titration.
7. Determine heat of solution of the provided salt using calorimeter.
8. Determine heat of neutralization of provided acid and base using calorimeter.

Recommended Books

1. Kuhn, H., Forsterling, H. D., Waldeck, D. H., “Principles of Physical Chemistry” 2009, John Wiley & Sons.
2. Analytical Chemistry, G.L. Hargis, Prentice Hall Inc. 2000.
3. Analytical Chemistry, G.D. Christian, J. Wiley 6thEd. 2003
4. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, FJ. Holler 7th Ed. Harcourt Asia 2001.
5. Richard M Pashley; Marilyn E Karaman. “Applied Colloid and Surface Chemistry”. John Wiley and Sons, Ltd.2004.

CY-141 Biochemistry and Biotechnology

CLOs	PLOs
Students will be able to demonstrate an understanding of biological macromolecules, functions mechanism and regulatory pathways.	1
Students will be able to demonstrate an understanding of physical chemistry and molecular structures that underline the biochemical processes.	2
Students will be able to demonstrate basic knowledge of biotechnology and its industrial applications	4

COURSE CONTENTS:

Biological Chemistry
Macromolecules, Biomolecules, Biological membranes and functions, Metabolic pathways and their regulations, Cell biology

Biophysical chemistry
Physical chemistry and molecular structures that underline biochemical processes (Thermodynamics, molecular structure and stability and biophysical methods)

Biotechnology
Basics of biotechnology, Cell and Tissue Culture, Bioprocess Engineering and Technology and its application in industry and environment.

Text Book:
Biochoemistry,Berg, J. M., Tymoczko, J. L., Strye, L., W. H Freeman and Co **(2002)**

Books Recommended
1. Biochemistry, Molecular Biology and Biotechnology, Gajera,H. P., Patel, S. V., Golakiya, B. A., New Indian Publishing Agency **(2015)**
2. Text Book of Biotechnology, Das, H. K., Wiley **(2010)**
3. Biochoemistry, Berg, J. M.,Tymoczko, J. L., Strye, L., W. H Freeman and Co **(2002)**
4. Principles of Biochemistry, Nelson, D. L., Cox, M. M.,W. H. Freeman and Co **(2005)**
5. Biochemistry, Biomolecules Mechanisms and Enzyme Action and Metabolism, Voet,D., **(2003)**
6. Principles and Techniques for Practical Biochemistry, Wilson, K., Walker, J., , Cambridge University Press **(2000)**

BS2nd Year
SEMESTER III

MATH-203 & MATH 203L Scientific Programming 2+1 Credit Hours

Contents:

Introduction to MATLAB, Working with MATLAB variables, Working with matrix and scalar operations, Creating functions, Understanding performance considerations, Building basic plots, Creating responsive programs, Editing variables manually, Working with the different Toolboxs. Numerical examples using MATLAB.

Text Book:

D. Hanselman and R. Littlefield, Mastering MATLAB 7, 5th Ed., Prentice Hall, **(2012)**

Reference Books:

1. Gilat, MATLAB: An Introduction with Applications, 5th Ed., Jhon Wiley **(2014)**
2. Edward B. Magrab et al.An Engineer's Guide to MATLAB, 3rd Ed., Prentice Hal, **(2000)**
3. E. Delores, Introduction to MATLAB for Engineers and Scientists, 3rd Ed., Prentice Hall, **(1995)**
4. R. PratapGetting Started with MATLAB 5, A Quick Introduction for Scientists and Engineers. Oxford University Press **(1988)**
5. Joe King, Matlab for Engineers, Addison-Wesley Pub Co, **(1988)**

CLOs

- Understand the basic Matlab computations to generate plots, and write programs to solve basic mathematical problems.
- Apply numerical techniques to solve system of equations and differential equations.

CY-212 Analytical Chemistry-I

Sr. No.	CLOs	PLO
1.	The students will get the practice of various Titration curves	1
2.	The students will be able to solve and study the analytical signals and measurement processes.	2

Titration curves for complex Acid/Base Systems

Mixtures for strong and weak acids or strong and weak bases

Polyfunctional Acids and Bases

Buffer solutions involving polyprotic acids

calculations of pH of solution of NaHA

Titration curves of polyfunctional Acids

Titration curves of polyfunctional bases

Titration curves for amphiprotic species

Measurement processes:

Definition, Preliminary operations, sample treatment.

Measurements and transducing of analytical signals:

Signal acquisition and data processes:

Practical:

1. Determination of transition temperature of provided sample.
2. Determination of alkalinity/acidity, conductivity and refractive index of provided water sample.
3. Purification of Solids By recrystallization
4. Determination of melting and Boiling point of Solids and Liquids.
5. Find out the strength of copper in the provided sample using AAS.

Text Book: Principle of Analytical Chemistry, A text book by Valcarcel , Miguel. Springer publisher. 2000.

Recommended Books:

1. Fundamentals of Analytical Chemistry 9th Edition By Skoog, West and Holler, Saunders College Publishing, **(2016).**
2. Introduction to spectroscopy; A Guide for Students as organic chemistry 5th Edn. By D. L. Pavia, G. M. Lampman and G. S. Kriz , J. A. Vyvyan **(2014)**.
3. Textbook of Practical Analytical Chemistry, 1st Edition by Mumtaz Alam **(2010)**.
4. Handbook of Practi al X-Ray Fluorescene Analysis by Beckhoff,B, Kanngießer, B.,Langhoff, N., Wedell, R., Wolff, H**. (2006)**

CY-251: PHYSICAL CHEMISTRY-I

CLOs	PLOs
To understand the Physical properties of liquids.	1
To enable the students to differentiate classical and quantum mechanics based on various principles and hypotheses.	2
To demonstrate the basics of chemical kinetics and effect of various parameters on kinetics of various chemical reactions.	1

Course contents:

Physical States of Matter:

Ideal and real gases, equations of state, critical phenomenon and critical constants. Physical properties of liquids: surface tension, viscosity, refractive index etc. and their applications. Brief account of interactions among the molecules in liquids.

Photochemistry: Principles of photochemistry. Laws of photochemistry. Einstein's law of photochemical equivalence. Rates of intermolecular processes. Chemical reactions and their quantum yields. Hydrogen-bromine and hydrogen-chlorine reactions.

Chemical Kinetics:

Rate of reaction. Rate law, order and molecularity of the reactions. Zero and first order reactions. Determination of reaction order and its rate constant. Effect of temperature on the reaction rate. Concepts of chemical equilibrium. Le-Chatelier's principle and its applications.

Quantum Chemistry:

Limitation of classical mechanics, Wave and particle nature of matter, de Broglie's equation, Heisenberg's uncertainty principle, Wave equation, interpretation of wave functions, properties of wave function.

PRACTICAL:

1. Determination of viscosity and parachor values of liquids.
2. Determination of percent composition of liquid solutions viscometrically.
3. Determination of refractive index and molar refractivity.
4. Determination of molecular weight of a compound by elevation of boiling point (ebullioscopic method).
5. Determination of molecular weight of a compound by lowering of freezing point (cryoscopic method).
6. Determination of heat of solution by solubility method.
7. Determination of heat of neutralization of an acid with a base.
8. Molar mass determination of high polymer by viscosity measurement.

Text Book

Atkins' Physical Chemistry, Atkins, P and Paula, J.D., OUP Oxford, **(2014)**

Recommended Books:

1. Atkins' Physical Chemistry, Atkins, P and Paula, J.D., OUP Oxford, **(2014)**
2. Chemical Kinetics and Reaction Mechanism, 2nd Ed, Espenson, J. H., McGraw Hill **(2002)**
3. Physical Chemistry, 4th Ed, Laidler K.J., John, H.M. and Bryan C.S., Houghton Mifflin Publishing Company Inc.**(2003)**
4. Quantum chemistry,5th Ed, Levine, I., Pearson education **(2000)**

5. Physical Chemistry, 17th Ed, Alberty R., John Wiley and Sons **(1987)**
6. Physical Chemistry, 6th Ed, Atkins, P.W., W.H. Freeman and Co. New York **(1998)**
7. The World of Physical Chemistry, 1st Ed, Laidler K.J., Oxford University Press **(1993)**
8. Radiation Chemistry, Hughes G., Oxford Series, UK **(1973)**
9. Quantum chemistry, 4th Ed, Chandra, A. K., TataMcGraw Hill **(1994)**
10. Experimental Physical Chemistry, Jaffar M., University Grants Commission **(1989)**
11. Findlay's Practical Physical Chemistry,9th Ed, Levitt B.P., Longman Group Limited **(1978)**
12. Experiments in Physical Chemistry, 5th Ed, Shoemaker D., McGraw Hill Publishing Company Limited **(1989)**

CY-222: INORGANIC CHEMISTRY-I

CLOs	PLOs
Students will be able to know types of Chemical bonding and interactions	1
Students will be able to classify the conventional concepts of Acid and Base	1
Students will be able to infer the knowledge of basic reactions for new synthesis	2

Course contents:

Coordination Chemistry

Introduction, Nomenclature, Various types of Bonding Models: VBT, CFT, and MOT
Concept of Chelating Agents and various Chelates.

Acid-base and donor-acceptor chemistry

History, Major Acid-Base Concepts (Arrhenius Concept, Broensted-Lowry Concept, Solvent System Concept, Lewis Concept, Frontier Orbitals and Acid-Base Reactions, Charge Transfer. Hard and Soft Acids and Bases (Theory of Hard and Soft Acids and Bases, Quantitative Measures), Acid and Base Strength (Measurement of Acid-Base Interactions, Thermodynamic Measurements, Proton Affinity, Acidity and Basicity of Binary Hydrogen Compounds, Inductive Effects, Steric Effects, Strength of Oxyacids, Acidity of Cations in Aqueous Solution, Solvation and Acid-Base Strength, Nonaqueous Solvents and Acid-Base Strength, Super acids.

PRACTICAL:

1. Complexometric Titrations:
   Cu^{2+}/Ni^{2+}; Ca^{2+}/Ba^{2+};Zn^{2+}/Pb^{2+};Cd^{2+}/Zn^{2+};$Ni^{2+}/Mg^{2+}/Zn^{2+}$
2. Estimation of Ions:
   Chloride/Phosphate; Chloride/Nitrate; Bromide/Nitrate; Iodide/Nitrate;Borate/ Acetate; Oxalate/ Chloride; Sulphate/Phosphate
3. KIO_3 Titrations: (Any two exercises)
4. Gravimetric estimations:
   Estimations of Ba^{2+}, Zn^{2+}, Ni^{2+} Oxalate ions, etc.

Text Book

Inorganic Chemistry, 5thEd, P. Atkins, T. Overton, M. Wheeler, Oxford University Press **(2010)**

Recommended Books:

1. Inorganic Chemistry, 5th Ed, Miessler, G. L., Fischer, P. J. and Tarr, D. A., Harlow : Pearson Education Limited, **(2014)**
2. Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed, Huheey, J. E., Keiter, E. A. and Keiter, R. L., Harper and Row, New York, **(2001)**

3. Chemicals Principles, Atkins, P. and Jones, L., Freeman and Company, **(2002)**
4. New Materials, Process and Methods Technology, Schwartz,M.,, CRC Press, New York **(2006)**
5. Basic Inorganic Chemistry, 3rd Ed, Cotton, F. A., Wilkinson, G. and Gaus, P. L., Wiley, New York**(1995)**
6. A New Concise Inorganic Chemistry, 5th Ed, Lee, J. D., Chapman and Hall, London**(1996)**
7. Modern Inorganic Chemistry, Aggarwal, R. C., Kitab Mahal, Allahabad**(1987)**
8. Basic Inorganic Chemistry, 3rd Ed,Cotton, F. A., Wilkinson, G. and Paul L. Gaus, John Wiley and Sons, New York.**(1995)**
9. A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis, Vogel, A. I., Longman Green and Co. **(1995)**
10. Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, 4th Ed, Bassette, J., Denney, G. H. and Mendham, J., English Language Book Society, **(1981)**

CY-261: ORGANIC CHEMISTRY-I

CLOs	PLOs
Students will learn about the basic organic chemistry with emphasis on reactions and reactivity	1
Students will be able to understand various functional groups in organic chemistry and their reactions	2

Course Contents:

Basic Concepts of Organic Chemistry:

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

Chemistry of Hydrocarbons:

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

Chemistry of Functional Groups:

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

CY-261L: ORGANIC CHEMISTRY-I (LAB)

CLOs	PLOs
Students will be able to separate and analyze various organic compounds from binary mixtures	3
Students will be able to identify various functional groups in organic chemistry and their reactions	2

List of Experiments:

1. Qualitative analysis of two component mixtures:
   (at least six mixtures to be analyzed).
2. Quantitative analysis:
   Carboxylic acids, phenols, sugars, amides, carbonyls, amines
3. Purification techniques:
   Fractional distillation, steam and vacuum distillation, fractional crystallization

Text Book

Organic Chemistry, 8th Ed, John, E. M., Brooks/Cole Publishing Co, USA, **(2012)**

Recommended Books:

1. Introduction to Organic Chemistry, 3rd Ed, Brown, W. and Poon, T., John-Wiley and Sons, Inc., **(2005)**
2. Organic Chemistry, 8th Ed, John, E. M., Brooks/Cole Publishing Co, USA, **(2012)**
3. Organic Chemistry, 6th Ed, Robert, T. M. and Robert, N. B., Prentice Hall, New Jersey, **(1992)**
4. A Textbook of Organic Chemistry, Younus, M., , Ilmi Kitab Khana, Urdu Bazar, Lahore, Pakistan, **(2006)**
5. A Guide Book to Mechanism in Organic Chemistry, 6th Ed, Sykes, P., Pearson Education Limited, England, **(1986)**
6. Organic Chemistry, 10th Ed, Solomons, T. W. G. and Fryhle, C. B., John-Wiley and Sons, Inc., **(2011)**
7. Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Furniss, B. S., Hannaford , A. J., Smith, P. W. G., Tatchell, A. R., Longman, UK, **(1989)**
8. A Microscale Approach to Organic Laboratory Techniques, 5th Ed, Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., Brooks/ Cole Cengage Learning, **(2013)**
9. Microscale Organic to Laboratory with Multistep and Multisacle Syntheses, 5th Ed, Mayo, D. W., Pike, R. M. and Forbes, D. C., John-Wiley and Sons, Inc., **(2011)**
10. Experimental Organic Chemistry: A Miniscale and Microscale Approach, 5th Ed,Gilbert, J. C. and Martin, S. F., B rooks/ Cole Cengage Learning, **(2010)**
11. Organic Chemistry, 6th Ed, Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., Brooks/ Cole Cengage Learning, **(2012)**
12. Experimental Organic Chemistry-A Small Scale Approach, 2nd Ed. Charles F. W. Jr. and Mary F. Wilcox, M. F., Prentice Hall, New Jersey, **(1995)**
13. Advanced Practical Organic Chemistry 2nd Edn. by Leonard J., Lygo B. and Procter G., Blackie Academic and Professional, London, **(1993)**
14. Microscale and Macroscale Techniques in Organic Chemistry by Pavia, D. L., Brooks Cole Publishers,**(2002)**
15. Advanced Practical Organic Chemistry, Vishnoi, N. K., Vikas Publishing House, **(1979)**

CY-201: ENVIRONMENTAL SCIENCES

CLOs	PLOs
Will educate students about the main chemical changes in the Atmosphere	1
Students will learn about sources of Water Pollution, Water Quality and various Water Treatments	2
Students will learn Energy Production and Environment and concept of Renewable Energy	3

Course contents:

Atmospheric Chemistry:

The air around us, atmospheric temperature and pressure profile, Temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, radioactivity, atmospheric aerosols, Acid rain –major sources, mechanism, control measures and effects on buildings and vegetation, Global warming – major green house gases, mechanism, control measures and global impact, The stratospheric ozone – the ozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

Water Pollution and Water Treatment:

Sources of water pollution-industrial sources and agricultural sources, heavy metals contamination of water, Eutrophification, detergents and phosphates in water, water quality criteria, Water purification – primary, secondary and advanced treatment, Removal of nitrogen and phosphorous compounds from polluted water, organic matter in water and its decomposition.

Soil Pollution:

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

Green Revolution:

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

Energy Production and Environment:

Liquid and gaseous fuel, hydrogen economy.

Renewable Energy:

Nuclear energy, solar energy, geothermal and tidal energy.

Text Book

Environmental Science: Toward A Sustainable Future, 13th Ed, Richard T. W., Dorothy F. B., Pearson, **(2017)**

Recommended Books:

1. Fundamentals of Environmental chemistry, 9th Ed, Stanley E. M., CRC press, **(2009)**
2. Environmental science living within the system of Nature, 3rd Ed, Charles E.K., Prentice Hall, **(1993)**
3. Environmental science earth as a living Planet, Botkin, D.B., Keller, E. A., John Willey and Sons, Inc, **(1995)**
4. Environmental Chemistry, 7th Ed, Kumar, A., New Age International (Pvt.) Ltd, Publishers, **(2010)**
5. Environmental Chemistry: A Global Perspective, 3rd rev. Ed,Van Loon, G. W., Stephen J. D., Oxford university press, **(2010)**
6. Soil and Environmental Chemistry, Bleam, W. F., Academic Press, **(2011)**

BS2nd Year
SEMESTER IV

CY-213 Analytical Chemistry-II

Sr. No.	CLOs	PLO
1.	The students will be able to corelate the qualitative information of various reactions.	**3**
2.	The students can learn different analytical schemes as well as the automated instrumental analysis.	**2**

COURSE CONTENTS

Automation Measurement Analysis

Introduction, Principles of automation, Automated Instruments, Process Control, Automatic Instruments, Flow injection Analysis, Application of Automation in various industries, Advantages of Automated methods of analysis, social impact, feasibility of Automated methods of analysis.

Semi micro analytical techniques, Dispensing Reagent Solutions, Quantitative Versus Qualitative Analysis, Analytical features, types of qualitative identification, classical qualitative analysis

Analytical Chemistry-II LABORATORY:

1. Determination of percentage composition of provided analyte solution using spectrophotometric analysis.
2. Qualitative analysis of selected organic compounds.
3. Quantitative analysis of selected organic compounds.
4. Different Purification techniques.
5. Separation of colored ions using column chromatography.
7. Preparation of stock and standard solutions for instrumental analysis.
8. Find out concentration of provided colored ion solution using uv/vis spectrophotometer.
9. Applications of buffer solutions

CY-253: PHYSICAL CHEMISTRY-II

CLOs	PLOs
To comprehend the molecular interactions in gases, solid state systems and various methods to describe the crystal systems.	1
To demonstrate the central concepts and principles of quantum mechanics.	2
To describe the adsorption phenomena occurring upon the surface and the role of catalysts in industry.	1

Course contents:

Physical states of Matter

Molecules in motion: collision diameter and mean free path. Brief account of interactions among the molecules in liquids. Method for the determination of the Avogadro number (N_A). Packing of atoms in solids. Unit cells and crystal systems. Method of crystal structure analysis.

Quantum Chemistry:

Schrodinger wave equation and its solution for particle in 1-D box. Eigen function, Eigen value. Orthogonal and normalize wave functions. Operators: Linear and non-linear operators, commutator of operators. Concept of quantization of energy and degeneracy.

Surface Chemistry:

Concept of interfaces. Adsorption and adsorption isotherms: Freundlich and Langmuir adsorption isotherms. Catalysis, colloids emulsion and their industrial applications.

Electrochemistry:

Basic concepts of electrochemistry. Conductance, Kohlrausch's law. Measurement of conductance and Application of conductance measurement. Redox potentials and chemical reactions, cell potential, electrochemical cells and its types. Types of electrodes, Nernst's equation and its application.

PRACTICAL:

1. Conductance measurements and verifications of Ostwalds dillution law.
2. Conductometric titrations.
3. Determination of distribution coefficient and verification of Distribution law.
4. Transition temperatures.
5. Gas analysis.
6. Determination of Eutectic temperature and Eutectic composition of a binary system by cooling curve method.
7. Degree of dissociation of week electrolytes.
8. Determination of activity coefficient from e.m.f. measurement.

Text Book

Physical Chemistry, 4th Ed, Laidler K. J., John H. M., and Bryan C. S., Houghton Mifflin Publishing Company Inc., **(2003)**

Recommended Books:

1. Quantum Chemistry, 6th Ed, Levine, I. N., John Wiley and Sons, **(2008)**
2. Physical Chemistry, 4th Ed, Laidler K. J., John H. M., and Bryan C. S., Houghton Mifflin Publishing Company Inc., **(2003)**
3. Electrochemical Methods: Fundamentals and Applications,2nd Ed, Bard, A. J. and Faulkner, L. R., John Wiley and Sons, **(2000)**
4. Physical Chemistry, 6th Ed, Atkins, P.W., Freeman and Co. New York, **(1998)**
5. The World of Physical Chemistry, Laidler K.J., Oxford University Press,**(1993)**
6. Physical Chemistry, 5th Ed, Barrow G. M., McGraw Hill, **(1992)**
7. Physical Chemistry, 17th Ed, Alberty R.,John Wiley and Sons, **(1987)**
8. Experimental Physical Chemistry, Jaffar M., University Grants Commission, **(1989)**
9. Findlay's Practical Physical Chemistry, 9th Ed, Levitt B.P. Longman Group Limited **(1978)**
10. Experiments in Physical Chemistry, 5thEd., Shoemaker D.,McGraw Hill Publishing Company Limited, **(1989)**

CY-223: INORGANIC CHEMISTRY-II

CLOs	PLOs
Students will know the basics of Coordination Chemistry	1
Students will be able to compare characterization methods for Coordination Complexes	2
Students will be able to demonstrate the usage of non-aqueous solvents	2

Course contents:

Structure and Properties of Coordination Compounds

Historical back ground of coordination compounds, geometry of complexes having coordination number 2 to 9, nomenclature, theories of coordination compounds; Werner's theory, valence bond theory, crystal field and; molecular orbital theory; Jahn-Teller theorem; magnetic properties; spectro chemical series, isomerism and stereochemistry, stability constants, techniques for studying complexes, applications of coordination compounds.

Non-Aqueous Solvents

Classification of solvents, types of reactions in solvents, effect of physical and chemical properties of solvent, detailed study of liq. NH_3, liq. H_2SO_4, liq HF, and liq. SO_2, BrF_3 and reaction in molten salts system.

PRACTICAL:

1. Preparation of at least four coordination compounds in a pure state
2. Complexometric titrations
3. Semi-micro analysis and Separation of anions in a mixture by paper chromatography
4. Preparation of Selected Inorganic compounds and their characterization by instrumental methods

Text Book

Inorganic Chemistry, 5thEd, P. Atkins, T. Overton, M. Wheeler, Oxford University Press **(2010)**

Recommended books:

1. Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed, Huheey, J. E., Keiter, E. A. and Keiter, R. L., Harper and Row, New York, **(2001)**
2. Basic Inorganic Chemistry, 3rd Ed, Cotton, F. A., Wilkinson, G. and Gaus, P. L., Wiley, New York, **(1995)**
3. Chemicals Principles, Atkins, P. and Jones, L., Freeman and Company, **(2002)**
4. A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis, Vogel, A. I., Longman Green and Co. **(1995)**
5. Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, 5th Ed, Bassette, J., Denney, G. H. and Mendham, J., English Language Book Society, **(2000)**
6. Basic Inorganic Chemistry, 3rd Ed, Cotton, F. A., Wilkinson, G. and Gaus, P. L., Wiley, New York, **(1995)**

CY-262: ORGANIC CHEMISTRY-II (THEORY)

Course Contents:

CLOs	PLOs
Students will be able to define the properties of organic compounds	1
Students will categorize the organic compounds on the basis of their structure and properties	2

Stereochemistry

Optical activity and chirality: Symmetry element and optical inactivity, Optical isomerism in compounds containing up to three asymmetric carbon atoms. Concept of R- and S-configurations. Asymmetric synthesis. Racemization. Epimerization. Walden inversion. Resolution of racemic mixture, Stereoisomerism of cyclic, diphenyl, allene and spiro compounds. Geometrical isomerism: Concept, determination of configuration of geometrical isomers, E- and Z- configurations, Geometrical isomerism in cyclic systems. Concept of conformational isomerism. Conformational analysis of organic molecules.

Oxidation and Reduction

Oxidation: oxidation of hydrocarbons, alcohols, carbonyl, nitro, nitroso, azo, enthylene group, aromatic side chain, amines, hydrazine and sulphides. Oxidation involving cleavage of carbon-carbon single and double bonds. A detail study of various oxidation reactions.

Reduction: Reduction of hydrocarbons, carbonyl compounds, nitro, nitroso, azo and oxime groups. Hydrogenolysis. Stereochemistry and mechanisms. Reduction by hydride transfer, $LiAlH_4$, NaBH4, diisobutyl aluminium hydride, cyanoborohydride, trialkylborohydride, Wolf-Kishner and other reductions; selectivity of reductions. A detail study of various reduction reactions.

Acids and Bases:

Concept and theories of acids and bases, Predicting acid base reactions and pKa, The effect of structure, medium, hydrogen bonding, hybridization and steric factors on the strength of acids and bases. Effect of structure on acid-base equilibria. Resonance and inductive effects on acidity and basicity. Linear free energy relationship; the Hammett Equation and Taft's Equation, their applications and limitations

CY-208L: ORGANIC CHEMISTRY-II (LAB)

CLOs	PLOs
Students will be able to separate and identify two component mixtures	2
Students will prepare organic compounds using simple organic reactions	3

1. Experiments using polarimeter such as to determine optical activity of a sugar solution and to determine sugar concentration by polarimeter, isomerization of maleic acid.
2. Experiments involving aliphatic addition, elimination and substitution reactions, e.g., synthesis of cyclohexene from cyclohexanol, addition reaction to cyclohexene etc.
3. Synthesis those explaining the concept of condensation and dehydration, n-alkylation of phthalimide etc.

Text Book

March's Advanced Organic Chemistry, Reactions, Mechanisms, and Structure Michael B. Smith, March, J., John Wiley and Sons, **(2007)**

Recommended Books:

1. Organic Chemistry, Clayden, J., Greeves, N., Warren, S., OUP Oxford, **(2012)**
2. Organic Chemistry, 4th Ed, Bruice, P. Y., Prentice Hall International, New Jersey, **(2003)**
3. Organic Chemistry, 6th Ed, Morrison and Boyd, Perason Education, **(2003)**
4. Organic Synthesis Concepts and Methods, 3rd Ed, Corey, E. J., Willey, **(2003)**
5. Organic Chemistry, 4th Ed., Loudon, G. M., Oxford University Press, **(2002)**
6. Modern Synthetic Reactions, 2nd Ed, Herbert O. H., W. A. Benjamin Inc. Menlo Park, California, **(1972)**
7. Principles of Organic Synthesis, 3rd Ed, Norman, R. O. C. and Coxon, J. M., Blakie Academic and Professional NY, **(1993)**
8. A Guide to Mechanisms in Organic Chemistry, Sykes, P., Longman Scientific and Technical, New York, **(1987)**
9. A Microscale Approach to Organic Laboratory Techniques, 5th Ed, Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., Brooks/ Cole Cengage Learning, **(2013)**
10. Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Furniss, B. S., Hannaford , A. J., Smith, P. W. G., Tatchell, A. R., Longman, UK, **(1989)**

CY-203: Workplace Hazardous Materials Information

CLOs	**PLOs**
Students will be able to understand basic knowledge of Labels, Supplier labels, Work site labels, Material Safety Data Sheets (MSDSs), Preventive Measures, First Aid Measures, Student Education	2
Training of the students on Laboratory Chemical Storage**,** Material Safety Data Sheet	5

Course contents:

Workplace Hazardous Materials Information

Labels, Supplier labels, Work site labels

Application

About WHMIS, Supplier and Importer Requirements - Overview / Program Objectives, Classification, Labels (Supplier and Importer), Material Safety Data Sheets (MSDSs), Students Requirements, Material Safety Data Sheets (MSDSs), Preventive Measures, First Aid Measures, Student Education

Training of the students on

Laboratory Chemical Storage, Material Safety Data Sheet, WHMIS CONTROLLED PRODUCTS LABEL

Text Book

Workplace Hazardous Materials Information System (WHMIS): A Guide to the Legislation,Ministry of Labour, Ontario, Canada, **(2009)**

Recommended Books/Readings:

Reading of various MSDS of various companies

WHMIS skills manual, Theisen, Eric, **(1994)**

CY-204: Energy Resources of Pakistan and its Management

CLOs	PLOs
Students will learn various types of Fuels	5
Students will learn ways to manage Energy in a better way	4
Students will learn to formulate policies and planning for the use of Fuel and Energy at National level	3

Course contents:

Energy Resources of Pakistan

Coal Resources, Natural Gas Resources, Oil Resources, LPG (Liquid Gas), Hydro Electric Resources, Nuclear Power

Energy management

Saving energy in businesses, public-sector/government organizations, and homes
Metering energy consumption and collecting the data. Finding opportunities to save energy, quantify routine energy waste management.

National Energy Policy and Planning

Demand and supply side planning, indigenous resources and strategies for imports of energy, Linkages of Energy Plans with other infrastructure sector. Policies for attracting investment by Independent Power Producers (IPPs) based on fossil fuels, renewable energy development, gas and coal sector.

Energy Conservation and Environments

Energy Conservation, measures for conservation of energy. Focus on energy demand and consumption in household commercial, industrial and transport sectors. Energy intensities, consumer's education about energy efficiency, Energy and Environment i.e environmental effects of energy production.

Text Book

Energy Studies, Shepherd, D. W., Imperial College Press, **(2003)**

Recommended Books

1. Energy Management Handbook, Wayne C. T., The Fairmont Press, Inc., **(2007)**
2. Energy Studies, Shepherd, D. W., Imperial College Press, **(2003)**
3. Problems and Solutions: Energy Studies, Shepherd, D. W., World Scientific Publishing, River Edge, NJ, (1998)
4. Energy and the Environment, 2nd Ed, Robert A. R, Kraushaar, J. P, John Wiley and Sons, **(2006)**

MATH-205: Ordinary Differential Equations 3 Credit Hours

CLOs

1. Develop the ability to model real world situations with appropriate differential equations and interpret solutions.
2. Apply different methods to solve ordinary differential equations.

Contents:

Introduction to differential equation basic definitions and terminology. First order differential equations Separable, Exact equations, Homogeneous equations, first order linear equations

with applications. Some nonlinear differential equation with known solutions, Modeling Exponential growth and decay, Half-life, Newton law of cooling, series circuits.

Differential equation of higher order: Homogenous equations, Non homogeneous equations Higher order linear equations with constant coefficients, Modeling Damped motion in mechanical and electrical systems.

Power series solution: Solution about ordinary points and singular points, Frobinious method. Generating function, Recurrence formulas, Orthogonality, Bessell's differential equation, Bessell functions of first and second kind,

System of first order Linear equations, Laplace Transformation, Laplace transform of elementary functions, Laplace transform theorems, Inverse Laplace transform, applications to the solutions of initial value problems, Convolution theorem.

Text Book:

N.A. Shah, Ordinary Differential Equations, 2nd Ed., A One Publisher, Urdu Bazar, Lahore, 2016.

Reference Books:

- W. E. Boyce, and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems 11th Ed., John Wiley & Sons, 2016..
- A Textbook on Ordinary Differential Equations, S, Ahmad, A. Ambrosetti, Springer 2014.
- D. G. Zill and M. R. Cullin, Differential equations with boundary-value problems, 8th Ed., Brooks/Cole., 2012/
- Erwin Kreyszig, Advanced Engineering Mathematics 10th Edition.

BS 3rd Year
SEMESTER V

CY-314: ANALYTICAL CHEMISTRY-III

Analytical Chemistry-III

Sr. No.	CLOs	PLO
1.	The students will be able to analyze the different compounds gravimetrically.	**4**
2.	The students can identify and quantify the components.	**2**

Gravimetric methods of analysis:

Overview of gravimetric methods using mass as signal, Types of gravimetry, Conservation of mass,

Precipitation gravimetric: Theory, Quantitative and qualitative application, Evaluating precipitation gravimetry.

Volatilization gravimetry: Theory, Quantitative applications, Evaluating volatilization gravimetry.

Particulate gravimetry: Theory, quantitative applications, evaluations.

Analytical Chemistry-III Laboratory:

1. Gravimetric Determination of the Iodide Ion Content in a Mixture.
2. Determination of thiosulfate concentrations by gravimetric analysis.
3. To determine the chlorine content of an unknown soluble chloride salt.
4. To find the amount of an aqueous ionic compound using precipitation gravimetry.
5. Determine the concentration of sulfate ion gravimetrically by precipitation with barium chloride.

Text Book.

Vogel's Textbook of Quantitative Chemical Analysis, 5th Edition. 2017.
Analytical Chemistry (7th edition) by Gary D. Christian, Purnendu K. (Sandy) Dasgupta and Kevin A. Schug in pdf. published by John Wiley and Sons, Inc. **(2014)**

Recommended Books:

1. Fundamentals of Analytical Chemistry 9th Edition By Skoog, West and Holler, Saunders College Publishing, **(2016).**
2. Introduction to spectroscopy; A Guide for Students as organic chemistry 5th Edn. By D. L. Pavia, G. M. Lampman and G. S. Kriz , J. A. Vyvyan **(2014)**.
3. Textbook of Practical Analytical Chemistry, 1st Edition by Mumtaz Alam **(2010)**.
4. Handbook of Practi al X-Ray Fluorescene Analysis by Beckhoff, B., Kanngießer, B., Langhoff, N., Wedell, R., Wolff, H**. (2006)**

CY-324: INORGANIC CHEMISTRY-III (THEORY)

CLOs	PLOs
Students will be able to develop basic knowledge of Inorganic Synthetic routes	2
Students will learn Experimental Evidence in Octahedral Substitution, Stereochemistry of Reactions, Substitution Reactions of Square-Planar Complexes, Reactions	2
Students will be able to plan synthesize inorganic compounds like: M(ac ac) complexes, $KMNO_4$, CuO, Barium nitrate, Lead carbonate, Lead oxide, Lead tetra oxide.	3

Course contents:

REACTIONS AND MECHANISMS

History and Principles, Substitution Reactions, Kinetic Consequences of Reaction Pathways, Experimental Evidence in Octahedral Substitution, Stereochemistry of Reactions, Substitution Reactions of Square-Planar Complexes, The *trans* Effect, Oxidation-Reduction Reactions, Reactions of Coordinated Ligands

INORGANIC CHEMISTRY-III (PRACTICALS)

Preparation of Inorganic Compounds: M(ac ac) complexes, $KMNO_4$, CuO, Barium nitrate, Lead carbonate, Lead oxide, Lead tetra oxide.

Text Book

Inorganic Chemistry, Principles of Structure and Reactivity, 4th Edition, Huhey, by J. E., Dorling Kindersley Pvt Ltd. **(2010)**

Recommended Books:

Inorganic Chemistry, 5thEd, P. Atkins, T. Overton, M. Wheeler, Oxford University Press **(2010)**

1. Advanced Topics in Crystallization by YitzhakMastai, InTechOpen (**2015**).
2. Ion Exchange - Studies and Applications by Ayben Kilislioglu, InTechOpen **(2015).**
3. Vogel's Qualitative Inorganic Analysis, 7th Ed., Svehla, G., Prentice Hall **(2013).**
4. A Manual for the Chemical Analysis of Metals by Thomas R. Dulski, ASTM Manual Series **(2012)**

CY-363 ORGANIC CHEMISTRY-III (THEORY)

CLOs	PLOs
Students will learn the chemistry of important organic reactions with special emphasis on the named organic reactions, elimination and pericyclic reactions	1
Students will be able to describe the chemistry of amino groups	3

CONTENTS:

Named Organic Reactions

Conditions mechanism and synthetic applications of the following reactions:
Aldol condensation and related reations, Arndt-Eistert, Baeyer-Villiger, Beckmann, Cannizzaro, Claisen, Claisen-Schmidt, Curtius, Daikin, Darzens, Dieckmann, Diels-Alder [4+2]-cycloaddtion, Favorskii, Fries, Gabriel, Hofmann, Knoevenagel, Lossen, Mannich, Michael, Perkin, Reformatsky, Schmidt, Stobbe, Wagner-Meerwein, Wittig.

Chemistry of Amino Group
The structure of aliphatic and aromatic primary, secondary and tertiary amines. Physical and chemical properties of amines, basicity and nucleophilicity of amines. Synthesis and reactions of amines with detailed mechanisms. Diazonium salts: Preparation and their synthetic applications.

Elimination Reactions:
Study of E1, E1cB and E2 mechanisms; Saytzeff and Hofmann Rules; The effects of the substrate structure, attacking base, leaving group and the reaction medium on the rates and mechanisms of elimination reactions; competition between elimination and substitution reactions.

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

ORGANIC CHEMISTRY-III (PRACTICAL)

CLOs	PLOs
Students will be able to separate and identify three component mixtures	2
Students will prepare organic compounds to understand the mechanism involved	3

1. Qualitative analysis of three component mixture
(at least six mixtures to be analyzed)
2. Separation techniques and characterization
(TLC, column, distillation, crystallization, GC etc.)
2. Synthesis and characterization (any four)
3. Representative reaction to be covered:
Esterification and saponification, Oxidation, Reduction (Cannizzaro, benzoic acid, Adipic acid), Nucleophilic substitution, Cycloaddition reactions, Grignard reaction, Condensation reactions (Cinnamic acid, Caumarin), Preparation of dyes (Malachite Green, Azo dyes), Aromatic electrophilic substitution (picric acid), Synthesis of Acetoacetic ester, Saccharin, Maritis yellow. Note book and Viva.

Text Book
Organic Chemistry by Morrison, R.T. and R. N. Boyd, 6th Edition, Allyn and Bacon Inc.(2006).

Recommended books:

1. Brown, W. and Poon, T., Introduction to Organic Chemistry, 3rd ed., John-Wiley and Sons, Inc., (2005).
2. John, E. M. Organic Chemistry, 8th ed., Brooks/Cole Publishing Co, USA, **(2012)**.
3. Textbook of Organic Chemistry, Younus, M., A, Ilmi Kitab Khana, Urdu Bazar, Lahore, Pakistan, **(2006)**.
4. Organic Chemistry, 10th ed., Solomons, T. W. G. and Fryhle, C. B., John-Wiley and Sons, Inc., **(2011).**
5. Microscale Approach to Organic Laboratory Techniques, 5th ed., Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., Brooks/ Cole Cengage Learning, **(2013).**
6. Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., Organic Chemistry, 6th ed., Brooks/ Cole Cengage Learning, **(2012).**
7. Advanced Organic Chemistry,by March,J 6th Edition, John Wiley and Sons,New York **(2007).**
8. Organic Chemistry by Solomon and Fryhle, 10th Edition, John Wiley and Sons,New York **(2014).**

9. Vogel's Text Book of Quantitative Chemical Analysis, 5th edition, by Jeffery G.H., Prentice Hall (**2000**).
10. Microscale and Macroscale Techniques in Organic Chemistry by Pavia (**2002)**.
11. Experimental Organic Chemistry, by Shriner 8th ed. John Wiley n Sons Inc. **(2004).**
12. Advanced Practical Organic Chemistry. Front Cover. N K Vishnoi. Vikas Publishing House Pvt Limited, Apr 1, (**1996**).

CY-354 PHYSICAL CHEMISTRY-III (THEORY)

CLOs	PLOs
To describe connections of molecular velocities and binary collisions on the basis of various laws and central concepts involved in kinetic of chemical reactions.	1
Students will demonstrate the ability to use core concepts of chemical thermodynamics to predict physical changes and reaction outcomes based on free energies	2
To strengthens the knowledge students regarding ionic conductance based on various principles and models.	3

CONTENTS:

Kinetic Theory of Gases
Virtual equations. Maxwell's law of molecular velocities. Calculation of molecular velocities and binary collisions. Maxwell-Boltzmann's law of energy distribution. Viscosity of gases and its determination.

Chemical Kinetics
Integrated Rate laws; second and third order reactions with same and different initial concentration of reactants. Elementary and complex reactions; opposing, parallel and consecutive reactions. Steady state approximation, Lindemann mechanism for uni-molecular reactions. Bimolecular collision theory, transition state theory, kinetics of thermal and photochemical reactions.

Chemical Thermodynamics
Second and third laws of thermodynamics and their applications. Relation of entropy and energy with equilibrium constant, and their dependence on temperature. Heat capacities, concept of entropy and probability. Clausius-Clapeyron's equation. Chemical potential. Partial molar quantities. Free energy change. Phase rule, phase diagram and stability of a single component system.

Electrochemistry
Conduction in solutions. Derivation of Debye-Huckel and Onsager equations of conductance. Debye-Huckel limiting law for a strong electrolytes, its derivations and applications. Activity and activity coefficients and their uses. Thermodynamics of cells and their applications

PHYSICAL CHEMISTRY-III (PRACTICALS)

1. Equilibrium constant of the $KI + I_2 = KI_3$ reaction
2. Determination of specific rate constants and activation energy of first and second order reactions
3. Kinetics of saponification of ethyl acetate
4. Kinetics of acid catalyzed hydrolysis of sucrose
5. Study of the adsorption isotherms of acetic acid-charcoal system

6. Study of the charge transfer complex formation between iodine and benzene
7. Determination of activation energy for the acid catalyzed hydrolysis of ethyl acetate
8. Determination of partial molar volumes
9. Molecular weight determination by various methods
10. Characterization of the given compound by UV-Vis spectroscopy

Textbook:

Physical Chemistry: Thermodynamics, Structure, and Change, 10th Ed., by Peter Atkins and Julio de Paula, W.H. Freeman **(2014).**

Recommended books:

1. Physical Chemistry, 4th ed., Laidler K.J., John H.M. and Bryan C.S., Houghton Mifflin Publishing Company Inc. **(2013).**
2. Electrochemical Methods: Fundamentals and Applications, 2nd ed, Bard, A. J. and Faulkner, L. R., John Wiley and Sons **(2000).**
3. Physical Chemistry, 4th ed, Alberty, R. A., Robert J.S. and Moungi G. B., John Wiley and Sons **(2014).**
4. Thermodynamics, Statistical Thermodynamics, and Kinetics, 1st ed., Engel, Thomas and .Reid p., Benjamin Cummings **(2006).**
5. Experimental Physical Chemistry:A Laboratory Textbook by Halpern, A., and McBane, G., **(2006).**

BS 3rd Year
SEMESTER VI

CY-315: ANALYTICAL CHEMISTRY-IV (THEORY)

CLOs	PLOs
Students will learn Solvent extraction, Efficiency of extraction, methods of extraction and applications, extraction of metal ions.	2
Will have a grip on Chromatography, Basic principles and classification, column chromatography, paper and thin layer, ion exchange, gel permeation, gas and high performance liquid chromatographic methods, electrophoresis, Teach about Quality Control and Management in Analytical Chemistry	2
Students will be able to create technical reports on the basis of analyses done	5

COURSE CONTENTS:

Introductory Separation Techniques

Solvent Extraction

Solvent extraction, Efficiency of extraction, methods of extraction and applications, extraction of metal ions.

Chromatography

Chromatography, Basic principles and classification, column chromatography, paper and thin layer, ion exchange, gel permeation, gas and high performance liquid chromatographic methods, electrophoresis

Quality Control and Management in Analytical Chemistry

ANALYTICAL CHEMISTRY-IV (PRACTICALS)

1. Percentage composition of mixtures of metals
2. Extraction of metals
3. Separation of cations by paper chromatography:
4. Separation of cations by TLC
5. Separation of cations by Column chromatography

Text Book:

Fundamentals of Analytical Chemistry 9th Edition BySkoog, West and Holler, Saunders College Publishing, (2016).

Recommended books:

1. Analytical Chemistry (7th edition) by Gary D. Christian, Purnendu K. (Sandy) Dasgupta and Kevin A. Schug in pdf. published by John Wiley and Sons, Inc. **(2014)**.
2. Fundamentals of Analytical Chemistry 9th Edition BySkoog, West and Holler, Saunders College Publishing, **(2016).**

CY-315 Analytical Chemistry-IV

Analytical Chemistry–IV

Sr. No.	CLOs	PLO
1.	The students will be able to calculate the kinetic data of many reactions.	**5**
2.	The students can evaluate the mode of chemical reactions.	**3**

Kinetic methods of analysis:

Methods based on chemical kinetics: Theory, instrumentation, quantitative applications, charecterization applications, evulation of chemical kinetics method,

Radiochemical methods of analysis: theory and instrumentation, quantitative applications and characterization.

Flow injection analysis: Theory, instrumentation and application.

Analytical Chemistry-IV Laboratory:

1. Determine the rate law for the reaction of the dye crystal violet with hydroxide.
2. To determine the activation energy of the reaction by finding the value of the rate constant, k, at several temperatures.
3. To determine the shift in equilibrium position of a chemical reaction with applied stress.
4 Quantitative determination of provided sample using refractometer.

Text Book:

Fundamentals of Analytical Chemistry 9th Edition BySkoog, West and Holler, Saunders College Publishing, (2016).

Recommended books:

1. Analytical Chemistry (7th edition) by Gary D. Christian, Purnendu K. (Sandy) Dasgupta and Kevin A. Schug in pdf. published by John Wiley and Sons, Inc. **(2014)**.
2. Fundamentals of Analytical Chemistry 9th Edition BySkoog, West and Holler, Saunders College Publishing, **(2016).**
3. Fábio R. P. Rocha and Joaquim A. Nóbrega, Flow Injection Analysis in the Undergraduate Laboratory, Chem. Educator 1999, 4, 179–182.

CY-325: INORGANIC CHEMISTRY-IV (THEORY)

Course contents:
Organometallic Chemistry
Historical Background
a) Organic Ligands and Nomenclature
The 18-Electron Rule, Counting Electrons, Why 18 Electrons? Square-Planar Complexes

b) Ligands in Organometallic Chemistry
Carbonyl (CO) Complexes, Ligands Similar to CO, Hydride and Dihydrogen Complexes Ligands Having Extended a Systems

c) Bonding Between Metal Atoms and Organic Π Systems

d) Complexes Containing M - C, M = C, and M -- C Bonds
e) Spectral Analysis and Characterization of Organometallic Complexes

Parallels Between Main Group and Organometallic Chemistry

INORGANIC CHEMISTRY-IV (PRACTICALS)

1. Preparation of selected coordination complexes and their characterization by instrumental methods , for eg. potassium tris(oxalate)ferrate (III) trihydrate, iron alum, Prussian blue sodium hexanitrito cobaltate (III) , hexaammine cobalt(iii) chloride, chloropentamminecobalt(III) chloride
2. Verification of Werner Theory by studying the conductivity of Cobalt ammine complexes.
3. Determination of number of chloride complexes ions in Cobalt ammine complexes, by potentiometric titration.

Text Book
Inorganic Chemistry, 5th Edition, by Gary L. Miessler, Paul J. Fischer, Donald A. Tarr, Pearson **(2014).**
Recommended Books:

1. Inroagnic Chemistry, 5thEd, P. Atkins, T. Overton, M. Wheeler, Oxford University Press **(2010)**
2. Advanced Topics in Crystallization by YitzhakMastai, InTechOpen (**2015**)
3. Ion Exchange - Studies and Applications by Ayben Kilislioglu, InTechOpen **(2015)**
4. Vogel's Qualitative Inorganic Analysis, 7th Ed., Svehla, G., Prentice Hall **(2013)**
5. A Manual for the Chemical Analysis of Metals by Thomas R. Dulski, ASTM Manual Series **(2012)**
6. Inorganic Chemistry, Principles of Structure and Reactivity, 4th Edition, Huhey, by J. E., Dorling Kindersley Pvt Ltd.**(2010)**
7.

CLOs	PLOs
Students will be able to understand basic knowledge of Organometallic Chemistry, Organic Ligands and Nomenclature, Ligands in Organometallic Chemistry,Bonding Between Metal Atoms and Organic Π Systems, Complexes Containing M - C, M = C, and M -- C Bonds ,	2
Will Learn Spectral Analysis and Characterization of Organometallic Complexes , Parallels Between Main Group and Organometallic Chemistry	4

Gives understanding of Metal-Metal Bonds, *Multiple Metal-Metal Bonds,* Cluster Compounds and give awareness about Main Group Parallels with Binary Carbonyl Complexes	1

CY-364 ORGANIC CHEMISTRY-IV

CLOs	PLOs
Students will distinguish between organic reactions including substitution, oxidation, reduction and pericyclic reaction	2
Students will prepare organic compounds using named and common reactions and will investigate the mechanisms involved	3

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

Note book and Viva

Text Book

Organic Chemistry, 10th Edition, by Solomon and Fryhle, John Wiley andSons,New York **(2014).**

Recommended books:

1. Brown, W. and Poon, T., Introduction to Organic Chemistry, 3rd ed., John-Wiley and Sons, Inc., (2005).
2. John, E. M. Organic Chemistry, 8th ed., Brooks/Cole Publishing Co, USA, **(2012)**.
3. Textbook of Organic Chemistry, Younus, M., A, Ilmi Kitab Khana, Urdu Bazar, Lahore, Pakistan, **(2006)**.
4. Organic Chemistry, 10th ed., Solomons, T. W. G. and Fryhle, C. B., John-Wiley and Sons, Inc., **(2011).**
5. Microscale Approach to Organic Laboratory Techniques, 5th ed., Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., Brooks/ Cole Cengage Learning, **(2013).**
6. Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., Organic Chemistry, 6th ed., Brooks/ Cole Cengage Learning, **(2012).**
7. Advanced Organic Chemistry,by March,J 6th Edition, John Wiley and Sons,New York **(2007).**
8. Organic Chemistry by Solomon and Fryhle, 10th Edition, John Wiley and Sons,New York **(2014).**
9. Vogel's Text Book of Quantitative Chemical Analysis, 5th edition, by Jeffery G.H., Prentice Hall (**2000**).
10. Microscale and Macroscale Techniques in Organic Chemistry by Pavia (**2002)**.
11. Experimental Organic Chemistry, by Shriner 8th ed. John Wiley n Sons Inc. **(2004).**
12. Advanced Practical Organic Chemistry. Front Cover. N K Vishnoi. Vikas Publishing House Pvt Limited, Apr 1, (**1996**)

CY-355: PHYSICAL CHEMISTRY-IV (THEORY)

CLOs	PLOs
To apply the principles of quantum mechanics for the solution of various problems and to describe the quantum derivation of hydrogen and hydrogen like systems.	2
To develop the understanding of Diffraction phenomena for the prediction of properties and composition at the atomic level making connections to structure, and bonding.	3
To recognize symmetry elements in a molecule; State the point group a molecule belongs to and rules for multiplications of symmetry operations.	1

Course contents:

Quantum Chemistry and Spectroscopy
Derivation, Particle in a 2-D and 3-D boxes. Tunnel effect. Introduction to spectroscopy of molecules, spectra of hydrogen atom.

Solid State Chemistry
Various crystalline systems. Bragg's equation. Unit cell. Determination of single cell by single crystal and powder methods. Structure factors. Basic ideas of Fourier Synthesis. Brief account of polymers and composite materials with special emphasis on superconductors, semi-conductors etc. Some applications of X-ray diffraction in chemistry and industry.

Symmetry and Group Theory
Symmetry and symmetry operations; identity, rotation, reflection, improper rotation and inversion center. Classifications of molecules into point groups. Introduction to group theory, properties of groups, matrices, transformation of matrices. Some general rules for multiplications of symmetry operations, Multiplication tables for water and ammonia. Representations: matrix representations for C_2V and C_3V point groups' irreducible representations, Character and character tables for C_2V and C_3V point groups. Symmetry of atomic orbitals and their applications in molecular spectroscopy.

PHYSICAL CHEMISTRY-IV (PRACTICALS)
1. Conductance measurements and verifications of Ostwald's dilution law.
2. Conductometric titrations.
3. Determination of distribution coefficient and verification of Distribution law.
4. Distribution coefficient of benzoic acid between benzene and water by distribution method
5. Transition temperatures.
6. Gas analysis.
7. Determination of Eutectic temperature and Eutectic composition of a binary system by cooling curve method.
8. Degree of dissociation of week electrolytes.
9. Determination of activity coefficient from e.m.f. measurement.

Textbook:

Physical Chemistry: Thermodynamics, Structure, and Change, 10th Ed., by Peter Atkins and Julio de Paula, W.H. Freeman **(2014).**

Recommended books:

1. Physical Chemistry, 4th ed., Laidler K.J., John H.M. and Bryan C.S., Houghton Mifflin Publishing Company Inc. **(2013).**
2. Electrochemical Methods: Fundamentals and Applications, 2nd ed, Bard, A. J. and Faulkner, L. R., John Wiley and Sons **(2000).**
3. Physical Chemistry, 4th ed, Alberty, R. A., Robert J.S. and Moungi G. B., John Wiley and Sons **(2014).**
4. Thermodynamics, Statistical Thermodynamics, and Kinetics, 1st ed., Engel, Thomas and .Reid p., Benjamin Cummings **(2006).**
5. Experimental Physical Chemistry: A Laboratory Textbook by Halpern, A., and McBane, G., **(2006).**

CY-331 APPLIED CHEMISTRY (THEORY)

CLOs	PLOs
Students will be able to understand basic knowledge of Various Industries	1
Will Learn Industrial Plant designing of selected industries	2
Gives understanding of. Textile Industry and Fabric Dyes	3

Course contents:

1. The Cane-Sugar Industries
2. Fermentation Industries
3. Milk Industries
4. Paper Industry
5. Textile Industry and Fabric Dyes

APPLIED CHEMISTRY (PRACTICAL)

1. Milk testing
2. Synthesis of Dyes and their Testing
3. Fermentation of sugar cane
4. Estimation of Ferrous and Ferric ions in drinking water by redox titration
5. Extraction of capsicum oil (soxhlet extraction)
6. Extraction of clove oil from cloves
7. Preparation of liquid detergents

Text Book

Roussak, O. V. and Gesser, H. D., Applied Chemistry: A Textbook for Engineers and Technologists, 2nd ed., Springer, **(2013).**

Recommended books

1. Homogeneous Catalysis: Mechanisms and Industrial Applications by Sumit Bhaduri, Dobl Mukesh 2nd Edition **(2014).**
2. Handbook of Industrial Chemistry: Organic Chemicals by Mohammad Farhat Ali, Bassam M. El. Ali, James G. and Speight **(2005).**

3. Prakash, N. B., Applied Chemistry Lab Manual, LAP Lambert Academic Publishing, **2013).**
4. Chawla, K. K., Composite Materials: Science and Engineering, 3rd ed., Springer, **(2012).**
5. Deborah, D. L., Composite Materials: Science and Applications, 2nd ed., Springer, **(2010).**
6. Gay, D. and Hoa, S. V., Composite Materials: Design and Applications, 2nd ed., CRC Press, LLC, **(2007).**
7. Callister, W. D. Jr., Materials Science and Engineering: An Introduction, 7th ed., John-Wiley and Sons, Inc., **(2007).**
8. Roussak, O. V. and Gesser, H. D., Applied Chemistry: A Textbook for Engineers and Technologists, 2nd ed., Springer, **(2013).**
9. Vermani, O. P., Applied Chemistry: Theory And Practice, 2nd ed., New Age International, **(2006).**
10. R. D., Composite Materials: Engineering and Sciences, CRC Press, **(2003).**
11. Wastewater Engineering: Treatment and Reuse by Tchobanoglous, G., Burton, F. L. and Stensel, H. D., 4th ed., McGraw-Hill, **(2003).**

SEMESTER VII

SPECIALIZATION In INORGANIC & ANALYTICAL CHEMISTRY

CY-411: SPECTROSCOPIC TECHNIQUES

Sr. No.	CLOs	PLO
1.	The students will be able to relate different emission spectroscopy Techniques.	3
2.	The students will be able to relate different FTIR and UV spectroscopic Techniques.	2

Course contents:

Atomic Emission and Absorption spectroscopy (AES, OES): Instrumentation; Principles, applications, Spectra interpretations, and limitations.

Vibrational and Transitional Spectroscopy: (FTIR & UV-Vis) Instrumentation; Principles, applications, Spectra interpretations, and limitations.

Text Book

Introduction to Instrumental Analysis, Robert D. B., Pharma Med Press, Hyderabad **(2006)**

Recommended Books:

1. Atkins' Physical Chemistry, Atkins, P. and Paula, J.D., OUP Oxford, **(2014)**
2. Physical Chemistry, 4th Ed, Laidler K.J., John, H.M. and Bryan C.S., Houghton Mifflin Publishing Company Inc.**(2003)**
3. Quantum chemistry, 5th Ed, Levine, I., Pearson education **(2000)**

CY-412: Thermal Analysis

Sr. No.	CLOs	PLO
1.	The students will analyze the different class of compounds on the basis of their thermal properties	
2.	The students can characterize the reactions and their types.	
3.	Will be able to interpret spectras and results of various thermal techniques	

Course contents:

Introduction to various thermal techniques, thermogravimetric analysis (TGA), differential thermal analysis (DTA), Instrumentation, interpretation of results, relationship among thermal properties their decomposition points and structure, applications in characterization of polymers and inorganic compounds, Influences of experimental factors on TGA and DTA. Detection of phase transitions, DTA, DSC curves, Applications, Polymers, Liquid crystals, Oxidative stability, Safety screening, Drug analysis, General chemical analysis

Text Book:

Introduction to Instrumental Analysis, Robert D Braun, Pharma Med Press, Hyderabad, (**2006)**

RECOMMENDED BOOKS

1. “Differential Scanning Calorimetry” Günther Höhne, Wolfgang F. Hemminger, H.-J. Flammersheim, 2013.

2. **"**Differential Scanning Calorimetry:" Applications in Fat and Oil Technology Emma Chiavaro, 2014.
3.
4. "Principles of Thermal Analysis and Calorimetry" Peter J. Haines, Royal Society of Chemistry (Great Britain), G. Roger Heal, 2002.
5. "Differential Scanning Calorimetry: Basics and Applications", Amy Woods, Lila Chavez, 2018.
6. "Modulated Temperature Differential Scanning Calorimetry theoretical and practical applications in polymer characterization" (Vol. 6) Mike Reading, Douglas J. Hourston, 2006.

CY-413: Electroanalytical Techniques

Sr. No.	CLOs	PLO
1.	The students will be able to evaluate different applications of electroanalytical techniques.	
2.	The students can categorize the theoretical principles of electrochemistry.	

Course contents:

Theoretical principles, Faradays Laws, Nernst equation and its applications, redox potential, voltaic cells, corrosion and its protection. Theory, instrumentation and Applications of. Potentiometry, coulometery, conductometry, polarography and voltammetry. Determination of reaction rates using Voltammetry and Potentiometry.

Text Book

Introduction to Instrumental Analysis, Robert D Braun, Pharma Med Press, Hyderabad, (**2006)**

Recommended books:

1. An Introduction to Chemo metrics: Data Analysis for the laboratory and Chemical plants, Richard G. B., John Wiley and Sons **(2003)**
2. Analytical Chemistry, 7th Ed, Christian, G. D., John Wiley and sons **(2014)**
3. Fundamentals of Analytical Chemistry, 6th Ed, Skoog, W. and Holler, S., College Publishing, **(1992)**
4. Instrumental Methods of Analysis, 7thEd, Willard, Merit, Dean, Settle. CBS Publishers and Distributors **(1986)**
5. Introduction to spectroscopy; A Guide for Students as organic Chemistry 3rd Ed, Pavia, D. L., Lampman, G. M. and Kritx, G. S., Harcourt Bruce Coll,**(2001).**
6. X-Ray Fluorescence spectrometry, 2nd Ed, Jenkins, Ron, John Wiley and sons **(1999)**
7. Organic Spectroscopy, 3rd Ed, William Kemp, Mac Millan**(1991)**
8. Analytical Chemistry, Principles and Techniques By Larry G. Hargis, Prentice Hall Englewood Cliffs, New Jersey **(1988)**
9. Fundamentals of Analytical Chemistry 8th Ed, Skoog, West and Holler, Saunders Collage Publishing, (**2006**)
10. Interpretation of mass spectra By Fred. W. Mc Lafferty, 20 Edge Hill Rd., Mill valley, **(1988)**
11. Analytical Atomic Absorption Spectroscopy 2nd ed, I. Ebdon Wiley John and sons **(1999)**
12. Modern Spectroscopy, J. Michaeal Hollas, 4th Ed, John Wiley Sons Ltd, **(2014)**

CY-414 STATISTICAL DATA HANDLING AND SPREADSHEETS

Sr. No.	CLOs	PLO
1.	The students will be able to adapt and design the statistical data.	
2.	The students can measure the comparative values by testing methods.	

Accuracy & Precession, Determinate Errors, Indeterminate Errors, Significant Figures, Rounding Off, Ways of Expressing Accuracy, Standard Deviation, Use of Spreadsheets in Analytical Chemistry, Propagation of Errors, Significant Figures and Propagation of Errors, Tests of Significance, Rejection of Results – Q Test, Detection Limits, Using Spreadsheets for Plotting Calibration Curves

Recommended Books

1. Data Analysis for Chemistry-An Introductory Guide for Students and Laboratory Scientists, D. Brynn Hibbert and J. Justin Gooding, Oxford University press, 2006.
2. Advanced Excel for Scientific Data Analysis, Robert de Levie, Oxford University Press, 2005
3. Practical Data Analysis in Chemistry, Volume 26, 1st Edition, Marcel Maeder Yorck-Michael Neuhold, Elsevier Science, 2007.
4. Statistical Methods in Analytical Chemistry, Peter C. Meier, Richard E. Zünd, John Wiley & Sons, 2005
5. Some general guidelines for choosing missing data handling methods in educational research Cheema, Jehanzeb R. (2014)

CY-415 VACUUM TECHNIQUES IN ANALYTICAL CHEMISTRY

Sr. No.	CLOs	PLO
1.	The students will be able to analyze the different vacuum technologies.	
2.	The students can co-relate the different analytical measurements.	

Basic terms and concepts in Vacuum Technology, Vacuum Generation, Vacuum Chamber Glove Boxes, Schlenk Lines and Vacuum Lines, Rotary Evaporator, Vacuum measurement, monitoring, control and regulations

BOOKS

1. Principles of instrumental analysis Skoog, Douglas, 2017.
2. Analytical chemistry for technicians Kenkel, John, 2013
3. Vacuum technology, thin films, and sputtering: an introduction Stuart, Robley V. 2012
4. High-vacuum Technology: a practical guide Hablanian, Marsbed H. (2017)
5. High Vacuum Techniques for Chemical Syntheses and Measurements P. H. Plesch, 2005
6. Data analysis for chemistry Hibbert, D. (2006)
7. General Scientific Data Analysis De Levie, Robert. (2001)
8. Practical data analysis in chemistry Maeder, Marcel, and Yorck-Michael Neuhold (2007)
9. Statistical methods in analytical chemistry Meier, Peter C. (2005)
10. Some general guidelines for choosing missing data handling methods in educational research Cheema, Jehanzeb R. (2014)

CY-416 PHYSIOCHEMICAL METHODS OF ANALYSIS-(THEORY)

Sr. No.	CLOs	PLO
1.	The students will be able to modify the separation techniques for further investigation.	
2.	The students will be able to operate different chromatographic techniques.	
3.	The students can creat new pathways for extraction methods.	

Course contents:

Introductory Separation Techniques

Solvent Extraction

Solvent extraction, Efficiency of extraction, methods of extraction and applications, extraction of metal ions.

Chromatography: Introduction of Chromatography, Basic principles and classification of, Adsorption and partition, Chromatography, Paper Chromatography, TLC Chromatography, Column chromatography, Ion exchange, Gel permeation, Gas and liquid chromatographic methods, electrophoresis

General theory of column chromatography, Column resolution, capacity factor, column selectivity, column efficiency, peak capacity, non-ideal behavior.

GC mobile phase, GC columns, stationary phase, sample introduction, Temperature control, Detectors of Gas Chromatography, Quantity and Quality Application,

Text Book:

Fundamentals of Analytical Chemistry 9th Edition BySkoog, West and Holler, Saunders College Publishing, (2016).

Recommended books:

3. Analytical Chemistry (7th edition) by Gary D. Christian, Purnendu K. (Sandy) Dasgupta and Kevin A. Schug in pdf. published by John Wiley and Sons, Inc. **(2014)**.
4. Fundamentals of Analytical Chemistry 9th Edition BySkoog, West and Holler, Saunders College Publishing, **(2016).**

CY-481: Fundamentals of Environmental Chemistry

CLOs	PLOS
Students will be able to outline the composition chemistry of soil, water and atmosphere	1
Students will be able to infer the phenomena of ozone depletion and smog formation	1
Students will be able to conclude methods for the treatment of waste water	2

Course contents:

Chemistry of the air: the atmosphere as a resource, pollution of the atmosphere and its prevention. Chemistry of the land: mineral resources, agricultural Chemistry. Chemistry of the waters: water as a resource, pollution of water, water treatment. Introduction to, acid precipitation, air pollution, water pollution and treatment, hazardous waste treatment, stratospheric ozone depletion, smog formation.

Text Book

Fundamentals of Environmental Chemistry, Standley E. Manahan, Lewis Publishers,**(1993)**

CY-202: Projects of Energy Resources of Pakistan and its Management (LIST OF PROJECTS)

1- Pyrolysis of shale to produce oil
2- Coal gasification
3- Production of biogas from manure
4- Production of biodiesel from used oils
5- Production of Levulinic acid (Potential biofuel precursor) from sugarcane bagasse.
6- Production of Ethanol from Sugarcane bagasse
7- Furfral Production from rice husk or wheat brans or sawdust.
8- Thermal depolymerization (Conversion of Plastic bottles into oil)

Text Book

1. Coal Gasification and Its Applications, Bell, D.A., Towler, B.F., Fan, M., Elsevier Science.**(2010)**

Reference books:

2. Coal Gasification and Its Applications, Bell, D.A., Towler, B.F., Fan, M., Elsevier Science.**(2010)**
3. Manure and Energy Crops for Biogas Production: Status and Barriers, Bernan, Henrik B. Møller, A.M., Renouf Publishing Company Limited. (**2008)**
4. Biodiesel: A Realistic Fuel Alternative for Diesel Engines, Demirbas, A, Springer, **(2007)**
5. Hog Manure Management, the Environment and Human Health, Guan, T.T.Y. and Holley, R.A., Springer US,**(2003)**
6. The Chemistry and Technology of Furfural Production in Modern Lignocellulose-feedstock Biorefineries, Marcotullio, G.,Arkhé Edizioni – LAquila, Italy, **(2011)**
7. Biofuels: Alternative Feedstocks and Conversion Processes, Pandey, A., Larroche, C., Ricke, S.C., Dussap, C.G., Gnansounou, E., Elsevier Science, **(2011)**
8. Planning and Installing Bioenergy Systems: A Guide for Installers, Architects and Engineers, Sonnenenergie, D.G. F., and ECOFYS, Routledge,**(2005)**
9. Handbook of Petroleum Product Analysis, Speight, J.G., Wiley, **(2002)**
10. An Introduction to Petroleum Technology, Economics and Politics, Speight, J.G., Wiley.**(2011)**
11. Oil Sand Production Processes., Speight, J.G., Elsevier Science, **(2012a)**
12. Shale Oil Production Processes, Speight, J.G., Elsevier Science,**(2012b)**
13. Enhanced Recovery Methods for Heavy Oil and Tar Sands, Speight, J.G., Elsevier Science.**(2013a)**
14. Shale Gas Production Processes, Speight, J.G., Elsevier Science, **(2013b)**
15. Bioalcohol Production: Biochemical Conversion of Lignocellulosic Biomass. Waldron, K., Woodhead Publishing, **(2010)**

CLOs	**PLOs**
Capable of analyzing different Energy Sources	2
Capable to design innovative methodologies for energy conservation	6
Capable to manage different for energy projects	3

CY-482: ENVIRONMENTAL TOXICOLOGY

CLOs	PLOS
Students will be able to explain the basis, history and scope of environmental toxicity	1
Students will be able to perceive understanding regarding the chemical nature and fate of toxicants	1
Students will be able to summarize the role of pesticides, PCBs, PAHs and food adulterants	2

Course contents:
Introduction to environmental toxicology, history and scope of toxicology, types of toxicology, toxicants, Dose response function, bioassays, Pseudo assignment, Tolerance resistance, bio-concentration, Environmental fate of toxicant. Toxicant case study of pesticides, PCBs, PCDDs, and PAHs, food adulterants, metals.

Text Book
Perspectives in Environmental Toxicology, **Kesari,** Kavindra (Ed.), Springer, **(2017)**

CY-483: GREEN CHEMISTRY

CLOs	**PLOs**
Students will be able to develop understanding of green chemistry and its applications	1
Students will be able to formulate and design products that would minimize hazardous substances	4
Student will be able to formulate chemical reactions related to green chemistry	1

Course contents:
Philosophy of chemical research and engineering that encourages the design of products and processes that minimize the use and generation of hazardous substances. three key developments in green Chemistry: use of supercritical carbon dioxide as green solvent, aqueous hydrogen for clean oxidations and the use of hydrogen in asymmetric synthesis Examples of applied green Chemistry: supercritical water oxidation, on water reactions, and dry media reactions.

Text Books

Green Chemistry for Environmental Remediation, Rashmi Sanghi (Ed), Vandana Singh (Ed), Wiley, **(2012)**

CY-484: ENVIRONMENTAL CHEMISTRY

CLOs	PLOS
Students will be able to explain basic principles of atmospheric pollution and its prevention	1
Students will be able to perceive chemistry of lithosphere and hydrosphere	1
Students will be able to elaborate and methods of water pollution determination	2

Course contents:

Atmospheric Chemistry and atmospheric pollution and its prevention. Chemistry of lithosphere: mineral resources, pollution and prevention. Chemistry of Hydrosphere: water as a resource, pollution of water, water treatment. Case studies of acid precipitation, air pollution, water pollution and treatment, hazardous waste treatment, stratospheric ozone depletion, smog formation.

Text Books:

Fundamentals of Environmental Chemistry, Standley E. M., Lewis Publishers **(1993)**

Recommended Books:

1. Series: Reviews of Environmental Contamination and Toxicology Vol. 233, springer, David M. (Ed.)**(2015)**
2. Series: Reviews of Environmental Contamination and Toxicology, Vol. 235, springer, Whitacre, David M. (Ed.)**(2015)**
3. Fundamental Toxicology, RSC, John, H. D., Howard, G. J.,Douglas B McGregor, **(2006)**
4. Green Chemistry: Theory and Practice, Warner, J. C., Paul T. A., Springer, **(2000)**
5. Green Chemistry: Greener Alternatives to Sythetic Organic Transformations, Ahluwalia, V. K., Narosa Publishing House,**(2011)**
6. Fundamentals of Environmental Chemistry, Standley E. M., Lewis Publishers **(1993)**
7. Environmental Chemistry, 3rd Ed, Kumar, A., New Age International (P) Ltd, **(1997)**

CY-485 ENVIRONMENTAL LAWS

CLOs	PLOs
The Student will be able to examine the parameters affecting the evolution of Environmental Laws.	1
The students will be able to interpret environmental laws and evaluate the NCS and NEP.	3
The students will be able to provide legal solution of the pollution problems in the light of environmental laws and relevant case laws.	7

Course contents:

- Evolution and History of International and National Environmental Laws
- National Conservation Strategy (NCS), 1992
- National Environmental Policy, 2005

- The Punjab Environmental Protection Act, 1997 (PEPA)
- Environmental Laws of Pakistan after the 18th Amendment of the Constitution of Pakistan
- The Punjab Environmental Tribunal Rules, 2012
- Review of IEE and EIA Regulations, 2000
- The Environmental Sample Rules, 2001
- The National Environmental Quality Standards (Certification of Environmental Laboratories) Regulations, 2000
- The National Environmental Quality Standards (Self-monitoring and Reporting Industry) Rules, 2001
- The Pollution Charge for Industry (Calculation and Collection) Rules, 2001
- Public Interest Litigation (PIL) in Environmental Laws
- Constitutional and Common Law Remedies in Environmental Matters
- Case Laws Pertaining to Environmental Pollution
- The Pakistan Climate Change Act, 2017
- New laws and policies in the area of environment protection.

Textbook:

Principles of International Environmental Law, Sands, P., Cambridge University Press, **(2003)**

Recommended Books:

1. Environmental Impact Assessment Handbook for Pakistan, Thomas, B., Fischer and Shadmeena Khanum, IUCN Pakistan, **(2014)**
2. Manual of Environmental Laws, Alam, A.R., Irfan Law Book House, Lahore, **(2016)**
3. Manual of Environmental Laws of Pakistan: With the Exhaustive Commentary, Hassan, J., Manzoor Law Book House, **(2016)**

CY-419 Experimental Methods in Analytical Chemistry Lab I

CLOs	**PLOs**
Student will be able to evaluate methods regarding the chemical analyses of water that includes heavy metals analysis, BOD, COD, hardness, UV Visible spectroscopy	3
Student will be able to compare thermal methods of chemical analysis	3

1. Sample preparation for analyses,
2. digestion of substances for analyses,
3. estimation of metals over AAS,

a. Estimation of Pb and Cd in water and soil sample
b. Estimation of heavy metals like, Pb, Cd, Zn in water
c. Estimation of heavy metals and minerals in various soil samples

4. Estimation of various PAHs from soil, water and meat samples
5. Estimation of COD and BOD of water
6. Estimation of water hardness
7. Estimation of acid values of various biological samples
8. determination of metals at UV-Visible Spectrophotometer by complex formation.
9. Thermo-gravimetric analyses of various hydrated compounds and their graphical representations, discussion on DTA and DSC theromgrams of various substances.

Recommended Book

8. Introduction to Instrumental Analysis, Robert D. B., Pharma Med Press, Hyderabad **(2006)**
9. Series: Reviews of Environmental Contamination and Toxicology, Vol. 233 & 235, springer, Whitacre, David M. (Ed.)**(2015)**
10. Perspectives in Environmental Toxicology, **Kesari,** Kavindra (Ed.), Springer, **(2017)**

CY-411 Experimental Methods in Analytical Chemistry II

Recommended Books:

PRACTICAL:

1. Designing safer Chemicals for simple experiments
2. Synthesis of Bio-fuel
3. Effect of different bio-fuels on germination of seeds
4. Synthesis of bio-based inks
5. Potentiometric titrations *vs* Indicator titrations
6. Synthesis of bio-diesel from used cooking oil
7. Combustion of biodiesel to determine flash point for energy efficient Chem calculations of various bio-fuels.

Recommended Books:

1. Green Chemistry: Theory and Practice, Warner, J. C., Paul T. A., Springer, **(2000)**
2. Green Chemistry: Greener Alternatives to Sythetic Organic Transformations, Ahluwalia, V. K., Narosa Publishing House, **(2011)**

CLOs	PLOs
To understand basic principles for atomic emission Phenomenon.	3
To learn construction and working of atomic emission spectrometer, x-ray spectrometer, SEM, XRF, EDX, WDX and ICP-MS	5

CY-421: ORGANOMETALLIC CHEMISTRY

CLO	**PLO**
Students will be able to conclude the history and structure of monometallic and bimetallic complexes and clusters	1
Students will be able to assume the problems related to reaction mechanisms involving transition metal complexes	2
Students will be able to categorize the main families of organometallic complexes	1

Course contents:

History of organometallic chemistry

The first complexes, the discovery of ferrocene and the boom of organometallic chemistry, The discovery of multiple metal-carbon bonds and the golden age of catalysis, Activation of C-H bonds in hydrocarbons, bond metathesis and H_2 as a ligand

Sstructures of the transition-metal complexes
Monometallic transition-metal complexes, bimetallic transition-metal complexes and clusters

The stoichiometric reactions of transition-metal complexes
Redox reactions, oxidative addition and-bond metathesis, Reactions of nucleophiles and electrophiles with complexes, Ligand substitution reactions, Insertion and extrusion reactions

The main families of organometallic complexes
Metal carbonyls and complexes of other monohapto L ligands, Metal-alkyl and-hydride complexes and other complexes of monohapto X ligands, -Metal-carbene and –carbyne complexes and multiple bonds with transition metals, complexes of mono-and polyenes and enyls, -Metallocenes and sandwich complexes

Text Books:
Inorganic Chemistry, 5thEd, P. Atkins, T. Overton, M. Wheeler, Oxford University Press **(2010)**

Recommended books:
1. Organometallic Chemistry and Catalysis, Didier, A., Springer **(2007)**
2. Inorganic Chemistry 2nd Ed, Shriver, D.F., Atkins, P. W., Wiley **(2003)**
3. Organo transition metal Chemistry. Fundamental concepts and applications by Yamamoto, O., Wiley**(2011)**
4. Modern Inorganic Chemistry, Jolly., W. L. McGraw **(1986)**
5. Inorganic Chemistry 3rd Ed, Snarp, A.G.,Longman**(1992)**

CY-422: INORGANIC CATALYSIS

CLOs	**PLOs**
Students will be able to describe the basis of chemical catalysis	1
Students will be able to infer the problems regarding the hydrogenation, hydro elimination, transformation, oxidation, carbonylation and carboxylation reactions with respect to catalysis	2
Students will be able to illustrate the skills to synthesize and characterize reactions involving catalysis	3

Course contents:
Introduction to catalysis, Hydrogenation and hydroelementation of alkenes, Transformations of alkenes and alkynes, Oxidation of olefins, C-H activation and functionalization of alkanes and arenes, Carbonylation and carboxylation reactions, Heterogeneous catalysis

Text Book:
1. Advanced Inorganic Chemistry, N. S. Hosmane, Elsevier Science **(2017)**

Recommended books:
1. Organometallic Chemistry and Catalysis, Didier, A., Springer **(2007)**
2. Inorganic Chemistry. Shriver, D.F., Atkins, P.W., C.H. Longford Freeman, New York **(1990)**
3. Organo transition metal Chemistry. Fundamental concepts and applications by Yamamoto, O., Wiley **(2003)**
4. Modern Inorganic Chemistry, Jolly, W. L., McGraw**(1989)**

CY-423: PRINCIPLES OF BIOINORGANIC CHEMISTRY

CLO	PLO
Students will be able to outline the basic knowledge of Bioinorganic Chemistry	1
Students will be able to perceive the role of metal ions in Enzyme, vitamins	2
Student will be able to demonstrate the synthesis and characterize the metal complexes for medicinal purposes	5

Course contents:

Development and importance of bio-inorganic Chemistry, introduction to metals of biological importance, Function of metals in enzyme catalysis. Oxygen carriers; nitrogen fixation; vitamin B_6 and B_{12}. Importance of metals and non-metals in biological systems. Metal ions and chelating agents for medicinal purposes

Text Books:

1. Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide 2nd Ed, Kaim, W., Schwederski, B., Axel Klein, WILEY **(2013)**

Recommended books:

1. Bioinorganic Chemistry, Rosette, M. R.,John Wiley and Sons**(2002)**
2. Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide 2nd Ed, Kaim, W., Schwederski, B., Axel Klein, Wiley **(2013)**

CY-424: INORGANIC CHEMISTRY OF MAIN GROUP ELEMENTS

CLO	PLO
Students will be able to describe the chemical nature and compounds of S and P Block elements	1
Students will be able to illustrate the impact of the compounds of S and P Block elements on industry	4
Student will be able to demonstrate the synthesis and characterization of compounds of S and P Block elements	3

Course contents:

The Chemistry of selected main group elements,

S-block elements: General discussion interests and importance, compounds, variety, synthesis and characteristics, alkalides and Alkali and alkaline earth metal complexation; ligands - Chemclic and crown ethers, cryptands and calixeranes biological significance, features of organometals of Na, K, Ca and Mg.

P-block elements: Chemistry of non-metals - B, Si, P and S. Compounds variety - E-H, E-X, E-O and E-N bond types in different molecules, Chemistry of simple boranes, silanes, phosphanes and sulphanes borazine, boron and silicon nitrides.

Industrial applications of compounds of main group elements.

Specific reagents of main-group elements: Synthesis, structure and reactions.

Text Book:

1. Main Group Chemistry, W. Henderson, Royal Chemical Society **(2000)**

Recommended books:

1. Organometallic Chemistry and Catalysis, Didier, A., Springer **(2007)**
2. Inorganic Chemistry. Shriver, D.F., Atkins, P.W., C.H. Longford Freeman, New York **(1990)**
3. Organo transition metal Chemistry. Fundamental concepts and applications by Yamamoto, O., Wiley **(2003)**
4. Modern Inorganic Chemistry, Jolly, W. L., McGraw Hill **(1989)**

CY-425: Special Topics in Inorganic Chemistry
Course contents:

CLOs	PLOs
Students will be able to explain basic knowledge of Noble Gas Chemistry: Halides, oxyhalides and oxides of noble gases - their structure and reactivity.	1
Students will be able to illustrate about Halogen Chemistry: Interhalogen, pseudohalogen ionic oxyhalogen species, xenon-oxides and fluoxides – their structure and reactivity. Recent advances in Halogen and noble gas Chemistry.	1
Students will be able to describe the understanding of Chemical applications of group theory, formal development of the subject and its applications to the physical methods of inorganic Chemical compounds.	3

Chemistry of Halogens and Noble Gases

Noble Gas Chemistry: Halides, oxyhalides and oxides of noble gases - their structure and reactivity. Halogen Chemistry: Interhalogen, pseudohalogen ionic oxyhalogen species, xenon-oxides and fluoxides – their structure and reactivity. Recent advances in Halogen and noble gas Chemistry.

F-Block Chemistry

Text Books:

1. Main Group Chemistry, W. Henderson, Royal Chemical Society **(2000)**
2. Chemistry of f-block elements, H. C. Aspinall, Gordon and Breach Publishers, Netherlands **(2001)**

Recommended books:

1. Organometallic Chemistry and Catalysis, Didier, A., Springer **(2007)**
2. Inorganic Chemistry. Shriver, D.F., Atkins, P.W., C.H. Longford Freeman, New York **(1990)**
3. Organo transition metal Chemistry. Fundamental concepts and applications by Yamamoto, O., Wiley**(2003)**
4. Modern Inorganic Chemistry, Jolly, W. L., McGraw**(1989)**

CY-426: Experimental Methods in Inorganic Chemistry I

CLO	PLO
Students will be able to develop the understanding regarding, lab safety, lab ethics scientific communication skills	5
Students will be able to demonstrate the lab techniques to handle and synthesize compounds of Si, Sb, Ca, S, I and K	3
Students will be able to plan the lab techniques regarding electrolytic reactions1	3

PRACTICAL:

1. Introduction to lab safety, Guidelines for Writing Lab Reports, Introduction to handling vacuum line and Schlenk apparatus, gas handling by conducting various experiments, for eg. drying of solvents like ether, THF and preparation of Metallocene.
2. . Preparation of Silicon (IV) and Tin (IV) Compounds
3. 2. Preparation of complexes of Calcium and Barium
4. 3. Preparation of Potassium Peroxy disulfate
5. (a) electrolytic preparation
6. (b) iodimetric determination of product yield
7. 4. Preparation of Potassium Trisoxalatoaluminate (III) Trihydrate
8.

Recommended books:

6. Organometallic Chemistry and Catalysis, Didier, A., Springer **(2007)**
7. Inorganic Chemistry 2nd Ed, Shriver, D.F., Atkins, P. W., Wiley **(2003)**
8. Organo transition metal Chemistry. Fundamental concepts and applications by Yamamoto, O., Wiley**(2011)**
9. Modern Inorganic Chemistry, Jolly., W. L. McGraw **(1986)**
10. Inorganic Chemistry 3rd Ed, Snarp, A.G.,Longman**(1992)**
11. Advanced Inorganic Chemistry, N. S. Hosmane, Elsevier Science **(2017)**

CY-427: Experimental Methods in Inorganic Chemistry II

CLO	PLO
Students will be able to develop knowledge about the synthesis and characterization of transition-metal complexes of Co and Fe	2
Students will plan the synthesis, modification and applications of inorganic molecular sieves	4
Students will be able to describe the role of metal ions in Enzymes and other proteins	2

PRACTICALS:

1. Preparation of Inorganic molecular sieves and other catalyst
2. Modification of Inorganic molecular sieves
3. Application of Inorganic molecular sieves in catalytic processes
4. Application of instrumental methods to study the catalyst

5. Introduction to bioinformatics and its application
6. Isolation of metals from biological samples and development of correlation of the concentration of metal to the health state of an organism
7. Introduction to online crystal structure data bases (Cambridge crystal structure data base.
8. Synthetic route to *trans*-$[Co(en)_2Cl_2]Cl \cdot HCl$ starting from $CoCl_2 \cdot 6H_2O$.
9. Reaction converting *trans*-$[Co(en)_2Cl_2]^+$ to *cis*-$[Co(en)_2Cl_2]^+$.
10. Determination of Oxalate in Potassium Tris(oxalato)ferrate(III) Trihydrate
11. Determination of Iron in Potassium Tris(oxalato)ferrate(III) Trihydrate
12. Application of inorganic methods to study these complexes
13. Preparation of report on the work done in the lab

Recommended books:

1. Organometallic Chemistry and Catalysis, Didier, A., Springer **(2007)**
2. Inorganic Chemistry 2nd Ed, Shriver, D.F., Atkins, P. W., Wiley **(2003)**
3. Organo transition metal Chemistry. Fundamental concepts and applications by Yamamoto, O., Wiley**(2011)**
4. Modern Inorganic Chemistry, Jolly., W. L. McGraw **(1986)**
5. Inorganic Chemistry 3rd Ed, Snarp, A.G.,Longman**(1992)**
6. Advanced Inorganic Chemistry, N. S. Hosmane, Elsevier Science **(2017)**
7. . Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide 2nd Ed, Kaim, W., Schwederski, B., Axel Klein, WILEY **(2013)**
8. Organo transition metal Chemistry. Fundamental concepts and applications by Yamamoto, O., Wiley **(2003)**
9. Main Group Chemistry, W. Henderson, Royal Chemical Society **(2000)**

SPECIALIZATION IN INDUSTRIAL, ENVIRONMENTAL & POLYMER CHEMISTRY

CY-431: ORGANIC BASED INDUSTRIES

Course contents:

Paper and Pulp:

Raw materials for pulp and paper industries, classification of paper products, Chemistry involved in the processing of Kraft pulp, sulphite pulp and semi-Chemical pulp, manufacture of paper and regeneration of spent liquor.

Polymers:

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

Sugar Industry:

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

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

Text Book
Schueller, R. and Romanowski, P., *Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,* 3rd ed., Allured Publishing Corporation, (2009)

Recommended books:

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

CLOs	**PLOs**
The course introduces management practices in industry and their applications.	1
This course will create the concepts of the production and applications of sugar and paper industries. It will also highlight the importance of polymers chemistry in real life.	6
Exhibit good work ethic and study skills.	7

CY-432: AGRO BASED INDUSTRIES AND POLLUTION CONTROL

Course contents:

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

Agro Chemicals:
Classification of pesticides, formulation and toxicity of pesticides, future trends of pest control, control of weeds, household agro chemicals, plant growth regulators and background Chemistry, and hazards associated with the use of agro chemicals and environmental aspects.

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

TEXT BOOK

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

Recommended books:

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

CLOs	PLOs
To enable the students to carry out industrial wastewater surveys, analysis of data and development of industrial wastewater management strategy.	4
The students will be able to learn the potential of agricultural chemicals and fertilizers. Also will understand the need for safety and security in handling these materials.	3

CY-433: INDUSTRIAL PROCESSES

Course contents:

General processes including

Liquefaction of gases – for ease of transportation
Supercritical drying, Freezes Drying
Scrubber – removing of pollution from exhaust gases

Chemical Processes:

Harber Process – Chemically binding gaseous nitrogen from the atmosphere to make ammonia.
Smelting – Chemically enhancing metals
Disinfection – Chemical treatment to kill bacteria and viruses
Pyroprocessing – using heat to chemically combine materials, such as in cement.

Physical Processes:

There are several physical processes for reshaping a material by cutting, folding, joining or polishing, developed on a large scale from workshop techniques.
Forgoing – the shaping of metal by use of heat and hammer
Casting - shaping of a liquid material by pouring it into moulds and letting it solidify
Progressive stamping - the production of components from a strip or roll
Stamping
Hydroforming - a tube of metal is expanded into a mould under pressure
Sandblasting - cleaning of a surface using sand or other particles
Soldering, Brazing, Welding - a process for joining metals

Tumble polishing - for polishing
Precipitation hardening - heat treatment used to strengthen malleable materials
Work hardening - adding strength to metals, alloys, etc.
Case hardening, Differential hardening, Shot peening - creating a wear resistant surface
Die cutting - A "forme" or "die" is pressed onto a flat material in order to cut, score, punch and otherwise shape the material.

Text Book

Shreve's Chemical Process Industries, 5th Ed., Shreve, R. M., George, T. A., McGraw-Hill Book Company Inc., New York, **(1984)**

Recommended books:

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

CLOs	**PLOs**
The Students will gain an understanding of the distinction between qualitative and quantitative physical and chemical processes.	7
To enable the students to carry out the standard techniques used in physico-chemical Experiments.	3

CY-434: PROJECTS OF APPLIED CHEMISTRY

Course contents:
Theoretical aspects of selected projects
Analysis of oils and fatty acids and their categorization on certain quality parameters
Preparation of gum
Water analysis
Analysis and report writing of industrial samples
Analysis of caustic soda and soda ash in mixtures
Analysis of effluents from tanneries
Preparation and Testing of:
- Varnish and Enamel Paints
- Adhesives
- Emulsion Paints

Text Book

Fundamentals of Industrial Chemistry, Tyrell, J. A., Wiley, **(2014)**

Recommended books:
1. A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis, Vogel, A. I., Longman Green and Co. **(1995)**
2. Fundamentals of Industrial Chemistry, Tyrell, J. A., Wiley, **(2014)**
3. Roger's Industrial Chemistry. Von Norstand Co. N. Y.
4. Reigel's Handbook of industrial Chemistry. Von Norstand Reeinhold Co. N. Y.
5. Chemical Process Industries, 5th Ed, Shreve and Dum. McGraw Hill.**(1985)**
6. Chemical Engineering series, 5th Ed, McGraw-Hill, Inc. ISBNO-07-112 721-6
   Barnes, MJK Thomas. The School of Chemical and Life Sciences University of Greenwich London

CLOs	PLOs
Learning of the theoretical aspects of industrial processes	3
Learning of the practical aspects of various industrial processes	4

CY-435: Experimental Methods in Industrial Chemistry I

PRACTICALS:
1. Preparation of various herbal shampoos, Creams Tooth Pastes, Mouthwashes and their applications,
2. Extraction of perfumes from natural sources
3. Chemical Analysis of various brands of Fertilizers
4. Study of Chemical effects of various fertilizers on crops and vegetables

Recommended Books:
1 The Fertilizer Industry, Woodhead, Park, M., Publishing Limited, **(2001)**
2 Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry,Schueller, R. and Romanowski, P., 3rdEd., Allured Publishing Corporation, **(2009)**
3 Handbook of Cosmetic Science and Technology, 3rd Ed., Barel, A. O., Paye, M. and Maibach, H. I., Informa Healthcare, **(2009)**

CY-436 Experimental Methods in Industrial Chemistry II

PRACTICAL:

1. Projects for the optimization of certain conditions at industrial scale processes.
2. Study of the practical aspects of above projects

Recommended Books:

1 A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis, Vogel, A. I., Longman Green and Co. **(1995)**
2 Fundamentals of Industrial Chemistry, Tyrell, J. A., Wiley, **(2014)**
3 Roger's Industrial Chemistry. Von Norstand Co. N. Y.
4 Reigel's Handbook of industrial Chemistry. Von Norstand Reeinhold Co. N. Y.
5 Chemical Process Industries, 5th Ed, Shreve and Dum. McGraw Hill.**(1985)**
6 Chemical Engineering series, 5th Ed, McGraw-Hill, Inc. ISBNO-07-112 721-6

CLOs	**PLOs**
To enable the students to carry out industrial wastewater surveys, analysis of data and development of industrial wastewater management strategy.	4
The students will be able to learn the potential of agricultural chemicals and fertilizers. Also will understand the need for safety and security in handling these materials.	3
Learning of the practical aspects of various industrial processes	1

CY-481: Fundamentals of Environmental Chemistry

CLOs	PLOS
Students will be able to outline the composition chemistry of soil, water and atmosphere	1
Students will be able to infer the phenomena of ozone depletion and smog formation	1
Students will be able to conclude methods for the treatment of waste water	2

Course contents:

Chemistry of the air: the atmosphere as a resource, pollution of the atmosphere and its prevention. Chemistry of the land: mineral resources, agricultural Chemistry. Chemistry of the waters: water as a resource, pollution of water, water treatment. Introduction to, acid precipitation, air pollution, water pollution and treatment, hazardous waste treatment, stratospheric ozone depletion, smog formation.

Text Book

Fundamentals of Environmental Chemistry, Standley E. Manahan, Lewis Publishers,**(1993)**

CY-486: PROJECTS OF ENERGY RESOURCES OF PAKISTAN AND ITS MANAGEMENT

1. Pyrolysis of shale to produce oil
2. Coal gasification
3. Production of biogas from manure
4. Production of biodiesel from used oils
5. Production of Levulinic acid (Potential biofuel precursor) from sugarcane bagasse.
6. Production of Ethanol from Sugarcane bagasse
7. Furfral Production from rice husk or wheat brans or sawdust.
8. Thermal depolymerization (Conversion of Plastic bottles into oil)

Text Book

Coal Gasification and Its Applications, Bell, D.A., Towler, B.F., Fan, M., Elsevier Science.**(2010)**

Reference books:

1. Coal Gasification and Its Applications, Bell, D.A., Towler, B.F., Fan, M., Elsevier Science.**(2010)**
2. Manure and Energy Crops for Biogas Production: Status and Barriers, Bernan, Henrik B. Møller, A.M., Renouf Publishing Company Limited. (**2008)**
3. Biodiesel: A Realistic Fuel Alternative for Diesel Engines, Demirbas, A, Springer, **(2007)**
4. Hog Manure Management, the Environment and Human Health, Guan, T.T.Y. and Holley, R.A., Springer US,**(2003)**
5. The Chemistry and Technology of Furfural Production in Modern Lignocellulose-feedstock Biorefineries, Marcotullio, G.,Arkhé Edizioni – LAquila, Italy, **(2011)**
6. Biofuels: Alternative Feedstocks and Conversion Processes, Pandey, A., Larroche, C., Ricke, S.C., Dussap, C.G., Gnansounou, E., Elsevier Science, **(2011)**
7. Planning and Installing Bioenergy Systems: A Guide for Installers, Architects and Engineers, Sonnenenergie, D.G. F., and ECOFYS, Routledge,**(2005)**
8. Handbook of Petroleum Product Analysis, Speight, J.G., Wiley, **(2002)**
9. An Introduction to Petroleum Technology, Economics and Politics, Speight, J.G., Wiley.**(2011)**
10. Oil Sand Production Processes., Speight, J.G., Elsevier Science, **(2012a)**
11. Shale Oil Production Processes, Speight, J.G., Elsevier Science,**(2012b)**
12. Enhanced Recovery Methods for Heavy Oil and Tar Sands, Speight, J.G., Elsevier Science.**(2013a)**
13. Shale Gas Production Processes, Speight, J.G., Elsevier Science, **(2013b)**
14. Bioalcohol Production: Biochemical Conversion of Lignocellulosic Biomass. Waldron, K., Woodhead Publishing, **(2010)**

CLOs	**PLOs**
Capable of analyzing different Energy Sources	2
Capable to design innovative methodologies for energy conservation	6
Capable to manage different for energy projects	3

CY-482: ENVIRONMENTAL TOXICOLOGY

CLOs	PLOS
Students will be able to explain the basis, history and scope of environmental toxicity	1
Students will be able to perceive understanding regarding the chemical nature and fate of toxicants	1
Students will be able to summarize the role of pesticides, PCBs, PAHs and food adulterants	2

Course contents:
Introduction to environmental toxicology, history and scope of toxicology, types of toxicology, toxicants, Dose response function, bioassays, Pseudo assignment, Tolerance resistance, bio-concentration, Environmental fate of toxicant. Toxicant case study of pesticides, PCBs, PCDDs, and PAHs, food adulterants, metals.

Text Book
Perspectives in Environmental Toxicology, **Kesari,** Kavindra (Ed.), Springer, **(2017)**

CY-483: GREEN CHEMISTRY

CLOs	**PLOs**
Students will be able to develop understanding of green chemistry and its applications	1
Students will be able to formulate and design products that would minimize hazardous substances	4
Student will be able to formulate chemical reactions related to green chemistry	1

Course contents:
Philosophy of chemical research and engineering that encourages the design of products and processes that minimize the use and generation of hazardous substances. three key developments in green Chemistry: use of supercritical carbon dioxide as green solvent, aqueous hydrogen for clean oxidations and the use of hydrogen in asymmetric synthesis Examples of applied green Chemistry: supercritical water oxidation, on water reactions, and dry media reactions.

Text Books

Green Chemistry for Environmental Remediation, Rashmi Sanghi (Ed), Vandana Singh (Ed), Wiley, **(2012)**

CY-484: ENVIRONMENTAL CHEMISTRY

CLOs	PLOS
Students will be able to explain basic principles of atmospheric pollution and its prevention	1
Students will be able to perceive chemistry of lithosphere and hydrosphere	1
Students will be able to elaborate and methods of water pollution determination	2

Course contents:
Atmospheric Chemistry and atmospheric pollution and its prevention. Chemistry of lithosphere: mineral resources, pollution and prevention. Chemistry of Hydrosphere: water as a resource, pollution of water, water treatment. Case studies of acid precipitation, air pollution, water pollution and treatment, hazardous waste treatment, stratospheric ozone depletion, smog formation.

Text Books:

Fundamentals of Environmental Chemistry, Standley E. M., Lewis Publishers **(1993)**

Recommended Books:

11. Series: Reviews of Environmental Contamination and Toxicology Vol. 233, springer, David M. (Ed.)**(2015)**
12. Series: Reviews of Environmental Contamination and Toxicology, Vol. 235, springer, Whitacre, David M. (Ed.)**(2015)**
13. Fundamental Toxicology, RSC, John, H. D., Howard, G. J.,Douglas B McGregor, **(2006)**
14. Green Chemistry: Theory and Practice, Warner, J. C., Paul T. A., Springer, **(2000)**
15. Green Chemistry: Greener Alternatives to Sythetic Organic Transformations, Ahluwalia, V. K., Narosa Publishing House,**(2011)**
16. Fundamentals of Environmental Chemistry, Standley E. M., Lewis Publishers **(1993)**
17. Environmental Chemistry, 3rd Ed, Kumar, A., New Age International (P) Ltd, **(1997)**

CY-485 ENVIRONMENTAL LAWS

CLOs	PLOs
The Student will be able to examine the parameters affecting the evolution of Environmental Laws.	1
The students will be able to interpret environmental laws and evaluate the NCS and NEP.	3
The students will be able to provide legal solution of the pollution problems in the light of environmental laws and relevant case laws.	7

Course contents:

- Evolution and History of International and National Environmental Laws
- National Conservation Strategy (NCS), 1992
- National Environmental Policy, 2005
- The Punjab Environmental Protection Act, 1997 (PEPA)
- Environmental Laws of Pakistan after the 18th Amendment of the Constitution of Pakistan
- The Punjab Environmental Tribunal Rules, 2012
- Review of IEE and EIA Regulations, 2000
- The Environmental Sample Rules, 2001
- The National Environmental Quality Standards (Certification of Environmental Laboratories) Regulations, 2000
- The National Environmental Quality Standards (Self-monitoring and Reporting Industry) Rules, 2001
- The Pollution Charge for Industry (Calculation and Collection) Rules, 2001
- Public Interest Litigation (PIL) in Environmental Laws
- Constitutional and Common Law Remedies in Environmental Matters
- Case Laws Pertaining to Environmental Pollution
- The Pakistan Climate Change Act, 2017
- New laws and policies in the area of environment protection.

Textbook:

Principles of International Environmental Law, Sands, P., Cambridge University Press, **(2003)**

Recommended Books:

4. Environmental Impact Assessment Handbook for Pakistan, Thomas, B., Fischer and Shadmeena Khanum, IUCN Pakistan, **(2014)**
5. Manual of Environmental Laws, Alam, A.R., Irfan Law Book House, Lahore, **(2016)**
6. Manual of Environmental Laws of Pakistan: With the Exhaustive Commentary, Hassan, J., Manzoor Law Book House, **(2016)**

CY-486 Experimental Methods in Environmental Chemistry

PRACTICAL:

pH titrations, conductance titrations, voltametry, polarograpy, coulometry, redox titrations and other electrochemical analyses.

1 To prepare phenol-formaldehyde resin.
2 To determine the acid value of given plastic material.
3 To determine the acid value of given oil sample.
4 To determine the normality of acids by conductometric titration.
5 To determine the cell constant of conductivity cell by using KCl solution.
6 To determine the calcium and magnesium hardness of water by EDTA method.
7 To determine the pH of unknown solution by pH meter and pH paper.
8 To study the factor's influcing on rate of electro Chemical corrosion.
9 To determine the relative viscosity of different liquid with respective water at different temperatures.

Recommended books:

1. An Introduction to Chemo metrics: Data Analysis for the laboratory and Chemical plants, Richard G. B., John Wiley and Sons **(2003)**
2. Fundamentals of Environmental Chemistry, Standley E. Manahan, Lewis Publishers,**(1993)**

3. Instrumental Methods of Analysis, 7thEd, Willard, Merit, Dean, Settle. CBS Publishers and Distributors **(1986)**
4. Introduction to spectroscopy; A Guide for Students as organic Chemistry 3rd Ed, Pavia, D. L., Lampman, G. M. and Kritx, G. S., Harcourt Bruce Coll,**(2001).**
5. X-Ray Fluorescence spectrometry, 2nd Ed, Jenkins, Ron, John Wiley and sons **(1999)**
6. Organic Spectroscopy, 3rd Ed, William Kemp, Mac Millan**(1991)**
7. Analytical Chemistry, Principles and Techniques By Larry G. Hargis, Prentice Hall Englewood Cliffs, New Jersey **(1988)**
8. Automated Chemical Analysis By J. K. For man Stock well. Johan Willey and sons, N. Y, **(1975)**

POLYMER CHEMISTRY

CY-471: POLYMER CHEMISTRY

CLOs	PLOs
Students will be able to understand nature of the polymers	1
Students will be to differentiate between different synthesis routes	2
Students will be to categorize polymers with respect to their applications	4

Course contents:

Introduction to polymer. Review of the Chemistry of naturally occurring and synthetic high polymers; polymerization techniques; kinetics and mechanism of chain reactions; structure and properties of polymers in solid and liquid states, determination of polymer molecular weights. A brief outline of the reactions and the processes involved in the manufacture of polyethylene, polystyrene, polyamides, polyurethane, polyesters and elastomers. Recent advances in polymer Chemistry, Structure determination and applications of polymers.

Textbooks:

1. Introduction to Polymers, Young, Lovell, Chapman and Hall **(1991)**

Recommended Books:

1. Polymer Synthesis and Characterization; A Laboratory Manual, Sandler, AP **(1998)**
2. Polymer Synthesis, Stanley Sandler, Wolf Karo, 2nd Ed, **(1991)**
3. Polymers, Polymer Blends, Polymer Composites and Filled Polymers,G.E.Zaikov,Nova **(2006)**
4. Polyolefin, Blends,Thein Kyu, Wiley **(2008)**
5. Biodegradable Polymer Blends and Composites from Renewable Resources, Long Yu, Wiley **(2008)**
6. Polymer Synthesis and Characterization; A Laboratory Manual, Sandler, AP **(1998)**
7. Principles of polymerization, 4th Ed., George Odian, Wiley **(2004)**
8. Introduction to Polymer Science and Chemistry, Chanda, CRC **(2006)**
9. Polymer Synthesis and Characterization; A Laboratory Manual, Sandler, AP **(1998)**

CY-472: POLYMER BLENDS AND COMPOSITES

CLOs	PLOs
Students will learn about different blends and composites	1
Students will be able to examine the physical properties of polymeric blends and composites	3
Students will be able to design environmentally benign new polymeric blends and composites	4

Course contents:

Polymer composites materials, physico-mechanical properties of conventional fibre and particulate polymer composites, advanced polymer composites, polymer nanocomposites, fillers used for polymer composites, polymer composites structure, characterization and design, physical and Chemical modification of polymer composites. Polymer blends: Thermo dynamical aspects of polymer blend miscibility, mixing, structure, properties and application of polymer blends.

Text Books:

1. Composite Materials Handbook, Vol. 2: Polymer Matrix Composites: Materials Properties, CRC **(2002)**

Recommended Books:

1. Polymer Synthesis and Characterization; A Laboratory Manual, Sandler, AP **(1998)**
2. Composite Materials Handbook, Vol. 2: Polymer Matrix Composites: Materials Properties, CRC **(2002)**
3. Flame Retardant Polymer Nanocomposites, Alexander B. Morgan,Wiley-Inter **(2007)**
4. Polymers, Polymer Blends, Polymer Composites and Filled Polymers, G.E.Zaikov,Nova **(2006)**
5. Introduction to Polymer Science and Chemistry, Chanda, CRC **(2006)**
6. Polyolefin Composites, Domasius Nwabunma, TheinKyu,Wiley **(2008)**
7. Flame Retardant Polymer Nanocomposites, Alexander B. Morgan, Wiley-Inter **(2007)**
8. Polymers, Polymer Blends, Polymer Composites and Filled Polymers, G. E .Zaikov, Nova **(2006)**
9. Polyolefin Blends, Thein Kyu, Wiley **(2008)**

CY-473: DEGRADABLE POLYMERIC MATERIALS

CLOs	PLOs
Students will learn about different kinds of degradation approaches	1
Students will able learn about different characterization techniques for the analysis of degradable polymers.	3
Students will be able to assess the impact of polymers on environment.	4

Course contents:

Introduction to polymers; physical and mechanical properties of polymers, what makes polymers degradable?; global degradable polymer market; natural degradable polymers; synthetic degradable polymers; biomedical applications of degradable polymers; environmentally degradable plastics biodegradable polymer blends and composites; methods for polymer degradation: Chemical, Characterization of degradable polymers: microscopy, spectroscopy, chromatography, mass spectroscopy and hyphenated techniques; processing

of degradable polymer: film blowing and casting, injection moulding, blow moulding, thermoforming, fibre spinning.

Text books:
Degradable Polymers: Principles and Applications, 2nd edition, G.Scott, Springer **(2003)**

Recommended Books

1. Handbook of Biodegradable Polymers; Synthesis, Characterization and Applications, A. Lendlein, A. Sisson, John Wiley **(2011)**
2. Biodegradable Polymers, David K. Platt, SmithersRapra **(2006)**
3. Biodegradable Polymer Blends and Composites from Renewable Resources, Long Yu, John Wiley **(2008)**

CY-474: POLYMER ANALYSIS AND CHARACTERIZATION

CLOs	PLOs
Students will be able to choose the suitable analytical techniques for polymer analysis	2
Students will be able to assess the chemical nature of polymers using spectroscopy	3
Students will be able to develop and optimize new environmentally benign methods for the analysis of polymer.	4

Course contents:
Introduction to polymers; (2) introduction to Physical analysis and Chemical analysis; (3) surface analyesis: surface Chemistry (FT-IR, X-ray Photoelectron Spectroscopy and Mass Spectrometry) and surface topology (SEM, TEM, AFM), (4) Molar-mass distribution and averaged molecular weight of polymers: osmometry, viscosimetry, gelpermeatgion chromatography (GPC)/size exclusion chromatography (SEC); (5) Chemical Analysis (a) UV/Vis Spectroscopy, (b) FT-IR Spectroscopy, (c) NMR, (d) Chromatography: Liquid Chromatography at critical conditions (LCCC), reversed-phase chromatography (RP-HPLC), two-dimensional chromatography, Gas chromatography of oilgomers (e) Mass spectrometry of polymers, (f) HPLC-MS, SEC-MS (g) LC-NMR, SEC-NMR; (6) Thermal analysis: TGA, DSC.

Text books:
Introduction to Polymer Analysis, T.R. Crompton, iSmithers Rapra **(2009)**

Recommended books:
1. Polymer Synthesis and Characterization; A Laboratory Manual, Sandler, AP **(1998)**
2. Handbook of Biodegradable Polymers; Synthesis, Characterization and Applications, A. Lendlein, A. Sisson, John Wiley **(2011)**
3. Biodegradable Polymers, David K. Platt, SmithersRapra **(2006)**
4. Polymers, Polymer Blends, Polymer Composites and Filled Polymers,G.E.Zaikov,Nova **(2006)**
5. Polymer Analysis (AnTs), Barbara H. Stuart, John Wiley **(2002)**
6. MALDI Mass Spectrometry for Synthetic Polymer Analysis, Liang Li, Wiley **(2009)**
7. NMR of Polymers Frank A. Bovey, P.A Mirau, Academic Press **(1996)**
8. Modern Size-Exclusion Liquid Chromatography, 2e, Andre Striegel, Wiley **(2009)**

9. Comprehensive Analytical Chemistry; Molecular Characterization and Analysis of Polymer, John M. Chalmers, Robert J. Meier, Elsevier **(2008)**
10. Mass Spectrometry of Polymers, Giorgio Montaudo, Robert P. Lattimer, CRC **(2002)**
11. Characterization of Polymer Surfaces and Thin Films, Springer **(2006)**
12. Thermal Analysis of Polymers, Fundamentals and Applications, Joseph D. Menczel, R. Bruce Prime, Wiley **(2009)**

CY-475: FUNCTIONAL POLYMERIC MATERIALS

CLOs	PLOs
Students will be able to understand the nature of functional groups and functional polymers	1
Students will be able to distinguish between different classes of functional polymeric materials.	3
Students will be able to design and develop novel functional polymeric materials for different industrial applications.	2

Course contents:

Introduction to polymers, general properties of polymers; introduction to functional polymers; analysis of global market for functional polymers; encapsulation and microencapsulation; functional coatings anticorrosive coating, high thermal-resistant and fire-retardant coating, scratch-and abrasion-resistant coating, self-cleaning coatings, antibacterial coatings, antifouling coatings; shape memory polymers; ,functional films; functional polymeric biomaterials, functional polymers in nanotechnology; functional polymers for light and fuel; functional textiles.

Text Books:

Functional Monomers and Polymers, 2nd Edition, Kiichi Takemoto, CRC **(1997)**

Recommended Books

1. Functional Coatings by Polymers, Swapan Kumar Ghosh, John Wiley **(2006)**
2. Functional Condensation Polymers, Charles E. Carraher Jr., Kluwer AP **(2002)**
3. Functional Polymer Films, Wolfgang Knoll, Rigoberto C. Advincula, John Wiley **(2011)**
4. Functional Materials and Biometerials, Ben Zhong Tang, Springer **(2007)**
5. Adaptive and Functional Polymers, Textiles and their Applications, Jinlian Hu, Imperial College Press **(2011)**

CY-476: Experimental Methods in Polymer Chemistry

CLOs	PLOs
Students will be able to learn about theory behind synthesis and characterization of polymers	1
Students will be able to compare different synthesis routes for polymers	3
Students will be able to categorize polymers with respect to their applications	2

PRACTICAL

1. Exercising Lab Safety measures.
2. Synthesis of Polystyrene (PS).
3. Preparation of acrylic based emulsions.
4. Synthesis of Phenol-formaldehyde based Polymeric resins (Bakelite).

5. Synthesis of polyamides (Nylon 6,6 and Nylon 6,10).
6. Synthesis of polyesters (PLA, PGA).
7. Preparation of polyurethane foams.
8. Mechanical analysis of polymer samples.
9. Spectroscopic analysis of polymers.
10. Chemical analysis of polymer samples.

Recommended Books:

1. Introduction to Polymers, Young, Lovell, Chapman and Hall **(1991)**
2. Flame Retardant Polymer Nanocomposites, Alexander B. Morgan,Wiley-Inter **(2007)**
3. Polymer Analysis (AnTs), Barbara H. Stuart, John Wiley **(2002)**
4. MALDI Mass Spectrometry for Synthetic Polymer Analysis, Liang Li, Wiley **(2009)**
5. Comprehensive Analytical Chemistry; Molecular Characterization and Analysis of Polymer, John M. Chalmers, Robert J. Meier, Elsevier **(2008)**
6. Polymer Synthesis, Stanley Sandler, Wolf Karo, 2nd Ed, **(1991)**
7. Polymers, Polymer Blends, Polymer Composites and Filled Polymers,G.E.Zaikov,Nova **(2006)**
8. Polyolefin, Blends,Thein Kyu, Wiley **(2008)**
9. Biodegradable Polymer Blends and Composites from Renewable Resources, Long Yu, Wiley **(2008)**
10. Principles of polymerization, 4th Ed., George Odian, Wiley **(2004)**
11. Introduction to Polymer Science and Chemistry, Chanda, CRC **(2006)**
12. Polymer Synthesis and Characterization; A Laboratory
13. Handbook of Biodegradable Polymers; Synthesis, Characterization and Applications, A. Lendlein, A. Sisson, John Wiley **(2011)**
14. Functional Coatings by Polymers, Swapan Kumar Ghosh, John Wiley **(2006)**

SPECIALIZATION IN ORGANIC CHEMISTRY (Organic, Food, Microbiology and Biochemistry)

CY-461: ORGANIC SPECTROSCOPY

CLOs	PLOs
Students will be able to interpret the spectras and chromatograms obtained from the spectroscopic techniques	2
Students will be able to assess various chemical samples	3

Course contents:

UV-Visible:

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

IR spectroscopy:

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

1H-NMR and 13C-NMR:

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

Mass Spectrometry:

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

Text Book

1. Handbook of Spectroscopy, Gauglitz, G., Tuan, V. D., WILEY-VCH Verlag GmbH and Co. KGaA, Weinheim **(2003)**

Recommended books:

1. Organic Analytical Chemistry: Theory and Practice, 1st Ed., Mohan, J., Alpha Science Int. Ltd. **(2003)**
2. Spectroscopy of Organic Compounds 6th Ed., Kalsi, P. S., New Age International, New Delhi, India **(2007)**
3. Organic Spectroscopy, Yadav, L. D. S., Springer, UK **(2005)**
4. Organic Spectroscopy 3rd Ed., Kemp, W., W. H. Freeman andCompany, New York, USA, **(1991)**

CY-462: HETEROCYCLIC AND ORGANOMETALLIC COMPOUNDS

CLOs	PLOs
Students will be able to describe the chemistry and synthesis of aromatic heterocyclic and organometallic compounds	2
Students will evaluate the right choice of reagents and methods for the synthesis of aromatic heterocyclic and organometallic compounds	4

Course contents:

Aromatic Heterocyclic:

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

Organometallic Compounds:

Principles, organo-magnesium, organo-lithium, organo-copper, organo-cadmium, organo-mercury and organo-zinc compounds: their structure and reactivity, methods of preparation and synthetic applications.

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

Text Book

Heterocyclic Chemistry 5th Ed, Joule, J. A., Mills, K, John-Wiley and Sons, UK, **(2010)**

Recommended Books:

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

CY-463: REACTION MECHANISM AND REACTIVE INTERMEDIATES

CLOs	PLOs
Students will be able to review various reactions mechanisms using standard methods of investigation	1
Students will check and define the mechanism of any reaction under investigation using evidence-based studies	2

Reaction Mechanism: Concept of reaction mechanism, Non-kinetic approach: Crossover experiments. Evidence from Isotopic labelling, Stereochemical, Intermediate studies and reaction catalysis.

Spectroscopic methods: Testing intermediates.

Kinetic approach: Measurement of rate of reaction, determining order of reaction and molecularity, Kinetic isotopic effect, Interpreting Kinetic data.

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.

Text Book

Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., Organic Chemistry, 6th ed., Brooks/Cole Learning, **(2012)**

Recommended books:

1. Organic Chemistry, 2nd Ed, Clayden, J., Greeves, N. and Warren, S., Oxford University Press, **(2012)**
2. Principles of Organic Synthesis, 3rd Ed, Coxon, J. M. and Norman, R.O.C., Chapman and Hall, UK, **(1993)**
3. Organic Chemistry, 6th Ed, Brown, W. H., Fotte, C. S., Iverson, B. L. and Anslyn, E. V., Brooks/Cole Learning, **(2012)**
4. Organic Chemistry, 8th Ed, John, E. M., Brooks/Cole Publishing Co., USA, **(2012)**
5. Organic Chemistry, 6th Ed Robert, T. M. and Robert, N. B.,., Prentice Hall, New Jersey, **(1992)**
6. Organic Analytical Chemistry: Theory and Practice, 1st Ed Mohan, J.,Alpha Science
7. Int.Ltd., **(2003)**
8. Spectroscopic Methods in Organic Chemistry,6th ed. Williams, D. H. and Flemming, I.,.,
9. McGraw-Hill Higher Education, **(2008)**
10. A Microscale Approach to Organic Laboratory Techniques, 5th Ed., Pavia, D. L., Kriz, G. S., Lampman, G. M. and Engel, R. G., Brooks/Cole Laboratory Series, CengageLearning, **(2013)**
11. Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Furniss, B. S., Hannaford, A. J., Smith, P. W. G., Tatchell, A. R., Longman, UK, **(1989)**

CY-464: NATURAL PRODUCTS

CLOs	PLOs
Students will be able to define various natural products	1
Students will be able to describe novel secondary metabolites	5

Course contents:

Alkaloids:
Introduction, classification, isolation methods, structure elucidation and discussion with particular reference to structure and synthesis and biosynthesis of typical alkaloids such as ephedrine, nicotine, atropine, quinine, papaverine and morphine.

Terpenoids:
Introduction, classification, isolation techniques and discussion with particular reference to structure and synthesis of typical terpenoids such as citral, α-terpineol, α-pinene, camphor and α-cadinene

Steroids: Introduction, classification, Isolation and general methods of structure determination of different steroids.

Flavonoids:
Introduction and classification of flavonoids, general charachterization, synthesis of flavone, flavonol and Chemanidin.

Text Book: Flavonoids: Chemistry, BioChemistry and Applications, Oyvind, M. A., and Kenneth, R. M., CRC, Taylor and Francis, New York, **(2010)**

Recommended books:

1. Medicinal Natural Products: A Biosynthetic Approach*,* Medicinal Natural Products, 3rd Ed, Dewick, P. M., John-Wiley and Sons, Ltd., **(2009)**
2. A Fragrant Introduction to Terpenoid Chemistry*,* Sell, C. S., The Royal Society of Chemistry, UK**, (2003)**
3. Fruit and Vegetable PhytoChemicals: Chemistry, Nutritional Value and Stability,De la Rosa, L. A., Parrilla, E. A. and Aguitar, G. A. G., Wiley-Blackwell, **(2009)**
4. Phenolics in Food and Nutraceuticals Shahidi, F. and Naczk M., CRC Press**, (2004)**
5. Flavonoids: Chemistry, BioChemistry and Applications, Oyvind, M. A., and Kenneth, R. M., , CRC, Taylor and Francis, New York, **(2010)**
6. StereoChemistry and the Chemistry of Natural Products*,* 5th Ed., Finar, I. L., Organic Chemistry, Vol. 2, Pearson Education Ltd., Delhi, **(2008)**
7. Alkaloid Chemistry, Hesse, M., ,John-Wiley and Sons, New York, **(1981)**
8. Chemistry of Natural Products Bhat, S. V., Nagasampagi, B. A. and Sivakumar, M., ,Narosa Publishing House, **(2005)**

CY-465: ADVANCED FOOD CHEMISTRY AND TECHNOLOGY

CLOs	PLOs
Students will be able to describe the chemistry of food, food additives and food contaminants	1
Students will be able to assess the role of chemicals involved in the lifespan of food	4

Course contents:
Carbohydrates, Proteins: Amino acids - structure, Classification and functional properties of proteins. Denaturation. Lipids: Classification and reactions. Rancidity: Vitamins: Structure, sources, functions. Sensitivity to processing conditions. Flavors and aroma compounds, synthetic and natural aroma compounds. Food Contaminants: Toxic trace elements, Toxic compounds of microbial origin, Pesticides.

Textbook:
Food Chemistry, Belitz, H.D., and Grosch, W., Springer-Verlag, New York, **(2004)**

Recommended books:
1. Food Chemical Composition: Dietary Significance in Food Manufacturing, Tim, H., Campden and Chorley Wood Research Association. Campden, UK, **(2002)**
2. The Food Chemistry Laboratory: A Manual for Experimental Foods, Dietetics, and Food Scientists, Weaver, M.C., and Daniel, J.R., Blackwell Pub. Co., Oxford, **(2003)**

CY-466: FOOD LAWS AND REGULATIONS

CLOs	PLOs
Students will be able to learn about the laws governing the quality of food in Pakistan	1
Student will be able to understand the rights and obligations of food manufacturers, operators and consumers.	5
Students will be able to interpret halal laws.	5

Course contents:
Introduction, The structure of Food Law, International Food Laws and Regulations, The World Trade Organization (WTO). GATT. Codex Alimentarius: general, procedural manual, standards, codes, legal force. Pakistan Standards and Quality Control Authority: functions, authorities, standards. Pure Food Rules and Regulations: definitions, significant features, enforcement, amendments. Food Safety Officer and Public Analyst: qualifications, duties, powers. Food adulteration: adulterants, health hazards, methods of detection. Food labelling: perspectives on nutrition labeling. Islamic food laws and regulations: sources, principles, lawful foods, unlawful foods. Consumer laws in Pakistan. Harmonization of Food Laws and Regulations.

Textbook:
Existing Laws, Rules and Regulations. PSQCA (Pakistan Standards and Quality Control Authority). Standards for different food items. PSQCA, Karachi, Pakistan, **(2010)**

Recommended books:

1. European food law handbook. Meulen, B., and Velde, M., Academic Publishers, Wageningen, The Netherlands, **(2008)**
2. The Punjab Pure Food Rules – 2007, Government of the Punjab. The Punjab Weekly Gazette. Government Printing Press, Lahore, Pakistan, **(2008)**
3. Halal food production, Riaz, M.N., and Chaudhary, M.M., CRC Press Taylor and Francis Group, Boca Raton, Florida, USA, **(2004)**
4. Consumer laws in Pakistan, Khan, M.S., Consumer Rights Commission of Pakistan, Islamabad, Pakistan, **(1999)**
5. Food Chemistry, Belitz, H.D. and Grosch, W., Springer-Verlag, New York, **(2004)**

CY-467: FOOD TECHNOLOGY IN DAIRY

CLOs	PLOs
Students will be able to describe the dairy technology	1
Students will learn to assess the quality of milk and dairy products	3

Course contents:

Milk: production statistics, importance, standards, Gross Chemical composition of milk and dairy products. Factors influencing raw milk quality. Food quality indices, Milk handling: manual and machine milking, farm cooling, collection, reception, analyses at different levels, transportation. Unit operations in milk processing: cream separation, bactofugation, filtration, thermization, standardization, homogenization, pasteurization, sterilization, UHT, aseptic packaging, storage, distribution, effect on milk constituents. Technology, Chemistry, microbiology of industrial products: evaporated, condensed and powder milks, butter, yogurt, cheese, ice cream etc. Milk by-products: dried whey, casein, etc. Aroma Defects

Textbook:

Dairy science and technology, Walstra P., Wouters J.T.M., and Guerts T.J., CRC Press Taylor and Francis Group, Boca Raton, Florida, USA, **(2006)**

Recommended books:

1. Dairy processing and quality assurance, Chandan, R.C., Kilara, A., and Shah, N., John Wiley and Sons Inc., New York, USA, **(2008)**
2. Milk and milk products, Winton A.L. and Winton K.B., Agrobios, Agro House, New Delhi, India, **(2006)**
3. Food Chemistry, Belitz, H.D., and Grosch, W., Springer-Verlag, New York, **(2006)**
4. Dairy processing handbook, Alfa Laval/Tetra Pak, Tetra Pak Processing System, Lund, Sweden, **(2003)**
5. Dairy processing: improving quality, Smith, G (ed)., CRC Press Taylor and Francis Group, Boca Raton, Florida, USA, **(2000)**

CY-468: Experimental Methods in Organic Chemistry Lab

CLOs	PLOs
Students will be able to synthesise selected organic compounds	1
Students will be able to characterize the synthesized organic compounds	3

PRACTICAL:

1. Synthesis and Spectroscopic characterization of Organic compounds. i.e. FTIR, AAS, UV-VIS, GC-MS; Scans of various organic molecules
2. Synthesis and characterization of various organic and organometallic compounds
3. Experiments based on spectroscopic techniques both of qualitative and quantitative nature. One- and two-step synthesis will also be designed.
4. Extraction, separation, qualitative and quantitative analysis of Flavanoids, Alkaloids, Lipids, Saponins etc

Recommended Books:

5. Organic Analytical Chemistry: Theory and Practice, 1st Ed., Mohan, J., Alpha Science Int. Ltd. **(2003)**
6. Spectroscopy of Organic Compounds 6th Ed., Kalsi, P. S., New Age International, New Delhi, India **(2007)**
7. Heterocyclic Chemistry 5th Ed, Joule, J. A., Mills, K, John-Wiley and Sons, UK, **(2010)**
8. Organic Analytical Chemistry: Theory and Practice, 1st Ed Mohan, J.,Alpha Science
9. Int.Ltd., **(2003)**
10. Spectroscopic Methods in Organic Chemistry,6th ed. Williams, D. H. and Flemming, I.,.,
11. McGraw-Hill Higher Education, **(2008)**
12. Flavonoids: Chemistry, BioChemistry and Applications, Oyvind, M. A., and Kenneth, R. M., CRC, Taylor and Francis, New York, **(2010)**
13. Alkaloid Chemistry, Hesse, M., ,John-Wiley and Sons, New York, **(1981)**
14. Chemistry of Natural Products Bhat, S. V., Nagasampagi, B. A. and Sivakumar, M., ,Narosa Publishing House, **(2005)**

CY-469: Experiments Methods in Food Chemistry

CLOs	PLOs
Students will be to evaluate various techniques for analysis and characterization of food and food products	3
Students will be able to assess various food and food products	4

PRACTICALS:

- Isolation and extraction of different food components
- Titrametric determination of sugars, vitamin C, Iodine etc.
- Separation of natural food colors. Extraction of pectin from fruit waste
- Estimation of starch, cholesterol, total dietary fiber, glucose, pigments etc.
- Testing of packed foods of different brands according to the Pakistan Standards and Quality Control Authority
- Milk sampling methods. Reception tests: Sensory test, sedimentation, pH, acidity; lactometer reading, clot on boiling, alcohol precipitation test, standard plate count, reductase test
- Physico-Chemical and microbiolgical analysis of milk and milk products
- Tests for adulterants

Recommended Books:

1. Food Chemical Composition: Dietary Significance in Food Manufacturing, Tim, H., Campden and Chorley Wood Research Association. Campden, UK, **(2002)**
2. The Food Chemistry Laboratory: A Manual for Experimental Foods, Dietetics, and Food Scientists, Weaver, M.C., and Daniel, J.R., Blackwell Pub. Co., Oxford, **(2003)**
3. PSQCA (Pakistan Standards and Quality Control Authority). Standards for different food items. PSQCA, Karachi, Pakistan, **(2010)**

4. Consumer laws in Pakistan, Khan, M.S., Consumer Rights Commission of Pakistan, Islamabad, Pakistan, **(1999)**
5. Dairy processing and quality assurance, Chandan, R.C., Kilara, A., and Shah, N., John Wiley and Sons Inc., New York, USA, **(2008)**
6. Milk and milk products, Winton A.L. and Winton K.B., Agrobios, Agro House, New Delhi, India, **(2006)**
7. Food Chemistry, Belitz, H.D., and Grosch, W., Springer-Verlag, New York, **(2006)**

CY-401: ESSENTIALS OF MICROBIOLOGY

CLOs	PLOs
Students will be able demonstrate an understanding of biology, genetics and chemistry of microbes	1
Students will be able to demonstrate an understanding of methods to control the production of microbes	2

Course contents:
Introduction and brief history of Microbiology, Basic Chemistry of Microbes, Microscopy, Cell Biology and Chemistry of Prokaryotes, Microbial metabolism, Microbial growth, Control of Microbial growth, Microbial genetics. Infectious Microbiology.

Text Book
Foundations in Microbiology: Basic Principles by Kathleen P. T., Barry Chess, McGraw-Hill Education, **(2014)**

CY-402: CHEMICAL MICROBIOLOGY

CLOs	PLOs
Students will be able to demonstrate an understanding of analytical and chemical methods to study the microorganism	2
Students will be able to understand antimicrobial chemotherapy, challenges and mechanism of action of selected antimicrobial agents	4

Course contents:
Staining and Culture:
Introduction of various techniques and Chemical methods of staining and bacterial growth.
Antimicrobial Chemotherapy:
Antimicrobial Chemotherapies and their impact on humans. Therapeutic challenges and mechanism of action of selected antimicrobial agents.

Text Book
Modern Industrial Microbiology and Biotechnology, Okafor, N., CRP-Press, Taylor and Francis Group, **(2007)**

Recommended books:
1. Foundations in Microbiology: Basic Principles, Kathleen P. T., Barry Chess, McGraw-Hill Education, **(2014)**
2. Microbiology, Spark N., Sterling Publishing Company Incorporated, **(2014)**
3. Industrial Microbiology: An Introduction, Michael J. W., Neil L. Morgan, John S. Rockey, Gary Higton, Wiley-Blackwell, **(2001)**

4. Modern Industrial Microbiology and Biotechnology, Okafor, N., CRP Press, Taylor and Francis Group, **(2007)**
5. Antimicrobial Chemotherapy, 4th Ed, Freeman, R., Oxford Press, **(2000)**

CY-441: STRUCTURAL BIOCHEMISTRY

CLOs	PLOs
Students will be able to understand molecular organization of cells and biochemical properties and structure of biological compounds	1
Students will be able to demonstrate an understanding of function of biomolecules, the cell membrane and membrane transport	2

Course contents:

Molecular organization of cells and the biochemical properties of the major classes of biological compounds e.g. amino acids, carbohydrates, lipids. Properties of water, pH and buffers. The structure and function of proteins, RNA and DNA as determinants of biological function, the cell membrane and membrane transport.

Text Book

1. Introduction to Protein Structure, Garland, 2ndEd, Branden, C. and Tooze, J., Garland Science, **(1999)**
2. Structural Biochemistry, 2ndEd, Lukas Buehler, WILEY, **(2003)**

Recommended Books:

1. Characterization of Protein Therapeutics using Mass spectrometry, Chen, Guodong (Ed.), Springer, **(2013)**
2. Protein Mass Spectrometry, Whitelegge, J., Elsevier, **(2008)**
3. Biochemistry Vol. II, Khan, M. R., The Carvan Book House, **(1995)**
4. Biochemistry, Abeles, R. H., Frey, P. A., Jencks, W. P., Jones and Bartlett Publishers International, **(1992)**
5. Introduction to Enzyme and Coenzyme Chemistry. 2nd Ed, Bugg, T., Blackwell Science, **(2004)**
6. Methods in Structural Biochemistry: A lab manual, 4th Ed., Structural chemistry program, Griffith University, (**2018**)

CY-442: BIOCHEMISTRY OF METABOLISM

CLOs	PLOs
Students will be able to understand the underlying chemistry of metabolism by studying selected metabolic pathways.	1
Students will be able to develop knowledge of analytical methods to integrate the different metabolic reactions	3

Course contents:

Metabolism of selected molecules (Carbohydrate metabolism, nucleotide and pyrimidine metabolism, Citric acid cycle, Oxidative phosphorylation, Photosynthesis, Lipid metabolism, Nitrogen metabolism), Integration of metabolism

Text Book
Advanced Nutrition and Human Metabolism, 6th Ed, Gropper, S. S., Smith, J. L., Wadsworth Publishing **(2012)**

Recommended Books
Haynie, D. T. Biological thermodynamics. CUP, 2nd edition, **(2008)**.

CY-443: INFORMATIONAL MACROMOLECULES

CLOs	PLOs
Students will be able to demonstrate an understanding of storage and expression of genetic information	1
Students will be able to demonstrate an understanding of synthesis and processing of life molecules	2

Course contents:
Structure of nucleotide. Storage and expression of genetic information, DNA synthesis and repair, RNA synthesis and processing. Protein synthesis and modifications.

Text Book
Harper's Biochemistry, 24th Ed, Murry, R. K., Granner, D. K., Mayes, P. A., Rodwell, V. W.,Appleton and Lange **(1998)**

Recommended Books
1. Introduction to proteins, structure, function and motion. Ammit Kessel and Nir Ben-Tal, CRC Press, **(2011)**
2. Informational Biopolymers of Genes and Gene Expression, properties and Evolution, R. D. Blake, University Science Books, (**2005)**

.**CY-444: BIOENERGETICS**

CLOs	PLOs
Students will be able to demonstrate an understanding of the structure, chemistry and theory relating to power house of cell and energy production and energy balance in living systems	1
Students will be able to apply techniques and methods in bioenergetics research	3

Course contents:
Conversion of food to energy in biological systems, energy balance, energy transductions occurring in living systems and molecular mechanisms of these processes, cells and mitochondria, Cotransport, role of high-energy phosphates as the 'Energy currency" of the cell, interconversion of adenine nucleotides, chemiosmotic theory, new techniques and findings in bioenergetics research.

Text Book
Biochemistry, Jeremy, M. B., Tymoczko, J. L., Stryer, L., W. H. Freeman, **(2006)**

Recommended Books:

1. Molecular Biology of the Cell, Aberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Water, P Garland Science, **(2008)**
2. Introduction to Organic and Biochemistry,12thEd,Frederick A. Bettelheim, William H. Brown, Brooks/Cole, **(2012)**
3. Principles of Bioenergetics, **Skulachev**, Vladimir, **Bogachev**, Alexander V., **Kasparinsky**, Felix O. Springer, **(2013)**
4. Biochemistry, Donald V.,Judith G. V., John Wiley and Sons, **(1995)**
5. Biochemistry, Biomolecules, Donald V.,Judith G. V., John Wiley and Sons, **(2003)**

CY-445: NUTRITIONAL BIOCHEMISTRY

CLOs	PLOs
Students will be able to demonstrate an understanding of nutrition at various levels	1
Students will be able to provide advice on nutrition, malnutrition and body energy	3

Course contents:

Classification of biological structures, digestion and absorption, Nutrients, Animal nutrition, Plant nutrition, Environmental Nutrition, Advice and guidance, Malnutrition, Body Energy.

Text Book

1. Introduction to Organic and Biochemistry By Frederick A. Bettelheim, William H. Brown, Publisher: Brooks Cole; 8 Har/Psc edition (Jan. 2012)
2. Nutritional Biochemistry, Tom Brody, 2nd Edition, Academic Press, 1998.

Recommended books:

1. Introduction to Organic and Biochemistry,12thEd,Frederick A. Bettelheim, William H. Brown, Brooks/Cole, **(2012)**
2. Biochemistry, Donald V.,Judith G. V., John Wiley and Sons, **(1995)**
3. Biochemistry, Biomolecules, Donald V.,Judith G. V., John Wiley and Sons, **(2003)**

CY-446: ADVANCED PROTEIN CHEMISTRY

CLOs	PLOs
Students will be able to demonstrate an understanding protein structure and function at a three dimensional level	2
Students will be able to apply various methods for the production, isolation and characterization of proteins	3
Students will be able to apply basic bioinformatics methods to understand protein data base, and understand their basic applications	3

Course contents:

Principles of protein structure, folding, and function, techniques used for the production, isolation and characterization of proteins. Pharmacological and industrial importance of proteins. Bioinformatics of proteins. Methods in protein purification.

Text Book

1. Introduction to Organic and Biochemistry,12th Ed,Frederick A. Bettelheim, William H. Brown, Brooks/Cole, **(2012)**
2. Introduction to proteins, Structure, Function, And Motion, Amit Kessel and Nir Bental, CRC Press, **(2011)**

Recommended books:

1. Molecular Biology of the Cell, Aberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Water, P Garland Science, **(2008)**
2. Introduction to Organic and Biochemistry,12thEd,Frederick A. Bettelheim, William H. Brown, Brooks/Cole, **(2012)**
3. Biochemistry, Donald V.,Judith G. V., John Wiley and Sons, **(1995)**
4. Protein Mass Spectrometry, Whitelegge, J., Elsevier, **(2008)**
5. Biochemistry Vol. II, Khan, M. R., The Carvan Book House, **(1995)**
6. Introduction to Protein Structure, 2nd Ed, Branden, C. and Tooze, J. Garland, **(1999)**
7. Introduction to Enzyme and Coenzyme Chemistry. 2nd Ed, Bugg, T., Blackwell Science, **(2004)**

CY-447: ENZYMES AND ENZYMOLOGY

CLOs	PLOs
Students will be able to demonstrate an understanding of characteristics of different enzymes	1
Students will be able to demonstrate an understanding of Enzymatic reactions and corresponding kinetics	2
Students will be able to demonstrate an understanding of Enzyme catalysis, biochemical transformations, and role of enzymes in aerobic metabolism	1

Course contents:

Historical perspective, Fundamentals characteristics of enzymes, monomeric; oligomeric, isoenzymes; soluble and membrane bound enzymes, methods for analysis of enzymatic reactions, enzyme activity, enzyme inhibition, Enzyme catalysis and biochemical transformations, Energy capture by the breakdown (catabolism) of complex molecules and the corresponding formation of NADH, NADPH, $FADH_2$ and ATP, tricarboxylic acid Chemical and oxidative phosphorylation in aerobic metabolism.

Text Book

Introduction to Organic and Biochemistry, Frederick A. Bettelheim, William H. Brown, Brooks Cole **(2012)**

Enzymes, Biochemistry, Biotechnology, clinical chemistry, Clinical Chemistry, Trevor Palmer, Phillip Bonner, Elsevier, **(2007)**

Recommended books:

Biochemistry, 5th ed, Berg, J.M., Tymoczko, J.L., Stryer, L., W.H. Freeman and Company, **(2002)**

Enzymology at the membrane interface: interfacial enzymology and protein-membrane binding, Michael H. Gelp, Elsevier **(2017).**

CY-448: METABOLISM AND RELATED DISEASES

CLOs	PLOs
Students will be able to develop basic knowledge of Metabolic processes	1
Students will learn to perform case studies on selected metabolic diseases	3

Course contents:

Metabolic processes result in the development of human diseases such as phenylketonuria, gout, hypercholesterolemia, diabetes and porphyria, mitochondrial electron transport: The Chemiosmotic hypothesis; respiratory chain structure and function; respiratory cofactors.
Diseases including phenylketonuria and gout. Vitamin D and bone disorders; Vitamin K and blood clotting. Glucose transporters and disease; Glycogen storage diseases; Pyruvate dehydrogenase complex defects. Metabolic adaptations in cancer and relation to Chemotherapy.

Text Book

Betrayed by Nature: The War on Cancer, Robin Hesketh, Macmillan Science, **(2012)**

Recommended books:

1 Introduction to Organic and Biochemistry, Frederick A. Bettelheim, William H. Brown, Brooks Cole **(Jan. 2012)**
2 The Oncogenes and Tumour Suppressor Gene Factsbook.,Hesketh, R. 2nd ed. Academic Press, (**1997)**
3 Bioenergetics,3rd Ed, Nicholls, D. G. and Ferguson, S. J, Academic Press, (**2002)**
4 Cell Signalling. 3rd ed. Hancock, J.T., OUPr, (**2010)**
5 The Protein Kinase Factsbook. Hardie, D. G. and Hanks, S. ed,Academic Press, **(1995)**

CY-403: Experimental Methods in Microbiology

CLOs	PLOs
Students will demonstrate the ability to perform selected microbial experiments as slide preparation, microbial growth and inhibition and their life cycle	2
Students will be learn to determine nutritional bioenergetics and nutritional value of selected food samples	4
Students will to carry out metabolic studies of selected diseases in patients	3
Students will be demonstrate the ability to write technical reports keeping in view lab and work ethics	5

PRACTICAL:

1. Model and sketch formation of various microbes, slide formation for microscope, antimicrobial activity of various antiseptics.
2. Life Cycle understanding of Fungi, Algae, Protozoa, Bacteria and Virus by sketching, Slide formation for Fungi and algae. Chlorophyll extraction from algae and Fungi.
3. Bacterial growth and factors affecting the growth, incubation techniques, antimicrobial
Chemotherapy, alcohol formation from antimicrobial activity.

. 4. Study of nutritional Bioenergetics in various types of food i.e. Fish, Meat, and Vegetables etc.

1. Study of nutritional values of fresh and cooked food.
2. Study of various metabolisms (Lipids, Nitrogen etc.) in the body of various patients and comparison with healthy people
3. Bioinformatics studies (Understanding of various data bases, Uniprot, NCBI, etc)

Recommended Books:

6. Microbiology, Spark N., Sterling Publishing Company Incorporated, **(2014)**
7. Industrial Microbiology: An Introduction, Michael J. W., Neil L. Morgan, John S. Rockey, Gary Higton, Wiley-Blackwell, **(2001)**
8. Modern Industrial Microbiology and Biotechnology, Okafor, N., CRP Press, Taylor and Francis Group, **(2007)**
9. Foundations in Microbiology: Basic Principles by Kathleen P. T., Barry Chess, McGraw-Hill Education, **(2014)**
10. . Enzymes, Biochemistry, Biotechnology, clinical chemistry, Clinical Chemistry, Trevor Palmer, Phillip Bonner, Elsevier, **(2007)**
11. Nutritional Biochemistry, Tom Brody, 2nd Edition, Academic Press, 1998.

CY-449: Experimental Methods in Biochemistry

CLOs	PLOs
Students will be able to extract biological molecules like amino acids, proteins, DNA and perform their analysis using several analytical methods like SDS-PAGE, UV-visible spectroscopy, Western blot	3
Students will be able to utilize online data bases and software to solve problems of bioinformatics	2
Students will be able to perform enzymatic reactions and study their kinetics	3
Students will be demonstrate the ability to write technical reports keeping in view lab and work ethics	5

PRACTICAL:

1. Analysis of amino acids in biological samples.
2. Determination of protein content of selected biological samples (Bradford assay)
3. Extraction and purification of proteins from biological samples.
4. SDS-PAGE
5. Western blotting
6. Crystallization of proteins (lysozyme)
7. Qualitative and quantitative analysis of RNA, DNA and lipids. Biological membranes
8. Structural stability and binding of macromolecules using fluorescence, SD spectroscopy and UV absorbance.
9. Enzyme kinetic and inhibition studies.
10. Metabolic regulation. Problems on control of enzyme activity by allosteric effectors and covalent modification
11. Bioinformatics studies (Use of data base to solve problems in biochemistry, preparation of three dimensional model structures of selected macromolecules and their interaction with other molecules)

Recommended Books:

1 Characterization of Protein Therapeutics using Mass spectrometry, Chen, Guodong (Ed.), Springer, **(2013)**
2 Protein Mass Spectrometry, Whitelegge, J., Elsevier, **(2008)**
3 Biochemistry Vol. II, Khan, M. R., The Carvan Book House, **(1995)**
4 Introduction to Enzyme and Coenzyme Chemistry. 2nd Ed, Bugg, T., Blackwell Science, **(2004)**
5 Methods in Structural Biochemistry: A lab manual, 4th Ed., Structural chemistry program, Griffith University, (**2018**)
6 Advanced Nutrition and Human Metabolism, 6th Ed, Gropper, S. S., Smith, J. L., Wadsworth Publishing **(2012)**
7 Introduction to proteins, structure, function and motion. Ammit Kessel and Nir Ben-Tal, CRC Press, **(2011)**

SPECIALIZATION IN PHYSICAL AND ELECTROCHEMISTRY

CY-464: SOLID STATE AND MATERIAL CHEMISTRY

CLOs	PLOs
To explain the structure of solids and get introduced with the importance of chemical and physical bonds, crystal disorder and defects for materials properties.	2
To enable to apply the different synthetic methods for preparation of different materials and interpretation of obtained data from characterization technique of these material.	3

Course contents:

Physical aspects of solids, Crystal lattice, Structure of solids, X-ray powder diffraction method, Single crystal X-ray diffraction method, Crystal defects, color centers, Band Theory of metallic state, Conductors, semiconductors and insulators, Controlled valenChem and hopping phenomena, Ionic conductivity and solid electrolytes, Electrical and optical properties of solids, Development in superconductivity, Introduction to material Chemistry, Synthetic methods of different materials Characterization (TGA/DTG, SEM, TEM, EDX, XRD), Introduction to catalysis, Industrial catalysts

Textbook:

Quantitative X-ray Fluorescence Analysis Theory and applications, Gerald, R.L., Fernand, C., John Willey and Sons, New York, **(1995)**

Recommended books:

1. Solid State Chemistry and Its Applications, West A. R., John Wiley and Sons, New York **(2014)**
2. Elements of X-ray Diffraction, Cullity, B.D., Addison-Wesley Publishing Company, Inc.California,**(2006)**
3. Thermal Methods, James, W.D., Kenneth, H.T, Brain, R.C., John Wiley and Sons, New York **(1987)**
4. Nanostructured Materials Processing, Properties and Potential Applications, Carl, C.K., William Andrew Publishing, New York **(2002)**

CY-465: Statistical THERMODYNAMICS (THEORY)

CLOs	PLOs
To explain the advanced concepts and principles in statistical thermodynamics,	2
To derive the distribution laws and State functions in terms of partition function	3

Course contents:

Basic Terminology: probability, phase space, micro and macro states, thermodynamic probability,
statistical weight, assembly, ensemble, probability considerations and Chemistry. The most probable distribution: Maxwell-Boltzmann distribution, Thermodynamic properties from statistical Thermodynamics, The Partition Function for monoatomic gas, State functions in terms
of partition function, separating partition function: the nuclear and electronic partition function, for molecules, electronic and vibrational partition function.

Textbook:

Thermodynamics, Statistical Thermodynamics and Kinetics 1st Ed., Thomas, E., and Reid, P., Benjamin Cummings, **(2006)**

Recommended books:

1. Thermodynamics and Statistics, Kauzmann, W., W. A. Benjamin Inc. California, **(1967)**
2. Thermodynamics and Statistical Mechanics,Seddon, J.M., and Gale, J.D., Royal Soc Chem, UK, **(2002)**
3. Thermodynamics and Statistical Thermodynamics, Aston, J.G., and Fritz, J.J., John-Wiley, New York, **(1987)**

CY-466: ELECTROCHEMISTRY AND CLEAN ENERGY

CLOs	PLOs
For understanding the process of energy transfer, explaining the operation of internal combustion, solar, photovoltaic and fuel cells and applying understanding to propose how clean technologies can be promoted.	4
For understanding technical and scientific systems and comparing alternative solutions	5

Course contents:

Fuel cells:
High temperature and low temperature fuel cells, Role of electrolysis in fuel cells.

Photovoltaics:
Technologyand applications

Solar cells:
Electrodeposited calcium sulphide and cadmium telluride for solar cells

Rechargeable batteries:
Lead acid battery, Rechargeable dry cells and Lithium batteries

Textbook
Handbook of Fuel Cells, Vielstich, W., Lamm, A., Gasteiger, H.A., Yokokawa, H., John Wiley and Sons, **(2013)**

Recommended books:

1. Physical Chemistry, Glasstone, S., Macmillan and Co. Ltd. St. marlins Street, London. **(1995)**
2. Atkins' Physical Chemistry, Atkins, P., Julio de Paula, OUP Oxford, **(2014)**

CY-467: APPLIED ELECTROCHEMISTRY

CLOs	PLOs
Students will be able to describe the chemical reactions that take place during the electrochemical conversions and to recognize the main physicochemical surface properties and to combine them with surface mediated processes such as adsorption and formation of surface compounds	2
Students will acquire the knowledge corrosion mechanism and assess the proper selection preventive measures.	3

Course contents:
Surface states and Adsorption
Thermodynamics of the solution electrode inter-phases, surface excesses, change in potential as a function of distance from electrode surface, correction for double layer effects in equations describing the kinetics of electrode reactions, charging currents. Adsorption isotherms, the influence of adsorption of reaction rates. The hydrogen evaluation reactions.

Corrosion and Corrosion protection
Corrosion, types of Corrosion, measurement of corrosion, methods of corrosion protection.

Textbook:
Modern Electrochemistry 4th Ed, Bockris, J.O.M., and Reddy, A.K.N., Plenum Press, London, **(2003)**

Recommended books:

1. Electrode Kinetics, Albery, J., Clarendon, Oxford, **(1975)**
2. Chemical Kinetics and Reaction Mechanism 2nd ed., McGraw Hill London **(2002)**
3. Chemical Kinetics and Reaction Mechanisms 2nd Ed. Espenson, J. H., McGraw Hill, New York, **(1995)**
4. Principles of Electrode Kinetics, Muhammad, M., and Amjad, M., Rooha Printers, Lahore **(2001)**
5. Electrode Kinetics, Albery, J., Clarendon, Oxford, **(1975)**
6. ElectroChemical Methods, Bard, A.J., and Faulkner, L.R., John Wiley and Sons, **(2001)**

CY-468: ELECTRO-KINETICS PHENOMENA

CLOs	PLOs
To illustrate the electrode reactions with special context to charge transfer reactions, electrocatalysis and kinetics of electrode reactions.	1
To enable the students to evaluate appropriate choice of electrochemical technique used for electrochemical investigations.	2

Course contents:

Electro Chemical devices, Electrical double layer and its structure, Electrochemical processes, Charge transfer processes in the absence and presence of electrical field, The Over potential. Butler-Volmer's equation, The Idea of equilibrium exchange current density, The Symmetry factor. High field and low field approximation, Tafel's equation,
Electrocatalysis: role in electrode kinetics, application in different electrochemical processes Electrochemical techniques: Cyclic voltammetry and its applications. Stripping voltammetry, Potentiometry, Electro-osmosis, Electrophoresis.

Textbook:

Electrokinetic and Colloid Transport Phenomena, Jacob H. Masliyah S. Bhattacharjee, John Wiley & Sons, Inc. **(2005).**

Recommended books:

1. Electrode Kinetics, Albery J., Clarendon, Oxford, **(1975)**
2. Modern ElectroChemistry 4th Ed, Bockris, J.O.M., and Reddy, A.K.N., Plenum Press, London, **(2003)**
3. Principles of Electrode Kinetics, Muhammad, M., and Amjad, M., Rooha Printers, Lahore, **(2001)**
4. ElectroChemical Methods, Bard, A.J., and Faulkner, L.R., John Wiley and Sons, **(2001)**

CY-469 Electrochemical Industrial Processes

CLOs	PLOs
Students will be able to describe, differentiate and explain the chemical processes that take place during the electrochemical conversions.	2
Students will be able to explain the process of electro refining and catalysis with suitable examples of industrial chemical processes	3

Course Contents:

Electrochemical Industrial Processes

Socialites of Electrohemical production method, Electrode materials and over potentials. Electrolytic manufacturing of caustic soda, electrolysis of aqueous sodium chloride. Special production process for hypochlorite, chlorates, perchlorate and hydrogen peroxide. Diaphragm and amalgam methods, Electro-refining and electro-winning of metals, molten salt electrolysis. Electro-organic synthesis, electrode process, adiponitrile process.

Textbook:

Modern ElectroChemistry 4th Ed, Bockris, J.O.M., and Reddy, A.K.N., Plenum Press, London, **(2003)**

Recommended books:

1. Electrode Kinetics, Albery, J., Clarendon, Oxford, **(1975)**
2. Chemical Kinetics and Reaction Mechanism 2nd ed., McGraw Hill London (2002).
3. Chemical Kinetics and Reaction Mechanisms 2nd Ed. Espenson, J. H., McGraw Hill, New York, **(1995)**
4. Principles of Electrode Kinetics, Muhammad, M., and Amjad, M., Rooha Printers, Lahore **(2001)**
5. Electrode Kinetics, Albery, J., Clarendon, Oxford, **(1975)**
6. ElectroChemical Methods, Bard, A.J., and Faulkner, L.R., John Wiley and Sons, **(2001)**

CY-470 QUANTUM CHEMISTRY

CLOs	PLOs
To describe Operators, Angular momentum, Perturbation, harmonic oscillator, rigid rotor and different theories.	2
To analyze model physical systems using common approximation techniques for hydrogen molecule ion and the MO treatment of diatomic molecules.	3
To discuss the difficulties with the theory of quantum measurements Obtain independent scientific knowledge from literature, and communicate it effectively to peers.	5

Course Contents:

Operators and their properties. Angular momentum. Central field problem. Approximate methods. Perturbation methods and variation principle. Many electron systems. Treatment of simple harmonic oscillator, enharmonic oscillator, diatomic rigid rotor. Valence bond and molecular orbital theories. Pi-electron calculations. The hydrogen molecule ion and the MO treatment of diatomic molecules. The H_2 molecule and its VB treatment. Comparison of MO and VB approaches for diatomic and polyatomic molecules.

Textbook:
Quantum Chemistry 7th Edition, Ira N. Levine, Pearson Education New York USA, (2013)

Recommended books:

1. Quantum Chemistry 2nd Ed., Donald A. McQuarrie, University Science Books Mill Valley, California (2008)
2. Elements of Quantum Mechanics, Micheal, D.F., Oxford University Press, (2005)
3. Introduction to Quantum Mechanics 2nd Ed., Griffiths, D.J., Prentice Hall, **(2004)**
4. Quantum Mechanics for Chemists 1st Ed, Hayward, D.O., John Wiley, **(2003)**
5. Fundamentals of Quantum Mechanics 2nd Ed., James E., Elsevier-Academic Press, (2003)

CY-491 SCIENTIFIC REPORT WRITING

Course contents:

This course aims to develop and refine the critical and analytical writing skills of the students in field of natural and applied sciences. Writing strategies, with an emphasis on well-organized report, concise sentences, coherent paragraphs etc., will be reviewed for effective communication. Following contents will be discussed in detail for this course.

- Introduction to “writing in the sciences”.
- Principles of effective writing (cutting unnecessary clutter).
- Crafting better sentences and paragraphs.
- Organization; and streamlining the writing process.
- The format of an original manuscript.
- Reviews, commentaries, and opinion pieces; and the publication process.
- Issues in scientific writing (plagiarism, authorship, ghostwriting, reproducible research).
- How to do a peer review; and how to communicate with the lay public.
- Writing a research article.
- Writing a research proposal.
- Writing a lab report.
- Posters and presentations.

Textbook:

Writing Research Papers: A Complete Guide 10th Ed, Lester, J.D., Longman, **(2001)**

Recommended Books:

1. English for Writing Research Papers, Wallwork, A., Springer,**(2011)**
2. A Short Guide to Writing a Research Proposal, Ziegler, A., Old Mountain Press, **(2014)**
3. Developing Effective Research Proposals 2nd Ed, Punch, F.K., SAGE Publications,**(2014)**
4. Research Design and Proposal Writing in Spatial Science 2nd Ed, Gatrell, D.J., Bierly, D.G., Jensen, R.R., Springer, **(2012)**
5. Successful Lab Reports: A Manual for Science Students, Lobban, S.C., and MarLa Schefter, Cambridge University Press, **(1992)**
6. Scientist's Guide to Poster Presentations, Gosling, J.P., Springer, **(1999)**

CLOs	**PLOs**
The Student will be able to improve their scientific writing skills	4
The students will be able to improve their formatting skills as per journals requirements	8
he students will be able to build their writing skills for research proposals and for presentations of their work at public level	7

CY-471: Physical and Electro Chemistry Lab I

PRACTICALS:

1. Synthesis of Nanomaterials.
2. Synthesis of polymers.
3. Synthesis of metal oxide nanoparticles and their characterization using IR and XRD techniques.
4. Determination of magnetic susceptibility of various magnetic materials
5. Determination of magnetic susceptibility of various magnetic materials
6. Impedance analysis of various magnetic materials
7. Effect of controlled heating on composition of given solids and monitoring of their IR spectra
8. Role of additives in electrodeposition
9. Surface area by adsorption methods
10. Determination of partial molal volumes and excess molar volumes for binary and ternary systems
11. Effect of mixture composition on the proton NMR spectrum of protic system; investigation of intermolecular interactions.
12. To determine amount of the each component of the ternary mixture of HCl, CH_3COOH and $CuSO_4$ by conductometric titration.
13. Determine the strength of a given solution of KCl using differential potentiometric titration technique
14. Construction of Phase Diagram: Phase diagram for liquids, (benzene and methanol, ----) and phase diagram for solids, (benzoic acid and cinnamic acid, benzoic acid and naphthalene and acetamide and saliChemlic acid).

Recommended Books:

1 Quantitative X-ray Fluorescence Analysis Theory and applications, Gerald, R.L., Fernand, C., John Willey and Sons, New York, **(1995)**

2 Thermodynamics, Statistical Thermodynamics and Kinetics 1st Ed., Thomas, E., and Reid, P., Benjamin Cummings, **(2006)**

3 Handbook of Fuel Cells, Vielstich, W., Lamm, A., Gasteiger, H.A., Yokokawa, H., John Wiley and Sons, **(2013)**

4 Modern Electrochemistry 4th Ed, Bockris, J.O.M., and Reddy, A.K.N., Plenum Press, London, **(2003)**

5 Chemical Kinetics and Reaction Mechanism 2nd Ed, Espenson, J. H., McGraw Hill London, **(2002)**

6 Chemical Kinetics and Reaction Mechanisms 2nd Ed, Espenson, J.H., McGraw Hill, New York **(1995)**

7 Kinetic and Mechanism 2nd Ed, Frost, A.A., and Pearson, R.G., John Wiley and Sons Inc, New York, **(1961)**

8 Modern ElectroChemistry 4th Ed, Bockris, J.O.M., and Reddy, A.K.N., Plenum Press, London, **(2003)**

9 Thermodynamics, Statistical Thermodynamics and Kinetics 1st Ed., Thomas, E., and Reid, P., Benjamin Cummings, **(2006)**

CY-472: Physical and Electro Chemistry Lab II

PRACTICALS:

1. Heat of solution of electrolytes by solubility measurements
2. Rotational probability distribution for HCl and CO at two different temperatures, comparison of their rotational partition function by direct calculation and by the simple formula q=T/qrot
3. Heat of transfer for benzoic acid between benzene and water and I2 between CCl_4 and water.
4. Conductometric determination of Cu (II) - EDTA mole ratio in the complex.
5. Measurement of Chemclic voltammograms of a different organic compounds and their interpretation.
6. Determination of strength of two acids by conductance measurements.
7. Determination of conductivity of given electrolytes at infinite dilution at different temperatures and their correlation with the viscosities of medium.
8. Study of two phases by mixing water and 1-butanol by refractometer. Spectrometric
9. Investigation of the distribution of a given transition metal ion between the two phases.
10. Conductometric determination of hydrolysis constant (K_h) of conjugate base of a weak acid.
11. Kinetics of electrodeposition and electrocrystallization.
12. Surface kinetic studies by Chemclic voltammetry
13. Verification of Debye-Huckel limiting law
14. Determination of pH and calculation of pKa
15. To determine the composition of complex ion in solution by spectrophotometric method for the systems Fe^{3+}-saliChemlic acid and Ni^{2+}-ethyldiamine.
16. To determine amount of the each component of the ternary mixture of HCl, CH_3COOH and $CuSO_4$ by conductometric titration.

17. To compare the cleaning power of different samples of soaps and detergents by surface tension measurements.

Recommended Books:

1 Quantitative X-ray Fluorescence Analysis Theory and applications, Gerald, R.L., Fernand, C., John Willey and Sons, New York, **(1995)**
2 Thermodynamics, Statistical Thermodynamics and Kinetics 1st Ed., Thomas, E., and Reid, P., Benjamin Cummings, **(2006)**
3 Handbook of Fuel Cells, Vielstich, W., Lamm, A., Gasteiger, H.A., Yokokawa, H., John Wiley and Sons, **(2013)**
4 Modern Electrochemistry 4th Ed, Bockris, J.O.M., and Reddy, A.K.N., Plenum Press, London, **(2003)**
5 Chemical Kinetics and Reaction Mechanism 2nd Ed, Espenson, J. H., McGraw Hill London, **(2002)**
6 Chemical Kinetics and Reaction Mechanisms 2nd Ed, Espenson, J.H., McGraw Hill, New York **(1995)**
7 Kinetic and Mechanism 2nd Ed, Frost, A.A., and Pearson, R.G., John Wiley and Sons Inc, New York, **(1961)**
8 Modern ElectroChemistry 4th Ed, Bockris, J.O.M., and Reddy, A.K.N., Plenum Press, London, **(2003)**
9 Thermodynamics, Statistical Thermodynamics and Kinetics 1st Ed., Thomas, E., and Reid, P., Benjamin Cummings, **(2006)**

CLOs	**PLOs**
Explain the basic concepts and principles in statistical thermodynamics,	1
To know about the Synthetic methods of different materials comparison of these methods, and about different Characterization technique of these material	2
Will learn the distribution laws and State functions in terms of partition function	3

CY-500 THESIS

Thesis Write up
Seminar
Viva