Document Code	Courses Description	Document Approval Date
AP01-PR06		

Department: Chemistry	**Program:** Master Degree in Chemistry Comprehensive Exam.	**Official Stamp:**
The courses description was approved by the decision of the Department's Council no. ..... on		

Course Name: Advanced Organic Chemistry (I) (Structure and Mechanism)	**Course Code and Number:** Chem. 611	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description

Objectives :

1. Know how chemical bonds are formed.
   - Description of the mechanism of organic reactions based on theory of frontier molecular orbitals and analysis of the results of practical experiments.
   - Determination of the thermodynamic and kinetic state of reactions.
2. To learn how to interpret the results of chemical reactions, depending on the size and charge distribution. Understanding the relationship between the different stereo types of molecules.
3. To find the energy profile diagrams of various organic reactions, and to understand the difference between energy states of molecules.

Course Description :

- Study the mechanisms of organic reactions and its relationship to chemical bonding (localized and delocalized).
- Study reaction intermediates, carbocations, carbanions, free-radicals and carbenes.
- Free energy relationship, undeophilic and electrophilic aromatic subsritution reactions, electrophilic aromatic and aliphatic substitution, reactions, addition reactions, eliminatin reactions and pericyclic reactions.

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	Learning outcomes : 1. Describe chemical and formation depending on the frontier molecular orbital theory. 2. Rationalize the results of experimental chemical reactions based on thermodynamic and kinetic states of reactions. 3. Describe the chemical reactions results based on size and charge distribution and stereochimal distribution of compounds. 4. Predict the lowest energy conformations of molecules and understand the stereochimal relationship between molecules. 5. Understand the energy profile diagrams of organic reactions and the difference between ground and transition states of molecules.

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Course Name: Advanced Organic Chemistry (II) (Synthesis and Reactions)	**Course Code and Number:** Chem. 612	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description

Objectives :

1. To know the transformations of different functional groups.
2. To know the reactions of ions leading to the formation of carbon carbon bonds.
3. To know the essential organic reaction mechanisms.
4. To know reagents and catalysts used in chemical reactions.

Course Description :

- Addition reactions of carbon carbon multiple bonds.
- Alkylatin of nucleophilic carbon.
- Carbon-carbon bond formation.
- Enolate and enamines.
- Reaction of nucleophilic carbons with carbonyl groups and other related groups.
- Oxidation reactions.
- Reactions include carbens and nitrenes.

Learning outcomes :

1. Understand transformations of functional groups and enolate reactions, leading to carbon-carbond bond formation.
2. Understand the major organic reactions mechanisms.
3. Reagents and catalysts used in organic reactions.

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Course Name: Heterocyclic Chemistry	**Course Code and Number:** Chem. 613	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. To know how to name the heterocyclic compounds, with different ring sizes. 2. To know different methods used to synthesize such heterocycles. 3. Identify the chemical reactions of such heterocycles and its mechanisms. **Course Description :** - Nomenclature of heterocyclic compounds with the ring size five and six as well fused ring systems. - Preparation methods of five, six and fused ring systems. - Study the reaction types and mechanisms of heterocyclic systems. **Learning outcomes :** 1. Identify the nomenclature methods of heterocyclic compounds. 2. Understand the familiar with synthetic methods of heterocyclic compounds. 3. Understand the familiar with reaction types and reaction mechanisms at heterocyclic compounds.	

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Course Name: Chemistry of Natural Products	**Course Code and Number:** Chem. 618	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. To know the isolation methods, classification and structural types, occurrence and biological activity of natural products. 2. To know the main biological reactions and the biosynthesized of the following types : Alkaloids, Terpenoids and phenolic compounds. 3. Biosynthesis and structure elucidation of alkaloids, terpenoides and phenolic compounds. **Course Description :** - Introduction to secondary metabolism, Isolation of secondary metabolites. - Classification, occurrence, biological activity and structure for the following types : alkaloids, terpenoids and phenolic compouds. **Learning outcomes :** 1. Knowledge of isolation, classification and structural types of secondary metabolites. 2. Knowledge of occurrence and biological activity of some natural. 3. Knowledge of biosynthesis of alkaloids, terpenoid and product phenolic compounds. 4. Understand methods of biosynthesis and classification of alkaloids, terpenoids and phenolic compounds.	

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Course Name: Chemical Applications of Group Theory	**Course Code and Number:** Chem. 621	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. Know how to apply molecular orbital theory (M.O.T.) in many organic and inorganic compounds. 2. Know how to do IR, Raman and U.v/Vis. Spectroscopic analysis in chemical compounds. **Course Description :** Definitions and theorems of Group theory, molecular symmetry and symmetry groups, Representations of groups and character tables. Applications of group theory : molecular orbital theory, hybrid orbitals and molecular orbitals for ABn type molecules, ligand field theory, electronic spectroscopy and vibrational spectroscopy. **Learning outcomes :** 1. Applications of molecular orbital theory (M.O.T.) in many organic and inorganic compounds. 2. IR, Raman and electronic spectroscopic applications in many chemical compounds.	

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Course Name: Advanced Transition Metals Chemistry	**Course Code and Number:** Chem. 622	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description

Objectives :

1. Know how to determine chemical formula and shape of chemical compounds using different chemical and physical methods.
2. Knowing isomerism in inorganic chemistry, especially optically active ones of coordination numbers 4 and 6.
3. Studying biological activity and reaction mechanism of compound containing transition elements.

Course Description :

General Introduction – Emphasis on the use of M.O. theory to explain properties of transition metal complexes. Calculations of formulas. Use of various physical and chemical techniques to predict the formula of a complex. Isomerism in coordination chemistry – Emphasis on stereoisomerism and in particular optically active isomers for both 4- and 6-coordinate complexes. Methods for the determination of absolute configuration : ORD and CD Spectra. Bioinorganic Chemistry : Importance of some transition metal ions in biological systems such as hemoglobin, myoglobin, cyctochromes and vitamin B_{12}. Nitrogen fixation process. Reaction Mechanisms – Electron Transfer Rxns and oxidative-addition Rxns. Seminars by students (30-35 min./student).

Learning outcomes :

1. On completion of the course the students will be able to know more about these advanced topics (discussed above).
2. Taught how to used chemical literature, find recent (2000-up till now) scientific information about topics given by the instructor then give a seminar and a report.

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Course Name: Transition Elements and Catalysis	**Course Code and Number:** Chem. 624	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. Understanding how catalysts work. 2. Understanding the role of transition metals in catalysis. 3. Studying the kinetics of some catalyzed reactions. **Course Description :** Principles of catalysis, homogeneous and heterogeneous catalysis, transition elements in the periodic table and volcano curves, electronic properties of transition elements and catalysis, the surface chemical bonds, group VIII elements and their catalytic effect, enhancement of catalyst action by addition of lanthanides and actinides, the kinetics and thermodynamics of some heterogeneous and homogeneous catalytic processes. **Learning outcomes :** 1. Understanding how catalysts work. 2. Understanding the catalytic effect of transition elements. 3. Understanding the thermodynamics and kinetics of some catalyzed processes.	

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Course Name: Separation Methods	**Course Code and Number:** Chem. 631	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. Identify different chromatography theories. 2. Identify the different methods of separation and understand the mechanics of each method. 3. Identify the basis for selecting the appropriate method of separation and the mechanisms to develop it. 4. Identify techniques related to different chromatography methods and their respective fields of use. **Course Description :** Classification of separation methods, separation by extraction, theories of chromatography, high performance liquid chromatography (HPLC), steps for the development of a separation method, ion-exchange chromatography, size exclusion chromatography, thin-layer chromatography, gas chromatography, supercritical fluid chromatography, electrophoresis, chromatographic instruments, fields of application. **Learning outcomes :** At the end of the course the student should be able to : 1. Explain basic principles of classification of different chromatographic methods. 2. Basic principles of the various chromatographic techniques. 3. Understand the basis for choosing the appropriate method of separation optimize chromatographic protocols for a variety of analytes. 4. Identify the technologies related to various chromatographic methods and areas of use of each of them.	

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Course Name: Atomic Spectrometric Methods of Analysis	**Course Code and Number:** Chem. 633	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description

Objectives :

1. Identify the methods of analysis of atomic spectroscopy and understand the mechanism of each method.
2. Identify special methods that can be connected to atomic spectrometers.
3. Learn the characteristics of the performance of the various techniques and basis of selecting the appropriate technique for analysis.

Course Description :

This course builds upon introductory courses in instrumental analysis and extends the scope to include the more in-depth principles of various atomic spectroscopy techniques, these include; Flame Atomic Absorption Spectroscopy (FAAS), Electro-thermal-AAS, Atomic Emission Spectroscopy (AES), Inductively coupled Plasma-AES (ICP-AES), Arc and spark sources, Hydride Generation Atomic Spectroscopy (HG-AS), X-ray fluorescence, methods of increasing sensitivity in AAS, Hyphenated Atomic Spectroscopy Techniques; (ICP-MS, Flow Injection Analysis, Liquid Chromatography …) , performance characteristics of AS techniques, selection of proper AS technique.

Learning outcomes :

At the end of the course the student should be able to :

1. Explain basic principles of the various atomic spectroscopy techniques.
2. Compare the performance of the atomic spectroscopy techniques.
3. Select the proper atomic spectroscopy technique for the analysis.

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Course Name: Advanced Analytical Methods	**Course Code and Number:** Chem. 636	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description

Objectives :

1. Understand the basic design and operating principles of some modern analytical instruments.
2. Understand the basis of choosing the appropriate method of analysis.
3. Identify the technologies related to automation of analytical methods.
4. Enhancing the student's ability to design appropriate methods of analysis.

Course Description :

This course covers the design, operational principles and practical application of modern instrumental methods used in chemical analysis, including :

Stoichiometric calculations, calibration of instrumental methods, Infrared spectroscopy, Raman spectroscopy, nuclear magnetic spectroscopy, thermal analysis, automated methods (flow injection analysis), surface analysis techniques and electroanalytical methods.

Learning outcomes :

At the end of the course the student should be able to :

1. Explain the operating principles of some modern analytical instruments.
2. Select the proper analytical technique for the analysis.
3. Identify the technologies related to automation of analytical methods.
4. Design analysis methods suitable for different types of samples.

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Course Name: Molecular Structure and Spectroscopy	**Course Code and Number:** Chem. 641	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description

Objectives :

1. Understanding the basic principles of quantum chemistry and spectroscopy.
2. Identifying and explaining experimental and theoretical methods employed in spectroscopic investigations.
3. Allowing the students to access the current state of the art research in the field.

Course Description :

This course is designed to provide students with theoretical background to understand experimental and theoretical aspects of the spectroscopy of atoms and molecules and allow them to access the current state of the art research in the field. Topics covered in this course include basic concepts of spectroscopy, atom spectroscopy, laser, rotational, vibrational and electronic spectroscopy of molecules, and nuclear and electron magnetic resonance spectroscopes.

Learning outcomes :

At the end of the course the student should be able to :

1. Understand and articulate the basic principles of quantum chemistry and spectroscopy.
2. Identify and explain experimental and theoretical methods employed in spectroscopic investigations.
3. Describe and explain the Born-Oppenheimer approximation and the appearance of spectroscopic selection rules.
4. Predict atomic spectra in absence and presence of external magnetic field.
5. Apply symmetry to interpret/predict molecules spectra.
6. Derive molecular properties based on spectroscopic data.
7. Assign bands in electronic spectra.
8. Select molecular spectroscopy methods suitable for solving given scientific problems.
9. Use NMR techniques to understand dynamic processes and molecular motions and molecular self-assemblies.

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Course Name: Chemical Kinetics	**Course Code and Number:** Chem. 642	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. Understanding the basic principles of Chemical kinetics. 2. Describing the fundamental chemical and physical properties that determine chemical reaction rates. 3. Identifying and explaining experimental and theoretical methods employed for kinetic investigations. 4. Allowing the students to access the current state of the art research in the field. **Course Description :** This course is designed to provide students with the knowledge, theoretical background and modeling tools to understand experimental and theoretical aspects of chemical reaction kinetics and allow them to access the current state of the art research in the field. Topics covered in this course include basic concepts of chemical kinetics, simple reactions, temperature dependence of reaction rate, kinetic measurements, concentration proportional properties, experimental techniques for fast reactions, complex reactions, kinetic gas theory, simple collision theory, reactions in solution, catalysis (including enzyme catalysis), adsorption and surface reactions, chain reactions, photoreactions, transition state theory and its applications. **Learning outcomes :** At the end of the course the student should be able to : 1. Understand and articulate the basic principles of Chemical kinetics. 2. Describe the fundamental chemical and physical properties that determine chemical reaction rates. 3. Identify and explain experimental and theoretical methods employed for kinetic investigations. 4. Carry out calculations on reaction rates using the rate law Rates.

	5. Determine rates and time dependence of the concentration of individual components for complex reactions using computational techniques based on analytic, numerical and approximate solutions such as steady state or pseudo–lower order approximations. 6. Estimate elementary reaction rate constants based on collision theory and transition state theory. 7. Evaluate the literature regarding kinetic measurements of complex reaction systems. 8. Have good skills in graph and data processing.
Course Name: Environmental Chemistry	**Course Code and Number:** Chem. 652 — **Number of Credit Hours:** 3
Teaching Language: English	
Pre-requisite:	
Course Description	**Objectives :** 1. Understand contemporary environmental issues and explain how they occurs. 2. Identify source of pollutants, reactions, transport and fates. 3. Identify the negative effects cause by environmental pollution. 4. Identify some methods of analysis and choose the appropriate method. **Course Description :** Introduction to environmental chemistry, air pollution, consequences of air pollution (acid rain, ozone depletion, global warming, urban smog, suspended particles, …) , transport of pollutants, water pollution, sources of water pollution (organic and inorganic pollutants), parameters related to water pollution (BOD, COD, …) soil pollution, methods of samples collections, sampling of air, water and soil for chemical analysis. Common methods of analysis and the basis of choosing the appropriate technique .

	Learning outcomes : At the end of the course the student should be able to : 1. Explain contemporary environmental issues and explain how they occurs. 2. Identify sources of pollutants, transport, reactions and fates. 3. Recognize the negative effects caused by environmental pollution. 4. Explain basic principles of common methods of analysis and basis of choosing the appropriate method.

Course Name: Special Topics in Organic Chemistry	**Course Code and Number:** Chem. 691	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description	**Objectives :** 1. Recognition of molecular structure and theoretical bond calculations. 2. Knowledge of stereochemistry. 3. Knowledge of some inorganic chemistry intermediate. **Course Description :** - Chemical bonding and molecular structure - Molecular orbital calculations - Electronic energy levels, bond orders, free-valence indexes and charge distributions - Stereochemistry, optical activity and cis-trans isomers and conformational analysis - Mechanistic organic chemistry - New articles selected from organic journals concerning carbanions **Learning outcomes :** 1. Understand the molecular structure and theoretical calculations of bonds 2. Understand some aspects of stereochemistry 3. Know some types of intermediates in organic chemistry

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Course Name: Special Topics in Inorganic Chemistry	**Course Code and Number:** Chem. 692	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. Knowledge of transition metal compounds and clusters, containing metal-metal bonds. 2. Knowledge of boron hydrides clusters. 3. Knowledge of low oxidation state transition metals oxide. **Course Description :** General Introduction-Formulas of complexes. Physical and chemical techniques used to identify the structures of complexes. Metal-metal bonds and metal clusters. Boron hydrides and their clusters. π-Complexes and low oxidation states of transition metals. Seminars by students. **Learning outcomes :** At the end of the course the student should be able to : 1. On completion of the course the students will be able to know more about the special topics listed previously. 2. Taught how to use chemical literature, find recent scientific information about topics given by the instructor then give a seminar and a report.	

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Course Name: Special Topics in Analytical Chemistry	**Course Code and Number:** Chem. 693	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. Identify the latest methods of analysis that were not exposed to the student previously. 2. To deepen student's understanding of the applications of specialized analytical methods. 3. Enhance the student's ability to complete graduate studies. **Course Description :** This course is designed to deepen the student's knowledge in advanced topics of analytical chemistry. The lecturer has the option of selecting the topics of this course taking into account the needs and interests of students. This course may be repeated under different topics. **Learning outcomes :** At the end of the course the student should be able to : 1. Explain the mechanism of operation of the advanced analytical techniques. 2. Understand most recent applications of specialized analytical methods. 3. Writing research projects that may help in the completion of graduate studies.	

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Course Name: Special Topics in Physical Chemistry	**Course Code and Number:** Chem. 694	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		
Course Description	**Objectives :** 1. Knowledge and understanding of Instrumentation in optical measurements. 2. Theory and applications of laser. **Course Description :** Introduction to electrical, electronic components and circuits. Operation amplifiers and Analog to Digital / Digital to Analog signal conversion. Professional operation of signal generators and oscilloscopes. Light sources, Band sources and Line sources). Introduction to Lasers, Theory and Applications in Optical Instruments. Wavelength separation devices: Optical Filters, Spectrographs and Monochromators. Optical Detectors: Single channel (PMT) and Multichannel (Diode Array). Frequency domain instruments. Time Domain Instruments for measuring emission lifetimes down to Pico second time scale. **Learning outcomes :** At the end of the course the student should be able to : 1. Differentiate between AC power and DC power, resistance, reactance and impedance in electricity. 2. Operate signal sources, frequency generators and oscilloscopes. 3. Describe the main units in optical spectrometers. 4. Differentiate between different sources of optical radiation and theory of operation for each source. 5. Understand the basic theory of lasers, their main types and specific examples of each type. 6. Understand the basic idea behind the operation of wavelength separation instruments : momochromators and spectrographs and how to perform wavelength calibration.	

	7. Will have detailed information about optical detectors in the different regions of the optical spectrum. 8. Differentiate between frequency and time domain spectrometers. 9. Perform system calibration and daily maintenance. 10. Collect optical spectral and perform data manipulation : smoothening, averaging, normalization …. Etc.

Course Name: Research Project	**Course Code and Number:** Chem. 695	**Number of Credit Hours:** 3
Teaching Language: English		
Pre-requisite:		

Course Description	**Objectives :** The main objective of this course is to develop an overall understanding of the theoretical and practical principles of scientific research as well as those of professional oral and written communication in science including accepted writing skills, presentation techniques, listening skills, critical analysis of scientific data, and participation in scientific discussions. In addition, the students are expected to actively defend the research results they present including methodology, data and conclusions and write an evaluation for each seminar given within this course or by an invited speaker. **Course Description :** This course provides graduate students with an introduction to the theory and practice of scientific research. Issues of safety in the laboratory, literature searching, experimental design, ethical conduct in research, intellectual property, entrepreneurship, funding agencies, job opportunities, curriculum vitae/résumé writing, and effective written and oral scientific communication skills are discussed. Students are required to attend departmental seminars and colloquia in order to learn about a broad range of current experimental and theoretical topics in chemistry. It also provides graduate students with experience in presenting scientific data,

orally and in written, in a professional manner with an emphasis on defense of data and interpretation. Each student will prepare at least one oral presentation and one written report of research topics of current interest. The students are also expected to write critique and evaluation of the other seminars held within this course or by invited speakers.

Learning outcomes :

Students who complete this course will/will be able to :

1. Have a working knowledge of the scientific process, including hypothesis development, experimental design, use of instrumentation, data collection and reporting.
2. Demonstrate the ability to present scientific material during a 40 minute presentation for general chemistry audience.
3. Demonstrate the ability to critically evaluate the research presented in a peer reviewed article and to answer questions posed by the audience on this research at the end of the presentation.
4. Demonstrate an ability to defend research approaches and conclusions by providing answers to questions on experimental rational and alternate interpretations of data.
5. Demonstrate an ability to listen to a scientific presentation and to ask pertinent questions regarding the material presented.
6. Actively participate in a discussion of strengths and weaknesses of a speaker's presentation and/or the scientific merit of the research presented.
7. Provide clear concise written critiques of research and/or journal presentations with respect to presentation style, multimedia and content.
8. Be prepared to accept criticism in a professional manner.
9. Have various soft skills strengthened: critical analysis of data, time management, confidence in public speaking, ability to ask questions, etc.

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Course Name: Comprehensive Exam	**Course Code and Number:** Chem. 698	**Number of Credit Hours:** 0
Teaching Language: English		
Pre-requisite:		
Course Description		