Course Specification
(Bachelor)

Course Title:	Quantum Chemistry
Course Code:	CHM 344
Program:	Chemistry
Department:	Chemistry
College:	College Of Science
Institution:	Majmaah University
Version:	TP-153
Last Revision Date:	11 December 2024

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: (3)					
2. Course type					
A.	☐University	☐College	☒ Department	☐Track	☐Others
B.	☒ Required		☐Elective		
3. Level/year at which this course is offered: (Level 5/year 3)					
4. Course General Description:					
The Quantum Chemistry course introduces undergraduate chemistry students to the fundamental principles and mathematical frameworks underpinning the quantum mechanical behavior of matter. It explores the application of quantum theory to atomic and molecular systems, focusing on the understanding of electronic structure, chemical bonding, and molecular spectroscopy.					
5. Pre-requirements for this course (if any)**:**					
MTH201					
6. Co-requisites for this course (if any)**:**					
None					
7. Course Main Objective(s):					
To develop an in-depth understanding of quantum mechanical principles and their relevance to chemistry. • To apply mathematical methods to solve quantum problems. • To analyze spectroscopic data using quantum theory. • To bridge theoretical knowledge with practical chemical applications. This course provides a critical foundation for advanced studies in physical chemistry, spectroscopy, and computational modeling in chemistry.					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom		

No	Mode of Instruction	Contact Hours	Percentage
2	E-learning		
3	Hybrid • Traditional classroom • E-learning	15 15	50% 50%
4	Distance learning		

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	45
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial**	
5.	**Others (specify)**	
Total		45

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	**Demonstrate Understanding of Quantum Principles. Analyze Atomic and Molecular Structures and interpret atomic and molecular orbital structures and their quantum mechanical underpinnings.**	**K1**	**-Lectures. - Conduct scientific research. - Seminars. -Discussions -Brainstorming**	**-Final exam - Midterm exam - Short tests -Quizzes. - Homework - Class exercises - Evaluation of research**
1.2				
...				
2.0	**Skills**			

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
2.1	Communicate effectively orally and written using appropriate presentation formats for different issues with recipients of different types.	S2	Lectures Active learning - E-learning -Self-learning -Cooperative Education -Examinations	- Final exam - Midterm exam - Short tests -Quizzes. - Homework - Class exercises - Evaluation of research
2.2	Demonstrate the ability to use modern technology and statistical applications that are used in the various fields of chemistry	S3	Lectures Active learning - E-learning -Self-learning -Cooperative Education -Examinations	
...				
3.0	**Values, autonomy, and responsibility**			
3.1	Apply standards of integrity, transparency and ethical behavior in various Academic and professional fields	V1	-Simulation programs -Cooperative work	- Research papers
3.2				
...				

C. Course Content

No	List of Topics	Contact Hours
1.	Introduction to Quantum Chemistry: • Historical context: Quantum mechanics in explaining atomic spectra, photoelectric effect, and blackbody radiation. •Transition from classical mechanics to quantum theory.	3
2.	Fundamental Principles:	9

	• Wave-particle duality and Heisenberg's uncertainty principle. • Schrödinger equation: Formulation and interpretation. • Quantum mechanical postulates and their implications for chemical systems.	
3.	Quantum Systems and Applications • Particle in a Box: Energy quantization and application to conjugated molecules. • Harmonic Oscillator: Molecular vibrations and infrared spectroscopy. • Rigid Rotor: Rotational energy levels and microwave spectroscopy. • Hydrogen Atom: Solutions to Schrödinger's equation, quantum numbers, and atomic orbitals.	12
4.	Atomic Structure and Chemical Bonding Theories • Molecular Orbital Theory (MOT): Bonding/antibonding orbitals and delocalized systems. • Valence Bond Theory (VBT): Hybridization and chemical reactivity. • Application to diatomic and polyatomic molecules.	6
5.	Spectroscopy and Quantum Mechanics • Interaction of radiation with matter. • Quantum mechanics in rotational, vibrational, and electronic spectroscopies. • Energy transitions and molecular characterization.	6
6.	Approximation Methods in Quantum Chemistry • Variational principle: Estimating ground-state energies. • Perturbation theory: Applications to chemical problems.	3
7.	Computational Applications in Quantum Chemistry • Basics of computational chemistry: Hartree-Fock theory, Density Functional Theory (DFT). • Use of quantum chemistry software to model molecular systems.	3
8.	Modern applications of Quantum Chemistry:	3

	• Chemical reactivity and catalysis from a quantum perspective. • Real-world applications in spectroscopy, materials science, and environmental chemistry.	
Total		**45**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Homework, exercises, periodic tests , Essays, laboratory reports, Presentation ,project	During the semester	20%
2.	Mid term 1	6th week	15%
3.	Mid term 2	11th week	15%
4.	Electronic exam	12th week	10%
5.	Final exam	End of semester	40%
Total			**100%**

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	**1. Atkins, Peter, and de Paula, Julio. Physical Chemistry. 11th Edition, 2017, Oxford University Press.**
Supportive References	**2. Levine, Ira N. Quantum Chemistry. 7th Edition, 2008, Pearson Education**
Electronic Materials	
Other Learning Materials	

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	**Classrooms**
Technology equipment (projector, smart board, software)	**projector, smart board, software, The electronic platform, Smart Board**
Other equipment (depending on the nature of the specialty)	**Virtual laboratories** **Research laboratory** **Library**

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	**Students**	**Student evaluation (electronically questionnaire) organized by the University**
Effectiveness of Students assessment	**Department**	**Analysis of electronically questionnaire.** **the Make decision through department Council**
Quality of learning resources	**Department / staff members**	**Analysis of course report by** **Chemistry Department Council**
The extent to which CLOs have been achieved	**Department** **Faculty**	**CLO Analysis Report**
Other		

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)
Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	**CHEMISTRY DEPARTMENT COUNCIL**
REFERENCE NO.	
DATE	