Course Specifications

Course Title:	**Chemical Applications of Group Theory**
Course Code:	**521CHEM-2**
Program:	**Master of Science in Chemistry**
Department:	**Chemistry**
College:	**Science**
Institution:	**KING KHALID UNIVERSITY**

Table of Contents

A. Course Identification

1. Credit hours:	2
2. Course type	
a.	University ☐ College ☐ Department ■ Others ☐
b.	Required √ Elective ☐
3. Level/year at which this course is offered:	Level 1 /First Year
4. Pre-requisites for this course (if any)**:**	None
5. Co-requisites for this course (if any)**:**	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	2	100%
2	Blended	0	0
3	E-learning	0	0
4	Correspondence	0	0
5	Other	0	0

7. Actual Learning Hours (based on academic semester)

No	Activity	Learning Hours
Contact Hours		
1	Lecture	30
2	Laboratory/Studio	0
3	Tutorial	0
4	Others (specify)	0
	Total	0
Other Learning Hours*		
1	Study	44
2	Assignments	12
3	Library	14
4	Projects/Research Essays/Theses	0
5	Others (specify)	0
	Total	70

* The length of time that a learner takes to complete learning activities that lead to achievement of course learning outcomes, such as study time, homework assignments, projects, preparing presentations, library times

B. Course Objectives and Learning Outcomes

1. Course Description

This course is designed to convey learning in the field of molecular symmetry and point groups. The course focuses on the mathematical background of applied group theory and the definition of symmetry operations in terms of their matrix representation. Previous knowledge

of matrix algebra will be extremely helpful, since we will have limited time for review. This course demonstrates to student to understand character tables and use them for molecular orbital theory and in the interpretation of electronic and vibrational spectra. A thorough treatment of infrared and Raman spectroscopy will be provided beyond its routine application in organic and inorganic chemistry.

2. Course Main Objective

The goal of this course is to show the students the important of symmetry which can be used to predict the electronic structure and the vibrational behavior of molecules. The material of this course will be a combination of theoretical background, including quantum mechanics, and practical applications of symmetry and character tables. In this course you will thoroughly review molecular symmetry and point groups. The course aims at learning the mathematical background of applied group theory and symmetry operations will be defined in terms of their matrix representation.

After completion of the course students should be able to:

- Identify the Mathematical Group.
- Learn the topic of symmetry elements and symmetry operations.
- Assignment of point groups.
- Understand to what a “Character Table” is.
- Assigning symmetry labels to “Symmetry adapted linear combination or orbital's.”
- Assigning symmetry labels to of vibration modes.
- Determining the IR and Raman activity of vibrational modes.
- Identify and Understand Selection Rules.
- Learn the Electronic Spectroscopy.
- Understand the MO Theory Background and Transition-metal complexes and ligand field splitting.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge:**	
1.1	To understand an advanced level of the theories and principles of group theory of Inorganic and Organic molecule.	K1-K3
1.2	To demonstrate an advanced level of the experimental findings and applications of group theory in chemistry and life.	K1-K3
1.3	To demonstrate the underlying group theories with practical measurement and research.	K3
2	**Skills :**	
2.1	To analyze, interpret and explain the molecular structure depend on the topic of symmetry elements and symmetry operations of point groups for problem solving in inorganic and organic molecules.	S1-S4
2.2	To apply the theorems of Group Theory upon the inorganic and organic molecules of selected topics in chemistry.	S2
3	**Competence:**	
3.1	To present an oral explanation for a subject in the area.	C3
3.2	To interact positively with colleagues in a group work.	C4

3.3	To contribute with colleagues to prepare and deliver a presentation and report of group work	C1-C2
3.4	To summaries the literature and sources for an area in the course.	C2

C. Course Content

No	List of Topics	Contact Hours
1	Definitions and theorems of Group Theory, Symmetry Elements and Operations: Recognize symmetry elements in a molecule; Combine two operations to find the equivalent simple operation.	4
2	Point Groups: State the point group to which a molecule belongs, Characters and Character Tables, Basis functions and Mulliken symbols. Find the complete set of symmetry operations, Arrange a set of symmetry operations into classes.	6
3	Matrices: Set up a matrix to perform a given transformation, Find the character of a matrix representing a symmetry operation using any given basis. Degenerate Representations.	4
4	Reduce any reducible representation into its components irreducible representations.	2
5	Applications to Molecular Vibrations: Symmetry of the normal modes of vibration of a molecule of a given symmetry, Selection rules for IR and Raman active vibrations.	5
6	Applications to chemical bonding: Find sets of hybrid orbital's with given directional properties, Find sets of orbital's suitable for pi bonding in a molecule, Molecular orbital's for sigma bonding in ABn molecules. Symmetry-adapted linear combinations SALCs on B atoms matching with atomic orbital's on A atom.	5
7	Ligand Field Theory: Splitting of levels and terms in a chemical environment.	4
Total		30

D. Teaching and Assessment

1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.0	**Knowledge**		
1.1	To understand an advanced level of the theories and principles of group theory of Inorganic and Organic molecule.	Lectures , Interactive teaching sessions	Written exams, electronic quizzes
1.2	To demonstrate an advanced level of the experimental findings and applications of group theory in chemistry and life.	Lectures , Interactive teaching sessions	Written exams, electronic quizzes
1.3	To demonstrate the underlying group theories with practical measurement and research.	Tutorials, problem solving sessions	Oral discussion and examinations

2.0	**Skills**		
2.1	To analyze, interpret and explain the molecular structure depend on the topic of symmetry elements and symmetry operations of point groups for problem solving in inorganic and organic molecules.	Lectures, problem solving sessions	Oral discussion, written examinations
2.2	To apply the theorems of Group Theory upon the inorganic and organic molecules of selected topics in chemistry.	Tutorials, problem solving sessions	Oral discussion, written examinations
3.0	**Competence**		
3.1	To present an oral explanation for a subject in the area.	opened essays on selected topics	Oral presentation
3.2	To interact positively with colleagues in a group work.	Interactive teaching sessions	Oral presentation and discussion
3.3	To contribute with colleagues to prepare and deliver a presentation and report of group work	Interactive teaching sessions	Discussion within a group
3.4	To summaries the literature and sources for an area in the course.	Guided reading of books and articles	(Assignments and Quizzes as Hard homework's),

2. Assessment Tasks for Students

#	*Assessment task	Week Due	Percentage of Total Assessment Score
1	Midterm Examination – I	7th	20%
2	Midterm Examination – II	11th	20%
3	Assignments, oral presentation	3rd, 5th, 8th, 10th	5%
4	Quizzes, oral exam (discussion)	Every month	5%
5	Final Examination	16	50%

***Assessment task** (i.e., written test, oral test, oral presentation, group project, essay, etc.)

E. Student Academic Counseling and Support

Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice :

The faculty member has 3 hours per week for the students in this course. Total 10 hrs of office hours for individual student consultations and academic advice per week.

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	K. C. Molloy ,Group Theory for Chemists: Fundamental Theory and Applications, 2nd ed., WOODHEAD PUB, 2015.

Essential References Materials	Inorganic Chemistry: Principles of Structure and Reactivity. James E Huheey, Ellen A Keiter, Richard L Keiter. 1997. 4th ed. Prentice Hall. ISBN: 978-0060429959 A. Vincent, Molecular Symmetry and Group Theory, ,2nd ed., Wiley & Sons, New York, 2001. F. A. Cotton , Chemical Applications of Group Theory, 3rd ed., Wiley & Sons, New York, 1990.. G. Davidson, Group Theory for Chemists, 1st ed., the MACMILLAN PRESS LTD, 1991
Electronic Materials	http://www.webqc.org/symmetry.php http://scholle.oc.uni-kiel.de/herges/modeling/gliederung.html http://chem-faculty.ucsd.edu/trogler/GroupTheory224/Grouptheory.html http://www.seas.upenn.edu/~chem101/sschem/solidstatechem.html http://xrayweb.chem.ou.edu/notes/symmetry.html#crystal
Other Learning Materials	handouts will be distributed to students

2. Facilities Required

Item	Resources
Accommodation Classrooms, laboratories, demonstration) (.rooms/labs, etc	Air-conditioned rooms Lecture rooms – 01 Number of seats in each class room – 20 Accessories – Overhead projector
Technology Resources AV, data show, Smart Board, software,) (.etc	Smart Board system with facile software.
Other Resources Specify, e.g. if specific laboratory) equipment is required, list requirements or (attach a list	Wireless Internet connection in class.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Strategies for Obtaining Student Feedback on Effectiveness of Teaching	Department chairmen Teachers	Confidential completion of standard course evaluation questionnaire. Discussion with small groups of students.
Other Strategies for Evaluation of Teaching by the Instructor or by the Department	Department member and outside member	Independent evaluation of staff members in the department Independent advice on assignment

		tasks, etc
Processes for Improvement of Teaching	Teachers	Developing the content and topics of the course and updating scientific content periodically Workshops on teaching methods, review of recommended teaching strategies. Developing the lectures periodically.
Processes for Verifying Standards of Student Achievement (e.g. check marking by an independent member teaching staff of a sample of student work, periodic exchange and remarking of tests or a sample of assignments with staff at another institution)	Teachers	Evaluating student's grades and course assignment by staff members in the department. Check marking of a sample of examination papers or assignment tasks. Meetings are conducting with teachers for checking the grading of the exams.
Describe the planning arrangements for periodically reviewing course effectiveness and planning for improvement	Teachers Students	Graduates questionnaire. Revising the course in the next semester by assessing the feedback forms, completion of the course and understanding of the subject by students. Teachers' survey. Students' survey.

Evaluation areas (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)
Evaluators (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

H. Specification Approval Data

Council / Committee	**Chemistry Department Council**
Reference No.	**Session number 22**
Date	**27/04/2021M / 15/09/1442H**