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[OBE DESIGN- CHEMISTRY DEPARTMENT]

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PREFACE

Outcome Based Education (OBE) is the educational approach which focuses on student centric education in the context of development of personal, social, professional and knowledge (KSA) requirements in one's career and life. It is the decade ago curriculum development methodology. The educational triangle of *LEARNING-ASSESSMENT-TEACHING* is the unique nature of the OBE approach. The curriculum practices such as Competency Based Curriculum, Taylor's Model of Curriculum Development, Spadys' Curriculum principles, Blooms taxonomy and further use of assessment methodologies like, Norm-reference testing and Criterion reference testing, etc is being practiced since decades. It is also interesting to know that, globally, different countries and universities adopts the curriculum development models/approaches such as, CDIO (Conceive-Design-Implement-Operate), Evidenced Based Education, Systems' Approach, etc as the scientific and systematic approaches in curriculum design.

The authorities of Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (M.S.) in-lieu of accreditation standards of National Assessment and Accreditation Council, decided to opt for Outcomes Based Education (OBE). As the part of the decision, different meetings, workshops and presentations were held at the campus of university.

This document is the outcome of different meetings and workshops held at university level and department level. The detailed document is designed and the existing curriculum of the department is transformed in to the framework of OBE. This is the first step towards the implementation of OBE in the department. The document will serve all stakeholders in the effective implementation of the curriculum. The OBE is continuous process for quality enhancement and it will go a long way in order to enhance the competencies and employability of the graduates/Post-graduates of the university department.

Head of Department

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OUTCOME BASED EDUCATION

Faculty of Science & Technology

Department of Chemistry

1. Mission:

Mission Statement

- To develop the researcher and scientist in chemical science through post-graduate education and research programme.
- To develop the competent manpower with technology based experimentation methodologies and value based practices for business and industries.
- To undertake projects to solve field base problems.
- To provide student centric learning facilities for the development of overall personality of learner.

2. Vision:

Vision Statement

A respectable teaching – learning and research organization nationally and internationally in the area of chemical sciences. By providing competitive trained chemists which will assist the chemical world, industries and stake holders

The mission and vision of the organization help in preparation of strategic plan.

3. Title of the Program (s):

a. Master Science - Chemistry

4. Program Educational Objectives:

The program educational objectives (PEO) are the statement that describes the career and professional achievement after the program of studies (graduation/ post-graduation). The PEO s are driven form question no. (ii) of the Mission statement (What is the purpose of organization). The PEOs can be minimum three and maximum five.

PEO1: To have advance knowledge of chemistry domain.

PEO2: To provide the professional services to industry, research organization, institutes.

PEO3: To provide the professional consultancy and research support for the relevant organization in the domain of super specialization.

PEO4: To opt for higher education, disciplinary & multi-disciplinary research and to be a life-long learner.

PEO5: To provide, value based and ethical leadership in the professional and social life.

5. Program Outcomes:

The program outcomes (PO) are the statement of competencies/ abilities. POs are the statement that describes the knowledge and the abilities the graduate/ post-graduate will have by the end of program studies.

a. In-depth and detailed functional knowledge of the fundamental theoretical concepts and experimental methods of chemistry.
b. Apply/implement interface between, on the one hand, the history of chemistry and natural science and, on the other hand, issues pertaining to the areas of modern technology, health, and environment.
c. Skills in planning and conducting advanced chemical experiments and applying structural-chemical characterization techniques.
d. Skill in examining specific phenomena theoretically and/or experimentally,
e. Generation of new scientific insights or to the innovation of new applications of chemical research.

6. Course- Program outcome Matrix:

The Program Outcomes are developed through the curriculum (curricular/co-curricular-extra-curricular activities). The program outcomes are attained through the course implementation. As an educator, one must know, ***"to which POs his/her course in contributing?"***. So that one can design the learning experiences, select teaching method and design the tool for assessment. Hence, establishing the Corse-PO matrix is essential step in the OBE. The course-program outcomes matrix indicates the co-relation between the courses and program outcomes. The CO-PO matrix is the map of list of courses contributing to the development of respective POs.

The **CO-PO MATRIX** is provided in the below table.

Analytical Chemistry

Course Title	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
Analytical Chemistry	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Spectroscopic Methods of Analysis	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Laboratory in Analytical Chemistry	*	*	*				
Laboratory in Inorganic Chemistry	*	*	*				
Laboratory in Organic Chemistry	*	*	*				
Laboratory in Physical Chemistry	*	*	*				
Strutural Elucidation by Spectral methods		*	*				
Electro Analytical Techniques			*	*	*		
Environmental Analysis & Monitoring			*	*	*		
Advanced Analytical Techiques			*	*	*		
Analysis of Ores, Alloys & Explosive			*	*	*		
Food Fertilizer & Pesticides Analysis			*	*	*		
Petrochemical & Polymer Analysis			*	*	*		
Pharmaceutical, Clinical & Forensic Analysis			*	*	*		
Laboratory Course (Analytical)			*	*	*		
Laboratory Course (Analytical)			*	*	*		
Laboratory Course (Analytical)			*	*	*		
Project Work (Analytical)	*	*	*	*	*		

Physical Chemistry

Course Title	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
Analytical Chemistry	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Spectroscopic Methods of Analysis	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Laboratory in Analytical Chemistry	*	*	*				
Laboratory in Inorganic Chemistry	*	*	*				
Laboratory in Organic Chemistry	*	*	*				
Laboratory in Physical Chemistry	*	*	*				
Structural Elucidation by Spectral		*	*				

Methods							
Solid State Chemistry			*	*	*		
Thermodynamics			*	*	*		
Advanced Electrochemistry			*	*	*		
Macromolecules and Biophysical Chemistry			*	*	*		
Surface and Magnetochemistry			*	*	*		
Chemical Dynamics and Catalysis			*	*	*		
Laboratory Course (Physical)			*	*	*		
Laboratory Course (Physical)			*	*	*		
Laboratory Course (Physical)			*	*	*		
Project Work (Physical)	*	*	*	*	*		

Inorganic Chemistry

Course Title	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**
Analytical Chemistry	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Spectroscopic Methods of Analysis	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Laboratory in Analytical Chemistry	*	*	*				
Laboratory in Inorganic Chemistry	*	*	*				
Laboratory in Organic Chemistry	*	*	*				
Laboratory in Physical Chemistry	*	*	*				
Structural Elucidation by Spectral Methods		*	*				
Bioinorganic and Supramolecular Chemistry			*	*	*		
Applied Inorganic Chemistry			*	*	*		
Chemistry of Materials			*	*	*		
Nuclear Chemistry			*	*	*		
Photo Inorganic Chemistry			*	*	*		
Therapeutic Bioinorganic & Chemistry of Forensic material			*	*	*		
Organotransition Metal Chemistry			*	*	*		
Laboratory course (Inorganic)			*	*	*		
Laboratory course (Inorganic)			*	*	*		
Laboratory course (Inorganic)			*	*	*		
Project Work (Inorganic)	*	*	*	*	*		

Organic Chemistry

Course Title	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
Analytical Chemistry	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Spectroscopic Methods of Analysis	*	*					
Inorganic Chemistry	*	*					
Organic Chemistry	*	*					
Physical Chemistry	*	*					
Laboratory in Analytical Chemistry	*	*	*				
Laboratory in Inorganic Chemistry	*	*	*				
Laboratory in Organic Chemistry	*	*	*				
Laboratory in Physical Chemistry	*	*	*				
Structural Elucidation by Spectral Methods		*	*				
Organic Synthesis			*	*	*		
Asymmetric Synthesis and Bio-Organic Chemistry			*	*	*		
Photochemistry, Free Radicals and Pericyclic Reactions			*	*	*		
Organic Sythesis' Retrosynthetic Approach			*	*	*		
Advanced Organic and Heterocyclic Approach			*	*	*		
Chemistry of Natural Products			*	*	*		
Medicinal Chemistry			*	*	*		
Laboratory course (Organic)			*	*	*		
Laboratory course (Organic)			*	*	*		
Laboratory course (Organic)			*	*	*		
Project Work (Organic)	*	*	*	*	*		

7. Course Outcomes (for all courses):

The course outcomes are the statement that describes the knowledge & abilities developed in the student by the end of course (subject) teaching. The focus is on development of abilities rather than mere content. There can be 5 to 7 course outcomes of any course. These are to be written in the specific terms and not in general. The list of Course Outcomes is the part of ***Annexure-C*** attached herewith.

8. Set Target levels for Attainment of Course Outcomes:

The course outcome attainment is assessed in order to track the graduates' performance w.r.t target level of performance. The CO-PO attainment is the tool used for continuous improvement in the graduates' abilities through appropriate learning & teaching strategies. In order to assess students' performance with respect to abilities (at the end of course teaching/by the end of

program) the course outcome attainment are measured/calculated. In order to calculate the program outcome attainment, the course outcome attainment is calculated. Prior to that, the course-program outcome mapping is done.

9. Set Target level for Attainment of Program Outcomes:

The program outcome attainment is assessed in order to track the graduates' performance w.r.t target level of performance. The CO-PO attainment is the tool used for continuous improvement in the graduates' abilities through appropriate learning & teaching strategies. In order to assess students' performance with respect to abilities (at the end of course teaching/by the end of program) the course outcome attainment and program outcome attainment is measured/calculated. The program outcome attainment is governed by curricular, co-curricular and extra-curricular activities including the stakeholders' participation. The direct method and indirect method is adopted to calculate the PO attainment. The direct method implies the attainment by course outcomes contributing to respective program outcomes. And indirect method is the satisfaction/feed-back survey of stakeholders. In order to calculate the program outcome attainment, the course outcome attainment is calculated. Prior to that, the course-program outcome mapping is done.

The set target level is the set benchmark to ensure the continuous improvements in the learners/ graduates' performance.

10. Course Attainment Levels:

a. CO attainment is defined/set at three levels;
b. The CO attainment is based on end term examination assessment and internal assessment;
c. The Co attainment is defined at three levels in ascending order-
d. Course Levels:
    i. Level-1: 40% students score greater than or equal to class average
    ii. Level-2: 50% students score greater than or equal to class average
    iii. Level-3: 60% students score greater than or equal to class average

    Target Level: Level - 2
e. The target level is set (e.g. Level-2). It indicates that, the current target is level-2; 50% students score more than class average. The CO attainment is measured and the results are obtained. Based on the results of attainment, the corrective measures/remedial action are taken.
f. CO Attainment= 80% (Attainment level in end term examination) + 20% (Attainment level in internal examination).
g. <u>The example of calculating CO attainment is provided for one of the course from Inorganic Chemistry in Point No. 12.</u>

11.Program attainment Level:

a. PO attainment is defined at five levels in ascending order;
b. The PO attainment is based on the average attainment level of corresponding courses (Direct Method) and feed-back survey (Indirect method);
c. The PO attainment levels are defined / set as stated below;
    i. Level-1: Greater than 0.5 and less than 1.0 (0.5>1)- Poor
    ii. Level-2: 1.0>1.5-Average
    iii. Level-3: 1.5>2.0-Good
    iv. Level-4: 2.0>2.5-Very Good
    v. Level-5: 2.5>3.0 -Excellent
d. The PO attainment target level is set/defined (say, Level-4). It implies that, the department is aiming at minimum level-4 (very good) in the performance of abilities by the graduates. Based upon the results of attainment, the remedial measures are taken;
e. PO Attainment= 80% (Average attainment level by direct method) + 20% (Average attainment level by indirect method).
f. <u>The example of calculating PO attainment is provided for one of the PO from Inorganic Chemistry in Point No. 13.</u>

12. The Results of CO Attainment:

PLEASE SEE THE ANNEXURE-B

<u>FOR EXAMPLE:</u>

<u>COURSE CODE/TITLE: CHE-103 ORGANIC CHEMISTRY</u>

e.g. For end term and internal examination;

i. Level-1: 40% students scored more than class average
ii. Level-2: 50% students score more than class average;
iii. Level-3: 60% students score more than class average

Average Marks in External examination: 26

% Students score more than 26 is 58/107 i.e. 54.20% i.e. Levl-2

Average Marks in Internal examination= 7

% Students score more than 7 is 71/107 i.e.66.35%, i.e. Level-3

A (CO) CHE-103= 80% (2) +20(3)

=1.6+0.6

= 2.2

Hence, The attainment level is Level-2 and the set target level is Level-2 and therefore the CO is Fully attained.

Table No. 1.0: CO Attainment Level

INORGANIC CHEMISTRY

Course Title	CO Attainment Value	Target Attainment Level	Fully Attained/ Not Attained	Remedial Measures
Analytical Chemistry	2.2	2	**Fully Attained**	
Inorganic Chemistry	3	2	**Fully Attained**	
Organic Chemistry	2.2	2	**Fully Attained**	
Physical Chemistry	2	2	**Fully Attained**	
Spectroscopic Methods of Analysis	2.2	2	**Fully Attained**	
Inorganic Chemistry	3	2	**Fully Attained**	
Organic Chemistry	2.2	2	**Fully Attained**	
Physical Chemistry	2.2	2	**Fully Attained**	
Laboratory in Analytical Chemistry	3	2	**Fully Attained**	

Laboratory in Inorganic Chemistry	3	2	**Fully Attained**	
Laboratory in Organic Chemistry	2.2	2	**Fully Attained**	
Laboratory in Physical Chemistry	2.2	2	**Fully Attained**	
Structural Elucidation by Spectral Methods	3	2	**Fully Attained**	
Bioinorganic and Supramolecular Chemistry	3	2	**Fully Attained**	
Applied Inorganic Chemistry	3	2	**Fully Attained**	
Chemistry of Materials	3	2	**Fully Attained**	

Nuclear Chemistry	2.2	2	**Fully Attained**	
Photo Inorganic Chemistry	3	2	**Fully Attained**	
Therapeutic Bioinorganic & Chemistry of Forensic material	3	2	**Fully Attained**	
Organotransition Metal Chemistry	3	2	**Fully Attained**	
Laboratory course (Inorganic)	3	2	**Fully Attained**	
Laboratory course (Inorganic)	2.2	2	**Fully Attained**	
Laboratory course (Inorganic)	3	2	**Fully Attained**	
Project Work (Inorganic)	3	3	**Fully Attained**	

ORGANIC CHEMISTRY

Course Title	CO Attainment Value	Target Attainment Level	Fully Attained/ Not Attained	Remedial Measures
Analytical Chemistry	2.2	2	**Fully Attained**	
Inorganic Chemistry	3	2	**Fully Attained**	
Organic Chemistry	2.2	2	**Fully Attained**	
Physical Chemistry	2	2	**Fully Attained**	
Spectroscopic Methods of Analysis	2.2	2	**Fully Attained**	
Inorganic Chemistry	3	2	**Fully Attained**	
Organic Chemistry	2.2	2	**Fully Attained**	
Physical Chemistry	2.2	2	**Fully Attained**	
Laboratory in Analytical Chemistry	3	2	**Fully Attained**	
Laboratory in Inorganic Chemistry	3	2	**Fully Attained**	

Laboratory in Organic Chemistry	2.2	2	**Fully Attained**	
Laboratory in Physical Chemistry	2.2	2	**Fully Attained**	
Structural Elucidation by Spectral Methods	2	2	**Fully Attained**	
Organic Synthesis	3	2	**Fully Attained**	
Asymmetric Synthesis and Bio-Organic Chemistry	3	2	**Fully Attained**	
Photochemistry, Free Radicals and Pericyclic Reactions	2	2	**Fully Attained**	
Organic Sythesis' Retrosynthetic Approach	2.2	2	**Fully Attained**	

Advanced Organic and Heterocyclic Approach	1.4	2	**Not Attained**	Assignments, tutorials, exercise and remedial coaching.
Chemistry of Natural Products	3	2	**Fully Attained**	
Medicinal Chemistry	3	2	**Fully Attained**	
Laboratory course (Organic)	3	2	**Fully Attained**	
Laboratory course (Organic)	3	2	**Fully Attained**	
Laboratory course (Organic)	2	2	**Fully Attained**	
Project Work (Organic)	3	2	**Fully Attained**	

ANALYTICAL CHEMISTRY ABAD

Course Title	CO Attainment Value	Target Attainment Level	Fully Attained/ Not Attained	Remedial Measures
Analytical Chemistry	2.2	2	Fully Attained	
Inorganic Chemistry	3	2	Fully Attained	
Organic Chemistry	2.2	2	Fully Attained	
Physical Chemistry	2	2	Fully Attained	
Spectroscopic Methods of Analysis	2.2	2	Fully Attained	
Inorganic Chemistry	3	2	Fully Attained	
Organic Chemistry	2.2	2	Fully Attained	
Physical Chemistry	2.2	2	Fully Attained	
Laboratory in Analytical Chemistry	3	2	Fully Attained	
Laboratory in Inorganic Chemistry	3	2	Fully Attained	

Laboratory in Organic Chemistry	2.2	2	Fully Attained	
Laboratory in Physical Chemistry	2.2	2	Fully Attained	
Strutural Elucidation by Spectral methods	3	2	Fully Attained	
Electro Analytical Techniques	3	2	Fully Attained	
Environmental Analysis & Monitoring	3	2	Fully Attained	
Advanced Analytical Techiques	3	2	Fully Attained	
Analysis of Ores, Alloys & Explosive	3	2	Fully Attained	
Food Fertilizer & Pesticides Analysis	2.2	2	Fully Attained	

Petrochemical & Polymer Analysis	3	2	Fully Attained	
Pharmaceutical, Clinical & Forensic Analysis	2.8	2	Fully Attained	
Laboratory Course (Analytical)	3	2	Fully Attained	
Laboratory Course (Analytical)	3	2	Fully Attained	
Laboratory Course (Analytical)	2	2	Fully Attained	
Project Work (Analytical)	3	2	Fully Attained	

PHYSICAL CHEMISTRY ABAD

Course Title	CO Attainment Value	Target Attainment Level	Fully Attained/ Not Attained	Remedial Measures
Analytical Chemistry	2.2	2	Fully Attained	
Inorganic Chemistry	3	2	Fully Attained	
Organic Chemistry	2.2	2	Fully Attained	
Physical Chemistry	2	2	Fully Attained	
Spectroscopic Methods of Analysis	2.2	2	Fully Attained	
Inorganic Chemistry	3	2	Fully Attained	
Organic Chemistry	2.2	2	Fully Attained	
Physical Chemistry	2.2	2	Fully Attained	
Laboratory in Analytical Chemistry	3	2	Fully Attained	
Laboratory in Inorganic Chemistry	3	2	Fully Attained	

Laboratory in Organic Chemistry	2.2	2	Fully Attained	
Laboratory in Physical Chemistry	2.2	2	Fully Attained	
Structural Elucidation by Spectral Methods	2	2	Fully Attained	
Solid State Chemistry	2	2	Fully Attained	
Thermodynamics	2	2	Fully Attained	
Advanced Electrochemistry	2	2	Fully Attained	
Macromolecules and Biophysical Chemistry	2	2	Fully Attained	
Surface and Magneto chemistry	2.8	2	Fully Attained	

Chemical Dynamics and Catalysis	2.2	2	Fully Attained	
Laboratry Physical	3	2	Fully Attained	
Laboratory Course (Physical)	3	2	Fully Attained	
Laboratory Course (Physical)	2	2	Fully Attained	
Laboratory Course (Physical)	3	2	Fully Attained	
Project Work (Physical)	2	2	Fully Attained	

13.The Results of PO Attainment:

PLEASE SEE THE ANNEXURE-B

FOR EXAMPLE: INORGANIC CHEMISTRY

PO NO.: PO5

(Note: Refer point No. 11 above which describes the attainment level and set target attainment level)

PO Attainment= 80% (Average attainment level by direct method) + 20% (Average attainment level by indirect method).

A (PO) 5 = 80% (3+3+3+2.2+3+3+3+3+2.2+3+3)/11 +20% (2.85)

=80% (2.85) + 20% (2.85)

= 2.85 i.e. Level-5. The Target Level is Level-4.

Hence, PO is attained.

Table No. 2.0 PO Attainment Level

INORGANIC CHEMISTRY

PO/PSO number	PO Attainment Value	Target Attainment level	Fully attained/ Not Attained	Remedial Measures
a	2.49	4	Fully attained	Not Applicable
b	2.53	4	Fully attained	
c	2.80	4	Fully attained	
d	2.85	4	Fully attained	
e	2.85	4	Fully attained	

ORGANIC CHEMISTRY

PO/PSO number	PO Attainment Value	Target Attainment level	Fully attained/ Not Attained	Remedial Measures
a	2.49	4	Fully attained	Not Applicable
b	2.46	4	Fully attained	
c	2.56	4	Fully attained	
d	2.60	4	Fully attained	
e	2.60	4	Fully attained	

ANALYTICAL CHEMISTRY

PO/PSO number	PO Attainment Value	Target Attainment level	Fully attained/ Not Attained	Remedial Measures
a	2.49	4	Fully attained	Not Applicable
b	2.53	4	Fully attained	
c	2.77	4	Fully attained	
d	2.82	4	Fully attained	
e	2.82	4	Fully attained	

PHYSICAL CHEMISTRY

PO/PSO number	PO Attainment Value	Target Attainment level	Fully attained/ Not Attained	Remedial Measures
a	2.42	4	Fully attained	Not Applicable
b	2.39	4	Fully attained	
c	2.40	4	Fully attained	
d	2.36	4	Fully attained	
e	2.36	4	Fully attained	

14. Planned Actions for Course Attainment:

The Course having CO attainment less than Level-2 shall be addressed by remedial measures such as assignments, tutorials, exercises and remedial coaching.

15.Planned Actions for Program Outcome Attainment:

Not Applicable

ANNEXURE-B

COURSE ATTAINMENT & PO ATATINEMENT LEVEL

INORGANIC CHEMISTRY ABAD

Course Title	PO1	PO2	PO3	PO4	PO5
Analytical Chemistry	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2	2			
Spectroscopic Methods of Analysis	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2.2	2.2			
Laboratory in Analytical Chemistry	3	3	3		

Laboratory in Inorganic Chemistry	3	3	3		
Laboratory in Organic Chemistry	2.2	2.2	2.2		
Laboratory in Physical Chemistry	2.2	2.2	2.2		
Structural Elucidation by Spectral Methods		3	3		
Bioinorganic and Supramolecular Chemistry			3	3	3
Applied Inorganic Chemistry			3	3	3
Chemistry of Materials			3	3	3

Nuclear Chemistry			2.2	2.2	2.2
Photo Inorganic Chemistry			3	3	3
Therapeutic Bioinorganic & Chemistry of Forensic material			3	3	3
Organotransition Metal Chemistry			3	3	3
Laboratory course (Inorganic)			3	3	3
Laboratory course (Inorganic)			2.2	2.2	2.2
Laboratory course (Inorganic)			3	3	3
Project Work (Inorganic)	3	3	3	3	3
	2.49	2.53	2.8	2.85	2.85

Course Title	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
Analytical Chemistry	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2	2			
Spectroscopic Methods of Analysis	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2.2	2.2			
Laboratory in Analytical Chemistry	3	3	3		
Laboratory in Inorganic Chemistry	3	3	3		

Laboratory in Organic Chemistry	2.2	2.2	2.2		
Laboratory in Physical Chemistry	2.2	2.2	2.2		
Structural Elucidation by Spectral Methods		2	2		
Organic Synthesis			3	3	3
Asymmetric Synthesis and Bio-Organic Chemistry			3	3	3
Photochemistry, Free Radicals and Pericyclic Reactions			2	2	2
Organic Sythesis' Retrosynthetic Approach			2.2	2.2	2.2

Advanced Organic and Heterocyclic Approach			1.4	1.4	1.4
Chemistry of Natural Products			3	3	3
Medicinal Chemistry			3	3	3
Laboratory course (Organic)			3	3	3
Laboratory course (Organic)			3	3	3
Laboratory course (Organic)			2	2	2
Project Work (Organic)	3	3	3	3	3
	2.49	2.46	2.56	2.6	2.6

ANALYTICAL CHEMISTRY
ABAD

Course Title	PO1	PO2	PO3	PO4	PO5
Analytical Chemistry	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2	2			
Spectroscopic Methods of Analysis	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2.2	2.2			
Laboratory in Analytical Chemistry	3	3	3		
Laboratory in Inorganic Chemistry	3	3	3		

Laboratory in Organic Chemistry	2.2	2.2	2.2		
Laboratory in Physical Chemistry	2.2	2.2	2.2		
Strutural Elucidation by Spectral methods		3	3		
Electro Analytical Techniques			3	3	3
Environmental Analysis & Monitoring			3	3	3
Advanced Analytical Techiques			3	3	3
Analysis of Ores, Alloys & Explosive			3	3	3
Food Fertilizer & Pesticides Analysis			2.2	2.2	2.2

Petrochemical & Polymer Analysis			3	3	3
Pharmaceutical, Clinical & Forensic Analysis			2.8	2.8	2.8
Laboratory Course (Analytical)			3	3	3
Laboratory Course (Analytical)			3	3	3
Laboratory Course (Analytical)			2	2	2
Project Work (Analytical)	3	3	3	3	3
	2.49	2.53	2.77	2.82	2.82

PHYSICAL CHEMISTRY ABAD

Course Title	PO1	PO2	PO3	PO4	PO5
Analytical Chemistry	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2	2			
Spectroscopic Methods of Analysis	2.2	2.2			
Inorganic Chemistry	3	3			
Organic Chemistry	2.2	2.2			
Physical Chemistry	2.2	2.2			
Laboratory in Analytical Chemistry	3	3	3		
Laboratory in Inorganic Chemistry	3	3	3		

Laboratory in Organic Chemistry	2.2	2.2	2.2		
Laboratory in Physical Chemistry	2.2	2.2	2.2		
Structural Elucidation by Spectral Methods		2	2		
Solid State Chemistry			2	2	2
Thermodynamics			2	2	2
Advanced Electrochemistry			2	2	2
Macromolecules and Biophysical Chemistry			2	2	2
Surface and Magneto chemistry			2.8	2.8	2.8

Chemical Dynamics and Catalysis			2.2	2.2	2.2
Laboratry Physical			3	3	3
Laboratory Course (Physical)			3	3	3
Laboratory Course (Physical)			2	2	2
Laboratory Course (Physical)			3	3	3
Project Work (Physical)	2	2	2	2	2

2.42 2.39 2.4 2.36 2.36

ANNEXURE-C
COURSE OUTCOMES

Inorganic Chemistry

- Describe advanced material synthesis and material characterization.
- Analyze the connections between the structure and properties of solids, including theory and methods
- To conduct chemical analyses and characterization of the physical properties of solids.
- To analyze the structural decisions with x-rays/ neutron/electron; diffraction and spectroscopy for studying bonds and electronic state – in bulk or on surfaces;
- To measure physical properties such as magnetism or electronic conductivity, studies of optical properties, use of mass spectrometry and other analytical techniques.

Organic Chemistry

- Describe chemical and molecular processes that take place in organic chemical reactions.
- to use modern methods when planning strategies for synthesis of new substances and characterization of products.
- To use modern methods of synthesis and conduct extremely advanced experiments, the synthesis of complex molecular structures and handling sensitive chemicals.
- To use complicated analytical and spectroscopic methods and advanced program packages
- To design and production (synthesis) of complex molecules.

Physical Chemistry

- Describe simple chemical kinetics including zero, first, and second order rate laws.
- Explain the concept of activation energy and its effects on the rates of chemical reactions.
- Apply the tools to derive the rate law for simple reaction mechanisms
- Describe steady state, steady state approximation and its use in deriving the rate law for complex mechanisms such as that found in unimolecular reactions.
- Implement the interaction of radiation with matter, and a basic understanding of absorption, emission and scattering processes.
- Apply the basic principles of the major spectroscopies, including ultraviolet & visible spectroscopy, infrared and microwave spectroscopies

Spectroscopy

- To describe the quantum mechanical models of molecular rotation and vibration
- Demonstrate microwave and IR spectra arise from molecular rotation and vibration.
- To use of spectroscopy to give chemical structure information
- To explain the the atomic term symbols and electronic selection rules
- To explain the electronic spectra of transition metal ions.

Application of Spectroscopy

- To able to interpret UV-Visible spectroscopy
- To able to interpret IR spectroscopy,
- To able to interpret NMR spectroscopy,
- To able to interpret elemental analysis technique
- To able to interpret fluorescence spectroscopy,
- To able to interpret atomic absorption spectroscopy,

Organic Photochemistry

- Describe the occurrence of excitation by irradiation of organic molecues.
- Describe the photochemical reactions for organic compounds.
- Explain the mechanistic aspects for the photochemical transformations.
- Describe reactors and other equipment used to perform photochemical reactions.
- Use relevant concepts and terminology in a correct fashion.

Environmental Chemistry

- Demonstrate knowledge of chemical and biochemical principles of fundamental environmental processes in air, water, and soil.
- Recognize different types of toxic substances & responses and analyze toxicological information
- Apply basic chemical concepts to analyze chemical processes involved in different environmental problems (air, water & soil)
- Describe watr purification and waste treatment processes and the practical chemistry involved
- Describe causes and effects of environmental pollution by energy industry and discuss some mitigation strategies.
- Explain energy crisis and different aspects of sustainability.

Bioorganic Chemistry

- Use rules for description of the structure and stereochemistry of bioorganic compounds
- Relate the chemical structure of biomolecules to properties such as solubility, binding ability (hydrogen bond ability, lipophilicity, hydrophilicity), chirality correlate the chemical structure of biomolecules to reactivity
- Compare between transformations of biomolecules in living systems (aquatic environment) and in vitro, e.g. industrial synthesis
- Describe the application of chemistry in the biomolecular - and pharmaceutical sciences
- Explain the chemical properties and reactivity that influence environmental and economic decisions
- Discuss appropriate chromatographic methods for determination of organic compounds

Biophysical Chemistry

- Describe the different interactions that are important for the formation of structures in biological systems and for how thermodynamic parameters can be measured.
- Explain the basic concepts within statistical thermodynamics and apply this to biological systems binding and cooperativity.
- Describe the structures and functions of biological membranes, as well as model systems and relevant, macromolecules in solution, conformational equilibria, membrane equilibria, ligand methods for the study of these structures and functions.
- Explain and apply methods for the determination of functional molecular mass of biological macromolecules in solution as well as determination of equilibrium - and rate constants for macromolecule-ligand interactions.
- Apply spectroscopic methods for the study of structures and functions in biological systems.

Drug Synthesis

- Describe the synthetic methods and strategies as well as retrosynthetic analysis of known drugs.
- Experiment the synthetic methods and strategies as well as retrosynthetic analysis of known drugs.
- Explain the biological and pharmacological properties of the drugs will also be included.

Analytical Chemistry

- Explain the theoretical principles and important applications of classical analytical methods within titration (acid/base titration, complexometric titration, redox titration), and various techniques within gravimetric and coulometric methods.
- Explain the theoretical principles of selected instrumental methods within electro-analytical and spectrometric/spectrophotometric methods, and main components in such analytical instruments.
- Explain the theoretical principles of various separation techniques in chromatography, and typical applications of chromatographic techniques.
- Assess and suggest a suitable analytical method for a specific purpose, and evaluate sensitivity, important sources of interferences and errors, and also suggest alternative analytical methods for quality assurance.
- Perform classical analytical experiments, and make observations and assessments of important factors that could affect the analytical result.
- Perform calculations in analytical chemistry, be able to calculate titration errors for method evaluation, and perform statistical evaluation of results from classical and instrumental chemical experiments and analyses.

Bioinorganic and supramolecular chemistry

- Describe the nature of non-covalent interactions at the basis of the formation of supramolecular compounds which are held together by intermolecular bonds.
- Explain the basic coordination chemistry and of the interdisciplinary approach to study the peculiar role of metals in biology and their interaction with organic and biological molecules.
- Use different spectroscopic techniques used to study metals in biological systems and intermolecular interactions.
- Analyse data resulting from the methods.

Chemistry of Materials

- Relate polymer properties to macromolecular structure when evaluating polymer crystallinity, glass and melt transition temperatures, and elastomeric vs. plastic behaviour.
- Demonstrate knowledge of the main features of polymer chain growth in step and chain polymerisations.
- Outline reactions and reaction conditions of industrial and laboratory processes relevant to the manufacture of polyamides, polyesters, polyurethanes and polymers derived from olefin monomers such as styrene, vinyl chloride, and acrylates.

- Describe examples of nanostructured materials which can be used in microelectronics and drug delivery technology.
- Illustrate composition of high-temperature superconductor and the main characteristics of photovoltaic cells.

Organic Synthesis

- Describe basic chemo-, regio- and stereochemical concepts
- Describe principles for selective synthesis, in particular for stereoselective synthesis
- Explain the selectivity observed in chemical reactions
- Suggest methods for selective synthesis of simple organic compounds, also containing stereogenic elements
- Identify suitable reagents for selective transformations
- Use retrosynthetic analysis for the construction of synthetic routes for simple organic compounds
- Prepare organic compounds using advanced synthetic methodology

Solid State Chemistry

- Design and development of materials with pre-required properties based on the structure of solids.
- Analyze the physical-chemical , unique optical, electrical, magnetic, thermal, and mechanical properties of solids that are not present for compounds in solution or in the gas phase properties of material.
- Describe phase relations, chemical synthesis, and reaction kinetics as well as characterisation methods.
- Use the methods used to prepare, purify, and crystallize that are specific for organic and inorganic solids.
- Use the spectroscopic, diffraction, microscopic, thermal, and magnetic methods used to characterize organic and inorganic solids.
- Graduate students will learn the unique optical, electrical, magnetic, thermal, and mechanical properties of solids that are not present for compounds in solution or in the gas phase.

Nuclear Chemistry

- Describe the nuclear structure, stable and unstable atomic nuclei, nuclear reactions and different modes of radioactive decay and also methods for measurements of radioactivity.

- Explain the fundamentals of radiochemistry, isotopic chemistry, radiation chemistry and the applications of these in measuring technology, kinetics, radical chemistry, biotechnology and materials and process technology.
- Operate and measurement of radioactive material.

Nano-Chemistry

- Describe the effects may emerge due to nano-dimensions of particles
- Compare nanochenistry with from solid state chemistry
  Analyze a nanostructured material for a given chemical compound to result in grossly modified chemical or physical properties
  Apply principles of nanoparticle preparation and modification
  Describe applications of nanochemistry and describe their advantages with respect to classical materials and device setups.

Pharmaceutical and Forensic Analysis

- Explain major types of chemical reaction for organic and inorganic molecules and the main characteristics associated with them.
- Explain the principles and procedures used in chemical analysis and the characterisation of chemical compounds.
- Explain the physico-chemical (thermodynamic and kinetic) principles underlying the chemistry of reactions, and their applications to synthetic chemistry.
- Explain the physico-chemical principles underlying analytical techniques and their significance to chemical analysis.
- Analyse and characterise organic, inorganic and organo-metallic compounds.
- Explain the nature and behaviour of functional groups in organic molecules.
- Explain the fundamental principles of pharmaceutical science.
- Apply chemical and pharmaceutical principles and skills to forensic investigation of volume and serious crimes, to a wide range of physical evidence types, and to forensic science.

Food and fertilizer analysis

1. Explain the concept of bioanalytical methods.
2. Describe the application of bioanalytical methods within pharmacology, biopharmaceutics, pharmacokinetics, pharmacodynamics, metabolism and toxicology
3. Experiment the effect of the biological sample on analysis methodology and - results
4. Describe and apply liquid-liquid extraction and solid phase extraction for sample pretreatment
5. Optimise the separation methods; liquid solid chromatography, ion exchange chromatography, gas chromatography and capillary electrophoresis

6. Relate the principles and applications of spectroscopic, electrochemical and mass spectrometric detection at quantitative and qualitative analysis in the area of bioanalysis.

Polymer Chemistry

- Explain the general reaction course for ring-opening, coordination, suspension and emulsion polymerization
- Suggest and motivate choices of a polymerization technique considering the monomer structure and describe properties of the manufactured product.
- Compare and value different polymerization techniques
- Compare green polymerization methods- from renewable materials to waste reduction and from biocatalysis to solvent-free methods

Biophysical Chemistry

- Describe the different interactions that are important at formation of structures in biological systems
- Explain basic concept within statistical thermodynamics and apply this on biological systems, macromolecules in solution, conformational equilibria, membrane equilibria, ligand binding and cooperativity
- Describe the different principles that apply to the role of transport proteins in biological membranes
- Explain typical membrane structures the most common model systems and the methods to study distribution to and transport through biological membranes
- Describe kinetic factors that influence the precision in an enzyme catalysed row reaction
- Explain the principles of processive enzymes
- Describe how binding equilibria can be influenced by steric impediments in one or two dimensions
- Account for the most common methods for determination of equilibrium - and rate constants for macromolecule-ligand interactions.
- Explain different transport processes and their importance within biological systems and biochemical experiments

Instrumentation method for chemical analysis

- Identify different types of analytical instruments in their respective laboratories.
- Implement the principles and operating conditions of the Chemical Instruments among others
- Use of Chemical Instruments for chemical analysis.

- Differentiate between classical and instrumental methods of Chemical analysis.
- Explain different types of Instrumental methods.
- Use spectrometry methods of chemical analysis
- Differentiate among molecular absorption, atomic absorption and atomic emission spectrometry

Polymer and Petrochemical analysis

- Evaluate methods and/or techniques of characterization technique in order to finally decide which one is the most appropriate for a particular study or characterization of polymer materials. Ability to establish appropriate quantitative and qualitative criteria in each case.
- Use the knowledge acquired to the proper functioning of several equipment of characterization.
- Evaluate and quantify errors associated with measurements made using instrumental techniques.
- Establish appropriate procedures and protocols for the characterization of polymers.
- Perform a complete process of characterization of polymers.
- Analysis of results, their interpretation and discussion, to its proper expression in the form of a scientific-technical report.

Green Chemistry

- Explain Green chemistry and sustainability which relates to problems of societal concern
- Describe Green chemistry and sustainability developments that affect society, the environment and economic development
- Analyze a process and identify parameters that make environmentally friendly/sustainable/green
- Integrate, synthesize, and apply knowledge of the relationship between science and technology and societal issues in both focused and broad interdisciplinary contexts
- Demonstrate the ability to effectively communicate to others the concepts learned in the course
- Analyze and compare chemical/industrial processes based on their relative "greenness"

Medicinal Chemistry

- Design a chemical synthesis;
- Describe the sources of drug compounds;
- Describe methods of drug development including design and discovery;

- Explain the relationship between drug's chemical structure and its therapeutic properties;
- Predict a drugs properties based on its structure;
- Describe the factors that affect its absorption, distribution, metabolism, and excretion, and hence the considerations to be made in drug design;
- Describe the common methods of spectroscopic and chromatographic analysis, and discuss how they can be applied to pharmaceuticals.

Thermodynamics

- Apply fundamental concepts of thermodynamics to engineering applications
- Estimate thermodynamic properties of substances in gas and liquid states
- Determine thermodynamic efficiency of various energy related processes

Heterocyclic Chemistry

- Describe the structures of classes of heterocyclic aromatic organic compounds
- Classify simple heterocyclic aromatic compounds as electron deficient or electron rich and explain their reactivity based on these properties.
- Apply organometallic reactions that applied in heterocyclic chemistry.
- Explain on a mechanistic level, reactions and synthesis of important electron deficient nitrogen containing heterocycles; pyridines, diazines and their benzo-condenced analogs.
- Explain on a mechanistic level,, reactions and synthesis of important electron rich heterocycles; furans, pyrroles and thiophenes and 1,3-azoles, and benzo-condenced analogs.

Chemical dynamics and catalysis

- Apply the laws of thermodynamics to chemical processes.
- Calculate differences in thermodynamic properties using equations of state, charts and tables, and computer resources.
- Explain the microscopic, fundamental basis of thermodynamics.
- Describe the concept of temperature dependence of the reaction rates.
- Develop a reaction rate expression for a given reaction mechanism.
- Propose a mechanism consistent with an experimentally determined rate law.
- Use experimental data to estimate parameters in a rate law.
- Assess whether numerical values of kinetics parameters are chemically meaningful and consistent with theory.
- Apply simple molecular reaction dynamics calculations.

Structural elucidation by spectral methods

- Describe the concept of structural elucidation.
- Describe spectral methods.
- Apply the knowledge of the chemistry of terpenes, alkaloids and steroids.
- Implement structure elucidation of new compound natural or synthetic

Electro analytical Techniques

- Describe electroanalytical techniques
- Explain the factors that controlled to obtain reliable and reproducible data from electroanalytical experiments
- Identifying the most appropriate electroanalytical technique for a specific analysis
- Perform the synthesis of information from results obtained from two or more electroanalytical techniques

Microbial and Clinical Analysis

- Apply principles of safety, quality assurance and quality control in Clinical Microbiology
- Evaluate specimen acceptability.
- Describe morphology and physiology of microbes.
- Identify and classify microorganisms.
- Demonstrate sterile technique.
- Perform and interpret antimicrobial susceptibility testing.
- Select additional procedures based on preliminary results.
- Correlate test results with patient condition(s)

Surface Chemistry

- Describe the significance of economic and industrial factors in modern heterogeneous catalysis.
- State the connections and constraints on chemisorption and catalysis by metals.
- State the importance of a multi-technique approach for the elucidation of reaction mechanisms
- Describe the kinetic isotope effect that can provide mechanistic insight for heterogeneously catalysed reaction systems.
- Derive and develop structure/activity relationships in heterogeneous catalysis.

Applied Inorganic Chemistry

- Explain the relevance of inorganic chemistry
- Describe the economic importance of inorganic compounds produced on the industrial scale.
- Describe the preparation methods of the most inorganic compounds produced on the industrial scale.
- Describe the environmental impact of the most inorganic compounds produced on the industrial scale.

Organ transition Metal Chemistry

- Explain and rationalize the synthesis, structure, bonding, properties and reactivity of both main group and transition metal organyls.
- Explain and rationalize industrially important catalytic processes through the application of organometallic principles.
- Implement the chemical synthesis laboratory demonstrating effective laboratory safety and etiquette especially in the areas of handling of air sensitive reagents, chromatographic techniques and spectroscopic characterization.

Theoretical and structural inorganic chemistry

- Explain the structural chemistry of organic and inorganic compounds.
- Describe the structures are influenced by the geometry of their building blocks.
- Explain the structure types can be built starting from simple structural principles.
- Explain the relationships between different structure types.
- Explain the properties of solid compounds starting out from structure.

Bioinorganic and supramolecular chemistry

- Describe the relation of chemistry and the kinetics of enzymes
- Operate the computer visualization of 3D structures of organic molecules and proteins
- Basic definitions and concepts in supramolecular chemistry.
  Overview of fundamental interactions and their applications in living organisms and in complexation of compounds.
- Explain the New trends in designing supramolecular complexes and devices