DOCTORAL PROGRAM IN

CHEMISTRY

UNIVERSITAS GADJAH MADA

YOGYAKARTA, INDONESIA

2022

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DOCTORAL PROGRAM IN CHEMISTRY

1. Introduction

The Department of Chemistry, established on September 1, 1960, was officially confirmed by the Decree of the Director General of Higher Education Number 22/DIKTI/Kep/1995 and further affirmed by the Decree of the Director General of Higher Education Number 221/DIKTI/Kep/1996 dated July 11, 1996. In response to the growing demand for doctoral-level professionals, the Graduate Program in Chemistry was established in 1981 under the Department of Graduate Science, Graduate School, Universitas Gadjah Mada (UGM). This program was formally recognized by the Decree of the Director General of Higher Education of the Republic of Indonesia Number 580/DIKTI/Kep/1993, dated September 29, 1993. Since the academic year 2007/2008, according to the Rector's Decree of UGM regarding Monodisciplinary Graduate Programs Number 89/P/SK/HT/2006, the Doctoral Program in Chemistry has been under the Faculty of Mathematics and Natural Sciences (MIPA).

2. Vision

The vision of the doctoral program in chemistry is to become an internationally recognized institution and excel nationally in education, research, and community service activities. The program aims to produce nationally and globally competitive and outstanding doctoral graduates in Chemistry.

3. Mission

The mission of the Doctoral Program in Chemistry, Faculty of Mathematics and Natural Sciences, UGM, is as follows:

1. To provide a forefront education in Chemistry at the doctoral level, producing internationally competent graduates for Indonesian citizens from all walks of life and regions with the potential for advancement.
2. To conduct integrated and internationally recognized basic and applied research that supports the development of science and technology for the welfare and comfort of the nation and humanity, both in material and spiritual aspects.

4. Educational Objectives

The educational objectives of the program are to produce Doctor of Philosophy (Ph.D.) graduates in Chemistry who possess the following characteristics:

1. To have faith and purity in the Almighty, uphold Pancasila values, and exhibit high integrity and personality.
2. To be open-minded and responsive to changes and advancements in scientific knowledge and societal issues, particularly in chemistry.
3. To excel nationally and be internationally recognized.
4. To continuously develop and apply the acquired knowledge to advance science and technology.
5. To produce research in the field of chemistry that contributes to the progress of scientific knowledge and the well-being and comfort of humankind.

5. Curriculum Objectives

The learning outcomes of the Doctoral Program in Chemistry aim to provide students with opportunities to acquire competencies in terms of knowledge, understanding, and skills in the field of chemistry at the doctoral level, as well as the necessary qualities and attributes.

6. Graduate Profile

1. Academic (lecturer) who possesses a profound mastery of scientific knowledge, is capable of teaching effectively, conducting independent research, presenting research findings effectively, and has a reliable area of expertise.
2. A researcher who possesses a profound mastery of scientific knowledge, is capable of conducting independent research, presenting research findings effectively, and has a reliable area of expertise.
3. An environmental consultant with in-depth knowledge of chemistry and a strong understanding of green chemistry.

7. Learning Outcomes

To achieve the graduate as mentioned earlier profile, the learning outcomes (Program Learning Outcomes, PLO) of the Doctoral Program in Chemistry consist of four elements: (1) Attitudes and Values, (2) Knowledge Mastery, (3) Work Skills, and (4) Managerial Skills. The program's learning outcomes have been aligned with Level 9 of the Indonesian National Qualification Framework (KKNI).

7.1 Attitudes and Values

1. [PLO-1] **Attitudes and Values:** (1) Being devout to the Almighty and demonstrating a religious attitude. (2) Respect cultural diversity, perspectives, religions, beliefs, and the original opinions or findings of others. (3) Collaborating and having social sensitivity and concern for society and the environment. (4) Obeying the law and maintaining discipline in social and national life. (5) Internalizing values, norms, and academic ethics. (6) Demonstrating responsibility for work in their field of expertise independently. (7) Internalizing the spirit of independence, diligence, and entrepreneurship. (8) Having a sense of

responsibility towards environmentally sustainable behavior. (9) Showing empathy and concern for the sustainable development of the field of chemistry for future generations. (10) Having a good personality, developing a professional attitude, and upholding norms and ethics in actions and achievements.

7.2 Knowledge Mastery

2. **[PLO-2] Fundamental Knowledge:** the graduates have a deep and comprehensive knowledge and understanding of the structure and properties of matter, as well as the energy associated with its transformations, based on both thermodynamic and kinetic principles, as well as the principles of synthesis, analysis, isolation, and purification of chemical compounds.
3. **[PLO-3] Expertise Knowledge**

Having the ability in one of the following areas of expertise:

- **Expertise in Inorganic Chemistry and Materials:** Being able to develop and apply knowledge of chemistry, synthesis concepts, and molecular-scale engineering for inorganic compounds and materials through research, resulting in innovative and validated works recognized nationally and internationally.
- **Expertise in Physical Chemistry and Nanocatalysis:** Being able to apply and manage research based on the concepts of Physical Chemistry in all fields of Chemistry, particularly advanced material engineering, the discovery of new and renewable energy sources, and pharmaceutical compound engineering.
- **Expertise in Organic Synthesis and Biomolecular Chemistry:** Having a deep understanding of knowledge in organic chemistry, especially the structure and reactions of organic compounds, through research to produce innovative and validated works, perform spectral interpretation for the elucidation of organic compound structures, and apply organic chemistry knowledge, especially in utilizing natural resources in the fields of agrochemistry, pharmaceuticals, food, and energy.

- **Expertise in Analytical Chemistry and Environmental Chemistry:** Mastering and developing the theories of chemistry and physics that underlie general and instrumental analytical chemistry measurements through research, resulting in innovative and validated works recognized nationally and internationally through scientific publications. Capable of solving problems in analytical and environmental chemistry and developing analytical methods through interdisciplinary or multidisciplinary approaches that can be applied and beneficial to society and other scientific fields.

7.3 Work Skills

4. **[PLO-4] Problem-solving Skills.** Having a robust scientific insight to solve scientific problems through interdisciplinary or multidisciplinary approaches that benefit society and the field of knowledge.
5. **[PLO-5] Research Skills**

Having a solid scientific insight to:

- Formulate, conduct, and develop research and community service themes based on chemical science independently and professionally.
- Possess in-depth knowledge and understanding of sustainability concepts in chemistry.
- Have insights and skills to utilize the potential of local resources in developing research themes, chemical products, and technologies.
- Have a sufficient understanding of the principles of chemical instrumentation.

6. **[PLO-6] Publication Skills:** The ability to contribute to knowledge by publishing research findings, both orally and in writing, in reputable accredited international and national journals, or producing intellectual works that receive legal protection (intellectual property rights).

7.4 Managerial Skills

7. **[PLO-7] Professional Attitude:** Having good interpersonal skills, being able to work collaboratively in a team, taking responsibility for one's work, and being assigned tasks to support the achievement of team goals.
8. **[PLO-8] Communication Skills:** Communicating effectively with stakeholders from diverse backgrounds, both in written and oral form, in Indonesian and English.
9. **[PLO-9] Lifelong Learning:** Having the willingness, awareness, and ability to keep up with the latest developments in research themes in chemistry.

8. Education Pathways

The Doctoral Program in Chemistry offers two pathways to achieve the learning outcomes for graduates (PLO): **the regular and research pathways (by research).** The main difference between these two pathways lies in achieving the learning outcomes in the specialized field (PLO-3). **In the regular pathway**, PLO-3 is achieved through elective courses (6-10 credit hours) relevant to the researcher's interests. On the other hand, in the research pathway, PLO-3 is achieved through a more intensive and extensive research process to produce scientific articles. Under this pattern, the Doctoral **Program by Research** is required to produce at least 2 internationally accepted scientific publications, while the regular program requires only 1 accepted scientific journal.

8.1 Regular Doctoral Program in Chemistry

The curriculum of the Regular Pathway Doctoral Program in Chemistry for the year 2022 consists of the following courses:

Compulsory Program Courses (6 credit hours):

- **MKK 7101 Philosophy of Chemistry** (2 credit hours, Semester 1): Provides a philosophical and fundamental framework for

innovative and creative thinking with a multidisciplinary approach.

- **MKK 7108 Research Design** (3 credit hours, Semester 1): Conducted in the form of scheduled weekly discussions with the supervisory team for 14 weeks (14 meetings) to develop the dissertation proposal in preparation for the comprehensive examination.
- **MKK 7107 Research Evaluation Seminar** (1 credit hour): A forum to evaluate the progress of students' research. It is conducted every semester, and the Evaluation Team consists of the respective student's supervisory team and the Dissertation Committee. Each student is required to present their research progress every semester until it is deemed sufficient and allowed to proceed with dissertation preparation by the Evaluation Team.

Elective Courses (6-10 credit hours)

These courses are intended to support student's research activities. The available elective courses are:

- MKK 7201 Synthesis and Characterization of Materials (2 credit hours, Semester 1)
- MKK 7204 Metal/Material Interactions and Design (2 credit hours, Semester 2)
- MKK 7303 Catalytic Processes (2 credit hours, Semester 1)
- MKK 7304 Computational Catalyst Design (2 credit hours, Semester 2)
- MKK 7404 Modern Research in Organic Chemistry (2 credit hours, Semester 1)
- MKK 7405 Current Research in Biomolecular Chemistry (2 credit hours, Semester 2)
- MKK 7504 Current Fundamental Research in Analytical Chemistry (2 credit hours, Semester 1)
- MKK 7505 Current Applied Research in Analytical Chemistry (2 credit hours, Semester 2)

The lectures of the Doctoral Program in Chemistry are scheduled for 14 weeks each semester, and the end-of-semester examinations are held in the form of seminars, assignments, or written exams, also scheduled accordingly. The distribution of courses for each semester can be seen in the following table.

Course type	Semester					
	I	II	III	IV	V	VI
Compulsory Courses (6 credits)	• MKK 7101 Philosophy of Chemistry (2 credits) • MKK 7108 Research Design (3 credits)**	MKK 7107 Research Evaluation Seminar (1 credit)*				
Elective Courses (6-10 credits)	Elective Courses (4-10 credits)	Elective Courses (2-4 credits)				
Dissertation		(34 credits)				
Total (44-50 credits)	11-16 credits	3-5 credits				

1. *The Research Evaluation Seminar course is taken every semester starting from the second semester.
2. ** The outcome of the Research Design course is a research proposal for the Comprehensive Examination, which can be conducted at the end of the second semester or the beginning of the third semester.

8.2 Doctoral Program by Research

The curriculum of the Doctoral Program in Chemistry for the year 2022, in the by Research track, consists of the following compulsory courses:

- **MKK 7101 Philosophy of Chemistry** (2 SKS, semester 1), to provide a philosophical-fundamental, innovative, and creative thinking framework with a multidisciplinary approach.
- **MKK 7108 Research Design** (3 SKS, semester 1), conducted in the form of scheduled weekly discussions with the supervisory team for 14 weeks (14 meetings) to prepare the dissertation proposal as a preparation for the comprehensive examination.

- **MKK 7107 Research Evaluation Seminar** (1 SKS, semester 2 until completion), serves as a forum for evaluating the progress of students' research and is conducted every semester. The Evaluation Team consists of the Supervisors and the Dissertation Committee. Every student is required to present the progress of their research each semester until it is deemed sufficient and authorized by the Evaluation Team to proceed with the dissertation preparation.

Elective Courses (0-4 SKS)

If necessary, students in the by Research track are allowed to take up to 4 SKS (2 courses) of elective courses offered, which include:

- MKK 7201 Synthesis and Characterization of Materials (2 SKS, semester 1)
- MKK 7204 Interaction and Design of Metals/Materials (2 SKS, semester 2)
- MKK 7303 Catalytic Processes (2 SKS, semester 1)
- MKK 7304 Computational Design of Catalysts (2 SKS, semester 2)
- MKK 7404 Modern Research in Organic Chemistry (2 SKS, semester 1)
- MKK 7405 Current Research in Biomolecular Chemistry (2 SKS, semester 2)
- MKK 7504 Current Research in Fundamental Analytical Chemistry (2 SKS, semester 1)
- MKK 7505 Current Research in Applied Analytical Chemistry (2 SKS, semester 2).

8.3 Comparison of Regular and by Research Doctoral Programs

The comparison of study loads between the Regular and by Research Doctoral Programs is as follows:

Component of Activities	Regular (credit)	by research (credit)
Compulsory Program Courses	6	6
Elective Courses	6-10	0-4

Dissertation, including components	34	40
• Comprehensive Examination	(4)	(4)
• Publication I	(12)	(9)
• Publication II	-	(9)
• Dissertation Manuscript	(6)	(6)
• Research	(6)	(6)
• Final Examination	(6)	(6)
Total	46-50	46-50

9. Implementation Regulations of Study Programs

9.1 Admission Requirements

The admission requirements for prospective students of the Doctoral Program in Chemistry, as determined by the Academic Directorate of Gadjah Mada University, are as follows:

General Requirements

- Graduates of a related Master's degree program: with a minimum GPA of 3.25, or a minimum GPA of 3.00 with three published scientific papers in reputable scientific journals and/or books relevant to their field of expertise.
- Graduates of a non-related Master's degree program: with a minimum GPA of 3.50, or a minimum GPA of 3.25 plus three relevant scientific papers published in reputable scientific journals and/or books relevant to their field of expertise.
- Graduates of a related Bachelor's degree program: with the highest honors (equivalent to cum laude), or a minimum GPA of 3.00 with five research-based scientific papers published in reputable scientific journals and/or books relevant to their expertise.
- Graduates of a non-related Bachelor's degree program: with the highest honors (equivalent to cum laude) or a minimum GPA of

3.25 with five research-based scientific papers published in reputable scientific journals and/or books relevant to their expertise.

- Master's degree students who have not conducted research with a GPA of 3.00 may be eligible to apply for a doctoral program in a related field, as decided in the selection meeting at the chosen study program level.

9.2 Specific Requirements

For graduates of Master's programs in 2017 and onwards:

- Minimum GPA of 3.25 on a scale of 4 or its equivalent.
- A minimum score of 550 on the Academic Potential Test (TPA).
- Valid English proficiency test score, the Institutional Testing Program (ITP) TOEFL with a minimum score of 500.

For graduates of Master's programs before 2017:

- Minimum GPA of 3.25 on a scale of 4 or its equivalent.
- Valid Academic Potential Test (TPA) score.
- Valid English proficiency test score.

The requirements for the TPA score and English proficiency test score, as mentioned in points (ii) and (iii), must be fulfilled before the implementation of the proposal seminar/comprehensive examination/research proposal examination.

For UGM alums before 2017 and DTPK:

- Minimum GPA of 3.00 on a scale of 4 or its equivalent.
- Valid Academic Potential Test (TPA) score.
- Valid English proficiency test score.

The requirements for the TPA score and English proficiency test score, as mentioned in points (ii) and (iii), must be fulfilled before the implementation of the proposal seminar/comprehensive examination/research proposal examination.

9.3 Promoter Team (Supervisors)

- The Promoter is determined during the admission selection meeting, taking into consideration the letter of commitment from the prospective Promoter accompanied by the proposed research topic/title by the prospective student.
- Co-promoters are proposed by the Promoter and determined during the selection meeting or can be determined later, considering the proposed research topic.
- The existing regulations of the Doctoral Program in Chemistry regarding the number of students under the supervision of each Promoter are as follows: a maximum of 3 students per year, and cumulatively a maximum of 9 students as a promoter.

Composition and provisions of the Promoter Team:

- Promoter: Faculty members of the Department of Chemistry with the rank of Professor or Associate Professor holding a Doctoral degree. The requirement for a prospective Promoter with the rank of Associate Professor holding a Doctoral degree is to have previously graduated students as co-promoters.
- The number of co-promoters is 1-2 individuals from the faculty members of the Department of Chemistry holding a Doctoral degree and/or a maximum of 1 faculty member from outside the Department of Chemistry, with the rank of Associate Professor holding a Doctoral degree and having publications in reputable journals.
- Priority for co-promoters is given to faculty members with the rank of Associate Professor or Assistant Professor as a means of academic mentoring.
- Changes or replacements in the Promoter Team can be made by submitting an official letter to the Chair of the Doctoral Program and approved by all members of the Promoter Team.

The responsibilities of the Promoter Team include:

- Guiding the preparation of the Dissertation proposal.

- At the end of the first semester, the Promoter Team reviews the academic progress of the student and prepares for the comprehensive examination no later than the end of the third semester.
- Monitoring the student's research progress by organizing regular seminars to monitor the student's research progress.
- Every semester, the Promoter Team, together with the Dissertation Committee, evaluates the student's research progress and provides recommendations for the student's continuation in the Doctoral program.
- Guiding the preparation of publication manuscripts and the Dissertation manuscript.

9.4 Dissertation Committee

The role of the Dissertation Committee includes:

- **Check and Balances:** The Dissertation Committee balances the Promoter Team's role in ensuring that the standards and guidelines of the Doctoral program are followed and avoiding excessive authority within the Promoter Team. However, the Dissertation Committee should not excessively interfere with the Promoter Team's responsibility in guiding the doctoral students.
- **Support for the Promoter Team:** Committee members who actively participate in the dissertation process can support and assist the Promoter Team in carrying out their responsibilities during the dissertation process. Suggestions from the Dissertation Committee are valuable as long as they do not conflict with the Promoter Team's policies.
- **Expert Resources:** The Dissertation Committee can serve as an expert resource for doctoral students to address any weaknesses in their research with the support of the Dissertation Committee.
- **Accountability:** The Dissertation Committee plays a crucial role in creating accountability by providing insights into the direction and path of the student's research for a smooth dissertation process.

The Dissertation Committee consists of 3 members, with the following provisions:

- Chair: a faculty member from the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Gadjah Mada University, holding the rank of Professor or Associate Professor with a Doctoral degree.
- Members: 1-2 faculty members from the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Gadjah Mada University, and/or a maximum of 1 faculty member from outside the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Gadjah Mada University, with a minimum rank of Associate Professor holding a Doctoral degree and having publications in reputable journals. Any exceptions to these provisions require approval from the Doctoral Program Management.

The names of the Committee members are proposed by the Promoter Team to the Chair of the Doctoral Program when applying for the comprehensive examination. The Promoter Team is requested to submit 6 candidates for the Dissertation Committee, and the program will select 3 out of the 6 candidates proposed. If any Committee members cannot fulfill their duties during their term, the Promoter Team submits a replacement request to the Chair of the Doctoral Program.

Responsibilities of the Dissertation Committee:

- Testing the research proposal in the comprehensive examination.
- Evaluating the student's research progress each semester until the research is deemed sufficient/complete.
- Assessing the suitability of the dissertation manuscript.
- Conducting the dissertation defense.

9.5 Comprehensive Examination

Requirements for taking the Comprehensive Examination:

- TOEFL and TPA requirements follow the regulations of the Faculty of Mathematics and Natural Sciences (TPA ≥ 550; TOEFL ≥ 500).
- Passed all courses with a minimum grade of B and GPA ≥ 3.25.
- Completed a dissertation proposal approved by the Promoter Team.

Conducting the Comprehensive Examination:

- The Comprehensive Examination is scheduled at the beginning of the second semester or no later than the third semester.
- Suppose a student is not ready to take the comprehensive examination on the scheduled date. In that case, they will be given one more opportunity to take the thorough examination no later than the end of the fourth semester.
- If a student has not taken the comprehensive examination by the end of the fourth semester, they will be declared dropped from the Doctoral Program in Chemistry.

The assessment of the proposal in the comprehensive examination includes:

- Mastery of theories and concepts in the field demonstrated through problem formulation and literature review.
- Originality and potential contribution to the discipline.
- Mastery of research methods.
- Writing quality.

Grading:

- Pass without revisions.
- Pass with revisions.
- Fail (re-examination).

A student who fails the comprehensive examination twice will be considered unsuccessful and cannot continue as a doctoral student.

9.6 Student Status

Classification of Student Status

As a means of evaluating student performance, students in the Doctoral Program in Chemistry are classified into 3 types of status based on their study/research progress:

- Status A: Students completing coursework, preparing a proposal, and not taking the Comprehensive Examination.
- Status B: Students who have passed the Comprehensive Examination and are conducting research.
- Status C: Students who have been declared to have completed their research by the Evaluator Team and are finalizing their dissertation.

In Absentia Status

In principle, Doctoral students in Chemistry are required to be in residence to attend classes and conduct research at the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Gadjah Mada (UGM). However, students are allowed to be in absentia and conduct research outside the Department of Chemistry, FMIPA UGM, under the following conditions:

- It is allowed for a maximum period of 1 year and can be extended for 2 years.
- The student has already passed the Comprehensive Examination.
- The required research facilities are not available at UGM.
- Conducting research outside UGM will ensure the progress of the research.
- The student must remain registered as a doctoral student at UGM.
- During the in-absentia status, the student is required to report the research progress to the Promoter Team.

9.7 Termination

The Graduate Program will terminate the candidate's doctoral status after two warnings if:

- They fail the comprehensive examination twice.
- They do not show satisfactory research progress, leading the Promoter Team and Dissertation Committee to believe that the student cannot complete the research within the available time frame.
- They fail to re-register for two consecutive semesters or declare their withdrawal from the Doctoral Program in Chemistry.
- They fail to communicate with the Promoter Team and Dissertation Committee for two consecutive semesters.

9.8 Publication Requirements

1. **Regular Track:** According to the current regulations of the Faculty of Mathematics and Natural Sciences, Universitas Gadjah Mada (UGM), the publication requirement for the dissertation defense is at least 1 scientific publication in an internationally indexed journal listed in the university-designated international database and adhering to ethical writing practices (except for Google Scholar).
2. **Research Track:** The publication requirement for the dissertation defense in the Research Track of the doctoral program is at least 2 scientific publications in internationally indexed journals listed in the university-designated international database and adhering to ethical writing practices.

Publications that can be used to fulfill the graduation requirement must be based on the dissertation research, excluding review articles or research articles unrelated to the dissertation.

9.9 Dissertation Manuscript Assessment

General provisions:

- The Dissertation Committee conducts the assessment within 3 weeks after receiving the manuscript.
- The assessment is carried out using the provided guidelines/form.
- The assessment of the Dissertation Manuscript includes:
- Explanation, contextualization, and articulation of the research problem and objectives.
- Relevant literature review.
- Formulation, development, and explanation of relevant theoretical background.
- Methodology, design, and implementation.
- Testing, results, analysis, and evaluation of findings.
- Writing structure and organization of the dissertation.

Assessment Results:

- Considered as suitable without the need for revisions.
- Considered as suitable with the need for revisions.
- Considered as suitable but requires additional data/research.
- Considered as unsuitable for further closed examination.

9.10 Dissertation Defense

Requirements:

- TOEFL ≥ 500; TPA ≥ 550. Students who have met the TOEFL ≥ 500; TPA ≥ 550 requirements during the admission selection process will have their scores recognized even if they have expired by the dissertation defense time.
- The Dissertation Manuscript is deemed suitable by the Dissertation Committee/Assessment Team.

The examination Panel consists of the following:

- Promoter Team.
- Dissertation Committee.
- 2 Additional Examiners (at least 1 person with a Doctoral degree from outside UGM).

Assessment:

- Pass.
- Pass with revisions.
- Fail.
- Retake examination for those who fail within a maximum of 6 months after the first examination.

10. Course Syllabus

MKK 7101 Philosophy of Chemistry (2 credits, semester 1)

Course Learning Outcomes (CLO):

Upon completing this course, students will be able to:

- CO1. Demonstrate an advanced understanding of the methods and processes of chemistry as a creative endeavor.
- CO2. Demonstrate an understanding of the close relationship between scientific research and the development of new knowledge in a global context.
- CO3. Show that current scientific knowledge can be compared and tested through further investigation.
- CO4. Apply concepts and theories from various advanced topics in the field of chemistry.
- CO5. Analyze, interpret, and critically evaluate research findings.
- CO6. Present information, arguments, and conclusions in various modes to audiences in their research field.
- CO7. Comply with regulatory frameworks and practice relevant professional ethics in chemistry.

Syllabus:

This course provides a philosophical-fundamental, innovative, and creative thinking framework with a multidisciplinary approach. Lectures will present

the philosophical foundations of various research developments in the Department of Chemistry by experts in their fields.

References:

- Baird, Eric Scerri, Lee McIntyre; 2006; Philosophy of Chemistry: Synthesis of a New Discipline; Springer,
- Dov M. Gabbay, Paul Thagard, John Woods, Robin Findlay Hendry, Paul Needham, Andrea Woody; 2011, Philosophy of Chemistry; Elsevier.

MKK 7108 Design Research (3 credits, semester 1)

Course Learning Outcomes (CLO):

Upon completing this course, students will be able to:

- CO1. Have a comprehensive knowledge of the literature and a thorough understanding of the applicable scientific methods and techniques for their research.
- CO2. Demonstrate originality in applying knowledge and a practical understanding of how research and investigation are used to create and interpret knowledge in their field.
- CO3. Develop the ability to evaluate research techniques, methodologies, and current research critically.
- CO4. Have direction and originality in addressing and solving problems.
- CO5. Act independently in the planning and implementation of research.

Syllabus:

This course is conducted in the form of scheduled weekly discussions with the supervisory team for 14 weeks (14 sessions) to develop a dissertation proposal in preparation for the comprehensive examination. The discussion topics may include research problem formulation, theoretical framework development, hypothesis formulation, and research methodology development.

References:

• Roy L. Tranter, 2000, Design and Analysis in Chemical Research, Sheffield Academic/CRC Press.

• Alexander M. Novikov, Dmitry A. Novikov, 2013, Research Methodology: From Philosophy of Science to Research Design, CRC Press.

MKK 7201 Synthesis and Characterization of Materials (2 credits, semester 1)

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1. able to classify and identify different types of materials based on various aspects (particle size, components, and sources).
- CO2. able to identify and select suitable materials synthesis and engineering methods.
- CO3. able to determine appropriate characterization techniques to support the successful proof of material synthesis and engineering.
- CO4. Evaluate the advantages and disadvantages of synthesis methods used to synthesize and engineer a functional material.

Syllabus:

Material classification: Nanomaterials, nanocomposites, ceramics, and polymers. Methods of synthesis of nanomaterials (bottom-up and bottom-down methods), composites, and macromaterials (sol-gel, co-precipitation, hydrothermal, etc.). Material characterization: IR, XRD, XPS, SEM-EDX, TGA, TEM, XRF, etc.

Reference:

- Nanocomposite Materials (Synthesis, Properties, and Applications), J. Kumar P. Pillai, N. Hameed, T. Kurian, Y. Yu, CRC Press, 2017.
- Synthesis Techniques for Polymer Nanocomposites, V. Mittal, Wiley-VCH Verlag GmbH & Co. KGAA 2015.
- Materials Science and Engineering, An Introduction, W.D. Callister, John Wiley & Sons, Inc., 2007.
- Recent articles related to synthesis, engineering, material characterization and application.

MKK 7204 Metal/Material Interaction and Design (2 SKS, semester 2)

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1. able to classify metals based on physical and chemical properties,
- CO2. capable of engineering metals and their compounds (metal nanoparticles, metal oxide nanoparticles, composites, etc.),
- CO3. able to explain theoretically the interaction of metal ions with various ligands both in solution and in solids,
- CO4 can theoretically explain the interaction of metals with the surface of various solid materials.

Syllabus:

Classification of metals: s group metals, d group, and f group metals. Inert metals and reactive metals. Metal engineering methods: metal defects, metal nanoparticles, metal oxides, metal complexes, and composites. Theory of interaction of metal ions in complexes in solutions and solids. Theory of interaction of metal and metal oxide nanoparticles in suspension, the interaction of metals with the surface of solid oxides, polymers, and ceramics.

Reference:

- Inorganic Chemistry, D. Shriver, M. Weller, T. Overton, J. Rourke, F. Armstrong, Issue 6, W. H. Freeman and Company, New York, 2014.
- Metal Complexes in Aqueous Solution, Martell, and Hancock, 1996.
- Frontier Nano Science (Metal Nanoparticle and Nanoalloy), Roy L. Johnston and J.P. Willcoxon, 2012.
- Recent articles related to the interaction of metals with other materials.

MKK 7304 Catalytic Process (2 credits, semester 1)

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1. Master the concept of catalytic processes in general,
- CO2. Master the concept of homogeneous and heterogeneous catalysis,
- CO3. Master the concept of catalyst material synthesis and its characterization,
- CO4. Understand the application of heterogeneous catalysts in catalytic processes in the industry.

Syllabus:

Introduction of homogeneous and heterogeneous catalysts and their applications. Review of articles and presentations on the hydrocracking process. Review articles and presentations on photocatalytic processes. Review articles and presentations on electrocatalytic processes. Review articles and presentations on biocatalytic processes. Review articles and presentations on industrial catalytic processes. Guest lecturer lectures relevant to the field of catalysts.

Reference:

- Sherrington, D.C and Kybett., AP, 2000, Supported Catalysts and Their Applications, RSC., Cambridge, ISBN : 0-85404-880-4.
- Chorkendorff, I., Niemantsverdriet, J.W., 2002, Concepts of Modern Catalysis and Kinetics, Willey- VCH Verlag GmbH & Co., Weinheim, ISBN : 3-527-30574-2.
- Anthony van Santen, R., and Neurock, M., 2006, Molecular Heterogeneous Catalysis : A Conceptual and Computational Approach, WILEY-VCH Verlag GmbH & Co. KgaA, ISBN-13: 978-3-527-29662-0, ISBN-10: 3-527-29662-X.
- Review articles from reputable journals related to catalytic processes.

MKK 7305 Computational Catalyst Design (2 credits, semester 2)

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1. Know the basics of catalyst material design using computational methods,
- CO2. able to predict the chemical and physical properties of the catalyst material theoretically accurately and correctly,
- CO3. Master the concepts of quantum chemistry and computational chemistry needed in designing catalysts,
- CO4. able to design and characterize the catalyst computationally.

Syllabus:

Introduction to theoretical catalyst design (computational chemistry). Review articles and presentations on homogeneous catalyst designs. Review articles and presentations on heterogeneous catalyst designs. Review of articles and presentations on solid acid catalyst designs. Review articles and presentations on solid base catalyst designs. Review articles and presentations on green catalyst designs. Guest lecturer lectures with relevant material.

Reference:

- van Santen., RA, and Neurock, M., 2006, Molecular Heterogeneous Catalysis, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN-13: 978-3-527-29662-0, ISBN-10: 3-527-29662-X.
- Reputable international journals related to theoretical and experimental catalyst design.

MKK 7404 Modern Research in Organic Chemistry

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1: uses computational chemistry to design organic compound targets
- CO2: understanding modern techniques in the synthesis of organic compounds
- CO3: Design and synthesis of organic compounds for anticancer, antidiabetic, and antimalarial properties
- CO4: able to design target compounds and their synthesis to be used as compounds with biological activity (anticancer, antidiabetic, antimalarial, antioxidant, etc.), adsorbents, and chemosensors.

Syllabus:

Computational chemistry assistance for target design of organic compounds. Modern techniques in the synthesis of organic compounds. Design and synthesis of organic compounds for chemosensors. Design and synthesis of organic compounds for anticancer. Design and synthesis of organic compounds for antidiabetics. Design and synthesis of organic compounds for malaria. Design and synthesis of organic compounds for adsorbents.

Reference:

- Green Chemistry in the Synthesis of Pharmaceuticals, Chem. Rev. 2022, 122, 3637-3710.
- Molecular Probes, Chemosensors, and Nanosensors for Optical Detection of Biorelevant Molecules and Ions in Aqueous Media and Biofluids, Chem. Rev. 2022, 122, 3459-3636.

MKK 7405 Current Research in Biomolecular Chemistry

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1: understanding the latest research developments in the fields of metabolomics and metabolic engineering
- CO2: understanding the latest developments in supramolecular protein research
- CO3: understanding the latest developments in genetic engineering research and gene editing
- CO4: able to design research in the newest field of Biomolecular Chemistry.

Syllabus:

Recent Developments in Biological Chemistry Research. Recent Developments in Metabolomics and Natural Products Chemistry Research. Recent Developments in Protein Engineering Research, Peptides, and Enzyme Technology. Recent Developments in Supramolecular Protein Research. Recent Developments in Research on the Interaction of Bioactive Molecules and Biomembranes. Recent Developments in Metabolic Engineering Research. Recent Developments in Genetic Engineering and Gene Editing Research. Recent Developments in Fermentation Technology Research.

Reference:

- Sosalagere, C., Kehinde, B.A., Sharma, P., 2022, Isolation and Functionalities of Bioactive Peptide from Fruits and Vegetables; A Reviews, Food Chemistry, Volume 366.
- Crowley, P.B., 2020, Supramolecular Protein Chemistry: Assembly, Architecture and Application, Royal Society of Chemistry.
- Stansbury, P., Whitaker, A., Hall, S.J., 2016, Principles of Fermentation Technology, Elsevier.
- Victor Aderemi, A.V., Ayeleso, A.O., Oyedapo, O.O., and Mukwevho, E., 2021, Review Metabolomics: A Scoping Review of Its Role as a Tool for Disease Biomarker Discovery in Selected Non-Communicable Diseases, Metabolites.
- Pinu, F.R., Goldansaz, S.A., and Jaine, J., 2019, Translational Metabolomics: Current Challenges and Future Opportunities, Metabolites.
- Peredo-Lovillo, A., Hernández-Mendoza, A., Vallejo-Cordoba, B., Eliza Romero-Luna, H., 2022, Conventional and in silico approaches to select promising food-derived bioactive peptides: A review, Food Chemistry: X, Volume 13, 100183.
- Mirzaei, M., Shavandi, A., Mirdamadi, S., Soleymanzadeh, N., Motahari, P., Mirdamadi, N., Moser, M., Subra, G., Alimoradi, H., Goriely, S., 2021, Bioactive peptides from yeast: A comparative review on production methods, bioactivity, structure-function relationship, and stability, Trends in Food Science & Technology, Volume 118, Part A, 297-315.

MKK 7504 Current Fundamental Analytical Chemistry Research (2 credits, semester 1)

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1: has broad and in-depth knowledge and is up-to-date in fundamental analytical research in the field of sampling methods and sample preparation

- CO2: has broad and deep insights and is up-to-date in fundamental analytical research in the field of analytical methods based on spectrometry, chromatography, electrometry, and X-rays
- CO3: has broad and deep, and up-to-date insights into fundamental analytical research in the field of microscopy methods and surface analysis
- CO4: has broad and deep, and up-to-date insights into fundamental analytical research in the field of statistical methods in analytical chemistry

Syllabus:

This course will discuss review articles or fundamental analytical research articles in the fields of (1) Sampling and sample preparation methods, (2) Spectrometry, chromatography, electrometry, and X-ray-based analytical methods, (3) Microscopy and surface analysis methods, (4) Statistical methods in analytical chemistry.

Reference:

- Review articles or research articles in the last 3 years from highly reputable analytical chemistry journals, including Analytical Chemistry, Analytica Chimica Acta, Talanta, Analytical, and Bioanalytical Chemistry.

MKK 7505 Latest Applied Analytical Chemistry Research (2 credits, semester 2)

Course Learning Outcomes (CPMK):

After attending this course, students will:

- CO1: has broad and in-depth, and up-to-date insights in applied analytical research in the field of Environmental Analysis

- CO2: has broad and in-depth, and up-to-date insights in applied analytical research in the field of Clinical and Forensic Analysis
- CO3: has broad and deep, and up-to-date insights in applied analytical research in the field of Food and Biomolecular Analysis
- CO4: has broad and in-depth knowledge and is up to date in applied analytical research in the field of Toxicology, Drug and Pharmaceutical Analysis

Syllabus:

This course will discuss review articles or applied analytical research articles in the fields of (1) Environment, (2) Clinical, (3) Forensics, (4) Food, (5) Biomolecular, (7) Toxicology, (8) Drug and pharmaceutical.

Reference:

- Review articles or research articles in the last 3 years from highly reputable analytical chemistry journals, including Analytical Chemistry, Analytica Chimica Acta, Talanta, Analytical and Bioanalytical Chemistry, Trends in Environmental Analytical Chemistry, Food Chemistry, Drug Testing, and Analysis, Forensic Chemistry, Journal of Pharmaceutical Analysis, Journal of Pharmaceutical and Biomedical Analysis.