Curriculum

MASTER OF CHEMISTRY PROGRAM

DEPARTMENT OF CHEMISTRY

FACULTY OF MATHEMATICS AND NATURAL SCIENCES

UNIVERSITAS GADJAH MADA

YOGYAKARTA

2022

Department of Chemistry

1. Department of Chemistry

1.1 Introduction

Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Gadjah Mada (UGM) was established on September 1, 1960, with the Decree of the Director-General of Higher Education No. 22/DIKTI/kep/1995 and confirmed by the Decree of the Director-General of Higher Education No. 221/DIKTI/Kep/1996 dated July 11, 1996. Based on the UGM Chancellor Decree No. 1619/P/SK/HT/2015 concerning Determination of the Organizational Structure of the Faculty of Mathematics and Natural Sciences, UGM, the name of the department changed to the Department of Chemistry. Department of Chemistry currently organizes three study programs (Prodi), namely Bachelor of Chemistry, Master of Chemistry, and Doctoral of Chemistry Study Programs. The Department of Chemistry has five laboratories, namely Basic Chemistry, Organic Chemistry, Physical Chemistry, Inorganic Chemistry, and Analytical Chemistry Laboratories.

In the era of global competition, comprehension of science and technology, including chemistry, greatly determines the nation's competitiveness. To improve the mastery of science and technology, strengthening education and research in universities is a strategic step since it will produce superior human resources who are able to produce research outputs with international quality.

As a higher education institution, the Department of Chemistry UGM is also responsible for preparing the human resources, with special expertise in chemistry, which can make major contributions to producing research for the development of science and technology. In addition, as part of Universitas Gadjah Mada, the Department of Chemistry has the responsibility to advance science and technology, including Chemistry in Indonesia, as mandated in Permendikbud No. 3 of 2020 concerning the National Higher Education Standards.

Department of Chemistry has prepared the vision, mission, and objectives of education to guide the direction and activities at the Department of Chemistry. The formulation of the vision, mission, and objectives refer to the vision, mission, and objectives of the Faculty of Mathematics and Natural Sciences, UGM, so that they can support each other and are synergistic. The formulation is based on the real current conditions of the Department of Chemistry, including human resources and infrastructure, and by taking into account the needs and competencies demanded by both the national and international job stakeholders. The Department of Chemistry's vision, mission, and educational objectives have been prepared by referring to the inputs submitted by both stakeholders and alumni and have also been arranged in such a way that they can be achieved in accordance with the carrying capacity of the study program.

The mechanism for formulating the vision, mission, and educational objectives of the Department of Chemistry begins with brainstorming at meetings at the level of the department. The results of the brainstorming in the form of the concept of the vision, mission, and educational goals were then brought to the plenary meeting of the Department of Chemistry to be refined. Having determined the concept together, the vision, mission, and educational objectives are then submitted to the Faculty/Dean for approval at the Faculty Senate meeting as the highest forum for academic policymaking

at the level of Faculty. The Department of Chemistry's vision, mission, and objectives are then disseminated to all academics, prospective students, and the wider community.

1.2 Visions of Department of Chemistry

The visions of the Department of Chemistry, Faculty of Mathematics and Natural Sciences, UGM are to become a higher education institution in the field of chemistry that:

1. excel nationally and be recognized internationally in education, research, and community service activities.
2. produce alumni who are superior and able to compete both nationally and internationally.

1.3 Missions of Department of Chemistry

Department of Chemistry, Faculty of Mathematics and Natural Sciences, UGM has missions to develop:

1. the education system that ensures the implementation of the learning process in the field of chemistry with international quality and useful learning outcomes for all levels of Indonesian society.
2. conducive conditions for the implementation of research activities (both fundamental and applied chemistry) and community services in the field of chemistry at the international level that supports the development of science and technology for the welfare of society.
3. public attitude, which shows that chemistry is a science and technology that plays an important role in improving the welfare and quality of humankind, both materially and spiritually.
4. networking with educational institutions and industry at national and international levels.
5. the ability to publish research results in the field of chemistry both orally and in writing at both national and international levels.

1.4 Objectives

The objectives to be achieved are the realization of the Department of Chemistry which excels nationally and is recognized internationally through:

1. implementation of qualified education in order to produce graduates of Bachelors, Masters, and Doctors of Chemistry with superior quality nationally and internationally.
2. conducting research and publications in the field of chemistry with the international standard that can increase scientific progress and for the welfare of humankind.
3. community service related to chemistry and its application to improve the community's welfare.
4. networking in the fields of education, research, and community service with educational institutions, research institutes, and industry both at national and international levels.

1.5 Targets and Strategies of Achievements

Target 1*: *The achievement of research-based learning

Strategies:

1. Multidisciplinary research growth program and increased protection of Intellectual Property Rights with a phasing policy. The first step is to increase the understanding

of multidisciplinary research concepts, the second is to increase the involvement of the number of multidisciplinary research researchers, and the third is to improve the quality of research.
2. Program to provide support for research facilities for students and lecturers, with policies of providing financial and non-financial support that is sought from various sources, especially from public and government funds.
3. Program to improve the quality and relevance of research-based learning in some courses.

<u>Target 2</u>: The achievement of increasing reputation and international accreditation in the fields of education, research, and community services

Strategies:

1. Continuous programs of improvement and quality assurance of curriculum and syllabus to meet the international standards.
2. Quality improvement programs in human resources, facilities, infrastructure, and management with careful, comprehensive, and integrated planning policies with attention to relevance to the focus of the development sector and considering the balance between activities and availability of resources. The optimization is carried out by prioritizing the acquisition of added value in internationally prospective aspects.
3. international standard research quality improvement program with policies of prioritizing the solution of the nation's problems and encouraging collaborative research with developed country partners, both in research, funding, and publication processes, as well as improving the quality of human resources and research infrastructure.
4. Maintain the achievement of the Royal Society of Chemistry (RSC) International Accreditation for Chemistry Undergraduate Study Program, FMIPA UGM, and strive to achieve international accreditation for Master and Doctoral Chemistry Study Program, FMIPA UGM.

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4. Maintain the achievement of the Royal Society of Chemistry (RSC) International Accreditation for Chemistry Undergraduate Study Program, FMIPA UGM and strive to achieve international accreditation for Master and Doctoral Chemistry Study Program, FMIPA UGM.

<u>Target 3</u>: The achievement of increasing international cooperation networks

Strategies:

1. Program to increase the number and quality of international cooperation networks by encouraging lecturers and students in staff exchange, student exchange, and international research collaboration activities, as well as holding/participating in joint international conferences and international publications.
2. Implementation of dual degree programs with universities from developed countries

***Target 4*: The achievement of good governance in the management system**

Strategies:

An independent chemical department organizational improvement program meets the standards of good governance, human resource management, and accountable financial management. This is audited regularly by the UGM Internal Audit Office (KAI) and by an external auditor (BPK/public accountant) to obtain qualified opinions.

Targets of Curriculum

The targets of the curriculum development are:

1. To increase the quality of the learning process in the Master of Chemistry, UGM.
2. To have a curriculum for the Master of Chemistry, UGM, that can follow the current scientific and research developments.
3. To create graduates who are able to adapt and have high academic abilities so that they can compete at national and international levels.

Achievement targets

Table 1. Indicators and achievement targets for the Master of Chemistry study program

No.	Indicator	Baseline (2022)	Midline (2027)	Target (2032)
1	Study Length (month)	29	27	24
2	Graduate GPA	3.59	3.65	3.71
3	Thesis work time (month)	17	15	12
4	International Publications of Students (Scopus) (manuscripts)	14	15	16
5	National Publications of Students	1	2	3
6	International Seminars	13	14	15
7	Student Seminars	0	1	2

1.6 Facilities and infrastructures

Department of Chemistry is part of the Faculty of Mathematics and Natural Sciences, UGM, which occupies a building space of about 6500 m^2 and has 5 research and practical laboratories, namely the Analytical Chemistry, Inorganic Chemistry, Physical Chemistry, Basic Chemistry, and Organic Chemistry laboratories. There is also a postgraduate chemistry laboratory in the postgraduate building, which is a place for master's and doctoral chemistry students to conduct thesis and doctoral research. In addition, the Department of Chemistry has a computational chemistry laboratory which is a collaboration with the Austrian-Indonesian for Computational Chemistry (AIC). All laboratories in the Chemistry Department have a Laboratory Information System (*SILAB*), which can be accessed by the academic community and the wider community. Starting in 2022, the Department of Chemistry has additional new rooms on the 6th floor of the new Faculty building, which will be used as a Computational Chemistry Laboratory, Reference Library, courtroom, and lecture hall.

Department of Chemistry, UGM is equipped with international standard research instrumentations such as TEM, XRD, AAS, GC-MS, HPLC, ^{1}H-NMR, FTIR, FT-IR ATR,

Surface Area Analyzer, UV-Vis Spectrophotometer, Electrophoresis, Potentiometer, Bomb Calorimeter, TLC Scanner, Organic Elemental Analyzer, and others. In addition, the department has a reference library that collects various libraries in textbooks, scientific works, and journals, including in the form of CD-ROM and other media.
The global internet network in the Department of Chemistry is connected with fiber optic cable technology (FO/Fiber Optics cable) which is equipped with 13 high-density access points spread over several points in the Department of Chemistry. Almost all places that become student activity centers are equipped with wireless internet (WiFi) facilities.

1.7 Quality assurance

To maintain and improve the academic quality, the Bachelor's, Master's, and Doctoral programs are routinely accredited by the National Accreditation Board for Higher Education (*BAN-PT*) every 5 years. All study programs at the Department of Chemistry, FMIPA UGM, received an "Excellent" accreditation certificate from *BAN-PT*. In addition, the Internal Quality Audit (*AMI*) for Bachelor, Master, and Doctoral Chemistry Study Programs is carried out by the Quality Assurance Office of Universitas Gadjah Mada (*KJM-UGM*). The *AMI* findings are then discussed in the Management Review Meeting (*RTM*), which is then followed up, and corrective action requests are monitored in the following year of *AMI*. The undergraduate program has also been internationally accredited by the Royal Society of Chemistry (RSC) London, England, since 2013.

1.8 Educational Staffs

In order to carry out the Visions of the University, the Department of Chemistry, UGM has started to step up to become a higher education institution that is not only superior nationally but also internationally in the fields of education and research activities. This step is taken based on the assumption that the existing institutional capacity or capital is deemed adequate, such as the number of staff holding Professor titles at 37%, the highest number of international publications in the Faculty, and high research funding.
The teaching staffs of the Master of Chemistry study program are as follows:
Management of Master of Chemistry Study Program
Head: Tri Joko Raharjo, S.Si., M.Si., Ph.D.
Secretary: Dr.rer.nat. Adhitasari Suratman, M.Sc

Inorganic and Material Chemistry Research Group:
Prof. Dr. Nuryono, MS. (Head of Group)
Prof. Dr. Bambang Rusdiarso, DEA.
Prof. Dr. Sri Juari Santosa, M.Eng
Prof. Dr. Eko Sri Kunarti, M.Si
Prof. Dr. Indriana Kartini, M.Si.
Dr. Suyanta, M.Si.
Dr. Sutarno, M.Si
Dr. Fajar Inggit Pambudi, M.Si
Adhi Dwi Hatmanto, S.Si., M.Sc., Ph.D.

Physical Chemistry and Nanocatalysis Research Group:
Prof. Dr. Karna Wijaya, M.Eng. (Head of Group)
Prof. Dr. Wega Trisunaryanti, MS.
Prof. Dr. Triyono, SU.

Prof. Dr. Iip Izul Falah
Dr. Sri Sudiono, M.Si
Akhmad Syoufian, Ph.D.
Dr.rer.nat. Niko Prasetyo, M.Sc
Dr. Aulia Sukma Hutama, S.Si., M.Si.

Organic Synthesis and Biomolecular Chemistry Research Group:
Dr. Endang Astuti, M.Si (Head of Group)
Prof. Dr. Jumina
Prof. Dr. Harno Dwi Pranowo, M.Si.
Prof. Dr. Chairil Anwar
Dr. Bambang Purwono, M.Sc.
Dr. Tutik Dwi Wahyuningsih, M.Si
Dr. Winarto Haryadi, M.Si.
Tri Joko Raharjo, S.Si., M.Si., Ph.D.
Dr. Respati Tri Swasono, M. Phil.
Dr. Deni Pranowo, M.Si
Dr.Sc. Robby Noor Cahyono, S.Si., M.Sc.
Dr. Muhammad Idham Darussalam Mardjan S.Si., M.Sc.

Analytical and Enviromental Chemistry Research Group:
Dr. Agus Kuncaka, DEA. (Head of Group)
Prof. Dr. Endang Tri Wahyuni, MS.
Prof. Dr. Mudasir, M.Eng.
Dr. Dwi Siswanta, M.Eng
Dr. Roto, M.Eng.
Dr.rer.nat. Nurul Hidayat A, M.Si
Dr.rer.nat. Adhitasari Suratman, M.Sc
Suherman, S.Si, M.Sc, PhD.
Taufik Abdillah Natsir, S.Si, M.Sc, PhD.

2. Master of Chemistry Program

2.1 Introduction

The Department of Chemistry was established on September 1, 1960, and had been confirmed by the Decree of the Director-General of Higher Education No. 22/DIKTI/Kep/1995 and further confirmed by the Decree of the Director-General of Higher Education No. 221/DIKTI/Kep/1996 dated July 11, 1996. Based on the growing demand for master's degrees in Indonesia, the Postgraduate Chemistry Study Program was opened in 1981 under the Faculty of Mathematics and Natural Science, Universitas Gadjah Mada. This program was acknowledged by the Decree of the Director-General of Higher Education, Ministry of Education and Culture of the Republic of Indonesia No. 580/DIKTI/Kep/1993, dated September 29, 1993. Based on the UGM Chancellor's Decree concerning the Monodisciplinary Postgraduate Program Number 89/P/SK/HT/2006, the Postgraduate Chemistry Study Program is moved under the Faculty of Mathematics and Science Nature (MIPA) in the 2007/2008 academic year. In 2011, a committee (Chairman and Secretary of the study program) was elected, responsible for the academic progress of the master's and doctoral chemistry study program. The master's and doctoral programs in the Department of Chemistry have been accredited A by BAN (National Accreditation

Board). Starting in 2016, the management of the master's and doctoral programs in Chemistry was separated.

The master of chemistry program was initially focused on general chemistry subjects. However, due to the development of internal capabilities such as human resources, facilities, and infrastructure, and the increasing number of prospective students who are interested in attending a more specific subject of chemistry and the demand for the job market, the focus of study has been expanded into five study interests. These are Inorganic Chemistry, Physical Chemistry, Organic Chemistry, Analytical Chemistry, and Environmental Chemistry. In 2022, the master of chemistry program has a new curriculum with four research focuses on Inorganic and Material Chemistry, Analytical and Environmental Chemistry, Physical Chemistry and Nanocatalysis, and Organic Synthesis and Biomolecular Chemistry. From 2007/2008 to 2013/2014, students from the master of chemistry program had an opportunity to conduct a double-degree program with the Technische Universitat Braunschweig (TUBS) Germany in environmental and sustainable chemistry.

2.2 Visions

The vision of the Master of Chemistry program is to establish a higher education system for a master's degree in chemistry that is nationally superior and internationally recognized in the aspects of education, research, and community service as well as to produce graduates who are superior and have competitiveness both nationally and internationally.

2.3 Missions

The mission of the Master of Chemistry program in the Department of Chemistry is to:

1. Carry out master's degree program in chemistry at the forefront with international standard graduates for Indonesian and international citizens.
2. Conduct basic and applied research in integrated and international standard criteria that support the development of science and technology for the welfare of the nation and mankind, both from the material and spiritual aspects.

2.4 Education Purposes

a. Provide the graduates of Master of Chemistry who have the following characters:
    a) have faith and fear of God Almighty, have the spirit of Pancasila, and have high integrity and personality,
    b) being open and responsive to changes and advances in science and problems faced by society, especially those related to the chemical field.
    c) excel nationally and be recognized internationally
    d) able to develop in an academic career, industry, and government
    e) able to continue to a higher level of education.
b. Produce research in the field of chemistry, which is beneficial for the welfare and civilization of mankind.

2.5 Target of Curriculum

The target of learning outcomes for the Master of Chemistry Program is providing opportunities for students to have competence in terms of knowledge, understanding, and skills in chemistry at the master's degree level as well as other required qualities and attributes.

2.6 Basic Curriculum Preparation

2.6.1 Legal Basis for Curriculum Preparation:

a. Law of the Republic of Indonesia Number 20 of 2003 concerning the National Education System
b. Government Regulation of the Republic of Indonesia Number 60 of 1999 concerning Higher Education
c. Decree of the Minister of National Education of the Republic of Indonesia Number 232/U/2000 concerning Guidelines for the Preparation of Higher Education Curriculum and Assessment of Student Learning Outcomes
d. Decree of the Minister of National Education of the Republic of Indonesia Number 045/U/2002 concerning the Core Curriculum of Higher Education
e. Regulation of the Minister of Research, Technology and Higher Education of the Republic of Indonesia Number 03 of 2020 concerning National Higher Education Standards
f. Regulation of the Chancellor of Gadjah Mada University Number 14 of 2020 concerning the Basic Curriculum Framework

2.6.2 Reasons for Changes to the 2022 Curriculum

a. Evaluation of the 2017 curriculum implementation
b. Insight from stakeholders (students, alumni, users) is continuously collected through the internet (online).

2.6.3 Targets of curriculum change

a. Obstacles found in the implementation of the 2017 curriculum can be overcome so that the objectives of the curriculum can be achieved optimally
b. Graduates will have competencies that are equivalent to the standards of developed countries, so they can be more competitive in the world of work and in continuing their studies to a higher level
c. The Master of Chemistry program in the Department of Chemistry can obtain international recognition through an accreditation scheme

2.7 Profession/Job for graduates

Professions or jobs that are suitable for graduates of the Master of Chemistry program are as follows:

1. Lecturer at Universities
2. Researchers at research institutes and industry
3. Manager of research and development (R&D) in industry
4. Manager of Industrial Quality Assurance (QA)
5. Manager of Consultants for environmental management and waste treatment
6. Science-based business

From the results of surveys, the majority of graduates of the Master of Chemistry Program pursue the profession as lecturers at universities. This becomes a special concern in the preparation of the 2022 curriculum.

2.8 Graduate Profile

1. Academics (lecturers) who have deep scientific understanding, are capable of teaching well and conducting an independent research project and are able to present research results and be ready to continue their studies to the doctoral level.
2. Researchers who have deep scientific knowledge are capable of conducting an independent research activity and are able to present research results as well as ready to continue their studies to the doctoral level.
3. Managers of research and development (RnD) in the industry who has in-depth basic and applied knowledge in chemistry, experts in functional materials engineering, organic synthesis, and data processing
4. Managers of quality assurance in the industry who has in-depth basic and applied knowledge of chemistry, an expert in analytical chemistry, chemometrics, and data processing
5. Consultants in industrial waste management who has in-depth knowledge of applied chemistry and insight into green chemistry processes
6. Entrepreneurs who have basic knowledge in the field of chemistry as well as problem-solving, communication, and managerial skills.

2.9 Learning Outcomes

To obtain the expected graduate profile, the learning outcomes (Program Learning Outcome, PLO) of the Master of Chemistry program consist of four elements which are (1) Attitudes and Values, (2) Knowledge Mastery, (3) Work Ability, and (4) Managerial Ability. The learning outcomes of the master's program have been equated with level 8 in the KKNI.

2.8.1 [PLO-1] Attitude and Value

Students have the following attitudes and values:

a. Fear of God Almighty and able to show a religious attitude.
b. Appreciate the diversity of cultures, views, religions, and beliefs, as well as the opinions or original findings of others.
c. Work together and have social sensitivity and concern for society and the environment.
d. Obey the law and discipline in social and state life.
e. Internalize academic values, norms, and ethics.
f. Demonstrate a responsible attitude towards work in their area of expertise independently.
g. Internalize the spirit of independence, struggle, and entrepreneurship
h. Have a sense of responsibility for environmental sustainability-based behavior.
i. Have empathy and concern for the next generation in terms of the development of sustainable chemistry
j. Good personality, develop professional attitude, and uphold norms and ethics in acting and working.

2.8.2 Knowledge

[PLO-2] Basic Knowledge: The student has in-depth and comprehensive basic knowledge in terms of the structure and properties of matter, the energy that accompanies its changes based on thermodynamics and kinetics, as well as the principles of synthesis, analysis, isolation, and purification of chemical compounds.

[PLO-3] Skill knowledge, possessing abilities in accordance with one of the following areas of expertise:

a. Expertise in Inorganic Chemistry and Materials: able to develop and apply knowledge of chemistry, concepts in synthesis, and molecular-scale engineering for inorganic and material compounds through research as well as to produce innovative and tested works and gain national and international recognition,

b. Expertise in Physical Chemistry and Nanocatalysis: able to apply and manage research based on the concepts of physical chemistry in all areas of chemistry, especially: nanocatalysis, engineering of advanced materials, and discovery of new and renewable energy sources

c. Expertise in Organic Synthesis and Biomolecular Chemistry: able to understand knowledge in the field of organic chemistry, especially the structure and reactions of organic compounds through research. Students are capable of producing innovative and tested works, performing spectral interpretation for the structure elucidation of organic compounds, and producing works that are recognized nationally and internationally. In addition, graduates apply organic chemistry concepts in the use of natural products in agrochemicals, medicine, food, and energy

d. Expertise in the field of Analytical and Environmental Chemistry: students are able to master and develop chemical and physical theories that underlie the measurement of analytical chemistry in general and instrumentally through research and are capable of producing innovative and tested works and gaining national and international recognition through scientific publications. They are able to solve problems in the field of analytical and environmental chemistry as well as develop analytical methods through an inter or multidisciplinary approach.

[PLO-4] Educational Knowledge: students have educational insight as a teacher.

2.8.3 Work Ability

[PLO-5] Problem solving: students have a strong scientific insight so that they are able to solve scientific problems through an inter or multidisciplinary approach that is beneficial to society and science.

[PLO-6] Research ability, students have a strong scientific knowledge so that they are able to:

a. Formulate, conduct and develop research themes and community services based on chemistry.

b. Have an in-depth knowledge and understanding concept of sustainability in chemistry.

c. Have the knowledge and ability to utilize the potential of local resources in the development of research themes, products, and chemical technology.

d. Have a sufficient understanding of the principles of modern chemical instrumentation.

[PLO-7] Publication Ability: The student has the ability to develop knowledge through publications of both written and oral presentations in accredited international and national journals and or produce intellectual works protected by law (HAKI).

2.8.4 Managerial Ability

[PLO-8] Professional Attitude: Students have good interpersonal skills, the ability to work together in a team, and have a sense of responsibility in their own work. In addition, they can be assigned tasks to support the achievement of team works.

[PLO-9] Communication Skills: students are able to communicate in written or orally with stakeholders from various backgrounds in both Indonesian and English.

[PLO-10] Lifelong Learner: students have the will, awareness, and ability to keep up with the latest developments in chemistry research.

2.9 Correlation between Learning Outcomes and Bloom Taxonomy

Bloom's taxonomy of cognitive domains is one of the basic frameworks for categorizing educational goals and curriculum development. Bloom taxonomy includes (1) knowledge; (2) understanding (comprehension); (3) application; (4) analysis; (5) synthesis; and (6) evaluation. Bloom's taxonomy has been revised by Krathwohl and Anderson to (1) remember; (2) understand; (3) apply; (4) analyze; (5) evaluate; and (6) create. At the master's degree level, the expected level of graduates achievement is application-analysis-synthesis. Graduates must be able to synthesize various knowledge and experiences during their studies and solve problems both within the scope of academic research and in everyday social life. Thus, graduates will show an attitude of scientific maturity that is in accordance with their level of education.

Knowledge is the ability to know or remember terms, facts, rules, sequences, methods, etc. Comprehension is the ability to translate, interpret, estimate, understand the main content, interpret tables, and so on. Application is the ability to solve problems, make charts, use concepts, rules, principles, methods, and so on. Analysis is the ability to identify and distinguish in detail of the parts, the relationship in between, and so on. Synthesis is the ability to compose, such as essays, plans, and work programs. Evaluation is the ability to judge based on norms, such as assessing written works.

Learning Outcomes		**cognitive (*Knowledge*)**	**Affective (*Attitude*)**	**Psychomotor (*Skills*)**
PLO-1	Attitude and Value		v	
PLO-2	Basic Knoweldge	V		
PLO-3	Skill Knoweldge	V		

PLO-4	Educational Knowledge	V		
PLO-5	Problem Solving			V
PLO-6	Research Ability			V
PLO-7	Publication Ability			V
PLO-8	Professional Attitude			V
PLO-9	Communication Skill			V
PLO-10	Lifelong Learner			V

2.10 Study Materials

To support the maximum achievement of the learning outcomes (PLO), the Master of Chemistry program prepares various courses which are grouped into 22 block topics and consist of 73 sub-topics. The following is a block matrix of study materials.

Block of topics		**Topics**		**Courses**
BK-1	Structure and reactivity	BK-1.1	Structure of inorganic compounds	Structure of Inorganic and Material Compound
		BK-1.2	Molecule reactivity	Synthesis and mechanism of organic reaction
		BK-1.3	Chemical bonds and group theory	Structure of Inorganic and Material Compound
		BK-1.4	Structure and reactivity of drugs	Medicinal chemistry and drug design
		BK-1.5	Structure of organic compounds	Analysis of Materials and Structures of Organic Compounds
		BK-1.6	Structure and reactivity of heterocyclic compounds	Heterocyclic chemistry and agrochemistry
BK-2	Thermodynamics	BK-2.1	Energetic of inorganic compound	Structure of Inorganic and Material Compound
		BK-2.2	Energy transfer	Nanocatalysis
		BK-2.3	Thermodynamics in organic reaction	Synthesis and mechanism of organic reaction
		BK-2.4	Structure and surface dynamics	Homogenous and heterogenous catalysts
		BK-2.5	Thermodynamics in adsorption and desorption	
BK-3	Kinetic and reaction mechanism	BK-3.1	Kinetics of inorganic reaction	Structure of Inorganic and Material Compound
		BK-3.2	Kinetic in flow reaction	Application of catalysts in industry
		BK-3.3	Reactivity of coordination complex	Coordination complexes and metal-organic framework
		BK-3.4	Mechanism in organometallic reaction	
		BK-3.5	Kinetic of catalytic reaction on surfaces	Nanocatalysis, Homogenous and heterogenous catalysts
		BK-3.6	Activity and selectivity of catalyst	

Block of topics		Topics		Courses
		BK-3.7	Kinetic and mechanism of organic reaction	Synthesis and mechanism of organic reaction
BK-4	Quantum chemistry	BK-4.1	Interaction of atoms	Computational simulation method for nanoscience
		BK-4.2	Schrodinger equation	Material design with computer
		BK-4.3	Hartee-Fock and DFT	
		BK-4.4	Molecular design	
		BK-4.5	Design of drug compound	Medicinal chemistry and drug design
		BK-4.6	Correlation of structure and activity	
BK-5	Chemical equilibrium	BK-5.1	Equilibrium in binary system	Homogenous and heterogenous catalysts
BK-6	Electrochemistry	BK-6.1	Thermodynamics in electrochemistry and electrode reaction	Electro and biocatalysis
		BK-6.2	Advanced in electrochemistry analysis instrument	Trends in chemistry of electroanalysis
BK-7	Synthesis of chemical compounds	BK-7.1	Synthesis of organic compounds	Synthesis and mechanism of organic reaction
		BK-7.2	Synthesis of chemoselective and stereoselective	
BK-8	Spectrophotometry	BK-8.1	Spectroscopy atom and molecule of inorganic compound	Structure of Inorganic and Material Compound, Coordination complex and metal-organic framework
		BK-8.2	Vibrational analysis of inorganic compounds	
		BK-8.3	Application of spectroscopy in organic compounds	Analysis of Materials and Structures of Organic Compounds
		BK-8.4	Application of spectrometry in clinical analysis	Clinical and forensic analysis
		BK-8.5	Application of spectrometry in forensic analysis	
		BK-8.6	Application of spectrometry in environmental analysis	Analysis of environmental pollutants

Block of topics		Topics		Courses
		BK-8.7	Spectroscopy of coordination complexes	Structure of Inorganic and Material Compound, Coordination complex and metal-organic framework
		BK-8.8	Inorganic material characterization	Structure of Inorganic and Material Compound
		BK-8.9	Solid-state characterization	Nanocatalysis
		BK-8.10	Synthesis and characterization of catalysts	Nanocatalysis
		BK-8.11	Instrumentations and application of spectrometry methods	Trends in analytical chemistry
BK-9	Separation chemistry	BK-9.1	Advance in separation chemistry technique	Trends in analytical chemistry
BK-10	Sustainability concept	BK-10.1	Sustainability in chemical research	Contemporary organic chemistry
		BK-10.2	Toxicokinetic mechanism	Analysis method in toxicology
BK-11	Materials Chemistry	BK-11.1	Design and synthesis of inorganic materials	Structure of Inorganic and Material Compound
		BK-11.2	Synthesis and application of nanomaterials	Chemistry of carbon material, Chemistry of metal oxide material
		BK-11.3	Chemical and mechanical properties of materials	Homogenous and heterogeneous catalysts
		BK-11.4	Energetic and kinetic of materials	
BK-12	Bioinorganic chemistry	BK-12.1	Metal-Ligand in metalloenzyme	Coordination complexes and metal-organic framework, Biomaterial chemistry
		BK-12.2	Biogeochemistry cycle of earth	Coordination complexes and metal-organic framework, Biomaterial chemistry
BK-13	Solid-state chemistry	BK-13.1	Structure and properties of solid-state materials	Nanocatalysis
BK-14	Natural Product chemistry	BK-14.1	Natural resources from the sea	Natural Products and Marine Chemistry
		BK-14.2	Biosynthesis of natural resources	

Block of topics		Topics		Courses
BK-15	Biotechnology	BK-15.1	Molecular genetics and genetics design	Biotechnology of food and energy
		BK-15.2	Mechanism of enzyme	
		BK-15.3	Biofuel	
BK-16	Sampling technique	BK-16.1	Environmental sampling technique	Sampling strategy and data analysis
		BK-16.2	Clinical sampling technique	Clinical and forensic analysis
		BK-16.3	Forensic sampling technique	
BK-17	Chemometry	BK-17.1	Data analysis	Sampling strategy and data analysis
BK-18	Environmental management	BK-18.1	Environmental Impact Analysis (EIA) process	Environmental management system
BK-19	Communication	BK-19.1	Academic writing	Academic English
		BK-19.2	Presentation Technique	Thesis Seminar
		BK-19.3	Idea communication	
BK-20	Education	BK-20.1	Cognition development	Psychology of cognitive development
		BK-20.2	Comparative psychology	
BK-21	Research methodology	BK-21.1	Literature study	Research Methodology
		BK-21.2	Proposal preparation	
		BK-21.3	Communication of research results	
		BK-21.4	Advanced laboratory techniques for research	Laboratory Technique
		BK-21.5	Data analysis technique and presentation of research data	
BK-22	Research	BK-22.1	Research laboratory technique	Thesis research

Block of topics		Topics		Courses
		BK-22.2	Analysis of research problems	
		BK-22.3	Research report writing	

2.11 Courses-Topics-Learning Outcomes (PLO)-Graduate's profile

2.11.1 Graduate Profile and Learning Outcomes Maps

Learning Outcomes		Lecturer	Researcher	Manager in R&D	Manager in QA	Consultant in environmental management	Entrepreneurs
PLO-1	Attitude and Value	√	√	√	√	√	√
PLO-2	Basic Knowledge	√	√	√	√	√	√
PLO-3	Skill Knowledge	√	√	√	√	√	√
PLO-4	Educational Knowledge	√					
PLO-5	Problem Solving	√	√	√	√	√	√
PLO-6	Research Ability	√	√	√	√		√
PLO-7	Publication Ability	√	√	√			
PLO-8	Professional Attitude	√	√	√	√	√	√
PLO-9	Communication Skill	√	√	√	√	√	√
PLO-10	Lifelong Learner	√	√	√	√	√	√

2.11.2 Topics-Courses-Learning Outcomes (PLO) Maps

Topics		Courses		PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10
BK-1	Structure and reactivity	MKK 5213	Structure of Inorganic and Material Compound		√	√							
		MKK 5403	Synthesis and mechanism of organic reaction		√	√							
		MKK 5407	Medicinal chemistry and drug design			√							
		MKK 5402	Analysis of Materials and Structures of Organic Compounds			√							
		MKK 5406	Heterocyclic chemistry and agrochemistry			√							
BK-2	Thermodynamics	MKK 5213	Structure of Inorganic and Material Compound		√	√							
		MKK 5313	Nanocatalysis			√							
		MKK 5403	Synthesis and mechanism of organic reaction		√	√							
		MKK 5319	Homogeneous and heterogeneous catalysts			√							
BK-3	Kinetic and reaction mechanism	MKK 5314	Application of catalysts in industry			√							
		MKK 5215	Coordination complex and metal-organic framework		√	√							
		MKK 5313	Nanocatalysis			√							

Topics		Courses		PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10
		MKK 5319	Homogeneous and heterogeneous catalysts			√							
		MKK 5403	Synthesis and mechanism of organic reaction		√	√							
BK-4	Quantum chemistry	MKK 5315	Computation method for nanoscience		√	√							
		MKK 5317	Material design with computer			√							
		MKK 5407	Medicinal chemistry and drug design			√							
BK-5	Chemical equilibrium	MKK 5319	Homogeneous and heterogeneous catalysts		√								
BK-6	Electrochemistry	MKK 5312	Electro and biocatalysis			√							
		MKK 5515	Trends in the chemistry of electroanalysis			√							
BK-7	Synthesis of chemical compounds	MKK 5403	Synthesis and mechanism of organic reaction		√	√							
BK-8	Spectrophotometry	MKK 5213	Structure of Inorganic and Material Compound		√	√							
		MKK 5402	Analysis of Materials and Structures of Organic Compounds			√							
		MKK 5505	Clinical and forensic analysis			√							
		MKK 5512	Analysis of environmental pollutants			√							
		MKK 5215	Coordination complex and metal-organic framework			√							

Topics		Courses		PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10
		MKK 5313	Nanocatalysis			∨							
		MKK 5513	Trends in analytical chemistry			∨							
BK-9	Separation chemistry	MKK 5513	Trends in analytical chemistry			∨							
BK-10	Sustainability concept	MKK 5413	Contemporary organic chemistry			∨							
		MKK 5513	Trends in analytical chemistry			∨							
		MKK 5514	Analysis method in toxicology			∨							
BK-11	Materials Chemistry	MKK 5213	Structure of Inorganic and Material Compound		∨	∨							
		MKK 5217	Chemistry of carbon material			∨							
		MKK 5219	Chemistry of metal oxide material			∨							
		MKK 5319	Homogeneous and heterogeneous catalysts			∨							
BK-12	Bioinorganic chemistry	MKK 5215	Coordination complex and metal-organic framework			∨							
BK-13	Solid-state chemistry	MKK 5313	Nanocatalysis			∨							
BK-14	Natural product chemistry	MKK 5404	Natural Product and Marine Chemistry			∨							
BK-15	Biotechnology	MKK 5405	Biotechnology of food and energy			∨							

Topics		Courses		PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10
BK-16	Sampling technique	MKK 5517	Sampling strategy and data analysis			∨							
		MKK 5505	Clinical and forensic analysis			∨							
BK-17	Chemometry	MKK 5517	Sampling strategy and data analysis			∨							
BK-18	Environmental management	MKK 5706	Environmental management system			∨							
BK-19	Communication	MKK 5101	Academic English									∨	∨
		MKK 6901	Thesis Seminar	∨				∨	∨	∨	∨	∨	∨
		MKK 6903	Thesis	∨				∨	∨	∨	∨	∨	∨
BK-20	Education	PSU 6401	Psychology of cognitive development				∨						
BK-21	Research methodology	MKK 5102	Research Methodology	∨				∨	∨	∨	∨		∨
		MKK 5103	Laboratory Technique	∨				∨	∨	∨	∨		∨
BK-22	Research	MKK 6902	Thesis research	∨				∨	∨	∨	∨		∨
		MKK 5104	Pre-thesis research										

2.12 Path of Educational Program

For the achievement of the graduate program learning outcomes (PLO), the Master of Chemistry Study Program provides 2 pathways, namely the regular pathway through lectures (by course) and the research pathway (by research). The main difference between these two pathways is in the method of achieving learning outcomes in the field of expertise (PLO-3). In the regular pathway, PLO-3 is achieved through elective courses of expertise that match their interests, while in the by research pathway, PLO-3 is achieved through a more intensive and extensive research process. Through this pattern, the by-research program must produce at least 2 publications, while the regular program requires only 1 publication.

2.13 List of Compulsory and Elective Courses of the Regular Program

In order to achieve the visions, missions, and competencies of graduates, the academic activities in the Master of Chemistry Study Program, Department of Chemistry, UGM, are focused on increasing mastery of chemistry, both theoretical and experimental, based on 4 study interests. The Master Study Program can be completed by a student within 3 to 4 semesters, with a minimum cumulative achievement index (GPA) of 2.75, with the assumption that research in the framework of a thesis is carried out in 1 to 2 semesters. The minimum number of credits that must be completed is 40 credits, including 24 credits of compulsory courses, 12 credits of compulsory courses of the study interest, and a minimum of 4 credits of elective courses of study program or courses of other study interests. The complete list of courses is presented in the following table:

2.13.1 List of Compulsory Courses of Master Study Program

No	Code	Courses	Credit	Semester
1	MKK 5213	Structure of Inorganic and Material Compound	3	I
2	MKK 5313	Nanocatalysis	3	I
3	MKK 5513	Trends in Analytical Chemistry	3	I
4	MKK 5413	Contemporary Organic Chemistry	3	I
5	MKK 5103	Laboratory Technique	2	I
6	MKK 5104	Pre-Thesis Research	2	II
7	MKK 7900	Thesis consists of:	8	
8		Thesis Seminar	1	III/IV
9		Thesis Research	4	III/IV
10		Thesis Defend	3	III/IV
Total			24	

2.13.2 List of Elective Courses of Master Study Program

No	Code	Courses	Credit	Semester
1	MKK 5102	Research Methodology	2	II

2	MKK 5101	Academic English	1	II
3	PSU 6401	Psychology of cognitive development	2	II
Total			3	I

2.13.2 List of Study Interest Courses

- **Study Interest in Inorganic and Material Chemistry**

No	Code	Courses	Credit	Semester
1	MKK 5215	Coordination Complex and Metal-Organic Framework	2	I
2	MKK 5217	Chemistry of Carbon Materials	2	I
3	MKK 5219	Chemistry of Metal Oxide Material s	2	I
4	MKK 5212	Chemistry of Natural Polymers	2	II
5	MKK 5214	Chemistry of Magnetic Materials	2	II
6	MKK 5216	Biomaterial chemistry	2	II
Total			12	

- **Study Interest of Physical Chemistry and Nanocatalysis**

No	Code	Courses	Credit	Semester
1	MKK 5315	Computational Simulation Method for Nanoscience	2	I
2	MKK 5317	Computer-Aided-Material Design	2	I
3	MKK 5319	Homogeneous and Heterogeneous Catalysts	2	I
4	MKK 5312	Electro and Biocatalysis	2	II
5	MKK 5314	Application of Catalysts in industry	2	II
6	MKK 5316	Integration of Theory and Experiment in Nanocatalysis	2	II
Total			12	

- **Study Interest in Organic Synthesis and Biomolecular Chemistry**

No	Code	Courses	Credit	Semester
1	MKK 5403	Synthesis and Mechanism of Organic Reactions	2	I
2	MKK 5405	Biotechnology of Food and Energy	2	I
3	MKK 5407	Medicinal Chemistry and Drug Design	2	I
4	MKK 5402	Analysis of Materials and Structures of Organic Compounds	2	II
5	MKK 5404	Natural Products and Marine Chemistry	2	II
6	MKK 5406	Heterocyclic Chemistry and Agrochemistry	2	II
Total			12	

- **Study Interest in Analytical and Environmental Chemistry**

No	Code	Courses	Credit	Semester
1	MKK 5515	Trends in Chemistry of Electroanalysis	2	I

2	MKK 5505	Clinical and Forensic Analysis	2	I
3	MKK 5517	Sampling Strategy and Data Analysis	2	I
4	MKK 5512	Analysis of Environmental Pollutant	2	II
5	MKK 5514	Analysis Method in Toxicology	2	II
6	MKK 5706	Environmental Management System	2	II
Total			12	

Distribution of courses in each semester can be seen in the following table.

Courses	Semester			
	I	II	III	IV
Compulsory study program (22 Credits)	1. Structure of Inorganic and Material Compound (3) 2. Nanocatalysis (3) 3. Contemporary Organic Chemistry (3) 4. Trends in Analytical Chemistry (3) 5. Laboratory Technique (2)	1. Pre-Thesis Research (2)	1. Thesis Seminar (1) 2. Thesis Research (4) 3. Thesis (3)	
Study Interest (20-24 Credits)	Study Interest (6)	Study Interest and Elective Study Program (10-20)		
40-50 Credits	20 Credits	12-22 Credits	8 Credits	

2.14 List of Compulsory and Elective Courses of the By-Research Program

In the by-research program, the learning outcomes are achieved through a more intensive and extensive research process. Research-related learning activities include Pre-Thesis Research, Preparation of Research Proposal, Research I and II, Thesis Seminars I and II, Publications I and II, and Thesis Preparation and Thesis Examination. The details are shown in the following table.

2.14.1 List of Compulsory Courses of the By-Research Program

No	Code	Course	SKS	Semester
1	MKK 5211	Structure of Inorganic and Material Compound	3	I
2	MKK 5313	Nanocatalysis	3	I
3	MKK 5511	Trend in Analytical Chemistry	3	I

4	MKK 5411	Contemporary Organic Chemistry	3	I
5	MKK 5103	Laboratory Technique	2	I
6	MKK 5104	Pre-Thesis Research	2	I
7	MKK 5105	Research Proposal	4	I
8	MKK 5901	Thesis Seminar I	1	II
9	MKK 5902	Thesis Research I	4	II
10	MKK 6904	Thesis Seminar II	1	III
11	MKK 6905	Publication I	6	III
12	MKK 6906	Thesis Research II	4	IV
13	MKK 6907	Thesis	3	IV
14	MKK 6908	Publication II	6	IV
Total			45	

2.13 Transition Rules

a. The new curriculum will be implemented in the first semester of the academic year of 2022/2023 and must be fully followed by students from the class of 2022 and partly by students from the previous year.
b. For all courses that have been completed in the old curriculum, the credits of these courses are still recognized with credits attached to the course.
c. Compulsory courses in the old curriculum can become elective courses if the equivalence courses in the 2022 curriculum change to non-compulsory ones.
d. The repetition of a course in the old curriculum is carried out by taking its equivalence course in the 2022 curriculum, then the recognized courses are determined by the student themselves, with the value and number of credits attached to them.
e. Matters that have not been covered by this transitional regulation are accommodated and handled by the Master Degree of Chemistry Study Program.
f. The provisions in this transitional regulation only apply to students of the class of 2021/2022 and earlier.

2.14 General Rules

2.14.1. Admission Requirements

The general requirements for admission to the Master of Chemistry study program at UGM, refer to the admission requirements for the master's program at Universitas Gadjah Mada and Faculty of Mathematics and Natural Sciences, UGM. Admission to the Master of Chemistry study program is carried out in odd and even semesters. The Master of Chemistry study program conducts a substantive selection through a written test and an assessment of the research plan (for the Master by research program). Prospective students are graduates of Bachelor of Chemistry or graduates of undergraduate and applied degrees outside the field of chemistry but still relevant to the field of chemistry (such as Chemistry Education, Pharmacy, Chemical Engineering, Agriculture, Agricultural Technology, Health Laboratory Technology, Environmental Health) with a minimum GPA of 2.75 and have held a bachelor degree for not more than 8 years. The Master of Chemistry study program provides mentoring in the field of chemistry aimed at students

who are accepted from non-graduate study programs in chemistry with technical provisions regulated based on the conditions of each student.

2.14.2 Evaluation of Study Results

Evaluation of study results is expressed quantitatively through Study Results Cards in the form of an Achievement Index (GPA) value with a scale of 4. At the end of the first year of study, an evaluation is carried out to determine whether the student concerned is allowed to continue the studies or must stop studying (drop out). The conditions that must be met to be able to continue the study are:

- collect at least 16 credits
- The cumulative GPA obtained for the 16 credits is at least 2.75.

A student can be declared to have passed the Master of Chemistry Study Program if he has met the requirements that were evaluated at the time of graduation. At the graduation ceremony, for determining the final grade list, students are allowed to drop/cancel the elective courses a maximum of 10% of the total credits obtained. Graduation requirements include:

1. Have a minimum of 40 credits, including all required compulsory courses and the completion of a thesis
2. have a cumulative GPA of at least 3.0
3. There is no C grade in the compulsory course grades.

2.14.3. Credit Load Per Semester

1. Semester 1: 20 credits,
2. Next semester according to GPA with the following criteria:
    a. GPA semester ≥ 3.50: maximum 20 credits
    b. GPA semester 3.00 – 3.49: maximum 16 credits
    c. GPA semester less than 3.00: maximum 12 credits

2.14.4 Credit for Thesis

The total number of thesis credits is 8 credits and is divided into thesis seminars (1 credit), thesis research (4 credits), and thesis (3 credits).

2.14.5 Minimum total credits for graduation

The minimum number of credits for graduation is 40 credits. Students can take courses up to 50 credits. Cancellation of credits is a maximum of 10% of the total credits taken.

2.14.6 Length of Study

The length of study is 2-4 semesters, with a maximum study period extension of 2 semesters.

2.14.7 Graduation GPA

Graduation GPA ≥ 3.00, with a minimum thesis score of B, and compulsory subjects > C.

2.14.8 Obligation for Publication

Students, at least, submit their publication to the scientific journals, which are recognized by study programs or presentations at National/International seminars as a requirement for thesis exams, with a note that students who can publish in indexed international journals get the highest points for the publication aspect.

2.14.9 English and Academic Potential Test (*TPA*)

The entry requirements are in accordance with the Rector Decree No. 11 of 2016, namely *TPA* of at least 450 and TOEFL: minimum of 400. The Master of Chemistry Study Program adds a minimum *TPA* requirement of 500 and a minimum TOEFL of 450 as graduation requirements.

2.14.10 Sabbatical rule

The sabbatical rule follows the Rector regulations, which is a maximum of 2 semesters and submitted every semester after taking 1 year of study.

2.14.11 Requirements for Cumlaude Predicate

The maximum study period is 2 years with a minimum GPA of 3.76.

2.15 Equivalence of Courses

	Curriculum 2017			**Curriculum 2022**		
No	**Code**	**Course**	**Credit**	**Code**	**Course**	**Credit**
1	MKK 5211	Advanced Inorganic Chemistry	2	MKK 5213	Structure of Inorganic and Material Compound	3
2	MKK 5311	Advanced Physical Chemistry	2	MKK 5313	Nanocatalysis	3
3	MKK 5511	Spectrometric Analysis	2	MKK 5513	Trend in Analytical Chemistry	3
4	MKK 5411	Advanced Physical Organic Chemistry	2	MKK 5413	Contemporary Organic Chemistry	3
5	MKK 5103	Laboratory Technique	1	MKK 5103	Laboratory Technique	2
6	MKK 5102	Research Metodology (Compulsory)	2	MKK 5102	Research Metodology (Elective)	2
7	MKK 5101	Academic English (Compulsory)	1	MKK 5101	Academic English (Elective)	1
8	MKK 5705	Toxicology Chemistry	2	MKK 5514	Analysis Method in Toxicology	2
9	MKK 5504	Electroanalysis	2	MKK 5515	Trends in Chemistry of Electroanalysis	2
10	MKK 5704	Sampling and Data Analysis	2	MKK 5517	Sampling Strategy and Data Analysis	2

2.16 Learning Methods

The learning method used in the Master Chemistry study program is highly dependent on the type of the course. Several choices of learning methods that can be used include:

1. The lecture method is a learning method by providing a verbal explanation of learning materials to a relatively large number of students (classes) to achieve certain learning objectives. The lecture method is delivered online, offline or mixed. With creative lecture

methods, lecturers can encourage the emergence of inspiration for students. This method is suitable for the delivery of learning materials in the form of information and if the learning materials are difficult to obtain or difficult to understand by students.

2. The discussion method is interactive learning, which involves two or more participants to interact, exchange opinions, and/or defending each other's opinions in problem solving so that students can obtain an agreement. Compared to the lecture method, the discussion method can improve understanding of concepts and problem-solving skills. In the transformation of knowledge, the discussion method results in slower results than the use of lectures, so the lecture method is more effective in increasing the quantity of student knowledge than the discussion method.
4. The demonstration method is an effective learning method to help students find answers to questions such as: How to organize it? How does the process work? How is the process of doing it? Demonstration as a learning method by showing the whole class a process, for example, the operation of an instrument, a synthesis method, etc.
5. Lecture Plus Learning Method is a learning method that uses more than one method, namely the lecture method combined with other methods. There are three kinds of lecture plus methods: (1). Lecture method plus questions and answers and assignments; (2) Lecture method plus discussion and assignments; (3) Lecture method plus demonstration and practice.
6. The experimental learning method is a learning management method in which students carry out experimental activities by experiencing and proving what they have learned for themselves. In this method, students are given the opportunity to experience themselves or do it themselves by following a process, observing an object, analyzing, proving, and drawing their own conclusions about the object they are studying.

2.17 Method of Assessment

The assessment method follows the rules at the Faculty level, except for the thesis, which will be regulated separately at the Study Program level. According to course requirements, the course assessment components include mid-semester examinations, end-of-semester examinations, plus written assignments, seminar assignments, and library review assignments.

The components of the final project assessment will include seminars, final project research, paper writing, and thesis exams, each of which will be arranged in more detail in the form of an assessment rubric.

2.18 Quality Assurance

The quality assurance was conducted by the Faculty of Mathematics and Natural Science Quality Office according to guidelines set by Universitas Gadja Mada Office for Quality Assurance. The activity includes regular academic quality internal audits followed by a series of corrections and corrective action that are finally reported in a management review meeting at the faculty and university level. In addition, Magister Chemistry Study Program has also conducted regular surveys and discussion meetings with the student in order to get feedback on the curriculum implementation.

2.19. Course Syllabus

2.19.1 Mandatory Courses

MKK 5213 Structure of Inorganic and Material Compound (3 credits)

Learning Outcomes:

1. Know the principles of the structure of inorganic compounds
2. Able to use symmetry and crystallography as a tool to describe the atomic arrangement of molecules, complexes, and solids
3. Have insight into the structure-property relationship of functional inorganic materials
4. Be able to describe the bonding and electronic properties of complex ions and certain inorganic compounds
5. Can explain the thermodynamic and non-stoichiometric stability of inorganic compounds as a function of pressure and temperature, and with respect to the partial pressure of gases
6. Have insight into the collection of thermodynamic data and X-ray diffraction data and be able to evaluate the quality of the data and the use of these results in inorganic chemistry
7. Can apply simulation tools for thermodynamics, gas equilibrium, crystal structure considerations, and complex electronic properties
8. Understand how the atomic and chemical arrangements of compounds can give rise to functional properties and potential applications

Syllabus:

1. The atomic structure, according to quantum mechanics, approaches Dualism of electron properties, radial and angular wave functions, orbitals, term symbols, and atomic spectra.
2. Molecular structure with molecular orbital theory through symmetry approach and group theory and molecular spectra.
3. Structure of complex compounds with molecular orbital theory and complex compound spectra.
4. The structure of inorganic materials: metals and metal alloys, ionic compounds, defects and non-stoichiometry.
5. Synthesis of materials; defects and ion transfer, metal oxides, nitrides, and fluorides, chalcogenides, intercalation compounds, and metal-rich phases; Framework structures, Hydrides, and hydrogen-storage materials, Inorganic pigments, Semiconductor chemistry
6. Structure of Inorganic Compounds: structure-properties relationship; symmetry; chemical bonds; complex electronic, magnetic, and optical properties; thermodynamics; and stability.
7. Structure of Inorganic Materials: crystal structure, bonding, and physical properties (electric, magnetic, optical, etc.) of the material. Focus is given to the relationship between properties and crystal structure.

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2. J. E. Huheey, E.A. Keiter, R.L.Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition, , HarperCollins College Publisher, 1993.
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9. Bruce, D. W. and D. O'hare. *Inorganic Materials*. Chichester: John Wiley & Sons, 1997.
10. Weller, Mark. *Inorganic Materials Chemistry*. Oxford, UK: Oxford University Press, 1994.
11. Recent articles from several inorganic materials chemistry journals: Journal of Inorganic Materials, Journal of Inorganic Materials, Inorganic Materials, and International Journal of Inorganic Materials

MKK Nanocatalysis (3 credits)
Learning Outcomes:
1. Students understand the basic concepts of nanocatalysts, homogeneous and heterogeneous catalysts, nanocatalysis, synthesis of nanocatalyst materials, and their characterization
2. Students understand the application of nanocatalysts in photocatalysis, biocatalysis, and electrocatalysis.
3. Students are able to apply the principles of nanocatalysis in research.
4. Students are able to design the right catalyst for certain chemical reactions.

Syllabus:
1. Discussing the Basic Concepts of Nanocatalysis
2. Classification of Nanocatalysts, Homogeneous and Heterogeneous Catalysts
3. Activity, Selectivity, Stability, and Deactivation
4. Adsorption Process on Solid Nanocatalyst Surface
5. Kinetics and Mechanism of Nanocatalytic Reaction
6. Nanocatalyst synthesis and modeling
7. Nanocatalyst Characterization
8. Photocatalysis, Biocatalysis, and Electrocatalysis
9. Hydrocracking Catalysis,
10. Supported Catalyst, Solid Acid Catalyst, Solid Base Catalyst

References:
1. Sherrington, D.C and Kybett., A.P., 2000, *Supported Catalysts and Their Applications*, RSC., Cambridge, ISBN: 0-85404-880-4.
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3. Anthony van Santen, R., Zinola., C.F., 2010, *Electrocatalysis: Computational, Experimental, and Industrial Aspects*, CRC Press, New York, ISBN: 978-1-4200-4544-4.
4. Zuliani, A., Ivars, F., & Luque, R. (2018). Advances in nanocatalyst design for biofuel production. *ChemCatChem*, *10*(9), 1968-1981.

MKK 5413 Contemporary Organic Chemistry (3 credits)
Learning Outcomes:
1. Understand the concept of sustainability in organic synthesis on a laboratory and industrial scale
2. Understand the technical types of sustainable organic synthesis
3. Understand the potential uses of renewable materials in organic synthesis

4. Designing sustainable organic synthesis

Syllabus:

1. The concept of sustainability in organic synthesis on a lab and industrial scale
2. Microwave-assisted organic synthesis
3. Ultrasound-assisted organic synthesis
4. Mechanochemical synthesis
5. Synthesis with ionic liquid solvents and renewable solvents
6. One-pot reaction
7. Renewable organic synthesis

References:

1. Green Solvents for Sustainable Organic Synthesis: State of the Art, DOI 10.1039/b418069ka
2. Power ultrasound in organic synthesis: moving cavitational chemistry from academia to innovative and large-scale applications, DOI 10.1039/B503848K
3. Microwave chemistry: history, development and legacy, DOI 10.1515/9783110479935-001
4. Pot economy and one-pot synthesis, DOI 10.1039/C5SC02913A

MKK 5513 Trend in analytical chemistry (3 credits)

Learning Outcomes:

1. Students have broad knowledge about the latest advances in analytical chemistry.
2. Students understand broadly and deeply the uses and applications of analytical chemistry in various fields.
3. Students have broad and in-depth knowledge regarding the importance of sample integrity, sample preparation, and separation techniques.
4. Students understand the latest techniques and instrumentation commonly used in analytical chemistry and are able to apply them for certain purposes.

Syllabus:

1. Recent reviews in the field of analytical chemistry and its applications
2. Sampling technique and sample preparation
3. Separation technique
4. Spectrometry analysis method
5. Electrochemical analysis method
6. X-ray based analysis method
7. Data processing techniques
8. Green Analytical Chemistry

References:

1. https://pubs.acs.org/toc/ancham/94/1 (review Anal. Chem. Th. 2022)
2. https://pubs.acs.org/toc/ancham/93/1 (review Anal. Chem. Th. 2021)
3. https://pubs.acs.org/toc/ancham/92/1 (review Anal. Chem. Th. 2020)

MKK 5103 Laboratory Technique (2 credits)

Learning Outcomes:

1. Understand the basics of laboratory techniques
2. Understand the advances in laboratory techniques
3. Able to analyze data and present it as a research report
4. Understand risk analysis and work safety in the laboratory

Syllabus:

1. Basic Laboratory Techniques: Basic principles, Health, and safety working with liquids, principles of chemical solutions, pH solutions, and buffers. Investigative approaches:

creating and recording measurements, SI units and their use, scientific method, and experimental design.
2. Data analysis and presentation: using graphs, presenting data in tables, instructions for solving numerical problems, descriptive statistics, selecting and using statistical tests, drawing chemical structures, chemometrics, computational chemistry.
3. Safety and disaster management: (a) Emergency response: chemical spill, radiation spill, biohazard spill, compressed gas cylinder leak, fire, emergency work accident reporting (b) General safety: safety and operational regulations, safety equipment, protective equipment safety, compressed gas safety, safety practices for the disposal of broken glass articles, centrifugal safety, treated biomedical waste and scientific ethics.

References:

1. Tanmoy Chakraborty, Lalita Ledwani (editor), 2017, Research Methodology in Chemical Sciences: Experimental and Theoretical Approach, CRC Press, ISBN 149872860X, 9781498728607
2. Fiona N.-F. How (editor), 2011, Research Methodology in Chemistry, IIUM Press, International Islamic University Malaysia, ISBN 9674182020, 9789674182021
3. J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers and A Jones, 2002, Practical Skills in Chemistry Pearson Education Ltd. [Prentice Hall].

MKK 5104 Pre-Thesis Research (2 credits)

Learning Outcomes:

1. Have the ability and skills to conduct research in the laboratory.
2. Have the ability to create and develop research ideas
3. Have the ability to analyze research problems.
4. Have the ability to write research results in a scientific report.

Syllabus:

Students conduct research that is related to the topic of their thesis. The research results are processed and written in the form of a scientific report.

References:

Mansfield, N., 2008, *Your Chemical Science Thesis: An Introductory Guide to Writing Up Your Research Project*, Royal Society of Chemistry, London.

MKK 6901 Thesis Seminar (1 credit)

Learning Outcomes:

1. Have the ability to present research results.
2. Have the ability to search the latest literature.

Syllabus:

Students attend weekly presentations. Each student is required to present literature studies, proposals, progress, and final results related to their research.

References:

1. Rivera, M.M. Jr., and Rivera, R.V., 2007, *Practical Guide to Thesis and Dissertation Writing*, Katha Pub. Inc. Quezon City.

MKK 6902 Thesis Research (4 credits)

Learning Outcomes:

1. Have the ability and skills in conducting research in chemical laboratories.
2. Have the ability to create and develop research ideas
3. Have the ability to analyze research problems.

4. Have the ability to express research results in scientific work in the form of a thesis.

Syllabus:

Students conduct laboratory research and compile the results in the form of a thesis by following the format determined by the Faculty. The thesis supervisor conducts the assessment of the entire research process and thesis preparation.

References:

Mansfield, N., 2008, *Your Chemical Science Thesis: An Introductory Guide to Writing Up Your Research Project*, Royal Society of Chemistry, London.

MKK 6903 Thesis (3 credits)

Learning Outcomes:

1. Have the ability to communicate ideas, knowledge, and research results to the public.
2. Presenting research results in a scientific forum.

Syllabus:

Students defend their thesis report in front of the board of examiners. Examiners carry out assessments on several aspects, such as the quality of presentation, thesis report, and the ability to explain research results.

References:

Burton S., and Steane, P., 2004, *Surviving Your Thesis,* Routledge, London.

2.19.2 Elective Courses

MKK 5102 Research Methodology (2 credits)

Learning Outcomes:

1. Capable of using information technology and library resources
2. Able to communicate research results in a scientific report
3. Able to prepare a research proposal
4. Understand the process of publishing scientific papers
5. Understanding ethics in science

Syllabus:

1. Information technology and libraries: Internet and World Wide Web, Internet resources for chemistry, using spreadsheets, word processors, databases, and other packages, finding and citing information

2. Communicating information: general aspects of scientific writing, essay writing, reporting on practical work and projects, writing surveys and literature reviews, arranging poster displays, and giving oral presentation exams.

3. Research problems: meaning of research problems, sources of research problems, criteria/characteristics of good research problems, errors in the selection of research problems.

4. Hypothesis: meaning, types of hypotheses, making research proposals: research proposal formats, individual research proposals, and institutional proposals.

5. Research Report: format of the research report, report writing style, references, and bibliography.

6. Ethics in science: plagiarization, authorship, and others

References:

1. Tanmoy Chakraborty, Lalita Ledwani (editor), 2017, Research Methodology in Chemical Sciences: Experimental and Theoretical Approach, CRC Press, ISBN 149872860X, 9781498728607
2. Fiona N.-F. How (editor), 2011, Research Methodology in Chemistry, IIUM Press, International Islamic University Malaysia, ISBN 9674182020, 9789674182021

MKK 5101 Academic English (1 credit)

Learning Outcomes:

1. Extensive knowledge of English, especially on grammatical as well as lexical and textual aspects of academic writing in a scientific context
2. Improve critical reading skills, think and write more clearly and sharply
3. Identify the structural features of specific academic writing genres relevant to each discipline.
4. Effectively use the work of others in writing, including the use of sources and citation methods.

Syllabus:

1. Address the grammatical, lexical, and textual aspects of academic writing and to provide students with tools to solve their own language problems.
2. Students are asked to produce a number of revised short texts after feedback from the instructor.
3. Improve students' ability to give presentations in English.

References:

1. Bailey S., 2011, Academic Writing: A Handbook for International Students (3rd edition). London: Routledge
2. Gillett A., A. Hammond & M. Martala, 2009, Inside Track to Successful Academic Writing. Harlow: Pearson Education
3. Jordan R., 1999, Academic Writing Course. London: Longman
4. Oshima A. & Hogue A., 2006, Writing Academic English. Harlow: Pearson Longman
5. Porter D., 2001, Check your Vocabulary for Academic English: A workbook for students 2nd ed. London: Peter Collin
6. Swales J. & Feak C., 2004, Academic Writing for Graduate Students. Ann Arbor: University of Michigan Press

PSU 6401 Psychology of Cognitive Development (2 credits)

Learning Outcomes:

A. Have an understanding of objects, quantities, and agents of cognitive development
B. Have an understanding of language development and how language affects the development of conceptual thinking.
C. Have insight into comparative psychology.

Syllabus:

This course explores cognition development, focusing primarily on conceptual development in several domains of knowledge: objects, quantities, and agents. The study of language development is extended not only to an understanding of how language works and is acquired but how language affects conceptual thinking. Discusses how knowledge is organized, remembered, enriched, and transformed. Combines insights from comparative psychology, adult psychology, neuroscience, and cross-cultural psychology to characterize the foundations of cognitive processes and overall developmental mechanisms.

References:

1. Eric Amsel, James P. Byrnes (editor), 2002, Language, Literacy, and Cognitive Development: The Development and Consequences of Symbolic Communication, Jean Piaget Symposia Series, Psychology Press, New Jersey
2. Usha Goswami (editor), 2006, Cognitive Development: Critical Concepts in Psychology; Critical Concepts in Psychology Series; Routledge; ISBN 0415360633, 9780415360630

2.19.3 Courses for Inorganic Chemistry and Materials

MKK 5215 Coordination Compound and Metal-Organic Frameworks (2 credits)

Learning Outcomes:

1. Students are able to relate the concept of coordination chemistry with various types of complex compounds.
2. Students understand the structure, properties, and applications of complex compounds.
3. Students are able to relate the concept of coordination chemistry to metal-organic frameworks, including metal-biomolecules.
4. Students understand the concept of synthesis, crystal design, defects, and applications of metal-organic frameworks, as well as the concept of reactivity in the active center of metal-biomolecules.

Syllabus:

1. Contemporary developments in the design and application of complex compounds (organometallic compounds)
2. Structure and design of complex compounds
3. Techniques and reactions in the formation of complex compounds
4. Main metal-based complex compounds
5. Coordination compounds based on transition metals
6. Coordination compounds based on rare earth metals
7. Coordination compound applications (catalysis, health, etc.)
8. Current developments in the design and application of metal-organic frameworks and biomolecular metals
9. Synthesis and morphological design of metal-organic frameworks
10. Study of the formation of metal-organic framework (nucleation, crystal growth, Oswald rule of the stage, etc.) and metal biomolecules
11. Metal-organic framework structure (reticular chemistry, topology) and metal biomolecules
12. In situ and ex situ characterization of metal-organic frameworks and metal biomolecules
13. Modeling in metal-organic frameworks (density functional theory and modeling in crystal growth)
14. Application of metal-organic frameworks and metal biomolecules in various fields (environment, health, etc.)

References:

1. Warren E. Piers, Future Trends in Organometallic Chemistry: Organometallic Approaches to Water Splitting, *Organometallics*, 2011, 30, 1, 13-16.
2. Fabrizio Ortu, Rare earth starting materials and methodologies for synthetic chemistry, *Chem. Rev.*, 2022
3. Roger Davey and John Garside, *From Molecules to Crystallizers: An Introduction to crystallization*, Oxford Chemistry Premier
4. Christopher Hammond, *The basic of crystallography and diffraction*, 2015, Oxford Scholarship
5. Mary J. van Vleet, Tingting Weng, Xinyi Li, J.R. Schmidt, In situ, Time-Resolved, and Mechanistic Studies of Metal-Organic Frameworks Nucleation and Growth, *Chem. Rev.*, 2018, 118, 3681 – 3721.
6. Stefan Kaskel, *The Chemistry of Metal Organic Frameworks*, Wiley-VCH Verlag GmbH & Co. KGaA, 2016
7. Chao, A.E. and Goddard III, W.A. (Eds.) Metalloprotein: Theory, Calculation, and Experiments, CRC Press, Boca Raton, 2015.

MKK 5217 Chemistry of Carbon Materials (2 SKS)

Learning Outcomes:

1. Explain and compare the structure and properties of the carbon allotrope (0D-3D)
2. Relate the structure and properties of 0D-3D carbon allotropes with their potential applications
3. Describe, develop and engineer suitable synthesis techniques for 0D-3D carbon allotropes.
4. Understanding and interpreting of 0D-3D carbon allotrope through characterization

Syllabus:

1. The origin of carbon on earth, Structure and bonding in carbon materials (0-3D of carbon allotrophs, i.e., diamond, graphite, other allotropes of carbon)
2. Synthesis, characterization, and application of 0-3D carbon allotropes, including biochar, carbon black, activated carbon, conducting polymers, fullerenes, and graphite materials (graphite, graphene, reduced graphene), carbon nanomaterials (carbon fiber, carbon nanotubes) (CNT), carbon dot.

References:

1. Timothy D. Burchell, 1999, Carbon Materials for Advanced Technologies, Pergamon, Elsevier Ltd., New York.
2. Liming Dai (editor), 2006, Carbon Nanotechnology: Recent Developments in Chemistry, Physics, Materials Science and Device Applications, Elsevier, Oxford.
3. Raz Jelinek, 2017, Carbon Quantum Dots: Synthesis, Properties and Applications, Springer, Switzerland.
4. Nazario Martin and Jean-Francois Nierengarten (editor), 2012, Supramolecular Chemistry of Fullerenes and Carbon Nanotubes, Wiley-VCH Verlag & Co. KGaA, Weinheim.
5. Takeshi Akasaka, Fred Wudl and Shigeru Nagase, 2010, Chemistry of Nanocarbons, John Wiley & Sons, Ltd., Chichester.
6. Huang, C, *et al*., 2018, Progress in Research into 2D Graphdiyne-Based Materials, Chem. Rev., 118, 7744-7803.
7. Sun, Z., *et al*., 2018, 3D Graphene Meresaterials: From Understanding to Design and Synthesis Control, Chem. Rev., 118, 7744-7803.

MKK 5219 Chemistry of Metal Oxide Materials (2 credits)

Learning Outcomes:

1. Understand the definition and classification of metal oxide materials.
2. Understand the synthesis method and design of metal oxide-based materials.
3. Understand the technique of characterization and functionalization of metal oxide materials
4. Understand the application of metal oxide-based materials.
5. Understand the latest research on metal oxide materials.

Syllabus:

1. Introduction: metallic and nonmetallic oxide structures; chemical and physical properties of metal oxide materials
2. Synthesis, engineering, and functionalization of metal oxide materials (silica, titania, zirconia, alumina, ceria, zinc oxide, etc.), mixed-metal oxides, nanostructures of metal oxide
3. Metal oxide material application.

References:

1. Oxide-Based Materials and Structure: Fundamentals and Applications, 2020, 1st edition, edited by Rada Savkina Larysa Khomenkova, CRC Press Taylor & Francis Group, 64 pages
2. Metal Oxide Nanostructures Chemistry: Synthesis from Aqueous Solutions, 2019, 2nd edition, Jean-Pierre Jolivet, Oxford University Press, New York, 408 pages.
3. Lin-Hua Xu, Dnyaneshwar S. Patil, Jiazhi Yang, and Jingzhong Xiao, 2015, Metal Oxide Nanostructures: Synthesis, Properties, and Applications, Journal of Nanotechnology, Volume 2015, 1-2.
4. Metal Oxides: Chemistry and Applications, 2005, 1st edition, edited by J.L.G. Fierro, CRC Press, Boca Raton, 808 pages.
5. Metal Oxide Chemistry and Synthesis: From Solution to Solid State, 2000, 1st edition, Jean-Pierre Jolivet, John Wiley & Sons Inc, United States, 338 pages

MKK 5212 Chemistry of Natural Polymer (2 credits)

Learning Outcomes:

1. Understand the definition of polymer and polymerization along with the classification of natural polymers.
2. Understand the synthesis method and design of functional materials based on natural polymers.
3. Understand the technique of characterizing functional materials based on natural polymers.
4. Understand the application of natural polymer-based functional materials.
5. Understand the latest research developments in natural polymer-based functional materials.

Syllabus:

1. Introduction: definition of polymers and polymerization, classification and examples of natural polymers, differences between polymers and macromolecules, general techniques for characterizing polymer-based materials.
2. Morphology and Regularity of Structures in Natural Polymers: polymer chain configuration, polymer crystal structure, amorphous polymers, liquid crystal polymers, single-crystal polymer morphology, factors affecting polymer crystallinity.
3. Solubility and Mechanical Properties of Natural Polymers: introduction to rheology, definitions, Newton's Law and Hooke's Law, the relationship between stress and strain, viscoelasticity, stress-strain behavior of elastomers, mechanical properties of crystalline polymers.
4. Silicate/aluminosilicate 1 (Zeolite): structure and classification of zeolite, modification of pores and surface of zeolite, characterization technique, and application of modified zeolite.
5. Silicate/aluminosilicate 2 (Cation and Anionic Clay): structure and classification of clays, modification of clay pores and surfaces, characterization techniques, and applications of modified clays.
6. Biodegradable polymer 1 (cellulose and chitosan): cellulose and chitosan polymer chain structure, intra and intermolecular interactions of cellulose and chitosan polymer chains, modification of the structure of cellulose and chitosan polymers, application of cellulose and chitosan as functional materials
7. Biodegradable polymer 2 (gelatin and collagen): structure of gelatin and collagen, intra and intermolecular interactions of gelatin and collagen, modification and application of gelatin and collagen as functional materials

8. Humic substances: abundance, structure, and chemical properties of humic substances (humic acid, fulvic acid, humin), modification and application of humic substances as functional materials
9. Hybrid polymers: functional materials based on a combination of organic and inorganic natural polymers
10. Special Topics in Natural Polymers: current research topics in polymer materials (smart polymers, polymers for drug delivery, conducting polymers, polymer-based actuators, etc.)

References:

1. Polymer Chemistry - M. P. Stevens, 2nd Ed., Oxford University Press, 1990.
2. Polymer Chemistry: Properties and Applications - Andrew Peacock, Allison Calhoun, Hanser Publishers, Munich, 2006.
3. The Chemistry of Polymers - John W. Nicholson, 3rd edition, Cambridge, 2006
4. Inorganic Polymers - James E. Mark, Harry R Allcock, and R. West, First Edition, Prentice-Hall, Englewood Cliffs, New Jersey, 1992.
5. Inorganic Polymers - P.B. Saxena, Discovery Publishing House, New Delhi, 2007.
6. Humic Substances – E.A. Ghabbour and G. Davies, The Royal Society of Chemistry, Cambridge, 2000.
7. Journals: *Nature Materials, Biomaterials, Biomacromolecules, Advanced Materials, Functional Materials, Angew. Chem. Inter. Ed., Macromolecules, Chemistry of Materials, Journal of Materials Chemistry, etc.*

MKK 5214 Chemistry of Magnetic Materials (2 credits)

Learning Outcomes:

1. Describe and compare the properties of magnetic materials
2. Understand and explain how to synthesize magnetic materials
3. Understand and interpret data generated by Gouy Balance and magnetization curves generated by VSM (Vibrating Sample Magnetometer)
4. Understand and explain the application of magnetic materials in industries

Syllabus:

1. Electron magnetism in atoms, Classification of magnetic materials: diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, ferrimagnetic and superparamagnetic.
2. Magnetic dipole and magnetic moment; Magnetization, permeability, and magnetic fields
3. Anisotropy of ferromagnetic crystals, Magneto-elastic effect, Domain structure, and hysteresis loop
4. Curie temperature and Weiss temperature.
5. Synthesis of magnetic materials.
6. Methods of measuring magnetic properties with Gouy Balance and VSM (Vibrating Sample Magnetometer)
7. The latest developments and applications of magnetic material
8. Metal and ceramic magnetic materials

References:

1. Cullity, B.D., and Graham, C.D., 2009, Introduction to Magnetic Materials, 2nd edition, John Wiley & Sons, Inc., Hoboken, https://www.academia.edu/20298510/Introduction to Magnetic Materials 2nd edition
2. Coey, J.M.D., 2010, Magnetism and Magnetic Materials, Cambridge University Press. pp. 374 – 438, DOI: https://doi.org/10.1017/CBO9780511845000.012

3. Kronmüller, H., and Parkin, S.S.P., 2007, Handbook of magnetism and advanced magnetic materials, Hoboken, NJ: John Wiley & Sons, https://www.worldcat.org/title/handbook-of-magnetism-and-advanced-magnetic-materials/oclc/124165851

MKK 5216 Biomaterials Chemistry (2 credits)

Learning Outcomes:

1. Understand the meaning of biomaterials and application classification
2. Understand the physical, mechanical, and biocompatibility tests of biomaterials
3. Explain the composition, structure, synthesis, and engineering of metallic biomaterials, ceramics, polymers, and composites.
4. Explain the current and future development of biomaterials

Syllabus:

1. Basic understanding of biomaterials; Classification of biomaterials based on their main components (metals, ceramics, polymers, and composites) and their application in medicine
2. Investigation of the properties of biomaterials (chemical, physical, mechanical, and biocompatibility); Structure, synthesis, and engineering of various types of biomaterials and their applications
3. Current and future developments of biomaterial research.

References:

1. Saeid Kargozar, Seeram Ramakrishna and Masoud Mozafar, Chemistry of biomaterials: future prospects, Current Opinion in Biomedical Engineering, 2019, 10:181–190
2. Arun Arjunan, and Ahmad Baroutaji, Ayyappan S Praveen, Vel Tech Rangarajan Dr. Sagunthala John Robinson, Chang Wang, Classification of Biomaterial Functionality, Encyclopedia of Smart Materials, 2020, https://doi.org/10.1016/B978-0-12-815732-9.00027-9
3. Rosario Pignatello (ed), Biomaterials Science and Engineering, InTech, 2011, Rijeka, Croatia
4. Recent articles in biomaterials journals: Biomaterials, Journal of Biomaterials, Journal of Biomaterial Applications, International Journal of Biomaterials, and Current Opinion in Biomedical Engineering.

2.19.4 Courses in Physical Chemistry and Nanocatalysis

MKK 5315 Computation method for nanoscience (2 credits)

Learning Outcomes:

1. Students have broad and in-depth knowledge of the latest research in computational chemistry, especially in the field of nanocatalysts.
2. Students are able to understand concepts in the field of computational chemistry related to nanocatalysis.
3. Students are able to understand the molecular level of reactions involving nanocatalysis.
4. Students are able to apply appropriate computational chemistry methods in studying reactions involving nanocatalysts.

Syllabus:

1. The electrical characteristics of the interfacial region between molecules and the bulk phase
2. Computation of pure and binary nanocluster structure
3. Computation of solid-liquid phase transition in nanoparticles
4. Multiscale modeling in quantum synthesis nanodots
5. Computation of structure characterization of nanomaterials and mesoporous material

6. Molecular dynamics simulation of thermal stability of carbon nanosystems,
7. Carbon nanotube simulation and modeling
8. Hydrogen adsorption in corannulene materials
9. Ab initio simulation of the interaction of semiconductor materials and molecules

References

1. Balbuena, P. and Seminario, J.M. eds., 2006. *Nanomaterials: Design and Simulation*, Elsevier.
2. Tuckerman, M.E. and Martyna, G.J., 2000. Understanding Modern Molecular Dynamics: Techniques and Applications. The Journal of Physical Chemistry B, 104(2), pp.159-178.
3. Allen, M.P., 2004. Introduction To Molecular Dynamics Simulation. Computational Soft Matter: From *Synthetic* Polymers To Proteins, 23(1), pp.1-28.
4. Hofer, T. S., & Tirler, A. O. (2015). Combining 2d-periodic quantum chemistry with molecular force fields: a novel QM/MM procedure for the treatment of solid-state surfaces and interfaces. *Journal of Chemical Theory and Computation*, *11*(12), 5873-5887.
5. Le, J. B., Chen, A., Li, L., Xiong, J. F., Lan, J., Liu, Y. P., ... & Cheng, J. (2021). Modeling electrified Pt (111)-Had/water interfaces from ab Initio molecular dynamics. *JACS Au*, *1*(5), 569-577.

MKK 5317 Computer-Aided Material Design (2 credits)

Learning Outcomes:

1. Students have knowledge of the basics of material design using existing methods in the field of computational chemistry.
2. Students are able to understand the principles of machine learning and its application in computer-aided material design.
3. Students are able to predict the chemical and physical properties of materials theoretically, accurately, and correctly.
4. Students are able to apply the latest methods in computational chemistry in designing new materials.

Syllabus:

1. Molecular Mechanics: Intra and Intermolecular Potentials.
2. Manybody Effect: Polarized Model, Manybody Potential and Reactive Force Field.
3. Monte Carlo Method, Introduction to the Monte Carlo Method (Metropolis Algorithm and Random Numbers), Grand Canonical Monte Carlo Simulation, and Kinetic Monte Carlo.
4. Multiscale Modeling, Hybrid Concept of Quantum Mechanics/Molecular Mechanics, Coarse Graining Model.
5. Computational Quantum Mechanics, Molecular Orbital Calculation (Hartree-Fock, Basis Sets And Density Functional Theory (DFT), Excited State Modeling Using DFT, Plane Wave Basis Sets (Paw), Density Functional Tight Binding (DFTB) and Its Applications.
6. Machine learning: Introduction to machine learning concepts and, Machine learning applications for materials design.

References:

1. Leach, A.R. and Leach, A.R., 2001. Molecular Modelling: Principles and Applications. Pearson Education.
2. Frenkel, D. and Smit, B., 2001. Understanding Molecular Simulation: From Algorithms *to* Applications (Vol. 1). Elsevier.
3. Hasnip, P.J., Refson, K., Probert, M.I., Yates, J.R., Clark, S.J. and Pickard, C.J., 2014. Density Functional Theory in The Solid State. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 372(2011), p.20130270.

4. Sun, B., Barron, H., Opletal, G., & Barnard, A. S. (2018). From Process to Properties: Correlating Synthesis Conditions and Structural Disorder of Platinum Nanocatalysts. *The Journal of Physical Chemistry C*, *122*(49), 28085-28093.
5. Häse, F., Galván, I. F., Aspuru-Guzik, A., Lindh, R., & Vacher, M. (2019). How machine learning can assist the interpretation of ab initio molecular dynamics simulations and conceptual understanding of chemistry. *Chemical science*, *10*(8), 2298-2307.

MKK 5319 Homogeneous and Heterogeneous Catalysis (2 credits)
Learning Outcomes:
1. Students understand the concept of homogeneous catalysts.
2. Students understand the concept of heterogeneous catalysts.
3. Students understand thermodynamic processes and the kinetics of catalyzed reactions.
4. Students are able to design catalyzed reactions using appropriate catalysts for certain chemical reactions.

Syllabus:
1. Homogeneous catalysis: Acid-base catalysis with metal ions
2. Kinetics and mechanism of homogeneous catalytic reactions
3. Heterogeneous Catalysis: Catalyst Preparation, Physical Adsorption, Chemisorption, Kinetics and Mechanisms of Heterogeneous Catalytic Reactions: Empirical and Mechanistic Models, Activities, Selectivity and Stability of Catalysts, Selectivity and Deactivation, Physical Properties of Catalysts and Mechanical Properties of Catalysts.

References:
1. van Leeuwen, P.W.N.M., 2003, *Homogeneous Catalysis, Understanding the Art*, KLUWER Academic Publishers, London.
2. van Santen., R.A., 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
3. Polshettiwar, V., & Varma, R. S. (2010). Green chemistry by nano-catalysis. *Green Chemistry*, *12*(5), 743-754.
4. Bender, T. A., Dabrowski, J. A., & Gagné, M. R. (2018). Homogeneous catalysis for the production of low-volume, high-value chemicals from biomass. *Nature Reviews Chemistry*, *2*(5), 35-46.

MKK 5314 Application of catalyst in industry (2 credits)
Learning Outcomes:
1. Students are able to understand the importance of catalysts in industries.
2. Students are able to understand the various types of catalysts used in industries.
3. Students are able to understand various types of catalytic processes that are applied for environmental protection.
4. Students are able to design catalysts that can operate on an industrial scale.

Syllabus:
1. Importance of catalysis in industry, acid catalysis
2. Petroleum and hydrocarbon processing.
3. Catalytic oxidation.
4. Syntheses of gases and related processes
5. Steam reforming
6. Methanation process.
7. Ammonia production.
8. Fischer-Tropsch process.
9. Catalysts for environmental protection and biofuel production

References:

1. Leach, B. (Ed.). (2012). *Applied industrial catalysis*. Elsevier.
2. Bhatia, S. (2020). *Zeolite catalysis: principles and applications*. CRC press.
3. Zhong, J., Yang, X., Wu, Z., Liang, B., Huang, Y., & Zhang, T. (2020). State of the art and perspectives in heterogeneous catalysis of CO 2 hydrogenation to methanol. *Chemical Society Reviews*, *49*(5), 1385-1413.
4. Schießl, J., Schulmeister, J., Doppiu, A., Wörner, E., Rudolph, M., Karch, R., & Hashmi, A. S. K. (2018). An industrial perspective on counter anions in gold catalysis: on alternative counter anions. *Advanced Synthesis & Catalysis*, *360*(20), 3949-3959.

MKK 5312 Electro and Biocatalysis (2 credits)

Learning Outcomes:

1. Students are able to explain the concepts of electrocatalysis
2. Students are able to explain the concepts of biocatalysis
3. Students are able to explain how the application of biocatalytic and electrocatalytic processes
4. Students are able to apply the principles of electron and biocatalysis in research.

Syllabus:

1. Electrocatalysis principle
2. Principle of biocatalysis
3. Biocatalyst kinetics
4. Electrocatalytic kinetics
5. Fuel cell electrochemical reaction
6. Electrocatalytic reactor
7. Biocatalysis reactor
8. Bio and electrocatalysis applications in industry

References:

1. Bommarius, A.S., and Riebel, B.R., 2004, *Biocatalysis*, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim ISBN: 3-527-30344-8
2. Santos. E., and Schmickle, W., 2011, *Catalysis In Electrochemistry From Fundamentals To Strategies For Fuel Cell Development*, John Wiley & Sons, Inc ISBN 978-0-470-40690-8
3. Yu, F., Yu, L., Mishra, I. K., Yu, Y., Ren, Z.F., and Zhou, H.Q., (2018). Recent developments in earth-abundant and non-noble electrocatalysts for water electrolysis. *Materials Today Physics*, *7*, 121-138.
4. Yi, D., Bayer, T., Badenhorst, C. P., Wu, S., Doerr, M., Höhne, M., and Bornscheuer, U.T., (2021). Recent trends in biocatalysis. *Chemical Society Reviews*, *50*(14), 8003-8049.

MKK 5316 Integration of Nanocatalysis Theory and Experiments (2 credits)

Learning Outcome:

1. Students are able to understand the nanocatalysis process in theory and experiment.
2. Students are able to integrate various theories of catalysis with laboratory experiments.
3. Students are able to understand the latest research in the field of nanocatalysts.
4. Students are able to design the synthesis nanocatalyst and their applications in studying various kinds of chemical reactions.

Syllabus

1. Integration of theory and experiments: acidity of catalysts
2. Integration of theory and experiments: mechanisms of catalytic reactions
3. Integration of theory and experiments: selectivity and activity of catalysts

4. Integration of theory and experiments: hydrocracking reaction
5. Integration of theory and experiments: electrolysis
6. Integration of theory and experiments: biocatalysis
7. Integration of theory and experiments: Photocatalysis

References

1. Li, H., Tian, J., Zhu, Z., Cui, F., Zhu, Y. A., Duan, X., & Wang, S. (2018). Magnetic nitrogen-doped nanocarbons for enhanced metal-free catalytic oxidation: Integrated experimental and theoretical investigations for mechanism and application. *Chemical Engineering Journal*, *354*, 507-516.
2. Li, B., Ma, J. G., & Cheng, P. (2019). Integration of metal nanoparticles into metal–organic frameworks for composite catalysts: design and synthetic strategy. *Small*, *15*(32), 1804849.
3. Xu, H., Shang, H., Wang, C., & Du, Y. (2020). Ultrafine Pt-based nanowires for advanced catalysis. *Advanced Functional Materials*, *30*(28), 2000793.
4. Ahn, S., Hong, M., Sundararajan, M., Ess, D. H., & Baik, M. H. (2019). Design and optimization of catalysts based on mechanistic insights derived from quantum chemical reaction modeling. *Chemical Reviews*, *119*(11), 6509-6560.

2.19.5 Courses of Study Interest in Organic Synthesis and Biomolecular Chemistry

MKK 5403 Synthesis and Mechanism of Organic Reaction (2 credits)

Learning outcomes:

1. Understand the concept of retrosynthesis of organic compounds through a disconnection approach.
2. Understand the different types of reactions in organic chemistry and use them in designing the synthesis of organic compounds.
3. Know the effect of electronic and steric properties on the reagents, intermediates, and products in organic chemical reactions.
4. Understand the basic principles of nucleophile, electrophile, and acid-base in synthesizing organic compounds.
5. Predict the mechanism of organic chemical reactions and predict the products of the reaction based on the mechanism of organic reactions.
6. Understand the concepts of chemoselectivity, regioselectivity, stereospecificity, and stereoselectivity.

Syllabus:

1. Disconnection approach and retrosynthetic strategy
2. Organic reaction mechanism
3. Concept of chemoselectivity and regioselectivity
4. Stereoselective and stereospecific synthesis.

References:

1. Warren, S. and Wyatt, P., 2009, *Organic Synthesis: The Disconnection Approach*, 2nd ed., John Wiley and Sons Ltd., New York
2. Smith, M.B and March J., 2000, *March's Advanced Organic Chemistry; Reaction, Mechanism and Structure*, 5th ed., John Wiley & Sons, Inc., New York.
3. Sykes, P., 1996, *Guidebook to Mechanism in Organic Chemistry*, 6th ed., Prentice Hall, Cambridge.
4. Clayden, J., Greeves, N., and Warren, S., 2012, *Organic Chemistry*, 2nd Ed., Oxford University Press, New York.
5. Zweifel, G.S., Nantz, M.H., Somfai, P., 2017, *Modern Organic Synthesis*, 2nd Ed., John Wiley and Sons, Hoboken.

MKK 5405 Biotechnology of Food and Energy (2 credits)
Learning outcomes:
1. Know the process of molecular genetics and genetic engineering, transgenic plants and animals, metabolite engineering, isolation, and microbial culture.
2. Understand the basic principles of fermentation.
3. Know the types of enzymes and the mechanism of action of enzymes.
4. Describe the role of microorganisms in the biofuel production process.
5. Know the potential of biomass and its use in biofuel production.

Syllabus:
1. Biotechnology review on molecular genetics and genetic engineering
2. GMO plants and animals
3. Metabolite engineering
4. Microbial isolation and culture
5. Biomass transformation
6. Biofuel production
7. Food fermentation technology.

References:

1. Andersen, R.A., 2005, *Algae Culturing Techniques*, 1st ed., Elsevier Academic Press, Oxford.
2. Richmond, A., 2003, *Handbook of Microalgal Culture: Biotechnology and Applied Phycology*, 1st Ed., Blackwell Publishing Ltd, Oxford.

MKK 5407 Medicinal Chemistry and Drug Design (2 credits)
Learning outcomes:
1. Know the method of developing drug compounds, including the design and discovery of drug compounds.
2. Understand the relationship between the chemical structure of drugs and their biological activity.
3. Know the drug design process by looking at the absorption, distribution, metabolism, and excretion processes.
4. Understand the theory of receptors and effectors and the quantitative relationship between structure and reactivity.
5. Use computational chemistry studies in drug design and development.

Syllabus:
1. Review of physicochemical properties and their relationship to biological action
2. Drug metabolism
3. Effector receptor theory
4. Optimization of target interactions
5. 5quantitative structure-reactivity relationships (QSAR)
6. Use of computational chemistry and combinatorial synthesis for drug development.

References:

1. Ekinci, D., 2012, *Medicinal Chemistry and Drug Design*, InTech, 1st ed., Rijeka.
2. Nogrady, T. and Weaver, D.F., 1985, *Medicinal Chemistry*, 3rd ed., Oxford University Press, New York.

MKK 5402 Analysis of Materials and Structures of Organic Compounds (2 credits)
Learning outcomes:

1. Understand the basic principles and developments of chromatography in the process of separating organic compounds as well as qualitative and quantitative analysis of organic compounds, pharmaceuticals, and agriculture.
2. Understand the basic principles of MS in analyzing organic compounds, macromolecules, and polymers.
3. Determine the chromophore group of an organic compound with a UV spectrometer and predict the maximum wavelength of the organic compound.
4. Understand the basic principles of IR in identifying functional groups in organic compounds.
5. Interpret 1D and 2D NMR data.
6. Use NMR, MS, and IR in the structure elucidation of organic compounds.

Syllabus:

1. Trend in HPLC & UPLC chromatography Development
2. MS tandem chromatography, MS for organic and forensic quantitative analysis, MS on macromolecular and polymeric analysis
3. Identification of functional groups by IR
4. Determination of chromophore by UV
5. Interpretation of 1D and 2D NMR data
6. Interpretation of combined UV, IR, NMR, and MS spectra.

References:

1. Silverstein, R.M., Webster, F.X., and Kiemle, D. J., 2005, *Spectrometric Identification of Organic Compounds*, 7th ed., Wiley, New York.
2. Williams, D. and Fleming I., 2005, *Spectroscopic Methods in Organic Chemistry*, 5th ed., McGraw-Hill, London.

MKK 5404 Natural Product and Marine Chemistry (2 credits)

Learning outcomes:

1. Know the various types of natural compounds derived from both land and sea.
2. Understand the role of natural compounds in living organisms and their biosynthetic processes.
3. Understand the process of synthesis of natural materials
4. Understand the application of natural compounds in chemistry, pharmacy, and biology.
5. Understand the isolation technique and identification of secondary metabolite compounds
6. Understand the OMIC principle in chemical research of natural materials.

Syllabus:

1. Discussing the chemical content and biosynthesis of natural products from land and sea
2. The use of natural products as raw materials for syntheses
3. Chemical bioprospecting of natural products from land and sea.
4. OMIC approach to natural product chemistry research
5. Isolation techniques and identification of secondary metabolites

References:

1. Dewick, P.M., 2002, *Medicinal Natural Products: a Biosynthetic approach*, 2nd ed., John Wiley and Sons Ltd., New York.
2. Bhat, S.V., Nagasampagi, B.A., and Sivakumar, M., 2004, *Chemistry of Natural Products*, 1st ed., Springer-Narosa, New Delhi.
3. Bhakuni, D.S., and Rawat, D.S., 2005, *Bioactive Marine Natural Product*, 1st ed., Springer–Anamaya, New Delhi.
4. Cannell, R.J.P., 1998, *Natural Products Isolation*, 1st ed., Humana Press, New Jersey.

MKK 5406 Heterocyclic Chemistry and Agrochemistry (2 credits)
Learning outcomes:
1. Know the classification of heterocyclic aromatic compounds as poor or electron-rich and explain their reactivity based on their electronic properties.
2. Understand the mechanism of reactions involving heterocyclic compounds as reactants, intermediates, or products.
3. Know the importance of heterocyclic compounds in the pharmaceutical and agrochemical fields.
4. Understand the mechanism of action and environmental review of agrochemical products.

Syllabus:
1. Classification, physical and chemical properties of heterocyclic compounds
2. Retrosynthesis and synthesis of heterocyclic compounds
3. Application of heterocyclic compounds in pharmaceutical, agrochemical, and dye fields.
4. Classification of pesticides
5. Mechanism of action of agrochemicals and pesticides
6. Environmental review of pesticide use.

References:
1. Joule, J. A. and Mills, K., 2010, *Heterocyclic Chemistry*, 5th ed., John Wiley and Sons Ltd., Chichester.
2. Gilchrist, T. L, 1997, *Heterocyclic Chemistry*, 3rd ed., Prentice Hall, New York.

2.19.6 Courses of Study Interest in Analytical and Environmental Chemistry
MKK 5512 Trend in Electroanalysis Chemistry (2 credits**)**
Learning outcomes:
1. Master the principles that underlie modern electrochemical methods for studying processes occurring at electrodes.
2. Interpret the results from experimental and theoretical methods to determine the reaction mechanism at the electrodes and obtain relevant important information.
3. Able to read and understand the contents of the latest scientific publications related to the use of electrochemical methods in analysis.
4. Able to determine appropriate electrochemical analysis methods related to electron transfer and mass transfer processes

Syllabus:
1. constant potential amperometric method
2. High-speed chronoamperometry
3. Fast cyclic voltammetry
4. differential pulse voltammetry
5. Electrochemical impedance spectroscopy

References:
Allen J. Bard, Larry R. Faulkner, 2000, Electrochemical Methods Fundamentals and Applications

MKK 5505 Clinical and Forensic Analysis (2 credits)
Learning outcomes:
1. Understand the principles and analytical procedures in clinical chemistry.

2. Understand real examples of the application of various analytical methods in the clinical field
3. Understand aspects of analytical chemistry in the field of forensic science as well as analytical procedures and instrumentation to characterize samples in forensic applications
4. Have broad and in-depth knowledge regarding examples of forensic cases that require analytical data support.

Syllabus:

1. the principles and procedures of various tests performed in Clinical Chemistry: basic principles, physiology and procedures and clinical significance of test results, including quality control and reference values.
2. blood alcohol analysis (BAC), drug analysis, forensic toxicology, fire residue analysis, fiber, and DNA analysis for forensic purposes, and some examples of forensic cases

References:

1. Kaplan, L. A., and Pesce, A. J., 2009, Clinical Chemistry: Theory, Analysis, Correlation, 5th Ed., Elsevier, Amsterdam.
2. Hempel G., 2004; Drug Monitoring and Clinical Chemistry, Volume 5 (Handbook of Analytical Separations), Elsevier Science, Oxford.
3. Aboul-Enein, 2003, Techniques in Clinical Chemistry, Marcel Dekker, New York.
4. Brunelle R. L., and Crawford K. R., 2003, Advances in the Forensic Analysis and Dating of Writing Ink, Charles C Thomas Publisher, Illinois.
5. Blackledge, R. D., 2007, Forensic Analysis on the Cutting Edge: New Methods for Trace Evidence Analysis, Wiley, NJ.

MKK 5517 Sampling Strategy and Data Analysis (2 credits)

Learning outcomes:

1. Understand the concept of environmental sampling and sample preparation
2. Understand sampling procedures and strategies in water, soil, air, and other environmental constituents.
3. Understand the chemical data processing process, both reading, data analysis, and data validation
4. Know the use of chemical data and the results of chemical data analysis

Syllabus:

1. Principles and strategies of environmental sampling
2. sampling equipment
3. environmental sampling procedures (water, soil, air, and others)
4. preservation and preparation of environmental samples
5. validation of chemical data (error, LoD and LoQ, precision, accuracy)
6. test the data hypothesis
7. ANOVA
8. Correlation and Regression
9. Multivariate method
10. Monitoring and Impact Assessment
11. Using control charts and Cusum charts with monitoring data
12. Design and analysis for impact assessment

References:

1. Keith L. H., 1996, Principles of environmental sampling, 2nd ed., American Chemical Society, New York.
2. Zhang, C., 2007, Fundamentals of Environmental Sampling and Analysis, Wiley, Hoboken, NJ.

3. Popek, E. P., 2003, Sampling & Analysis of Environmental Chemical Pollutants. A Complete Guide, Academic Press, Waltham, Massachusetts.
4. Einax, J. W., Zwanziger, H. W., and Gei, S., 1997, Chemometrics in Environmental Analysis; John Wiley & Sons, Hoboken, New Jersey.
5. Brereton, R. G., 2003, Chemometrics: Data Analysis for the Laboratory and Chemical Plant, John Wiley & Sons, Hoboken, New Jersey.

MKK 5512 Analysis of Environmental Pollutants (2 credits)

Learning outcomes:

1. Analyze the chemical parameters of metals in various types of water samples in the environment
2. Analyze non-metallic chemical parameters in various types of water samples in the environment
3. analyze the gas parameters in the air
4. analyze the particulate parameters in the air
5. evaluate and determine the air quality index

Syllabus:

1. Analysis of COD and BOD, Analysis of sulfur compounds, Analysis of nitrogen compounds, Analysis of phosphate compounds, Analysis of active compounds, Analysis of hazardous heavy metals,
2. Analysis of environmental pollutants in the air includes analysis of particulate pollutants, metals, sulfur and nitrogen compounds, secondary gaseous pollutants, hydrocarbons and carbon monoxide, halogen compounds, and determination of the air quality index (AQI)*).*

References:

1. van Loon, G.W., and Duffy, S.J. 2000, Environmental Chemistry: A Global Perspective, University Press, Oxford.
2. Arthur C. Stern, 2013, Analysis, Monitoring, and Surveying. Air Pollution, Volume 2, Elsevier Science, England, ISBN:9781483268316, 1483268314
3. Roger Perry, Roy M.Harrison, 2012, Handbook of Air Pollution Analysis, Springer, Nederlands, ISBN:9789400940833, 9400940831
4. van Loon, G.W., and Duffy, S.J. 2000, Environmental Chemistry: A Global Perspective, University Press, Oxford.
5. Anonim, 1980, Standard Methods for the examination of water and wastewater, 15th ed., APHA, AWWA, WPCF. Washington.
6. Sawyer, C.N., and Mc. Carty, P.L. 1978, Chemistry for Environmental Engineering, 3th ed, Mc. Graw Hill, New York.

MKK 5514 Analysis Method in Toxicology (2 credits)

Learning outcomes:

1. Understand the principles of chemical toxicology in humans and the environment
2. Understand the risks and exposure to chemicals in the environment
3. Understand the phenomenon of chemical transport and its changes.
4. Understand the application of various analytical methods in the study and analysis of chemical toxicology

Syllabus:

1. Principles of toxicology, distribution, transport, and chemical changes in the environment (water, soil and air), intoxication mechanisms, risks and exposure to chemicals.

2. Analytical/instrumental methods (spectroscopy, chromatography, electrochemical based) in toxin analysis in complex biological and environmental samples.

References:

1. Crosby, D.G., 1998, Environmental Toxicology and Chemistry, Oxford University Press, Inc., New York, USA.
2. van Leeuwen, C. J. and J. L. M. Hermens (Editors), 1995, Risk Assessment of Chemicals : An Introduction, Kluwer Academic Publishers, Dordrecht, The Netherlands.
3. D.A. Skoog, F.J. Holler and S.R. Crouch, 'Principles of Instrumental Analysis", 6th or 5th ed., Thomson-Brooks/Cole Belmont, CA, (2007).
4. D.C. Harris, "Quantitative Chemical Analysis", 8th ed. (2010) or 7th ed. (2006), W.H. Freeman and Company, New York, USA.

MKK 5706 Environmental Management System (2 credits)

Learning outcomes:

1. Acquire knowledge of Environmental Management System
2. Designing Environmental Management System and Environmental Management System document
3. Prepare an environmental management and monitoring plan
4. Life cycle Assessment

Syllabus:

1. ISO 14001 Principles, Environmental Policy and Environmental Aspects,
2. Planning: Identification of Environmental Aspects, Legislation, Goals and Targets, and Environmental Management
3. Implementation: Organizational Structure and Responsibilities, Training, Communication, and Documentation
4. Check and Correction: Monitoring, Monitoring and Correction/Non-conformance
5. Management Review: Environmental Management Performance Analysis and Recommendations for Improvement
6. Improvement of Sustainable Environmental Management

References:

1. United Nations. Economic and Social Commission for Asia and the Pacific, 2003, Integration of Environmental Quality Management Systems for Sustainable Development, UN Publications.
2. Burden, F. R., and McKelvie, I., 2002, Environmental Monitoring Handbook, McGraw-Hill, New York.

2.19 General Rubric

2.19.1 Rubric RS2-1 for PLO-1 Attitude and Value

Criteria	Poor	Fair	Good	Very Good	Score
	Score = 1	Score = 2	Score = 3	Score = 4	
Attitude	Refuse to participate, do not care	Willing to participate with encouragement. Able to change to a more positive attitude.	Ready to participate, attend with a positive attitude and stay positive.	Ready to participate consistently. Support others. Involve in working with other people. Enthusiastic.	
Organization	Does not prepare materials. Late work. Materials and space are messy and disorganized.	Some materials are missing. Work is sometimes late. Materials and space are sometimes messy and disorganized.	Prepare all the materials. Work is finished on time. Materials and space are organized and tidy.	Prepare all the materials. Manage time and produce the best work. Organized, neat and precise materials and spaces. Remind others to be ready.	
Respect Other People	Annoying others. Unsupportive comments and unwilling to work with others.	Sometimes annoying others. Sometimes making unsupportive comments and need encouragement to work with others	Do not disturb other people. Polite to others and regularly ready to work with others.	Do not disturb other people. Support others and take on a leadership role.	
Initiative	Do not ask for help. Always need a hint to start a task.	Sometimes asking for help when needed. Sometimes it takes a cue to get to work. Generally need to revise work.	Regularly asking for help when needed. Organized and ready to work. Regularly revising work.	After trying independently, always asking for help, consistently exceeds expectations. Always trying hard.	

Attention	Negligent and annoying.	Inconsistent engagement. It is annoying sometimes.	Focused, always engaged, ask relevant questions, and make relevant comments.	Attentive. Likes to encourage discussion, encourages others to be active and helps bring back focus.	
				Total	

2.19.2 Rubric RS2-2 for PLO-5 Problem Solving Ability

Criteria	**Highly dependent individual**	**Individual who relies on others**	**Independent individual**	**Professional Consultant**	**Main problem solver**	**Score**
	Score = 1	**Score = 2**	**Score = 3**	**Score = 4**	**Score = 5**	
Depth in seeing the problem	Only see the surface factors of a problem, and their understanding of the problem is always unclear.	Identify the problem with feelings and clarify it through emotional expression.	Can identify and classify the subject matter to focus on the most important things.	Can help others see the problems they are facing and clarify them to the satisfaction of others.	Can see hidden issues that people are ignoring and clarify them so others can see the importance.	
Problem identification ability	Unable to identify important issues and assumptions.	Issues regarding personal needs and identification of assumptions others make about them.	Able to identify some of the main issues and some important assumptions.	Able to identify most of the key issues related to context, constraints, needs, and the most important assumptions.	Able to identify all major issues concerning context, constraints and needs, and important assumptions.	

Problem solving organization	Disorganized, no priority, and accepts fast solutions without testing and validation.	Be emotional and reactive to everyday problems and test to see if solutions make them comfortable.	Somewhat organized with a few priorities and making sure they are satisfied with the solution.	More systematic and have priorities and criteria, which they use to test and validate solutions.	Highly systematic and applies clear priorities and quality criteria to test and validate processes and solutions.	
Use of Information	Using information without judgment and taking inappropriate risks.	Using the information provided and will do what others ask.	Take advantage of available information and take the necessary risks to get what they really want.	Access extensive information so they can take risks that no one else will.	Access all important information so they can take the necessary risks with minimal sacrifice.	
Generalization of the problem	Using other people's solutions and never learning from the past.	Changing other people's solutions and occasionally seeing patterns in how they use them.	Generate acceptable solutions and sometimes reuse the most obvious solutions.	Strong enough in problem modeling and sometimes generalizing solutions for future reuse.	Very good at problem modeling, taking the time to generalize future use and reuse accordingly	

2.19.3 Rubric RS2-3 for PLO-8 Professionalism

Criteria	Unacceptable Score = 2	Acceptable Score = 3	Professional Score = 4	Score
Time management Professional skills in reliability, scheduling, time management to optimize projects, clients, superiors, and desired results.	Missing a group or part of a group frequently. Do not call or try to get an assignment when the group goes unanswered. Missed deadlines due to missing the group or wasting time. Sub-standard level of work due to less effort.	Miss the group at times. The instructor contacts when the group is lost and tries to get the assignment. Make no-show arrangements. Meet all deadlines. The occasional waste of group time.	Attend groups activities on time. Utilize course time optimally. Meet all the deadlines while exceeding the standards for professional presentations. Utilize time management processes for independent and team projects.	
Work environment Create and maintain a professional work environment for all individual safety.	Not maintaining the work environment. No cleaning and picking up after using an item. Leaving trash and food containers for others to take. Little attention to the work environment.	Maintaining the work environment by complying with safety regulations. Usually participates in maintaining the work environment, cleaning and picking up the work area most of the time. Respect the work environment.	Maintaining the work environment by adhering to safety rules. Clean and remove the work area properly after each use. Acknowledging a shared workspace requires an extension of co-worker appreciation of the shared space by keeping the overall work environment clean in order to be safe.	
Equipment Professional practice in the maintenance, use and storage of equipment.	Does not have proper procedures for use, maintenance, storage of equipment in many instances. Often skips the check-in process. Leave the equipment. Expect someone else to take care of the equipment for them.	Understand and utilize appropriate procedures for the use, maintenance, and storage of equipment. Follow the check-in process. Store equipment properly. Handle equipment with care for safety and maintenance.	Understand and utilize proper procedures for the use, maintenance, and storage of equipment for each use. Follow the check-in process on time and store equipment properly. Handle equipment with care for safety and maintenance.	

Group Participation Positive and frequent participation in group activities.	Not contributing to team projects and group discussions. Sleeping in a group or focusing on activities unrelated to the group. Requires excessive rest time.	Contribute to the majority of group team projects and discussions. Provides meaningful feedback, stays on task and pays attention in groups.	Contribute to all group team projects and discussions. Give meaningful feedback and stay on task. Keep on track on-course activities.	
Professionalism Courteous and respectful towards individuals both in language and actions.	Annoy, ignore, and disrespect others. Using inappropriate language and/or behavior such as harassment, ridicule, racism, or sexism.	Listening while others are talking, participating in group activities, uses appropriate language. Prepared for most groups.	Be polite and respectful to others, do not interfere when others are talking, and use appropriate language. Always ready for whatever course activities may be.	

2.19.4 Rubric RS2-4 for PLO-9 Communication Skills

Criteria	**Extraordinary**	**Very Good**	**Good**	**Fair**	**Poor**	**Score**
	Score = 5	**Score = 4**	**Score = 3**	**Score = 2**	**Score = 1**	
Interaction	Can present ideas in an articulate and persuasive manner in complex discussions. Sophisticated sparring and tournament strategy. Has no difficulty understanding idiomatic language or different registers.	Can successfully present and justify ideas informal discussions. Turn-taking is handled appropriately. Can recognize register shifts and various idiomatic expressions.	Join the discussion and be able to justify an opinion. Responds and interacts adequately with other speakers. Use good communication strategies when unsure about, e.g., Idiomatic use	Has some difficulty following discussions and debating opinions. Limited turn-taking and use of communication strategies.	Characterized by difficulty in participating in discussions and only making occasional contributions.	

Professional vocabulary	Have a very good command of professional vocabulary, allowing gaps to be easily overcome by using too many words (circumlocutions).	Have a good command of professional vocabulary, allowing gaps, in general, to be overcome by the use of too many words (circumlocutions).	Have adequate vocabulary to express himself in matters related to his field.	Limited professional vocabulary.	Professional basic vocabulary only.	
Language Quality	Consistently maintains a high level of grammatical accuracy; errors are rare and hard to spot. Correct using idiomatic expressions and collocations.	Can maintain a good level of grammatical accuracy; Occasional errors don't get in the way of communication. Most of the correct use of idiomatic expressions and collocations.	Can communicate with reasonable accuracy and can correct errors if they have caused misunderstandings.	Communication is generally successful, although limited in terms of accuracy. Some misunderstandings have not been resolved.	Communication is characterized by frequent inaccuracies and misunderstandings.	
Fluency	Can express himself fluently and spontaneously, almost effortlessly. Only conceptually difficult subjects can hinder the flow of natural and fluent language. Extensive vocabulary proven.	Fluent and spontaneous but occasionally needs to find expression or compromise to say exactly what he wants.	Can produce stretches of language with a fairly light tempo. Even though you can hesitate when looking for an expression, there's rarely a long pause.	Tempo is generally acceptable but often hesitates when he seeks expression. Some gaps are visible.	Frequent hesitation and pauses can only produce a small amount of language	
Pronunciation	Mastery of the English voice system is clear. Accurate pronunciation	Pronunciation and intonation are generally accurate; mistakes do not	Some inaccuracies in pronunciation and intonation, for example, Problems with	Often inaccurate in pronunciation and intonation. Mother	Keywords are regularly misunderstood, and the influence of the	

	and intonation in many ways.	cause misunderstandings.	voiced/unvoiced consonants.	tongue interference is obvious.	mother tongue is strong.	
Presentation	Students are thoroughly familiar with the topic and can respond confidently and spontaneously to complex questions. The presentation is well structured, uses transition elements, and follows conventions in the field. Good eye contact, no reading from the paper. The right level for the intended audience.	Know the topic well. Can handle complex questions with relative ease. The presentation is clearly structured and appropriate for the audience. Consistent use of transition elements. Good eye contact; at least need to refer to the paper. Appropriate level for the intended audience.	Evidence of a standard three-part structure and some use of transition elements. Maintain contact with the audience. The right level, but the listener is not completely sure that the presenter knows the topic well.	Some structural weaknesses and only limited transition elements. Basic level of acquaintance with the topic	The structure lacks coherence. The speaker is unfamiliar with the topic. The transition elements are mostly missing.	

2.19.5 Rubric RS2-5 for PLO-10 Lifelong Learner

Criteria	Extraordinary Score = 4	Very Good Score = 3	Good Score = 2	Fair Score = 1	Score
Curiosity	Exploring a topic in-depth generates awareness and/or little-known information that demonstrates a strong interest in the subject.	Explores a topic in-depth, generating insights and/or information that demonstrates interest in the subject.	Explores a topic with some in-depth evidence, providing occasional insight and/or information that shows mild interest in the subject.	Explores a topic at a surface level, providing little insight and/or information beyond basic facts that indicate low interest in the subject.	
Initiative	Complete required work, generate and pursue opportunities to expand knowledge, skills, and abilities.	Complete required work, identify and pursue opportunities to expand knowledge, skills, and abilities.	Complete required work and identify opportunities to expand knowledge, skills, and abilities.	Complete the required work.	
Independence	Educational interests and pursuits exist and develop beyond the requirements of the classroom. Knowledge and/or experience pursued independently.	Beyond classroom requirements, pursuing substantial additional knowledge and/or actively pursuing independent educational experience	Beyond the class requirements, pass on additional knowledge and/or show an interest in pursuing a self-study experience	Begins to look beyond class requirements, showing interest in pursuing knowledge independently	
Transfer	Make explicit references to previous learning and apply innovatively (new & creatively) so that knowledge and skills demonstrate understanding and performance in new situations.	Make references to previous learning and show evidence of applying that knowledge and skills to demonstrate understanding and	Make references to previous learning and apply knowledge and skills to demonstrate understanding and performance in new situations.	Makes vague references to previous learning but does not apply knowledge and skills to demonstrate understanding and performance in new situations.	

		performance in new situations.			
Reflection	An in-depth review of previous learning (past experiences inside and outside the classroom) to reveal significantly changed perspectives on educational and life experiences, which provide the basis for knowledge, growth, and maturation that is expanded over time.	Reviews of previous learning (past experiences inside and outside the classroom) in-depth, revealing fully clarified meanings or showing a broader perspective on educational or life events.	Reviews of previous learning (past experiences inside and outside the classroom) in-depth, revealing a bit of clarified meaning or showing a bit of a broader perspective on educational or life events.	Reviews previous learning (past experiences inside and outside the classroom) at a surface level, without revealing clear meaning or showing a broader perspective about educational or life events.	

2.20 Rubrics for Assessment of Thesis Component

2.20.1 Rubric for Assessment of Thesis

No.	Rubric code	Title	Examiner
1.	RS2-6	Rubric of Student Seminar	Lecturer of Thesis Seminar
2.	RS2-7	Rubric of Thesis Writing	Thesis Supervisor and Thesis Examiner
3.	RS2-8	Rubric of Publication Manuscript Writing	Thesis Supervisor and Thesis Examiner
4.	RS2-9	Rubric of Thesis Exam	Thesis Examiner
5.	RS2-10	Rubric of Conducting Research Skills	Thesis Supervisor

2.20.2 Components of Final Assignment Grade

No.	Code	Course	Credit	Components of Grade
1.	MKK 6901	Thesis Seminar	1	RS2-6
2.	MKK 6902	Thesis Research	4	RS2-7, RS2-8, and RS2-10
3.	MKK 6903	Thesis	3	RS2-7, RS2-8, and RS2-9

2.20.3 Calculation of Final Score

1. MKK 6901 Thesis Seminar

No.	Component	Rating	Score	Score*rating
1.	The average score of RS2-6 Rubric of seminars	2		
2.	Active in discussion (passive = 2; moderate = 3; active = 4)	1		
3.	Attendance (<60% = 2; 60%-80% = 3;> 80% = 4	1		
Total Score				
Average Score = Total Score/4				

2. MKK 6902 Thesis Research

No.	Component		Score		Total
			Supervisor I	Supervisor II	
Eligibility Exam					
1.	RS2-6	Rubric of Thesis Seminar			
2.	RS2-7	Rubric of Thesis Writing			
3.	RS2-8	Rubric of Publication Manuscript Writing			
Closed Exam					
4.	RS2-7	Rubric of Thesis Writing			
5.	RS2-8	Rubric of Publication Manuscript Writing			
6.	RS2-10	Rubric of Research Skill			
Total Score					
Average Score = Total Score/12					

3. MKK 6903 Thesis

No.	Component	Score		Total
		Examiner I	Examiner II	

Eligibility Exam					
1.	RS2-6	Rubric of Thesis Seminar			
2.	RS2-7	Rubric of Thesis Writing			
3.	RS2-8	Rubric of Publication Manuscript Writing			
Closed Exam					
4.	RS2-7	Rubric of Thesis Writing			
5.	RS2-8	Rubric of Publication Manuscript Writing			
6.	RS2-9	Rubric of Thesis Exam			
Total Score					
Average score = Total score/12					

3. Guidelines for Final Score Determination

Score	Score
A	**≥ 3.80**
A/B	**3.25 – 3.79**
B	**2.75 – 3.24**
B/C	**2.01 – 2.75**
Failed	**≤ 2.00**

2.20.4 Rubric RS2-6: Rubric for Seminar

No.	Attributes	Inadequate	Average	Admirable	Extraordinary	Score
		Score = 1	Score = 2	Score = 3	Score = 4	
Knowledge and content						
1.	**Presentation organization**	1. Difficult to follow; information orders are misplaced	2. Most of the information is presented sequentially	3. Information is presented in a logical	4. Information is presented as a logically	

				order and is easy to follow	interesting story, easy to follow sequences	
2.	**Background**	5. The material is not clearly related to the topic, or the seminar is dominated by background	6. Materials are sufficient for clear understanding but not clearly presented	7. Materials are sufficient for clear understanding and presented effectively	8. Materials are sufficient for clear understanding and very well presented	
3.	**Method**	9. The method is too short, or the understanding is insufficient or too detailed	10. Sufficient for understanding but not clearly presented	11. Sufficient for understanding and effectively presented	12. Sufficient for understanding and very well presented	
4.	**Results (number, graph, table, etc.)**	13. Some figures are hard to read 14. Some of the formats are not correct 15. Lack of explanation for some description	16. Generally clear figures 17. In general, the format is correct 18. In general, an explanation is given.	19. Most of the figures are clear 20. Most of the formats are correct 21. Well explained.	22. All figures are clear 23. All the formats are right 24. Very well explained	
5.	**Work contribution**	Significance is not stated or only hinted	Significance is mentioned	Significance is explained	Significance is very well explained	
6.	**Knowledge about subject**	Do not understand information; answer imperfectly	Understand information; answer most questions	Mastering information; answered all the questions but failed to understand more deeply	Demonstrate full knowledge; answer all questions with elaboration	
	Presentation skill					
7.	**Graphics (Powerpoint usage)**	Using graphics that do not support text and presentation	Using graphics related to the text and presentations	Using those graphics to explain text and presentations	Using graphics to explain and amplify text and presentations	
8.	**Mechanics**	Lots of misspellings and/or grammatically mistakes	Few misspellings and/or grammatical errors	Very few spelling and/or grammatical errors	Almost no misspellings and/or grammatical errors	

9.	**Eye contact**	Reads most of the slides, no or only occasional eye contact	Refer to slides for pointing out discussion and occasional eye contact.	Refer to slides to show discussion points and almost always make eye contact.	Refer to slides to show discussion points and always make eye contact with listeners.	
10.	**Voice intonation**	Incorrect use of some words, unclear pronunciation (hard to be heard)	Incorrect use of some words, fluctuating intonation, and unclear pronunciation (hard to be heard)	Most of the terms are correct, and clear voices can be heard almost completely	Pronunciation of all terms is correct, the voice is clear and heard well at any time	
11.	**Duration and timing**	Short; less than 15 minutes Fast pace	Short, 15 minutes or long > 30 minutes, Intermediate fast pace	Enough 20-35 minutes, Almost throughout the seminar, the timing is good	Exactly (25-30 minutes), The timing is good throughout the seminar	
Total score						
Average score= Total score/11						

2.20.5 Rubric RS2-7 for Thesis Writing

No.	Attributes for thesis writing	Not fulfilling expectation	Fulfilling expectation	Exceeded expectations	Score
		Score = 2	Score = 3	Score = 4	
Overall scientific quality					
1.	**Argumentation**	Arguments are incorrect, incoherent, or flawed	Coherent and clear arguments	Very good arguments	
2.	**Defining goals**	Goals are not well defined	Goals are clear	Goals are well defined	
3.	**Critical thinking skills**	Demonstrate rudimentary critical thinking skills	Demonstrate average critical thinking skills	Demonstrate maturity and critical thinking skills	
4.	**Understanding of research materials**	It does not reflect an understanding of research material and related literature	Reflects an understanding of the research material and related literature	Demonstrate mastery of research materials and related literature.	
5.	**Understanding of theoretical concepts**	Demonstrate poor understanding of theoretical concepts	Demonstrate understanding of theoretical concepts	Demonstrate mastery of theoretical concepts	

6.	**Research originality**	Show limited originality	Show originality	Show outstanding originality	
7.	**Creativity and insight**	Show limited creativity and insight	Show creativity and insight	Show outstanding creativity and insight	
Contribution to the discipline of Chemistry					
8.	**Invention**	Limited invention evidence	There is some evidence of invention	Outstanding invention evidence	
9.	**Development from previous research**	Limited expansion in previous research	Built based on previous research	Greatly expand on previous research	
10.	**Theoretical significance**	Limited theoretical or applied significance	Reasonable theoretical or applied significance	Outstanding theoretical or applied significance	
11.	**Impact of publication**	Limited publication impacts	Fair publication impacts	Great publication impacts	
Writing quality					
12.	**Writing**	Not good writing	Adequate writing	Publication-quality writing	
13.	**Grammar and spelling mistakes**	Lots of grammar and spelling mistakes	Some clear grammar and spelling mistakes	No grammar or spelling mistakes	
14.	**Writing organization**	Writing organization is not good	Logical organization	Very good organization	
Total Score					
Average Score = Total Score/14					

2.20.6 Rubric RS2-8 Rubric for scientific writing

No.	Criteria	Unacceptable	Acceptable	Good	Very Good	Score
		Score = 1	Score = 2	Score = 3	Score = 4	
1.	Aim	• The purpose or argument is generally not clear.	• The main purpose or argument is not consistently clear throughout the writing	• The writing has a clear purpose or argument but sometimes gets out of line	• The main purpose or argument of the author is easy to understand.	
2.	Content	• The main purpose or argument is not clearly identified. • Unclear analysis or no evidence. • Readers are confused or may be misinformed.	• Information supports the main objective or argument at all times. • Analysis is basic or general. • Readers gain some insight.	• Information that makes sense to support the main objective or argument and presents significant basic analytical evidence. • Readers gain some insight.	• Balanced presentation • Relevant and legitimate information supports the main objective or argument and demonstrates an in-depth analysis of a significant topic. • Readers gain important insights	
3.	Organization	• The writing is not logically organized • Ideas do not make sense. • The reader cannot identify the line of reasoning and loses interest.	• In general, the writing is arranged logically • Sometimes ideas do not make sense. • The reader is quite clear about what the author means.	• The ideas are logically arranged to support the main purpose or argument • The ideas are usually clearly related to each other. • Most readers can follow the line of reasoning	• Ideas are arranged logically to support a goal or argument. • The ideas flow smoothly from one to another and are clearly related to one another. • Readers can follow the flow of reasoning	
4.	Feel	• The writing has a bit of personality. • Readers quickly lose interest and stop reading.	• The writing is boring and not challenging. • Even though the paper has several interesting sections, readers find it difficult to maintain interest.	• Writing is generally interesting, but has some dry parts. • In general, stay focused and keep the reader's attention.	• The writing is very interesting. • Attracts the reader and is interested in all parts of the paper.	

5.	**Tone**	• The tone is unprofessional. • Not suitable for academic research papers	• The tone is not consistently professional or appropriate for an academic research paper	• Generally, it has a professional tone. • For the most part, it is appropriate for academic research papers.	• Consistent professional tone and appropriate for an academic research paper	
6.	**Structure of sentence**	• Errors in sentence structure are quite frequent and become a big annoyance for readers.	• Some sentences feel awkward so that the reader is occasionally disturbed	• Sentences are well-phrased, and there is some variation in length and structure. • The flow of sentences is generally smooth.	• Sentences are well expressed and vary in length and structure. • The writing flows smoothly from one section to another.	
7.	**Word choice**	• Many words are used incorrectly, confusing the reader.	• The choice of words is only adequate, and the range of words is limited. • Some words are used incorrectly.	• The choice of words is generally good. • Writers often go beyond generic words to find the right and effective word	• Consistently precise and accurate word choice	
8.	**Grammar, Spelling, Writing**	•	• The writing has many errors, and the reader can be distracted.	• There are occasional errors, but they are not very distracting or obscure.	• The writing is free or almost free from error	
9.	**Length**	• The Paper has more or less pages than specified in the assignment.	•	•	• The Paper has the number of pages as specified in the assignment.	
10.	**References usage**	• Infrequently cited references to support statements	• Despite the occasional attribution, many statements seem unfounded.	• Professionally legitimate sources support claims and are generally presented	• Attractive evidence from professionally valid sources is provided to support claims.	

			• Readers are confused about sources of information and ideas.	and attributed clearly and fairly.	• Attribution is clear and fairly represented	
11.	**Reference quality**	Almost no professionally reliable source. • Readers strongly doubt the value of the material and stop reading	• Most references come from sources that are not peer-reviewed and of uncertain reliability. • Readers doubt the accuracy of most of the material presented	• Although most references are professionally legitimate, few are questionable (e.g., trade books, internet resources, popular magazines, ...). • Readers are unsure of the reliability of some sources.	• References are taken from peer-reviewed professional journals or other approved sources • The reader believes that the information and ideas can be trusted.	
12.	**Reference format usage**	• Incorrect document format.	• Frequent errors in formatting.	• The format is used with minor errors	• Formats are used accurately and consistently in the paper and on the "Reference" page.	

2.20.7 Rubric RS2-9 for Thesis Examination

No.	Attributes for oral exams	Not fulfilling expectations Score = 2	Fulfilling expectations Score = 3	Exceeding expectations Score = 4	Score
Overall presentation quality					
1.	**Organization**	The organization is not good	The organization is clear	well organized	
2.	**Presentation**	The presentation is not good	The presentation is clear	Professional presentation	
3.	**Communication skills**	Poor communication skills	Good communication skills	Very good communication skills	
4.	**Slide**	Slides and handouts are hard to read	Clear slides and handouts	Great slides and handouts	

Overall breadth of knowledge					
5.	**Presentation content**	The presentation cannot be understood	Presentation is understandable	Easy-to-understand and attractive presentation	
6.	**Depth of knowledge**	The presentation reveals important weaknesses in the depth of knowledge in the research material	The presentation reveals some depth of knowledge in the research material	The presentation reveals an incredible depth of knowledge in research material	
7.	**Critical thinking skills**	The presentation does not reflect well-developed critical thinking skills	The presentation reveals average critical thinking skills	The presentation also reveals the development of critical thinking skills	
8.	**Scope of insight**	Narrow scope of presentation	Presentations reveal the ability to draw knowledge from several disciplines	Presentations reveal the ability to connect and expand knowledge from multiple disciplines	
Quality in responding to inquiries					
9.	**Feedback quality**	Incomplete response or need help	Full response	Fluent response	
10.	**Argumentation**	Arguments are poorly presented	Well organized argument	Arguments skillfully presented	
11.	**Mastery of research materials**	Demonstrate a lack of knowledge in the research area	Respondents demonstrate adequate knowledge in the researched field	Respondents demonstrate superior knowledge in the researched field	
12.	**Feedback weight**	The response does not meet the level expected of the master's program	Responses meet the level expected of the master's program	The response exceeds the level expected of the master's program	
Total score					
Average score = Total core/12					

2.20.8 Rubric RS2-10 for Rubric Conducting Research Skill

No.	Criteria	Insufficient: fail to meet academic requirements	Satisfying: meet academic requirements	Good: in the top 10%	Score
		Score = 2	Score = 3	Score = 4	
Ability to do research					
1.	Research/experimental plan design	• Carry out the plan made by the supervisor only	• Propose a new valid trial based on previous results • Have creative ideas	• Propose many relevant new experiments (with proper controls) • A sense of "owning" research, having creative and original ideas	
2.	Data analysis and interpretation	• Rely on the supervisor for correct interpretation of results • Invalid statistical analysis	• Provide analysis of correct interpretation of results at later stages of the project • Statistical analysis is correct	• Provide correct analysis and interpretation of results from the start of the project • Understanding implications	
3.	Discussion of research results (own results and other results)	• Barely participates in the discussion • Failing to put research into perspective	• Participate in discussions • Discussion in light of the (latest) literature	• Important and sometimes leads during discussions. • Stay on top of the latest literature	
Laboratory practice skills					
4.	Technical skills	• Failed to master technical/lab skills • Failed to apply technique independently	• Mastering requires technical/lab skills • Applying the technique independently	• Have excellent technical ability • Finding and mastering new technical approaches, improving existing procedures	
5.	Efficiency	• The waiting time in the protocol is spent inefficiently	• Uses timeouts to prepare buffers, reads, etc.	• Run parallel experiments to use time efficiently and effectively	
6.	Organization Laboratory journals / notes / work records	• Poorly organized • Required information is missing	• Well organized • All necessary information is available	• Well organized • It is possible to repeat the experiment based on the information provided easily	

7.	Workplace organization/ Use of application safety protocols/instructions/regulations	• Messy workplace • Failed to clean the equipment after use • Not following guidelines and protocols	• Workplace tidy up regularly • Clean equipment after use • Following guidelines and protocols	• Always clean workplace • Equipment is always clean • Suggest improvements to the protocol	
Professional Behavior					
8.	Initiative, independence, Creativity, feedback handling	• Multiple feedback sessions required • Rely on the guide's instructions only • Minimal improvements based on feedback	• Regular feedback sessions required • Taking the initiative (initially) after being stimulated • Feedback leads to reasonable improvement	• The amount of feedback required is minimal • Consult with experts outside the group in consultation with supervisors, design most projects • Finding relevant new literature • Response to feedback results in excellent improvement	
9.	Critical attitude	• There is no critical attitude • No self-reflection	• Demonstrate self-reflection and have a critical attitude towards research (published)	• Critical attitude is based on intellectual depth and depth	
10.	Integrity, Awareness	• Data manipulated or abandoned	• Accurate, reliable, and trustworthy, demonstrating awareness of the confidentiality of information	• Accurate, reliable, and trustworthy, demonstrating awareness of the confidentiality of information	
11.	Perseverance, Dedication	• Loss of motivation when experiment/research fails	• Repeat the experiment until satisfactory results are obtained	• persevering, but knowing when to stop	
12.	Communication with coworkers	• Thinking he is the only worker in the laboratory	• Taking into account the needs of colleagues • Communicating with colleagues, e.g., Sharing equipment	• Know when to ask • Accept, communicate and learn from your own failures	

13.	Punctuality	• Failed to meet the deadline • Failed to keep appointments	• Meet most of the deadlines • Keep promise	• Set your own deadline and stick to it • Schedule appointments when needed	
Total score					
Average score = Total score/13					