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Curriculum

Module title / Moduls Code	CP	Semester			
		1	2	3	4
1. Introduction to Principles of Sustainability SuC-MC1	6	Le Se			
2. M. Sc. Seminar: New Frontiers in Chemical Sustainability SuC-MC2	6	Se			
3. Principles of Green Chemistry: Sustainability of Organic Reactions SuC-MC3	6	Le Ex			
4. Optional Module*	6				
5. Optional Module*	6				
CP 1st semester	**30**				
6. Sustainable inorganic chemistry: criticality, synthesis, substitution, and recovery SuC-MC4	6		Le Ex		
7. Sustainable Energy Technologies SuC-MC5	6		Le Ex		
8. Circular Economy SuC-MC6	6		Le Ex		
9. Optional Module*	6				
10. Optional Module*	6				
CP 2nd semester	**30**				
11. Research module 1 (in chemistry) SuC-MC7	10			Pr Se	
12. Research module 2 (in any group) SuC-MC8	10			Pr Se	
13. Laboratory Project SuC-MC9	10			Pr Se	
total CP 3rd semester	**30**				
14. Thesis SuC-MC10	30				Th
CP 4th semester	**30**				
Total	**120**				

Le=Lecture
Se=Seminar
Ex=Exercise
Pr=Practice
Th=Thesis

* The optional modules are to be chosen from the offered optional modules of the Master's programme M.Sc. Chemistry (see Annex 2 of the Special Regulations for the Master's programme Chemistry of the Faculty 08 - Biology and Chemistry - of the Justus Liebig University Giessen of 16.02.2022 i n the currently valid version)

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Module Descriptions

SuC-MC1	**Introduction to Principles of Sustainability** **Einführung in die Prinzipien der Nachhaltigkeit**	6 CP
Core module	08 / Chemistry / Physical Chemistry, Organic Chemistry, Inorganic and Analytic Chemistry First offered in winter 2024/25	1st semester

Academic objectives:

Students can
- discuss the different declinations of sustainability on a scientific as well as a socio-economic level;
- address the challenges posed by climate changes & global warming, resource depletion; general environmental issues in a holistic and interconnected approach;
- perform a critical analysis of current state of the art and literature in the field of sustainability;
- address the complexity of sustainability by correlating in a holistic view different aspects and concepts related to apparently far disciplines (e.g., chemistry and economics).

Content:
- basics concepts of sustainability, starting from an historical perspective and providing different declinations of chemistry related sustainability (e.g., but not limited to, circular economy, resource depletion, raw materials criticality, global warming)
- complexity and interdependencies underpinning the concept of sustainability (e.g., relationships between global warming and chemical processes)

Module frequency and duration: each year, 1 Semester (winter)

Professorship or position responsible for module coordination: Professor of Physical Chemistry, Professor of Organic Chemistry, Professor of Inorganic Chemistry*

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module, M.Sc. Chemistry / optional module

Participation prerequisites: none

Course:	Contact hours	Preparation and follow-up work
Lecture	45	90
Seminar	15	30
Total:	180	

Examination requirements: none

Module examinations:
- Type of examination: oral exam (20-40 min) or oral presentation (20-40 min) or written exam (90-120 min)
- Module grade: oral exam or oral presentation or written exam, 100%

Language of tuition and examination: English

Notes: *currently: Prof. Dr. Bernd Smarsly, Prof. Dr. Richard Göttlich, Prof. Dr. Klaus Müller-Buschbaum

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SuC-MC2	**M.Sc. Seminar: New Frontiers in Chemical Sustainability** **M.Sc. Seminar: Aktuelle Themen der chemischer Nachhaltigkeit**	6 CP
Core module	08 / Chemistry / Organic Chemistry, Physical Chemistry First offered in winter 2024/25	1st semester

Academic objectives:

Students can

- familiarize themselves independently with the context of a selected topic from current research in the field of sustainable chemistry;
- independently conduct a search to obtain the scientific knowledge required to solve a subtask (databases, literature research, etc.);
- summarize the state-of-the-art in the current literature;
- explain a current research topic in a larger context and present it;
- conduct a scientific discussion about a specific topic in the field of sustainable chemistry.

Content:

- project work with chemical content within framework of current research work on a topic of sustainable chemistry

Module frequency and duration: each year, 1 Semester (winter)

Professorship or position responsible for module coordination: Professor of Organic Chemistry, Professor of Physical Chemistry*

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module, M.Sc. Chemistry/optional module

Participation prerequisites: none

Course:	Contact hours	Preparation and follow-up work
Seminar	60	75
Self-structured work	45	
Total:	180	

Examination requirements: none

Module examinations:

- Type of examination: oral presentation (20-40 min) or report (20-30 pages)
- Module grade: oral presentation or report (100%)

Language of tuition and examination: English

Notes: *currently: Prof. Dr. Richard Göttlich, Prof. Dr. Bernd Smarsly

SuC-MC3	**Principles of Green Chemistry: Sustainability of Organic Reactions** **Prinzipien der „Green Chemistry“: Nachhaltigkeit organischechemischer Reaktionen**	6 CP
Core module	08 / Chemistry / Inorganic Chemistry, Organic Chemistry First offered in winter 2024/25	1st semester

Academic objectives:

Students can

- evaluate reactions and processes based on the principles of Green Chemistry;
- correlate sources and available technologies for designing sustainable organic chemical processes;
- design alternative (sustainable) modes of performing organic chemical transformations;
- correlate quantitative and qualitative measures to evaluate the sustainable potential of chemical processes;
- define major sources of biomass and their valorisation for useful chemicals and materials;
- identify and evaluate the environmental parameters of a chemical process;
- design sustainable organic chemical processes and circular processes;
- analyse the influence of reaction components and isolation procedures on the sustainable parameters of a chemical process.

Content:

- basic concepts of green chemistry and the evolution of the field.
- overview of alternative modes of activation of chemical reactions (i.e., microwaves, ultrasound, light), their mode of action and use in organic chemistry
- principles of photochemistry and photocatalysis for the synthesis of organic molecules
- application of mechanochemistry for selective transformations of organic molecules
- principles of electrochemistry and their application in organic synthesis
- flow systems and microreactors for synthesis
- homogeneous and heterogeneous catalysts for the development of sustainable chemical processes
- valorization of the use of organic solvents and an overview of the development of alternative solvents (new solvents from biomass resources, ionic liquids, deep eutectic salts, water...)
- biomass as a source of chemicals and an analysis of the sustainable use of biomass
- biorefinery concept for valorization of biomass to useful chemicals and materials
- green chemistry metrics for valorization of chemical reactions and processes
- quantitative and qualitative evaluation of the environmental potential of chemical processes

Module frequency and duration: each year, 1 Semester (winter)

Professorship or position responsible for module coordination: Professor of Organic Chemistry*

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module, M.Sc. Chemistry/optional module

Participation prerequisites: none

Course:	Contact hours	Preparation and follow-up work
Lecture	60	75
Exercise	15	30
Total:	180	

Examination requirements: none
Module examinations: – Type of examination: written exam (90-120 min) or oral exam (20-40 min) – Module grade: written exam or oral exam (100%)
Language of tuition and examination: English
Notes: *currently: Prof. Dr. Hermann A. Wegner

SuC-MC4	**Sustainable inorganic chemistry: criticality, synthesis, substitution and recovery** **Nachhaltige Anorganische Chemie: Kritikalität, Synthese, Substitution und Rückgewinnung**	6 CP
Core module	08 / Chemistry / Inorganic and Analytic Chemistry First offered in summer 2025	2nd semester

Academic objectives:

Students can:

- acquire knowledge of sustainability criteria in inorganic chemistry;
- learn about important synthesis methods of inorganic chemistry in the context of sustainability;
- know and understand most important structure - syntheses relations and draw conclusions for structure-property relations of inorganic materials for substitution;
- apply advanced methods and concepts of describing chemical and physical properties of sustainable inorganic compounds and present the results;
- apply principles and concepts of qualitative and quantitative developments of sustainable chemistry to inorganic compounds;
- understand and describe the life-time of inorganic materials, including critical resources;
- learn about methods of inorganic chemistry for the recovery of critical elements;
- understand and evaluate recovery for state of the art and new recycling processes.

Content:

- sustainability criteria in inorganic chemistry
- sophisticated synthesis methods of inorganic chemistry in the context of sustainability
- structure-syntheses relations, structure-properties in sustainable inorganic chemistry
- chemical and physical properties of sustainable inorganic compounds,
- principles and developments of sustainable chemistry of inorganic compounds
- critical resources, life-time, substitution,
- recovery, recycling, and urban mining of critical resources

Module frequency and duration: each year, 1 semester (winter)

Professorship or position responsible for module coordination: Professors of Inorganic Chemistry*

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module, M.Sc. Chemistry/optional module

Participation requirements: none

Course:	Contact hours	Preparation and follow-up work
Lecture	45	45
Exercise	15	30
Self-structured work	45	
Total:	180	

Examination requirements: none

Module examination: – Type of examination: written exam (90-120 min) or oral exam (20-40 min) – Module grade: written exam or oral exam (100%)
Language of tuition and examination: English
Notes: *currently: Prof. Dr. Klaus Müller-Buschbaum, Prof. Dr. S. Schindler, Prof. Dr. Maren Lepple

SuC-MC5	**Sustainable Energy Technologies** **Nachhaltige Energietechnologien**	6 CP
Core module	08 / Chemistry / Physical Chemistry First offered in summer 2025	2nd semester

Academic objectives:

Students can:

- apply basic concepts and fundamental principles of thermodynamics and kinetics to energy storage and conversion systems and methods;
- name, understand and discuss the basics of modern technologies for energy storage, conversion, and transport, especially battery concepts, thermoelectric generators, photovoltaics, electrolysis (water splitting), fuel cells;
- demonstrate their knowledge of different new technology devices, understand their principles, and appreciate their differences;
- analyze, interpret and discuss experimental data of important energy technologies;
- define suitable experiments to classify the performance of energy storage and conversion devices;
- determine and discuss sustainability parameters of modern energy technologies, appreciate important novel developments in these technologies.

Content:

- thermodynamic, physical and kinetic fundamentals of energy storage and conversion
- energy harvesting:
  - fundamentals of solar technologies: Solar heat; Photovoltaics: charge carrier generation and transport in different types of solar cells
  - fundamentals of mechanical technologies: Wind energy, Tidal power plants
  - fundamentals of thermal technologies: Heat pumps
- thermoelectrics
- energy storage, transport and conversion:
  fundamentals of electrochemical storage: Galvanic cells, batteries, electrolytes, electronic and ionic transport; Experimental electrochemical methods; Electrolysis (H_2 …)
  - mechanical storage (Pumped hydro, pumped air)
  - thermal storage
  - (bio)chemical storage
- key chemical subjects and challenges: Secondary batteries (also beyond Lithium-based batteries, e.g., redox-flow concepts), fuel cells, solar cells, photo catalysis, electrolysis (water splitting)

Module frequency and duration: each year, 1 semester (summer)

Professorship or position responsible for module coordination: Professors of Physical Chemistry*

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module, M.Sc. Chemistry/optional module

Participation requirements: none

Course:	Contact hours	Preparation and follow-up work
Lecture	45	45

Exercise	30	60
Total:	180	
Examination requirements: none		
Module exam: – Type of examination: written exam (90-120 min) or oral exam (20-40 min) – Module grade: written exam or oral exam (100%)		
Language of tuition and examination: English		
Notes: *currently: Prof. Dr. Bernd Smarsly, Prof. Dr. Jürgen Janek, Prof. Dr. Herbert Over		

SuC-MC6	**Circular Economy** **Chemische Wertstoffkreisläufe**	6 CP
Core module	08 / Chemistry / Organic Chemistry, Inorganic and Analytic Chemistry First offered in summer 2025	2nd semester

Academic objectives:

The students can

- discuss consequences of circular economy for chemical production and processes;
- apply basic concepts of chemistry to recycling processes and regeneration of relevant chemicals;
- analyze and interpret the single chemical and processing steps in the generation of compounds; comprising the entire chain starting from the raw materials to the final products;
- analyze, interpret and discuss relevant chemical parameters (yield, energetic costs, etc.) of important chemical substances and compounds in regard to their recycling;
- name and discuss recovered substance cycles for important chemical goods;
- determine and discuss sustainability parameters of chemical processes;
- discuss why certain compounds are difficult to recycle;
- discuss the pros and cons of renewable resources for chemical processes
- create and evaluate recycling concepts.

Content:

- current technologies and the respective relevant chemicals/compounds: resources, mining, production
- critical elements and compounds: abundance, exploitation, processing and usage
- closed-loops and recycling of important compounds: Energy balance and energy efficiency
- life cycle of materials and substances in emerging mass technologies
- renewable resources

Module frequency and duration: each year, 1 semester (summer)

Professorship or position responsible for module coordination: Professor of Organic Chemistry, Professors of Inorganic Chemistry*

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module, M.Sc. Chemistry/optional module

Participation prerequisites: none

Course:	Contact hours	Preparation and follow-up work
Lecture	45	45
Exercise	30	60
Total:	180	

Examination requirements: none

Module examination:

- Type of examination: written exam (90-120 min) or oral exam (20-40 min) (100%)
- Module grade: written exam or oral exam (100%)

Language of tuition and examination: English
Notes: *currently: Prof. Dr. Peter Schreiner, Prof. Dr. Maren Lepple

SuC-MC7	**Research module 1 (in Chemistry)** **Forschungsmodul 1 (Chemie)**	10 CP
Core module	08 / Chemistry First offered in winter 2025/26	3rd semester

Academic objectives:

The students are able to

- discuss the project results in context of current literature;
- make predictions regarding their project and to plan and execute new research;
- gather, present and defend project results.

Content:

- collaboration on a project in a research group of the Chemistry department
- work on literature related to the project
- planning and executing research
- discussion regarding the project with co-workers and professors
- compile a project report and a presentation

Module frequency and duration: each year, 1 semester (winter), 8 weeks full-time

Professorship or position responsible for module coordination: Professors of the Chemistry department

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module

Participation prerequisites: 5 out of 6 core modules from semester 1 and 2 need to be passed

Course:	Contact hours	Preparation and follow-up work
Practice	150-220	30-60
Seminar	8-16	10-20
Total:	300	

Examination requirements: none

Module examination:

- Type of examination: report (15-25 pages) and oral presentation (20-40 min)
- Re-exam: Revision of report and/or revision of oral presentation
- Module grade: report (50%), oral presentation (50%)

Language if tuition and examination: English

Notes:

SuC-MC8	**Research module 2 (in any group)** **Forschungsmodul 2 (in einer beliebigen Arbeitsgruppe)**	10 CP
Core module	08 / Chemistry First offered in winter 2025/26	3rd semester

Academic objectives:

The students are able to

- discuss the project results in context of current literature;
- make predictions regarding their project and to plan and execute new research;
- gather, present and defend project results.

Content:

- collaboration on a project in a research group
- work on literature related to the project
- planning and executing research
- discussion regarding the project with co-workers and professors
- compile a project report and a presentation

Module frequency and duration: each year, 1 semester (winter), 8 weeks full-time

Professorship or position responsible for module coordination: Professors of the Chemistry department

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module

Participation prerequisites: 5 out of 6 core modules from semester 1 and 2 need to be passed

Course:	Contact hours	Preparation and follow-up work
Practice	150-220	30-60
Seminar	8-16	10-20
Total:	300	

Examination requirements: none

Module examination:

- Type of examination: report (15-25 pages) and oral presentation (20-40 min)
- Re-exam: Revision of report and/or revision of oral presentation
- Module grade: report (50%), oral presentation (50%)

Language if tuition and examination: English

Notes:

SuC-MC9	**Laboratory Project** **Laborprojekt**	10 CP
Core module	08 / Chemistry First offered in winter 2025/26	3rd semester

Academic objectives:

The students are able to

- assess and interpret deeper scientific relationships and own research results;
- independently access and grasp sophisticated literature;
- develop an own approach to a solution for scientific problems and use appropriate methods;
- plan and execute a scientific project independently.

Content:

Additional questions from current research of the working group:

- independent work on literature
- independent planning and execution of research
- development of a project, preparation of a task schedule, execution
- project defence

Module frequency and duration: each year, 1 semester (winter), 8 weeks full-time

Professorship or position responsible for module coordination: Professors of the Chemistry department

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module

Participation prerequisites: 5 out of 6 core modules from semester 1 and 2 and research module 1 need to be passed

Course:	Contact hours	Preparation and follow-up work
Practice	150-220	30-60
Seminar	8-16	10-20
Total:	300	

Examination requirements: none

Module examination:

- Type of examination: report (15-25 pages) and oral presentation (20-40 min)
- Re-exam: Revision of report and/or revision of oral presentation
- Module grade: report (50%), oral presentation (50%)

Language if tuition and examination: English

Notes:

SuC-MC10	**Thesis**	30 CP
	Thesis	
Core module	08 / Chemistry	4th semester
	First offered in summer 2026	

Academic objectives:
The students have the competence to independently work out and complete a project based on a specific task from a field of sustainable chemistry, using scientific methods, evaluating and interpreting their results, and presenting and defending them as scientific work.

Content:
- conception of a work plan
- familiarization with the literature
- development of measurement and evaluation methods, implementation and evaluation, discussion of the results
- preparation of the thesis
- put own work in the context of other scientific results and applications

Module frequency and duration: each year, 1 semester (summer), approx. 6 months full-time

Professorship or position responsible for module coordination: Professors of the Chemistry department

Applicable to following study programs: M.Sc. Sustainable Chemistry/core module

Participation prerequisites: 5 out of 6 core modules from semester 1 and 2 and research module 1 need to be passed

Course:	Contact hours	Preparation and follow-up work
Scientific work	780	120
Total:	900	

Examination requirements: none

Module examination:
- Type of examination: thesis (50-100 pages) and defense (oral exam, 30 - 60 min)
- Re-exam: newly made thesis according to AIIB §21
- Module grade: thesis (70%), defense (oral exam) (30%)

Language if tuition and examination: English

Notes: