Please note that only the German version of the modules is official and legally binding. The English version is for informative purposes only.

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. Sustainability of Organic Reactions: Principles of Green Chemistry: 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:

The students
- can discuss the different declinations of sustainability on a scientific as well as a socio-economic level,
- can address the challenges posed by climate changes and global warming as well as resource depletion and understand general environmental issues in a holistic and interconnected approach,
- can perform a critical analysis of current state of the art and literature in the field of sustainability,
- can 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),
- know the relevant standards and regulations on sustainability and sustainability assessments for Germany and the EU and can apply them.

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)
- relevant standards and regulations on sustainability for Germany and the EU
- 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

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

Academic objectives:

The 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 including carrying out a sustainability assessment

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

Professorship or position responsible for module coordination: Professor of Organic Chemistry, Professor of Inorganic and Analytic 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. Klaus Müller-Buschbaum, Prof. Dr. Bernd Smarsly

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

Academic objectives:

The students can

- analyse and evaluate organic-chemical processes based on the relevant sustainability standards for Germany and the EU,
- evaluate reactions and processes according to the principles of green chemistry and categorise them in the context of sustainability,
- 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 as a subfield of sustainable chemistry
- 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
- relevant sustainability standards for Germany and the EU
- 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:

The students can

- recognise and apply sustainability criteria in inorganic chemistry based on the relevant standards for Germany and the EU,
- evaluate important synthesis methods in inorganic chemistry in the context of sustainability,
- apply principles and concepts of qualitative and quantitative developments in sustainable chemistry to inorganic compounds,
- understand and describe the lifespan of inorganic materials,
- understand and evaluate criticality for inorganic compounds including the criteria of critical resources and possibilities for substitution and reduction,
- describe and evaluate inorganic chemistry methods for recovering critical elements including urban mining,
- understand and evaluate the importance of developing new recycling processes for a circular economy,
- apply advanced methods and concepts such as green inorganic chemistry, carry out sustainability assessments and present the results.

Content:

- sustainability criteria in inorganic chemistry
- synthesis methods of inorganic chemistry in the context of sustainability including large-scale production processes (e.g. basic elements, metals, semiconductors and selected compounds)
- structure-synthesis relations, structure-properties of sustainable and green inorganic chemistry
- principles and developments of sustainable chemistry of inorganic compounds
- critical resources, life-time, substitution, reduction with reference to inorganic chemistry (raw material extraction of inorganic minerals, the problem of so-called "rare earths", use of inorganic resources in future technologies, e.g. electromobility and renewable energies, batteries, PV, wind turbines, LEDs)
- recovery, recycling, and urban mining of critical inorganic resources
- technical examples of circular economy (e.g. lead batteries, precious metal recovery)

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. 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:

The students can

- apply basic concepts and fundamental principles of thermodynamics and kinetics to energy storage and conversion systems and methods,
- recognise and evaluate international and national sustainability criteria in the field of energy technologies,
- apply thermodynamic variables as parameters for sustainability in energy processes,
- 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,
- define suitable experiments to classify the performance of energy storage and conversion devices,
- determine and discuss sustainability parameters of modern energy technologies as well as 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, Professor of Inorganic 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
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 Sustainable Chemistry)** **Forschungsmodul 1 (in Nachhaltiger Chemie)**	10 CP
Core module	08 / Chemistry First offered in winter 2025/26	3rd semester

Academic objectives:

The students are able to

- discuss the results of a project directly related to sustainable chemistry in the context of the current literature,
- make predictions regarding their project and to plan and execute new research,
- gather, present and defend project results,
- carry out sustainability assessments based on standards and regulations relevant to Germany and the EU.

Content:

- collaboration on a project directly related to sustainable chemistry 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 including sustainability assessment for the implemented project

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 with a focus on sustainability)** **Forschungsmodul 2 (in einer Arbeitsgruppe zum Thema Nachhaltigkeit)**	10 CP
Core module	08 / Chemistry First offered in winter 2025/26	3rd semester

Academic objectives:
The students are able to
- discuss the results of a project directly related to sustainable chemistry in the context of the current literature,
- make predictions regarding their project and to plan and execute new research,
- gather, present and defend project results,
- carry out sustainability assessments based on standards and regulations relevant to Germany and the EU.

Content:
- collaboration on a project directly related to sustainable chemistry 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 including sustainability assessment for the implemented project

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 in Sustainable Chemistry** **Laborprojekt Nachhaltige Chemie**	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:

- advanced questions on current research by a working group directly related to sustainable chemistry
- independent work on literature
- independent planning and execution of research
- development of a project, preparation of a task schedule, implementation including sustainability assessment for the implemented project
- 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** **Thesis**	30 CP
Core module	08 / Chemistry First offered in summer 2026	4th semester

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 including a sustainability assessment
- 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: