Modulhandbuch
für den
Masterstudiengang
Sustainable and Innovative Natural Resource Management

Inhaltsverzeichnis

Abkürzungen

KA: schriftliche Klausur / written exam
MP: mündliche Prüfung / oral examination
AP: alternative Prüfungsleistung / alternative examination
PVL: Prüfungsvorleistung / prerequisite
MP/KA: mündliche oder schriftliche Prüfungsleistung (abhängig von Teilnehmerzahl) / written or oral examination (dependent on number of students)

SS, SoSe: Sommersemester / sommer semester
WS, WiSe: Wintersemester / winter semester

SX: Lehrveranstaltung in Semester X des Moduls / lecture in module semester x

SWS: Semesterwochenstunden

Data:	AHTEM MA Nr. 3708 / Examination number: 52601	Version: 29.06.2020	Start Year: SoSe 2021
Module Name:	**Analysis of High Temperature Processes in Extractive Metallurgy**		
(English):			
Responsible:	Charitos, Alexandros / Prof.		
Lecturer(s):	Charitos, Alexandros / Prof.		
Institute(s):	Institute for Nonferrous Metallurgy and Purest Materials		
Duration:	1 Semester(s)		
Competencies:	The goal of the module is to train the students in the analysis of high temperature processes from a process engineering perspective. After successful completion of the course, the students will be in a position to analyze aformentioned processes with regard to (i) thermodynamics (ii) fluid-dynamics (iii) link the above with unit operations and their mass and heat balances (iv) be able to conduct a short literature research and present results (v) understand troubleshooting methodology associated to these processes.		
Contents:	The lecture is divided to sub-modules: (i) **Brief thermodynamics recap** to aid understanding for the rest of the modules (ii) **Gas-solid reaction processes:** Roasting and calcination – a description of unit operations, Themodynamics – Construction of Kelogg predominance diagrams, Discussion on fluidized bed fluid dynamics, Mass and heat balances (iii) **Reduction processes:** Analysis of ferroalloy production processes with focus on silicon/ ferrosilicon is included amongst other examples, Discussion on the Pidgeon process for the production of magnesium (iv) **Oxidative smelting processes:** The extractive metallurgy of copper / matte smelting fundamentals / bath and flash smelters (mass and heat balances) / P-S converters / fire refining – casting and brief description in electrorefining (v) **Electrolysis in molten salt baths:** Introduction to the Hall Heroult process for aluminium production (vi) **Recycling processes:** Introduction to Li-ion battery and electronic waste recycling processes.		
Literature:	Gaskell D.R., Laughlin D.E.: Introduction to the Thermodynamics of Materials Gilchrist J.D.: Extraction Metallurgy Schlessinger M.E., King M.J., Sole K.C., Davenport W.G.: The extr. metallurgy of copper Schei A., Tuset J.Kr., Tveit H.: Production of High Silicon Alloys Kunii D., Levenspiel O.: Fluidization Engineering		
Types of Teaching:	S1 (SS): Lectures (4 SWS) S1 (SS): Presentation of the assignment / Seminar (1 SWS)		
Pre-requisites:	**Recommendations:** Revision of courses associated to metallurgical thermodynamics		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP*: Assignment KA* [180 min] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP*: Schriftliche Arbeit KA* [180 min]		

	* Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Credit Points:	7
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP*: Assignment [w: 1] KA* [w: 3] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 210h. It is the result of 75h attendance and 135h self-studies.

Data:	BMER MA. / Examination number: 23204	Version: 03.10.2022	Start Year: WiSe 2023
Module Name:	**Biotechnology for Metal Extraction and Recycling**		
(English):			
Responsible:	Hedrich, Sabrina / Prof.		
Lecturer(s):	Hedrich, Sabrina / Prof.		
Institute(s):	Institute of Biosciences		
Duration:	1 Semester(s)		
Competencies:	After successfully completing the module, the students are able to: • describe basics in microbiology and the general concept of microbial lifestyle and metabolism • balance the advantages and limitations of various biohydrometallurgical process options • identify the role of different types of microorganisms in the process and how they catalyze metal recovery and interact with each other and their environment • apply the taught methods and basics to analyze given case studies and present and discuss the results in a seminar		
Contents:	Contents 1. Microbial basics, cell structure, metabolism 2. Energy acquisition, redox reactions, microbial element cycling 3. Microbial habitats and biofilms, extremophiles 4. Biomining microorganisms, iron- and sulfur metabolizing acidophiles 5. Basics of bioleaching and biooxidation, mechanisms 6. Biomining technologies, stirred tank, heap and dump bioleaching, BIOX process 7. Bioleaching of primary and secondary resources, ores, technologies 8. Metal extraction from secondary resources, mine tailings, urban waste, advances in application and technologies 9. Stirred tank bioreactor operation, heap bioleaching, set up and control 10. Biological metal recovery from waste water, iron oxidizing and sulfate reducing microorganism, application examples 11. Biosorption, bioaccumulation, biosynthesis of nanomaterials 12. Analytical methods in biohydrometallurgy		
Literature:	• Michael T Madigan; Kelly S Bender; Daniel H Buckley; W Matthew Sattley; David Allan Stahl, Brock biology of microorganisms, Pearson, 2018. • D. R. Lovley (Ed.): Environmental Microbe-Metal Interactions, ASM Press, 2014. • D.B. Johnson, C.G. Bryan, M. Schlömann, F.F. Roberto (Eds.) - Biomining Technologies. Springer. 2022. • E. R. Donati & W. Sand (Eds.) Microbial Processing of Metal Sulfides, Springer, 2007. • L. G. Santos Sobral, D. Monteiro de Oliveira & C. E. Gomes de Souza (Eds.): Biohydrometallurgical Processes: a Practical Approach, CETEM/MCTI, 2011.		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Seminar (1 SWS)		
Pre-requisites:	**Recommendations:** Bachelor degree in natural science, mining- or metallurgy-related		

	engineering. Basic knowledge in chemistry.
Frequency:	yearly in the winter semester
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA* [60 min] AP*: Case study presentation * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA* [60 min] AP*: Präsentation der Fallstudie * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Credit Points:	4
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA* [w: 2] AP*: Case study presentation [w: 1] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.

Data:	BIOMIN. MA. Nr. 3043 / Examination number: 21006	Version: 27.09.2018	Start Year: WiSe 2019
Module Name:	**Biotechnology in Mining**		
(English):			
Responsible:	Schlömann, Michael / Prof. Dr.		
Lecturer(s):	Schlömann, Michael / Prof. Dr.		
Institute(s):	Institute of Biosciences		
Duration:	1 Semester(s)		
Competencies:	In an interdisciplinary approach the students will obtain an understanding of the general concept of bioleaching for the winning of metals, and specifically of the advantages and problems of various process options. The students will understand the involvement of different types of microbes, the stresses to which the microbes are exposed and how they may react. They will also obtain an understanding of the generation and of the biotechnological treatment options for acidic mine drainage. In a lab course the students will obtain experience with methods and problems related to the cultivation of microorganisms relevant for bioleaching or mine water treatment. They will also gain experience in analytical methods to describe and control corresponding processes. In a seminar the students will gain experience with current literature and with reporting about it to other participants. In addition, the students will exercise to plan a lab-scale bioleaching process.		
Contents:	1. Basics: concepts of microbial energy metabolism, chemolithotrophic growth, diversity of electron donors and acceptors, microbial redox reactions. 2. Processes in conventional metal winning. 3. Basic setup of bioleaching and biooxidation operations: heap leaching, reactor leaching, and their respective advantages and problems. 4. Microorganisms relevant for aerobic bioleaching: relevant properties, taxonomy, communities, succession. 5. Methods for the cultivation and characterization of microbial strains and communities. 6. Microbe-mineral interactions: attachment, bioleaching mechanisms, formation of secondary minerals. 7. Important pathways in energy metabolism and biomass formation: proteins/pathways involved in iron and sulfur oxidation, uptake mechanisms (siderophores), CO_2 fixation, nitrogen metabolism, energetic problems. 8. Environmental challenges for and responses of bioleaching microorganisms: acidity, oxidative stress, metal toxicity, osmolarity, temperature. 9. Current trends for the improvement of aerobic bioleaching: chalcopyrite bioleaching, bioleaching of arsenic containing materials, use of salt-containing waters for bioleaching, *in situ* -bioleaching, bioleaching of electronic scrap. 10. Reductive bioleaching: iron- and manganese-reducing microorganisms, examples of reductive bioleaching. 11. Bioflotation. 12. Biological methods for winning metals from the aqueous phase: biological sulfafte reduction and biological iron oxidation as active treatment options, wetlands, biosorption. 13. Lab course: Techniques for cultivation of acidophilic bacteria,		

	measurement of parameters to follow growth and leaching activity of relevant microorganisms.
Literature:	W. Reineke & M. Schlömann: Umweltmikrobiologie, Springer Spektrum, 2015. D. R. Lovley (Ed.): Environmental Microbe-Metal Interactions, ASM Press, 2000. D. E. Rawlings & D. B. Johnson (Eds.): Biomining, Springer, 2007. E. R. Donati & W. Sand (Eds.) Microbial Processing of Metal Sulfides, Springer, 2007. L. G. Santos Sobral, D. Monteiro de Oliveira & C. E. Gomes de Souza (Eds.): Biohydrometallurgical Processes: a Practical Approach, CETEM/MCTI, 2011. A. Schippers, F. Glombitza & W. Sand (Eds.): Geobiotechnology I. Metal-related Issues, Springer, 2014. Abhilash, B. D. Pandey & K. A. Natarajan (Eds.): Microbiology for Minerals, Metals, Materials and the Environment, CRC Press, 2015. H. L. Ehrlich, D. K.Newman & A. Kappler: Ehrlich's Geomicrobiology, CRC Press, 2016. R. Quatrini & D.B. Johnson: Acidophiles. Life in Extremely Acidic Environments. Caister Academic Press, 2016.
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Seminar (1 SWS) S1 (WS): Practical Application (1 SWS) S1 (WS): Excursion (1 SWS)
Pre-requisites:	**Mandatory:** 1. Bachelor in Naturwissenschaften, Bergbau oder der metallurgischen Ingenieurwissenschaften oder Module der ersten sechs Semester (Studienablaufplan) eines Studiums mit angemessenen naturwissenschaftlichen Inhalten und 2. "Grundlagen der Biochemie und Mikrobiologie" und "Mikrobiologisch-biochemisches Praktikum"oder "Microbiology for Resource Scientists: Lecture" und "Microbiology for Resource Scientists: Lab Course" oder Äquivalent.1. Bachelor degree in a natural science or in mining- or metallurgy-related engineering or modules of the first six semesters (study schedule) of a study programme with appropriate content in natural science mit and 2. "Grundlagen der Biochemie und Mikrobiologie" and "Mikrobiologisch-biochemisches Praktikum" or "Microbiology for Resource Scientists: Lecture" and "Microbiology for Resource Scientists: Lab Course" or equivalent **Recommendations:** Basic knowledge in chemistry.
Frequency:	yearly in the winter semester
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA [90 min] PVL: Presentation in the seminar PVL: Planning of a lab-scale bioleaching process. PVL have to be satisfied before the examination.
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA [90 min] PVL: Seminarvortrag PVL: Planung eines Biolaugungs-Prozesses im Labormaßstab. PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.
Credit Points:	5

Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]
Workload:	The workload is 150h. It is the result of 75h attendance and 75h self-studies.

Data:	CMCRMI. MA. Nr. 3626 / Examination number: 42810	Version: 19.09.2017	Start Year: WiSe 2019
Module Name:	**Classifying Machines, Crushers, Mills**		
(English):			
Responsible:	Lieberwirth, Holger / Prof. Dr.-Ing.		
Lecturer(s):	Lieberwirth, Holger / Prof. Dr.-Ing.		
Institute(s):	Institute for Mineral Processing Machines and Recycling Systems Technology		
Duration:	1 Semester(s)		
Competencies:	The students will be enabled to select, calculate and design classifying machines, crushers and mills according to the specific requirements of their applications.		
Contents:	Planning and design of classifying machines, crushers and mills (Static, Vibrating and Drum Screens, Cyclons and Air Separators; Jaw, Double Roll, Cone, Gyratory, Hammer and Impact Crushers; Tumbling, High Pressure Grinding, Vertical Roller, Vibrating, Stirred Media, Impact, Beater and Jet Mills)		
Literature:	Wills, B.A.; Napier-Munn, T.J.: Mineral Processing Technology, Elsevier, 2007 Gupta, A.; Yan, D.: Mineral Processing, Design and Operations, Elsevier, 2016 Metso: Crushing and Screening Handbook, 2006 Höffl, K.: Zerkleinerungs- und Klassiermaschinen, Dt. Verlag für Grundstoffindustrie, Leipzig 1985		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS) S1 (WS): Experimental trainings, exercises and a design exercise. / Practical Application (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP/KA (KA if 10 students or more) [MP minimum 30 min / KA 90 min] PVL: At least 90% of the exercises are completed successfully (protocols). PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP/KA (KA bei 10 und mehr Teilnehmern) [MP mindestens 30 min / KA 90 min] PVL: Mindestens 90 % der Praktika und Übungen erfolgreich absolviert (Protokolle). PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP/KA [w: 1]		
Workload:	The workload is 150h. It is the result of 60h attendance and 90h self-studies. The latter includes the preparation and preparation of the exercises, experimental trainings and preparation for the examination.		

Data:	LSBP. MA. Nr. 3648 / Examination number: 43111	Version: 08.01.2016	Start Year: WiSe 2017
Module Name:	**Literature Study and Business Plan**		
(English):			
Responsible:	Stephan, Johannes / Prof. Dr.		
Lecturer(s):	Stephan, Johannes / Prof. Dr.		
Institute(s):	Professor of International Resource Policy and Economic Development		
Duration:	1 Semester(s)		
Competencies:	On completion of the course the student shall be able to: • Consult specialist literature and interpret it critically according to scientific standards. • Plan, monitor and steer scientific research. • Collect, process, critically analyse and interpret data. Identify new and remaining bottlenecks and research questions based on knowledge, insights and experience. • Deploy own knowledge in a creative, purposeful and innovative way in research, design and production processes. • Argue in a scientifically correct way in a multidisciplinary context. • Exhale openness to innovative scientific developments and their applications in a broad scientific, economic and social context. • Adopt an active attitude towards permanent knowledge development, lifelong learning and steer the own learning process independently. • Clearly communicate research results in English. • Conceptualize, plan and execute independently result-oriented new concepts at the level of a starting professional. • Understand the complexity of a problem/system using quantitative methods. • Extract useful information from superfluous, incomplete or contradictory data. • Consider specifications and technical, economic and social preconditions and transform them into a sustainable and qualitative system, product, service or process idea. • Integrate aspects related to sustainable resource management into research, production, quality assessment, management and/or policy. • Entrepreneurial mindset to develop new ideas within a multidisciplinary context. After passing the course, the student should be able to describe and understand the essence of: • Problem solving – how to analyse a complex problem • Basic project design • Innovation and entrepreneurship essentials • Project planning and project management basics • An overview of scientific methods • Problem characteristics and the choice of methods • Group dynamics and group thinking • IQ and emotional intelligence • Basic presentation techniques and rhetoric		
Contents:	The students will prepare a written thesis. It will be compilation of self		

	-researched literature on a given specific scientific or technical question and should include possible business models to generate systems, products, services or processes. The results from the thesis will be presented in a seminar lecture and discussed afterwards. The students should attend most of the other presentations and participate actively in the corresponding discussions.
Literature:	Depend on selected topic
Types of Teaching:	S1 (WS): incl. consultations with the supervisor / Seminar (3 SWS)
Pre-requisites:	
Frequency:	yearly in the winter semester
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP*: Course work AP*: Active participation in the seminar AP*: Presentation * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP*: Seminararbeit AP*: Aktive Teilnahme am Seminar AP*: Präsentation * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Credit Points:	5
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP*: Course work [w: 3] AP*: Active participation in the seminar [w: 1] AP*: Presentation [w: 2] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.

Data:	MTSIM. MA. Nr. 3647 / Examination number: -	Version: 23.11.2020	Start Year: SoSe 2017
Module Name:	**Master Thesis in Sustainable and Innovative Natural Resource Management**		
(English):			
Responsible:	Frisch, Gero / Prof. Dr.		
Lecturer(s):	Beteiligte Hochschullehrer (involved lecturers)		
Institute(s):	Institute of Inorganic Chemistry		
Duration:	1 Semester(s)		
Competencies:	The students should get the ability to solve scientific tasks in the field of advanced resource managment. They should be able to prepare a scientific presentation of its work and defend it in front of an audience. Economic aspects also have to be considered in the work. The thesis can be written in any institute at the university which provided a obligate lecture and/or in a company which was involved in the training. The master thesis is a kind of examination which completes the entire course. The work is the proof, that the students are able to solve scientific problems by their own.		
Contents:	Concept of the work schedule; analysis of literature; familiarize with methods, testing equipment, numerical methods; realization and analysis of tests in situ and in the laboratory; realization of calculations and numerical simulations; summary, scientific analysis and generalization of the results (period of four months). Preparation of a scientific work and paper in a colloquium (30 min oral presentation with discussion)		
Literature:	Guideline for the preparation of scientific works at TU Bergakademie Freiberg from 27.06.2005, DIN 1422, part 4 (08/1985); Hints for taskspecific literature will be given.		
Types of Teaching:	S1: Consultations, on demand: instruction in laboratory work and software, colloquium / Thesis (24 Wo) / Thesis		
Pre-requisites:	**Mandatory:** Abschluss von Modulen des ersten und zweiten Semesters im Umfang von mindestens 50 Leistungspunkten (modules with the total of 50 credit points of the first and second term have to be passed)		
Frequency:	constantly		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP*: Written thesis MP*: Defense of master thesis [20 min] with discussion [</=45 min] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP*: Masterarbeit MP*: Verteidigung der Masterarbeit [20 min] und Diskussion [bis zu 45 min] * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.		
Credit Points:	30		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP*: Written thesis [w: 3]		

	MP*: Defense of master thesis [20 min] with discussion [</=45 min] [w: 1] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 900h. It is the result of 0h attendance and 900h self-studies.

Data:	MRSLab. MA. Nr. 3652 / Examination number: 21020	Version: 01.07.2019	Start Year: WiSe 2018
Module Name:	**Microbiology for Resource Scientists: Lab Course**		
(English):			
Responsible:	Schlömann, Michael / Prof. Dr.		
Lecturer(s):	Kaschabek, Stefan / Dr.		
Institute(s):	Institute of Biosciences		
Duration:	1 Semester(s)		
Competencies:	The students will have obtained experience in basic microbiological methods. They are able to prepare sterile media, to cultivate microorganisms and to enrich as well as isolate pure cultures. They are able to follow the growth of cultures and to analyse substrate conversion and product formation during cultivation.		
Contents:	Working sterile; preparation of minimal and complex media; pouring of plates; enrichment, isolation and identification of microorganisms. Experiments on various metabolic properties of microorganisms (e.g. leaching of sulfides). Turbidity measurement, HPLC analyses, colorimetric determination of ions in solution.		
Literature:	Strete: Mikrobiologisches Grundpraktikum Steinbüchel & Oppermann-Sanio: Mikrobiologisches Praktikum		
Types of Teaching:	S1 (WS): Lectures (1 SWS) S1 (WS): Practical Application (5 SWS)		
Pre-requisites:	**Mandatory:** Microbiology for Resource Scientists: Lecture, 2018-07-03 oder (or)"Grundlagen der Biochemie und Mikrobiologie" oder (or) Ä (e)quivalent **Recommendations:** Knowledge in general, inorganic and organic chemistry.		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: PVL: Online test on the description of the experiments AP: Lab reports PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: PVL: Online-Test zu den Versuchsbeschreibungen (Skripten) AP: Praktikumsprotokolle PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Lab reports [w: 1]		
Workload:	The workload is 120h. It is the result of 90h attendance and 30h self-studies.		

Data:	MRSLEC. BA. Nr. 3651 / Examination number: 21019	Version: 03.07.2018	Start Year: WiSe 2018
Module Name:	**Microbiology for Resource Scientists: Lecture**		
(English):			
Responsible:	Schlömann, Michael / Prof. Dr.		
Lecturer(s):	Schlömann, Michael / Prof. Dr.		
Institute(s):	Institute of Biosciences		
Duration:	1 Semester(s)		
Competencies:	Students will have obtained a basic understanding of the functioning of a microbial cell. Specifically they will have obtained an understanding of the diversity of microbial energy metabolism, of the effects of microbial activities on the environment and how that can be used for the winning of metals and oil and for mine-water treatment. Students understand how microorganisms are classified into certain taxa, and they will have some insight into molecular tools for the classification and for the prediction of properties of the microorganisms.		
Contents:	Eukaryotic versus prokaryotic cell; important biomolecules (carbohydrates, lipids, proteins, nucleic acids); Basics of fundamental cell processes (replication, transcription, translation); structure of the microbial cell, microbial taxonomy and phylogeny; growth of microorganisms; principles of energy metabolism; microbial activities in the carbon cycle: energy metabolism on the example of aerobic degradation of carbohydrates; simple fermentations; aerobic degradation of alkanes; CO_2 fixation in photosynthetic and lithotrophic microorganisms; activities in the nitrogen cyle (nitrification, denitrification, N_2 fixation); microbial iron oxidation and reduction; microbial oxidation and reduction of sulfur compounds.		
Literature:	Madigan, Martinko, Stahl, Clark: Brock - Microbiology Reineke & Schlömann: Umweltmikrobiologie		
Types of Teaching:	S1 (WS): All main topics are also covered in the German lecture "Grundlagen der Biochemie und Mikrobiologie" which is available online and will be subtitled in English. (E-learning platform: OPAL) / Lectures (2 SWS)		
Pre-requisites:	**Recommendations:** Background in general, inorganic and organic chemistry; high school knowledge in biology		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA [90 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA [90 min]		
Credit Points:	3		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]		
Workload:	The workload is 90h. It is the result of 30h attendance and 60h self-studies.		

Data:	SINREMB. MA. Nr. 3614 / Examination number: 43110	Version: 08.01.2016	Start Year: WiSe 2016
Module Name:	**Problems and Innovations in the Process Chain of Mineral Resources**		
(English):			
Responsible:	Bertau, Martin / Prof. Dr.		
Lecturer(s):	Haseneder, Roland / Dr. rer. nat. Höck, Michael / Prof. Dr. Unland, Georg / Prof. Dr.-Ing. Bertau, Martin / Prof. Dr. Joseph, Yvonne / Prof. Dr. Lieberwirth, Holger / Prof. Dr.-Ing. Frisch, Gero / Prof. Dr. Charitos, Alexandros / Prof. Hedrich, Sabrina / Prof.		
Institute(s):	Institute of Thermal, Environmental and Natural Products Process Engineering Professor of Industrial Management, Production Management and Logistics Institute for Mineral Processing Machines and Recycling Systems Technology Institute of Chemical Technology Institute of Electronic and Sensor Materials Institute of Inorganic Chemistry Institute for Nonferrous Metallurgy and Purest Materials Institute of Biosciences		
Duration:	1 Semester(s)		
Competencies:	On completion of the course the student shall be able to explain real world problems in the process chain of special resources. They have an understanding about how different sectors have to interact to form a working unit in research. Innovative solutions on current issues in industries shall be highlighted and still occurring problems discussed to create an idea of entrepreneurship for various fields of the here outlined process chain.		
Contents:	1. Introduction of lecturers, companies, and students by short talks. Later social events will force the team building. 2. 5 Lectures on the process chain (Preprocessing technologies, (Bio-)Leaching, Separation processes, Hydrometallurgy, Process analysis) in combination with seminars to form working groups on individual topics. 3. Excursions and field trips, company talks and lectures.		
Literature:	not applicable		
Types of Teaching:	S1 (WS): Lectures - Bloc course / Lectures (1 SWS) S1 (WS): with short report of the team - Bloc course / Seminar (2 SWS) S1 (WS): Excursion - Bloc course / Excursion S1 (WS): Thesis - Bloc course / project (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Problem based learning course work		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Projektarbeit problemorientiertes Lernen		

Credit Points:	4
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Problem based learning course work [w: 1]
Workload:	The workload is 120h. It is the result of 60h attendance and 60h self-studies.

Data:	RCTec. MA. Nr. / Examination number: 20110	Version: 26.09.2018	Start Year: WiSe 2018
Module Name:	**Resources Chemical Technology**		
(English):			
Responsible:	Bertau, Martin / Prof. Dr.		
Lecturer(s):	Bertau, Martin / Prof. Dr.		
Institute(s):	Institute of Chemical Technology		
Duration:	1 Semester(s)		
Competencies:	After completing this module, students should be able to ◦ understand raw material processing on a technical scale ◦ explain the chemical-technological concepts behind modern production techniques		
Contents:	**Fundamentals:** Chemical technology of raw material recovery processes, chemistry of main group and transition metals as well as lanthanides, basic unit operations, basic reaction engineering. **Applications:** Realisation of raw material processing on a technical scale, process economy, environmental safeguards.		
Literature:	M. Bertau, P. Fröhlich, M. Katzberg, Industrial Inorganic Chemistry, Wiley, 2016 Kirk-Othmer et al., Chemical Technology, Wiley, 2013 J. Huheey et al., Inorganic Chemistry, Pearson, 2008		
Types of Teaching:	S1 (WS): Lectures (1 SWS) S1 (WS): Tutorials / Exercises (1 SWS) S1 (WS): Problem-based learning workshops / Seminar (1 SWS)		
Pre-requisites:	**Recommendations:** Fundamental knowledge in chemical technology, chemical engineering and inorganic chemistry		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA* [60 to 120 min] AP*: Course work * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA* [60 bis 120 min] AP*: Projektarbeit * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA* [w: 2] AP*: Course work [w: 1] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	RECH. MA. Nr. 3649 / Examination number: 20109	Version: 23.11.2020	Start Year: WiSe 2020
Module Name:	**Resources Chemistry**		
(English):			
Responsible:	Bertau, Martin / Prof. Dr. Frisch, Gero / Prof. Dr.		
Lecturer(s):	Bertau, Martin / Prof. Dr. Frisch, Gero / Prof. Dr.		
Institute(s):	Institute of Chemical Technology Institute of Inorganic Chemistry		
Duration:	2 Semester(s)		
Competencies:	After completing this module, students should be able to ◦ describe the chemical properties of complex raw materials, ◦ explain the chemical concepts behind modern enrichment, purification and production techniques, ◦ suggest a suitable technology for the processing of a particular resource.		
Contents:	**Fundamentals:** Chemistry of ore deposits, phase diagrams, basic coordination chemistry, modelling of solvation equilibria, kinetic aspects of precipitation and extraction, chemical foundations of metallurgical processes, and applied electrochemistry. **Applications:** Hydro- und pyrometallurgical processing and recycling technologies, such as smelting, leaching, digestion, flotation, extraction, precipitation, electrowinning and ion exchange; applications of unconventional solvents; economic viability of processing and separation techniques.		
Literature:	• J. Huheey et al., Inorganic Chemistry, Pearson, 2008 • M.Bertau et al., Industrial Inorganic Chemistry, Wiley, 2016 • Kirk-Othmer et al., Chemical Technology, Wiley, 2013		
Types of Teaching:	S1 (WS): Case Studies - E-Learning / Seminar (2 SWS) S2 (SS): Block-course / Lectures (2 SWS) S2 (SS): Block-course / Exercises (2 SWS) S2 (SS): Block-course with excursions / Practical Application (3 SWS) The order of the module semesters is flexible.		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA* [60 to 120 min] AP*: Case studies AP*: Practicals * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA* [60 bis 120 min] AP*: Fallstudien AP*: Praktikum * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0)		

	bewertet sein.
Credit Points:	9
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA* [w: 2] AP*: Case studies [w: 1] AP*: Practicals [w: 2] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 270h. It is the result of 135h attendance and 135h self-studies.

Data:	SSSE. MA. Nr. 3653 / Examination number: 43112	Version: 24.09.2018	Start Year: WiSe 2018
Module Name:	**Selective Separation of Strategic Elements**		
(English):			
Responsible:	Bräuer, Andreas / Prof. Dr.-Ing.		
Lecturer(s):	Haseneder, Roland / Dr. rer. nat.		
Institute(s):	Institute of Thermal, Environmental and Natural Products Process Engineering		
Duration:	1 Semester(s)		
Competencies:	On completion of the course the student shall be able to explain membrane technology and the different applications like extraction and membrane assisted processes regarding the separation of value products. Focus is put on strategic elements. They can use their physico-chemical knowledge on membrane separation, development of hybrid operation systems and the influences for practical applications and are familiar with the methods and problems related to separation devices. Due to the seminar the students will be able to dicuss the current literature on the topic.		
Contents:	• membranes, modules, hybrid processes • driving forces, transport resistances • structures, materials • mass transfer • module construction • MF, UF, NF, RO • standard applications • scaling, fouling effects • special applications: mine water treatment, leaching solutions, resourcerecovery • internship to membrane processes		
Literature:	Heinrich Strathmann: Introduction to Membrane Science and Technology, Wiley-VCH, 2011 Anil K. Pabby, Syed S.H. Rizvi, Ana Maria Sastre Requena: Handbook of Membrane Separations, CRC-Press 2008		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Seminar (1 SWS) S1 (WS): Practical Application (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA [90 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA [90 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]		
Workload:	The workload is 150h. It is the result of 60h attendance and 90h self-studies.		

Data:	SA. MA. Nr. / Examination number: 50734	Version: 20.02.2015	Start Year: WiSe 2016
Module Name:	**Sensors and Actuators**		
(English):			
Responsible:	Joseph, Yvonne / Prof. Dr.		
Lecturer(s):	Joseph, Yvonne / Prof. Dr.		
Institute(s):	Institute of Electronic and Sensor Materials		
Duration:	1 Semester(s)		
Competencies:	Apply techniques for qualitative and quantitative exploration and physicochemical characterization of resources present in the environment, including spatial and temporal variability. Apply techniques to assess environmental impacts of products and processes. Insights in the different (technological) options for optimizing resource flows in the different parts of the value chain and be able to compare them, taking technical and economic aspects as well as social and environmental impact into account. Consult specialist literature and interpret it critically according to scientific standards. Understand the complexity of a problem/system using quantitative methods. Consider specifications and technical, economic and social preconditions and transform them into a sustainable and qualitative system, product, service or process. Entrepreneurial mindset to develop new ideas within a multidisciplinary context.		
Contents:	Physical (e.g. temperature, force, acceleration, etc.) chemical (gas sensors, ion sensors) and biological sensors and actuators will be discussed. First, the physical principles are presented and then applications will be given. The focus is on the relationship between the parameters of the finished device and the properties of the used materials to enable their applications. Specific examples of sensors and actuators are discussed in their measurement environment.		
Literature:	Peter Gründler, Chemical Sensors, Springer, 2007, ISBN: 9783540457435;		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Seminar (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP/KA (KA if 10 students or more) [MP minimum 30 min / KA 120 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP/KA (KA bei 10 und mehr Teilnehmern) [MP mindestens 30 min / KA 120 min]		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP/KA [w: 1]		
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.		

Data:	SSMP MA. / Examination number: 51119	Version: 13.11.2018	Start Year: SoSe 2019
Module Name:	**Simulation of Sustainable Metallurgical Process**		
(English):			
Responsible:	Stelter, Michael / Prof. Dr.-Ing. Reuter, Markus / Prof. Dr.		
Lecturer(s):	Reuter, Markus / Prof. Dr.		
Institute(s):	Institute for Nonferrous Metallurgy and Purest Materials		
Duration:	1 Semester(s)		
Competencies:	1. Simulation of reactor types • modelling and simulation of hydro- and pyrometallurgical reactors for primary and secondary resources and determination of mass and energy balances as well as minerals processing • determination of ecological and economic footprint of reactors 2. Modelling of processing flowsheets • develop processing flowsheets for non-ferrous metal containing resources • modelling and simulation of hydro- and pyrometallurgical processing plants for primary and secondary non-ferrous resources as well as minerals processing • determination of mass and energy balances of the complete flowsheet and determine optimal processing routes • determination of ecological and economic footprint of complete flowsheets 3. Methods and tools • use of simulation tools such as HSC Sim 9.0, FACTSAGE etc. and environmental software tools such as GaBi to evaluate different processing options • create process designs and communicate results to a client and/or stakeholders e.g. NGOs		
Contents:	Reactor types in process metallurgy and minerals processing (e.g. TSL, Kaldo, flash smelting, QSL, flotation cells etc.) will be compared using simulation cases, evaluated and optimised for metal and minor metal recovery. The environmental footprint as also the economic performance of each reactor type will be compared with each other to establish best options for reactor flotation types as a function of feed types. The student will understand minerals processing and metallurgical reactor technology better and also be in a better position to create more sustainable industry and society. Process design cases will be performed by the students to optimally process different feed types. By using a wider range of reactor types the student will be able to simulate complete flowsheets, provide mass and energy balances at the same time also determine the environmental footprint as well as economic analysis. This course will also examine the impact of product design on the recycling of various end-of-life products such as mobile phones etc. Thus, not only will natural resources be processed in the simulated systems but also materials from the “urban mine”. Therefore, this course will also use this rigorous simulation basis to critically discuss environmental legislation as well as communicate		

	these results to all stakeholders. The course takes place as a 2 week block course in September.
Literature:	• E. Worrell, M.A. Reuter (2014): Handbook of Recycling, Elsevier BV, Amsterdam, 595p. (ISBN 978-0-12-396459-5). • M.A. Reuter, R. Matusewicz, A. van Schaik (2015): Lead, Zinc and their Minor Elements: Enablers of a Circular Economy World of Metallurgy – ERZMETALL 68 (3), 132-146. • M.A. Reuter, A. van Schaik, J. Gediga (2015): Simulation-based design for resource efficiency of metal production and recycling systems, Cases: Copper production and recycling, eWaste (LED Lamps), Nickel pig iron, International Journal of Life Cycle Assessment, 20(5), 671-693. • M.A. Reuter, I. Kojo (2014): Copper: A Key Enabler of Resource Efficiency, World of Metallurgy – ERZMETALL 67 (1), 46-53 (Summary of plenary lecture Copper 2013). • S. Creedy, A. Glinin, R. Matusewicz, S. Hughes, M.A. Reuter (2013): Outotec® Ausmelt Technology for Treating Zinc Residues, World of Metallurgy – ERZMETALL, 66(4), 230-235. • M.A.H. Shuva, M.A. Rhamdhani, G. Brooks, S. Masood, M.A. Reuter (2016): Thermodynamics data of valuable elements relevant to e-waste processing through primary and secondary copper production - a review, J. Cleaner Production, 131, 795-809. • M.A. Reuter (2016): Digitalizing the Circular Economy - Circular Economy Engineering defined by the metallurgical Internet of Things-, 2016 TMS EPD Distinguished Lecture, USA, Metallurgical Transactions B, 47(6), 3194-3220 (http://link.springer.com/article/10.1007/s11663-016-0735-5). • I. Rönnlund, M.A. Reuter, S. Horn, J. Aho, M. Päällysaho, L. Ylimäki, T. Pursula (2016): Sustainability indicator framework implemented in the metallurgical industry: Part 1-A comprehensive view and benchmark & Implementation of sustainability indicator framework in the metallurgical industry: Part 2-A case study from the copper industry, International Journal of Life Cycle Assessment, 21(10), 1473-1500 & 21(12), 1719-1748.
Types of Teaching:	S1 (SS): Block course / Lectures (1 SWS) S1 (SS): Block course / Seminar (2 SWS) S1 (SS): Block course / Practical Application (2 SWS)
Pre-requisites:	**Recommendations:** Basic thermodynamic, thermodynamic and kinetic knowledge in process metallurgy
Frequency:	yearly in the summer semester
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Report of simulation The student should solve a case/example and hand in the computer file as a document.
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Simulationsbeleg Der Student soll einen Fall/Beispiel lösen und die Computerdatei als Dokument einreichen.
Credit Points:	6

Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Report of simulation [w: 1]
Workload:	The workload is 180h. It is the result of 75h attendance and 105h self-studies.

Data:	TInII. MA. Nr. 3650 / Examination number: 23102	Version: 23.11.2020	Start Year: WiSe 2021
Module Name:	**Training in Industry**		
(English):			
Responsible:	Frisch, Gero / Prof. Dr.		
Lecturer(s):	Beteiligte Hochschullehrer (involved lecturers)		
Institute(s):	Institute of Inorganic Chemistry		
Duration:	1 Semester(s)		
Competencies:	The student is able to: • reflect critically on the experience gained. • integrate and participate in the day-to-day-activities of the workplace. • give a scientific account of the experience gained in the form of an oral presentation and a scientific report. • analyse the workplace and the activities it undertakes within it's economical, managerial or strategic context.		
Contents:	The student shall during 5 weeks (minimum) participate in a full-time internship, with an appointed supervisor within the host organization. The work/tasks during the internship must be clearly related to SINREM, and train the student in independent work and cooperation with others. Innovation and entrepreneurship in raw material and resource science are of major interest. The student will be engaged in every-day working activities at a level corresponding to the final degree. During the training the student has to report to a mentor which is a teacher of the courses of the program (should be elected in advance, two reports are needed). Further a oral presentation will be given at the end of the training in front of the group of respective teacher. Upon completion of the internship, the student will write a report. In the report students will pay attention not only to the practical work they performed but also to methodology, results, managerial, economical and strategic aspects of the internship and workplace. Course introduction takes place at the university, while supervision is undertaken at the internship location.		
Literature:	not available		
Types of Teaching:	S1: Practical Application as block course (7 SWS) / Practical Application (7 SWS)		
Pre-requisites:	**Recommendations:** Completed first year of studies in the Master program for sustainable development		
Frequency:	constantly		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP*: Continuous assessment of practical work AP*: Final Report * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP*: Begleitende Beurteilung der praktischen Arbeit		

	AP*: Abschlussbericht * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Credit Points:	10
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP*: Continuous assessment of practical work [w: 1] AP*: Final Report [w: 1] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 300h. It is the result of 105h attendance and 195h self-studies.

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