Modulhandbuch
für den
Masterstudiengang
Sustainable and Innovative Natural Resource Management

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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: 04.07.2025	Start Year: WiSe 2025
Module Name:	**Analysis of High Temperature Processes in Extractive Metallurgy**		
(English):			
Responsible:	Charitos, Alexandros / Prof.		
Lecturer(s):	Charitos, Alexandros / Prof.		
Institute(s):	Institute of 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-dynamic phenomena during metallurgical processing (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 (WS): Lectures (4 SWS) S1 (WS): Presentation of the assignment / Seminar (1 SWS)		
Pre-requisites:	**Recommendations:** Revision of courses associated to metallurgical thermodynamics		
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: Assignment KA [180 min] There is the possibility of obtaining additional points for the written examination through the assignment. PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: PVL: Schriftliche Ausarbeitung KA [180 min]		

	Es besteht die Möglichkeit, durch die schriftliche Ausarbeitung Zusatzpunkte für die Klausur zu erzielen. PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.
Credit Points:	7
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]
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:	RECH. MA. Nr. 3649 / Examination number: 21210	Version: 20.03.2024	Start Year: WiSe 2020
Module Name:	**Chemical Principles and Sustainable Technologies along the Raw Materials Value Chain**		
(English):			
Responsible:	Frisch, Gero / Prof. Dr.		
Lecturer(s):	Haseneder, Roland / Dr. rer. nat. Höck, Michael / Prof. Dr. Bertau, Martin / Prof. Dr. Mischo, Helmut / Prof. Dr.-Ing. Lieberwirth, Holger / Prof. Dr.-Ing. Frisch, Gero / Prof. Dr. Vogt, Carla / 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 of Chemical Technology Institute of Mining and Special Civil Engineering Institute for Mineral Processing Machines and Recycling Systems Technology Institute of Inorganic Chemistry Institute of Analytical Chemistry Institute of Nonferrous Metallurgy and Purest Materials Institute of Biosciences		
Duration:	2 Semester(s)		
Competencies:	Upon completion of this module, students should be able to • apply fundamental chemical concepts to modern raw materials analysis, extraction, purification, and production techniques, • analyse how different disciplines and technologies must interact to design a process in the raw materials sector, • propose an appropriate technology to process a given resource, • discuss and design innovative solutions to current industry challenges, including aspects of circular economy and entrepreneurship.		
Contents:	Theoretical and practical aspects of • raw materials analysis and process analysis techniques, • raw materials processing and recycling technologies, including mechanical, hydro-, pyro- and electrometallurgical methods, • chemistry of minerals and ore deposits, modelling of chemical equilibria and kinetics • process chain design, circular economy and process economics in the raw materials sector		
Literature:	J.S. Gaffney et al., General Chemistry for Engineers, Elsevier 2018 D. Möller, Chemistry for Environmental Scientists, De Gruyter 2015 M. Bertau et al., Industrial Chemistry, Wiley, 2016 Kirk-Othmer et al., Chemical Technology, Wiley, 2013		
Types of Teaching:	S1 (WS): Lectures (1 SWS) S2 (SS): Lectures (2 SWS) S1 (WS): workshops / Exercises (1 SWS)		

	S2 (SS): workshops / Exercises (1 SWS) S2 (SS): laboratory practicals / Practical Application (4 SWS) S1 (WS): course work / case studies / research project (1 SWS) S2 (SS): course work / case studies / research project (1 SWS) S2 (SS): Excursion (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*: written exam [180 min] AP*: case studies AP*: practicals PVL: fundamental chemistry workshops PVL have to be satisfied before the examination. * 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*: written exam [180 min] AP*: Fallstudien AP*: Praktika PVL: Workshops PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden. * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Credit Points:	13
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA*: written exam [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 390h. It is the result of 180h attendance and 210h self-studies.

Data:	CMCRMI. MA. Nr. 3626 / Examination number: 42810	Version: 23.10.2023	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:	MA. Nr. / Examination number: 60621	Version: 08.12.2022	Start Year: WiSe 2023
Module Name:	**Financial and Sustainability Reporting, Financial Planning and Business Valuation**		
(English):			
Responsible:	Sopp, Karina / Prof. Dr.		
Lecturer(s):	Sopp, Karina / Prof. Dr.		
Institute(s):	Professor of Entrepreneurship and Corporate Taxation		
Duration:	1 Semester(s)		
Competencies:	Students can assess the effects of business decisions on their asset, financial and earnings position and understand financial and sustainability reports of companies. In addition, students get to know financial and non-financial key performance indicators and their relevance for the management and financing process of companies. The students are enabled to draw up and interpret financial plans. They can assess the importance of financial planning and sustainable economic activities on business financing. Reasons for a business valuation can be recognized and factors influencing business valuation can be identified.		
Contents:	In this module the EU legal basis for preparing financial and sustainability reports is explained and global developments in (non-)financial reporting are discussed. In financial reporting, especially the Accounting Directive and the International Financial Reporting Standards (IFRS) are covered. The accounting instruments and the main reporting principles according to these regulations are discussed. The connection between the asset, financial and earnings position of companies is worked through using business cases. In sustainability reporting, the EU legal requirements and global developments are discussed. The focus is on the CSRD (Corporate Sustainability Reporting Directive) and the ESRS (European Sustainability Reporting Standards). The content of sustainability reports and their standardization are discussed. In addition, important non-financial key performance indicators (KPIs) are examined using concrete examples. Furthermore, the link between financial and sustainability reporting is shown for financing decisions. For this purpose, financial plans are drawn up and the importance of non-financial KPIs for financing decisions is shown under consideration of EU regulations like the so called Taxonomy Regulation. Finally, reasons for business valuations are discussed and discounted cash-flow methods and multiples methods for carrying out business valuations are presented and calculated.		
Literature:	Current legal provisions and papers		
Types of Teaching:	S1 (WS): Lectures (1 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** No previous knowledge is required.		
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; Active participation in the seminar; Presentation		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Seminararbeit und Präsentation sowie aktive Teilnahme am Seminar		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following		

	weights (w): AP: Course work; Active participation in the seminar; Presentation [w: 1]
Workload:	The workload is 150h. It is the result of 30h attendance and 120h self-studies.

Data:	MTSIM. MA. Nr. 3647 / Examination number: -	Version: 23.07.2025	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 aller Pflichtmodule des ersten und zweiten Semesters gemäß Studienablaufplan (all mandatury courses of the first and second term in accordance with the study schedule 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 [40 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 [40 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 [40 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: 25.06.2024	Start Year: WiSe 2018
Module Name:	**Microbiology for Resource Scientists: Lab Course**		
(English):			
Responsible:	Hedrich, Sabrina / Prof.		
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:** Grundlagen der Biochemie und Mikrobiologie, 2025-01-17 or Biotechnology for Metal Extraction and Recycling, 2022-10-03 or Introduction to Biohydrometallurgy, 2021-03-16 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:	RCTec. MA. Nr. / Examination number: 20110	Version: 20.03.2024	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): laboratory practicals / Practical Application (1 SWS) S1 (WS): course work / case studies / research project (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: AP*: case studies AP*: presentation 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: AP*: Fallstudien AP*: Präsentation AP*: Praktica * 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*: case studies [w: 2] AP*: presentation [w: 1] AP*: practicals [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:	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:	SMLCV MA. / Examination number: 22606	Version: 16.06.2025	Start Year: SoSe 2026
Module Name:	**Sensors, Machine Learning and Computer Vision**		
(English):			
Responsible:	Heitmann, Johannes / Prof. Dr.		
Lecturer(s):	Gloaguen, Richard / Dr.		
Institute(s):	Helmholtz Institute Freiberg Institute of Applied Physics		
Duration:	1 Semester(s)		
Competencies:	Students acquire in-depth knowledge of the principles and possible applications of imaging sensor technologies and gain insights into current developments in the field of computer vision (CV) and machine learning (ML). Students learn the practical application of basic image processing techniques. They develop an understanding of the possible applications and limitations of imaging technologies for scientific questions. They are able to discuss more complex methods of imaging and image processing and to implement them cooperatively in the context of a current scientific problem.		
Contents:	The module teaches the basics of imaging and image processing and takes an excursion into current developments in computer vision and machine learning. Practical examples and supervised exercises are used to teach important aspects of image creation, calibration and processing, e.g.: - Sensor technology and image acquisition - Camera calibration and corrections - Feature detection and co-registration - Data fusion and classification Subsequently, important current publications in the fields of image processing and computer vision are discussed and potential fields of application are developed. Examples of topics are: - Pattern and object recognition - 3D reconstruction from image data and active 3D imaging (light field, lidar, structured light) - Multidimensional imaging (multi-/hyperspectral data) - Motion detection and object tracking - Image restoration (inpainting, denoising) - Machine learning / deep learning for segmentation The students then independently implement a sensor approach for a current scientific problem as part of small group work (co-operative project work). Project progress and results are recorded in a project report and presented at the end in a scientific lecture.		
Literature:	Hartley, R., & Zisserman, A. (2004). Multiple View Geometry in Computer Vision (2nd ed.). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511811685 Howse, J. & Minichino, J. (2020). Learning OpenCV 4 Computer Vision with Python 3. Packt Publishing		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Seminar (2 SWS)		
Pre-requisites:			
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 a co-operative project work AP*: oral 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*: Projektbericht 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*: report of a co-operative project work [w: 2] AP*: oral 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 150h. It is the result of 60h attendance and 90h 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:	Reuter, Markus / Prof. Dr. Charitos, Alexandros / Prof.		
Lecturer(s):	Reuter, Markus / Prof. Dr.		
Institute(s):	Institute of 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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