# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Methods of metal recovery [S2TOZ1-RMiOC>MOM]

## Course

Field of study
Circular System Technologies

Year/Semester
1/2

Area of study (specialization)
Material recycling and chemical recovery

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

## Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
15

## Number of credit points

5,00

## Coordinators

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## Lecturers

## Prerequisites

Knowledge of basic environmental principles related to chemical production and waste management. Ability to retrieve, interpret, draw conclusions and form opinions from literature, databases and other sources related to the chemical sciences.

## Course objective

Gain knowledge of modern technologies for the production of metals (including copper, cobalt, nickel, aluminium, rare earth elements) from primary and secondary resources by pyro-, hydro-, electro- and biometallurgical processes.

## Course-related learning outcomes

Knowledge:
The student gains an in-depth knowledge of material balance and the problems of extracting raw materials (mainly metals) from natural resources and from waste. K_W01

The student has in-depth knowledge of modern methods of recovering metals from natural resources and waste, including sustainable production of metals, principles of behaviour and development trends in the circular economy related to metal production. K_W03
The student has deep knowledge of designing technological processes of metal recovery based on the principles of the circualar economy. K_W07
The student has in-depth knowledge of material recycling methods and raw material recovery of metals from waste materials necessary to design and implement innovative technological processes. K_W12
The student has detailed knowledge of selected environmental aspects of metal recovery processes. K_W12

Skills:
The student is able to communicate orally with specialists in the field of environmental services and related areas. K_U01
The student is able to plan, prepare and present a presentation on the implementation of a research task and to conduct a substantive discussion on a given topic. K_U02
The student is able to analyse and critically evaluate new areas in technologies applied in the circular economy and related fields, assessing their innovativeness and technical feasibility. K_U16
The student can interact with others in a team to solve technical problems related to methods and equipment used in metal recovery technologies, including those related to the circular economy. K_U9
The student is able to prepare and calculate the material balance of systems/installations with and without chemical reaction.

Social competences:
The student is aware of the personal responsibilities deriving from their professional role and of the moral and ethical problems arising in the context of professional activities. K_K01
The student understands the need to disseminate knowledge on sustainable production and technological solutions in the circular economy. K_K02
The student critically appraise one's own knowledge and understand the need for continuing education and improvement of one's professional, personal and social competences. K_K03

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Written exam (lecture), knowledge test before each laboratory exercise (laboratory) and report on the completed laboratory exercise, assessment of team presentations/projects on a given topic (project).
Grading scale:
2.0 less than 51%
3.0 51-60%
3.5 61-70%
4.0 71-80%
4.5 81-90%
5.0 91-100%
In the case of a distance learning requirement, the course will be delivered via the eKursy platform and similar assessment methods and criteria will be used.

## Programme content

Modern technologies for obtaining strategic metals for industry by pyro-, hydro-, electro- and biometallurgical methods from natural raw materials and waste.

## Course topics

The lecture presents modern technologies for the extraction of copper, zinc, lead, aluminium, nickel, cobalt, rare earth metals, etc. by pyro-, hydro-, electro- and biometallurgical methods, discusses issues of flotation, leaching of metals from ores, scrap, spent batteries and alloys, dissolution, separation of metal ions by classical and unconventional extraction. The issues of physico-chemistry of processes, efficiency and selectivity of unit operations, technologies used, apparatus, environmental problems arising from ore extraction and processing (environmental disasters) are considered. Basic concepts of mass balance are introduced and mass balances of apparatus related to metal recovery processes are solved. In addition, students develop a topic based on the latest scientific and technical literature

relating to the recovery of metals relevant to the global economy and prepare a presentation on this topic, taking into account issues of sustainable production of these metals.
In the laboratory, students carry out metal recovery using various unit operations such as leaching, flotation, extraction, stripping, adsorption from waste materials such as e-waste, spent catalysts or waste solutions.

## Teaching methods

Lecture, discussion, working with scientific literature, preparing presentations, solving tasks, working in groups

## Bibliography

Basic:
1. Z. Pater, Podstawy metalurgii i odlewnictwa, Wyd. Politechniki Lubelskiej, Lublin 2014. Wersja elektroniczna dostępna na: http://bc.pollub.pl/dlibra/publication/8929/edition/8711/content?ref=desc
2. E. Kociołek-Belawejder (Red.), Technologia chemiczna nieorganiczna - wybrane zagadnienia, Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław 2013.
3. K. Schmidt, J. Sentek, J. Raabe, E. Bobryk, Podstawy technologii chemicznej. Procesy w przemyśle nieorganicznym. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2004.
4. A. Ciszewski, Technologia chemiczna. Procesy elektrochemiczne, Wydawnictwo Politechniki Poznańskiej, Poznań 2008.
5. Z. Ziołkowski, Ekstrakcja cieczy w przemyśle chemicznym, PWT, Warszawa 1961.
6. A. Sobczyńska, J. Szymanowski, ”Bilanse masowe procesów stacjonarnych”, Wydawnictwo Politechniki Poznańskiej, Poznań 2003.

Additional:
1. Metals in wastes, pod red.: K. Wieszczycka; B. Tylkowski; K. Staszak, DE GRUYTER, Berlin 2018.
2. J. Rydberg, M. Cox, C. Musicas, G. R. Coppin, Solvent extraction and practice, Taylor & Francis, 2004. E-book in: MyiLibrary (na stronach biblioteki głównej PP: http://www.ml.put.poznan.pl/pl/1_2_1.html#m).
3. C.K. Gupta, Chemical Metallurgy - Principles and Practice. Wiley VCH, Weinheim 2003.
4. J. Kępiński, Technologia Chemiczna Nieorganiczna, PWN, Warszawa,1984.
5. J. Szymanowski, Ekstrakcja miedzi hydroksyoksymami, PWN, Warszawa, Poznań 1990.
6. F.K. Crundwell, M.S. Moats, V. Ramachandran, T.G. Robinson, W.G. Davenport, Extractive Metallurgy of Nickel, Cobalt and Platinum-Group Metals, Elsevier, Oxford 2011. E-book na: Referex Engineering (na stronach biblioteki głównej PP).

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 125 | 5,00 |
| Classes requiring direct contact with the teacher | 64 | 2,50 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 61 | 2,50 |