



University of Miskolc

Faculty of Materials Science and Engineering  
Antal Kerpely Doctoral School of Materials Science  
& Technology



# Processes of Metal Extraction and Refining

Prof. Tamás Kékesi, DSc

**COURSE DESCRIPTION**

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## Lecturer

Dr. Tamás Kékesi Tamás, professor, Institute of Metallurgy.

Room: B1 3<sup>rd</sup> Floor, 310b. mail: [kekesi@uni-miskolc.hu](mailto:kekesi@uni-miskolc.hu), tel: ext.1545, +36306556371, <http://www.metont.uni-miskolc.hu>.

## Target group

The course is offered for all students of the Kerpely Doctoral School, especially in the field of chemical metallurgy and foundry engineering.

## Language

English or Hungarian.

## Scope

The objective of the course is to discuss and correlate the processes of extractive and refining metallurgical processes on a theoretical basis by offering the knowledge of theoretical and practical background for the metallurgical processes allowing the extraction and refining of crude metals.

## Learning outcomes

The content of the course offers the deepening of the general metallurgical knowledge linked to the field of research and the consolidation of the theoretical understanding of the relevant chemical metallurgical methods. The resulting knowledge primarily serves the success of doctoral students pursuing research in the field of chemical metallurgy, but it can be utilised indirectly also in other related technological fields.

## Methodology

The course is held in weekly 2 hour lectures for larger groups, but it is offered on a personal basis for 1-2 students, by defining the actual curriculum and providing test questions. The main blocks are terminated by personal consultations, when the learning outcomes are promoted by interactive communication and controlled instruction.

## Constituent topics

The conditions of the processes allowing the extraction and refining of metals on the industrial scale and the elimination of impurities to a special grade are discussed in detail on the basis of the laws of thermodynamics and kinetics. The theoretical approach is complemented by practical examples, which provide further knowledge in terms of technical conditions required for practical applications.

- The types, sources and the main characteristics of the primary and secondary raw materials suitable for metal extraction.
- The beneficiation of raw materials before metal extraction.
- The technical and economic trends of metal production.

- A systematic survey of the chemical processes suited for the extraction and refining of metals.
- The chemical fundamentals of the main pyrometallurgical processes (various roasting and smelting operations).
- The physical-chemical characteristics, conditions and practical methods of pyrometallurgical processes.
- The types and sources of slags and their significance in metallurgy.
- The examination of chemical and physical processing underlying the high temperature metal purification and fire refining technologies.
- The criteria and limits of impurity removal by selective reactions.
- The physical-chemical characteristics of processes taking place in the main stages of hydrometallurgical metal extraction (leaching, solution purification, metal extraction). The conditions of practical applications.
- The requirements of selective metal deposition.
- Methods and processes of ionic separation suitable for solution purification.
- The reactions and the practical procedures of electrowinning. The equilibrium and dynamic characteristics of electrolytic procedures.
- The processes, methods and technologies of electrorefining.
- The preparation methods and characteristics of high purity metals.
- The source and utilization of industrial by-products.
- Metallurgical environment protection.

**Test questions:**

1. *How can the primary raw materials of metals be structured into categories?*
2. *What are the characteristics of origin and distribution of the various minerals of metals?*
3. *What have the main production and market trends for iron, steel and for the light and heavy non-ferrous metals been for the past decades?*
4. *What is the significance and what are the ways of mechanical pre-treatment in ore beneficiation?*
5. *What physical methods can be utilised for ore beneficiation?*
6. *What are the main types of metal containing waste materials, and how is scrap prepared for metallurgical processing?*
7. *What are the main physical methods of mineral separation?*
8. *What are the basic physical-chemical processes of the various oxidising roasting procedures, and what are their roles before smelting?*
9. *What are the thermodynamic and kinetic characteristics of the chemical processes of oxidising roasting?*
10. *The use of predominance area diagrams and thermodynamic stability characteristics in defining the composition of the products of roasting and smelting operations.*
11. *What are the possible complex methods to be used for the economical processing of low-grade ores?*
12. *How can the thermodynamic characteristics of carbothermic reductions be defined?*
13. *What are the conditions of direct and indirect reduction, and what is the role of their ratio in the economy of the procedure?*
14. *What are the main process steps of converting?*
15. *How are metallurgical slags formed? What are their main properties, and how can they be treated?*
16. *Which are the main processes of iron making?*
17. *Which are the main processes of steel making?*
18. *What are the main thermodynamic and kinetic conditions of metal refining?*
19. *What is the practice of fire refining?*
20. *What equilibrium characteristics make the electrorefining of metals possible?*

21. *What are the main kinetic characteristics influencing the efficiency of electrorefining?*
22. *How can the solubility of metal compounds be characterised, and how can the leaching of metals be carried out?*
23. *What are the stability conditions allowing the purification of metal containing solutions?*
24. *What methods are used for ionic separation?*
25. *How can the kinetics of ion-exchange separations be described?*
26. *What are the processes and procedures to be used for the preparation of super pure metals?*
27. *What processes can be used for treating industrial and communal waste materials containing special metallic values?*
28. *How can valuable metals be recovered from industrial dusts and sludges?*
29. *What procedures can be used for the processing of smelter slags?*
30. *What technology is used for the melting and alloying of scrap metals?*
31. *What special methods can be used for the refining of aluminium melts and what are the practical alternatives?*

### Recommended literature

1. Tamás Kékesi: Fundamentals of Chemical Metallurgy, Digital textbook, 2013.
2. Gilchrist, J.D.: Extraction Metallurgy, 2nd Ed., Pergamon Press, Oxford, 1980.
3. Fathi Habashi: Textbook of Hydrometallurgy, Métallurgie Extractive Québec, 1999
4. Fathi Habashi: Textbook of Pyrometallurgy, Métallurgie Extractive Québec, 2002
5. Biswas, A.K., Reginald Bashforth, G.: The Physical Chemistry of Metallurgical Processes, Chapman & Hall, London, 1962.
6. Erdey-Grúz, T: Kinetics of electrode processes, Akadémiai kiadó, Budapest, 1972.

+ If need be, the student may get literature directly relevant to his/her research.

### Completion, examination

Oral examination, following the adequate answering of control questions.

### Relevant topics for the complex examination

1. Physical preparation of primary and secondary raw materials for metal extraction.
2. The processes of pyrometallurgical metal extraction and refining.
3. The electrode processes and the practical efficiency of electrorefining.
4. Extraction processes of pure metals by hydrometallurgical operations.
5. Preparation of high-purity metals.
6. The types and processing methods of metal containing waste materials.