UNIVERSITY of MISKOLC
Faculty of Materials Science and Engineering

Antal Kerpely Doctoral School of Materials Science & Technology

Theoretical Fundamentals of Chemical Metallurgy

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COURSE DESCRIPTION

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Theoretical Fundamentals of Chemical Metallurgy

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MAKD

Lecturer

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Recommendation

The lecture is offered for all students of the Kerpely Doctral School, especially in the field of chemical metallurgy.

Language

English

Scope

The objective of the course is to interpret the principal physico-chemical concepts determining the reactions involved in metal extraction and refining.

Methodology

The course is held in contact lectures and seminar discussions organised in a way depending on the number of students. The dates and the time of contact courses are based on mutual agreements. The learning outcomes are promoted by interactive communication and actual examples of applications.

Learning outcomes

The contents of the course offer a deeper understanding of thermodynamic and kinetic principles underlying the feasibility and the applicability of reactions for the purposeful transformation of metalliferous or metallic materials by pyro- hydro- and electrometallurgical techniques. Students will be capable of analysing and determining the conditions required for the efficient recovery and purification of metals from primary and secondary raw materials. They acquire the fundamental theoretical knowledge for controlling, developing or interpreting the processes.

Topics

The equilibrium conditions and the possible reactions of classical metallurgical processes are assessed by the methods of classic thermodynamic methods. The students learn the way of determining the equilibrium constants of simple and complex processes as functions of physical-chemical parameters. Thermodynamic functions are determined by manual and

computer aided methods. The kinetic conditions of the processes are interpreted and are determined by experimental methods. The equilibria of solubility and solution stability, giving the basis for hydrometallurgical processes, as well as the separation and neutralisation reactions of metal ions are examined. By the interpretation of the equilibria in redox reactions and the related electrode potentials, the students learn the principles and practical characteristics of electrolytic processes suited to the extraction and purification of metals.

- Thermodynamic examination of reactions of metals
- Determination of the thermodynamic functions
- The expected course of reactions
- The compositions of equilibrium systems and the degrees of conversion
- Assessing the possibility of carbo-thermic reduction
- Thermodynamic determination of the selectivity of molten metal refining.
- Kinetics of metallurgical reactions. rate equations and the rate constant
- The temperature dependence of the reaction rate
- Determination and interpretation of the activation energy of processes
- Dissolution and precipitation in aqueous media. Solubility equilibria
- The role of the pH and the redox potential
- Reactions and characteristics of dissolved ions
- Methods of ion separation suitable for the purification of solutions
- The formation and the equilibria of complex ions
- The reactions of solution purification and concentration based on ion-exchange
- The concept and the significance of electrode potentials
- The principal reactions and applications of electro-refining and electrowinning
- The role of electrode-kinetic phenomena
- The concept and the determination of the polarization and overpotentials
- The methods of enhancing electrorefining efficiency
- Electro-deposition of reactive metals

References

1. Tamás Kékesi: Fundamentals of Chemical Metallurgy, Digital textbook, 2018.
2. Kubaschewski, O., Alcock, C.B.: Metallurgical Thermochemistry, Vol. 24. International Series on Materials Science and Technology, , Ed. Raynor, G.V., Pergamon Press, 1979.
3. Biswas, A.K., Reginald Bashforth, G.: The Physical Chemistry of Metallurgical Processes, Chapman & Hall, London, 1962.
4. Erdey-Grúz, T: Kinetics of electrode processes, Akadémiai kiadó, Budapest, 1972.
5. Pourbaix, M, Zoubov, N, Van Muylder, J.: Atlas d'Équilibres Électrochimiques, Gauthier-Villars, Paris, 1963.
6. The student may be referred to literature directly relevant to his/her research

Exam

Oral exam after correctly answering some basic questions.

Complex exam topics and sample questions

1) Raw materials of metal extraction

Types of primary and secondary raw materials
Physical preparation of raw materials for processing
Concentrating the metallic values in raw materials

2) Thermodynamic properties of reactions affecting metal extraction and purification
Thermodynamic functions characteristic of the metals and their compounds
Temperature dependence of the thermodynamic functions
Thermodynamic conditions of carbo-thermic reduction of metal oxides
Selectivity of reactions taking place in multicomponent metal melts

3) Reaction kinetics in processes of metal extraction
The rate of reactions and the determining factors
Metallurgical processes based on heterogeneous reactions
Interpretation and determination of the activation energy

4) Hydrometallurgical metal extraction
The role of metal hydroxide stability in Hydrometallurgy
Pourbaix-type diagrams
Separation of ions dissolved in various aqueous media
Formation of complex ions in aqueous solutions
Ion-exchange equilibria
Ion-chromatographic separation

5) Electrowinning and electrorefining principles
The origin and the characteristics of electrode potentials
Cathodic metal deposition from aqueous solutions
Purification of metals by electrorefining
Causes and types of overpotentials arising at working the electrodes
Characteristics of electro-crystallization