GDAŃSK UNIVERSITY OF TECHNOLOGY

# Subject card

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| Subject name and code | Chemical power sources, PG_00037313 | | |
| Field of study | Technical Physics | | |
| Date of commencement of studies | October 2023 | Academic year of realisation of subject | 2026/2027 |
| Education level | first-cycle studies | Subject group | Optional subject group<br>Subject group related to scientific research in the field of study |
| Mode of study | Full-time studies | Mode of delivery | at the university |
| Year of study | 4 | Language of instruction | Polish |
| Semester of study | 7 | ECTS credits | 2.0 |
| Learning profile | general academic profile | Assessment form | assessment |
| Conducting unit | Department of Chemistry and Technology of Functional Materials -> Faculty of Chemistry -> Faculties of Gdańsk University of Technology | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | prof. dr hab. Anna Lisowska-Oleksiak | |
| | Teachers | | |

**Lesson types**

| Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
|---|---|---|---|---|---|---|
| Number of study hours | 15.0 | 0.0 | 15.0 | 0.0 | 0.0 | 30 |
| E-learning hours included: 0.0 | | | | | | |

**Learning activity and number of study hours**

| Learning activity | Participation in didactic classes included in study plan | Participation in consultation hours | Self-study | SUM |
|---|---|---|---|---|
| Number of study hours | 30 | 2.0 | 18.0 | 50 |

**Subject objectives**

The aim of the course is to provide and consolidate knowledge in the field of the fundamentals of electrochemistry and materials chemistry of electrical conductors. The acquired knowledge will serve to understand the role of conductors in the operation of electrochemical devices for energy storage and conversion

**Learning outcomes**

| Course outcome | Subject outcome | Method of verification |
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| [K6_U01] Can learn independently, obtain information from literature, databases and other properly selected sources. | The student is able to independently supplement and update their knowledge in the field of developing technologies of chemical power sources | [SU5] Assessment of ability to present the results of task<br>[SU3] Assessment of ability to use knowledge gained from the subject |
| [K6_W01] Understands the importance of physics and its applications in connection to civilization. | The student understands the importance of employing electrochemical phenomena in applications such as electrical energy storage and others. | [SW1] Assessment of factual knowledge<br>[SW3] Assessment of knowledge contained in written work and projects |

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| Subject contents | Course content – lecture<br><br>Fundamentals of Electrochemistry<br>Ionics Charge Transport in Electrolytes: aqueous electrolytes, aprotic electrolytes, polymer electrolytes, gel electrolytes, solid electrolytes, polymer electrolytes based on PEO.<br>Electrode / electrolyte phase boundaries: metal/electrolyte, semiconductor/electrolyte, membrane/ electrolyte. Kinetics of electrode reactions; ButlerVolmer equation, exchange current, transfer coefficient, overpotential. Processes of new phase formation electrocrystallization, electropolymerization. Mechanisms of selected electrode processes: oxidation of hydrogen, methanol, methane, ethanol, glucose; oxygen reduction. Methods of studying electrode processes: voltammetry, chronopotentiometry, chronoamperometry, electrochemical impedance spectroscopy.<br>II. Devices for Electrical Energy Storage and Conversion<br>A) Primary cells: zincmanganese dioxide, zincsilver oxide, metalair cells, primary lithium cells, large-scale primary cells for special applications, etc. Anode passivation in primary cells, solid electrolyte interphase. Solid cathode materials, liquid cathodes in lithium cells. High-power redox-flow systems (RFC).<br>B) Rechargeable cells: leadacid batteries new technical solutions; metal hydride batteries NiMH; lithium batteries (lithium anodes, carbon anodes, intercalation cathodes); lithium-ion batteries (LIBs); sodium-ion cells.<br>C) Electrochemical capacitors (EDLC, supercapacitors): electrode materials ($sp^2$ carbon materials, electroactive polymers, transition metal oxides). Hybrid systems supercapacitor/galvanic cell. Batteries ecological aspects, European Union regulations.<br>D) Fuel cells (optional): SOFC, MCFC, PMFC, DMFC, others. Fuel cell electrodes: catalysts for the oxygen reduction reaction in proton-exchange membrane fuel cells. Methanol oxidation. Hydrogen as a fuel. Sources of hydrogen hydrogen from water (photoelectrocatalysis). Currentvoltage characteristics of devices. Powerenergy diagrams for electrochemical power sources (ChŹP).<br><br>Course content – laboratory<br><br>Laboratory<br>1.<br>Gel electrolytes with aprotic solvents and PMMA matrix determination of electrolyte conductivity.<br>2.<br>Polymer electrodes for supercapacitors determination of charge transport parameters in the material.<br>3.<br>Cyclic voltammetry applied to the characterization of intercalation electrodes, exemplified by Prussian blue.<br>4.<br>Determination of hydrogen evolution overpotential. Electrocatalytic influence of electrode material on the H/H reaction.<br>5.<br>Commercial batteries and identification of chemical components of the device. Basics of recycling. | | |
| Prerequisites and co-requisites | Knowledge of the fundamentals of chemistry and physics in the area of electricity and magnetism<br>Assessment methods | | |
| Assessment methods and criteria | Subject passing criteria | Passing threshold | Percentage of the final grade |
| | Lab | 100.0% | 40.0% |
| | lecture | 51.0% | 60.0% |
| Recommended reading | Basic literature | [1] A. Kisza Elektrodyka, WNT 1997<br>[2] A. Czerwiński, Akumulatory baterie, ogniwa, WKŁ Warszawa 2005<br>[3] W. Bogusz, F. Krok, Elektrolity stałe WNT 1995<br>[4] Solid State Electrochemistry, ed. . P.G. Bruce, Cambridge University Press 1995. | |
| | Supplementary literature | Comprehensive review of lithium-ion battery materials and development challenges, doi:https://doi.org/10.1016/j.rser.2024.114783<br>Comprehensive review of Sodium-Ion Batteries: Principles, Materials, Performance, Challenges, and future Perspectives doi:https://doi.org/ 10.1016/j.mseb.2024.117870<br>Electrochemical Supecapacitors, Fundamentals and Technological Applications, B.E. Conway, ed. KLuwer 1999<br>Current articles available from Scopus | |
| | eResources addresses | Supplementary<br>https://www.sciencedirect.com/referencework/9780444527455/ encyclopedia-of-electrochemical-power-sources?prefix=a- - | |

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| Example issues/ example questions/ tasks being completed | • **Models of the electric double layer at the electrode (metal, semiconductor) / electrolyte interface.**<br>• **Kinetics of electrode reactions, charge transfer process in the ButlerVolmer model.**<br>• **Diffusion transport Cottrell equation description.**<br>• **The phenomenon of electrocatalysis.**<br>• **Determination of kinetic parameters of electrode reactions using polarization curve analysis.**<br>• **Hydrogen evolution overpotential in the context of fuel cell cathodes and green hydrogen.**<br>• **Electrocatalysis of oxygen molecule (O) reduction.**<br>• **Photoelectrocatalysis, photoanodes, photocathodes, green hydrogen.**<br>• **Lithium and lithium-ion batteries, sodium-ion batteries.**<br>• **The role of solid electrolyte interfaces in high-energy batteries.**<br>• **Flow batteries vanadium electrolyte systems as an example.**<br>• **Ragone plots.** |
| Practical activites within the subject | Not applicable |