GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Chemical power sources, PG_00037313		
Field of study	Technical Physics		
Date of commencement of studies	October 2026	Academic year of realisation of subject	2029/2030
Education level	first-cycle studies	Subject group	Optional subject group 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

eNauczanie source address: https://

Additional information:

lecture course 15 h and labotratories 15 h

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 introduce the fundamentals of electrochemistry related to the application of electrode processes in devices for the storage and conversion of electrical energy, and to familiarize students with the chemistry of materials used, among others, in the construction of galvanic cells, electrochemical capacitors, and photoelectrochemical (PEC) cells.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_W01] demonstrates an understanding of the civilisational significance of physics and its applications.	Understands the civilizational importance of knowledge concerning chemical sources of electricity	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects
[K6_U01] demonstrates the ability for lifelong independent learning, including acquiring information from literature, databases and other appropriate sources.	Is aware of the necessity for independent learning and is able to critically use literature sources	[SU1] Assessment of task fulfilment [SU3] Assessment of ability to use knowledge gained from the subject

Subject contents	Course content – lecture I. Fundamentals of Electrochemistry**Ionics** electrolytes: aqueous electrolytes, aprotic electrolytes, polymer electrolytes, gel electrolytes, and solid electrolytes.**Electrodics** Metal/electrolyte, semiconductor/electrolyte, and membrane/electrolyte interfaces. Kinetics of electrode reactions: the ButlerVolmer equation, Tafel equation, exchange current, transfer coefficient, and overpotential. Diffusion control of electrode processes. The Cottrell equation. Electrocatalysis. Processes of new phase formation electrocrystallization and electropolymerization. Mechanisms of selected electrode processes. Measurement methods: voltammetry, chronopotentiometry, chronoamperometry, EIS.II. Devices for EESCD A) Primary Cells Zincmanganese oxide cells, zincsilver oxide cells, metalair cells, primary lithium cells, and large-scale cells for special applications. Passivation of primary cell anodes, solid electrolyte interphase. Solid cathode materials and liquid cathodes for lithium cells. B) Secondary Cells Lead-acid batteries, metal hydride alloy batteries (NiMH), lithium batteries, lithium-ion batteries, sodium-ion batteries, and lithium-polymer batteries. Intercalation/insertion phenomena, sp^2 carbons, layered oxides, and tunnel oxides. Electroactive polymers, polymer electrolytes, etc. Flow cells. Batteries environmental aspects and EU legislation concerning recycling. RoHS EU directive.C) Electrochemical Capacitors a) EDLC electric double-layer capacitance,b) supercapacitors redox pseudocapacitance c) hybrid systems.Electrode materials, current collector materials, aqueous and nonaueous electrolytes.D) Fuel Cells: biofuel cells, SOFC, MCFC, PEMFC, and DMFC cells. ORR catalysts in PEMFCs.E) Photoelectrochemical water splitting (PEC cells) principles of selecting electrode materials. Green hydrogen production from water.		
	Course content – laboratory 1. Determination of the chemical diffusion coefficient of a depolarizer using the chronovoltammetry method. 2. Electroactive polymers for the construction of supercapacitors using PEDOT/PSS as an example. 3. Prussian blue an electrode material based - inorganic redox network (a potential cathode material for sodium-ion cells). Synthesis and electrode properties in an aqueous electrolyte. 4. Hydrogen evolution overpotential (HER) on solid semiconductor electrodes (oxides and nitrides of selected transition metals), on metals (Pt, Pb, Cu, Zn), and on glassy carbon (GC). 5. Spent commercial batteries identification of materials. Evaluation of the importance of recycling in the context of raw material management		
Prerequisites and co-requisites	Basic knowledge in chemistry		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	ocena sprawozdan o testów	100.0%	40.0%
	egzamin pisemny	51.0%	60.0%
Recommended reading	Basic literature	A. Kisza, Elektrodyka, WNT 2000 A. Kisza, Jonika , WNT 2000 A. Czerwinski Ogniwa Baterie, wydawnictwo C.A.Vincent, B. Scrosati, Modern Batteries , New York, 1997 Ed. P.J. Gellings, H.J.M.Bouwmeester The CRS Hanbook of Solid State Electrochemistry	
	Supplementary literature	B.E.Conway, Electrochemical supercapacitors, Kluwer Academic/ Plenum Publishers, New York 2000 A. Lasia, Electrochemical Impedance Spectroscopy and its application, Springer, New York Heiderberg, London, 2014 C.A. Grimes O.K.Varghese, S. Rajjan, Light, Water, Hydrogen, Springer 2008. Springer handbook on electrochemical energy, ed. Cornelia Breitkopf, Karen Swider-Lyons, https://books.google.pl/books?hl=pl&lr=&id=I_qoDQAAQBAJ&oi=fnd&pg=PR5&ots=Ul6AQ461YQ&sig aktualne doniesienia literaturowe z bazy WoS.	
	eResources addresses		

Example issues/ example questions/ tasks being completed	Example Topics 1. Investigation of the influence of the electrode substrate on the kinetics and mechanism of the hydrogen evolution reaction (HER). 2. Synthesis and characterization of an electroactive polymer using electrochemical methods. 3. Transition metal oxides as electrodes for electrochemical capacitors voltammetric studies. 4. Titanium dioxide as a photoanode in a PEC cell; determination of photocurrents for Ti/TiONTs and ITO/TiO/BP electrodes. 5. Gel electrolytes determination of the conductivity of the prepared gel electrolyte. 6. Determination of the diffusion coefficient of a depolarizer based on voltammetric curves. Example Questions Calculate the theoretical charge capacity of a graphite electrode in a lithium-ion cell. Determine the exchange current and transfer coefficient of the investigated electrode reaction from the measured polarization curve. How does the electrical conductivity of a synthetic metal change with temperature? Describe the structure of an EDLC-type electrochemical capacitor. What do you know about the corrosion of current collectors in high-energy galvanic cells? Present a Ragone diagram for selected electrochemical energy storage devices (arrange Li-ion cells, Na-ion cells, EDLC electrochemical capacitors, and lead-acid batteries). Sketch the polarization curves ($j = f(E)$) for transfer coefficients α of 0.3, 0.5, and 0.7 at the same exchange current.
Practical activites within the subject	Not applicable

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