Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Sensory chemiczne i biosensory – podstawy i zastosowanie
**Name of subject in English** Chemical sensors and biosensors - fundamentals and applications
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Technologies
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code: W03CET-SM2017W, W03CET-SM2017L**
**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 30 | | |
| Number of hours of total student workload (CNPS) | 25 | | 50 | | |
| Form of crediting (Examination / crediting with grade) | passing with a grade | | passing with a grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | **1** | | **2** | | |
| including number of ECTS points for practical classes (P) | 0 | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | 1,2 | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge in the field of inorganic, analytical, physical, organic chemistry, and physics.
2. Basic knowledge of instrumental analytical techniques.
3. Fundamental skills in analytical techniques

**SUBJECT OBJECTIVES**

C1. Familiarizing students with the mechanisms of operation of chemical and biosensors, as well as the detection methods used in sensing.
C2. Introducing students to the physicochemical fundamentals of the construction of chemical and biosensors.
C3. Providing students with an understanding of the potential applications of chemical and biosensors as analytical tools in medical diagnostics, bioanalytics, food analysis, and environmental protection.

## SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01: Knows the definitions of a sensor and biosensor and has knowledge regarding the classification of sensors based on their operating principle and method of analyte detection.

PEU_W02: Understands the principles of operation (detection) of electrochemical, optical, mass, thermal, and piezoelectric sensors.

PEU_W03: Knows the receptor elements in a sensor device, understands their operation principles in various types of sensors and biosensors.

PEU_W04: Familiar with the analytical parameters of sensors and biosensors, and knows their application possibilities as analytical tools in various industries, environmental protection, and broad diagnostics.

relating to skills:

PEU_U01: Can safely conduct oneself during laboratory work.

PEU_U02: Can correctly carry out a planned experiment.

PEU_U03: Can apply instrumental techniques in designing and creating a simple analytical system.

PEU_U04: Can prepare a written report on a conducted experiment, analyze the obtained results, and draw valid conclusions.

relating to social competences:

PEU_K01: Can collaborate in a group during laboratory sessions.

PEU_K02: Is ready to effectively organize one's work, critically assess the knowledge possessed, and evaluate the progress of tasks being carried out.

## PROGRAMME CONTENT

| | Lecture | Number of hours |
|---|---|---|
| Lec 1 | Definition of a sensor and a biosensor. General characteristics and structure of a sensor and a biosensor. Application of sensors. Types of chemical sensors. Classification of biosensors based on the classical operating principle. Discussion of course grading principles. | 1 |
| Lec 2 | Fundamentals of chemical sensing - operational parameters of sensors: measurement range, detection limits, sensitivity, selectivity, result repeatability, response time, operational lifetime, and storage lifetime. | 1 |
| Lec 3-4 | The classic classification of sensors based on the type of transducer. | 2 |
| Lec 5 | Classification of biosensors based on the type of receptor (e.g., enzymes, antibodies, DNA) influencing the bioselectivity of the sensor, as well as the type of transducer affecting the sensitivity of the biosensor. | 1 |
| Lec 6-7 | Fundamentals of analytical optical methods used in sensing: absorption of radiation, fluorescence, chemiluminescence, bioluminescence. Surface Plasmon Resonance (SPR). Piezoelectric phenomenon. Application of piezoelectric crystal as a mass sensor (quartz crystal microbalance). Sensors utilizing acoustic waves in piezoelectric crystals. | 2 |
| Lec 8 | Biological materials used in the construction of biosensors: enzymes, tissues, cellular organelles (mitochondria, chloroplasts), microorganisms (bacteria, yeast, single-cell algae), higher organisms and their organs (e.g., insects), antibodies, nucleic acids (DNA), other biologically active compounds (e.g., hemoglobin). Indicator organisms as biosensors. | 1 |
| Lec 9 | Methods of immobilizing biological material in biosensors: adsorption, cross-linking, entrapment in polymeric gels, covalent binding, microencapsulation. | 1 |
| Lec 10 | Applications of sensors and biosensors in medicine, production control, analysis of food (including genetically modified food), control of biotechnological processes, environmental protection, defense, and scientific research. | 1 |

| | | |
|---|---|---|
| Lec 11-12 | Chip-based laboratory - LOC - Lab-on-a-chip, the concept of operation of an analytical microchip, application of LOC in chemical and biochemical analysis (medical diagnostics), use of devices in the food, cosmetic industry, and environmental protection. | 2 |
| Lec 13-14 | Biomimetic sensor devices: artificial nose, artificial tongue, odor reproduction. | 2 |
| Lec 15 | Prospects for the development of sensor devices: further miniaturization of devices and associated challenges, multifunctional devices, personalized diagnostics (POC, point-of-care). | 1 |
| | Total hours | 15 |

| **~~Classes~~** | | **~~Number of hours~~** |
|---|---|---|
| Cl 1 | | |
| Cl 2 | | |
| Cl 3 | | |
| Cl 4 | | |
| .. | | |
| | ~~Total hours~~ | |

| **Laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Organizational activities - Occupational Health and Safety regulations, discussion of the course program, and conditions for course completion. Overview of basic electroanalytical techniques applied in sensing and biosensing (voltammetric techniques, including cyclic voltammetry - CV, pulse voltammetry - differential pulse voltammetry - DPV, chronoamperometry - CA; polarographic techniques; potentiometric techniques). | 2 |
| Lab 2 | Potentiometry - direct potentiometric methods (standard addition method), application of ion-selective electrodes for determining the content of, among others, chloride, magnesium, potassium, and hydrogen ions in food products. Selectivity of ion-selective electrodes, limits of detection. | 4 |
| Lab 3 | Voltammetric methods - characteristics of the working electrode (platinum, carbon, glass, and gold electrodes). Selection of the reference electrode. Preparation of electrodes for work, storage, cleaning, measurements, and selection depending on the depolarizer used. | 4 |
| Lab 4 | Constant current voltammetry techniques in sensing - determination of N-acetyl-4-aminophenol (paracetamol) using cyclic voltammetry (CV) and differential pulse voltammetry (DPV). | 4 |
| Lab 5 | Semiconductor structures in sensing - electrode modification. Electropolymerization of conjugated systems (e.g., aniline and its derivatives) using voltammetric and chronoamperometric methods. Characteristics of the obtained polymer film. | 4 |
| Lab 6 | Biosensors. Investigation of the activity of enzymatic proteins used in biosensing using spectrophotometric methods. Determination of optimal working conditions for enzymes as native and immobilized proteins. | 4 |
| Lab 7 | Biosensor for determining glucose levels. Characterization of the operation of enzymatic biosensors based on a glucometer - introduction to techniques of enzyme immobilization on the electrode surface, determination of glucose concentration in solutions and biological samples. Determination of detection limits, sensor selectivity (interferences). | 4 |
| Lab 8 | Semiconductor nanostructures in sensing and biosensing - synthesis and surface modification of nanomaterials to prepare a matrix for constructing biosensors. | 4 |

| | | |
|---|---|---|
| | Total hours | **30** |
| **~~Project~~** | | **~~Number of hours~~** |
| Proj 1 | | |
| Proj 2 | | |
| Proj 3 | | |
| Proj 4 | | |
| … | | |
| | ~~Total hours~~ | |
| **~~Seminar~~** | | **~~Number of hours~~** |
| ~~Semin 1~~ | | |
| ~~Semin 2~~ | | |
| ~~Semin 3~~ | | |
| ~~…~~ | | |
| | ~~Total hours~~ | |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture with audiovisual aids.<br>N2. Laboratory classes - conducting experiments.<br>N3. Laboratory classes - preparation of a report. |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01- PEU_W04 | passing with a grade |
| F1 (laboratory) | PEU_U01 - PEU_U04 | passing with a grade |
| F2 (laboratory) | PEU_U01 - PEU_U04, PEU_K01_K02 | Assessment of the correctness of experiment execution and preparation of a report after completing laboratory classes |
| P (laboratory) = = 0,6 x F1 + 0,4 x F2; | | |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|

**PRIMARY LITERATURE:**

[1] Florinel-Gabriel Bănică, *Chemical Sensors and Biosensors: Fundamentals and Applications*, John Wiley and Sons, Chichester, 2012

**SECONDARY LITERATURE:**

[2] R. F. Taylor, J. S. Schultz (red.), *Handbook of chemical and biological sensors*, IOP, Philadelphia, Bristol, 2003

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

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