SUBJECT CARD

Faculty of Medicine and Health Sciences
Field of studies: Medicine
Form of studies: Full-time
Degree: Long-cycle Master's program
Specializations: No specialization
Academic year: 2022/2023

PHYSICO-CHEMICAL PRINCIPLES OF LIFE	
SUBJECT	**Physico-chemical principles of life**
NUMBER OF ECTS POINTS	5
LANGUAGE OF INSTRUCTION	English
TEACHER(S)	Artur Budzowski, MD, PhD Diana Dołęga, MD, PhD Małgorzata Kalemba-Drożdż, MD, PhD Janusz Ligęza, MD, PhD Marzena Lipińska, MD, PhD Beata Rysiewicz, MD Sonia Trojan, MD
PERSON RESPONSIBLE	Janusz Ligęza, MD, PhD
NUMBER OF HOURS	
LECTURES	20 h
CLASSES	40 h
GENERAL OBJECTIVES	
OBJECTIVE 1	The aim of the course is to introduce students to the basic laws of physics and chemistry underlying biological processes.
OBJECTIVE 2	To acquaint students with the theoretical physical and chemical principles of medical diagnostics methods.
LEARNING OUTCOMES	
MK1	**Knowledge**: Student describes water-electrolyte balance in biological systems. (B.W1.)
MK2	**Knowledge:** Student describes acid-base equilibrium and buffer action mechanism as well as their significance in systemic homeostasis. (B.W2.)
MK3	**Knowledge:** Student knows and understands the concepts of: solubility, osmotic pressure, isotonia, colloidal solutions and Gibbs-Donnan equilibrium. (B.W3.)

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MK4	**Knowledge:** Student knows basic reactions of organic and inorganic compounds in water solutions. (B.W4.)
MK5	**Knowledge:** Student knows physical laws describing fluid flow and factors affecting blood flow vascular resistance. (B.W5.)
MK6	**Knowledge:** Student knows the structure of simple organic compounds found in the macroparticles present in cells, intercellular matrix and systemic fluids. (B.W10.)
MS1	**Skills:** Student can find relationship between factors disrupting the equilibrium of biological processes and the physiological and pathophysiological changes. (B.U3.)
MS2	**Skills:** Student calculates molar and percentage concentration of compounds; computes concentration of substances in single and multi-compound isosmotic solutions. (B.U4.)
MS3	**Skills:** Student calculates solubility of inorganic compounds, determines chemical background of solubility or lack of solubility of organic compounds and its practical significance for nutrition and therapy. (B.U5.)
MS4	**Skills:** Student determines solution pH and the effect of pH changes on inorganic and organic compounds. (B.U6.)
MC1	**Social competency:** Student is aware of his/her own limitations and is able to constantly improve their education.
MC2	**Social competency:** Student is able to work in a team.

INTRODUCTORY REQUIREMENTS
Knowledge of chemistry and physics at high school level.

COURSE PROGRAM	DETAILED DESCRIPTION OF THE TOPIC BLOCKS
LECTURE 1	Course regulations. Exam criteria and grading scale. Structure of an atom. Chemical elements. Biogenic elements. Isotopes. Radioactive decay. **(2 h)**
LECTURE 2	Periodic table of elements. Elements properties. Ion bond. Biologically important ions and occurrence in the body. Covalent bonds. Molecular orbitals. Multiple bonds. The shape of chemical molecules. **(2 h)**
LECTURE 3	Electromagnetic radiation and its interaction with matter. Emission and absorption spectroscopy. Types of spectroscopic techniques. Absorption laws and rules. Lambert-Beer law. **(2 h)**

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LECTURE 4	Acid-base balance. Theories of acids and bases. Electrolytes and non-electrolytes. Ostwald's law of dilution. Acid protolysis constant and base dissociation constant. pH acidity scale. The strength of acids and bases. Calculation of the pH of acid and base solutions. Buffer solutions - definition and calculation of pH. Ionic composition of body fluids. Basic reactions of inorganic compounds. **(2 h)**
LECTURE 5	Buffering properties of body fluids. Oxygen and carbon dioxide transport in the body. Acid-base imbalance. Types of solutions. Characteristics and properties of real and colloidal solutions and suspensions. Units of concentrations of solutions and mixtures. The molecular structure of water and its physical and chemical properties. Non-covalent interactions. Solubility of the substances. Solubility product. Phase transitions. **(2 h)**
LECTURE 6	Raoult's law. Osmotic pressure. Osmotic and tonic solutions. Body water balance and dehydration. Ion economy. Transport of substance through biological membranes. Oncotic pressure. Gibbs-Donnan equilibrium. Gas Rights. Partial gas pressure. External and internal energy. Energy exchange between the system and the environment (work and heat). The first law of thermodynamics. Enthalpy. Heat capacity. Kirchoff's law. Thermal effects of the reaction. Calculation of reaction enthalpy. Hess's law. **(2 h)**
LECTURE 7	Entropy, free enthalpy and spontaneity of reaction. The second law of thermodynamics. Biological standard. Equilibria in biological systems. Coupled systems. Kinetics of chemical reactions. Kinetic equations, rate constants, half-lives. Activation energy. Arrhenius equation.**(2 h)**
LECTURE 8	Redox reactions Standard redox potential. Oxidation and reduction - definitions. The degree of oxidation of elements. Half-cell. Electromotive force and its relationship with the equilibrium constant and free enthalpy of reaction. Deviations from equilibrium. Biological standard potential. Biological redox systems. **(2 h)**
LECTURE 9	Organic chemistry. Structure, names and properties of organic compounds. Important organic reactions. Basic mechanisms of organic reactions. Characteristics of important groups of organic compounds. **(2 h)**
LECTURE 10	Flow rate. Viscosity. Classification of liquids. Examples and discussion of non-Newtonian liquids. Types of flows. Bernoulli's law. Venturi effect. Poiseuille-Hagen law. Blood circulation in the body. Blood properties. **(2 h)**
CLASS 1	Chemical calculations: conversion of concentrations. Calculation of the solubility of inorganic and organic compounds. – dr Małgorzata Kalemba-Drożdż

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CLASS 2	Quantitative analysis - pH-metric titration. – mgr Sonia Trojan
CLASS 3	Spectrophotometry. Lambert-Beer law and its application in laboratory tests. – dr Marzena Lipińska
CLASS 4	Complexometry. – dr Artur Budzowski
CLASS 5	Colloids. Osmotic pressure. Donnan's balance. – mgr Beata Rysiewicz
CLASS 6	Viscosity. – dr Beata Rysiewicz
CLASS 7	Kinetics and chemical equilibrium. Quantitative analysis. – dr Marzena Lipińska
CLASS 8	Chromatography. - dr Artur Budzowski
CLASS 9	Redox reactions Kinetics and chemical equilibrium - qualitative research. – dr Diana Dołęga
CLASS 10	Electrophoretic techniques - protein electrophoresis. – mgr Sonia Trojan
DIDACTIC METHODS (APPLIED)	
M2	Laboratory exercises
M16	Lectures
M10	Multimedia presentations
STUDENTS WORKLOAD	
NUMBER OF HOURS UNDER SUPERVISION	60 hours
NUMBER OF PREPERATION HOURS	Preparation for classes: 20 hours Preparation of the reports: 20 hours Preparation for the exam: 40 hours
TOTAL NUMBER OF HOURS FOR THE COURSE	140 hours
CONDITIONS FOR COURSE COMPLETION	
Prior to the laboratory classes the student is obliged to read the safety regulations and the rules of safe operation and safe use of chemical reagents. Students staying in the laboratory are obliged to strictly comply with the laboratory regulations, including the use of personal protective equipment in the form of a lab coat and protective glasses, which the student should bring for the exercises.	
Student attendance of all lectures and classes is compulsory. In case of absence student must compensate for missed classes in consultation with the teacher.	

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Prior each laboratory exercise, the student must read the literature given by the teachers, including textbooks, laboratory classes protocols, as well as tips on how to prepare reports. Prior to each laboratory classes, the student completes the preliminary test, for which them can receive a maximum number of 8 points.	
After each completed laboratory class the student prepares a report. Reports are prepared in groups and must be handwritten. It is allowed to attach printouts of graphs prepared using a computer. The student has 1 week (5 working days) to submit the report. Reports should be submitted to laboratory staff in room C 322 or 320. The teacher has 2 weeks (10 working days) to check and evaluate the report. The report shall be deemed passed if it does not require amendment. If corrections are needed, students must follow the teacher's instructions and attach the improvement to the original report. The teacher may demand further amendments until the report takes an acceptable form. In order to pass the laboratory exercises it is required to pass all the reports on the exercises to which the student was present.	
Active participation in classes allows to get 2 additional points for each exercise. Maximum of 100 points may be obtained during all 10 exercises. Pass mark for the laboratory classes is 55 points.	
METHODS OF ASSESMENT	
IN TERMS OF KNOWLEDGE	Multiple choice test, written tests with open questions.
IN TERMS OF SKILLS	Proper execution of laboratory exercises, analysis of data obtained from conducted experiments and interpretation of results, preparation of report.
IN TERMS OF SOCIAL COMPETENCY	Activity during classes, observation of group work, preparation of reports in groups.
FORMATIVE	Written tests, 3-4 open questions.
SUMMATIVE (I & II term)	**I term (EXAM):** Multiple Choice Test – 75 questions, each correct answer scored for 2 points. **II term (RETAKE EXAM):** Multiple Choice Test – 75 questions, each correct answer scored for 2 points. Total number of points from the exam – 150 points. Pass mark for written exam – 82 points (41 questions answered correctly).
GRADING SCALE	
CALCULATION CONDITIONS OF THE FINAL GRADE	The sum of points possible to obtain during laboratory exercises (100 points) and written exam (150 points) is 250. The final grade for the subject is calculated according to the following scale.
3,0 (SATISFACTORY)	From **55%** of the maximum number of points to be obtained during the course.

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3,5 (SATISFACTORY PLUS)	From **64%** of the maximum number of points to be obtained during the course.
4,0 (GOOD)	From **73%** of the maximum number of points to be obtained during the course.
4,5 (GOOD PLUS)	From **82%** of the maximum number of points to be obtained during the course.
5,0 (VERY GOOD)	From **91%** of the maximum number of points to be obtained during the course.

BASIC LITERATURE

[1] Fundamentals of General, Organic and biological chemistry - John McMurry – Pearson. Chapters 1-19;
[2] Julie Fisher, John Arnold — BIOS Instant Notes in Chemistry for Biologists, United Kingdom, 2012, Taylor & Francis. Whole book;
[3] Clinical Biochemistry – An illustrated colour textbook. Michael Murphy. Elsevier:
Chapter 7 Fluid and electrolytes: basic concepts,
Chapter 21 Acid -base: concepts and vocabulary,
Chapter 22 Metabolic acid-base disorders,
Chapter 23 Respiratory and mixed acid-base disorders;
[4] Biophysics - An introduction. Roland Glazer Springer:
Chapter 3.2. The Aqueous and ionic equilibrium of the living cell,
Chapter 3.6.1 Some Basic Properties of Fluids,
Chapter 3.6.2 The Viscosity of Biological Fluids,
Chapter 3.7.1 Laminar and Turbulent Flows,
Chapter 3.7.2 Biomechanics of Blood Circulation;
[5] Analytical chemistry 2.0 by David Harvey. Chapter 10. Spectroscopic methods;
[6] Physiology, Biophysics and Biomedicine Engineering. W. Wood. Chapter - Rheology of blood.

SUPLEMENTARY LITERATURE

[1] An Introduction to General, Organic, and Biological Chemistry - Karen C. Timberlake – Pearson. Chapters 1-4 and 6-15;
[2] Gavin Whittaker — BIOS Instant Notes in Physical Chemistry, United Kingdom, 2000, Taylor & Francis:
B. Thermodynamics,
C. Equilibria,
D. Solutions,
E. Ionic solutions, E1-E5,
G1. Nuclear structure,
I1. General features of spectroscopy;
[3] An Introduction to General, Organic, and Biological Chemistry - Karen C. Timberlake – Pearson: Chapters 1-4 and 6-15;
[4] Giancoli Physics: Principles With Applications: Chapter 10 – Fluids.