Study Course Description — Medical Chemistry

Study Course Information			
Course code:	CFUBK_006	**Branch of science:**	Chemistry; Medical Chemistry
Course level:	Level 6	**Credit points:**	3
Target audience:	Medicine	**ECTS points:**	4,5
Course Author			
Course author:	Assistant Professor Aris Kaksis; Aris.Kaksis@rsu.lv		
Course Implementer			
Academic unit:	Department of Human Physiology and Biochemistry		
Head of academic unit:	Pēteris Tretjakovs		
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Planning of the Course			
Length of lectures:	2 academic hours	**Length of classes:**	2 academic hours
Full-time studies:	0 lectures, 0 classes; 0 contact hours.		
Part-time studies:	0 lectures, 0 classes; 0 contact hours.		
Course Description			
Prerequisites:			
Language skills (spoken and written), mathematics (algebra and geometry), chemistry, physics and biology (within the secondary school program).			
Course objective:			
to promote modern concept formation about the substance basics of life processes in the human organism, including metabolic pathways and composition of the human body and its functions, as well as understanding of biochemical mechanisms and biomedical properties in order to identify the causes of diseases and to find scientific solutions to medical problems.			

Topic outline of the study course:

No	Topic	Type of	Number	Venue
1.	Amounts of substance, solvent, solution, dilution, molar concentration molarity, mol fraction, mass fraction (in percent's %), salts-acids-bases dissociation stoichiometry, dissociation degree, isotonic coefficient, ionic force, concentration gradient osmolar pressure on cell membrane	implementation Practice	1	laboratory
1.	a) Colligative properties, concentration expressions, electrolytes, osmosis. b) Oxidation-reduction processes, Nernst's potential;	Lecture	1	auditory
2.	Oxidation-reduction half reactions balancing of electrons for resolving the reaction equations Nernst's potential: acidose, oxidative stress as non-enzymatic oxidation hasards for damages in organisms	Practice	1	laboratory
2.	a) Thermodynamics, Homeostasis, Chemical equilibrium, Le Chatelier's. Kinetics. b) Water dissociation, pH, pOH, pKw, Ostwald's dilution Law	Lecture	1	auditory
3.	Thermodynamics analyses of neutralisation reaction Evaluation of Thermodynamics criteria enthalpy H, entropy S and free Gibb's energy G in studies of biochemical reactions: Photosynthesis, Glucose biooxidation, Respiration Thermodynamics	Practice	1	laboratory
3.	a) Buffer solutions, buffer systems in human body, pH of a buffer system b) Atoms, molecules, types of bonds and interaction forces	Lecture	1	auditory
4.	Chemical reaction kinetics – reaction velocity depends to concentration proportionally, reaction velocity constant, activation energy E_A half-life period, types of catalysis, enzyme driven processes. Practical studies of active mass Law	Practice	1	laboratory
4.	a) Carbohydrates in human organism b) Amino acids, Polypeptides and Proteins in human organism	Lecture	1	auditory
5.	Equilibrium constant K_{eq} expression, factors (concentration, gradient, T, ΔG_r) affecting the constant K_{eq}, the solubility product K_{sp} and crystallic compound mol fraction Nx=1, Le Chatelier's Principle (Theorem) concentration gradient driven homeostasis processes in osmosis H_2O+O_2 , shuttle of O_2, H^+, HCO_3^- hemoglobin and respiration of **O_2, CO_2**	Practice	1	laboratory
5.	a) Lipids and surface active compounds in human organism b) Complex proteins: Glyco, Chromo, Lipo and Nucleoproteins	Lecture	1	auditory

6.	I colloquium. Osmolar concentration, gradient osmotic pressure π=iCMRT, mol fraction. Cryoscopy constant K_{cr}=1.86 for osmometer. Concentrations w%, c_M , mass, molar mass, number of moles, mol fraction. Ox-Red reactions balance electrons in half reactions. I, II Law of Thermodynamics: exothermic or endothermic, exoergic or endoergic reactions are or not spontaneous. Equilibrium constant K_{eq} solubility product K_{sp}. Reaction velocity and velocity constant. Reactions enzymatic benefit and non-enzymatic hazards.	Practice	1	laboratory
7.	pH calculation for acids, bases, salts and neutralization reactions pK values; Ostwald's dilution law pH calculation for weak electrolytes and amino acids	Practice	1	laboratory
8.	Studies of Henderson–Haselbalh equation with titration graph. Buffer middle point pH=pK and equivalence point Veq experimental observation and analyses.	Practice	1	laboratory
9.	Buffer solutions, pH calculations, maximal buffer capacity βmax studies. Blood enzymes carbonic anhydrase-hemoglobin shuttle buffered physiologic pH=7,36 stability	Practice	1	laboratory
10	Complex formation and destruction studies. Complex dissociation and instability constant Kinstab. Geometry of complex compounds and related substances in human body. B2 vitamin oxidized form light absorption studies: A=log(Io/I); A=aCl. Spectrometry.	Practice	1	laboratory
11	II colloquium Water dissociation and ionization. Protolytic acid base theory and acid base reactions. Salt hydrolyze. Buffer solutions Henderson-Haselbalh pH=pKa+lg(nsalt/nacid) and buffer capacity 13ac, 13b. RedOx and membrane potentials. Trans membrane channels and metabolic transport. Coordinative compounds. B2 vitamin oxidized form light absorption: A=log(Io/I); A=aCl. Spectrometry.	Practice	1	laboratory
12	Monosaccharide functional groups, chirality-optical isomerism. Carbohydrate projections linear Fisher projections and cyclic Haworth projections. Monosaccharide properties: oxidation, reduction, complex formation, esterification, hydrolyse	Practice	1	laboratory
13	Condensation of mono saccharides and opposite hydrolysis of di and polysaccharides. glycosidic bond formation. Drawing di and polysaccharides	Practice	1	laboratory
14	Peptide and protein primary 1° structure synthesis (poly condensation) and hydrolyse. Protein primary 1° structure folding and assemble to secondary 2°, tertiary 3°, quaternary 4° structures. Intermolecular forces: hydrogen bond, salt bridge, hydrophobic, disulphide and coordinative bonds. Protein denaturation destroying intermolecular forces in protein 2°, 3°, 4° structures	Practice	1	laboratory
15	Lipids and Surface active compounds SAC in human organism. Esterification and hydrolysis. Cell membrane composite lipids: fats, oils, phospho, sphingo, eicosanoids, cholesterol, steroids. Composite lipids double layer studies for cell membranes and physiologic functions.	Practice	1	laboratory
16	Complex proteins – glyco, chromo, nucleo, lipoprotein vesicles, Lipocalins, albumin (extra cellular) and START (intracellular) lipo proteins.	Practice	1	laboratory
17	III colloquium Carbohydrates. Blood oligosaccharides. Proteins primary 1°, secondary 2°, tertiary 3°, quaternary 4° structures. Five intermolecular forces. Hemoglobin, myoglobin carbonic anhydrase enzymes governed oxygen O2 carbon dioxide CO2 metabolism physiologic pH=7.36 stability. Denaturation of proteins. Lipoprotein functions. Lipocalins and START with cholesterol and composite lipids in membrane metabolism, Albumin, chylomicrons, VLDL,LDL & HDL. Nucleo proteins DNS, tRNS, mRNS-codons, Nucleo somes 8 Histons.	Practice	1	laboratory

Students' independent work and tasks:

Independent studies of original sources, preparation of conclusions for laboratory work.

Learning outcomes:

Knowledge: Upon successful completion of the course the students will be able to: - define and explain the concepts of medical chemistry and static biochemistry;
- describe quantitative and qualitative relationship between chemical processes;
- estimate the role of the oxygen, glucose, CO2 and osmolar concentration and blood pH levels;
- explain the main principles how the ion channels influence membrane potential;
- contrast the impact of natural substances used in healthy nutrition and the impact of harmful compounds.

Practical Skills: Students will be able to:
- analyses biological functions of the compounds exchange and states of homeostasis;
- estimate metabolic pathways and conversion into equivalent amounts, taking into consideration law of conservation of mass-energy;
- analyses integration of the atomic properties of chemical elements and conversion into molecular buildings and aggregate properties in order to estimate interaction with environment and integrated compound exchange for maintenance of living functions.

This will be reflected in the conclusions of the students' papers, conclusions of laboratory work, tests and colloquia.

Clinical skills: Field Level Title

Competence: Students will be able to use their knowledge of the various processes and mechanisms of Medical Chemistry and practical skills in assessing the functionality of processes and mechanisms for drawing proficient, integrated conclusions on the life homeostasis taking place in the body.

Final examination:	Exam
Assessment criteria:	
colloquia, written tests and a test on conclusions of laboratory work; an examination at the end of the course.	
Readings:	
Recommended:	1. A. Rauhvarger © 1993. General Chemistry. For Medical Students. Riga, AML. Part I, II, III, IV. http://aris.gusc.lv/GenChem93/ChemistryRauhvarger.html
	2. A.Kaksis. "General Medical Chemistry", Med. Biochemystry Data Base RSU department, 2017.g, in RSU *e- studies* Lectures and practicals refferences in Home Page:http://aris.gusc.lv/
	3. D.L. Nelsone, M.M. Cox. Lehninger Principles of Biochemistry, 2005: 1119.
Optional:	1. P.W. Atkins. Physical Chemistry (7th ed. Oxford University Press), 2006: 480. 2. CRC Handbook of Chemistry and Physics 89Ed David R. Lide New York, 2009: 2388p.
Other sources:	nav uzdoti

APSTIPRINĀTS
Rīgas Stradiņa universitātes
Cilvēka fizioloģijas un bioķīmijas katedras
http://aris.gusc.lv/2018MFArz1LekcLdVK1sem.pdf; sanāksme 01.02.2018., protokola nr. 24.14.-3/1

Study course **"Medical Chemistry"**

Spring semester 2018 Year 1, Semester 1

Lectures (Febr.12 – March 12); On Wednesday, Lecture hall 3, 10:15 – 11:45 (2 x 45 min lectures)

Week	Lecture topic
1. Febr 12, 2018	a) Colligative properties, concentration expressions, electrolytes, osmosis. b) Oxidation-reduction processes, Nernst's potential; http://aris.gusc.lv/BioThermodynamics/ColigatConcOsmosOxRed.pdf
2. Febr 19, 2018	a) Thermodynamics, Homeostasis, Chemical equilibrium, Le Chatelier. Kinetics. b) Water dissociation, pH, pOH, pKw, Ostwald's dilution Law http://aris.gusc.lv/BioThermodynamics/ThermKinEquilibrH2O.pdf
3. Febr 26, 2018	a) Buffer solutions, buffer systems in human body, pH of a buffer system b) Atoms, molecules, types of bonds and interaction forces; http://aris.gusc.lv/BioThermodynamics/BuferCO2AtomBond.pdf
4. March 5, 2018	a) Carbohydrates in human organism b) Amino acids, Polypeptides and Proteins in human organism; http://aris.gusc.lv/BioThermodynamics/CarbohydratesProteins.pdf
5. March 12, 2018	a) Lipids and surface active compounds in human organism b) Complex proteins: Glyco-, Chromo-, Lipo-and Nucleo-proteins in human organism; http://aris.gusc.lv/BioThermodynamics/LipCholestFatSAC.pdf

Practical laboratory classes (Feb 13 – Jun 21)

Room and time– **According to individual group Schedule** (duration 2 h 15 min)

Week	Practical class topic
1.Feb 13-19	Amounts of substance, solvent, solution, dilution, molar concentration molarity, mol fraction, mass fraction (in percent's %), salts-acids-bases dissociation stoichiometry, dissociation degree, isotonic coefficient, ionic force, concentration gradient osmolar pressure on cell membrane
2.Feb 20-26	Oxidation-reduction half reactions balancing of electrons for resolving the reaction equations Nernst's potential: acidose, oxidative stress as non-enzymatic oxidation hasards for damages in organisms
3.Feb 27-5	Thermodynamics analyses of neutralisation reaction Evaluation of Thermodynamics criteria enthalpy H, entropy S and free Gibb's energy G in studies of biochemical reactions: Photosynthesis, Glucose biooxidation, Respiration Thermodynamics
4.Mar 6 12	Chemical reaction kinetics – reaction velocity depends to concentration proportionally, reaction velocity constant, activation energy E_A half-life period, types of catalysis, enzyme driven processes. Practical studies of active mass Law
5. Mar 13-19	Equilibrium constant K_{eq} expression, factors (concentration, gradient, T, ΔG_r) affecting the constant K_{eq}, the solubility product K_{sp} and crystallic compound mol fraction Nx=1, Le Chatelier's Principle (Theorem) concentration gradient driven homeostasis processes in osmosis H_2O+O_2 , shuttle of O_2, H^+, HCO_3^- hemoglobin and respiration of **O_2, CO_2**
6. Mar 20-21	***Colloquium I*** Osmolar concentration, gradient osmotic pressure π=iCMRT, mol fraction. Cryoscopy constant K_{cr}=1.86 for osmometer. Concentrations w%, c_M , mass, molar mass, number of moles, mol fraction. Ox-Red reactions balance electrons in half reactions. I, II Law of Thermodynamics: exothermic or endothermic, exoergic or endoergic reactions are or not spontaneous. Equilibrium constant K_{eq} solubility product K_{sp}. Reaction velocity and velocity constant. Reactions enzymatic benefit and non-enzymatic hazards.
7.Apr 03-09	pH calculation for acids, bases, salts and neutralisation reactions pK values; Ostwald's dilution law pH calculation for weak electrolytes and amino acids
8.Apr 10-16	Potentiometric titration Practical studies of Henderson–Haselbalh equation titration graph and it's analysis

Week	Practical class topic
9.Apr 17-23	Buffer solutions, Henderson–Haselbalh pH, buffer capacity β Experimental research studies of buffer solutions. Physiological pH=7,36 of human blood
10. Apr 24-30	Practical experiments on complex formation and destruction. Complex dissociation and instability constant K_{instab}. Complex geometry and human vitamin B_2 "JunyWay" spectrophotometry.
11. May 08-14	***Colloquium II*** Water dissociation and ionization. Protolytic acid base theory and acid base reactions. Salt hydrolyze. Buffer solutions Henderson-Haselbalh pH=pKa+lg(nsalt/nacid) and buffer capacity 13ac, 13b. RedOx and membrane potentials. Trans membrane channels and metabolic transport. Coordinative compounds. B2 vitamin oxidized form light absorption: A=log(Io/I); A=aCl. Spectrometry.
12. May 15 - 21	Monosaccharide properties (main functional groups, atom chirality, numbering) Forms of carbohydrate projections (linear Fisher projections and cyclic Haworth projections) Monosaccharide chemical properties – oxidation, reduction, complex formation, esterification
13. May 22 - 28	Condensation of mono saccharides; hydrolysis of di-and polysaccharides. Glycosidic bond formation. Di-and polysaccharide structures drawing and publication
14. May29 – 04 Jun	Peptide and protein primary 1° structure synthesis (poly condensation) and hydrolyse reactions Protein primary 1° structure folding and assemble to secondary 2°, tertiary 3°, quaternary 4° structures Intermolecular forces: hydrogen bond, salt bridge, hydrophobic, disulphide and coordinative bonds Protein denaturation: destroying intermolecular forces in naturally formed protein 2°, 3°, 4° structures
15. Jun 05– 11	Lipids as well as Surface active substances (SAC) in human organism Esterification and hydrolysis of fats, oils, phospholipids sphingolipids Other classes of human cell membrane related lipids sphingolipids , eicosanoids, cholesterol, steroids
16. Jun12 17	Complex proteins – glyco, chromo, nucleo, lipoprotein vesicles, Lipocalins, albumin (extra cellular) and START (intracellular) lip proteins.
17. Jun 18 – 21	***Colloquium III***

Final Exam: Tuesday, June 26, 2018 Lecture halls **Nr 2**

Lecturers:

RSU department of Human Physiology and Biochemistry

Assist. Professor **Āris Kaksis**, lecturer **Agnese Brangule** and lecturer **Mihails Halitovs**

Literature

Most of the sources are available at RSU library either as a hard copy or through RSU Library data bases

1. 1. A. Rauhvarger © 1993. General Chemistry. For Medical Students. Riga, AML. Part I, II, III, IV. http://aris.gusc.lv/GenChem93/ChemistryRauhvarger.html in RSU *e- studies*

   ***A. Rauhvargers "General Medical Chemistry" for medical students**, AML, 1993,*

   19 selected chapters from Part I, II, III, IV.
2. ***J. McMurry, R.C. Fay, Chemistry**, Prentice Hall/Pearson, 2012, 954 p.*
3. ***Rao, N. Mallikarjuna, Medical Biochemistry**, New Age International, 2006, 837 p.*
4. ***L. Indira, K. Nagaraju, K. Zameer Ahmed, College Biochemistry**, Himalaya Publishing House, 2010, 180 p.*
5. ***A.L. Lehninger, Lehninger principles of biochemistry**, New York:W.H.Freeman, 2013, 1198 p.*
6. ***R.K. Murray, D.K. Granner, V.W. Rodwell, Harper's illustrated biochemistry**, New York, 2009, 693 p.*

Nosūtu kolokviju datumus: I kolokvijs SSNMF 20.marts 13.gr. 8.gr.,15.gr.;
21.marts 1.gr., 11.gr., 16.gr.;
II kolokvijs SSNMF 08.maijs 13.gr. 8.gr.,15.gr.; 09. maijs 1.gr.;
10. maijs 11.gr., 16.gr.;
III kolokvijs SSNMF 18. jūnijs 11.gr., 16.gr.;
19. jūnijs 13.gr. 8.gr.,15.gr.; 20. maijs 1.gr.;