Degree Course in Dentistry and Dental Prosthetics 2021/2022

Integrated Course: Chemistry and Biochemistry
CFU Number: 10
SSD Course: BIO/10
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PREREQUISITES

No prerequisites are foreseen to sustain this examination. However, in order to learn contents of this course it is necessary to have knowledge of basic mathematical notions (logarithms, exponentials, second-degree equations) and a general knowledge of the structure of the atom, stoichiometry and the general rules of nomenclature of inorganic and organic chemistry compounds.

LEARNING OBJECTIVES

The aim of the Integrated Course of Chemistry and Biochemistry (General and Inorganic Chemistry, Introductory Biochemistry and Biochemistry), is to provide students with the fundamental knowledge of the structure of the basic constituents of matter (atoms, elements) and the structure of macromolecules necessary for the functioning and regulation of living organisms and their transformation processes. To enable the student to understand the basics of organic and inorganic chemistry and cellular metabolism. The integrated course also aims at providing the student with the fundamental knowledge of the basic concepts of chemistry, related to the structure of the macromolecules at the basis of the metabolic processes necessary for the functioning and regulation of living organisms: carbohydrates, lipids, nucleic acids and proteins. To enable the student to understand the basics of cellular metabolism. The course aims to provide the student with some essential methods used in chemical and biochemical practice and the theoretical principles on which these methods are based and their field of application.

LEARNING OUTCOMES

Knowledge and understanding

The Integrated Course of Chemistry and Biochemistry aims to provide students with a comprehensive theoretical knowledge of the principles, rules and structures of molecular chemistry and biochemistry. At the end of the course, the student must also acquire the ability to identify the main structural components of naturally occurring inorganic and organic compounds.

At the end of this teaching, the student will acquire:

- Knowledge of the fundamental constitution of the atom and the various types of chemical bonds.
- Knowledge of the principles of chemical thermodynamics
- Knowledge of the water-based reactions, acid-base theories, and their role in maintaining the homeostasis in the human body
- Knowledge of the mechanisms of oxidation-reduction reactions
- Knowledge of the fundamentals of the carbon chemistry and of the other main elements important in the biological world.
- Knowledge of the different classes of organic compounds, with particular reference to those of potential biological interest
- Knowledge of the principles of stereochemistry
- Knowledge of the structure and function of the main biological macromolecules
- Knowledge of the principles of enzymatic catalysis
- Knowledge of the different metabolic cycles that occur in eukaryotic cells
- Knowledge of the role of different "fuels" in energy production
- Knowledge of the role of the mitochondrion as the power plant of the cell
- Knowledge of the biosynthetic pathways of the main molecules of biochemical interest
- Knowledge of the molecular basis of biological processes of eucariotic cells and microorganisms.

Applying knowledge and understanding

The student will learn to apply the theoretical knowledge acquired during the course to the clinical context he/she will analyze, and will be able to recognize the general diagnostic aspects of chemical and metabolic abnormalities. The student will also acquire the ability to identify and appropriately assess chemical and metabolic abnormalities and their influence in determining the clinical scenario.
At the end of this teaching, the student will be able to:

- Adequately interpret the importance of biochemical processes alterations, as a cause of various pathological conditions.
- Use the acquired knowledge for an in-depth study of aspects related to his future professional activity
- Understand the molecular basis of human diseases
- Understand application of molecular techniques for diagnostic purpose

Communication skills

At the end of this teaching, the student will be expected to:

- Communicate scientific contents in a clear and unambiguous way, using appropriate technical language

Making judgments

At the end of this teaching, the student will be able to:

- Carry out assessments of the topics covered.
- Autonomously interpret the data pertaining the topics covered by the course

Learning skills

At the end of the course, the student should have acquired independent method for studying and updating through different kind of literature or through scientific literature.

PROGRAM:

Module:

General and inorganic chemistry (3 CFU):

Introductory notes - Periodic table of the elements and its meaning: Inorganic nomenclature: acids, bases, salts. Balance of a chemical reaction. Concept of mole, Avogadro number.

Constitution of the atom - Elementary particles: proton, neutron, electron. Isotopes. Electrons and electronic configuration of atoms. Quantum numbers and orbitals. Aufbau. The chemical bond: covalent, ionic, dative. Hybridization. Weak bonds: ion-dipole, Van der Waals, hydrogen bond. Electronegativity.

States of matter - Gas: equation of state of ideal gases. Absolute temperature and relationship with the average molecular speed. Gaseous mixtures; Dalton's law. Liquids: vapor pressure of a liquid. Solids: structural characteristics of covalent, ionic, molecular solids. Metallic solids (outline).

Chemical thermodynamics - Concept of state function. Internal energy of a system. Enthalpy, Hess's law. Entropy. Free energy.

Solutions - Concentration of solutions: % by weight, mole fraction, molarity, molality, normality. Dilutions and mixing of solutions. Vapor pressure of a liquid-liquid solution (Raoult's law). Ideal solutions. Colligative properties: variation of vapor pressure, of melting and boiling temperatures; osmosis and osmotic pressure. Solubility of gases in liquids: Henry's law.

Chemical equilibrium - Equilibrium in the gas phase. Expression of the equilibrium constant. Relationship between Kc and Kp. Factors that influence the balance. Homogeneous and heterogeneous equilibria.

Electrolyte Solutions - Strong and Weak Electrolytes; degree of dissociation. Colligative properties of electrolyte solutions; combination of Van't Hoff. Acids and bases according to Arrenius, Bronsted and Lowry, Lewis. Strong and weak acids and bases. Ionic dissociation of water. Kw. Equilibrium constant of an acid and a base. Relationship between the equilibrium constant and the degree of dissociation of a weak electrolyte: Oswald's law of dilution. The pH; calculation of pH in solutions of strong and weak acids (and bases). Saline hydrolysis. Buffer solutions. Dissociation of polyprotic acids (outlines). Acid-base titrations.

Chemical Kinetics - Introduction to Kinetics; activated complex theory; activation energy. Kinetic equations

Redox reactions and electrochemical potentials - Oxidation number. Redox reactions and their balance. Standard reduction potentials.

<u>Introductory biochemistry (2 CFU):</u>

Hybridization of the carbon atom - sp^3, sp^2, sp hybridizations and their geometry.

Hydrocarbons and saturated hydrocarbons - alkanes and cycloalkanes. Nomenclature. Conformational isomerism and geometric isomerism (cis-trans).

Unsaturated hydrocarbons: alkenes and alkynes. Nomenclature. Reactions of unsaturated hydrocarbons (overview).

Aromatic compounds - Structure of benzene: the resonance model. Nomenclature of aromatic compounds. Polycyclic aromatic hydrocarbons (overview).

Alcohols, phenols, thiols - Nomenclature. Acidity and basicity of alcohols and phenols. Thiols, analogues of alcohols and phenols.

Aldehydes and ketones - Nomenclature. Preparations of aldehydes and ketones. The carbonyl group. The nucleophilic addition to the carbonyl groups; formation of semiacetals and acetals. The aldol condensation (overview).

Carboxylic acids and their derivatives - Nomenclature of acids. Derivatives of carboxylic acids: esters, amides. Mechanism of esterification; triesters of glycerol.

Amines and other nitrogen compounds - Classification of amines and nomenclature. Maine basicity.

Stereoisomery - Chirality. Enantiomers. Polarized light; the polarimeter (overview). Diastereomers.

Biochemistry (5 CFU):

Carbohydrates - Definitions and classification. The monosaccharides. Chirality in monosaccharides; Fischer's projections. Cyclic structures of monosaccharides. Anomers. Phenomenon of mutarotation. Pyranosic and furanosic structures.

Lipids - Structure, nomenclature, properties and biological functions

Nitrogen bases and nucleotides -Structure, nomenclature and biological functions.

Proteins - Amino acids and their properties.-Peptide bond. Primary structure. Non-protein amino acids. Secondary structure: alpha helix, beta sheet, loops and beta turn. Tertiary and quaternary structure: hydrogen bonds and hydrophobic effect. Misfolding and related pathologies. Generic structure of fibrous and globular proteins. Techniques for the analysis and purification of proteins

Enzyme kinetics - steady state. The Michaelis-Menten equation. Meaning of Km. Catalytic efficiency: meaning of kcat / Km. Reciprocal Doubles Graph. Classification of enzymes. Inhibitors: competitive and uncompetitive inhibition. Mechanisms and graphs of reciprocal doubles. The inhibitors: a-competitive (pure non-competitive) and mixed (non-competitive) inhibition. Irreversible inhibitors and suicide inhibitors. - The transport and storage of oxygen.

Myoglobin - structure and function.

Hemoglobin - structure and function. The Bohr effect; the effect of 2,3 BPG; the transport of CO_2 and NO. Introduction to the theory of protein-ligand interaction: case of only 1 site. Case of *n* fully cooperative sites. General case. Concerted and sequential model. Effects of point mutations.

Membrane lipids. Cholesterol. Lipids-signal and cofactors: eicosanoids, steroid hormones, fat-soluble vitamins. Architecture of biological membranes: composition of membranes, common properties of membranes, the bilayer sheet, types of proteins in biological membranes. Dynamics of biological membranes. Transport across biological membranes: simple diffusion and passive transport, glucose transporter, chloride-bicarbonate exchanger, active transport, sodium-glucose symports, aquaporins.

Vitamins - historical introduction. Fat-soluble vitamins structure, function, avitaminosis, hypervitaminosis. Water-soluble vitamins structure, function avitaminosis.

Bioenergetics - free energy in biochemical reactions. Standard free energy and Keq free energy. Examples.

Glycolysis. Pentose phosphate pathway. Coordinated control of glucose metabolism. Lactic fermentation and alcoholic fermentation. Anaerobic metabolism and caries. The Krebs cycle. Glycogen metabolism and its regulation. Glycogen storage diseases.

Physiological digestion of fats. Lipoproteins - structure and function of chylomicrons, VLDL, LDL and HDL. Glucagon-induced fat mobilization: roles of triacylglycerol lipase and perilipin. Activation of fatty acids and transport across the mitochondrial membrane. Carnitine. Beta-oxidation of saturated fatty acids, even. Examples. Ketogenesis. Beta-oxidation of unsaturated and odd fatty acids.

Protein digestion - role of pH and digestive enzymes. Alanine-glucose cycle. Transamination, oxidative deamination, non-oxidative deamination. Glutammine-synthetase: role and its regulation.

Urea cycle.

Overview of branched amino acids catabolism and "maple syrup" urine disease. Catabolism of glycine and serine.

Overview of nitrogenous bases catabolism - excess uric acid and gout.

The metabolism of heme - introduction to biosynthesis (the glycine pathway, the synthesis of δ-aminolevulinate and the formation of porphobilinogen). The porphyrias. Notes on the catabolism of EME and its degradation to biliverdin and bilirubin.

Chemiosmotic coupling - general principles; the change in free energy associated with the flow of electrons and protons; ATP synthase as an energy transducer. Electron transporters: nicotinamide and flavin nucleotides; ubiquinone; cytochromes; iron-sulfur proteins; complexes I, II, III, IV; Q cycle; respirasome. ATP synthase (structure and catalysis; ATP synthase as molecular motor). Inhibitors and uncouplers of respiratory chain.

LECTUR MODE

The course is structured in 100 hours of frontal teaching broadcast simultaneously in streaming. Divided into 2-hour lessons basing on the academic calendar, including theoretical parts and exercises. Attendance is mandatory.

EXAM

The verification of the students' preparation will take the form of a written test, followed by an oral exam.

The written test will consists of open-ended and multiple-choice questions. The mark is given in thirtieths. The questions may have a different weighting based on the complexity of the question and the particular knowledge being tested. Zero points will be awarded for each incorrect or missing answer. In order to pass the written test and to be admitted to the oral test, a score of 18 or more is required.

The oral test will focus on some questions relative to the entire program. The score of the oral test will be averaged with that of the written test to obtain the final score (in thirtieths).

During the oral proof, the examiner will test the student's skills in applying the knowledge obtained and in solving chemistry and biochemistry issues. Further skills which will be evaluated, that encompass making judgments, communication skills and learning skills according with Dublin Descriptors.

SUGGESTED TEXTBOOKS LIST

- *Chemistry 10th edition*, Kenneth W. Whitten/Raymond E. Davis/Larry Peck/George G. Stanley.
- *Foundations of College Chemistry, 14 Edition*, Hein M, Arena S. John Wiley and Sons Inc.
- *Lehninger Principles of Biochemistry*, Nelson D. Cox Michael M.