Course Unit	Applied Thermodynamics			Field of study	Physics		
Bachelor in	Biomedical Technology			School	School of Technology and Management		
Academic Year	2023/2024	Year of study	3	Level	1-3	ECTS credits	6.0
Type	Semestral	Semester	1	Code	9600-752-3104-00-23		

Workload (hours)	162	Contact hours	T -	TP 60	PL -	TC -	S -	E -	OT -	O -

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): Manuel Luís Pires Clara, Simão Pedro de Almeida Pinho

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Apply to systems and control volumes the mass conservation, linear and angular momentum, and energy conservation relationships.
2. Calculate system thermodynamic proprieties.
3. Distinguish and calculate heat transfer mechanisms.
4. Recognize the importance of the interactions between molecules and its impact on the properties of substances.
5. Understand the thermodynamic formalism for the description of multicomponent systems. Calculate phase equilibria, in particular for systems containing
6. Apply the concepts of a sponteneous process and the standard state in biochemical reactions. Make calculations for acid-base equilibria, electrochemistry and coupling reactions in biological systems.

Prerequisites

Before the course unit the learner is expected to be able to:
1. Differential and integral calculation.
2. Concepts of classic physics.
3. Use informatic tools such as MATLAB or MS Excel.

Course contents

This course works on basic principles of classical thermodynamics and heat transfer mechanisms, seeking to apply them to biological systems. States of Matter and Intermolecular Forces. Phase and Chemical Equilibria.

Course contents (extended version)

1. Thermodynamic System. Work and Heat.
   - Heat Capacity. Specific and latent heat.
   - The states of matter. Phase transition. Temperature.
2. The ideal gas. Temperature and kinetic energy. Specific heats.
   - Real gases: Van der Waals equation.
3. Energy: The thermodynamic principles.
   - Reversible and irreversible transformations. Thermal machines. Inverse thermal machines.
4. Heat transfer: conduction, convection and radiation.
5. States of Matter and Intermolecular Forces
   - Fundamental concepts of Physical-Chemistry.
   - Intermolecular forces: electrostatic, induced dipoles, London forces, hydrogen bonds.
   - Dipolar moment, dielectric constant, polarisability, and other physical-chemistry parameters.
6. Phase and Chemical Equilibrium
   - Phase changes of pure substances. Clausius-Clapeyron equation.
   - Phase rule and Duhem theorem. Liquid-Vapor Equilibrium equations. Raoult and Henry laws.
   - Second order Margules model. Regular solutions theory and UNIFAC method.
   - Liquid-Liquid, Liquid-Liquid-Vapor, and Solid-Liquid equilibria. Phase diagrams.
   - Colligative properties.
   - Chemical equilibrium. Equilibrium constant method. Temperature effect on the equilibrium constant.
   - Relation between equilibrium constant and composition. Reactive processes in liquid and gas phase.
   - Aqueous solutions containing electrolytes, proteins, amino acids, or antibiotics. Coupled reactions.

Recommended reading

1. Afonso, C - Termodinâmica para Engenharia - FEUP Edições - 2012
2. Yunus A. Çengel, Mehmet Kanoglu e Michael A. Boles. Thermodynamics: An Engineering Approach, SI. Ninth ed.
3. P. Atkins; J. Keeler and J. de Paula, Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018.
4. J. M. Smith; M. Swihart; H. C. Van Ness and M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, 9th Edition, McGraw-Hill, 2021.
5. R. Chang, Physical Chemistry for the Chemical and Biological Sciences, 3rd Edition, University Science Books, 2000.

Teaching and learning methods

Theoretical analysis of fundamental tools and concepts for the compreension, application and calculations in the thermodynamics area. Presentation of practical examples and model exercices. Problem solving and critical analysis of the results. Evaluation of homework. Development of application projects.

Assessment methods

1. Tests - (Regular, Student Worker) (Final)
   - Intermediate Written Test - 40% (First Test at the middle of semester.)
   - Intermediate Written Test - 50% (Second Test at the end of semester.)
   - Development Topics - 10% (Group work on Medical Equipment that uses the concepts of Thermodynamics discussed.)
2. Tests - (Regular, Student Worker) (Final)
   - Intermediate Written Test - 50% (First Test at the middle of semester.)
   - Intermediate Written Test - 50% (Second Test at the end of semester.)
3. Final Exam - (Regular, Student Worker) (Final, Supplementary, Special)
   - Final Written Exam - 100%

Language of instruction

Portuguese, with additional English support for foreign students.

Electronic validation

Manuel Luís Pires Clara, Simão Pedro de Almeida Pinho	João Eduardo Pinto Castro Ribeiro	Joana Andrea Soares Amaral	José Carlos Rufino Amaro
03-10-2023	03-10-2023	31-10-2023	04-11-2023