Course Unit	Electrochemistry and Fuel Cells			Field of study	Physics/Chemistry		
Bachelor in	Renewable Energy Engineering			School	School of Technology and Management		
Academic Year	2023/2024	Year of study	2	Level	1-2	ECTS credits	6.0
Type	Semestral	Semester	1	Code	9910-743-2101-00-23		

Workload (hours)	162	Contact hours	T	TP	PL	TC	S	E	OT	O
			30	-	30	-	-	-	-	-

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): Ana Maria Alves Queiroz da Silva

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. know fundamental concepts of electrochemistry and solve problems applying Nernst equation.
2. know the fundamental parameters of a battery.
3. know examples of electrochemistry applications in the industry. Acquire the concept of electrolysis.
4. apply the concept of electrochemical corrosion of materials and know the main protection techniques against corrosion.
5. apply concepts about the kinetics of electrode reactions and know to apply the Tafel equation.
6. know the basic concepts of the fuel cell technologies and how they work.
7. apply basic concepts about the thermodynamics of fuel cells.
8. know the caracteristics of different types of fuel cells.

Prerequisites

Before the course unit the learner is expected to be able to:
Have knowlegde of chemistry and mathematics.

Course contents

Fundamentals of electrochemistry. Caracteristics of batteries. Electrochemistry and industry. Corrosion. Electrochemical kinetics. Fuel cells. Fuel cells thermodynamics and performance. Fuel cell systems.

Course contents (extended version)

1. Fundamentals of electrochemistry.
   - Redox reactions. Balance of redox equations.
   - Concept of anode, cathode, anodic reaction, cathodic reaction.
   - Galvanic cells. Electrolitic cells.
   - Standard electrode potencials.
   - Spontaneity of redox reactions.
   - Effect of concentration on cell e. m. f. : the Nernst equation. Concentration cells.
2. Battery parameters.
   - Batteries.
   - Voltage.
   - Charge capacity.
   - Discharge curves.
   - Stored energy.
   - Specific power.
   - Primary batteries. Secondary batteries. Fuel cells.
3. Electrochemistry and industry.
   - Electrolysis.
   - Faraday equation.
   - Electrometallurgy.
4. Electrochemical corrosion.
   - Corrosion concept.
   - Factors that affect corrosion.
   - Forms of corrosion.
   - Electrochemical corrosion.
   - Corrosion rate.
   - Passivity. Cathodic protection. Anodic protection.
   - Pourbaix diagrams.
5. Electrochemical kinetics.
   - Introduction.
   - Reaction rate.
   - Electrochemical polarization (activation, concentration, ohmic losses).
   - Tafel equation.
   - Mixed potencial theory.
6. Fuel cells.
   - Introduction.
   - Classification of fuel cells.
   - Caracteristics of fuel cells systems.
   - Advantages. Disadvantages.
   - Applications.
7. Fuel cell thermodynamics and performance.
   - Introduction.
   - Electrochemical reactions at fuel cells.
   - Ideal performance of a fuel cell.
   - Relation between Gibbs´ energy change in a cell reaction and cell potencial.
   - Fuel cell eficiency.
   - Actual performance of a fuel cell.
   - Electrode polarization. Types of overvoltage.
   - Factors affecting the performance of fuel cells.
8. Fuel cell systems.
   - Polymer Electrolyte Fuel Cell (PEFC).
   - Alkaline Fuel Cell (AFC).
   - Phosphoric Acid Fuel Cell (PAFC).
   - Molten Carbonate Fuel Cell (MCFC).
   - Solid Oxid Fuel Cell (SOFC).
   - Direct Methanol Fuel Cell (DMFC).

Recommended reading

1. K. Kordesch, G. Simader, Fuel cells and their applications, VCH, 2001
2. N. Perez, Electrochemistry and Corrosion Science, Kluwer Academic Publishers, 2004
3. R. O´Hayre, S. Cha, W. Colella, F. Prinz, Fuel Cells Fundamentals, 2nd Edition, John Wiley and Sons, 2009
4. E. McCafferty, Introduction to Corrosion Science, Springer, 2010

Teaching and learning methods

Theoretical lessons: Explanation of the theoretical concepts. Presentation, analysis and discussion of application examples. Practical lessons: resolution of application exercises and clarification of doubts related with exercises made at home by the students. Non-presential period: study of the theoretical contents, resolution of exercises.

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final)
   - Intermediate Written Test - 25% (Chapters 1, 2 and 3)
   - Final Written Exam - 40% (All chapters. Minimum 6 values)
   - Development Topics - 25% (Topics about Corrosion and Fuel Cells (mandatory), with oral presentation)
   - Case Studies - 10% (Exercises)
2. Alternative 2 - (Student Worker) (Final)
   - Final Written Exam - 85%
   - Development Topics - 15% (Topics about Fuel Cells, with oral presentation (mandatory))
3. Alternative 3 - (Regular, Student Worker) (Supplementary)
   - Final Written Exam - 85%
   - Development Topics - 15% (Topics about Fuel Cells, with oral presentation (mandatory))
4. Alternative 4 - (Regular, Student Worker) (Special)
   - Final Written Exam - 100%

Language of instruction

Portuguese, with additional English support for foreign students.

Electronic validation

Ana Maria Alves Queiroz da Silva	Hélder Teixeira Gomes	José Carlos Rufino Amaro
14-10-2023	25-10-2023	31-10-2023