Basic Sciences

Division

Department of Chemistry

Electrochemistry I

CUCEI

UNIVERSIDAD DE GUADALAJARA
CENTRO UNIVERSITARIO DE CIENCIAS EXACTAS E INGENIERÍAS

1.- GENERAL INFORMATION

Learning Unit Electrochemistry Lab I		**Department** Chemistry		**Format** Lab
Prerequisites(P) None	**Corequisites (CO)** Electrochemistry I	**Ascribed Academy** Physical Chemistry Academy	**Module** M2: Synthesis, purification and chemical transformation.	
Type Basic particular mandatory.	**Lecture hours** 0	**Practice hours** 51	**Total hours** 51	**Credits** 3
Degree in which this class is taught: B.S in Chemistry.				

2.- GENERIC COMPETENCIES

-Problem solving
-Synthesis and analysis.
- Team work.
-Computer skills
-Managing information
-Oral and written skills to present scientific information
-Discerning and decision making
- Good lab practices.

Specific competencies:
-Follow up skills through the measurement and observation of chemical properties, events or changes and the corresponding filing in a reliable and systematic way.
-Autonomous development of the acquired knowledge.
-Ability to apply what is learnt to specific and complex situations.
-Autonomy and teamwork
-Ability to solve electrochemical problems.

3.- SPECIFIC CHARACTERISTICS OF THE COMPETENCY

Knowledge	Students: • … Prove with experiments the basic concepts of electrochemistry in order to understand the charge transfer processes through electrode solution interfaces, mass transport in cells and conventional and modern electroanalytical techniques • . …are able to describe, reproduce, and control electrochemical processes in everyday and professional lives.

Skills	• … solve problems that involve laws and equations specific to electrochemistry. • …handle the software to solve electrochemical problems. • …apply the knowledge they acquired in order to solve specific and common problems that involve electrochemical processes. • …acquire the ability to analyze, synthesize and evaluate electrochemical processes.
Aptitudes	• …identify and solve problems through the formulation of hypotheses and the application of the necessary principles in an analytical and synthetic way. • … relate different knowledge of different fields and apply it in professional and ordinary situations. • …develop study habits and manages his own learning. • …find solutions to specific theoretical or practical problems where they apply the knowledge they learned.
Values	• …develop and exercise values such as responsibility, honesty, tolerance, respect, solidarity, willingness and positive attitude towards individual and group work.

4.- TRANSVERSAL COMPETENCIES

☑	Foreign Language (English)
☑	Critical, analytical and synthetic thinking.
☑	Oral and written expression
☑	Professional ethics
☐	Administration of human and material resources
☐	Leadership and sustainability
☑	Creativity, innovation and entrepreneurship
☐	Others

5.- COURSE CONTENT OF THE LEARNING UNIT

Content	**Practice**
Unit 1. Main applications of electrochemistry. 1.1 Introduction to electrochemistry 1.11 Electrochemical cells and redox pairs. 1.12 Types of cells, electrodes and notation.	Course presentation
1.2 Main applications of electrochemistry. 1.21 Electrolysis 1.22 Electro-synthesis	**Practice 0A**. Workshop of Electrochemistry I applications.

1.23 Batteries	
1.24 Corrosion 1.25 Galvanoplasty 1.26 Electro erosion 1.27 Electro-refining	**Practice 0B**. Workshop of Electrochemistry I applications.
Unit 2. Experimental Electrochemical Thermodynamics 2.1 Measurements and electric units. 2.11 Digital multimeter 2.12 Summary of electric equivalences and circuits.	**Practice 1.** Handling the multimeter and electric measurements.
2.2. Potentiostats 2.21 Three electrode cells. 2.22 Properties, handling and use of the potentiostat.	**Practice 2**. Handling the potentiostat.
2.3 Electrochemical potential 2.31 Reference electrodes and their characteristics 2.32 Primary reference electrode 2.33 Reference electrodes: Calomel and silver chloride electrodes.	**Practice 3.** Building a silver chloride electrode.
2.34 Conversion of potential value. 2.35 Free energy and Nernst Equation	**Practice 4.** Measurement of ion pair potentials.
2.36 Liquid junction potential and Lingane classification. 2.37 Liquid junction potential measurement and calculation. 2.38 Salt bridges	**Practice 5.** Building and measuring potential using a salt bridge.
Unit 3. Ion transport in solutions and experimental electrochemistry kinetics. 3.1 Migration phenomena 3.12 Measurement of conductance and conductivity. 3.13 Ion mobility. 3.14 Equivalent conductance and dissociation degree.	**Practice 6.** Conductivity and dissociation degree.
3.2 Electrochemical kinetics 3.21 Polarization curves and overpotential. 3.22 Butler-Volmer equation, Tafel equation, transference coefficients and equilibrium potential.	**Practice 7.** Polarization curves and electrode kinetics.
Unit 4. Electrochemical techniques 4.1 Classification of the electro analytical methods. 4.2 Potentiometry 4.21 Direct: Ion-selective electrodes (ISE) 4.22 Instrumentation and selectivity coefficient	**Practice 8.** Building and application of a sulfide ion selective electrode.
4.23 Indirect: titrations 4.24 Equivalence point detection methods and Determination of Keq.	**Practice 9.**

4.25 Types of potentiometric titrations 4.26 Mathematic follow up of a titration curve	Potentiometric titrations of $FeCl_2$ with $CeCl_4$
4.3 Coulometry 4.31 Foundations and instrumentation 4.32 Acid-vase evaluation	**Practice 10.** Acid-base Coulometry
4.4 Voltammetry 4.41 Introduction to cyclic voltammetry: Foundations and instrumentation 4.42 Reversible and irreversible reaction mechanisms.	**Practice 11.** Even cyclic voltammetry $K_3[Fe(CN)_6]$ and $K_4[Fe(CN)_6]$
4.43 Rotating ring-disc electrode 4.44 Levich equation and determination of the diffusion coefficient.	**Practice 12.** Rotating ring disc electrode
4.5 Chronoamperometry 4.51 Foundations and instrumentation 4.52 Applications: determination of the diffusion coefficients.	**Practice 13.** Chronoamperometry and chronocoulometry
	Practice 14. Voltammetric determination of de acetaminophen

6.- ASSESSMENT	
☑	Numeric Grade
☐	
☐	

7.- GRADING CRITERIA OF THE LEARNING UNIT	
Indicator of evaluation	**Percentage**
Departmental exams	30
Partial exam	0
Homework	0
Research activities	20
Practice reports	40
Class participation	10

8.- REQUIRED MATERIAL (for students)	
☑	Calculator
☑	Periodic table
☐	Lab coat
☑	Text book
☑	Workbook
☑	Tables of standard potential, table of mobility, etc.
☐	

9.-SPECIFIC CONTENT BY LEARNING UNITS

Content unit	Generic competency of the content unit	Topics	Practice	Class hours	Professor activities	Student activities	Bibliography
Unit 1. Main applications of electrochemistry.	Students review, reaffirm and prove experimentally the basic concepts and principles of electrochemistry to understand their application.	1.1 Introduction to electrochemistry 1.11 Electrochemical cells and redox pairs. 1.12 Types of cells, electrodes and notation.		3	Professor… Encourages students to prove experimentally electrochemical phenomena and their applications.	Students… Relate the basic concepts of electrochemistry with experimental activities.	▪ Harris, D. C. (2007). *Análisis Químico Cuantitativo*. 3rd edition Spain, Barcelona: Editorial Revertè. ▪ Casillas, N., Gudiño, B. (2016) Chapter 1. *Notas de Electroquímica I*. UdeG - CUCEI
		1.2 Main applications of electrochemistry. 1.21 Electrolysis 1.22 Electro-synthesis 1.23 Batteries 1.24 Corrosion 1.25 Galvanoplasty 1.26 Electro erosion 1.27 Electro-refining	**Practice 0A and 0B**. Workshop of Electrochemistry I applications.	6			
Unit 2. Experimental Electrochemical Thermodynamics	Students distinguish the characteristics of the thermodynamic	2.1 Measurements and electric units. 2.11 Digital multimeter	**Practice 1.** Handling the multimeter and electric measurements	3	Professor… Encourages students to prove experimentally the thermodynamic	Students… Give opinions, comment and	▪ Allen J. Bard and Larry R. (2001). *Electrochemical Methods: Fundamentals and*

	principles that rule over the electrochemical processes.	2.12 Summary of electric equivalences and circuits.			concepts of the electrochemical processes.	discuss the contents of the practice. Do research about the topics of the lab practices. Write professional reports related to the lab results. Discuss and make conclusions about the lab experiments.	*Applications*. Faulkner John Wiley and Sons ▪ P.W. Atkins (2006), *Química Física* (8th edition). Ed. Addison –Wesley Iberoamérica ▪ Casillas, N., Gudiño, B. (2016) Chapter. 2. *Notas de Electroquímica I*. UdeG - CUCEI
		2.2. Potentiostats 2.21 Three electrode cells. 2.22 Properties, handling and use of the potentiostat.	**Practice 2**. Handling the potentiostat.	3			
		2.3 Electrochemical potential 2.31 Reference electrodes and their characteristics 2.32 Primary reference electrode 2.33 Reference electrodes: Calomel and silver chloride electrodes.	**Practice 3.** Building a silver chloride electrode.	3			
		2.34 Conversion of potential value. 2.35 Free energy and Nernst Equation	**Practice 4.** Measurement of ion pair potentials.	3			

		2.36 Liquid junction potential and Lingane classification. 2.37 Liquid junction potential measurement and calculation. 2.38 Salt bridges	**Practice 5.** Building and measuring potential using a salt bridge.	1.5			
Unit 3. Ion transport in solutions and experimental electrochemistry kinetics.	Students understand the essential concepts in order to apply the mathematical theoretical knowledge of the kinetic models in electrochemical cells.	3.1 Migration phenomena 3.12 Measurement of conductance and conductivity. 3.13 Ion mobility. 3.14 Equivalent conductance and dissociation degree.	**Practice 6.** Conductivity and dissociation degree.	1.5	Professor… Encourages students to prove experimentally the basic concepts to integrate understand the ion transport in solutions and the kinetics that rules the electrochemical processes. .	Students… Prove experimentally the basic concepts of ion transport in kinetic and electrochemical solution.	▪ Allen J. Bard and Larry R. (2001). *Electrochemical Methods: Fundamentals and Applications*. Faulkner John Wiley and Sons ▪ Casillas, N., Gudiño, B. (2016) Chapter. 3. *Notas de Electroquímica I.* UdeG - CUCEI
		3.2 Electrochemical kinetics 3.21 Polarization curves and overpotential. 3.22 Butler-Volmer equation, Tafel equation,	**Practice 7.** Polarization curves and electrode kinetics.	3			

		transference coefficients and equilibrium potential.					
Unit 4. Electrochemical techniques	Students use the knowledge and information acquired in this unit to integrate it in the creation of analytical techniques relevant to chemistry.	4.1 Classification of the electro analytical methods. 4.2 Potentiometry 4.21 Direct: Ion-selective electrodes (ISE) 4.22 Instrumentation and selectivity coefficient	**Practice 8.** Building and application of a sulfide ion selective electrode	3	Professor… Teaches the basic concepts to guarantee the experimental foundations of electroanalytical techniques of the unit. Guides students through the proper use of instruments and equipment in the lab. Discusses the advantages and disadvantages of the different	Students… Give opinions, comment and discuss the contents of the practice. Do research about the topics of the lab practices. Write professional reports related to the lab results. Discuss and make conclusions about the lab experiments	▪ Skoog, D., West, D., et al (2014). *Fundamentos de Química Analítica.* Mexico, D.F.: CENGAGE Learning. ▪ Rubinson K & Rubinson, J. (2000) *Análisis Instrumental*. Madrid, Spain: Prentice Hall ▪ Casillas, N., Gudiño, B. (2016) Chapter. 4. *Notas de Electroquímica I*. UdeG - CUCEI
		4.23 Indirect: titrations 4.24 Equivalence point detection methods and Determination of Keq. 4.25 Types of potentiometric titrations	**Practice 9.** Potentiometric titrations of $FeCl_2$ with $CeCl_4$	3			

		4.26 Mathematic follow up of a titration curve			techniques that were learnt.	Reproduce and modify an electrochemical method in order to know a physicochemical property or quantify and analyte.	
		4.3 Coulometry 4.31 Foundations and instrumentation 4.32 Acid-base evaluation	**Practice 10.** Acid-base coulometry	3			
		44.4 Voltammetry 4.41 Introduction to cyclic voltammetry: Foundations and instrumentation. 4.42 Reversible and irreversible reaction mechanisms.	**Practice 11.** Even cyclic voltammetry $K_3[Fe(CN)_6]$ and $K_4[Fe(CN)_6]$	3			
		4.43 Rotating ring-disc electrode 4.44 Levich equation and determination of the diffusion coefficient.	**Practice 12.** Rotating ring disc electrode	3			

		4.5 Chronoamperometry 4.51 Foundations and instrumentation 4.52 Applications: determination of the diffusion coefficients.	**Practice 13.** Chronoamperometry and chronocoulometry	3			
			Practice 14. Voltammetric determination of de acetaminophen	3			

COURSE EVIDENCE (Deliverables)

- **Departmental exam**
- **Research tasks**
- **Problem and concept solutions**
- **Practice evidence reports and/or logbook.**

10.-PROFESSOR'S PROFILE

Bachelor, Master or Doctorate degree in Chemistry.
Specific knowledge in electrochemistry.
Teaching experience in electrochemistry.

11.-AUTHORS OF THE LEARNING UNIT

Bernardo Gudiño Guzmán and Dr. José Miguel Velázquez López

12.-MODIFICATION AND LAST UPDATE

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