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 I		**Department:** Chemistry		**Course format** Lecture
Prerequisites(P) Physical Chemistry II	**Corequisites (CO)** Electrochemistry lab I	**Ascribed academy:** Physical Chemistry	**Module** M2: Synthesis, purification and chemical transformation.	
Type Particular basic Mandatory	**Lecture hours** 4 hrs. per week	**Practice hours** 0 hrs.	**Total hours** 68 hrs.	**Credits** 9
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 production
-Discerning and decision making

Specific competencies:
- 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… • … discuss 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 • …define the particular theoretical principles in which the processes mentioned above are founded. • … are able to enunciate laws and apply the corresponding laws to representative calculations. • …are able to describe 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 manage their 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. a
☑	Oral and written expression
☑	Professional ethics
☐	Administration of human and material resources
☐	Leadership and sustainability
☑	Creativity, innovation and entrepreneurship
☐	Other

5.- COURSE CONTENT OF THE LEARNING UNIT

Unit 1. Introduction to Electrochemistry

1.1 Introduction to Electrochemistry
- 1.1.1 Measurements and electric units
- 1.1.2 Summary of electric equivalences

1.2 The electrochemical cell (visualization of the metal interface - electrolyte)

1.3 Electrochemical cells
- 1.3.1 Types of cells
- 1.3.2 Redox pair
- 1.3.3 Types of electrodes

1.4 Standard electrode potential
- 1.41 Normal hydrogen electrode

1.42 Other types of reference electrodes
1.43 Standard potential scales.
1.44 Electrochemical cell notation
1.5 Free standard energy and cell spontaneity.
1.6 Equilibrium potential
1.7 Polarization curves
1.8 Potential differences between phases. (Galvani Potential)
E1.9 Potentiostat properties.
1.10 Luggin-Habert Capillary

Unit 2. Thermodynamics in electrochemical cells.
2.1 Reversibility
2.1.1 Reversibility and free energy
2.4 Concentration and electromotive force (Nernst equation)
2.5 Formal Potential
2.6 Ionic force
2.7 Activity coefficient
2.7.1 Medium activity coefficient
2.7.2 Galvani potential (Part II)
2.7.3 l Electrochemical potential
2.8 Liquid junction potential
2.9 Migration phenomena
2.9.1 Transport numbers.
2.9.2 Conductance and Conductivity
2.9.3 Ion mobility
2.9.4 Equivalent Conductance
2.10 Kohlrausch's law
2.11 Dissociation degree
2.12 Liquid junction liquid potential calculation.
2.12.1 Type I liquid junction potential.
2.12.2 Type II and III liquid junction potential (Henderson equation)
2.12.3 Lewis-Sargent's equation
2.12.4. Minimization of the junction-liquid potential.

Unit 3. Electrochemical kinetics
3.1 Introduction
3.2 Kinetic model based on free energy curves.
3.3 Standard speed constant and skewness coefficient.
3.4 Current-potential equation.
3.5 Exchange current
3.6 Current- overpotential equation
3.7 Approaches to the current- overpotential equation
3.7.1 Mass transfer effects (Bulter-Volmer's equation)
3.7.2 Exchange current effect on the current- overpotential curve.
3.7.3 Charge transfer coefficient effect on the current- overpotential curve

3.8 Butler-Volmer's equation on low overpotentials (lineal approach)
3.9 Butler-Volmer's equation on high overpotentials (Tafel equation)
3.10 Tafel graphs
3.11 Allen and Hicklin model
3.12 Exchange current graphs
3.13.Reaction mechanisms and Eyring equation

Unit 4. Analytical electrochemistry
4.1 Ion Selective Electrodes (ISE)
- 4.1.1 Bases
- 4.1.2 Instrumentation
- 4.1.3 Total ionic strength adjustment buffers (TISAB)
- 4.1.4 Selectivity coefficient
- 4.1.5 Method of standard addition

4.2 Potentiometry: Titrations
- 4.2.1 Detection methods of endpoint
- 4.2.2 Types of potentiometric titrations
- 4.2.3. Use of spreadsheets to solve problems.
- 4.2.4 Mathematic follow up of a titration curve.
- 4.3 Coulometry
- 4.3.1 Bases, instrumentation and applications
- 4.3.2 Coulometry types
- 4.3.3 Acid-base evaluation

4.4 Voltammetry
- 4.5.1 Polarography: instrumentation and applications
- 4.5.2 Cyclic voltammetry: instrumentation and applications
- 4.5.3 Disc electrode and rotating ring: instrumentation and applications

4.5 Chronoamperometric disc
- 4.4.1 Bases
- 4.4.2 Instrumentation and applications

6.- ASSESSMENT

☑	Numeric grade
☐	
☐	

7.- GRADING CRITERIA OF THE LEARNING UNIT

Indicator of evaluation	Percentage
Departmental exams	30

Partial exam	30
Homework	30
Research activities	10
Practice reports	0
Class participation	0

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**	**Class hours**	**Professor activities**	**Student activities**	**Bibliography**
Unit 1. Introduction to electrochemistry	Students review, reinforce and systematize the concepts and principles of electricity and electrochemistry in order to integrate the theoretical bases of the electrochemical processes. Describe some of the main applications of electrochemistry.	1.1. Introduction to electrochemistry	15 min	Professor… Teaches the basic concepts of electricity and electrochemistry. Prompts students to solve problems using the knowledge they acquired. Assigns readings about the topic of the unit.	Students… Play a prominent role in the search for information and answers to problems stated by the teacher. Do homework related to the concepts seen in class. Solve exercises on the topics of the unit. Relate the knowledge seen in this class with the experimental activities carried	▪ Harris, D. C. (2007). *Análisis Químico Cuantitativo* 3rd edition Spain, Barcelona: Editorial Revertè. S.A. ▪ Allen J. Bard and Larry R. (2001). *Electrochemical Methods: Fundamentals and Applications.* Faulkner John Wiley and Sons, ▪ Casillas, N., Gudiño, B. (2016) Chapter 1. *Notas de Electroquímica I*. UdeG - CUCEI
		1.2. Electrochemical cells: (metal – electrolyte interface visualization)	30 min			
		1.3. Electrochemical cells	1 h			
		1.4. Standard electrode potentials	1 h			
		1.5. Free standard energy and cell spontaneity.	15 min			
		1.6 Equilibrium potential	1 h			
		1.7 Polarization curves	15 min			
		1.8 Potential differences between phases. (Galvani Potential)	30 min			
		E1.9 Potentiostat properties.	1 h			

		1.10 Luggin-Habert capillary	30 min		out in the class of Electrochemistry Lab I. (Co-requisite class).	
Unit 2. Thermodynamics in electrochemical cells.	Students apply analytical, critical and synthetic thinking to use theoretical concepts for problem solving Organize information through ideas and concepts expressed verbally or graphically. Distinguish the characteristics of the thermodynamic principles that rule over the electrochemical processes.	2.1 Reversibility	3 h	Professor… Teaches the basic thermodynamic concepts of electrochemical processes. Prompts students to solve problems using the knowledge they acquired. Designs and provides students with feedback of the homework they deliver.	Students… Play a prominent role in the search for information and answers to problems stated by the teacher. Do homework related to the concepts seen in class. Solve exercises on the topics of the unit. Relate the knowledge seen in this class with the experimental activities carried out in the class of Electrochemistry Lab I. (Co-requisite class).	▪ Allen J. Bard and Larry R. (2001). *Electrochemical Methods: Fundamentals and Applications*. Faulkner John Wiley and Sons ▪ Harris, D. C. (2007). *Análisis Químico Cuantitativo*. 3rd edition Spain, Barcelona: Editorial Revertè. S.A. ▪ Gilbert W. Castellan (1987), *Fisicoquímica* 2nd edition.. Addison – Wesley Iberoamérica ▪ P.W. Atkins (2006), *Química Física*. 8th edition). Ed. Addison – Wesley Iberoamérica ▪ Casillas, N., Gudiño, B. (2016) Chapter. 2. *Notas de*
		2.2. Concentration and electromotive force (Nernst equation)	1 h			
		2.3 Formal Potential	15 min			
		2.4. Ionic force	30 min			
		2.5. Activity coefficient	4 h			
		2.6. Galvani Potential (Part II)	15 min			
		2.7. Liquid junction potential	30 min			
		2.8. Migration phenomena	4 h			
		2.9. Kohlrausch's law	1 h			
		2.10. Dissociation degree	1 h			
		2.11. Calculation of the junction-liquid potential.	3 h			
		2.13. Minimization of the junction-liquid potential.				

						Electroquímica I. UdeG - CUCEI
Unit 3. Electrochemical kinetics	Students apply analytical, critical and synthetic thinking to use theoretical concepts for problem solving. Organize information through ideas and concepts expressed verbally or graphically. Understand the essential concepts in order to apply the mathematical theoretical knowledge of the kinetic models in electrochemical cells.	3.1. Introduction	15 min	Professor… Teaches the basic concepts to understand the kinetics that rules the electrochemical processes. Prompts students to solve problems using the knowledge they acquired. . Designs and provides students with feedback of the homework they deliver.	Students… Play a prominent role in the search for information and answers to problems stated by the teacher. Do homework related to the concepts seen in class. Solve exercises on the topics of the unit. Relate the knowledge seen in this class with the experimental activities carried out in the class of Electrochemistry Lab I. (Co-requisite class).	▪ Allen J. Bard and Larry R. (2001). *Electrochemical Methods: Fundamentals and Applications*. Faulkner John Wiley and Sons ▪ Casillas, N., Gudiño, B. 2016. Chapter. 5. *Notas de Electroquímica I*. UdeG - CUCEI
		3.2 Kinetic model based on free energy curves.	2 h			
		3.3 Standard speed constant and skewness coefficient.	2 h			
		3.4 Current-potential equation.	1 h			
		3.5 Exchange current	1 h			
		3.6 Current- overpotential equation	1 h			
		3.7 Approaches to the current- overpotential equation	2 h			
		3.8 Butler-Volmer's equation on low overpotentials (lineal approach)	2 h			
		3.9 Butler-Volmer's equation on high overpotentials (Tafel equation)	3 h			
		3.10 Tafel graphs	2 h			

		3.11 Allen and Hicklin model	1 h			
		3.12 Exchange current graphs	1 h			
		3.13.Reaction mechanisms and Eyring equation	3 h			
Unit 4. Analytical Electrochemistry	Students apply analytical, critical and synthetic thinking to use theoretical concepts for problem solving. Organize information through ideas and concepts expressed verbally or graphically. Use the acquired knowledge and information to create analytical techniques relevant to chemistry and electrochemistry.	4.1 Ion Selective Electrodes (ISE)	5 h	Professor... Teaches the basic concepts in order to reaffirm the foundations of electroanalytical techniques relevant to this unit. Prompts students to solve problems using the knowledge they acquired. Designs and provides students with	Students… Play a prominent role in the search for information and answers to problems stated by the teacher. Do homework related to the concepts seen in class. Solve exercises on the topics of the unit. Relate the knowledge seen	▪ Harris, D. C. (2007). *Análisis Químico Cuantitativo.* 3rd edition Spain, Barcelona: Editorial Revertè. S.A. ▪ Allen J. Bard and Larry R. (2001). *Electrochemical Methods: Fundamentals and Applications*. Faulkner John Wiley and Sons ▪ Skoog, D., West, D., *et al* (2014). *Fundamentos de Química Analítica.*
		4.2 Potentiometry: Titrations	5 h			
		4.3 Coulometry	3 h			
		4.4. Voltammetry	8 h			

		4.5 Chronoamperometry	3 h	feedback of the homework they deliver. .	in this class with the experimental activities carried out in the class of Electrochemistry Lab I. (Co-requisite class).	Mexico, D.F.: Editorial 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

COURSE EVIDENCE
(Deliverables)

- Partial Exam
- Departmental exam
- Research tasks
- Problem and concept solutions

10.-PROFESSOR'S PROFILE

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

11.-AUTHOR OF THE LEARNING UNIT
Bernardo Gudiño Guzmán

12.-MODIFICATION AND UPDATE
March 2017