1. General information

Course:	PHYSICAL-CHEMISTRY I: THERMODYNAMICS	**Code:**	57310
Type:	CORE COURSE	**ECTS credits:**	6
Degree:	409 - CHEMISTRY	**Academic year:**	2023-24
Center:	1 - FACULTY OF SCIENCE AND CHEMICAL TECHNOLOGY	**Group(s):**	20 23
Year:	2	**Duration:**	First semester
Main language:	Spanish	**Second language:**	English
Use of additional languages:		**English Friendly:**	Y
Web site:		**Bilingual:**	N

Lecturer: **JOSE ALBALADEJO PEREZ** - Group(s): **20 23**

Building/Office	Department	Phone number	Email	Office hours
EDIFICIO MARIE CURIE, 2ª PLANTA	QUÍMICA FÍSICA	3451	jose.albaladejo@uclm.es	

Lecturer: **MARÍA ANTIÑOLO NAVAS** - Group(s): **20 23**

Building/Office	Department	Phone number	Email	Office hours
Edificio Marie Curie, 1ª planta, despachos 1.05	QUÍMICA FÍSICA	926052532	maria.antinolo@uclm.es	

Lecturer: **FRANCISCO JAVIER POBLETE MARTIN** - Group(s): **20 23**

Building/Office	Department	Phone number	Email	Office hours
EDIFICIO MARIE CURIE 2ª PLANTA, DESPACHOS 2.03	QUÍMICA FÍSICA	926052177	fcojavier.poblete@uclm.es	

Lecturer: **MARIA SAGRARIO SALGADO MUÑOZ** - Group(s): **20 23**

Building/Office	Department	Phone number	Email	Office hours
EDIFICIO MARIE CURIE	QUÍMICA FÍSICA	3450	sagrario.salgado@uclm.es	

2. Pre-Requisites

There are no prerequisites, although it is recommended, to have passed the Chemical subject, from module 1

3. Justification in the curriculum, relation to other subjects and to the profession

Chemical Thermodynamics is a branch of Physical Chemistry that studies the effects of changes in magnitudes of systems at a macroscopic level. It constitutes a phenomenological theory, based on deductive reasoning, that studies real systems, without modeling and follows an experimental method. The changes studied are those of temperature, pressure, volume and composition. We can also say that thermodynamics was born to explain the processes of exchange of mass and thermal energy between different thermal systems. More specifically, heat means "energy in transit" and dynamics refers to "movement", so, in essence, thermodynamics studies the circulation of energy and how this energy affects, in our case, the stability and reactivity of chemical substances. Historically, thermodynamics was developed out of the need to increase the efficiency of the first steam engines.

4. Degree competences achieved in this course

Course competences

Code	Description
CB01	Prove that they have acquired and understood knowledge in a subject area that derives from general secondary education and is appropriate to a level based on advanced course books, and includes updated and cutting-edge aspects of their field of knowledge.
CB02	Apply their knowledge to their job or vocation in a professional manner and show that they have the competences to construct and justify arguments and solve problems within their subject area.
CB03	Be able to gather and process relevant information (usually within their subject area) to give opinions, including reflections on relevant social, scientific or ethical issues.
CB04	Transmit information, ideas, problems and solutions for both specialist and non-specialist audiences.
CB05	Have developed the necessary learning abilities to carry on studying autonomously
E04	Understand the principles of thermodynamic and their applications in chemistry
E10	Know and understand the characteristics of chemical equilibrium
E14	Know and know how to apply the metrology of chemical processes, including quality management
E15	Know how to handle the standard chemical instrumentation and be able to elaborate and manage standardized procedures of work in the laboratory and chemical industry
E16	Plan, design and develop projects and experiments
E17	Develop the ability to relate to each other the different specialties of Chemistry, as well as this one with other disciplines (interdisciplinary character)
G01	Know the principles and theories of Chemistry, as well as the methodologies and applications characteristic of analytical chemistry, physical chemistry, inorganic chemistry and organic chemistry, understanding the physical and mathematical bases that require
G02	Be able to gather and interpret data, information and relevant results, obtain conclusions and issue reasoned reports on scientific, technological or other problems that require the use of chemical tools
G03	Know how to apply the theoretical-practical knowledge acquired in the different professional contexts of Chemistry

G04	Know how to communicate, orally and in writing, the knowledge, procedures and results of chemistry, both specialized and non-specialized
T03	Proper oral and written communication
T05	Organization and planning capacity
T06	Ability to approach decision making
T07	Ability to work as a team and, where appropriate, exercise leadership functions, fostering the entrepreneurial character
T08	Skills in interpersonal relationships
T09	Motivation for quality, job security and awareness of environmental issues, with knowledge of internationally recognized systems for the correct management of these aspects
T10	Ability to use specific software for chemistry at user level
T11	Ability to obtain bibliographic information, including Internet resources

5. Objectives or Learning Outcomes

Course learning outcomes

Description

Ability to search, understand and use relevant bibliographic and technical information.

Ability to define the state of a chemical system and analyze its spontaneous evolution, based on its macroscopic properties

Dexterity in the analysis of errors of the magnitudes measured in the laboratory and in the use of computer programs for the treatment of experimental data.

Skill in the use of computer programs for calculating properties of matter and simulation of chemical.

Dexterity in the handling of the main instrumental techniques used in physical chemistry and in the experimental determination of the structural, thermodynamic and kinetic properties of chemical systems

Ability to solve chemical problems applying the proper methodologies of physical chemistry

Ability to correctly use scientific language.

Additional outcomes

Ability to experimentally determine the thermodynamic properties of chemical systems

6. Units / Contents

Unit 1: INTRODUCTION TO THERMODYNAMICS: ZERO PRINCIPLE. EQUATIONS OF STATE. Purpose of chemical thermodynamics. Fundamental thermodynamic definitions. Thermodynamic variables. State functions and their properties. Thermodynamic balance. Zero principle of thermodynamics. Temperature and temperature scales.

Unit 2: FIRST LAW OF THERMODYNAMICS. THERMAL CHEMISTRY. Heat and work. Reversible and irreversible processes. Internal energy. First Law of thermodynamics. Enthalpy. Heat capacities. Joule experiment: Joule coefficient. Joule Thomson's coefficient. Calculation of thermodynamic magnitudes in different processes. Heat and enthalpy of reaction. Experimental determination of heats of reaction: Hess's law. Ratio of heat of reaction to pressure and constant volume. Enthalpy dependence of reaction with temperature: Kirchhoff's law.

Unit 3: SECOND AND THIRD PRINCIPLE OF THERMODYNAMICS. GIBBS ENTROPY AND ENERGY. Second principle of thermodynamics. Thermal machines and their performance. Carnot cycle. Thermodynamic temperature scale. Entropy Irreversible processes in isolated systems. Calculation of variation of entropy in different processes. Third principle of Thermodynamics. Absolute entropy calculation. Helmholtz and Gibbs functions. Spontaneity and balance conditions. Gibbs equations. Maxwell relations. Gibbs-Helmholtz equations.

Unit 4: CHEMICAL BALANCE. General condition of chemical equilibrium. Ideal gas balance. Balance constant. Dependency of the equilibrium constant with temperature: van¿t Hoff's equation. Le Châtelier principle. Chemical balance in non-ideal systems. Chemical balance in heterogeneous systems. Determination of the equilibrium constant.

Unit 5: VARIABLE COMPOSITION SYSTEMS. BALANCES OF PHASES IN PURE SUBSTANCES. Partial molar magnitudes. Definition of chemical potential. Gibbs equations for open systems. Gibbs Duhem equation. Chemical potential of an ideal gas. One-phase multiphase systems. Phase rule. Stability of phases and ¿-T diagram. first-order phase transitions. Effect of pressure on steam pressure. Second order phase transitions

Unit 6: IDEAL SOLUTIONS. Ideal solutions: Raoult's law. Thermodynamic magnitudes of the mixing process. Ideal solubility of gases and solids. Ideal diluted solution. Henry's Law. Distribution of a solute between two immiscible solvents. Colligative properties

Unit 7: REAL SOLUTIONS. Activity and activity coefficient. Chemical potential in real solutions. Determination of the activity coefficients. Variation of activity coefficients with pressure and temperature. Experimental determination of activities. Gibbs-Duhem equation applied to obtain the activity coefficients. Excess and mixing functions.

Unit 8: MULTICOMPONENT SYSTEMS. Two component systems. Liquid-vapor balance. Separation of miscible liquids by distillation. Deviation from ideal behavior: Azeotropes. Liquid-liquid balance. Distillation of partially miscible and immiscible liquids. Solid-liquid balance. Eutectic mixture and compound formation. Solid-gas balance. Three component systems. Triangular phase diagrams.

Unit 9: PRACTICE 1. DETERMINATION OF PARTIAL MOLAR VOLUMES OF BINARY MIXTURES. The contraction or expansion of volumes that occurs when various substances are mixed can be described quantitatively in terms of the partial molar volume. In this practice, the partial molar volumes of ethanol solutions in water are calculated from density measurements with a pycnometer

Unit 10: PRACTICE 2. VAPOR PRESSURE AND HEAT OF LIQUID VAPORIZATION. The vapor pressure of a liquid (for example, toluene) is determined by measuring the pressure at which bubbles begin to flow from it by connecting to a vacuum system. From the manometric reading, the vapor pressure is obtained at the temperature of the experiment. If repeated at various temperatures, the integrated form of the Clausius-Clayperon equation allows the heat of vaporization to be obtained. Once the heat of vaporization of various liquids has been determined, Trouton's rule can also be checked.

Unit 11: PRACTICE 3. DETERMINATION OF ACTIVITY COEFFICIENTS BY CRYOSCOPY. Here we analyze one of the colligative properties, the drop in the freezing point of a solvent when adding a solute, which allows us to calculate the activity coefficient and the molecular mass of the solute. In the proposed experiment the freezing point of a solution containing a known weight of a solute, for example glycerin in a known amount of water, is determined. We need a simple apparatus that consists of a test tube containing the solution, a stirrer and a thermometer (for example a precision digital of ¿0.01ºC). The test tube is isolated in a methanol bath, and placed in a mixture of ice and salt at a temperature so low as to allow freezing of the solutions.

Unit 12: PRACTICE 4. CONSTRUCTION OF A TERNARY PHASE DIAGRAM. In this practice, the solubility relationships of mixtures of water, toluene and acetic acid are studied. The toluene-acetic acid and water-acetic acid components are completely miscible, but the toluene-water system is not. The corresponding triangular phase diagram is constructed and the binodal curve (curve showing the limits of immiscibility) and the critical point (point at which the two miscible phases have the same composition) are determined.

7. Activities, Units/Modules and Methodology

Training Activity	Methodology	Related Competences (only degrees before RD 822/2021)	ECTS	Hours	As	Com	Description

Class Attendance (theory) [ON-SITE]	Lectures	E04 E10 G01 G02 G03 G04	0.96	24	N	-	Theory classes, dedicated to exposing the fundamental aspects of the agenda. The student will be provided with the necessary teaching material to continue the course. Examples will be presented to understand the concepts acquired
Workshops or seminars [ON-SITE]	Problem solving and exercises	E04 E16 E17 G02 G03 G04 T11	0.64	16	Y	N	Seminars. Problems and practical cases that allow a better understanding of the subject will be solved with the active participation of the students.
Laboratory practice or sessions [ON-SITE]	Practical or hands-on activities	E15 E16 G02 G03 G04 T10	0.64	16	Y	Y	Laboratory practices. The student will use instrumental techniques and apply the knowledge acquired for the determination of reaction heats, thermodynamic magnitudes, and construction of a triangular diagram.
Mid-term test [ON-SITE]	Assessment tests	E04 E10 E15 E16 E17 G01 G02 G03 G04 T10 T11	0.08	2	Y	N	Eliminatory written test for the evaluation of theoretical content, exercises and problems.
Final test [ON-SITE]	Assessment tests	E04 E10 E15 E16 E17 G01 G02 G03 G04 T10 T11	0.08	2	Y	Y	Written test of global evaluation of theoretical contents, exercises and problems
Writing of reports or projects [OFF-SITE]	Self-study	E04 E16 E17 G02 G03 G04 T11	0.48	12	Y	N	Seminar preparation
Study and Exam Preparation [OFF-SITE]	Self-study	E04 E10 G01 G02 G03 G04	1.44	36	N	-	Study theoretical content
Practicum and practical activities report writing or preparation [OFF-SITE]	Group Work	E14 E15 E16 G02 G03 G04 T10	0.32	8	Y	Y	Preparation of the memory of the practical classes
Study and Exam Preparation [OFF-SITE]	Self-study	E04 E10 E15 E16 E17 G01 G02 G03 G04 T10 T11	1.36	34	N	-	Study content seminars
		Total:	**6**	**150**			
		Total credits of in-class work: 2.4					**Total class time hours: 60**
		Total credits of out of class work: 3.6					**Total hours of out of class work: 90**

As: Assessable training activity
Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System

Evaluation System	**Continuous assessment**	**Non-continuous evaluation***	**Description**
Mid-term tests	30.00%	0.00%	Elimination partial test for continuous assessment students
Laboratory sessions	20.00%	20.00%	The evaluation includes a laboratory qualification, a qualification of the corresponding laboratory memory and an examination of the practices carried out.
Assessment of active participation	20.00%	0.00%	The evaluation of the seminars includes the computation of the active participation, as well as the exercises delivered or solved in the seminars
Final test	30.00%	80.00%	Second partial exam (30%). Or final exam (60%) of the subject for students who have not passed the first part
Total:	**100.00%**	**100.00%**	

According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject , an ordinary and an extraordinary one (evaluating 100% of the competences).

Evaluation criteria for the final exam:

Continuous assessment:

- The evaluation of theoretical content and exercises will be carried out through the corresponding written tests.

A minimum grade of 4.0 out of 10 must be obtained in each exam in order to apply the percentage corresponding to each test and obtain the final grade.

Non-continuous evaluation:

It will be compulsory to carry out and evaluate the laboratory practices (20%). The rest of the contents will be evaluated through a final exam (80%)

Specifications for the resit/retake exam:

The grade in the extraordinary call will be: 80% exam and 20% laboratory practices.

9. Assignments, course calendar and important dates

Not related to the syllabus/contents

Hours	**hours**
Writing of reports or projects [AUTÓNOMA][Self-study]	2
Study and Exam Preparation [AUTÓNOMA][Self-study]	4
Study and Exam Preparation [AUTÓNOMA][Self-study]	4.5

Unit 1 (de 12): INTRODUCTION TO THERMODYNAMICS: ZERO PRINCIPLE. EQUATIONS OF STATE. Purpose of chemical thermodynamics. Fundamental thermodynamic definitions. Thermodynamic variables. State functions and their properties. Thermodynamic balance. Zero principle of thermodynamics.

Temperature and temperature scales.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	2
Study and Exam Preparation [AUTÓNOMA][Self-study]	3
Study and Exam Preparation [AUTÓNOMA][Self-study]	1.5

Comment: INTRODUCTION TO THERMODYNAMICS: ZERO PRINCIPLE. EQUATIONS OF STATE. Purpose of chemical thermodynamics. Fundamental thermodynamic definitions. Thermodynamic variables. State functions and their properties. Thermodynamic balance. Zero principle of thermodynamics. Temperature and temperature scales.

Unit 2 (de 12): FIRST LAW OF THERMODYNAMICS. THERMAL CHEMISTRY. Heat and work. Reversible and irreversible processes. Internal energy. First Law of thermodynamics. Enthalpy. Heat capacities. Joule experiment: Joule coefficient. Joule Thomson's coefficient. Calculation of thermodynamic magnitudes in different processes. Heat and enthalpy of reaction. Experimental determination of heats of reaction: Hess's law. Ratio of heat of reaction to pressure and constant volume. Enthalpy dependence of reaction with temperature: Kirchhoff's law.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	4
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	1.5
Study and Exam Preparation [AUTÓNOMA][Self-study]	4.5
Study and Exam Preparation [AUTÓNOMA][Self-study]	4.5

Comment: FIRST LAW OF THERMODYNAMICS. THERMAL CHEMISTRY. Heat and work. Reversible and irreversible processes. Internal energy. First Law of thermodynamics. Enthalpy. Heat capacities. Joule experiment: Joule coefficient. Joule Thomson's coefficient. Calculation of thermodynamic magnitudes in different processes. Heat and enthalpy of reaction. Experimental determination of heats of reaction: Hess's law. Ratio of heat of reaction to pressure and constant volume. Enthalpy dependence of reaction with temperature: Kirchhoff's law.

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Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	4
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	1.5
Study and Exam Preparation [AUTÓNOMA][Self-study]	4.5
Study and Exam Preparation [AUTÓNOMA][Self-study]	4.5

Comment: SECOND AND THIRD PRINCIPLE OF THERMODYNAMICS. GIBBS ENTROPY AND ENERGY. Second principle of thermodynamics. Thermal machines and their performance. Carnot cycle. Thermodynamic temperature scale. Entropy Irreversible processes in isolated systems. Calculation of variation of entropy in different processes. Third principle of Thermodynamics. Absolute entropy calculation. Helmholtz and Gibbs functions. Spontaneity and balance conditions. Gibbs equations. Maxwell relations. Gibbs-Helmholtz equations.

Unit 4 (de 12): CHEMICAL BALANCE. General condition of chemical equilibrium. Ideal gas balance. Balance constant. Dependency of the equilibrium constant with temperature: van¿t Hoff's equation. Le Châtelier principle. Chemical balance in non-ideal systems. Chemical balance in heterogeneous systems. Determination of the equilibrium constant.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	3
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2
Mid-term test [PRESENCIAL][Assessment tests]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	4
Study and Exam Preparation [AUTÓNOMA][Self-study]	4

Comment: CHEMICAL BALANCE. General condition of chemical equilibrium. Ideal gas balance. Balance constant. Dependency of the equilibrium constant with temperature: van¿t Hoff's equation. Le Châtelier principle. Chemical balance in non-ideal systems. Chemical balance in heterogeneous systems. Determination of the equilibrium constant.

Unit 5 (de 12): VARIABLE COMPOSITION SYSTEMS. BALANCES OF PHASES IN PURE SUBSTANCES. Partial molar magnitudes. Definition of chemical potential. Gibbs equations for open systems. Gibbs Duhem equation. Chemical potential of an ideal gas. One-phase multiphase systems. Phase rule. Stability of phases and ¿-T diagram. first-order phase transitions. Effect of pressure on steam pressure. Second order phase transitions

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	4
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	3
Writing of reports or projects [AUTÓNOMA][Self-study]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	4
Study and Exam Preparation [AUTÓNOMA][Self-study]	4.5

Comment: VARIABLE COMPOSITION SYSTEMS. BALANCES OF PHASES IN PURE SUBSTANCES. Partial molar magnitudes. Definition of chemical potential. Gibbs equations for open systems. Gibbs Duhem equation. Chemical potential of an ideal gas. One-phase multiphase systems. Phase rule. Stability of phases and ¿-T diagram. first-order phase transitions. Effect of pressure on steam pressure. Second order phase transitions

Unit 6 (de 12): IDEAL SOLUTIONS. Ideal solutions: Raoult's law. Thermodynamic magnitudes of the mixing process. Ideal solubility of gases and solids. Ideal diluted solution. Henry's Law. Distribution of a solute between two immiscible solvents. Colligative properties

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	3
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	4
Study and Exam Preparation [AUTÓNOMA][Self-study]	4.5

Comment: IDEAL SOLUTIONS. Ideal solutions: Raoult's law. Thermodynamic magnitudes of the mixing process. Ideal solubility of gases and solids. Ideal diluted solution. Henry's Law. Distribution of a solute between two immiscible solvents. Colligative properties

Unit 7 (de 12): REAL SOLUTIONS. Activity and activity coefficient. Chemical potential in real solutions. Determination of the activity coefficients.

Variation of activity coefficients with pressure and temperature. Experimental determination of activities. Gibbs-Duhem equation applied to obtain the activity coefficients. Excess and mixing functions.	
Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	3
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	4
Study and Exam Preparation [AUTÓNOMA][Self-study]	4
Comment: REAL SOLUTIONS. Activity and activity coefficient. Chemical potential in real solutions. Determination of the activity coefficients. Variation of activity coefficients with pressure and temperature. Experimental determination of activities. Gibbs-Duhem equation applied to obtain the activity coefficients. Excess and mixing functions.	

Unit 8 (de 12): MULTICOMPONENT SYSTEMS. Two component systems. Liquid-vapor balance. Separation of miscible liquids by distillation. Deviation from ideal behavior: Azeotropes. Liquid-liquid balance. Distillation of partially miscible and immiscible liquids. Solid-liquid balance. Eutectic mixture and compound formation. Solid-gas balance. Three component systems. Triangular phase diagrams.	
Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	1
Final test [PRESENCIAL][Assessment tests]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	4
Study and Exam Preparation [AUTÓNOMA][Self-study]	2
Comment: MULTICOMPONENT SYSTEMS. Two component systems. Liquid-vapor balance. Separation of miscible liquids by distillation. Deviation from ideal behavior: Azeotropes. Liquid-liquid balance. Distillation of partially miscible and immiscible liquids. Solid-liquid balance. Eutectic mixture and compound formation. Solid-gas balance. Three component systems. Triangular phase diagrams.	

Unit 9 (de 12): PRACTICE 1. DETERMINATION OF PARTIAL MOLAR VOLUMES OF BINARY MIXTURES. The contraction or expansion of volumes that occurs when various substances are mixed can be described quantitatively in terms of the partial molar volume. In this practice, the partial molar volumes of ethanol solutions in water are calculated from density measurements with a pycnometer	
Activities	**Hours**
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4
Practicum and practical activities report writing or preparation [AUTÓNOMA][Group Work]	2
Comment: PRACTICE 1. DETERMINATION OF PARTIAL MOLAR VOLUMES OF BINARY MIXTURES. The contraction or expansion of volumes that occurs when various substances are mixed can be described quantitatively in terms of the partial molar volume. In this practice, the partial molar volumes of ethanol solutions in water are calculated from density measurements with a pycnometer	

Unit 10 (de 12): PRACTICE 2. VAPOR PRESSURE AND HEAT OF LIQUID VAPORIZATION. The vapor pressure of a liquid (for example, toluene) is determined by measuring the pressure at which bubbles begin to flow from it by connecting to a vacuum system. From the manometric reading, the vapor pressure is obtained at the temperature of the experiment. If repeated at various temperatures, the integrated form of the Clausius-Clayperon equation allows the heat of vaporization to be obtained. Once the heat of vaporization of various liquids has been determined, Trouton's rule can also be checked.	
Activities	**Hours**
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4
Practicum and practical activities report writing or preparation [AUTÓNOMA][Group Work]	2
Comment: PRACTICE 2. VAPOR PRESSURE AND HEAT OF LIQUID VAPORIZATION. The vapor pressure of a liquid (for example, toluene) is determined by measuring the pressure at which bubbles begin to flow from it by connecting to a vacuum system. From the manometric reading, the vapor pressure is obtained at the temperature of the experiment. If repeated at various temperatures, the integrated form of the Clausius-Clayperon equation allows the heat of vaporization to be obtained. Once the heat of vaporization of various liquids has been determined, Trouton's rule can also be checked.	

Unit 11 (de 12): PRACTICE 3. DETERMINATION OF ACTIVITY COEFFICIENTS BY CRYOSCOPY. Here we analyze one of the colligative properties, the drop in the freezing point of a solvent when adding a solute, which allows us to calculate the activity coefficient and the molecular mass of the solute. In the proposed experiment the freezing point of a solution containing a known weight of a solute, for example glycerin in a known amount of water, is determined. We need a simple apparatus that consists of a test tube containing the solution, a stirrer and a thermometer (for example a precision digital of ¿0.01ºC). The test tube is isolated in a methanol bath, and placed in a mixture of ice and salt at a temperature so low as to allow freezing of the solutions.	
Activities	**Hours**
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4
Practicum and practical activities report writing or preparation [AUTÓNOMA][Group Work]	2
Comment: PRACTICE 3. DETERMINATION OF ACTIVITY COEFFICIENTS BY CRYOSCOPY. Here we analyze one of the colligative properties, the drop in the freezing point of a solvent when adding a solute, which allows us to calculate the activity coefficient and the molecular mass of the solute. In the proposed experiment the freezing point of a solution containing a known weight of a solute, for example glycerin in a known amount of water, is determined. We need a simple apparatus that consists of a test tube containing the solution, a stirrer and a thermometer (for example a precision digital of ¿0.01ºC). The test tube is isolated in a methanol bath, and placed in a mixture of ice and salt at a temperature so low as to allow freezing of the solutions.	

Unit 12 (de 12): PRACTICE 4. CONSTRUCTION OF A TERNARY PHASE DIAGRAM. In this practice, the solubility relationships of mixtures of water, toluene and acetic acid are studied. The toluene-acetic acid and water-acetic acid components are completely miscible, but the toluene-water system is not. The corresponding triangular phase diagram is constructed and the binodal curve (curve showing the limits of immiscibility) and the critical point (point at which the two miscible phases have the same composition) are determined.	
Activities	**Hours**
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4
Practicum and practical activities report writing or preparation [AUTÓNOMA][Group Work]	2
Comment: PRACTICE 4. CONSTRUCTION OF A TERNARY PHASE DIAGRAM. In this practice, the solubility relationships of mixtures of water, toluene and acetic acid are studied. The toluene-acetic acid and water-acetic acid components are completely miscible, but the toluene-water system is not. The corresponding triangular phase diagram is constructed and the binodal curve (curve showing the limits of immiscibility) and the critical point (point at which the two miscible phases have the same composition) are determined.	

Global activity	
Activities	**hours**
Study and Exam Preparation [AUTÓNOMA][Self-study]	36
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	16
Practicum and practical activities report writing or preparation [AUTÓNOMA][Group Work]	8

Study and Exam Preparation [AUTÓNOMA][Self-study]	34
Class Attendance (theory) [PRESENCIAL][Lectures]	24
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	16
Writing of reports or projects [AUTÓNOMA][Self-study]	12
Final test [PRESENCIAL][Assessment tests]	2
Mid-term test [PRESENCIAL][Assessment tests]	2
Total horas:	150

10. Bibliography and Sources

Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
J. A. Rodriguez Renuncio, J. J. Ruiz Sánchez, J. S. Urieta Navarro	TERMODINÁMICA QUÍMICA.	SINTESIS			2000	
J. A. Rodriguez Renuncio, J. Ruiz Sánchez, J. S. Urieta Navarro	PROBLEMAS RESUELTOS DE TERMODINÁMICA QUÍMICA	SINTESIS			2000	
I. N. Levine	FISICOQUÍMICA	McGraw-Hill			2004	
J. J. Ruiz Sánchez	CUESTIONES DE TERMODINÁMICA QUÍMICA	U. Cordoba			1999	
Donald A. McQuarrie	Student Solutions Manual for Physical Chemistry: A Molecular Approach	Heather Cox			1998	
I.N. Levine	Principios de Fisicoquímica	Mc Graw Hill			2014	
I.N.Levine	Physical Chemistry	McGraw Hill			2008	