UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2016/2017
MASTER'S DEGREE (MSC)	CHEMICAL ENGINEERING
SUBJECT	CHEMICAL REACTORS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50352-Ingegneria chimica
CODE	06205
SCIENTIFIC SECTOR(S)	ING-IND/24
HEAD PROFESSOR(S)	LODDO VITTORIO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**LODDO VITTORIO** Monday 11:00 12:00 STANZA 332 EDIFICIO 6 Tuesday 11:00 12:00 STANZA 332 EDIFICIO 6 Wednesday 11:00 12:00 STANZA 332 EDIFICIO 6 Thursday 11:00 12:00 STANZA 332 EDIFICIO 6 Friday 11:00 12:00 STANZA 332 EDIFICIO 6

DOCENTE: Prof. VITTORIO LODDO

PREREQUISITES	Knowledge of thermodinamics Knowledge of mathematics
LEARNING OUTCOMES	Knowledge and understanding The student, at the end of the course, will have acquired knowledge and methods to address and solve in an original way kinetic modeling problems of reagent systems and modeling of homogeneous and heterogeneous reactors. Applying knowledge and understanding The student will have acquired knowledge and methods for the interpretation of kinetic data and for the optimal design of homogeneous and heterogeneous chemical reactors. Making judgments The student will have acquired a useful methodology for the proper planning and conduction of experiments in order to determine the kinetics of simple and complex reactions and for the detection of deviations from idealities in plant reactors. Communication skills The student will be able to communicate competently and with a proper language issues of reaction systems also complex in the industrial context. Learning ability The student will be able to face independently any problrm related to the design and operation of chemical reactors as well as the planning of laboratory experiments to investigate the kinetics of reagent systems where mass and heat transfer can become crucial.
ASSESSMENT METHODS	Written test Oral examination
EDUCATIONAL OBJECTIVES	The course is structured to provide at the student applied chemical kinetics information for the correct design of real chemical reactors. The knowledge of Chemical Thermodynamics and those concerning heat, mass and momentum transport phenomena, are used. The student should be able at the end of the course to solve problems of design and conduction of a chemical reactor. The course is divided into the following general topics. Applied chemical kinetics. Definitions of chemical kinetics: degree of advancement, progress variable, conversion and reaction rate. Reactions in liquid phase. Homogeneous catalytic reactions. Analysis of reaction rate data. The integral method. The differential method. Complex reaction systems. Reactions in parallel, in series and series-parallel. Enzymatic reactions. Ideal chemical reactors. Batch reactor, semi-continuous reactor, tubular reactor with plug flow, continuous perfectly stirred tank reactor, reactor with recycling. Design equations of ideal reactors. Mass and energy balances. Transitional regimen in continuous reactors. Optimization of ideal reactors. Optimization of complex reactions. Design of non-isothermal reactors. Thermal optimization of continuous reactors. Thermal optimization of complex reactions. Deviations from ideal flow conditions. The curve F (t). The residence time distribution function. Axial dispersion model. Model of CSTR reactors in series. Models with two adjustable parameters. Reactors for heterogeneous reacting systems. Progressive conversion and shrinking-core Models. Controlling resistances for spherical particles of variable and invariable size. Distribution of particle sizes and flow patterns of fluid and solid for the design of fluid-solid reactors. heterogeneous catalytic reactors. Mass transfer mechanisms in porous catalysts. Efficiency of a catalyst. Thiele module. Efficiency factor and effective diffusivity . Efficiency factor for non-isothermal catalytic particles. Pseudo-homogeneous models of fixed-bed reactors. Fluidised bed reactors. Gas-liquid reactors. Role of mass transfer in chemical reactors. Mass trasfer from a gas to a liquid. Absorption with chemical reaction. Choosing the type of gas-liquid reactor. Calculation of the height of a packed column for chemical absorption. biochemical reactors. Introduction to industrial fermentation processes. The main types of fermenters. Determination of the parameters of a biological system. Fermenters containing microbial films. Reactors containing enzymes in solution. Reactors containing immobilized enzyme systems.
TEACHING METHODS	Lectures Numerical exercises
SUGGESTED BIBLIOGRAPHY	•O. Levenspiel, Ingegneria delle reazioni chimiche, 1995 Ambrosiana •L. D. Schmidt, The Engineering of Chemical Reactions, 1998 Oxford University Press. •P. Trambouze, H. Van Landeghem, J. P. Wauquier, Chemical Reactors, 1989 Technip •G. Astarita, D. W. Savage, A. Bisio, Gas treating with chemical solvents, 1985 Wiley

SYLLABUS

Hrs	Frontal teaching
1	Introduction to applied chemical kinetics.
2	Kinetic equations for elementary and non-elementary reactions.
2	Differential methods for the analysis of kinetic data.
2	Integral methods for the analysis of kinetic data.
2	Reactions in liquid phase and in solution.
2	Homogeneous and heterogeneous catalysis
2	Reaction mechanisms on solid catalysts
3	Kinetic methods in heterogeneous catalysis
1	Catalysts deactivation
1	Complex catalytic systems
1	Heterogeneous non-catalytic reactions
1	Enzymatic reactions
2	Ideal chemical reactors
2	Mass balances for batch, PFR and CSTR
2	Energy balances
2	Thermal optimization of reactors
1	Non-ideal flow
1	Residence time distribution function
1	Step and pulse stimulus
1	Axial dispersion model
1	Stirred tanks in series model
1	Heterogeneous reacting system reactors
2	Progressive conversion and shrinking-core models
2	Heterogeneous catalytic reactors
2	Mass transfer mechanisms in porous catalysts
2	Catalyst efficiency. Thiele Module
1	Efficiency factor and effective difffusivity
2	efficiency factor for non-isothermal catalytic particles
1	Heat and Mass transfer coefficients in fixed bed reactors. Ergun equation
1	Pseudo-homogeneous modes for fixed bed reactors
1	Fluidized bed reactors
1	Gas-liquid reactors: role of mass trasfer in chemical reactors
1	Packed columns. Buibbling columns with and without mechanical mixing.
1	Mass balances in gas-liquid reactors
1	Mass tranfer with chemical reaction theory
1	Reaction factor: 1st and 2nd order reactions
1	Choosing of the gas-liquid reactor type.
1	Height of a packed column calculation

Hrs	Practice
2	Kinetic equations for elementary and non-elementary reactions.
2	Differential methods for the analysis of kinetic data.

Hrs	Practice
2	Integral methods for the analysis of kinetic data.
1	Reaction mechanisms in solid catalysts
2	Kinetic methods in heterogeneous catalysis
1	Enzymatic reactions
3	Mass balances for batch, PFR and CSTR reactors.
2	Energy balances
1	Axial dispersion model
1	Stirred tanks in series model
1	Mass transfer mechanisms in porous catalysts
1	Catalyst efficiency. Thiele module.
1	Efficiency factor and effective diffusivity.
1	Efficiency factor for non-isothermal catalytic particles.
1	Heat and mass transfer coefficients in fixed bed reactors. Ergun equation
2	Pseudo-homogeneous modes for fixed bed reactors
2	Height of a packed column calculation