MASTER'S DEGREE IN INDUSTRIAL CHEMISTRY AT THE UNIVERSITYOF PARMA

(2-year programme, 120 Credits)

The Master's Degree Programme in Industrial Chemistry at the University of Parma consists of 10 compulsory courses (66 credits), one (6 credits) at choice within a menu of 3 and two elective subjects (12 credits). At the end of the programme the student must undertake an internship on a research project. This internship, which on average require 6 months, may be splitted into two modules, part A and B, of 20+10 credits. The internship may be carried out in a research group within the University of Parma or in external companies/research structures, either in Italy or abroad. The Master's Degree Programme is completed with the final exam (Esame di Laurea - 3 credits) where the student will be awarded the Master's Degree title in Industrial Chemistry. For detailed information on each of the subjects and on the curricula, please check out the relevant syllabus for the academic year 2018/2019 (information provided may be subject to change, year by year).

This Master's Degree Programme is offered by the Department of Chemistry, Life Sciences and Environmental Sustainability, a Department that has been awarded the title of "Department of Excellence" by the Italian Ministry of Education and specifically funded for the 2018-2022 five-year period.

Where not indicated, lectures are given in Italian. Book Exams* are available for all subjects. The experimental thesis internship work is held in English. For the academic year 2018/2019, one subject from of this master will be given in English, but a student can possibly choose other subjects in English from the Master in Chemistry (Solid State Chemistry and Bio-inorganic Chemistry). The offer of subjects in English is going to be expanded in the academic year 2019/2020.

*Book Exams means that the lectures are held in Italian but the lecturer gives the student the necessary study material in English and also the exam is held in English.

- first term: October – February
- second term: March - June.

Year 1			
I Term	**ECTS**	**II Term**	**ECTS**
METALORGANIC CHEMISTRY	6	CHEMISTRY AND TECHNOLOGY OF GLASSES	6
ADVANCED ORGANIC CHEMISTRY	6	APPLIED PHYSICAL CHEMISTRY	6
MODERN SYNTHETIC STRATEGIES IN ORGANIC CHEMISTRY	6	CHEMISTRY AND TECHNOLOGY OF INDUSTRIAL PROCESSES AND OF FORMULATIONS	9
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Year 2			
I Term	**ECTS**	**II Term**	**ECTS**
STATISTICAL PROCESS CONTROL	6	EXPERIMENTAL THESIS – PART A	20
FUNCTIONAL MATERIALS (in English)	9	EXPERIMENTAL THESIS – PART B	10
SUSTAINABLE TECHNOLOGIES AND ALTERNATIVE SOURCES	6	FINAL EXAM	3
ELECTIVE SUBJECTS (other subjects from the menu or any other subject offered by the University of Parma)			12

MENU SUBJECTS	ECTS
ANALYTICAL CHEMISTRY OF PROCESSES	6
DEVELOPMENT AND MANAGEMENT OF INDUSTRIAL CHEMICAL PROCESSES	6
GREEN CHEMISTRY	6

I YEAR SUBJECTS

METALORGANIC CHEMISTRY

Review of some basic knowledge of coordination chemistry (metal-ligand bonding, coordination geometries, chelation). Metal-carbon interaction based on the type of C-ligand (sigma-donor, sigma-donor/pi-acceptor, pi-donor/pi-acceptor), 18e rule. Organometallic chemistry of some s and p-blocks metals: organolithium compounds, organomagnesium compounds, organoalluminium compounds, organisilicon compounds, organophosphorious compounds. Systematic study of the main classes of C-based ligands for transition metals: alkyls and aryls, carbonyls, monoolefins, dienes, allens, alkynes, cyclopentadienyls, arenes, carbenes, isonitriles. Agostic interactions, beta-elimination, alfa-elimination. Substitution reaction is octahedral and square-planar complexes. Nucleophilic and electrophilic addition reactions to coordinated ligands. Oxidative addition, migratory insertion, reductive elimination. Organometallic catalysis: main differences between homogeneous and heterogeneous catalysis, role played by an organometallic catalyst (ligand and metal effect), efficiency of a catalyst. Homogeneous hydrogenation, hydrogen transfer reaction, coupling reactions (Heck, Suzuki, Sonogashira, Negishi), nucleophilic addition to coordinated allenes.

ADVANCED ORGANIC CHEMISTRY

The concept of selectivity in organic synthesis: chemoselectivity; regioselectivity; stereoselectivity. The protecting groups (PGs) in organic synthesis: PGs for alcohols (phenols), amines, thiols, carboxylic acids, aldehydes and ketones. The synthesis of the C-C and C-X (X = N, O, S) bond using organometallic compounds. The literature in organic chemistry: introduction to the use of Reaxys program.

MODERN SYNTHETIC STRATEGIES IN ORGANIC CHEMISTRY

Order of events. One-group C-C disconnection. Disconnections 1,1-, 1,2- and 1,3-di C-X under direct and reversed polarity. One-C-C bond disconnection. Disconnection 1,1-, 1,2- and 1,3-di C-C. Sterocontrol. Stereospecific and stereoselctive processes. Carbonyl condensation. Disconnections 1,2-, 1,3-, 1,4-, 1,5- and 1,6-di C-O. Reconnection. Approach to cyclic and not aromatic heterocyclic systems. Access to 3, 4, 5, 6 and 7 ring systems. Kinetic and thermodynamic problems involved and choice of the best synthetic route. Pericyclic reactions. Kinetic and thermodynamic control in pericyclic reactions. Orbital symmetry role in thermal and photochemical processes. Electrocyclic reactions. Sigmatropic reactions. 2+2 and 4+2 cycloaddition reactions. 1,3-dipolar cycloadditions. Application of the empirical Woodward-Hoffmann rules..

INDUSTRIAL ORGANIC CHEMISTRY

Oxidation processes: how to use oxygen; hydrogen peroxide and others simple oxidants; role of the metals; homogeneous and heterogeneous catalysis of the oxidation processes of organic substrates; how to protect products and materials from the harmful effect of oxygen; catalyst design. Hydrogenation processes: use of hydrogen and hydride transfer in homogeneous catalysis; asymmetric catalysis; use of hydrogen in heterogeneous catalysis. Halogenation processes: chlorination, oxychlorination and fluorination. Oxidation-reduction processes (electrochemical): new technology in electrochemical processes in organic solvents with particular regard to the duplication of acrylonitrile; techniques of oxidation and reduction with chemical reagents that revert to the initial oxidation state electrochemically. Carbonylation processes: metal carbonyls; catalysis of the introduction of carbon monoxide into organic substrates to form aldehydes, ketons, acids and esters. Carboxylation processes: direct introduction of carbon dioxide into organic molecules. Formation of C-C bond processes: catalysis of cyanation, dimerization, oligomerization and metathesis of unsaturated substrates.

CHEMISTRY AND TECHNOLOGY OF GLASSES

The glassy inorganic materials are at the basis of several technological and traditional applications. The course is intended to provide the fundamentals of glass chemistry with particular attention to the role played by the composition of vitreous state in determining the desired optical physical and chemical properties. Some classes of glassy inorganic materials will be widely described in terms of their microstructure, optical properties, chemical behaviour and bio-activity. A series of experimental characterization procedures will be exposed for the study of the different aspects concerning the glass material. The principal industrial processes of glass fabrication will be discussed.

APPLIED PHYSICAL CHEMISTRY

Kinetic Theory of gases. Unified transport theory. Unified model for gases. Transport phenomena in liquids. Viscosity and measurements of viscosity (elements of rheology). Equations for fluid motion. Viscous fluids: energy dissipation. Motion of fluids in pipes. The Reynolds experiment. Dimensional analysis. Buckingham Theorem. Theory of similitude. Filtration. Fluidization. Heat conduction (Conduction, convection, irradiation). Diffusion. Generalized continuity equation. First and second Fick's law. Applications. Non-steady diffusion. Heterogeneous catalysis. External diffusion. Surface film theory. Internal diffusion. Thiele modulus and catalyst effectiveness. Two and three components phase diagrams. Chemical-physics of surfaces (elements). Chemical-physics of colloids (elements).

CHEMISTRY AND TECHNOLOGY OF INDUSTRIAL PROCESSES AND OF FORMULATIONS

Isobutene, 1-butene, butane, C5 hydrocarbons, benzene, toluene, xylenes, methanol. Industrial processes for the polymerization of the intermediate base: production of low density polyethylene (LDPE), high density polyethylene (HDPE), linear low density polyethylene (LLDPE), polypropylene, polybutadiene. Industrial processes for the production of dichloroethane and vinyl chloride. Oxidation products of the intermediate base and their main derivatives: processes of production of ethylene oxide and of propylene oxide, production processes of ethylene glycol, Wacker process, processes of production of acetic acid and acetic anhydride, production of vinyl acetate, the processes of oxidation and ammoxidation of propylene, production adiponitrile, production processes of acetone, industrial processes for production of methyl methacrylate, the processes of oxo-synthesis, production processes of formaldehyde, production processes of 'maleic anhydride and of butanediol, adipic acid production, oxidation of benzene to phenol, oxidation of toluene to benzoic acid, phthalic anhydride production processes, processes of production of terephthalic acid and dimethyl terephthalate. Processes of alkylation of benzene with ethylene and propylene: production of ethylbenzene and cumene, styrene production processes, processes of production of phenol, industrial processes for the production of caprolactam. Industrial processes for the nitration of benzene and toluene, aniline production processes, processes of production of isocyanates. Formulations of the most important industrial sectors. Additives.

ENGLISH B2

All the topics for English 1. Present Perfect Simple and Present Perfect Continuous. Second Conditional. The Passive voice. Indirect speech. Modal verbs of deduction. Main conjunctions. Use of prefixes and suffixes to build nouns, adjectives, etc. Expressing opinions.

II YEAR SUBJECTS

STATISTICAL PROCESS CONTROL

Process optimization (Experimental design, full factorial designs, fractional factorial designs, Plackett-Burmann designs, experimental error evaluation, desirability functions). Simplex method. Quality control: control charts. (Shewhart charts, Shewhart individuals control charts CUSUM charts, R-charts, D-charts, p-charts, np-charts, c-charts). Attention and warning limits. ARL. Data evaluation. Quality system and quality control.

FUNCTIONAL MATERIALS (in English)

Aim of the course: New materials represent one of the frontiers of chemical research. This course will highlight the working methodology in materials research through the study of three different classes of materials. For each class physical, chemical and application aspects will be discussed in a comprehensive way. Self-assembly: Nanofabrication via self-assembly and self-organization, transfer of the molecular properties to the macroscopic properties. Liquid crystals: Definition, physical properties, types of mesophases, synthesis, structure-property relationship, characterization, electrical and optical properties. LC polymers. Applications: LCD, thermochromism, flat panel TV, etc.

Chemical sensors: Working principle of piezoelectric and optical sensors. Sensing materials like ionophores, host-guest compounds, etc. Applications: gas sensors, liquid sensors, artificial olfactory systems. Specialty polymers: Conductive and self-healing polymers. Design, synthesis and functional properties.

SUSTAINABLE TECHNOLOGIES AND ALTERNATIVE SOURCES

Biomass gasification principles. Bioethanol and ethylene production. Chemicals production from biomasses and their uses in the biofuel production. Bio-oil production and upgrading. Bio-diesel hydrocarbons production from triglycerids. Biodegradable polymers production. Problems in the polymer recycle. Chemical recycle processes of polymers. Thermal depolymerization reactions. Polymer oxidative degradation. Chemical depolimerization reactions. Polymer natural degradation processes. Industrial wastewater and exhaust gases treatments. Wastewater biological treatments. Fuel cells.

SUBJECTS FROM THE MENU'

ANALYTICAL CHEMISTRY OF PROCESSES

Aims of process analytical chemistry and its applications in industrial processes. Role of analytical chemistry in the chemical / pharmaceutical industry. Process analytical chemistry as part of the quality control and quality assurance system. Instrumental techniques on which process analyzers are based (e.g. spectroscopy, chromatography, sensors, mass spectrometry) and their interfacing to chemical processes. Main chemometric techniques applied to process analytical chemistry. Examples from current literature and discussion of scientific articles.

DEVELOPMENT AND MANAGEMENT OF INDUSTRIAL CHEMICAL PROCESSES

Fundamentals and guidelines for the design of flow-sheets. Homogeneous and heterogeneous catalysis. Characteristic and structure of the chemical industry. Concepts of mass and energy balances. Concepts of chemical process economy. Concepts on toxicity and hazard of chemical compounds, and on their flammability. Concepts on the design of process flow-sheets. Concepts of thermodynamics and kinetics for the understanding of the effect of process parameters on yield and selectivity to products. Procedures for the regulation and authorization of chemicals. Life cycle of a product and added value. Scale-up of chemical processes. The management of chemical processes. Effect of the main operating parameters (temperature, pressure, partial pressures of reactants, time) on process performance indicators: conversion, yield, selectivity, productivity. The risk analysis in chemical processes. Separations: from reverse osmosis to distillation. Practical examples. Intellectual and industrial property. Human resource management and marketing strategies.

GREEN CHEMISTRY

Concepts of green chemistry, social and environmental sustainability. Sources and their evolution from the 80s. Solvents and green chemistry; how to measure the issue (yield, atom economy, E-factor) and its cost; synthetic applications. Green energy, pros, cons, costs and their evolution since 2000 (hydro, geo, photo and wind); impact of chemistry on the development of these technologies. Catalysis and heterogeneous materials, pros and cons through relevant synthetic examples. Presentation and discussion of these aspects in respect to selected recent literature. Free radicals, history, thermodynamics and kinetic, radical mediators and their developments (from tin to silicon and photocatalysis), synthetic application towards complex bioactive molecules.