CH140 - Engineering Chemistry

Instructors: Prof. Paul Murphy, Dr. Luca Ronconi (Coordinator)

Module Overview and General Aims

This Module lays a broad foundation in chemistry. It is designed to take students with diverse backgrounds and provide them with thorough grounding in the fundamentals of chemistry. The aim is to provide the learner with the knowledge, skills and competences associated with molecular and physico-chemical approaches to the study of matter and of chemical change.

Although a significant minority of students will have a Level 5 (NFQ Level 5) qualification in chemistry, the Module assumes no prior knowledge of chemistry.

Course Instances

- 1BE1 - BEng Civil (core)
- 1BEE1 - BEng Sports and Exercise (core)
- 1BG1 - BEng Biomedical Engineering (core)
- 1BLE1 - BEng Electrical & Electronic (core)
- 1BM1 - BEng Mechanical (core)
- 1BP1 - Electronic & Computer Engineering (core)
- 1BSE1 - BEng Energy Systems Engineering (core)
- 1EG1 - BEng Undenominated (core)

Module Delivery

The Module runs in Semesters I (12 weeks overall). It is delivered in 36 lectures (normally 3 one-hour lectures per week) and 9 tutorials (normally 1 one-hour tutorial per week). In order to improve the learning process and facilitate the effective interaction between the students and the lecturers, the same tutorial is delivered twice per week.

The indicative timetable is reported below and may be subject to changes.

Academic Year 2021/2022 (Semester I)

Week beginning	27-Sep	4-Oct	11-Oct	18-Oct	25-Oct	1-Nov	8-Nov	15-Nov	22-Nov	29-Nov	6-Dec	13-Dec
Week n.	1	2	3	4 (TEST)	5	6	7	8 (TEST)	9	10	11	12 (TEST)
Lectures & Tutorials (CH101/CH140/CP102)												
Mon 10-11 am (online)	LR	LR	LR	LR	Bank Holiday	PM	PM	PM	PM	PM	PM	PM
Tue 12-1 pm (online)	LR	LR	LR	LR	PM	PM	PM	PM	PM	PM	PM	PM
Thu 12-1 pm (online)	LR	LR	LR	LR	PM	PM	PM	PM	PM	PM	PM	PM
Thu 1-2 pm (tutorial) (on-campus, AMB-1021)		LR	LR	LR	PM	PM	PM		PM	PM	PM	
Fri 2-3 pm (tutorial) (on-campus, O'Flaherty)		PG	PG	PG	PG	PG	PG		PG	PG	PG	

LR	Dr. Luca Ronconi (12 lectures + 3 tutorials)
PM	Prof. Paul Murphy (11 lectures + 3 tutorials)
PM	Prof. Paul Murphy (12 lectures + 3 tutorials)
PG	TBA (9 tutorials)

All lectures will be delivered online, either live or pre-recorded, according to the timetable provided. Live lectures will be also recorded. All recordings will be made available on Blackboard. Further details will be provided in due course.

All tutorials will be delivered on campus. Students will have the option to attend the weekly tutorials either on Thursday or on Friday. Note that, due to the restrictions in place to prevent the spread of COVID-19, the capacity of the lecture theaters is reduced to 80%. Therefore, students are advised to split evenly between the two days.

Learning Outcomes

On successful completion of this Module, the learner will be able to:

LO1 predict chemical formulas of compounds using valence considerations and the knowledge of simple and complex cations and anions;

LO2 perform mass- and mole-type calculations, to include isotopes, chemical equations and chemical analyses;

LO3 use models of structure at the atomic/molecular level, including intermolecular forces, to explain the physical properties of matter and the properties of solutions;

LO4 draw representations of the bonding and geometry of simple inorganic and organic molecules and ions, to include Lewis structures, resonance structures, formal charges, ionic character, and the use of Valence Shell Electron Pair Repulsion (VSEPR) theory;

LO5 show how acid-base, redox and precipitation reactions in aqueous solutions are used for qualitative and quantitative analyses;

LO6 solve basic quantitative problems involving chemical equilibrium and chemical kinetics, to include thermochemistry, entropy, Gibbs free energy, the direction of spontaneous change, and the effect of temperature on the rate of reactions;

LO7 name simple chemical compounds according to IUPAC nomenclature.

Textbook and Reference Material

- P. Flowers, K. Theopold, R. Langley, W.R. Robinson, *Chemistry 2e*, OpenStax™, 2019 (downloadable for free at https://assets.openstax.org/oscms-prodcms/media/documents/Chemistry2e-OP_TkF9Jl3.pdf).
- Lecture notes, slides and literature papers provided in due course on Blackboard.

Module Outline

	Topic	Class time	Credits
Lectures	Basic concepts of chemistry, the structure of atoms and molecules	12 Lectures + 3 Tutorials	5
	Chemical reactions, stoichiometry and chemical reactivity	12 Lectures + 3 Tutorials	
	Bonding and molecular structure	12 Lectures + 3 Tutorials	

➢ Basic concepts of chemistry, the structure of atoms and molecules (Dr. Luca Ronconi)

Syllabus and homework (P. Flowers *et al.*, *Chemistry 2e*, OpenStax™, 2019)
- Chapter 1: Essential Ideas
- Chapter 2: Atoms, Molecules, and Ions
- Chapter 3: Composition of Substances and Solutions
- Chapter 6: Electronic Structure and Periodic Properties of Elements

Contents:
- Classification and properties of matter
- Elements, atoms, compounds and molecules
- Atomic number and mass number
- Isotopes and calculation of atomic masses from isotopic masses and natural abundances

- The Periodic Table
- Interpretation, prediction and drawing of formulas of ionic and molecular compounds
- Naming ionic and molecular compounds
- The concept of mole and the use of molar mass in calculations
- Derivation of chemical formulas (including empirical, molecular, structural and condensed formulas) from experimental data
- Properties of the electromagnetic radiation and the wave-particle duality
- The atomic structure, the atomic quantum numbers and their use to predict the electron configuration of atoms

➢ Chemical reactions, stoichiometry and chemical reactivity (Prof. Paul Murphy)

Syllabus and homework (P. Flowers *et al.*, *Chemistry 2e*, OpenStax™, 2019)
- Chapter 4: Stoichiometry of Chemical Reactions
- Chapter 5: Thermochemistry

Contents:
- Reactants, products and stoichiometric coefficients in the chemical reactions
- Aqueous solutions and solubility
- Balancing simple chemical reactions
- Definition of acids and bases, and their behavior in aqueous solution
- The oxidation numbers and their use in oxidation-reduction (redox) reactions
- Stoichiometric calculations using balanced chemical equations
- The concept of limiting reactant and its consequences in chemical reactions
- Theoretical and actual percent yields of chemical reactions
- Definition, measurement and calculation of the concentration of chemical compounds in solution
- The transfer of energy as heat associated with changes in temperature and changes of state
- The First Law of Thermodynamics
- Definition of state functions (enthalpy, internal energy) and their relationship with chemical reactions
- Calculation of the energy evolved or required for physical changes and chemical reactions using the tables of thermodynamic data

➢ Bonding and molecular structure (Prof. Paul Murphy)

Syllabus and homework (P. Flowers *et al.*, *Chemistry 2e*, OpenStax™, 2019)
- Chapter 7: Chemical Bonding and Molecular Geometry
- Chapter 8: Advanced Theories of Covalent Bonding

Contents:
- Application of valence, octet rule and formal charges to draw Lewis structures of simple chemical compounds
- Selected exceptions to the octet rule (*e.g.* B_2H_6, NO, NO_2, O_2)
- Application of the expanded octet to draw Lewis structures of PCl_5, SF_4, BrF_3 and SF_6
- Definition of electronegativity and its periodic trends according to the Pauling scale
- Dipole moments and classification of bond polarity
- Derivation of the shape of molecules from Lewis structures and according to the Valence Shell Electron Pair Repulsion (VSEPR) theory
- Prediction of bond angles using the VSEPR theory

- Classification of intermolecular forces (*e.g.* hydrogen bonding and London dispersion forces) and their effects on physical properties
- Description of the hybridization model and the Valence Bond (VB) theory (including their limitations), and their practical applications to derive the molecular geometry of simple chemical compounds

Module Assessment

NO FORMAL WRITTEN EXAMINATION AT THE END OF SEMESTER I

The Module will be assessed through Continuous Assessment only as follows.

- **Online homework** ⇒ weekly assignments to be worked out online (worth30%)
  A total of 9 online homework will be assigned on a weekly basis during the teaching semester and will need to be completed and submitted through Blackboard by the relevant deadline (to be communicated in due course). Each homework will be marked out of 10 and will comprise of short-answer questions, numerical problems and multiple-choice questions.
- **Online tests** ⇒ periodic assignments to be worked out online (worth 70%)
  Three online tests of 45 min duration each will be held during the teaching semester and will need to be completed and submitted through Blackboard. Each test will be marked out of 10 and will comprise of short-answer questions, numerical problems and multiple-choice questions. Further details will be provided in due course.

Marks of online tests and online homework will be made available on Blackboard. Students will be communicated the aggregate mark for the Module once the overall examination process is complete.

A student will have **passed** if the overall mark for the Module is at least 40%.

A student will have **failed** the 1st sitting where the overall mark for the Module is less than 40%. In this case, the student will have to undergo a written examination in the 2nd sitting with a view to improving the overall Module mark. Should the student underperform also in the 2nd sitting (that is, by obtaining an overall mark for the Module lower than 40%), they will have **failed** the 2nd sitting and will have to **re-register** for the Module the following year and **re-engage in all parts** of the Module again.