First Year Chemistry

Module (ECTS)	Semester(s)	Course Instance(s)	Coordinator
CH101 - Chemistry (15)	I & II	1BPC1, 1BS1, 1EV1, 1OS1, 1OS9	Dr. Luca Ronconi
CH120 - Chemistry: Molecular Science (15)	I & II	0MB3, 1BGG1, 1BO1, 1MR1	Dr. Patrick O'Leary
CH130 - Chemistry: The World of the Molecule (15)	I & II	1BMS1, 1BY1, 1EH1,	Dr. Patrick O'Leary
CH140 - Engineering Chemistry (5)	I	1BE1, 1BEE1, 1BG1, 1BLE1, 1BM1, 1BP1, 1BSE1, 1EG1	Prof. Donal Leech
CP102 - Chemistry/Physics (7.5 Chemistry)	I	1BGS1, 1EHS1, 1EV1	Prof. Donal Leech
Instructors: Dr. David Cheung, Prof. Donal Leech, Prof. Paul Murphy, Dr. Patrick O'Leary, Dr. Luca Ronconi			

The following prospectus refers specifically to the CH101 - Chemistry Module.
Exceptionally for the Academic Year 2020/21 all 1st Year Chemistry Modules (that is, CH101, CH120, CH130, CH140 and CP1012) will follow substantially the same syllabus and delivery programme. Further details will be provided in due course.

Module Overview and General Aims

This Module lays a broad foundation in chemistry for students who have an option of continuing to study chemistry in subsequent years. Some of these students will study chemistry to degree level and pursue careers as chemists. The Module assumes no prior knowledge of chemistry, although a significant minority of students will have a Level 5 (NFQ Level 5) qualification in 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. The Module is designed to develop an understanding of how chemicals function in "real world" applications and how chemistry integrates with human, social and environmental issues. Students will also develop the knowledge, skills and competences appropriate for effective and safe work in a chemistry laboratory.

Module Delivery

The Module runs over both semesters I and II (24 weeks overall, 12 in Semester I/12 in Semester II).

The theory course is delivered in 72 lectures (normally 3 one-hour lectures per week, 36 in Semester I/36 in Semester II) and 18 tutorials (normally 1 one-hour tutorial per week, 9 in Semester I/9 in Semester II).

Unless otherwise stated, all lectures and tutorials will be pre-recorded and made available on Blackboard according to the timetable provided. Further details will be provided in due course.

As far as the practical component of the course is concerned, the number of practicals to be actually carried out in the teaching laboratory will be limited to 50%. There will be overall 20 hours of actual laboratory work split into 8 practical sessions of 2.5 h each (**1 practical every second week, 4 in Semester I/4 in Semester II**). The remaining practicals will take the form of "virtual" laboratory experiments (**1 virtual practical every second week, 4 in Semester I and 4 in Semester II**). A pre-

recorded pre-practical talk will be made available on Blackboard in advance to each practical session (either actual or virtual). Further details will be provided in due course.

Students will be notified by the College the day of practicals and allocated a bench number. **Note that students are expected to carry out their laboratory work on the assigned day, regardless of the practical being actual or virtual.**

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

CH101 - Chemistry (2020/21, Semester I)

Week beginning	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct	2-Nov	9-Nov	16-Nov	23-Nov	30-Nov	7-Dec	12-Dec
Week n.	1	2	3	4	5	6	7	8	9	10	11	12
Lectures & Tutorials												
Mon 10-11 am	LR	LR	LR	LR	Bank Holiday	PM	PM	PM	PM	PM	LR	PM
Tue 12-1 pm	LR	LR	LR	PM	PM	PM	PM	PM	PM	PM	LR	PM
Thu 12-1 pm	LR	LR	LR	PM	PM	PM	PM	PM	PM	PM	PM	PM
Thu 2-3 pm (tutorial)		LR	LR	LR	PM	PM	PM	PM	PM	PM		
Practicals (4 in the laboratory, 4 virtual)												
Mon 2-4.30 pm					Bank Holiday (anticipated to 23 Oct)	Practical 1	Practical 3	Practical 3	Practical 5	Practical 5	Practical 7	Practical 7
Mon Virtual						Practical 2	Practical 4	Practical 4	Practical 6	Practical 6	Practical 8	Practical 8
Tue 3-5.30 pm					Practical 1	Practical 1	Practical 3	Practical 3	Practical 5	Practical 5	Practical 7	Practical 7
Tue Virtual					Practical 2	Practical 2	Practical 4	Practical 4	Practical 6	Practical 6	Practical 8	Practical 8
Wed 2-4.30 pm					Practical 1	Practical 1	Practical 3	Practical 3	Practical 5	Practical 5	Practical 7	Practical 7
Wed Virtual					Practical 2	Practical 2	Practical 4	Practical 4	Practical 6	Practical 6	Practical 8	Practical 8
Thu 3-5.30 pm					Practical 1	Practical 1	Practical 3	Practical 3	Practical 5	Practical 5	Practical 7	Practical 7
Thu Virtual					Practical 2	Practical 2	Practical 4	Practical 4	Practical 6	Practical 6	Practical 8	Practical 8
Fri 2-4.30 pm				Practical 1	Practical 1	Practical 1	Practical 3	Practical 3	Practical 5	Practical 5	Practical 7	Practical 7
Fri Virtual				Practical 2	Practical 2	Practical 2	Practical 4	Practical 4	Practical 6	Practical 6	Practical 8	Practical 8

LR	Luca Ronconi (12 lectures + 3 tutorials)
PM	Paul Murphy (12 lectures + 3 tutorials)
PM	Paul Murphy (11 lectures + 3 tutorials)
	Group 1 (up to 44 students per lab session)
	Group 2 (up to 44 students per lab session)

CH101 - Chemistry (2020/21, Semester II)

Week beginning	8-Feb	15-Feb	22-Feb	1-Mar	8-Mar	15-Mar	22-Mar	29-Mar	12-Apr	19-Apr	26-Apr	3-May
Week n.	1	2	3	4	5	6	7	8	9	10	11	12
Lectures & Tutorials												
Mon 10-11 am	POL	POL	POL	POL	DC	DC	DC	LR	LR	LR	POL	Bank Holiday
Tue 12-1 pm	POL	POL	POL	DC	DC	DC	DC	LR	LR	LR	POL	LR
Thu 12-1 pm	POL	POL	POL	DC	DC	DC	LR	LR	LR	LR	DC	LR
Thu 2-3 pm (tutorial)		POL	POL	POL	DC	DC	DC	LR	LR	LR	DC	
Practicals (4 in the laboratory, 4 virtual)												
Mon 2-4.30 pm	Practical 9	Practical 9	Practical 11	Practical 11	Practical 13	Practical 13	Practical 15	Practical 15				
Mon Virtual	Practical 10	Practical 10	Practical 12	Practical 12	Practical 14	Practical 14	Practical 16	Practical 16				
Tue 10 am-12.30 pm	Practical 9	Practical 9	Practical 11	Practical 11	Practical 13	Practical 13	Practical 15	Practical 15	Practical 13			
Tue 3-5.30 pm	Practical 9	Practical 9	Practical 11	Practical 11	Practical 13	Practical 13	Practical 15	Practical 15				
Tue Virtual	Practical 10 / Practical 10	Practical 10 / Practical 10	Practical 12 / Practical 12	Practical 12 / Practical 12	Practical 14 / Practical 14	Practical 14 / Practical 14	Practical 16 / Practical 16	Practical 16 / Practical 16	Practical 14			
Wed 2-4.30 pm	Practical 9	Practical 9	Practical 11	Practical 11	Practical 13	St. Patrick's Day (postponed to 13 Apr)	Practical 15	Practical 15				
Wed Virtual	Practical 10	Practical 10	Practical 12	Practical 12	Practical 14		Practical 16	Practical 16				
Thu 10 am-12.30 pm	Practical 9	Practical 9	Practical 11	Practical 11	Practical 13	Practical 13	Practical 15	Practical 15				
Thu 3-5.30 pm	Practical 9	Practical 9	Practical 11	Practical 11	Practical 13	Practical 13	Practical 15	Practical 15				
Thu Virtual	Practical 10 / Practical 10	Practical 10 / Practical 10	Practical 12 / Practical 12	Practical 12 / Practical 12	Practical 14 / Practical 14	Practical 14 / Practical 14	Practical 16 / Practical 16	Practical 16 / Practical 16				
Fri 2-4.30 pm	Practical 9	Practical 9	Practical 11	Practical 11	Practical 13	Practical 13	Practical 15	Practical 15				
Fri Virtual	Practical 10	Practical 10	Practical 12	Practical 12	Practical 14	Practical 14	Practical 16	Practical 16				

POL	Patrick O'Leary (12 lectures + 3 tutorials)
DC	David Cheung (12 lectures + 3 tutorials)
LR	Luca Ronconi (11 lectures + 3 tutorials)
	Group 1 (up to 44 students per lab session)
	Group 2 (up to 44 students per lab session)
	Group 3 (up to 44 students per lab session)
	Group 4 (up to 44 students per lab session)

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 inorganic and organic compounds according to IUPAC nomenclature;
LO8 demonstrate familiarity with the chemistry of representative elements and their compounds, and with the structure and reactivity of the main organic functional groups;
LO9 rationalize the properties of the elements and their compounds using basic quantum-mechanical models (including electron configuration, atomic spectra and periodic trends), and using the concepts of oxidation state and charge density;
LO10 draw mechanisms for a range of simple organic reactions;
LO11 relate the chemical properties of selected elements and compounds to their uses, human and social relevance, and environmental impact.

On successful completion of the associated practical work in the laboratory, the learner will be able to:
LO12 analyze salts for the presence of common cations and anions, and simple organic substances for the presence of common functional groups;
LO13 use appropriate laboratory techniques and equipment to synthesize, separate and purify chemical compounds;
LO14 use titrimetry and physico-chemical techniques for quantitative analysis and to determine physico-chemical properties;
LO15 implement safe work practices in a chemistry laboratory, to include awareness of common hazards and appropriate safety precautions;
LO16 report to a scientifically acceptable standard on laboratory work.

Textbook and Reference Material

- J.C. Kotz, P.M. Treichel, J.R. Townsend, D.A. Treichel, *Chemistry & Chemical Reactivity*, 10th Ed., Cengage Learning, 2017
- First Year Chemistry Laboratory Manual (downloadable from Blackboard).
  For all practicals, students MUST purchase their white laboratory coat and safety glasses (available at the SU shop)
- Lecture notes, slides and literature papers provided in due course on Blackboard

Module Outline

	Topic	Class/Laboratory time	Credits (15 overall)
Semester I			
Lectures	Basic concepts of chemistry, the structure of atoms and molecules	12 Lectures + 3 Tutorials	6
	Chemical reactions, stoichiometry and chemical reactivity	12 Lectures + 3 Tutorials	
	Bonding and molecular structure	12 Lectures + 3 Tutorials	
Laboratory	Introduction to the chemistry laboratory	1 Practical	1.5
	Qualitative analysis of inorganic salts	2 Practicals	
	Inorganic synthesis	1 Practical	
	Quantitative analysis	3 Practicals	
	Thermochemistry	1 Practical	
Semester II			
Lectures	Organic chemistry	12 Lectures + 3 Tutorials	6
	Physical chemistry	12 Lectures + 3 Tutorials	
	Inorganic chemistry	12 Lectures + 3 Tutorials	
Laboratory	Chromatography and molecular structure	1 Practical	1.5
	Identification of organic compounds	3 Practicals	
	Organic synthesis	1 Practical	
	Spectrophotometry	1 Practical	
	Kinetics	1 Practical	
	Chemical equilibrium	1 Practical	

Semester I

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

  Syllabus and homework (J.C. Kotz *et al.*, *Chemistry & Chemical Reactivity*, 10th Ed., 2017)
  - Chapter 1: Basic concepts of chemistry
  - Chapter 2: Atoms, molecules and ions
  - Chapter 6: The structure of atoms

  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 (J.C. Kotz *et al.*, *Chemistry & Chemical Reactivity*, 10th Ed., 2017)
- Chapter 3: Chemical reactions
- Chapter 4: Stoichiometry: quantitative information about chemical reactions
- Chapter 5: Principles of chemical reactivity: energy and chemical reactions

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 (J.C. Kotz *et al.*, *Chemistry & Chemical Reactivity*, 10th Ed., 2017)
- Chapter 8: Bonding and molecular structure
- Chapter 9: Bonding and molecular structure: orbital hybridization and Molecular Orbitals

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

Semester II

➢ Organic chemistry (Dr. Patrick O'Leary)

Syllabus and homework (J.C. Kotz *et al.*, *Chemistry & Chemical Reactivity*, 10th Ed., 2017)
- Chapter 23: Carbon: not just another element

Contents:
- Drawing accurately the structures of organic compounds from chemical formulas and by applying Lewis method and the VSEPR theory where appropriate
- Naming organic compounds according to IUPAC rules and nomenclature (including the concept of *cis-trans* and the *E-Z* priority rules in naming alkenes)
- The main organic functional groups (including alkanes, alkenes, alkynes, alcohols, ethers, benzene, phenols, aldehydes, ketones, carboxylic acids, esters, amines and amides) and their general reactivity
- How functional groups determine a molecule's reactivity and physical properties
- Acidity and basicity, acid/base reactions
- Curly arrow mechanisms
- Electrophiles and nucleophiles
- Chemical bonding in organic compounds (*e.g.* alkanes, alkenes, alkynes, benzene, aldehydes, ketones and amines) using the hybridization model (sp, sp^2 and sp^3)
- The concept of chirality

➢ Physical chemistry (Dr. David Cheung)

Syllabus and homework (J.C. Kotz *et al.*, *Chemistry & Chemical Reactivity*, 10th Ed., 2017)
- Chapter 10: Gases and their properties
- Chapter 11: Intermolecular forces and liquids
- Chapter 13: Solutions and their behavior
- Chapter 15: Principles of chemical reactivity: equilibria
- Chapter 16: Principles of chemical reactivity: the chemistry of acids and bases
- Chapter 17: Principles of chemical reactivity: other aspects of aqueous equilibria
- Chapter 18: Principles of chemical reactivity: entropy and free energy
- Chapter 14: Chemical kinetics: the rates of chemical reactions

Contents:
- Role of the intermolecular forces in determining the physical state of substances (contribution to the properties of liquids, relationship with solubility, driving forces for the formation of solutions)
- Chemical equilibrium and the effect of concentration and temperature
- Evaluation of the equilibrium constants of reactions and the concentration of reactants and products at the equilibrium
- Application of the principles of chemical equilibrium to acid-base reactions and solubility
- Basic of entropy and Gibbs free energy, and their contribution to the direction of spontaneous change
- The concept of reaction rate and the effect induced by altering the temperature or adding a catalyst

➢ Inorganic chemistry (Dr. Luca Ronconi)

Syllabus and homework (J.C. Kotz *et al.*, *Chemistry & Chemical Reactivity*, 10th Ed., 2017)
- Chapter 7: The structure of atoms and periodic trends
- Chapter 15: Principles of chemical reactivity: equilibria
- Chapter 16: Principles of chemical reactivity: the chemistry of acids and bases
- Chapter 17: Principles of chemical reactivity: other aspects of aqueous equilibria
- Chapter 21: The chemistry of the Main Group elements

Contents:
- The periodic properties/trends of the elements
- Definition and identification of metals, non-metals and semimetals
- Chemical families of the main group elements
- Chemical and physical properties/trends of the elements belonging to the same chemical family (including the diagonal relationship and the inert pair effect)
- Chemistry, bonding, composition and structure of selected compounds of the main group elements
- Practical application of the principles of stoichiometry (*e.g.* stoichiometric coefficients and calculations, reactions going to completion *vs.* reactions at the equilibrium, reactions in gaseous phase, homogeneous and heterogeneous reactions, acid-base reactions, pH, solubility, etc.
- Practical uses and implications of selected main group elements and derivatives to socially relevant general themes, and their environmental impact

Module Assessment

No formal written examination will take place at the end of Semester I.

The Module will be assessed over two Semesters as follows.

➢ Continuous Assessment (CA, worth 70% overall)
- Three 45 min duration online tests which will be held during Semester I (worth 30%).
- Mandatory attendance to laboratory sessions (both actual and virtual), and submission of a written report on the laboratory work each week (worth 30%)
- Weekly online homework on topics dealt with during lectures/tutorials (worth 10%)

➢ One formal 2 h duration written examination at the end of Semester II on the theory course (worth 30%).

Marks of online tests, laboratory reports and online homework will be available on Blackboard in due course.

Students will be communicated the aggregate mark for the Module once the overall examination process is complete.

A student will have **passed** if the mark in the CA component is at least 35% **and** the aggregate mark for the Module is at least 40%.

A student will be deemed **incomplete** if the mark in the CA component is less than 35%, and **will not** be able to progress **regardless** of the performance in the written examination for the Module in the 1st sitting. In this case, the student **cannot** re-sit either, and must **re-register** for the Module the following year and **re-engage in all parts** of the Module again.

A student will have **failed** the 1st sitting where the mark in the CA component is at least 35% but the overall Module mark is less than 40%. In this case, the student must repeat the written examination in the 2nd sitting with a view to improving the overall Module mark, retaining the CA mark from the 1st sitting. Should the student underperform also in the 2nd sitting (that is, by obtaining an aggregate 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.

Written Exam

Past exam papers are available in the Exam Papers Archive (https://www.mis.nuigalway.ie/regexam/paper_index_search_main_menu.asp) of the James Hardiman Library. Note that, according to the School of Chemistry policy, past repeat (*i.e.* 2nd sitting) exam papers are **not** made available.

- **Final Exam at the end of Semester II**

  The written examination of 2 h duration will be marked out of 100 and will divided into three parts (sections A, B and C). Students are required to answer questions from **all** three sections as described in the exam paper.

  Questions will be allocated to the three sections as follows:
  - Section A: Organic chemistry (Dr. Patrick O'Leary)
  - Section B: Physical chemistry (Dr. David Cheung)
  - Section C: Inorganic chemistry (Dr. Luca Ronconi)

  Further details about the format/type of exam paper will be provided in due course.

Continuous Assessment

- **Attendance** ⇒ mandatory for all laboratory sessions (both actual and virtual)

- **Laboratory reports** ⇒ written reports of the laboratory work submitted each week through Blackboard

  Downloadable templates of the laboratory reports (as Word documents) will be available in due course in the "Lab Reports Submission" section on Blackboard.

  Attending the laboratory only is **not** enough to get credits: practicals must be completed satisfactorily and complete laboratory reports must be submitted weekly through Blackboard by the relevant deadline (see table below).

Day of the Practical	Submission deadline
Monday	the following Saturday by 5pm
Tuesday	the following Sunday by 5pm
Wednesday	the following Monday by 5pm
Thursday	the following Tuesday by 5pm
Friday	the following Wednesday by 5pm

  Each report will be marked out of 10. A "zero" will be assigned for late or no submission.

- **Online homework** ⇒ weekly assignments to be worked out online over the two semesters

  A total of 18 online homework will be assigned on a weekly basis over the two semesters and will need to be completed and submitted through Blackboard by the relevant deadline (to be announced 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 during Semester I

  Three online tests of 45 min duration each will be held during Semester I and will need to be completed and submitted through Blackboard. Each test will be marked out of 10 and will comprise of 10 short-answer questions, numerical problems and multiple-choice questions. Further details will be provided in due course.