**CH140 - Engineering Chemistry**

Instructors: Prof. Henry Curran (Co-ordinator), Dr. Stanislas Von Euw, Dr. Chongwen Zhou.

**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 physicochemical 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 Un-denominated (core)

**Module Delivery**

The Module runs in Semesters I (10 weeks overall). It is delivered in 30 lectures (normally 3 one-hour lectures per week) and 9 tutorials (normally 1 one-hour tutorial per week).

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

Monday at 10:00 AM: ENG-G018 and ENG-2002

Tuesday at 12: PM: ENG-G018 and ENG-G047

Wednesday at 2:00 PM: ENG-G018 and ENG-G047

Thursday at 12:00 PM: ENG-G018 and ENG-2002



All lectures will be delivered in person in ENG018 and will also be streamed to another room (see Table above). There will be no recording of lectures made available on Blackboard as students are expected to engage with and attend the lectures. All tutorials will also be delivered in person on campus, as per the above timetable.

**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://openstax.org/details/books/chemistry-atoms-first-2e>.

* Lecture notes, slides and literature papers provided in due course on Blackboard.

**Module Outline**

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| --- | --- | --- |
| **Topic** | **Class time** | **Credits** |
| **Lectures** | Basic concepts of chemistry, the structure of atoms and molecules | 10 Lectures + 3 Tutorials | 5 |
| Chemical reactions, stoichiometry, and chemical reactivity | 10 Lectures + 3 Tutorials |
| Bonding and molecular structure | 10 Lectures + 3 Tutorials |

 **Basic concepts of chemistry, the structure of atoms and molecules** (Prof. Henry Curran)

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** (Dr. Stanislas Von Euw)

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** (Dr Chongwen Zhou)

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., B2H6, NO, NO2, O2)

- Application of the expanded octet to draw Lewis structures of PCl5, SF4, BrF3 and SF6

- 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**

* **There will be one continuous assessment examination on Friday 27th October (worth 20% of you overall chemistry mark) and one exam held at the end of the semester (worth 80% of your overall chemistry mark).**
* 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.