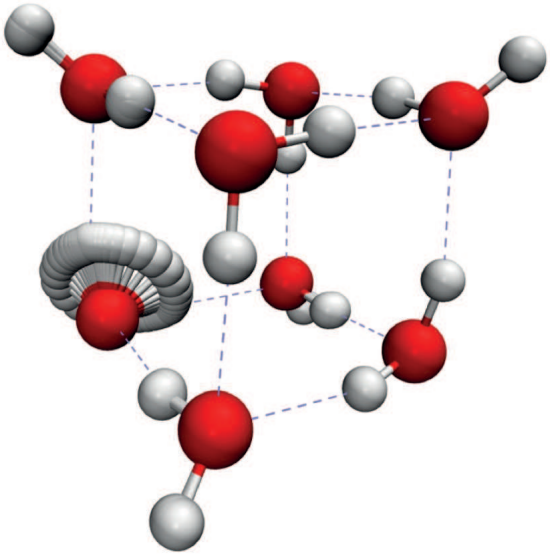
UNIVERSITY OF CAMBRIDGE

Yusuf Hamied Department of Chemistry

Part III Chemistry:
A Guide to the Course



Academic Year 2026/2027

The Department of Chemistry endeavours to develop an inclusive, supportive and intellectually stimulating environment for our undergraduate community.

Athena SWAN is an ongoing program to address the underrepresentation of women in the sciences. The Silver Award recognises the progress that the Department has made in recent years, and the actions that benefit not only our female students, but all our undergraduate chemists.

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1 Introduction

The fourth year – Part III – is in many ways quite different to the preceding years and we hope that you will find that your final year is a challenging and exciting finale to your undergraduate career in Cambridge.

The picture on the cover is taken from Professor Stuart Althorpe's website and shows an 'instanton' in the water octamer. For further details concerning research in the Althorpe group see http://www-stuart.ch.cam.ac.uk

There are just two components to this year's work. Firstly, a series of advanced lecture courses which will explore topics in which members of the Department are actively engaged. A wide range of topics are on offer, reflecting the enormous breadth of research work undertaken in the Department and each course aims to take you to the 'research frontier' so that you can begin to obtain a feel of just where modern chemistry is going.

The second component of the course is a sixteen-week research project covering the Michaelmas and Lent Terms. You have already selected the research group you will work with, and over the coming weeks you will begin to get involved in their work. The experience you have gained in the practical classes and in the computer room over the past three years should have given you a solid base of experience and skills which you can bring to bear on your research topic.

The lecture programme includes three interdisciplinary courses (I1, I2 and I3) in the Lent Term. These courses have been designed to address topics which cross the traditional boundaries between chemistry, physics and earth sciences. One of the courses, I1 *Atmospheric Chemistry and Global Change*, is hosted by the Department of Chemistry and given principally by our own staff. We encourage you to have a careful look at the other two courses and see if they catch your interest. These courses present a good opportunity for you to widen your horizons.

2 Introductory and safety talks

On Wednesday 7th October at 09:00 in the Pfizer Lecture Theatre there will be introductory talks about the course and in particular about the research project; it is vital that you attend.

On Wednesday 7th October at 09:00 the introductory talk will be followed by a Safety Lecture also in the Pfizer Lecture Theatre. The Head of Department requires all new Part III students, without exception, to attend this talk.

You will not be able to start your project unless we have a record of your attendance at this safety lecture.

On Friday 9th October from 17:00 there will be a 'Welcome Party' in the Cyber Café for all new Part II and Part III students. We do hope that you will be able to come along and mark the beginning of the year in a suitable way.

3 Careers for chemists

On 20th October at 17:00 in the Pfizer lecture theatre Dr Raj Sidhu, from the Careers Service, will give an online presentation on Careers for Chemists.

Even if you are thinking of carrying on for a PhD it is as well to inform yourself about other career options, and Dr Sidhu's talk is therefore highly recommended for all the class.

4 Outline of the course

Lectures

There are a total of seventeen separate lecture courses on offer. The courses offered in the Michaelmas Term are denoted M1, M2 . . . and those in the Lent Term L1, L2 . . . Several of these courses are interdisciplinary and cross the traditional divisions of the subject, so before making

your decision as to which courses to attend, please do read the synopses carefully. In addition, there are the three Interdisciplinary Courses I1 – I3 run in conjunction with other departments.

The structure of the examination (see page 27) is such that you will need to answer questions on *three* separate courses from the Michaelmas Term and *three* separate courses from the Lent Term. You may choose to prepare more than this minimum of six lecture courses: this will give you more choice in the examinations, but will of course increase your workload. In any case, you will probably want to attend several lectures from a course before deciding whether or not to pursue that course fully.

Apart from the requirement to take a minimum of three courses in the Michaelmas and three in the Lent Terms, you have a completely free choice as to which lectures to follow. Lectures are confined to weekday mornings, leaving you the afternoons free for supervision and project work. There are no lectures in the Easter Term.

You should think carefully about which courses to follow, and should seek advice from your Director of Studies; other members of staff will also be happy to advise, as will the Director of Teaching.

Research project

The way in which your project operates will depend very much on the group you have chosen to work in. However, whatever the topic, you should expect to find the work more challenging than conventional set practicals; research is, by its very nature, an exploration of the unknown and so results cannot be guaranteed.

The project will be assessed on the basis of a written report which you will submit at the start of the Easter Term, a report from your supervisor and an interview. The assessment is not based on the results obtained – this would be unfair as results cannot be guaranteed – but is based on the commitment and aptitude you have shown and how well you have written up the account of your work.

Students are required to present a summary of their project in the format of a poster at a Poster Showcase Event on Thursday 4th February 2027

Reading Lists Online (RLO)

The link below gives access to the online reading lists for all the Chemistry courses. They have been compiled to follow the structure of the Course Guides. Each one includes a record of the borrowable items held in the Cambridge University Libraries' collections (including the Chemistry Library) and those accessible as eBook titles.

www-library.ch.cam.ac.uk/reading-lists-online-rlo

5 Lecture synopses: Michaelmas Term

M0: Advanced polymer chemistry

Prof. Oren Scherman (9 lectures) and Prof. Hugo Bronstein (3 lectures)

The course will cover the synthetic methodologies used to prepare polymers. A quantitative and mechanistic approach for these polymerisations will be discussed in detail. Preparation of co-polymers and functional polymeric materials and their useful applications will also be covered.

This course assumes knowledge of the organic chemistry covered in Part II as well as the Part II course B9, Polymers: synthesis, characterisation and application.

Topics Synthesis of macromolecules: chain vs step polymerization
Detailed reaction mechanisms and kinetics
Molecular weight and topology
Characterisation techniques and analysis
Polymer properties in solution & bulk
Block copolymer preparation methods
Functional polymers & applications

Recommended books – see Reading Lists Online (RLO)

M1: Inorganic materials

Dr Paul Wood

The course will describe the magnetic (and electronic) properties of molecular solids, extended networks and metal oxides, and show how unusual properties can be rationalised from knowledge of the compounds' structures. The material will be illustrated by real examples and the course will progress from fundamental theory to the most up-to-date topics in molecular magnetism such as the search for highly efficient data storage compounds using clusters and chains. Methods for measuring magnetism and magnetic phenomena directly and indirectly will be discussed including heat capacity measurements and neutron diffraction.

It is desirable, but not essential, to have taken the Part II Course *C3: NMR*.

Topics Fundamental properties in magnetism; diamagnetism, paramagnetism and magnetic susceptibility.

Magnetic properties of isolated ions; understanding the behaviour of first-row transition metals and lanthanides including the van Vleck equation to model their magnetic behaviour.

Extensions to a wider series of oxides including perovskites, spinels and garnets (including a brief description of the different structures and the basic crystallographic notation used to describe them).

Trends across the 3d series: from delocalised (metallic) to localised paramagnetic (magnetic) properties.

An introduction to magnetic anisotropy focusing on single ion anisotropy.

Magnetic properties of clusters; Communication between unpaired electrons via direct exchange and superexchange pathways; models for the magnetism of clusters using Kambe's vector coupling approach; single molecule magnets.

Magnetic properties of extended networks; ferro-, ferri- and antiferromagnetism; molecular field theory. Exotic types of ordering such as metamagnetism, canted antiferromagnetism and spin flop phases. Spin frustration. Single chain magnets.

Characterisation methods such as heat capacity measurements and neutron diffraction leading to magnetic phase diagrams.

Double exchange and magnetic phenomena; high-spin low spin transitions; uses of magnetism and magnetic materials in devices/applications

Recommended Books – see RLO

M2: Bio-Inorganic chemistry

Prof. Paul Barker

This is not a traditional bioinorganic course. It brings together fundamental aspects of inorganic chemistry with biological chemistry to examine how and why biology uses the metals it does.

The basis of the course deals with the interaction of inorganic cofactors with biological molecules (mainly proteins) and how the fundamental chemistry of metallic elements is controlled and manipulated for catalytic and structural chemistry. This will be illustrated by structural spectroscopic and mechanistic insights into proteins and enzymes using zinc, iron and copper as paradigms. Fundamental to those is the chemistry of dioxygen O_2 - specifically, its coordination and redox properties. We will also look briefly at molybdenum and cobalt systems.

Once we have considered how the chemistry of metallic components of biology are manipulated by biomolecules (and *vice versa*), we will examine the principles underlying the use of metallic cofactors in complex, highly organised structures seen in natural charge transfer processes. We will discover how multiple redox centres can be organised in a variety of ways for harnessing electrochemical and photochemical potentials and also consider what we can learn from biological systems for the construction of useful molecular electronic devices. Along the way we will examine how biology acquires metal ions and regulates their concentration in cells. This will lead on to a consideration of the biological chemistry of heavy metals (e.g. Pb, Cd, Pt and Ru) and their interactions with nucleic acids and proteins. The course will finish by looking at the very topical embryonic field of artificial metalloenzymes in the context of synthetic biology.

This is a highly interdisciplinary course and calls upon basic chemistry encountered in IA and IB courses. We will need to think about metal ion properties (Chem B level) including redox chemistry and ligand exchange (Part II course A1), as well as some simple IA biochemistry. There is some small overlap with the B3 biological catalysis course from Part II. Prior knowledge of basic biomolecular structures, particularly proteins covered in Part II course C4, is helpful but not essential. I do not aim to deliver or test biochemical knowledge, rather to uncover the fundamental metallochemistry that biology uses in an amazing variety of ways. My goal is not to ask you to remember specific reactions (well, not many) but rather to understand how metal ion chemistry is manipulated and structured in biology so that you can analyse unseen cases.

Topics **Lectures 1-8**: Basic metalloprotein chemistry: coordination, thermodynamics, structure and catalysis, exemplified by zinc, iron and copper.

Lectures 9-10: Organisation and principles of electron transfer in biological systems.

Lectures 11-12: Engineering unnatural metal cofactors and artificial metalloenzymes for medicine and synthetic biology.

The course will be supported by 4 supervisions in groups of 4-6 students. One supervision will be devoted to the critical analysis of a recent research paper in the area of artificial metalloenzymes.

Recommended books – see RLO

M3: Soft matter – from molecules to materials

Prof. Tuomas Knowles (6 lectures) and Dr Leif Deck (6 lectures)

Soft materials are systems which are readily deformed by thermal fluctuations or mechanical stresses. Many of the objects and materials in the world around us deform when squashed, can flow or are sensitive to temperature changes. These types of materials, including paint, yoghurt, shampoo, rubber and foam, are all thus soft materials. Concepts from soft matter also allow us to understand materials in biology; living matter is for the large part soft matter. As such the study of soft matter is an area with a rich set of interdisciplinary connections.The properties of soft matter systems are not used just in nature. They are also key for technological applications, including in engineering everyday products such as plastics, foods, creams and gels This course will focus on the fundamental physical principles that allow us to understand, predict and control the behaviour of some of the most important classes of soft materials: polymers, liquid droplets, self-assemblies, colloids, surfactants, and biological membranes.

Recommended Books – see RLO

M4: Energy landscapes and soft matter

Prof. David Wales (6 lectures)and Prof. Robert Jack (6 lectures)

Energy Landscapes

The study of potential energy surfaces, or “energy landscapes”, is of central importance in addressing a wide range of scientific problems in chemical and condensed matter physics. This part of the course will introduce the basic theoretical framework for describing and exploring energy landscapes and will demonstrate how this framework can be exploited to understand the observed structure, thermodynamics, and dynamics of a system.

Several case studies will be considered, illustrating applications to clusters, biomolecules, supercooled liquids, and soft matter systems.

A background of the Part II course *Statistical Mechanics* (B7) will be assumed.

Soft Matter

We give an overview of some important classes of soft materials, including colloids, liquid crystals, and polymers. We focus on three main questions: First, what are the interparticle interactions that control the behaviour of these materials? Second, what is the resulting phase behaviour? Third, what are the relevant time scales (and transport properties)? For the first question, examples include electrostatic interactions, depletion forces, and excluded volume effects. For the second, we focus on colloidal phase behaviour, including colloidal crystals and liquid crystal phases. For the third, examples include homogeneous nucleation and electrokinetic flow.

The course builds on material discussed in the Part II course *Statistical Mechanics* (B7).

Example classes are offered during the course and supervisions may be requested in the Easter term.

Recommended books – see RLO

M5: Stereocontrolled organic synthesis

Dr Pawel Dydio (6 lectures) and Prof. Jonathan Goodman (6 lectures)

Modern organic synthesis plays a key role in providing useful quantities of organic compounds, which include natural products and their structural analogues for biological evaluation, new materials, and molecules with diverse chemical structures and properties.

This course aims to add to your range and understanding of important chemical reactions used in modern synthetic chemistry, with an emphasis on how they can control the stereochemistry, regioselectivity and chemoselectivity. This builds on the Part II A2 course *The Foundations of Organic Synthesis* and considers more challenging synthetic targets (several stereocentres, highly functionalised, multiple rings, etc.), where retrosynthetic analysis combined with efficient synthetic methods are exploited to allow a high level of control in the execution of the synthesis. In addition to A2, it is usual to have done the part II courses B2, B5 and C5 before starting M5. The main emphasis of the first part of this course is to link stereochemistry with retrosynthetic analysis, strategic bond recognition and stereocontrolled reactions (both diastereoselective and enantioselective). Illustrative examples will be given throughout from partial and total syntheses of a variety of natural (and unnatural) products. The course then focusses on the reactivities of

p-block elements and how these can be exploited to design selective transformations. The final section of the course comprises a detailed look at pericyclic reactions.

Topics Part I: strategies for stereocontrol
Controlling and understanding relative and absolute stereochemistry in modern organic synthesis. Diastereoselective reactions of enantiomerically pure starting materials (chiral pool manipulation). Enantioselective synthesis using chiral reagents, substrates and auxiliaries.

Part II: reactions and mechanisms
The use of p-block elements in organic synthesis; Pericyclic reactions and the Woodward-Hoffmann rule.

Recommended books – see RLO

M8: Main group organometallics

Dr Robert Less (6 lectures) and Prof. Andrew Wheatley (6 lectures)

Many main group metallated organic compounds find applications both as large-scale industrial chemicals and as important reagents in organic sytheses. This course will examine in detail the fundamental chemistries of main group organometallics. Modern bonding theories will be used to describe the interactions they form and to explain the diversity of their structures. The extent to which electron counting schemes can rationalise the structures of these molecules will be a common theme.

Students will benefit from having done Part II course *Inorganic I: A1 The heavier transition metals,lanthaniods and actinoids* and should be familiar with Wades's Rules of electron counting as covered in the Part II course *Inorganic II: B0 Electron deficient compounds*

Topics s-block metals – Synthesis, structure and bonding of systems containing s-block metals, especially lithium, with organic ligands. The concepts of 'ring stacking' and 'ring laddering' will be used to rationalise and predict structures. Recent developments in the chemistry of heterobimetallic reagents ('ate complexes) will be introduced. Reactions and selectivity will be discussed, as will techniques for the elucidation of structures in the solid state and also in solution.

p-block metals – The greater covalency in compounds of p-block elements, compared to s-block elements, is manifested in the structures of the organometallics. Particular interest will be devoted to compounds formed from metals in low oxidation states and the unusual structures they form. The bonding and shapes of main group metallocenes are contrasted with those of the d-block, and the ability of p-block metals to act as ligands to transition metals is discussed.

Supervision arrangements: this course will be taught through *examples classes only*.

Recommended books – see RLO

M9: Aromatic heterocycles and medicinal chemistry

Dr Stephanie Smith

It is estimated that 2/3 of all known compounds are aromatic heterocycles: molecules with cyclic delocalised π systems like that of benzene but incorporating one or more heteroatoms such as nitrogen, oxygen or sulfur into the ring in place of carbon. The introduction of such atoms has a significant effect on the reactivity of these molecules, as well as opening the door to a range of synthetic methods, and in this course we will examine some of the rich chemistry of aromatic heterocycles and investigate how such molecules can be synthesised.

Aromatic heterocycles feature strongly in medicinal chemistry, with many top-selling drugs being based on or containing a heteroaromatic ring. The pharmaceutical industry is one of the major employers of organic chemistry graduates, and the last part of this course gives an overview of modern drug discovery, development and production, illustrated with a number of case studies.

This is an organic chemistry course with a strong focus on reaction mechanisms and no prior knowledge of biochemistry is required. Usually, students that do this course will have done the following courses in Part II: A2 *The foundations of organic synthesis;* B5 *Structure and reactivity*; C5: *Control in organic chemistry.*

Topics Structure and reactivity of aromatic heterocycles: pyridines and pyridones, quinolines and isoquinolines, pyrroles, furans, thiophenes and indoles, diazines, diazoles, triazoles and tetrazoles.

Synthesis of aromatic heterocycles.

The drug discovery process: lead identification, drug optimisation, and drug production.

There will also be the chance to hear abour process chemistry through a lecture by Dr Sabine Fenner, currently working in this area at GSK.

Recommended Books – see RLO

M10: Advanced quantum mechanics

Prof. Alex Thom

This course introduces modern methods for treating the correlated many-electron problem beyond the approaches encountered in earlier courses. Second quantisation provides a common language for representing many-electron states and operators, and for developing specialised methods which introduce electron correlation systematically, ranging from configuration-space and stochastic sampling approaches to real-space wavefunction methods. Methods to calculate excited electronic states are introduced. The mathematical foundations of density-functional theory are explored in greater depth, including the adiabatic connection. Finally, quantum computation is introduced as a new framework for representing many-electron states and operators on qubits, manipulating them with quantum circuits, and solving both ground- and excited-state electronic-structure problems.

Topics Second quantisation and occupation-number representations; electron correlation; configuration interaction and selected configuration spaces; determinant-space and real-space Quantum Monte Carlo methods; reduced density matrices; strongly correlated and multireference problems; excited states, including time-dependent Hartree–Fock and equation-of-motion coupled-cluster methods; mathematical foundations of density-functional theory, Hohenberg–Kohn and Kohn–Sham theory, exchange-correlation and the adiabatic connection; qubits and quantum states; fermionic operators on qubits; quantum gates and circuits; variational quantum algorithms, quantum sampling and subspace methods; quantum phase estimation.

Recommended books – see RLO

6 Lecture synopses: Lent Term – Interdisciplinary courses

Part III Chemists are permitted to take up to *two* of these interdisciplinary courses, substituting them for the Lent Term chemistry courses.

I1: Atmospheric chemistry and global change

This course is hosted by and based in the Department of Chemistry.

Prof. Chiara Giorio (12 lectures) and guest lecturers (2 lectures)

This course examines global change from the perspective of atmospheric composition and its relationship to the climate system. Issues covered include the fundamental photochemical and dynamical processes which control atmospheric composition and structure, and how they would differ in a modified climate. The course is designed to complement the material covered in Course I2 *The Earth System and Climate Change* although either course can be taken independently. The course will be lectured and examined in a way that assumes no prior knowledge for those taking the course.

Core lectures (12)

Atmospheric composition and structure. Stratospheric and tropospheric chemical processes.

Major stratospheric catalytic cycles of NOx, HOx, ClOx and BrOx. Ozone depletion in the Antarctic (ozone hole), Arctic and middle latitudes. Future O_3 trends.

Tropospheric ozone and tropospheric oxidation processes, including the importance of the OH radical. The ozone balance - the role of NOx and hydrocarbons.

Greenhouse gases. Radiative balance. Climate change and the links between atmospheric chemistry and climate.

Atmospheric aerosols, their physical and chemical properties, and their influence on the Earth's climate through aerosol-radiation interactions and aerosol-cloud interactions.

Ice cores and their role in understanding atmospheric composition, climate forcing, and future climate/air quality linkages

Guest lectures (2)

Prof Michael Herzog: "Aerosol Effects on Climate: too cool to be true?"

Dr Ahmad Elabbar: "History and Philosophy of Climate Science"

Recommended books – see Reading Lists Online (RLO)

R. P. Wayne, *Chemistry of Atmospheres*, Third Edition (2006), OUP. [QC879.6.W39]

G. P. Brasseur, J. J. Orlando and G. S. Tyndall, *Atmospheric Chemistry and Global Change*, (1999), OUP. [QC879.6.A86]

T. E. Graedel and P. J. Crutzen, *Atmospheric Change - An Earth System Perspective*, (1993) W. H. Freeman and Co (New York). [QC981.8.G73]

J. H. Seinfeld and S. N. Pandis, *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change,* 2nd Edition, (2006) Wiley. [QC879.6.S45]

B. J. Finlayson-Pitts and J. N. Pitts, *Jr Chemistry of the upper and lower atmosphere*, Academic Press. [QC879.6.F56]

D. J. Jacob, *Introduction to Atmospheric Chemistry*, (1999) Princeton University Press. [QC879.6.J33]

R. T. Pierrehumbert, *Principles of planetary climate,* (2010) Cambridge University Press. [QB603.A85.P54]

U. Lohmann, F. Ĺúond and
F. Mahrt, *An Introduction to Clouds: From the Microscale to Climate,* (2016) Cambridge University Press.
https://www.cambridge.org/core/books/an-introduction-to-clouds/F5A8096E7A3BD5C8FFD9208248DD1839
J. T. Houghton, *Global warming, the complete briefing*, (2004), CUP. [QC981.8.G56.H68]
International Panel on Climate Change, Climate Change 2021: The Physical Science Basis,
https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/

I2: The Earth System and Climate Change: from Past to Future

This course is hosted by and based in the Department of Earth Sciences.

Course coordinator: Prof. Luke Skinner

This course will assume a knowledge of Part IA NST Earth Sciences

Students who have had no prior Earth Science education are welcome to contact the lecturer for reading and background material before the course starts.

This course aims to provide a long-term 'systems perspective' on future climate change. The course is broken up broadly into three parts that provide:

1. some background on 'big climate questions' that emerge when considering the 'continuum' of climate variability that is expressed in the record of past climate change
2. an overview of Earth's key climate components, with a focus on their role in abrupt climate transitions
3. case studies in past climate change, that illustrate both fast- and slow dynamics in the Earth's climate system

The course builds towards a long view on Earth's future climate, drawing on the lessons that we can learn from the past.

Course structure: 12 lectures, with supervisions available during the course and additional revision sessions in Easter term.

Examination: One 2-hour exam that will include a compulsory 1-hour 'short answer' section, and a 1-hour essay question selected from a choice of two.

I3: Materials, electronics and renewable energy

This course is hosted by and based in the Department of Physics. Lectures will be at 12:15 to allow for travelling time from other departments.

Prof. Akshay Rao

This interdisciplinary course looks at the physical concepts and challenges concerning energy generation, storage and use. The course aims to develop knowledge of the basic physical principles governing renewable energy materials and devices. It will develop skills in using simple quantitative estimates for a wide range of renewable energy problems to give a fact-based approach to energy questions.

Only IA-level physics is a prerequisite; those who have experience of solid-state physics will find some parts of the course more straightforward, but the material will be taught and examined such that no prior knowledge in this area is required.

> **Energy requirements and energy use** Energy cost of transport of people and freight. Exergy and exergy efficiency. Lighting. Computing.
>
> **Alternatives to fossil fuels** Intro to the science of climate change. Availability of renewable energy. nuclear, wind, geothermal, solar, wave, tide — scale required. Energy density: Petrol, coal, biofuel, hydro, nuclear.
>
> **Energy Transmission** AC *vs* DC electricity. Pipelines. Heat engines, heat pumps, ACs.
>
> **Semiconductor Crash Course** Semiconductor electronic structure. Tight-binding band structure. Optical properties (direct and indirect gaps, excitons). Interaction with light. Excitons. Electrons and holes. Doping.

Solar Energy–1: How nature powers the biosphere Structure and optoelectronic operation. Charge separation and recombination. Efficiency. Solar Fuels including hydrogen

Solar Energy–2: Manufactured solutions Solar concentration. Solar thermal. The p-n junction. PV devices operation.

Solar Energy–3: Next generation technologies Electrical properties; silicon, III-V semiconductors, 2D semiconductors and heterostructures. Si, Perovskites, III-Vs. Tandems, MEG etc.

Electrochemistry Crash Course Galvanic cells and electrodes. Half and full cell reactions. Charge transport. Potentials and thermodynamics — relationship to structure.

Energy Storage–1 Requirements and specifications. Metrics – energy density, power density, rate capacity. Fly wheels, pumped, electrochemical, chemical and comparison with fossil fuels and back of the envelope calculations.

Energy Storage—2 Electrochemical energy storage. Batteries – lead acid, Li-ion and beyond. Supercapacitors.

Energy Storage–3 Fuel cells. principles of operation, materials challenges. Hydrogen storage, materials challenges. Hydrogen vs. electric vehicles.

Recommended books

Sustainable Energy – Without the Hot Air, Mackay D. J. C. UIT : Cambridge (2009) [TJ808.M33]
Solar energy: fundamentals, technology and systems, Jager K. D. : UIT, 2016 [Online Electronic Legal Deposit only]
Molecular Mechanisms of Photosynthesis, Blankenship R. E. Blackwell Science (2002) [QK882.B53]
Modern Batteries, Colin Vincent and Bruno Scrosati, Arnold, 2nd Edition (1997)

7 Lecture synopses: Lent Term – Chemistry courses

L1: Catalysis in synthesis

Prof. Robert Phipps

This course introduces the important role of catalysis in organic synthesis. The first half will deal with transition metal catalysis and will cover fundamental mechanisms of transition metal complexes and conceptually relevant stoichiometric advances before moving onto the main body of the material dealing with cross-coupling reactions and metathesis processes. The second part will introduce enantioselective catalysis and will cover topics such as enantioselective oxidation and reduction of simple organic molecules, C–C bond forming reactions with chiral Lewis acid catalysis as well as covering more recent advances in organocatalysis. A specific objective of this course is to illustrate how concepts in asymmetric and transition metal catalysis can be routinely applied to construct natural products and medicinal compounds.

Recommended books – see Reading Lists Online (RLO)

L3: Electronic structure of solid surfaces

Dr David Madden

The surface of a solid material is of crucial importance in its interaction with the outside world. This is the location where molecules from the surrounding gas or liquid can modify the chemistry of the solid (e.g. corrosion) and equally where the solid can influence the chemistry of external molecules (e.g. catalysis). Furthermore, the physical properties of solid surfaces are often rather different from those of the parent bulk material (e.g. surface–localised electronic or magnetic phenomena) and these differences can often be critical in a variety of practical applications.

This course will examine the nature of solid surfaces, with a particular focus on their electronic structure. Not only will it cover the inherent electronic properties of surfaces themselves, but it will also describe the chemisorption of atoms and molecules via ionic and covalent interactions. A variety of experimental techniques capable of probing surface electronic structure will also be discussed.

Topics Surfaces of face–centred cubic and body–centred cubic materials
Friedel oscillations, surface dipole and work function
Ultra-violet Photoemission Spectroscopy (UPS); X–ray Photoemission Spectroscopy (XPS)
Inverse Photoemission Spectroscopy (IPES); Auger Electron Spectroscopy (AES)
Near–Edge X–ray Absorption Fine Structure (NEXAFS)
Frontier–Orbital description of chemisorption: ionic and covalent adsorption
Surface–localised electronic states: Shockley, Tamm and Image states
Scattering of Shockley states from surface steps
Itinerant ferromagnetism in bulk solids and at their surfaces
Surface-enhanced and surface–induced ferromagnetism
Adsorbate-induced quenching of ferromagnetism

Recommended books – see RLO

L4: Synthetic biology

Dr Mateo Sanchez

Physicist and Nobel Laureate Richard Feynman is quoted as saying “what I cannot create, I do not understand,” which encapsulates a fundamental and philosophical cornerstone of Synthetic Biology.

The overarching goal of this course will be to explain the engineering principles used to modify or create molecular systems with altered properties and living organisms with novel functions.

The course will begin with an introduction from a chemical perspective regarding the molecular mechanisms underlying different techniques to assemble DNA, from traditional approaches based on restriction enzymes, to isothermal assembly, or CRISPR-Cas9 methods. The basics regarding DNA transcription and translation in prokaryotes in eukaryotes will also be explained, followed by more advanced lectures related to orthogonal transcription and translation. In these lectures, there will be a focus on the expansion of genetic code, the total synthesis of genomes, and the development of engineered polymerases to create non-natural nucleic acids. Finally, different methods in protein engineering such as directed evolution and its applications in biosensors or catalysis will be discussed, and how they have transformed different fields ranging from asymmetric synthesis to neuroscience.

While it is not a fundamental prerequisite, students will find it very useful if they have previously completed Part II courses: B3 (Enzymes), C4 (Proteins) and C9 (Nucleic acids)

Recommended books – see RLO

L5: Solid electrolytes

Prof. Stephen Elliott (6 lectures) and Dr Sergei Taraskin (6 lectures)

This course is concerned with the motion of ions through solids, and it builds upon material given in the IB course *Electronic Structure and Properties of Solids*.

Ions can move between sites only in defective solids: an introduction is therefore given of the types of disorder and the nature of defects that can occur in solids. A detailed description will be given of various aspects of ionic motion in solids: this relates to topics such as percolation, random walks on lattices, phase transformations, fractals etc. Experimental techniques for obtaining information about ionic transport in materials, such as electrical conductivity, radioactive-tracer diffusion, NMR and quasielastic neutron scattering, will be introduced. Finally, a discussion will be given of the various applications of ionically-conducting materials, including solid-state batteries, ion sensors and fuel cells.

Topics Structure of crystalline and disordered materials. Models and behaviour of defects in solids. The basics of diffusion. Examples of fast ion conductors: structure and transport properties. Models of ionic motion in solid electrolytes. Linear response theory: conductivity and diffusion. Lattice models for diffusion: mean-field approaches. Experimental probes of ionic diffusion. A.C. conductivity and percolation. Applications of solid electrolytes.

Recommended books – see RLO

L6: Supramolecular chemistry and self-organisation

Prof. Jonathan Nitschke

Physical laws can direct the flow of matter toward a more organised state. One particular strand of matter that began to organise itself chemically over 3 billion years ago started down the road to Darwinian evolution, eventually leading to the emergence of multicellular organisms such as the one reading this text. This course covers fundamental aspects and selected recent advances in the broad area of synthetic self-organising chemical systems and supramolecular chemistry.

Prerequisites include a good working knowledge of basic organic chemistry and coordination chemistry, as well as NMR spectroscopy.

1–6 **Fundamentals.** Thinking "beyond the molecule" – the sense behind "supramolecular". Thermodynamics and equilibria. Structural and spectroscopic characterisation methods for large and complex architectures. Non-covalent interactions: hydrogen bonding, metal-ligand, aromatic ($\pi - \pi$), cation – π, van der Waals, donor–acceptor. Dynamic covalent linkages. Building blocks, host-guest chemistry. Dynamic combinatorial chemistry

7–12 **Complexity and Function.** Molecular topology and entanglements. Molecular machines, energy transduction. Molecular switches and sensors. Maxwell's Demon, summoned. Reactions within container molecules and supramolecular catalysis. Self-replication. Supramolecular polymers. The emergence of complexity. The interface with biology.

Recommended books – see RLO

L7: Machine learning in atomistic simulation

Dr Fabian Berger (6 lectures) and Prof. Gábor Csányi (6 lectures)

This is an incredibly exciting time for theoretical chemistry, particularly for the simulation of complex condensed-phase materials, liquids, interfaces, and reactions. First-principles methods now enable accurate predictions across a wide range of chemical systems, providing valuable insights for experiments and, in many cases, driving experimental innovation. Their application is limited by the comparatively large computational expense. Over the past decade, that limitation has been lifted by machine learning interatomic potentials (or force fields). This course will provide an overview of the current state of the art in using machine learning for first principles atomistic simulations. We will cover modern approaches to representing the Born–Oppenheimer potential energy surface (PES), and how they are used to accelerate simulations of thousands of atoms (many nanometers of length scale) for millions of time steps (many nanoseconds), bringing significantly more realism to computer simulations than was possible before. Reaching these length and time scales enables the study of solvated reactions, electrochemical interfaces, heterogeneous catalysis, evolution of materials under operando conditions.

Required Part II course: *Statistical Mechanics* (B7).

Topics

- Descriptors for representing chemical environments
- Machine learning models for PES construction
- Incorporation of physical information into models
- Techniques for generating representative reference data, active learning
- Linear models, Gaussian processes, neural networks, message passing
- Short range and long range electrostatic models

- Reaction and materials discovery

Recommended books – see RLO

L8: Total synthesis

Prof. Matthew Gaunt

This course will deal with strategy and design in the total synthesis of natural products and medicines. The lectures will draw together the principles of many of the other synthetic chemistry lecture courses to illustrate how they can be combined in complex molecules applications.

The course will take a concept driven approach to how complex molecules can be synthesised, addressing aspects of chemical reactivity, catalysis, ring forming reactions, protecting groups, inter- and intramolecular reactions, tandem and cascade processes, and multi-component reactions. These topics will be illustrated with real examples of total synthesis. A key aim of this course will be to teach the design principles that underpin the synthesis of complex molecules.

Previous course requirements. All Part II and Michaelmas term Part III synthetic chemistry courses would be helpful.

Recommended books – see RLO

L9: Bio-orthogonal and site-specific chemistry for biology and medicine

Dr Michael Geeson (6 lectures) and Dr Unnikrishnan V.B (6 lectures)

Our understanding of biological processes at the molecular level is developing at an unprecedented rate. Advances in genomics and proteomics, coupled with a rapid increase in the amount of structural information about proteins, are providing a wealth of information about the interaction between a protein and its ligand. In this course we will use some key biological systems to explain ideas about the interplay between structure, function and inhibition in chemical biology. We will also highlight chemical strategies that allow for site-selective protein modification [1] and how these are being used to provide biological insight and for the construction of protein conjugates for therapeutics [2].

In the second part we pivot to bioorthogonal chemistry: reactions that form or cleave bonds inside living cells without disturbing native biology [3, 4]. We explore bond-forming ligations for precise labelling, imaging, and capture [5], alongside bond-cleavage strategies that unlock function on demand, enabling controlled activation of probes and therapeutics with spatial and temporal precision [6]. Emphasis will be on practical design principles such as chemoselectivity, kinetics at low concentration, handle stability and biocompatibility, and how these govern success in real biological settings. Case studies will show how bioorthogonal tools reveal mechanism, map interactions, and build advanced protein conjugates for research and medicine. We will also connect to enabling platforms (e.g., site-selective installation of reactive handles and engineered delivery systems) to illustrate how chemistry can be programmed to ask and answer pressing questions in living cells.

While it is not a fundamental prerequisite, students will find it very useful if they have previously completed Part II courses: B3 (Enzymes), C4 (Proteins) and C9 (Nucleic acids)

1. Site-selective protein-modification chemistry for basic biology and drug development, Krall N; da Cruz FP; Boutureira O; Bernardes GJL, Nat. Chem. **2016**, 8, 103–113.
2. Antibody-drug conjugates come of age in oncology. Dumontet C, Reichert JM, Senter PD, Lambert JM, Beck A. Nat Rev Drug Discov. **2023**, 22, 641-661.

3 Scientific Background: Click chemistry and bioorthogonal chemistry. The Royal Swedish Academy of Sciences. **2022**: historical context and foundational concepts behind the 2022 Nobel Prize.

4 Bioorthogonal chemistry. Scinto, S. L.; Bilodeau, D. A.; Hincapie, R. et al. *Nat. Rev. Methods Primers*, **2021**, 1, 30.

5 Bioorthogonal Chemistry: Fishing for Selectivity in a Sea of Functionality. Sletten, E. M.; Bertozzi, C. R. *Angew. Chem., Int. Ed.* **2009**, 48, 6974– 6998.

6 Unleashing the Power of Bond Cleavage Chemistry in Living Systems. Wang, J.; Wang, X.; Fan, X.; Chen, P. R. *ACS Cent. Sci.* **2021,** 7, 929– 943

Recommended books – see RLO

8 Research project

Duration and pattern of work

You may start work on your project at the beginning of the Michaelmas Term, although it will of course be up to your supervisor to set the programme of work. You may not start any experimental work until you have attended the Departmental safety talk.

The number of hours that you will need to be in the laboratory working on your project will depend on the nature of the research you are doing – some projects will require most of the time to be spent 'at the bench', while others may involve devoting significant amounts of time learning background theory or mastering new skills. You may find that the pattern of work is uneven, too: for example, you may have an very intensive period of taking data, followed by a longer period of digesting and analysing you measurements. You may also find that at times your progress is held up while you wait for equipment or analytical services. You will need to be flexible in your approach.

We expect that most mornings you will have several lectures to attend, and as a result although you may have the odd hour to devote to your project, it will not be possible to get down to concentrated work. The main work on the project will therefore be in the afternoons, and as a norm we suggest that you devote about four afternoons per week to your project.

You will have work for supervisions to prepare and supervisions to attend. This, along with attendance at lectures, should take priority over work on your project.

Supervision and safe working

Your supervisor will be the member of the academic staff in whose group you are working and he or she will be responsible for the direction of your work and for ensuring safe working. The day to day supervision of your work may be delegated to another member of the research group.

If you have any doubt about how to proceed or about the safety of any experimental procedure you should stop work immediately and seek advice from your supervisor. It is your responsibility to ensure that you comply with any safety instructions given and follow the procedures set out for you. Safety is your responsibility.

Laboratory hours

Normal working hours are 09:00 – 17:00, weekdays *during Full Term*. You may undertake experimental work outside these hours only in exceptional circumstances determined by your supervisor. Work outside these normal hours you must be under the continuous and direct supervision of your supervisor or another senior person delegated by him or her.

Experimental work during the Christmas and Easter vacations is *expressly forbidden*. The only exception to this is where work during the term has been significantly disrupted, in which case permission may be given for limited work during the vacation. You project supervisor should contact the Director of Teaching to arrange this.

Assessment

The dissertation will only count 35% towards your final mark. You should bear this in mind when allocating your time between the project, lectures, supervision work and so on.

The project will be assessed not on the basis of the results you obtain, but on your input to and commitment to the project, the progress you have made and how much you have contributed to this, the analysis and presentation of you work. Details of the assessment procedure is given below.

Monitoring progress

Your supervisor will be responsible for monitoring your progress. If, however, you feel concerned about your progress you should not hesitate to contact your Director of Studies, the Director of Teaching or the members of staff designated to oversee projects in your area (Inorganic: Dr Sally Boss; Organic: Dr Bill Nolan; Physical: Dr James Keeler). It is particularly important that you do not spend too much time on the project, and if you feel that you are being pressurized into doing this you should seek advice.

Presentation of the dissertation

The dissertation should not exceed 5000 words in length, excluding the abstract, figure captions, footnotes, table of contents, references and acknowledgements; experimental details are, for these purposes, classified as footnotes.

The dissertation should be typed or word processed and sufficient margins should be used such that the text is easily readable i.e. it does not get lost into the binding edge. The dissertation should either be spiral bound or bound in a soft cover; loose-leaf or ring binders are not acceptable.

The dissertation should have (in this order): a title page, the signed declaration (see below), acknowledgements, a one-page summary of the dissertation (an abstract), a table of contents. The main text then follows. You may place literature references at the end of each chapter or at the end of the main text.

Figures, tables and schemes should be numbered so that they can be referred to easily; it is usual to give captions to figures. References should be indicated by superscript numerals or numerals in brackets. Pages should be numbered sequentially.

Your dissertation should contain the following declaration, which you should sign and date in each copy.

This dissertation is submitted in partial fulfilment of the requirements for Part III Chemistry. It describes work carried out in the Department of Chemistry in the Michaelmas Term 2026 and the Lent Term 2027. Unless otherwise indicated, the research described is my own and not the product of collaboration.

What should be in the Dissertation

The details of what to write up and how to go about it vary very much from subject to subject; you supervisor will advise on this. However, in general a dissertation ought to contain:

- An introduction, describing what you set out to do and how this fits into the ‘bigger picture’. You should address the question as to why it was important to work on this topic.
- Some background discussion (perhaps also background theory) setting out the framework in which your work was done, establishing the language you are going to use, and describing the ‘prior art’.
- A description of your work, taking care to make the underlying logic plain, how each experiment was conceived and executed; results and interpretation of results; significance of the results.
- A conclusion, setting out the achievements, their significance, and possibly suggesting directions for future work.

All this needs to be illustrated with appropriate figures, tables and schemes.

Style

Traditionally, scientific papers and theses are written in the impersonal voice e.g. 'an experiment was developed' rather than 'I developed an experiment'. Some people use 'we', but this can irritate after a while if it is used excessively; sparing use of this construction is probably acceptable. Never use I – it sounds vain and pompous. Addressing the reader as 'you' is not appropriate in a dissertation. Generally you should aim for good plain English, avoiding the temptation for jokiness or informality.

You can get a good idea of the usual typographic conventions by looking at papers and books published in the area you are working in. Here is a list of some key points to look out for

1. Chemical formulae are printed in a roman (upright) type face and not in italic e.g. H_2O and not H_2O. The state, if needed, is also given in roman e.g. $H_2O(g)$ and not $H_2O(g)$.

2. In mathematical expressions it is normal to use italic for variables, but a roman type face for the names of functions and numbers e.g. $\sin(2x)$ and not $sin(2x)$ nor $sin(2x)$. The number e and the complex i are numbers and so are set in roman e.g. e^x and $\exp(i\theta)$. In integrals, the variable of integration is indicated with the 'd' in roman e.g. dx and not dx.

3. Units are given in roman e.g. mol dm^{-3} and not *mol* dm^{-3}. Be sure to leave a *space* between the number and the unit, and also leave spaces between each unit e.g. 3.0 s *not* 3.0s; mol dm^{-3} *not* moldm^{-3}.

4. If using exponent notation be careful to set the number out clearly, using spaces and the correct multiplication symbol $\times$ rather than 'x' or 'X' e.g. 3.1×10^{-4} and *not* 3.1E−4 *nor* 3.1x10(−4)

References

It is important to give correct and appropriate references to the scientific literature or published books throughout your dissertation. Generally speaking it is *not* appropriate to cite web sites as a source of information unless these are repositories of information or data maintained by a learned society or other official body; similarly, you should not cite unpublished lecture notes.

Experimental section

An important part of your dissertation is that it should contain sufficient details of how you performed your experiments so as to enable someone else in the field to repeat your work. In synthetic chemistry it is also important to give all of the details as to how you characterised your compounds e.g. NMR data. The conventions as to how these data are presented vary somewhat, but it is common to gather the data together in an 'Experimental Section'.

You should find out what the conventions are in the area in which you are working and then make sure that your dissertation conforms with these conventions. A poor or incomplete experimental section will result in the loss of marks in the assessment.

Diagrams and schemes

Diagrams and schemes should be numbered, and you will probably want to use a short figure caption for the diagrams. All diagrams and schemes *must* be referred to in the text: i.e. you cannot have a 'Fig. 10' to which no reference is ever made in the text.

Modern technology makes it easy to 'rip off' diagrams from books, web pages, papers and other people's dissertations or theses. It is only acceptable to do this *if* you make the source of the diagram entirely clear by making an *explicit statement* to that effect in the caption e.g. 'figure taken from Bloggs 1999' or 'figure taken from reference 9'. It is not sufficient just to give a

reference in the caption – you must state explicitly that the figure is reproduced from that reference.

Ideally, you ought to obtain the author's permission to use the diagram, but as these Part III dissertations are not intended for direct publication it is not necessary – on this occasion – to obtain such permissions. If you are using a diagram from someone currently in your research group, it would be wise to ask permission.

Pay close attention to the legibility of diagrams, especially if they have been scanned in. It is all too common for Part III dissertations to contain diagrams which are essentially unreadable due to poor reproduction, particularly the lettering on scales.

In preparing graphs and tables, pay close attention to the advice you were given in the Part IB and II Physical laboratory. Common pitfalls are: poorly labelled axes, missing units, poorly chosen axes, numbers quoted with excessive precision on either axis labels or tabulated quantities.

Spelling, grammar and proof reading

Do use the spell check facility that comes with the word processing package (most can be set to learn technical words). For each sentence you write you need to ask the question 'does it say what I mean it to say'? Too often, sentences at the first draft are ambiguous and open to several interpretations. In formal writing, it is not usual to use contractions (doesn't, can't, it's etc.).

Ideally, you need two kinds of people to read your work: one who knows what it is about, and so can advise on errors of fact or interpretation; one who does not know too much about the work and so will comment on the quality of the writing.

Please note that you cannot expect your supervisor or members of their research group to comment on multiple drafts of your dissertation. Your supervisor will, however, advise on the content and presentation of your work in broad terms.

Deadline for completion

The deadline for submitting dissertations is the Friday before the start of Easter Full Term i.e. **Friday 23th April**.

You will submit an electronic version of your dissertation to the *Turnitin* system, via Moodle. Details of how this can be done will be circulated nearer the time.

www.plagiarism.admin.cam.ac.uk/turnitin-uk

9 Assessment of projects

The project will be assessed on the basis of your input to and commitment to the work, the progress you have made, and the way in which you present and explain your work, both in written and oral form. There are no specific marks awarded for the results you obtain.

5% of the marks for your project will be awarded upon the production and presentation of a summary of your project in poster format at the start of the Lent term. Further details on the task are given in the next section of the course guide.

25% of the marks for your project will be awarded by your supervisor (in consultation with your day-to-day supervisor, if there is one): these marks are for your commitment, competence and intellectual contribution. They are not related to the written dissertation.

The remaining **70%** of the marks are assigned by one of the Part III Examiners together with another member of staff who is familiar with your area of work. This part of the assessment

focuses on the written thesis **40%** and your presentation and discussion of it in a 40 minute oral examination/interview **30%**

Interviews/oral examination

As part of the assessment process you will be called for an interview (of 40 minutes duration) in which you can expect to give a formal 10-minute presentation on your work and be asked questions about your project, the conclusions you have drawn and the general area. The interview will be conducted by the two people who are assessing your written project.

These interviews are expected to be held in the two week period **Monday 3 May – Friday 14 May 2027**

Details of the marking procedure

The marks are divided up into several categories. In each category, some questions are given which are intended to focus the assessors on relevant issues; these questions are simply indicative and are neither exclusive nor exhaustive. The Examiners may vary the marks awarded in each category:

Marks awarded for production and presentation of a Part III poster (5%)

See the next section for more details about the Poster Presentation

Marks awarded by the project supervisor in consultation with the day-to-day supervisor (25%)

Commitment (10 marks)

Did the student devote an appropriate amount of time to the project?
Were they a willing worker or did they need to be 'chased' by their day-to-day supervisor?
Did they take a wider interest in the work of the group and participate in relevant activities?
Did they take the work seriously?
Did they engage with/seek out relevant literature?

Competence (10 marks)

Did the student have the expected skills on arrival?
How quickly did they learn new skills and techniques?
Were they a safe and reliable worker, or did they need close supervision?
Were they able to interpret their results?
Were they appropriately critical of their results?
Were they able to work out the next steps?

Intellectual contribution (5 marks)

Did the student simply follow the route set out for them or were they able to suggest or develop alternatives?
When there were difficulties, were they able to develop their own solutions?
Were they able to work out possible ways forward to take the project further?

Marks awarded by the two assessors (one of the Examiners and another member of staff) (70%)

Assessment of the dissertation (40%)

The presentation and content of the dissertation (40 marks)

Does the introduction set out the aims of the project?
Is the prior art made clear, with appropriate references?
Is it clear how the present work fits into the bigger scheme?

Is the material organized in an appropriate order that makes the development of the ideas and experiments easy to follow?
Does the writing convey a sense that the student understands the work? Are appropriate conclusions drawn?
Are there appropriate suggestions for future work?

How is the overall 'look' of the dissertation? Has it been well prepared? Are the diagrams and figures of an appropriate standard and used to good effect?
Is the written English clear, grammatical and of a good standard?
Is the description of the experimental work appropriate within the conventions of this kind of work?

Oral examination (30%)

A 40 minute interview structured as follows

Formal 10-minute presentation

Disussion of the project

10 Part III Poster Presentation

Students are required to present a summary of their project in the format of a poster at a **Poster Showcase Event on Thursday 4th February 2027, 5.30pm** (location to be confirmed).

You will create an **A2-sized poster** (portrait or landscape orientation are both acceptable) which you will present to other Part III students, Part II students to help inform their choice of Part III research project preference, as well as academic staff.

The aim of this task is to encourage you to:

a. summarise the work done on your project in the Michaelmas Term (which might also include creating a first draft of your introduction)

b. plan your next project steps for the Lent Term

c. think about how to present your research to other scientists who are not familiar with your work.

Reading the background literature relevant to your project over the vacation is a good use of time as it will be helpful for your work in the Lent Term as well as your dissertation. In addition, any figures you make for the poster may be used again in your report and in your oral examination in the Easter Term.

The way that poster presentation usually works is that you stand by your poster and have a real-time dialogue with interested people individually or as a small group as they begin to look at it. This means you will have ample opportunity to elaborate on the information on your poster in person during the session and to answer any questions from other students or staff on the work you are presenting.

Importantly then, please do not try to include every detail on your poster; you will need to

summarise the main components of your work instead and leave out the parts that you will be able to explain in person.

We really hope that you will find this task both useful and fun in equal measure and will seek your feedback on the task and event once it is finished.

Support

There is some guidance below on producing a poster to a high standard. Professors Boss and Longbottom will also run a session towards the end of the Michaelmas Term (date/time TBC), where they will emphasise the major points given in the guidance and answer any questions you have in addition.

Deadline

Printing deadline: **Tuesday 19th January, 5.00pm**

Please send the file to reprographics@ch.cam.ac.uk for printing.

Event date and time: **Thursday 4th February 2027, 5.30-7.00pm**.

Note: no self-certified one week extensions will be permitted for either component of this activity.

Assessment

The poster will form 5% of your final project mark and you will receive this mark if you make your poster and attend the presentation showcase. If you are not able to produce a poster and/or attend the poster presentation session, you will need to ask your DoS to please inform the Teaching Office, explaining why this is the case (teaching.office@ch.cam.ac.uk).

Making your poster

Posters will be assessed on their technical content and presentation. You should think carefully about the following points when designing your poster:

- Clear, defined layout and structure
- Appropriate technical content for specified audience
- Choice of font size/type
- Amount of material (not too much)
- A professional quality creation (e.g. free from typos)

Before designing your poster on a computer, sketch it out on paper. There should be a clear flow to the poster, and it shouldn't be too full of content. Your poster should contain the following sections:

- **Title**: No more than two lines, should be catchy and encourage people to read your poster
- **Introduction**: Short background about your topic, setting the context
- **Methods**: Describe what you did - images can be useful to enhance this section
- **Results**: Describe your results if you have any to show - graphs and charts can be useful here. Don't worry if you do not have results to present yet, this is not unusual for Part III projects. Instead, you can discuss what you hope to learn from your planned experiments
- **Conclusions**: What will/did you learn, what is its relevance, what is your future research plan?
- **References**: Approximately 5-10 references, quoted correctly and consistently

- **Further information**: Your contact details (normally just email is fine)

When you are ready to make an electronic version, see **Part III Moodle** course for information on how to design a poster using PowerPoint and LaTeX.

Use of AI

Please refer to **Part III Moodle** for the Departmental policy on the use of AI and for the most up-to-date guidance available.

Prizes

There will be a prize for each of the three posters which receive the most votes from participants on the day.

11 Supervision

The arrangements of supervisions is the responsibility of your College, specifically your Director of Studies. However, given the specialized nature of the courses offered in Part III, the lecturers will suggest the names of suitable supervisors. If you require supervisions on a course, you should sign up on any lists provided – do not wait until the course is over before requesting supervisions.

It is not appropriate to have large numbers of supervisions for Part III courses. The relatively small number of people likely to be taking each course should enable the lectures to be more informal in style, giving the opportunity to ask questions and to raise points during or after lectures.

For some popular Part III courses it may be the case that there are insufficient supervisors available. Under these circumstances the lecturer(s) will arrange classes rather than supervisions.

12 Plagiarism

Plagiarism is defined as submitting as one's own work that which derives in part or in its entirety from the work of others without due acknowledgement. It is both poor scholarship and a breach of academic integrity. The University views plagiarism as a serious matter and, under Discipline Regulation 6, has the power to take disciplinary action against those found guilty of plagiarising the work of others.

The general university statement on plagiarism, and further general advice on plagiarism and how to avoid it, is given on the University's plagiarism and good academic practice website www.educationalpolicy.admin.cam.ac.uk/plagiarism-and-academic-misconduct. Generally the Department follows the advice and policies set out by the University. This section gives further guidance as to how these policies apply to study in the Department of Chemistry.

Supervision work and Tripos questions

The majority of questions set as supervision work and in Tripos examinations take the form of problems to be solved. In presenting their solutions to these problems students are not expected to quote the source or authority of the facts, theories and concepts they use to formulate their solutions.

Continuously assessed work (principally practical work)

Here the rules against plagiarism are especially relevant as they prohibit copying and colluding. Basing a write-up on data or answers provided by another student is an example of plagiarism (or, more simply, cheating). The following rules apply to all continuously assessed work

- Unless otherwise instructed, you must work alone. Where you are permitted to work in a group, the names of those you have worked with must be stated on your practical write-up.
- The write-up must be entirely your own work. In particular, you may not use spreadsheets or templates prepared by others.
- It is expressly forbidden to invent, falsify or modify data, spectra or observations, or to use data, spectra or samples obtained from other persons unless authorised to do so by a Senior Demonstrator.
- Where data from other sources is quoted in a write-up, the source must be identified.

Part III project

Students must be particularly mindful of the need to avoid plagiarism when preparing their project report. This means being sure to acknowledge the source of ideas, data and diagrams by a reference given in the accepted form (i.e. to a published book or paper). Where the work has been collaborative, it is important to make clear the extent of the collaboration, and which parts of the work presented in the report are the results of collaboration. The following are all examples of plagiarism in project reports

- Quoting directly another person's language, data or illustrations without clear indication that the authorship is not your own and without giving due acknowledgement of the source.
- Paraphrasing the critical work of others without due acknowledgement – even if you change some words or the order of the words, this is still plagiarism if you are using someone else's original ideas and are not properly acknowledging it.
- Using ideas taken from someone else without reference to the originator.
- Cutting and pasting from the Internet to make a 'pastiche' of online sources.
- Submitting as part of your own project, report or dissertation, someone else's work without identifying clearly who did the work (for example, where research has been contributed by others to a joint project).

Plagiarism can occur in respect to all types of sources and all media:

- not just text, but also illustrations, computer code, experimental results etc;
- not just text published in books and journals, but also downloaded from websites or drawn from other media;
- not just published material but also unpublished works, including lecture handouts and the work of other students.

The following summarizes succinctly the key point:

> *The Golden Rule: The examiners must be in no doubt as to which parts of your work are your own original work, and which are the rightful property of someone else.*

13 Guidance on using GenAI in undergraduate Chemistry studies

Artificial intelligence (AI) encompasses a wide range of sub-specialities with distinct and overlapping research areas, tasks, technologies and applications. Generative AI (GenAI), and specifically a sub-type—Large Language Models (LLMs, including ChatGPT, Claude, CoPilot, and DeepSeek amongst others), have been the subject of debate in higher education institutions as the pros and cons of using software of this type are considered.

Students studying undergraduate chemistry are permitted to make appropriate use of GenAI tools to support their personal study, research and formative work. In some cases, using GenAI can aid your learning very effectively, but much like other aspects of academic practice, you should think about GenAI and related software as options within a wider tool set. GenAI is not, and never will be, an effective replacement for developing skills or understanding in your subject area or bypassing critical thinking processes.

The undergraduate chemistry course at Cambridge has been carefully designed to illustrate the fundamental principles of the subject and lay the foundations for further study of chemistry: the more you engage with the teaching and other resources available to you, the more you will learn and develop as a chemist.

Some important principles to bear in mind when using GenAI tools and websites are as follows:

1. GenAI tools can commonly produce incorrect or unsubstantiated information and as such should always be verified from trusted and reliable sources.
2. Consider thoughtful use of GenAI and associated software where possible, making appropriate use to support your own development, using the most effective tool for the task at hand, and using efficient prompt-engineering to reduce the amount of iteration necessary.
3. Be aware of the limitations, inconsistencies and biases that can exist within GenAI tools and data sets, and exercise caution when deciding to use information provided by software.
4. Be accountable and take responsibility for how, when, and why **you** decide to use generated materials or information from GenAI software. Remember, if you submit something that is GenAI generated and it is wrong, this is not the software's fault. Using GenAI is easy; checking everything is hard.
5. Be aware that there are restrictions on sharing material with restricted copyright (such as lecture handouts, pre-publication research information and other confidential or personal information) with any GenAI tool.
6. Be aware of the environmental impact of your use of GenAI tools and behave accordingly.

14 Examinations

Which papers you sit, and the structure of the papers, depends on whether or not you are taking any interdisciplinary courses.

Arrangements for candidates not taking any interdisciplinary courses

There are three papers set, each of three hours duration.

Paper 1A will contain one question relating to each Part III lecture course; candidates will be required to answer *six* questions. The short questions on this paper will be designed to test the basic understanding of the subject material.

Paper 2 will be divided into as many sections as there are courses given in the Michaelmas Term; each section will contain two questions. Candidates will be required to answer *four* questions, taken from at least *three* different sections. The longer questions on this paper will be designed to test a deeper understanding of the subject material.

Paper 3A will be divided into as many sections as there are courses given in the Lent Term; each section will contain two questions. Candidates will be required to answer *four* questions, taken from at least *three* different sections. The longer questions on this paper will be designed to test a deeper understanding of the subject material.

Each paper is preceded by an extra ten minutes during which you may read the paper, but not write your answers.

Arrangements for candidates taking interdisciplinary courses

If you are taking one or more of the interdisciplinary courses I1, I2 and I3, then special arrangements apply.

1. You are permitted to offer up to *two* interdisciplinary courses.
2. For each interdisciplinary course offered you will sit a 90 minute written paper (the Interdisciplinary Papers, details below) devoted to that course.
3. All candidates must take Paper 2.
4. If you are offering **one** interdisciplinary course then you must also take
   (a) Paper 1B which has the same structure as Paper 1A, but from which you have to answer *five* questions in a time of 2 hours 30 minutes.
   (b) Paper 3B which has the same structure as Paper 3A, but from which you have to answer *three* questions, taken from at least *two* different sections, in a time of 2 hours 15 minutes.
5. If you are offering **two** interdisciplinary courses then you must also take
   (a) Paper 1C which has the same structure as Paper 1A, but from which you have to answer *four* questions in a time of 2 hours.
   (b) Paper 3C which has the same structure as Paper 3A, but from which you have to answer *two* questions, without restriction, in a time of 1 hours 30 minutes.

Interdisciplinary papers

Each interdisciplinary course is examined in a separate paper which lasts for 90 minutes. For course I1 the paper will contain three questions, of which candidates are required to answer two.

When you complete your exam entry form (online via *CamSIS*) you will have to indicate whether or not you wish to take I1, I2 or I3. We appreciate that you are being asked this question before the lectures have been given, so that you cannot answer it sensibly. We recommend that in the first instance you *do not* indicate that you want to take I1, I2 or I3. In the middle of the Lent Term, when you are ready to make a decision, you can change your examination entry to include these interdisciplinary courses, if you so wish. *Please note that only your College Tutorial Office can make such a change on your behalf; the Teaching Office cannot do this.*

Data book and molecular models

In all of the examinations you will be provided with a Data Book (identical to the one you used in Part IB and Part II) which contains a simple Periodic Table, values of physical constants, certain mathematical formulae and definitions and selected character tables. A copy of the Data Book is available at www.ch.cam.ac.uk/teaching/data-book. You may take (unassembled) molecular models into the examinations.

Past papers

Past papers and suggested answers from the past ten years are available from the relevant section of *Moodle* (www.vle.cam.ac.uk).

Timetable for the examinations

Although the Examination timetable will not be announced formally until early in the Easter Term, we expect the papers to be scheduled as follows (all 2027): Paper 2 Wednesday 2nd June, Paper 3 Friday 4th June, and Paper 1 Monday 31st May all 0900–1200 (note the order of the papers). You are given an extra ten minutes to read each of the papers, on account of their complexity. The examination for IDP1 will be held at 1330 on Thursday 3rd June.

We expect that the class list will be posted on Friday 25th June.

Please note that these dates are all provisional and subject to confirmation.

Pass marks and carrying forward marks

The regulations allow the Part III examiners to take into account a candidates performance in Part II from the previous year. In effect, this means that marks will be 'carried forward' from Part II to Part III.

Our expectation is that the Part III examiners will, in the first instance, draw up the class list by combining the Part II and Part III marks with the following weighting:

Part II	15%
Part III Project	35%
Part III Written Papers	50% (i.e. 16.7% for each).

The Examiners may, however, at their discretion alter the weight given to different papers or the dissertation. The final allocation of a class will not simply be done by a mechanical process. Rather, the Examiners will consider each candidate's mark profile and will give particularly careful consideration to candidates who fall on class boundaries or for whom there is a large discrepancy between their Part II and Part III marks, or between the marks on the written papers and on the project.

Please note that to be awarded a pass in the whole examination candidates will need to achieve: (1) a pass mark (40%) in the combined total of the Part III written papers, AND (2) a pass mark (40%) for the dissertation.

Disclosure of examination marks

The marks which are disclosed (via *CamSIS*) are those for each of the papers, a mark for the dissertation, and the final overall total and class. In addition you will be notified separately of your question-by-question marks, and a break down of your marks for the dissertation in the categories listed above.

Senior Examiner

The Senior Examiner for Part III Chemistry in 2026/2027 is Prof. Deborah Longbottom.

15 Chemistry teaching website

You can find up-to-date information on the course and other related matters from the teaching web site: www.ch.cam.ac.uk/teaching.

Lecture handouts and other course materials will be posted in *Moodle*: www.vle.cam.ac.uk. If you find that you do not have access to the Chemistry part of Moodle, please email the Teaching Office on teaching.office@ch.cam.ac.uk.

16 Chemistry Consultative Committee

The Chemistry Consultative Committee consists of representatives of students and academic staff. It meets towards the end of each term and is a forum for the discussion of all aspects of the teaching of Chemistry in the Department. Student representatives are elected during the Michaelmas term; comments and suggestions can be passed on to them so that they can be discussed at the meetings.

The minutes of previous meetings can be found on Moodle and the composition of the committee can be found on the teaching website:

www.ch.cam.ac.uk/committees/consultative-committee

17 The Department of Chemistry Library

www-library.ch.cam.ac.uk

Library, photocopying, printing, scanning and computing

The Chemistry Library is located in the Centre for Molecular Informatics (CMI) building (first floor, beneath the Cybercafe). You can access it between 08:00 and 20:00 (Monday to Friday), 08:00 and 16:00 (Saturdays and Sunday) using your University Card. Please visit the 'Access to the library' website: www-library.ch.cam.ac.uk/access-library for further information.

Books recommended in the Blue Book are either short loan and can be borrowed for four days, or are for reference only. Main loan books can be borrowed for 28 days and are auto-renewed until you return them or someone else requests them from you; short loan books cannot be renewed. You can borrow up to 10 books (incl. max. two short loan books) at a time. All Chemistry books and ebooks are listed on iDiscover, the online catalogue for the libraries of the University: //idiscover.lib.cam.ac.uk There is a dedicated computer in the Library for searching the catalogue. A self-service machine is available for borrowing and returning books.

The Library has four PCs which are hosted on the UMD (University Managed Desktop) network. Print jobs can be sent from these to a MultiFunctional Device (MFD) situated in the small room next to the Library Office. The MFD offers colour printing, photocopying and free scanning. Online payment for printing and photocopying is made through the Common Balance scheme. You can send print jobs to the MFD from your own desktop, laptop, tablet, or phone; there are

instructions for setting this up and information on paying for printing/photocopying at help.uis.cam.ac.uk/service/printing

There are also eight docking solutions you can connect your laptop to, consisting of a 27" monitor, USB and HDMI cables. Additional cables may be borrowed from the Library Office. Wifi and power points are available throughout the Library.

For comprehensive guidance on the library collections (printed and online), services and much more consult the Chemistry Library website at:

www-library.ch.cam.ac.uk

Reading Lists Online (RLO)

The link below gives access to the online reading lists for all the Chemistry courses. They have been compiled to follow the structure of the Course Guides. Each one includes a record of the borrowable items held in the Cambridge University Libraries' collections (including the Chemistry Library) and those accessible as eBook titles.

www-library.ch.cam.ac.uk/reading-lists-online-rlo

18 Further details of the Department

In order to access areas of the Department other than the lecture theatres you will need your University card so that you can pass the turnstiles and various internal doors. You should therefore make it a point to *always* bring your card with you when you come to the Department.

We hope that by the time you arrive you will already have the appropriate access. If you find that your access rights are different to others in your year group, or access suddenly stops, please contact Mifare Admin (mifareadmin@ch.cam.ac.uk).

In general you will *not* have access to research areas other than that needed for your project work; you will need your group leader to request access to appropriate areas.

Your card will give you access to the building from 08:00–20:00 on weekdays and 08:00–16:00 on Saturdays and Sundays. Outside these times you are not permitted to be in the Department unless some specific arrangement has been made. If you remain in the Department after 20:00 you risk becoming trapped by the security doors and/or the turnstiles.

Cybercafé

The Departmental tea room (Cybercafé) is located on the top floor of the Centre for Molecular Informatics Building. Service is available from 09:30 – 15:30. Hot and cold drinks, as well as a selection of snack foods are available. Part III students working in the labs are welcome in the Cybercafé but please bear in mind there is limited space and it is intended for use by the research workers and staff in the Department (the lunchtime periods are especially busy).

19 Part III Chemistry 2026/2027: Titles of lecture courses

	Title	Lecturer(s)
	Michaelmas Term	
M0	Advanced polymer chemistry	Scherman(9), Bronstein (3)
M1	Inorganic materials	Wood
M2	Bio-inorganic chemistry	Barker
M3	Soft matter-from molecules to materials	Knowles (6), Deck (6)
M4	Energy landscapes and soft matter	Wales (6), Jack (6)
M5	Stereocontrolled organic synthesis	Dydio (6), Goodman (6)
M8	Main group organometallics	Less (6), Wheatley (6)
M9	Aromatic heterocycles and medicinal chemistry	Smith
M10	Advanced quantum mechanics	Thom
	Lent Term	
L1	Catalysis in synthesis	Phipps
L3	Electronic structure of solid surfaces	Madden
L4	Synthetic biology	Sanchez
L5	Solid electrolytes	Elliott (6), Taraskin (6)
L6	Supramolecular chemistry and self-organisation	Nitschke
L7	Machine learning in atomistic simulation	Berger (6), Csányi (6)
L8	Total synthesis	Gaunt
L9	Bio-orthogonal and site specific chemistry for biology and medicine	Geeson (6), Unnikrishnan V.B (6)
	Lent Term – Interdisciplinary Couses	
I1	Atmospheric chemistry and global change hosted by the Department of Chemistry	Prof. Chiara Giorio
I2	The Earth System and Climate change hosted by the Department of Earth Sciences	Coordinator: Prof. Luke Skinner
I3	Materials, electronics and renewable energy hosted by the Department of Physics	Prof. Akshay Rao

Part III Chemistry – Michaelmas Term 2026

Wk	Date	Day	09:00	10:00	11:00	12:00	Courses
1	8/10	Th	M1 U		M0 P	M4 P	
	9/10	Fr	M4 W	M5 W	M0 W	M2 P	
	12/10	Mo	M1 W		M0 W	M2 P	M0
	13/10	Tu			M0 P	M4 P	M1
	14/10	We	M1 W	M5 W	M0 W	M2 P	M2
2	15/10	Th	M1 U		M0 P	M4 P	M4
	16/10	Fr	M4 W	M5 W	M0 W	M2 P	M5
	19/10	Mo	M1 W	M5 W	M0 W	M2 P	
	20/10	Tu	M5 SP		M0 P	M4 P	
	21/10	We	M1 W	M5 W	M0 W	M2 P	
3	22/10	Th	M1 U		M0 P	M4 P	
	23/10	Fr	M4 W	M5 W	M0 W	M2 P	
	26/10	Mo	M1 W	M5 W		M2 P	
	27/10	Tu				M4 P	
	28/10	We	M1 W	M5 W		M2 P	
4	29/10	Th	M1 U			M4 P	
	30/10	Fr	M4 W	M5 W		M2 P	
	2/11	Mo	M1 W	M5 W		M2 P	
	3/11	Tu				M4 P	
	4/11	We	M1 W	M5 W		M2 P	
5	5/11	Th				M8 P	M3
	6/11	Fr	M8 W	M3 W	M9 W	M10 W	M8
	9/11	Mo		M3 W	M9 W	M10 W	M9
	10/11	Tu	M8 SP				M10
	11/11	We		M3 W	M9 W	M10 W	
6	12/11	Th				M8 P	
	13/11	Fr	M8 W		M9 W	M10 W	
	16/11	Mo		M3 W	M9 W	M10 W	
	17/11	Tu	M8 SP			M3 P	
	18/11	We		M3 W	M9 W	M10 W	
7	19/11	Th				M8 P	
	20/11	Fr	M8 W		M9 W	M10 W	
	23/11	Mo		M3 W	M9 W	M10 W	
	24/11	Tu	M8 SP			M3 P	
	25/11	We		M3 W	M9 W	M10 W	
8	26/11	Th				M8 P	
	27/11	Fr	M8 W	M3 W	M9 W	M10 W	
	30/11	Mo		M3 W	M9 W	M10 W	
	1/12	Tu	M8 SP			*additional, non-examinable	
	2/12	We		M3 W	M9 W	M10 W	

SP = Scott Polar LT; U = Unilever LT; W = Wolfson LT; P = Pfizer LT; TH = Todd-Hamied

Please note that the lectures are not always in a regular pattern – check times and dates carefully

Part III Chemistry – Lent Term 2027

Wk	Date	Day	09:00		10:00		11:00		12:00		Courses
1	21/1	Th	I1	U	I2						L1
	22/1	Fr	L1	W	L5	W	L3	W	L4	W	L3
	25/1	Mo	L1	W	L5	W	L3	W	L4	W	L4
	26/1	Tu	I1	SP	I2						L5
	27/1	We	L1	W	L5	W	L3	W	L4	W	
2	28/1	Th	I1	U	I2						
	29/1	Fr	L1	W	L5	W	L3	W	L4	W	
	1/2	Mo	L1	W	L5	W	L3	W	L4	W	
	2/2	Tu	I1	SP	I2				I3		
	3/2	We	L1	W	L5	W	L3	W	L4	W	
3	4/2	Th	I1	U	I2				I3		
	5/2	Fr	L1	W	L5	W	L3	W	L4	W	L7 2 pm/W
	8/2	Mo	L1	W	L5	W	L3	W	L4	W	L7 2 pm/W
	9/2	Tu	I1	SP	I2				I3		
	10/2	We	L1	W	L5	W	L3	W	L4	W	L7 2 pm/W
4	11/2	Th	I1	U	I2				I3		
	12/2	Fr	L1	W	L5	W	L3	W	L4	W	L7 2 pm/W
	15/2	Mo	L1	W	L5	W	L3	W	L4	W	L7 2 pm/W
	16/2	Tu	I1	SP	I2				I3		
	17/2	We	L1	W	L5	W	L3	W	L4	W	L7 2 pm/W
5	18/2	Th	I1	U	I2				I3		
	19/2	Fr	L7	W	L6	W	L8	W	L9	W	
	22/2	Mo	L7	W	L6	W	L8	W	L9	W	
	23/2	Tu	I1	SP	I2				I3		
	24/2	We	L7	W	L6	W	L8	W	L9	W	
6	25/2	Th	I1	U	I2				I3		
	26/2	Fr	L7	W	L6	W	L8	W	L9	W	L6
	1/3	Mo	L7	W	L6	W	L8	W	L9	W	L7
	2/3	Tu	I1	SP	I2				I3		L8
	3/3	We	L7	W	L6	W	L8	W	L9	W	L9
7	4/3	Th	I1	U	I2				I3		
	5/3	Fr			L6	W	L8	W	L9	W	
	8/3	Mo			L6	W	L8	W	L9	W	
	9/3	Tu	I1	SP	I2				I3		
	10/3	We			L6	W	L8	W	L9	W	
8	11/3	Th	I1		I2				I3		
	12/3	Fr			L6	W	L8	W	L9	W	
	15/3	Mo			L6	W	L8	W	L9	W	
	16/3	Tu	I1		I2						
	17/3	We			L6	W	L8	W	L9	W	

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