# CH166-15 Molecules and Materials across the Periodic Table

## 24/25

**Department**
Chemistry
**Level**
Undergraduate Level 1
**Module leader**
Paolo Coppo
**Credit value**
15
**Module duration**
10 weeks
**Assessment**
100% exam
**Study location**
University of Warwick main campus, Coventry

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## Description

## Introductory description

The module aims to build on prior knowledge, acquired by students in term 1 and apply concepts to molecules and more complex structures in the form of real world materials.

Module web page

## Module aims

The module aims to provide students with the necessary tools to understand the structure and properties of molecules as a function of atomic properties, bonding and geometry, as well as the structure and function of crystalline materials and soft matter.

## Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Topic A: Periodicity and Main Group Chemistry

We will start by revising periodic trends introduced in Term 1 and extend this to trends in oxidation states across the whole Periodic Table: main group, transition metals, and f-block, including the ‘lanthanide contraction’, the ‘inert pair effect’ and the hard-soft model for Lewis acids. Descriptive chemistry of the main-group elements will be presented, showing how knowledge of electronic configuration can explain oxidation states, bond strengths, coordination number and reactivity of compounds. The emphasis will be on using the fundamental principles and not learning sets of compounds.

Topic B: Solid-State Structures and Materials
Solid-state structures will be considered using the ideas of sphere packing and filling of holes. Methods for calculating lattice enthalpy will be developed and used to test the ionic model and explain stability and solubility of salts. Ways of drawing three-dimensional structure will be introduced and distances within structures calculated. Metals, alloys and related phases will be described.

Topic C: Transition-Metal Complexes
Bonding in transition-metal complexes will be introduced, building on the concepts of MO theory to show coordination numbers and molecular shape depend on d-electron configuration. CFSE stabilisation will be introduced and used to rationalise electronic configurations (high / low spin) to explain properties such as magnetism, colour and ligand exchange. Distortions of molecular geometry from the ideal shapes will be introduced. Introduction of common types of neutral donor ligands.

Topic D: Macromolecules and Soft Materials
The topic of polymer chemistry will be introduced, starting from concepts of synthesis introducing concepts of structure and bonding, leading to properties that contrast those of solid-state materials. This will include polyalkenes, polyesters and polyurethanes. Real-world examples will be brought in from everyday uses of polymers to illustrate the concepts, and experimental techniques for understanding structure will be introduced.

## Learning outcomes

By the end of the module, students should be able to:

- Demonstrate an understanding of chemistry of an element in relation to its position in the Periodic Table
- To make predictions about the stability and reactivity of elements and their compounds
- Show an appreciation of periodic trends, both across a period and down a group, and use these to rationalise compositions and structures of observed compounds
- Understand and draw unit cells of simple crystalline materials, and use them to calculate atom-atom distances
- Understand the crystal structure of metals, alloys and ionic solids
- Use lattice enthalpies to predict decomposition and solubilities
- Understand how bulk properties of solids are derived from crystal structure
- Understand interaction of d-orbitals with ligands (sigma-only) in transition-metal complexes
- Account for number of unpaired electrons in a transition-metal complex
- Explain magnetic and electronic properties of transition-metal complexes
- Account for distortions of transition-metal complexes from regular geometry depending on

their electronic configuration
- Appreciate bonding and bond strength and the role of metal complexes in optimising catalytic synthesis of polymers
- Understand the concepts of the synthesis, structure and bonding in synthetic organic polymers.
- Appreciate properties of synthetic polymers that contrast those of solid-state materials, including polyalkenes, polyesters and polyurethanes.
- Appreciate experimental techniques for understanding structure of organic polymers and soft materials
- Appreciate how chemical industry has changed the material world that we live in
- Understand how bonding, packing, molecular properties and crystallisation affect macroscopic material properties, from solid-state materials to macromolecules
- Appreciate how the properties and applications of everyday substances and materials found in Nature arise from fundamental chemical principles of structure and bonding

## Indicative reading list

TBC

## Subject specific skills

Understanding of the properties of elements as a function of their place in the periodic table. Reinforcement of the ideas of bonding, including metallic and ionic bonding. The unit cell and crystals. Energetics and defects of solids. Transition metals and complexes as a function of d-orbital population. Magnetic and spectroscopic properties of TM complexes and materials. Properties of macromolecules as a function of their structure. Emphasis throughout on real-world examples arising from these fundamental principles.

## Transferable skills

Problem solving. Geometry and Maths in the real world. Team work via the use of problem based workshops and tutorials.

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## Study

## Study time

| Type | Required |
|---|---|
| Lectures | 30 sessions of 1 hour (20%) |
| Tutorials | 3 sessions of 1 hour (2%) |
| Practical classes | 3 sessions of 1 hour (2%) |
| Total | 150 hours |

| Type | Required |
| --- | --- |
| Private study | 114 hours (76%) |
| Total | 150 hours |

## Private study description

N/A

## Costs

No further costs have been identified for this module.

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## Assessment

You must pass all assessment components to pass the module.

### Assessment group B1

| | Weighting | Study time | Eligible for self-certification |
| --- | --- | --- | --- |
| Written examination | 100% | | No |

- Answerbook Green (8 page)
- Students may use a calculator
- Periodic Tables

### Feedback on assessment

Cohort level examination feedback provided via Moodle following the Exam Board.

Past exam papers for CH166

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## Availability

## Courses

This module is Core for:

- UCHA-4 Undergraduate Chemistry (with Intercalated Year) Variants
  - Year 1 of F101 Chemistry (with Intercalated Year)
  - Year 1 of F122 Chemistry with Medicinal Chemistry (with Intercalated Year)
- UCHA-3 Undergraduate Chemistry 3 Year Variants
  - Year 1 of F100 Chemistry

    - Year 1 of F121 Chemistry with Medicinal Chemistry
- UCHA-F110 Undergraduate Master of Chemistry (with Industrial Placement)
    - Year 1 of F100 Chemistry
    - Year 1 of F110 MChem Chemistry (with Industrial Placement)
    - Year 1 of F112 MChem Chemistry with Medicinal Chemistry with Industrial Placement
- Year 1 of UCHA-F107 Undergraduate Master of Chemistry (with Intercalated Year)
- UCHA-F109 Undergraduate Master of Chemistry (with International Placement)
    - Year 1 of F109 MChem Chemistry (with International Placement)
    - Year 1 of F111 MChem Chemistry with Medicinal Chemistry (with International Placement)
- UCHA-4M Undergraduate Master of Chemistry Variants
    - Year 1 of F100 Chemistry
    - Year 1 of F105 Chemistry
    - Year 1 of F110 MChem Chemistry (with Industrial Placement)
    - Year 1 of F109 MChem Chemistry (with International Placement)
    - Year 1 of F125 MChem Chemistry with Medicinal Chemistry
- Year 1 of UCHA-F127 Undergraduate Master of Chemistry with Medicinal Chemistry(with Intercalated Year)