

# CH272-15 Materials and Polymers

**20/21**

**Department**

Chemistry

**Level**

Undergraduate Level 2

**Module leader**

David Haddleton

**Credit value**

15

**Module duration**

10 weeks

**Assessment**

20% coursework, 80% exam

**Study location**

University of Warwick main campus, Coventry

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## Description

### Introductory description

N/A.

[Module web page](#)

### Module aims

Materials and Polymers are used in all applications from functional to structural applications. They turn molecules into useful devices and items, or are extended arrays of connected atoms that have unique properties as solids. This module will give students an appreciation of how materials can be made, how they need to be characterised and how macroscopic properties can be designed for use in energy, healthcare, electronics, personal care and other applications.

### 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.

Here follows an illustrative syllabus for each section of the module.

Part 1. Polymers (16 lectures + 4 workshops)

BLOCK 1: Polymer Physics

LECTURE 1: Introduction to the fascinating material features of polymers in the liquid state. Polymer solutions and polymer melts. Introduce the concept of viscosity (and visco-elasticity: the latter by means of a movie to watch as homework).

LECTURE 2: Understand the conformation of a polymer chain in the liquid state. The concepts of end-to-end distance, radius of gyration. A recap of molar mass distributions and the introduction of size exclusion chromatography.

LECTURE 3: Understand the structure of polymers in the solid state. Amorphous and crystalline states. The solid-liquid phase transition. The concept of a glass transition, the concept of crystalline polymers. Note that elastomers/gels/rubbers will only be addressed briefly.

LECTURE 4: Concepts and details of T<sub>g</sub>, crystallinity, XRay (SAXS and WAXS), DSC, DMA  
WORKSHOP 1

BLOCK 2: Step-growth/Condensation Polymerization

LECTURE 5: The underlying chemistry: polyesters, polyamides and polyaramids, polyurethanes, polycarbonates, etc.

LECTURE 6: Conducting polymers and polymers for OPV applications

LECTURE 7: Polymers from renewable sources, problems associated with replacing oil based chemistry, use of carbon dioxide

LECTURE 8: Hyperbranched polymers, dendrimers and gels

WORKSHOP 2

BLOCK 3: Chain-growth/Addition Polymers I

LECTURE 9: The concept of chain-growth/addition polymerization. Free radical, or ionic. Number degree of polymerization. Molar mass distributions in chain-growth polymerizations. The concept of tacticity, NMR.

LECTURE 10: The mechanism of free radical polymerization: initiation (radical generation and first monomer addition), propagation, bimolecular termination, and chain-transfer. Kinetic chain-length. Mayo-Equation

LECTURE 11: Case study: A closer look at a commercially important addition polymer.

LECTURE 12: Free radical copolymerisation

WORKSHOP 3

BLOCK 4: Living Polymerization

LECTURE 13: The concept of living polymerization: control of chain-growth. Its effect on the molar mass distribution and ability to control monomer sequence. Living ionic polymerization.

LECTURE 14: Living ionic ring opening polymerization of ethylene oxide, caprolactone, caprolactam. Group transfer polymerization

LECTURE 15: Case study: a closer look at a commercially important polymer made via living polymerization.

LECTURE 16: Biodegradable polymers for ring opening polymerisation and from fermentation including polymers from lactides, glycolides, etc

WORKSHOP 4

Part 2: Inorganic Materials and Structure Determination (12 lectures + 2 workshops)

Block 5:

Lecture 1: Introduction to Inorganic Materials

Classification of extended structures: ionic, covalent, molecular, polymeric.

Structure-property relationships (examples): nanomaterials, energy, biomaterials, electronics.

Revision of simple ionic structures (from CH160): packing of spheres and radius ratios

## Lecture 2: Transition-metal oxides and polymorphism

Binary and ternary oxides: rutilites, perovskites and spinels.

Prediction of structure type: tolerance factor and CFSE

Polymorphism and crystal structure: introduction to phase transitions

## Lecture 3: Synthesis of Oxide Materials

Solid-state, sol-gel hydrothermal and topochemical methods

Nanostructured metal oxides

## Lecture 4: Crystallography

The unit cell and Bravais Lattice: crystallographic notation

Basic crystal symmetry

Miller planes and distances between planes

## Lecture 5: Diffraction

Basic diffraction theory and the Bragg equation

Measurement of a diffraction pattern and indexing

Systematic absences and introduction to the structure factor

## Lecture 6: Experimental aspects of diffraction

Powder vs single crystal

Neutrons vs X-rays

Synchrotron vs laboratory X-rays

## Workshop 1: Analysis of powder X-ray diffraction

Worked examples (provided in advance) of indexing, determination of unit cell parameter of cubic materials and calculation of distances within a unit cell.

## Lecture 7: Advanced scattering theory

Scattering vectors, momentum transfer, periodicity and phase.

The reciprocal relationship between object and scattered image

Miller indices, scattering vectors and reciprocal space

## Lecture 8: A visual introduction to the mathematics of scattering theory

Sampling of periodic structures – another way to understand the Bragg equation

Fourier transforms explained visually.

Mathematics behind FTs.

Properties of periodic waves: amplitude, frequency and phase

## Lecture 9: Structure factors - a special case of Fourier transforms

Fourier transforms and Fourier synthesis

The phase problem

Lensing and reconstructing the diffracted image.

Understanding systematic absences

## Lecture 10: Small Angle Scattering

Scattering from non-periodic systems

Analysing small angle scattering patterns, determining particle size and shape.

Applications to polymer and soft matter science.

## Lecture 11: Electronic Properties of Transition-Metal Oxides

Revision of band structure

Examples of semiconductors, metals and insulators

Lecture 12: Magnetic Properties of Transition-Metal Oxides

Classification of cooperative magnetic behaviour

Examples of ferromagnetic, antiferromagnets and ferrimagnets

Workshop 2: Applications of Fourier transforms to scattering theory

Worked examples that will allow students to explore the relationship between an object and its scattering pattern.

## **Learning outcomes**

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

- Students should have a conceptual understanding of and be familiar with fundamental principles and approaches to solid-state materials, characterisation methods, and polymer chemistry, as laid out in the syllabus.

## **Indicative reading list**

1. Polymer Chemistry, 2nd Edition by Paul C. Hiemenz and Timothy P. Lodge
2. Polymer Chemistry: An introduction by Malcolm P. Stevens
3. Principles of Polymerization, 4th Edition by George Odian
4. Polymer Physics by Michael Rubinstein and Ralph H. Colby
5. From Polymers to Plastics by A. K. van der Vegt
6. Inorganic Chemistry, Oxford University Press, Sixth Edition: Chapter 24
7. Weller, Inorganic Materials Chemistry
8. Solid State Chemistry: An Introduction, Fourth Edition, Smart and Moore, CRC Press

## **Interdisciplinary**

e.g. co taught with another department or with an industry perspective, bridges two or more disciplinary concepts, ideas, etc.

## **International**

e.g. includes mobility opportunities, explores concepts and ideas in a global context, fosters a global mindset and awareness of diversity, etc.

## **Subject specific skills**

Numeracy

Problem solving

Critical thinking

Teamwork

## **Transferable skills**

Numeracy  
Problem solving  
Critical thinking  
Teamwork

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## Study

### Study time

Type	Required
Lectures	28 sessions of 1 hour (19%)
Practical classes	6 sessions of 1 hour (4%)
Private study	116 hours (77%)
Total	150 hours

### Private study description

Self-Study.

## Costs

No further costs have been identified for this module.

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## Assessment

You do not need to pass all assessment components to pass the module.

### Assessment group D1

	Weighting	Study time
Powerpoint presentation & Team business proposal 4 page Team Business Proposal	20%	
Online Examination	80%	
<ul style="list-style-type: none"><li>• Answerbook Pink (12 page)</li><li>• Students may use a calculator</li><li>• Periodic Tables</li></ul>		

### Feedback on assessment

Oral and written feedback on assessed work and tutorials from module leader/ tutors. Cohort level examination feedback provided via Moodle.

[Past exam papers for CH272](#)

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## Availability

### Pre-requisites

To take this module, you must have passed:

- All of
  - [CH160-30 Introduction to Inorganic Chemistry](#)

### Post-requisite modules

If you pass this module, you can take:

- CH3G3-30 Advanced Chemistry (Organic, Inorganic and Physical) Industrial Placement
- CH3F6-15 Polymer and Colloid Science
- CH404-15 Synthetic Chemistry III (Macromolecular Chemistry)
- CH3F3-30 Advanced Chemistry (Organic, Inorganic and Physical)

## Courses

This module is Core for:

- UCHA-4 Undergraduate Chemistry (with Intercalated Year) Variants
  - Year 2 of F101 Chemistry (with Intercalated Year)
  - Year 2 of F122 Chemistry with Medicinal Chemistry (with Intercalated Year)
- UCHA-3 Undergraduate Chemistry 3 Year Variants
  - Year 2 of F100 Chemistry
  - Year 2 of F121 Chemistry with Medicinal Chemistry
- Year 2 of UCHA-FN11 Undergraduate Chemistry and Business Studies
- UCHA-F110 Undergraduate Master of Chemistry (with Industrial Placement)
  - Year 2 of F110 MChem Chemistry (with Industrial Placement)
  - Year 2 of F112 MChem Chemistry with Medicinal Chemistry with Industrial Placement
- Year 2 of UCHA-F107 Undergraduate Master of Chemistry (with Intercalated Year)
- UCHA-F109 Undergraduate Master of Chemistry (with International Placement)
  - Year 2 of F109 MChem Chemistry (with International Placement)
  - Year 2 of F111 MChem Chemistry with Medicinal Chemistry (with International Placement)
- UCHA-4M Undergraduate Master of Chemistry Variants
  - Year 2 of F105 Chemistry
  - Year 2 of F110 MChem Chemistry (with Industrial Placement)

- Year 2 of F109 MChem Chemistry (with International Placement)
- Year 2 of F125 MChem Chemistry with Medicinal Chemistry
- Year 2 of UCHA-F127 Undergraduate Master of Chemistry with Medicinal Chemistry (with Intercalated Year)