# Ionic Materials

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**Aims**

The aim of this course is to provide an introduction to ionic materials, their applications and current research priorities, and some of the characterisation techniques used to understand them. The course will primarily focus on inorganic ionic materials, and will build on previous topics from both inorganic and physical chemistry.

**Synopsis**

1. **Ionic structures:** Types and applications of ionic materials; revision of crystallography; lattice energies and electrostatic interactions; close-packing of ions and common ionic structure types.
2. **Defects:** Introduction to defect; types of ionic defect; intrinsic vs extrinsic defects; defect equations, Kroger-Vink notation; ionic conductivity overview and mechanisms.
3. **Batteries:** revision of electronics and electrochemistry terms; overview of battery types and operating principle; approaches to improve battery capacity; alternative technologies; charging rates and power; galvanostatic characterisation techniques.
4. **Dielectrics:** ionic polarisation in infinite solids; capacitor operating principle and relevant formulae; impedance spectroscopy; piezoelectricity; ferroelectricity.
5. **Fuel cells:** fuel cell design and operating principles; alternative types of fuel cell; material requirements for fuel cell components (anode, cathode, solid electrolyte); defect clustering and ordered defect phases.

**Learning Outcomes**

By the end of this course, students will be able to:

- Link crystallographic structure with physical properties such as ionic conduction;
- Describe structures in terms of close-packing and holes;
- Explain the most common ionic defects, and write balanced defect equations;
- Discuss the different types of battery technology, and the materials properties required;
- Link dielectric properties to crystallographic symmetry, and understand the relationship between different dielectric classes;
- Compare different materials for fuel cell applications, and rationalise their advantages or disadvantages;
- Describe the impact of defect ordering on physical and structural properties.

**Reading**

Basic Solid State Chemistry, A. R. West, Wiley, **1988**.

M. Winter, Chem. Rev., **2004**, 4245.

Other references given throughout slides.