Inside the Atom connections to the GCSE (KS4) curriculum for England

Based on – Science programmes of study: key stage 4, National curriculum in England, December 2014

Introduction

The statutory requirements of the GCSE curriculum in England can be enriched and enhanced through connections to particle and nuclear physics. For some students, KS4 will be the beginning of further studies in science – but for others it will be the last time they formally study the subject. This is where the first explicit curriculum links with particle and nuclear physics occur and many of the stories from these research communities reinforce the aims of the national curriculum for science that pupils should:

- develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics
- develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them
- develop and learn to apply observational, practical, modelling, enquiry, problem-solving skills and mathematical skills, both in the laboratory, in the field and in other environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions, both qualitatively and quantitatively.

Curriculum Connections

Chemistry – Atomic structure and the periodic table.
Pupils are taught about:

- a simple model of the atom consisting of the nucleus and electrons, relative atomic mass, electronic charge and isotopes
- the number of particles in a given mass of a substance
- the modern Periodic Table, showing elements arranged in order of atomic number
- position of elements in the Periodic Table in relation to their atomic structure and arrangement of outer electrons
- properties and trends in properties of elements in the same group
- characteristic properties of metals and non-metals
- chemical reactivity of elements in relation to their position in the Periodic Table.

In chemistry students are taught about the nuclear model of an atom. Their knowledge of the periodic table (introduced in KS3) is developed further, allowing analogies to be drawn with the nuclear chart and the standard model of elementary particles. Students spend a significant amount of time studying chemical reactions and bonding as well as the properties and structure of some chemical compounds. This foundation can be built upon to talk about nuclear reactions, particle collisions and the structure of matter.

Physics – Energy
Pupils are taught about:

- renewable and non-renewable energy sources used on Earth, changes in how these are used.

Students start to learn about renewable and non-renewable energy resources and the factors affecting how these are used. They are also introduced to nuclear power as a source of electricity in the UK (for links to fission and nuclear waste see 'Physics – Atomic structure' unit below). The nuclear energy curriculum links at GCSE enable students to be taught about the importance of nuclear power in the UK and the basics of how nuclear energy is harnessed to produce electricity.

Physics – Forces (and motion)
- forces and fields: electrostatic, magnetic, gravity
- forces as vectors
- weight and gravitational field strength.

The 'forces' and 'forces and motion' units teach students about two of the fundamental forces and start to formalise the mathematics used to describe these forces. This basis can be used to introduce students to the four fundamental forces and their importance inside the atom and how they influence the fundamental particles.

Physics – Wave motion
- production and detection, by electrical circuits, or by changes in atoms and nuclei
- uses in the radio, microwave, infra-red, visible, ultra-violet, X-ray and gamma-ray regions, hazardous effects on bodily tissues.

Students are taught that changes in atoms and nuclei lead to the emission of electromagnetic radiation, what the different regions of the EM spectrum are and that some can be harmful to the human body. This enables a discussion of radioactivity, ionising radiation, as well as how the damaging effects of radiation can be used in medicine.

Physics – Atomic structure
- the nuclear model and its development in the light of changing evidence
- masses and sizes of nuclei, atoms and small molecules
- differences in numbers of protons, and neutrons related to masses and identities of nuclei, isotope characteristics and equations to represent changes
- ionisation; absorption or emission of radiation related to changes in electron orbits
- radioactive nuclei: emission of alpha or beta particles, neutrons, or gamma-rays, related to changes in the nuclear mass and/or charge
- radioactive materials, half-life, irradiation, contamination and their associated hazardous effects, waste disposal
- nuclear fission, nuclear fusion and our Sun's energy.

It is in the 'atomic structure' module that the first explicit nuclear physics curriculum links occur. This is the gateway into the basics of nuclear physics and the starting point for many nuclear physics outreach lectures. Students learn about:
- *Rutherford's discovery of the nucleus, leading to the birth of nuclear physics.*
- *How proton and neutron number defines elements and isotopes, the basis of explaining the nuclear chart.*
- *Radioactivity and ionising radiation, these topics provide great opportunities for practical physics – exploring the types and range of ionising radiation, as well as mathematical studies of probability and statistics through the random nature of radioactive decay. Examining half-lives can also lead to interesting discussions on the environmental impact of long lived radioactive waste and applications in radioactive dating.*
- *Nuclear fission, how nuclear energy is generated in power stations and what the future holds for nuclear energy in the UK.*
- *Nuclear fusion and our Sun, students can be taught about the research into fusion energy and introduced to the importance of nuclear reactions in our Sun and nuclear astrophysics in the life cycle of a star.*