# Scheme of work

## Combined Science: Trilogy

## Physics – Atomic structure

This resource provides guidance for teaching the Atomic structure topic from our new GCSE in Combined Science: Trilogy/Physics (8464). It has been updated from the draft version to reflect the changes made in the accredited specification such as the specification reference numbers. A few changes have also been made to learning outcomes and the opportunities to develop skills columns.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed. It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 6.4 Atomic structure

### 6.4.1 Atoms and isotopes

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.4.1.1 | The size and structure of an atom. | Atoms are very small, having a radius of about 1 x 10-10 metres.  The basic structure of an atom is a positively charged nucleus composed of both protons and neutrons surrounded by negatively charged electrons.  The radius of a nucleus is less than 1/10,000 of the radius of an atom. Most of the mass of an atom is concentrated in the nucleus.  The electrons are arranged at different distances from the nucleus (different energy levels). The electron arrangements may change with the absorption of electromagnetic radiation (move further from the nucleus; a higher energy level) of by the emission of electromagnetic radiation (move closer to the nucleus; a lower energy level). | 0.5 | How big is an atom?  What particles are in an atom?  Where is each particle found within the atom?  State the size of the atom in standard form.  Describe the composition of an atom and draw a fully labelled diagram of an atom showing protons and neutrons in the nucleus with electrons outside the nucleus.  Give the charges of all particles within the atom.  Calculate the size of an atom given the size of the nucleus and the scale of the nucleus compared to the atom.  Describe how the concentration of mass of an atom is not uniform but concentrated on the nucleus of the atom.  Describe how electrons are arranged within an atom.  Describe and explain how electrons can be moved further away from the nucleus of the atom and how they lose energy to move closer to the nucleus.  Explain how the wavelength of the electromagnetic wave emitted by an electron changes in relation to how far the electron has moved towards the nucleus. | Model an atom using plasticine. On the model show where most of the mass is concentrated and that most of the atom is empty space.  Research how absorption and emission spectra are formed. | Video clip  YouTube: [Powers of Ten™ (1977)](https://www.youtube.com/watch?v=0fKBhvDjuy0)  [Cyberphysics – The Atom](http://www.cyberphysics.co.uk/topics/atomic/atom.htm)  [Pass My Exams – Radioactivity, Atomic Structure, Atomic Number and Atomic Mass](http://www.passmyexams.co.uk/GCSE/physics/what-is-radioactivity-and-structure-of-atom.html)  [BBC Bitesize – Atomic structure and isotopes](http://www.bbc.co.uk/education/guides/z44xsbk/revision) | |
| 6.4.1.2 | Describing an atom in terms of protons, neutrons and electrons.  How to represent atoms. | In an atom the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.  All atoms of a particular element have the same number of protons. The number of protons in an atom of an element is called its atomic number.  The total number of protons and neutrons in an atom is called its mass number.  Atoms of the same element can have different numbers of neutrons. These atoms are called isotopes of that element.  Atoms can be represented as shown in this example:  Atoms turn into positive ions if they lose one or more outer electron(s) | 0.5 | What is ionisation?  How can an atom be ionised?  Why do some elements have isotopes?  Describe the composition of a given atom in terms of the number of protons and electrons.  Explain why atoms have no overall electrical charge, as the number of protons and electrons is equal.  Research how atoms can be ionised by making the number of protons different to the number of electrons in an atom.  State that the number of protons in a given element is always the same, though the mass number my change.  Define the atomic number for an element.  Calculate the number of neutrons for a stated element given the number of protons and the mass number.  Calculate the mass number for a particular element given the number of protons and neutrons in the atom. Rearrange the equation to find number of protons or number of neutrons and the mass number.  Explain how isotopes of elements, all have the same number of protons but have a different number of neutrons.  Define isotope.  Describe an atom in terms of number of protons, neutrons and electrons when given the following representation . | Use simple modelling techniques to show that the number of protons in an isotope of an element remains constant but the number of neutrons changes.  Produce a table showing the mass number, atomic number and number of neutrons for an element given in the form . | [BBC Bitesize – Structure of the atom](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/atoms_radiation/atomicstrucrev1.shtml)  [Pass My Exams – Radioactivity, Atomic Structure, Atomic Number and Atomic Mass](http://www.passmyexams.co.uk/GCSE/physics/what-is-radioactivity-and-structure-of-atom.html)  [Pass My Exams – Isotopes](http://www.passmyexams.co.uk/GCSE/physics/isotopes.html)  YouTube: [History of the Atom (Atomic Theory)](https://www.youtube.com/watch?v=IO9WS_HNmyg)  [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX)  [BBC Bitesize – Isotopes](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/atoms_radiation/atomicstrucrev3.shtml) | |
| 6.4.1.3 | Scientific models of the atom and how these models have changed. | New experimental evidence may lead to a scientific model being changed or replaced.  Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided.  The discovery of the electron led to the ‘plum-pudding model’ of the atom. The ‘plum-pudding model’ suggested that the atom was a ball of positive charge with negative electrons embedded in it.  The results from the alpha scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged.  The alpha scattering experiment led to the ‘plum-pudding model’ being replaced by the nuclear model.  Neils Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances.  Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, each particle having the same amount of positive charge. The name ‘proton’ was given to these particles.  Lastly, in 1932, the experimental work of James Chadwick provided the evidence to show the existence within the nucleus of the neutron. This was about 20 years after the nucleus became an accepted scientific idea. | 0.6 | Why has the model of the atom changed since ancient Greek times?  Describe and explain why scientific models are replaced.  Describe why ancient Greeks thought that the atom could not be divided.  Draw a diagram to illustrate the ‘plum-pudding model’ of the atom.  Explain why the ‘plum-pudding model’ was ‘better’ than the Greek model of the indivisible atom.  Describe the alpha scattering experiment What was so amazing about the alpha scattering experiment? Details of these experiments are **not** required.  Explain how the evidence from the scattering experiment led to a change in the atomic model of the atom.  Describe the difference between the ‘plum-pudding model’ of the atom and the nuclear model of the atom.  Produce a timeline to show how our ideas about atoms have changed since ancient Greek times.  Find out about the origins of the words protons, neutrons and electrons. | Model the alpha scattering experiment by flicking a 1p coin through stack of 2p coins. The 1p coin represents the alpha particle and the stack of 2p coins the gold foil. How must the stacks be arranged in order that 90% of the coins go straight through without scattering? What conclusion can be drawn about the arrangement of atomic nuclei in a material and the amount of free space between nuclei? | Video clip  YouTube: [Early Atomic Models – Science](https://www.youtube.com/watch?v=ajQEvtge0m0)  [BBC Bitesize – Development of atomic theory](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/periodic_table/atomstrucrev5.shtml)  Video clip  YouTube: [Rutherford Gold Foil Experiment – Backstage Science](https://www.youtube.com/watch?v=XBqHkraf8iE)  [Cyberphysics – Rutherford's Alpha Scattering Experiment](http://www.cyberphysics.co.uk/topics/atomic/Rutherford/rutherford.htm) | |

### 6.4.2 Atoms and radiation

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.4.2.1 | The radioactive decay of an unstable element.  Activity is measured in Becquerel (Bq). | Some atomic nuclei are unstable. The nucleus gives out ionising radiation as it changes to become more stable. This is a random process called radioactive decay.  Activity is the rate at which a source of unstable nuclei decays and is measured in Becquerel. | 0.4 | Why are some atoms radioactive?  Where does the radiation come from?  Describe radioactive decay as a process by which an unstable atom releases radiation.  How does activity change with time?  Research how nuclear radiation was discovered and who discovered it.  State that the part of the atom, which releases the radiation, is the nucleus.  Describe how the emission of radiation from a radioactive atom is a random process, but over time the amount of decay can be predicted. | Investigate the random nature of radioactive decay by throwing dice or coins. Is it possible to predict which dice will land on a six (or coins on a head)? | [BBC Bitesize – Radioactive decay](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/radiation/atomsisotopesrev3.shtml)  [Pass My Exams – Stable and Unstable Nuclei](http://www.passmyexams.co.uk/GCSE/physics/stable-and-unstable-nuclei.html) |
| 6.4.2.1 | The nature of different types of nuclear radiation. | The nuclear radiation emitted may be:   * an alpha particle (α) – this consists of two neutrons and two protons, it is identical to a helium nucleus * a beta particle (β) – a high speed electron ejected from the nucleus as a neutron turns into a proton * a gamma ray (γ) – electromagnetic radiation from the nucleus. * a neutron (n) | 0.4 | Are all radioactive sources the same?  Describe the composition of each type of radiation and where relevant, give the particle that the type of radiation is identical to, eg an alpha particle is a helium nucleus.  Research how with beta decay an electron happens to be in the nucleus.  Describe how in beta emission a neutron decays into a proton and an electron, with the electron then being ejected from the nucleus at high speed.  Describe gamma rays as being part of the electromagnetic spectrum as well as a type of nuclear radiation.  Describe how a neutron can be emitted from a nucleus. | Model alpha, beta, gamma and neutron decay using plasticine and/or stop frame animation. Models should show the atom before and after decay as well as the radiation emitted. | [Nuffield Foundation | Nature of ionising radiations](http://www.nuffieldfoundation.org/practical-physics/nature-ionising-radiations)  [Cyberphysics – Radioactivity Index](http://www.cyberphysics.co.uk/topics/radioact/Radio/infobank.htm)  [Pass My Exams – Alpha, Beta and Gamma Rays](http://www.passmyexams.co.uk/GCSE/physics/alpha-beta-gamma-rays.html) |
| 6.4.2.1 | The penetration of alpha, beta and gamma radiation through different materials. | Properties of alpha particles, beta particles and gamma rays limited to their penetration through materials and their range in air. | 0.4 | Which type of radiation is the most dangerous?  Where do radioactive sources come from?  Draw a diagram to illustrate the penetration of the different types of nuclear radiation.  Evaluate the use of different shielding materials for use when handling radioactive sources when supplied with relevant data.  Explain why gamma sources are usually the most harmful when outside the body and alpha are the most dangerous when inside the body in terms of penetration of the radiation. | Demonstrate the penetration of alpha, beta and gamma radiation. Link the penetration of each type of radiation to the nature of the radiation and the uses of the radioactive sources.  Plan an experiment to determine the type of radiation emitted by an unknown radioactive source. Produce a risk assessment for this experiment. | [BBC Bitesize – Penetrating properties of radiation](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/radiation/radioactiverev3.shtml)  [Cyberphysics – Ionizing Power and Penetrating Power](http://www.cyberphysics.co.uk/topics/radioact/Radio/ion&penet.htm) |
| 6.4.2.2 | Nuclear decay equations | Nuclear equations are used to represent radioactive decay.  In a nuclear equation an alpha particle may be represented by the symbol:  and a beta particle by the symbol:  The emission of the different types of ionising radiation may cause a change in the mass and/or the charge of the nucleus. For example:    Alpha decay causes both the mass and charge of the nucleus to decrease.    Beta decay does not cause the mass of the nucleus to change, but it does cause the charge of the nucleus to increase.  The emission of a gamma ray does not cause the mass or the charge of the nucleus to change. | 0.5 | How do atoms change when they undergo radioactive decay?  Describe what happens to an atom when it undergoes alpha, beta and gamma emission.  Calculate how the mass number, the proton number and the number of neutrons in an atom change when it undergoes alpha, beta and gamma emission.  State the composition of alpha and beta particles and be able to recall that an alpha particle can be represented as:  and a beta particle can be represented as:  Complete nuclear decay calculations for alpha and beta decay. The calculations may be in the form of an equation or a table of results showing the same data.  Describe in words how the nucleus of an atom changes when it undergoes alpha and beta decay.  Describe how the charge of a nucleus changes as it undergoes alpha and beta decay. | Model the radioactive decay of alpha and beta sources. Use the model to construct decay equations for alpha and beta decay. Critically analyse the limitations of the models produced by the class. | [ChemTeam – Writing Alpha and Beta Equations](http://www.chemteam.info/Radioactivity/Writing-Alpha-Beta.html)  [BBC Bitesize – Nuclear equations – Higher tier](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/atoms_radiation/nuclearradiationrev9.shtml)  [Cyberphysics – Alpha Particle Emission](http://www.cyberphysics.co.uk/topics/radioact/Radio/alpha.html)  [Cyberphysics – Beta Particle Emission](http://www.cyberphysics.co.uk/topics/radioact/Radio/beta.html) |
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| 6.4.2.3 | The randomness of radioactive decay. | Radioactive decay is random so it is not possible to predict which individual nucleus will decay next. But with a large enough number of nuclei it is possible to predict how many will decay in a certain amount of time. | 0.5 | How does the activity of a radioactive substance change with time?  Can you predict, with accuracy, which atoms in a radioactive substance will decay first?  Describe the process of radioactive decay as being a random event analogous to flipping lots of coins – not knowing which coins will fall on heads but knowing about half of them will on any given throw. | Demonstrate the randomness of the decay of a radioactive substance by throwing six dice and getting a prediction of the number of dice that will land on a six. Alternatively, drop 20 coins and get students to predict the number that will land on a head. | [BBC Bitesize – Properties of radiation](http://www.bbc.co.uk/education/guides/z996fg8/revision/1)  [Cyberphysics – Decay Animations](http://www.cyberphysics.co.uk/topics/radioact/Radio/decay/decay.htm) |
| 6.4.2.3 | Determination of half-life using calculations and graphical methods. | The half-life of a radioactive isotope is the time it takes for the number of nuclei of the isotope in a sample to halve, or the time it takes for the count rate from a sample containing the isotope to fall to half of its initial level.  Students should be able to calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives. HT only. | 0.6 | Define the term half-life.  Calculate the half-life of a radioactive source from a decay curve of the radioactive element.  Calculate the mass of a radioactive substance remaining after a given time when given the half-life of the substance and the initial mass of the radioactive source. | Investigate half-life by throwing a large number of Tillich bricks. Any that land on the side with the odd colour get removed and the number remaining is recorded. Plot a graph of the number of throws against number of cubes remaining. Determine the half-life of the cubes (the number of throws needed to get the number of cubes to reduce by half).  This experiment can also be carried out using coins. Is it possible to predict which cubes or coins will land on a certain side? | [S-cool, the revision website – Half life](http://www.s-cool.co.uk/a-level/physics/radioactive-decay-equations/revise-it/half-life)  [Cyberphysics – Half Life and Rate of Decay](http://www.cyberphysics.co.uk/topics/radioact/Radio/half_life.htm)  [Pass My Exams – Radioactive Half Life](http://www.passmyexams.co.uk/GCSE/physics/radioactive-half-life.html) |
| 6.4.2.4 | How to handle radioactive sources safely to avoid contamination. | Radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials. The hazard from contamination is due to the decay of the contaminating atoms. The type of radiation emitted affects the level of hazard. | 0.7 | Describe how radioactive contamination can occur.  If radiation is dangerous, why is it used in schools?  How would a person become contaminated by radiation?  Explain how the procedure followed by people dealing with radioactive sources reduces the risk of contamination.  If a person gets contaminated by radiation how are they decontaminated?  Research decontamination techniques for workers exposed to radioactive sources.  Describe how decontamination would take place if a person’s clothes or skin have been contaminated by a radioactive source.  Explain why contamination by a highly active alpha source may be a lot more damaging than a low activity gamma source. | Compare precautions taken by a teacher handling radioactive sources with those used by, say, in a nuclear power station. | [BBC Bitesize – Handling radioactive materials](http://www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway/energy_resources/nuclear_radiationsrev3.shtml) |
| 6.4.2.4 | The process and uses of irradiation. | Irradiation is the process of exposing an object to ionising radiation. The irradiated object does not become radioactive. | 0.5 | Explain how fruit is irradiated before sending on a long trip.  If radiation is harmful, why is food irradiated using radiation?  When irradiating food, does it become radioactive?  Find out the advantages and disadvantages of irradiating food. | Evaluate the use of irradiating fruit in terms of cost of goods and potential risk due to the exposure of workers and consumers of the irradiation process. | Video clip  YouTube: [Food irradiation: Is it safe?](https://www.youtube.com/watch?v=2MJc_WNl7ME)  [Cyberphysics – Radioactivity and Food](http://www.cyberphysics.co.uk/topics/radioact/Radio/food.htm)  [Pass My Exams – Uses of Radioactivity, Gamma Rays in Sterilisation](http://www.passmyexams.co.uk/GCSE/physics/gamma-rays-in-sterilisation.html) |
| 6.4.2.4 | Safety precautions taken when dealing with radioactive sources. | Suitable precautions must be taken to protect against any hazard the radioactive source used in the process of irradiation may present. | 0.5 | Describe and explain how radioactive sources are used safely within a science lab, looking in terms of reducing the risk of contamination and reducing the exposure to the radiation itself.  Explain the safety requirements needed in a work place that deals with radioactive sources.  Research the types of food irradiated at the sources of radiation used in this process. Find out the safety precautions taken in the food industry when dealing with radioactive sources and how this differs from the use of radioactive sources in schools. | Justify the use of radioactive sources in school in terms of risk-benefit analysis to the students in the class. | [BBC Bitesize – Hazards from radioactive materials](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_21c/radioactive_materials/safehandlingrev3.shtml)  [Cyberphysics – Radioactivity – safety](http://www.cyberphysics.co.uk/topics/radioact/Radio/safety.htm) |