# Scheme of work

## Combined Science: Trilogy - Foundation

## 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.

The scheme of work is designed to be a flexible 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.

### 6.7 Atomic structure

### 6.7.1 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* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.7.1.1 | The size and structure of an atom.  Content crosses over with Chemistry unit 5.1 | 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. The electron arrangements may change with the absorption of electromagnetic radiation (move further from the nucleus) of by the emission of electromagnetic radiation (move closer to the nucleus). | 1 | State the size of the atom in standard form.  Draw a 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.  Describe how, as charges are pulled apart, their potential energy increases (like an elastic band being stretched). The closer the electrons are to the nucleus, the less potential energy they have (but they move faster).  Describe how the wavelength of the electromagnetic wave emitted by an electron, as it moves closer to the nucleus, changes with how far the electron has moved. | Students can revisit different kinds of elements including metal and non-metal samples (cross reference with Chemistry unit 5.1.1).  Students can investigate simple flame tests of different elements (sodium, potassium, copper) to examine the different colours of light emitted. | [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 6.7.1 2 | Mass number, atomic number and isotopes | 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 can be represented as shown in this example: | 1 | Describe a carbon atom in terms of the number of protons and number of electrons.  Compare the charges in the carbon atom and describe how it has no overall electrical charge as the number of protons and electrons is equal.  State that the number of protons in a given element is always the same, though the mass number may change.  Define the atomic number for an element.  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. | Students can examine the Periodic table to identify mass and atomic numbers. Describe what happens to the element when protons are added.  Use plasticine to model the protons, neutrons and electrons. Complete the model on a pre-printed atom diagram.  Label the diagrams with appropriate charges.  Ask students to use plasticine to turn a helium atom into gold.  Students can determine the charge of the atom if electrons are removed. Calculate mass and atomic numbers using the model to subtract and add as required. |  |
| 6.7.1.2 |  | Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element. | 1 | Describe an atom in terms of number of protons, neutrons and electrons when given the following representation:  Define the word isotope.  Explain how isotopes of elements, eg hydrogen and uranium, all have the same number of protons but have a different number of neutrons.  Calculate the number of neutrons for a given element given the number of protons and the mass number. | Students can use cocoa pops (neutrons) and rice krispies (protons) to model the nucleus of an atom.  Add more cocoa pops to the model to make isotopes of carbon. Determine whether the charge changes when neutrons are added or removed.  Ask students to come up with their own ideas for making model atoms using other materials. Describe what each model shows/ does not show well. |  |
| 6.7.1.3  6.7.1.3 | The development of the model of the atom | 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 of Rutherford and Marsden’s 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.  Neils Bohr suggested that electrons orbit the nucleus at specific distances.  In 1932, James Chadwick showed the existence within the nucleus of the neutron.  Details of these experiments are not required. | 1 | Describe and explain why old scientific models have been replaced.  Produce a timeline of ideas about how the atom was thought to be arranged from ancient Greece to modern day.  Draw a diagram to illustrate the ‘plum-pudding model’ of the atom.  Describe the experiment carried out by Rutherford and Marsden into the scattering of alpha particles by a thin gold foil.  Describe how the evidence from the scattering experiment led to a change in the atomic model of the atom.  Compare the difference between the ‘plum-pudding model’ of the atom and the nuclear model of the atom. | Use a hula hoop to demonstrate the ‘plum-pudding model’ (suspend ‘electrons’ from various points using thread).  Ask students to throw soft balls (ping-pong balls or equivalent) at it and observe what happens.  Demonstrate Rutherford’s experiment using a quadrat with ‘gold nuclei’ attached to corners within the grid. Ask students to throw soft balls (ping-pong balls or equivalent) at it and observe what happens.  Discuss this in terms of Rutherford’s expectations and predictions made using the ‘plum-pudding model’. |  |

### 6.7.2 Atoms and nuclear 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* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.7.2.1 | Radioactive decay and nuclear radiation | 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 sources of unstable nuclei decay.  Activity is measured in Becquerel (Bq)  1 Becquerel = 1 decay per second  Count-rate is the number of decays recorded each second by a detector (eg Geiger-Muller tube). | 1 | Recap the work done on the electromagnetic spectrum and how radiation workers need to be protected from radiation.  Describe radioactive decay as a process by which an unstable atom releases radiation.  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. | Use a range of example radioactive sources (eg Vaseline glass, smoke detectors, bananas, brazil nuts, radium watches, granite) to demonstrate that radiation is a common occurrence.  Have a Geiger counter reading the background count in the class to establish that radioactive decay is a common event around us that we cannot sense. |  |
| 6.7.2.1 | The nature of different types of nuclear radiation.  The ionizing power and penetration of alpha, beta and gamma radiation through different materials. | The nuclear radiation emitted may be:   * an alpha particle (α) * a beta particle (β) * a gamma ray (γ) .     Properties of alpha particles, beta particles and gamma rays are limited to their penetration through materials and their range in air. | 1 | 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.  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.    Draw a diagram to illustrate the penetration of the different types of nuclear radiation and their ionising power.  Discuss the alleged alpha (polonium) radiation poisoning of Alexander Litvinenko. | Demonstrate the radioactive sources and their penetration into different materials. |  |
| 6.7.2.2 | Nuclear equations | Nuclear equations are used to represent radioactive decay.  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:    So alpha decay causes both the mass and charge of the nucleus to decrease.    So beta decay does not cause the mass of the nucleus to change but 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.  Students should be able to use the names and symbols of common nuclei and particles to write balanced equations that show single alpha (α) and beta (β) decay. This is limited to balancing the atomic numbers and mass numbers. The identification of daughter elements from such decays is not required. | 1 | Describe what happens to an atom when it undergoes alpha, beta and gamma emission.  Calculate how the mass, proton and neutron numbers in an atom changes following alpha, beta and gamma emission.  State the composition of alpha and beta particles and recall that an alpha particle is:  and a beta particle is:  Complete decay calculation for alpha and beta decay.  Describe how the nucleus of an atom and charges change when it undergoes alpha and beta decay. | Use plasticine to model the changes in an atom when it undergoes alpha or beta decay.  Use the models to form a 2D equation of the alpha and beta decay of an imaginary atom (as radioactive atoms have large nuclei).  Label the picture with the correct initial and subsequent mass and atomic numbers. |  |
| 6.7.2.3 | Half-lives and the random nature 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.  The half-life of a radioactive isotope is the average time it takes for the number of nuclei of the isotope in a sample to halve, or the average time it takes for the count rate from a sample containing the isotope to fall to half its initial level. | 1 | 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.  Define the term half-life.  Plot a graph of throw against decay.  Use the graph to calculate the half-life of the Skittles. | Students can use Skittles or M&Ms to calculate the half-life. Ask students to throw out a cupful of sweets and count the ones with the letter uppermost. Count and remove these. Throw the remaining ones until none are left. | Ask students to calculate the half-life of a radioactive source from a decay curve of a radioactive element. |
| 6.7.2.4 | Radioactive 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. | 1 | Describe how radioactive contamination can occur.  Describe how the procedure followed by people dealing with radioactive sources reduces the risk of contamination.  Describe how decontamination would take place if a person’s clothes or skin have been contaminated by a radioactive source.  Describe why contamination by a highly active alpha source may be a lot more damaging than a low activity gamma source. | Examine footage from radioactive disasters such as Chernobyl and Fukushima, eg:  [You Tube – Hiroshima Bomb Detonation](https://www.youtube.com/watch?v=ETbI0Ih0kVg) (3 mins)  [You Tube – A Walk around Chernobyl](https://www.youtube.com/watch?v=9DWnjcSo9J0) (8 mins)  Students can design protective clothing for use in a nuclear disaster, thinking about types of radiation released and penetration of each type. |  |
| 6.7.2.4 | The process and uses of irradiation | Irradiation is the process of exposing an object to ionising radiation. The irradiated object does not become radioactive. | 1 | Ask students to work out how they would transport soft fruit for weeks.  Describe what happens to strawberries which are irradiated before sending on a long trip.  Determine how irradiating fruit affects the cost of goods and whether there are any risks for the workers and consumers of the irradiation food process. | Depending on the season, have some examples of soft fruit left in a warm cupboard for a week (for raspberries, a couple of days maximum)  Students could investigate the length of time soft fruit can survive following various treatments (eg freezing, keeping cold, removing air etc.) and how the fruit survives the treatment. |  |
| 6.7.2.4 | 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. | 1 | 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.  Discuss the use of radioactive sources in school in terms of risk-benefit analysis to the students in the class.  Students can research different jobs that involve the use of radiation, including testing for water leaks, thickness control, dentistry, radiologists to identify the safety procedures involved:  [US NRC – Uses of Radiation](http://www.nrc.gov/about-nrc/radiation/around-us/uses-radiation.html)  [HSE – Ionising Radiation FAQs](http://www.hse.gov.uk/radiation/ionising/faqs.htm)  [NHS Radiation](http://www.nhs.uk/Conditions/Radiation/Pages/Introduction.aspx) | Examine the radioactivity log books for the science department. Use these to find out which teachers have had the most exposure to radiation. |  |