# Scheme of work

## Physics – Atomic structure

This resource provides guidance for teaching the Atomic structure topic from our new GCSE Physics (8463). 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.

### 4.4 Atomic structure

### 4.4.1 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* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.1.1 | 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 in 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) | |
| 4.4.1.2 | 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) | |
| 4.4.1.3 | 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) | |

### 4.4.2 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* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.2.1 | 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) |
| 4.4.2.1 | 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) |
| 4.4.2.1 | 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) |
| 4.4.2.2 | 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) |
|  |
| 4.4.2.3 | 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) |
| 4.4.2.3 | 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) |
| 4.4.2.4 | 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) |
| 4.4.2.4 | 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) |
| 4.4.2.4 | 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) |

### 4.4.3 Hazards and uses of radioactive emissions and of background radiation (physics only)

| **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* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.3.1 | Background radiation and sources of it. | Background radiation is around us all of the time. It comes from:   * natural sources such as rocks and cosmic rays from space * man-made sources such as the fallout from nuclear weapons testing and nuclear accidents. | 0.5 | Where does background radiation come from?  Do we (humans) contribute towards background radiation?  Describe sources of background radiation, both man-made and natural.  Explain why the level of background radiation is not the same across the planet in terms of altitude, geology and location of nuclear power stations.  Describe the effect of nuclear weapons and their testing on the level of background radiation. | Pose question: Are people in some areas exposed to more background radiation than others? If so why? | [BBC Bitesize – Background radiation](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/atoms_radiation/nuclearradiationrev1.shtml)  [Cyberphysics –Background Radiation](http://www.cyberphysics.co.uk/topics/radioact/Radio/background.htm)  [Pass My Exams – Background Radiation](http://www.passmyexams.co.uk/GCSE/physics/background-radiation.html) |
| 4.4.3.1 | How the amount of background radiation depends on where you live and the job you do. | The level of background radiation and radiation dose may be affected by occupation and/ or location.  Radiation dose in measured in Sieverts (Sv). | 0.5 | Evaluate the risks involved to certain groups of people based on their occupations and/or location when supplied with relevant data.  Research to see if the number of cases of cancer diagnosed per head of population increases in areas with higher levels of background radiation. Why is it not possible to link all the cases of cancer with levels of background radiation?  Calculate the dose of radiation that a person would be exposed to when given appropriate charts and data.  Find out the annual dose of radiation received by radiographers, airline pilots, nuclear industry workers, science teachers and astronauts.  Describe why airline pilots would have a higher exposure to radiation than teachers.  Convert quantities into SI units eg  millisieverts to sieverts. | Pose question: Are we at risk from background radiation?  Is this greater or less than other parts of the country and why? | [thisisphysics.wikispaces.com – Background radiation](https://thisisphysics.wikispaces.com/file/view/P2.11_1b+Background+radiation.pdf) PDF |
| 4.4.3.2 | The activity of a radioactive source affects its half-life. | Radioactive isotopes have a very wide range of half-life values. Sources containing nuclei that are most unstable have the shortest half-lives. The decay is rapid with a lot of radiation emitted in a short time. Sources with nuclei that are least unstable have the longest half-lives. These sources emit little radiation each second but emit radiation for a long time. | 0.5 | How does the activity of a radioactive source affect its half-life?  State that the most unstable nuclei have short half-lives as they decay much faster. Radioactive atoms with much longer half-lives are more stable.  If some radioactive sources have short half-lives, why are they still found on Earth?  Evaluate the use of the uranium-lead ratio to determine the age of rocks even though the decay is not straight from uranium into lead. | Research how isotopes with long half-lives and short half-lives are used. | As per section 4.4.3.1 |
| 4.4.3.2 | The hazards of radioactive sources. | The hazards associated with radioactive materials differ according to the half-life of the material involved. | 0.2 | Describe and explain how nuclear waste is sorted and then disposed of in terms of low, medium and high level waste. What precautions need to be taken and why?  Why can’t radioactive waste be sent into space or dropped into deep ocean trenches?  Describe the main problems of disposing of radioactive waste with reference to people local to the disposal site, ground water sources and security. | Pose question: Why can’t radioactive waste be thrown in landfill sites? | [BBC Bitesize – Hazards of radiation](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/radiation/radioactiverev6.shtml)  [Cyberphysics – Radioactivity – safety](http://www.cyberphysics.co.uk/topics/radioact/Radio/safety.htm) |
| 4.4.3.3 | Uses of nuclear radiation. | Uses of nuclear radiations in medicine include:   * as tracers * exploration of internal organs * control or destruction of unwanted tissue. | 0.4 | Describe and explain how radioactive sources are used as medical tracers.  Explain the properties required for a given tracer in terms of:   * state: solid, liquid or gas * type of radiation emitted * half-life.   Describe how the radiation from the tracer is detected. | Research some radioactive sources used in medicine and the properties of these tracers (half-life, type of radiation emitted and state).  Find out how nuclear radiation can be used in the diagnosis and treatment of cancer. | Video clip  YouTube: [Radioactive tracers in medicine](https://www.youtube.com/watch?v=7mSR--zJGv0)  [Cyberphysics – Uses of Nuclear Radiation](http://www.cyberphysics.co.uk/topics/radioact/Radio/applications.htm)  [Pass My Exams – Uses of Radioactivity, Alpha particles in smoke detectors](http://www.passmyexams.co.uk/GCSE/physics/alpha-particles-in-smoke-detectors.html) |

### 4.4.4 Nuclear fission and fusion (physics only)

| **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* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.4.1 | Nuclear fission. | Nuclear fission is the splitting of a large and unstable nucleus (eg uranium or plutonium). | 0.2 | What happens when you split the nucleus of an atom?  Can splitting the nucleus of an atom be done at home? What type of radiation is emitted when the nucleus of an atom splits?  Draw a diagram to illustrate the fission process.  Describe what happens to the nucleus of an unstable atom when it undergoes fission. | Model nuclear fission of a uranium nucleus. | [BBC Bitesize – Nuclear fission](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/radiation/nuclearfissionrev1.shtml)  [Cyberphysics – Fission – The splitting of the atom's nucleus](http://www.cyberphysics.co.uk/topics/nuclear/fission.html)  [Pass My Exams – What is Nuclear Fission?](http://www.passmyexams.co.uk/GCSE/physics/nuclear-fission.html) |
| 4.4.4.1 | Spontaneous fission and nuclear fission in power stations. | Spontaneous fission is rare. Usually for fission to occur the unstable nucleus must first absorb a neutron. | 0.2 | Describe and explain how nuclear fission happens in a nuclear power station.  State that the reason nuclear fission is used is that the uranium atom decays too slowly naturally. | Pose question: with reference to the conditions needed in a nuclear power station for fission to occur, does that affect their attitude towards having more nuclear power stations in the UK? | [Cyberphysics – Nuclear Power](http://www.cyberphysics.co.uk/topics/nuclear/nuclear_power.html)  [Pass My Exams – A Nuclear Power Station](http://www.passmyexams.co.uk/GCSE/physics/nuclear-power-station.html) |
| 4.4.4.1 | The process of nuclear fission.  How nuclear power stations release energy. | The nucleus undergoing fission splits into two smaller nuclei, roughly equal in size, and emits two or three neutrons plus gamma rays. Energy is released by the fission reaction.  All of the fission products have kinetic energy. | 0.4 | State the products of a fission reaction. What are the by-products of fission?  Explain how the products of the fission reaction are still moving very fast and it is this kinetic energy that it transferred to boil the water in a nuclear reactor.  Describe the fission of uranium as still being a random event and the splitting of the nucleus of the atom can take place in different ways – releasing two or three neutrons.  What happens to the neutrons that do not go on to split more uranium nuclei?  How does nuclear fission release energy? | Use ideas from Energy topic (4.2) to answer question: Explain how the kinetic energy of the products is transferred to boil water. | Video clip  YouTube: [Nuclear Reactor – Understanding how it works/Physics Elearnin](https://www.youtube.com/watch?v=1U6Nzcv9Vws)g  See section: 4.4.4.1 |
| 4.4.4.1 | Chain reactions. | The neutrons that are released during fission may go on to start a chain reaction. | 0.2 | What is a chain reaction? What is an uncontrolled chain reaction?  Define the term chain reaction.  Explain why all the neutrons emitted by the uranium nucleus do not go to split up more uranium atoms – in terms of some of the neutrons escaping into the reactor vessel itself.  If the sequence of number of decays of uranium atoms starts 1, 3, 9, 27 how many uranium atoms would be split on the 25th term of this sequence? | Model chain reactions using dominos or matches. | [BBC Bitesize – Nuclear fission](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/radiation/fissionrev2.shtml)  See section: 4.4.4.1 |
| 4.4.4.1 | Controlling chain reactions and consequences of not controlling them. | The chain reaction is controlled in a nuclear reactor to control the energy released. The explosion caused by a nuclear weapon is caused by an uncontrolled chain reaction. | 0.3 | Explain how the chain reaction in a nuclear power station is controlled by the use of boron control rods that absorb excess neutrons.  Are nuclear power stations safer now or are they more at risk?  Describe the Chernobyl nuclear disaster as being caused by the control rods being removed from the reactor to test a safety system (that didn’t work).  Explain how nuclear bombs use uncontrolled chain reactions. | Investigate the causes of the Chernobyl and Fukushima nuclear disasters. Have the lessons of these events been learnt? How can nuclear power be made safer than it is currently? | [atomarchive.com | Controlled Nuclear Fission](http://www.atomicarchive.com/Fission/Fission4.shtml)  [BBC News | EUROPE | The Chernobyl accident: What happened](http://news.bbc.co.uk/1/hi/world/europe/778477.stm) |
| 4.4.4.2 | Nuclear fusion. | Nuclear fusion is the joining of two light nuclei to form a heavier nucleus. In this process some of the mass of the smaller nuclei is converted into energy. Some of this energy may be the energy of emitted radiation. | 0.2 | Link to 8.1.2 on Nuclear fusion in stars.  Describe the conditions required for nuclear fusion to occur.  Describe nuclear fusion as being the joining of two light nuclei to make a heavier nucleus and releasing energy in the process.  Can we generate electricity using nuclear fusion?  What is the difference between fission and fusion?  What are the products of fusion?  Can fusion be used to make the heavy elements?  Explain why current nuclear power stations work on nuclear fission rather than nuclear fusion.  Describe what cold fusion means. Why the search for cold fusion in the 1990s led to a delay in scientific research in other fields? | Write simple word or symbol equations for the fusion of two hydrogen atoms or other light elements. | [S-cool, the revision website – Fusion and Fission](http://www.s-cool.co.uk/a-level/physics/nuclear-energy/revise-it/fusion-and-fission)  [Pass My Exams – What is Nuclear Fusion?](http://www.passmyexams.co.uk/GCSE/physics/nuclear-fusion.html)  [Cyberphysics – Nuclear Power](http://www.cyberphysics.co.uk/topics/nuclear/nuclear_power.html)  [BBC Bitesize – Cold fusion](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/radiation/fissionrev4.shtml)  [Cyberphysics – Nuclear Power](http://www.cyberphysics.co.uk/topics/nuclear/nuclear_power.html) |