# Triple Science - Physics

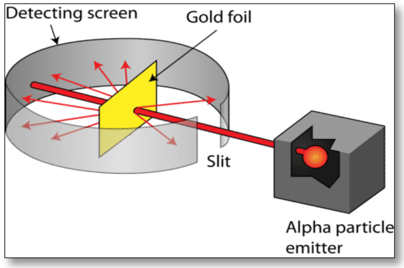
## SP6 Knowledge organiser

## P6: Radioactivity

### Lesson sequence

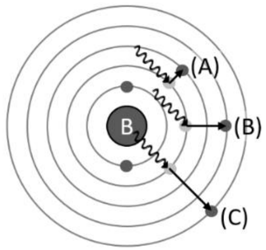
1. Atomic models
2. Inside atoms
3. Electron orbits
4. Background radiation
5. Types of radiation
6. Radioactive decay
7. Half-life
8. Using radioactivity
9. Dangers of radioactivity
10. Radioactivity in medicine
11. Nuclear Energy
12. Nuclear Fission
13. Nuclear Fusion

| 1. Atomic models | |
|---|---|
| **Atom** | Smallest stable particle of matter. |
| **Size of atoms** | 2.5 x$10^{-10}$ m in diameter |
| **Element** | Pure substance made of a single type of atom. |
| **John Dalton** | Pictured atoms as tiny hard round balls, with different elements having atoms of different sizes. |
| **J.J Thomson** | Discovered negative particles smaller than atoms called electrons. |
| **Plum-pudding model** | Atoms as a sphere of positively charged matter with negative electrons scattered throughout it. |
| **Rutherford's experiment** | Fired alpha particles at very thin gold leaf and used a special screen to record where they went. |
| **Rutherford's results** | Most alpha particles went straight through, some scattered (changed path). |
| **Rutherford's explanation** | Scattered particles hit a nucleus. Nucleus must be small because most went straight through without hitting it. |

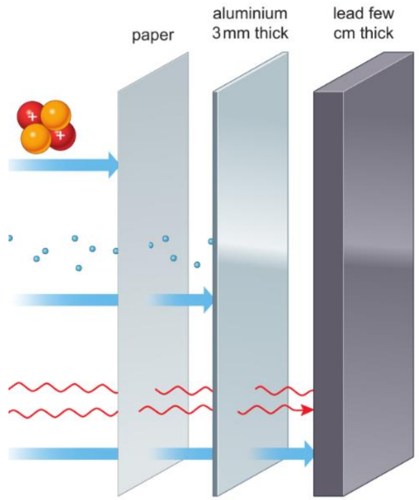



| 2. Inside atoms | |
|---|---|
| **Subatomic particle** | Particles smaller than atoms: protons, neutrons and electrons. |
| **Protons** | +1 charge, mass = 1, located in the nucleus |
| **Neutrons** | 0 charge, mass = 1, located in the nucleus |
| **Electrons** | -1 charge, mass = 1/1835, located around nucleus in shells |
| **Relative mass** | Not the actual mass because no units. Protons and neutrons have same relative mass: their mass is 1. |
| **Nucleons** | Subatomic particles found in the nucleus: protons and neutrons. |
| **Determining the element** | The number of protons determines which element an atom is. |
| **Atomic number** | The number of protons in an atom. Also electrons. |
| **Mass number** | The number of nucleons (protons and neutrons) in an atom. |
| **Number of neutrons** | Mass number – atomic number |
| **Isotopes** | Versions of an element with the same number of protons, but different number of neutrons. |
| **Naming isotopes** | Name followed by mass, e.g. carbon-13, or symbol preceded by mass, e.g. $^{13}C$. |

| 3. Electron orbits | |
|---|---|
| **Orbits** | The shells of electrons around an atom. |
| **Orbits and energy** | Higher orbit = higher energy |
| **Excited electrons** | When an electron has absorbed energy and jumped to a higher orbit. |
| **How to excite electrons** | - When atoms absorb light<br>- When electricity is passed through gases<br>- Strongly heating a material |
| **Emitting light** | Electrons emit light when they drop back down an orbit. A bigger drop down releases higher energy light. |
| **Absorbing light** | Light absorbed at specific wavelengths corresponds to energy gap in orbits: jumping up one orbit = redder light, jumping up several orbits = bluer light. |
| **Emission spectrum** | Pattern of bands of light at specific wavelengths caused by exciting a gaseous element with electricity. |
| **Absorption spectrum** | Pattern of dark band in a 'rainbow' spectrum caused by a gaseous element absorbing some of the light passed through it. |
| **Forming ions** | When an electron is given so much energy it leaves the atom entirely creating a positive ion. |
| **Ionising radiation** | Radiation that causes ionisation: (high energy) UV, x-rays, gamma rays. |




| 4. Background radiation | |
|---|---|
| ***Background radiation** | Low levels of ionising radiation that we are constantly exposed to. |
| **Radon gas** | The biggest source of background radiation: a radioactive gas produced by some rocks in the ground |
| **Other sources** | Food, hospitals, nuclear power industry, space (cosmic rays) |
| **Artificial sources** | 15%: 14% hospitals, 1% nuclear industry |
| **Geiger-Müller (GM) tube** | Used to measure radioactivity, produce a click each time radiation passes through it. |
| **Count-rate** | The number of time a GM tube detects radiation each second. |
| **Measuring background radiation** | Use a GM tube to take several readings and then calculate the average (mean). |
| **Measuring the activity of a source** | Measure the source, subtract the background radiation. |
| **Dosimeter** | A badge that changes colour in response to radiation exposure. |
| **Dose** | The amount of radiation received. |



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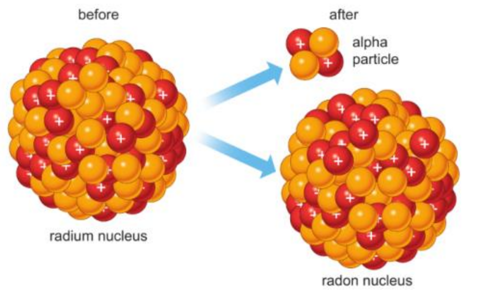
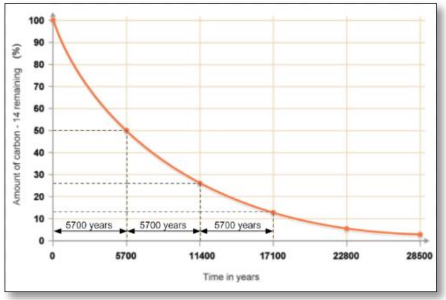
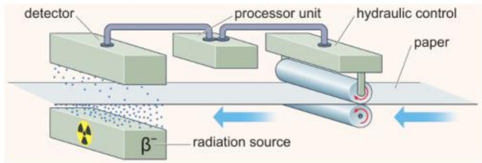
| 5. Types of radiation | |
|---|---|
| **Unstable atom** | An atom whose nucleus contains too much energy becomes unstable. |
| **Decay** | When an unstable atom releases its excess energy by changing. Releases ionising radiation. |
| **Alpha radiation** | Made of alpha particles: two protons and two neutrons. Symbol: α or $^{4}_{2}He$. |
| **Beta-minus radiation** | Made of beta particles: a fast-moving electron. Symbol: $\beta^-$ or $^{0}_{-1}e$. |
| **Beta-plus radiation** | Made of positrons: particles with same mass as electrons but a positive charge. Symbol: $\beta^+$ or $^{0}_{1}e$. |
| **Gamma radiation** | Extremely short wavelength / high frequency / high energy electromagnetic radiation. Symbol: γ. |
| **Neutron radiation** | Fast-moving neutrons. Symbol: n. |
| **Ionising power** | From most to least is alpha, beta gamma. |
| **Penetrating power** | From most to least is gamma, beta, alpha. |
| **Ionising vs penetrating power** | When the radiation ionises an atom it loses some of its energy. Alpha ionises particles most easily so loses it energy most quickly, and vice versa for gamma. |
| **Positrons** | the antiparticle or the antimatter counterpart of the electron |




| 6. Radioactive decay | |
|---|---|
| **Alpha decay** | Atomic number decreases by two, mass number decreases by four. |
| **Beta- decay** | Atomic number increases by one, mass number stays the same. |
| **Beta+ decay** | Atomic number decreases by one, mass number stays the same. |
| **Gamma decay** | Atomic number and mass number unchanged. |
| **Neutron decay** | Atomic number stays the same, mass number decreases by one. |
| **Writing nuclear equations** | - Write in what you know<br>- Balance the mass and atomic number<br>- Work out the symbols to match the numbers |

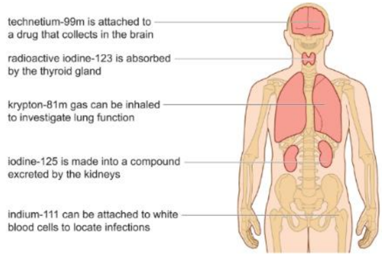



| 7. Half-life | |
|---|---|
| **Half-life** | The time taken for half of the undecayed atoms in a sample to decay. Stays constant for each isotope. |
| **Half-life and stability** | Less stable → shorter half-life<br>More stable → longer half-life |
| **Half-life and radioactivity** | Shorter half-life → more active<br>Longer half-life → less active |
| **Becquerels, Bq** | The unit of radioactivity: 1 Bq = one decay per second. |
| **Half-life graph** | x-axis = time, y-axis = radioactivity. The line curves downwards but never touches the x-axis. |
| **Determining half-life from a graph** | Pick two points on the y-axis, one half of the other, trace along to the line and down to the time. Half-life is the difference in the time. |
| **Calculations with half-life** | - Divide time by half-life to give a number of half-lives<br>- Forwards in time: halvings<br>- Back in time: doublings |




| 8. Using radioactivity | |
|---|---|
| **Irradiated** | expose (someone or something) to radiation. |
| **Sterilised** | make (something) free from bacteria or other living microorganisms. |
| **Radioactive tracer** | A chemical compound in which one or more atoms have been replaced by a radioisotope. |
| **Cancer** | A condition where cells in a specific part of the body grow and reproduce uncontrollably. |

| 9. Dangers of radioactivity | |
|---|---|
| **Mutations** | DNA damage caused by ionising radiation, can lead to cancer. |
| **Repairing damage** | Cells contain proteins that can repair DNA damage as long as the radiation dose is low enough. |
| **Minimising radiation risk** | - Wear protective clothing<br>- Handle with tongs<br>- Don't point at people<br>- Limit time<br>- Use protective shielding<br>- Wear dosimeter badges |
| **Nuclear power risks** | There is a small chance of accidents causing radioactive sources to escape |
| **Irradiation** | Exposure to radiation, stops when the source of radiation is removed. |
| **Contamination** | When particles of radioactive substances are on or in the body. |
| **Risks in perspective** | Using radioactivity carries serious risks, but so do many other things, so it is safe to use as long as it is treated with caution. |




| 10. Radioactivity in medicine | |
|---|---|
| **Gamma Cameras** | A device used to image gamma radiation emitting radioisotopes, a technique known as scintigraphy. |
| **Tumours** | A swelling of a part of the body, generally without inflammation, caused by an abnormal growth of tissue, whether benign or malignant. |
| **PET Scanner** | Detect the radiation given off by a substance injected into your arm called a radiotracer as it collects in different parts of your body. |
| **Internal radiotherapy** | Giving radiotherapy from inside your body. |
| **External radiotherapy** | Giving radiotherapy from outside your body. |

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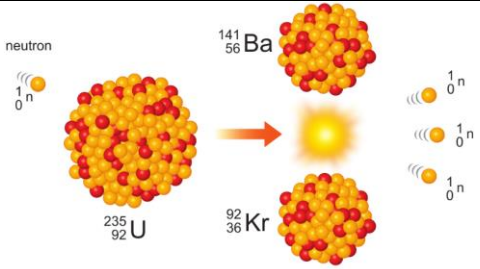
| 11. Nuclear energy | |
|---|---|
| **Nuclear fission** | A process in which the nucleus of an atoms split into two or more smaller, lighter nuclei, releasing a very large amount of energy. |
| **Nuclear fusion** | A process in which two or mor nuclei are combined to form one of more different atomic nuclei. Energy is produced as the atoms collide |
| **Non-renewable** | Not able to be renewed. |
| **Fossil fuels** | A natural fuel such as coal, oil or gas, formed from the remains of living organisms. |
| **Climate change** | A change in global or regional climate patterns, |
| **Decommission** | Make (a nuclear reactor) inoperative and dismantle it safely. |

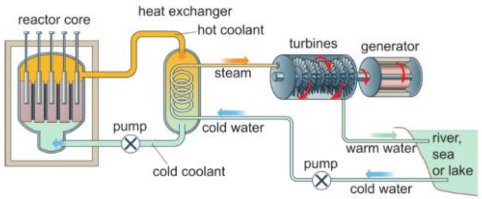
**Exam-style question**

Compare nuclear and fossil fuelled power stations in terms of any pollution they cause. *(3 marks)*

| 12. Nuclear fission | |
|---|---|
| **Daughter nuclei** | The two nuclei that result from the division of a single nucleus. |
| **Chain reaction** | A series of events, each caused by the previous one. |
| **Nuclear reactor** | An apparatus or structure in which fissile material can be made to undergo a controlled, self-sustaining nuclear reaction with the consequent release of energy. |
| **Fuel rods** | A rod-shaped fuel element in a nuclear reactor. |
| **Reactor core** | The portion of a nuclear reactor containing the nuclear fuel components where the nuclear reactions take place and the heat is generated. |

| | |
|---|---|
| **Moderator** | A material which slows down the neutrons. |
| **Control rods** | a rod of a neutron-absorbing substance used to vary the output power of a nuclear reactor. |




| 13. Nuclear fusion | |
|---|---|
| **Electrostatic repulsion** | Repulsion of electrostatically charged bodies for each other. |
| **Fusion reactors** | (also called a fusion power plant or thermonuclear reactor). A device to produce electrical power from the energy released in a nuclear fusion reaction. |