P7 Radioactivity Knowledge Organiser (Triple)

PT38.1

Radioactive decay	•The nuclei of atoms contain protons and neutrons •Radioactive nuclei are unstable due to the balance of protons and neutrons. They decay (break down) by releasing nuclear radiation to become stable. •A random process- we can't predict or change how it happens.
Nuclear radiation	•Radiation released when radioactive substances decay •There are three kinds: alpha (α), beta (β) and gamma (γ) •The three types of nuclear radiation have different properties
Discovering the nucleus	•Rutherford fired α particles at gold foil. Most went straight through, some were deflected slightly and a few were deflected by more than 90^o •Alpha particles are positively charged so something positively charged in the gold atoms must have been deflecting them. •Rutherford concluded that most of the mass of an atom must be located in the centre in a positively charged nucleus. •The plum pudding model of the atom said that the atom was a positively charged sphere with electrons dotted around inside it. Rutherford's discoveries showed that this couldn't be correct.
Atomic number, Z	•The number of protons in the nucleus of an atom. •Sometimes called the proton number •Usually the smaller number next to the element symbol in the periodic table
Mass number, A	•The number of protons + the number of neutrons in the nucleus of an atom •Usually the bigger number next to the element symbol in the periodic table •No of neutrons in a nucleus = Mass number – Proton number
Isotope	•Atoms of the same element with the same number of protons but a different number of neutrons •Same atomic number, different mass number

Alpha radiation	•A helium nucleus. •An alpha particle has a mass of 4 and a charge of +2. •When a nucleus decays and emits an alpha particle, the mass number of the original nucleus goes down by 4 and the atomic number goes down by 2. •The decay equation for alpha decay is •Alpha radiation is the most ionising nuclear radiation •Stopped by paper/skin (least penetrating) •Range of a few cm in air
Beta radiation	•A fast moving electron •Negatively charged •Zero (or negligible) mass •When a nucleus decays and emits a beta particle, the mass number stays the same but the proton number increases by 1 as a neutron changes into a proton. •The decay equation for beta decay is •Beta radiation is less ionising that alpha but more ionising than gamma •It is stopped by thin aluminium (second least penetrating) •Range of around a metre in air
Gamma radiation	•A wave of electromagnetic radiation •No charge as it is a wave •No mass as it is a wave •When a nucleus decays and emits a gamma wave, the mass number and atomic number stay the same. •Gamma radiation is the least ionising nuclear radiation •Mostly absorbed by thick lead •Unlimited range in air
Half life	•The average time taken for count rate of a radioactive isotope (or the number of radioactive nuclei) to fall by half. •Half life can be found using a decay curve graph . Find half the initial count rate on the y-axis, draw across to the curve then draw down and read the time off the x-axis. •Count rate after *n* half-lives = initial count rate ÷ 2^n

Radioactive Tracers	•Trace the flow of a substance through an organ •The tracer emits gamma radiation as these are penetrating enough to be detected outside the body. •Radioactive iodine is used to check if the kidneys are working properly. •Radioactive iodine is used because it has a half life of eight days, it emits gamma radiation and it decays into a stable isotope.
Gamma camera	•This images internal organs •The patient is injected with an isotope that emits gamma radiation. The isotope is absorbed by the organs and detected by the gamma camera. •The isotope used needs to have a half-life long enough to allow the image to be taken but must have a short half-life so that it decays quickly.
Gamma beam	•This is a narrow beam of gamma radiation used to destroy tumours without surgery •The gamma radiation is emitted by a radioactive isotope of cobalt
Radioactive implants	•A tiny rod or seed of a radioactive isotope is implanted in a tumour to kill cancerous cells. •The isotope is a beta or gamma emitter. •The half life needs to be long enough so that the cancer cells get irradiated but short enough that the isotope decays soon after treatment is finished.
Nuclear fission	•When the nucleus of an atom splits apart into two smaller nuclei and two or three neutrons. Energy is also released.
Induced fission	•This is when a nucleus absorbs a neutron, causing is to become unstable. •The nucleus breaks down into two smaller nuclei and two or three neutrons are released •Nuclear reactors use the fission of Uranium-235 or Plutonium-239
Spontaneous fission	•When a fission happens to a nucleus without it absorbing a neutron first •Rare!

Chain reaction	•When the neutrons released from fission collide with other nuclei, causing them to undergo fission. •Each fission event causes further fission events..
Nuclear reactor	•Uses the chain reaction of fission to release energy from Uranium-235 or Plutonium-239 •The nuclear energy released heats water in a heat exchanger. •The reactor core has the fuel rods, control rods and water at high pressure. The fission neutrons collide with the water molecules, slowing them down. The water acts as a moderator. •Control rods are used to stop the reaction from going out of control •The control rods absorb neutrons so that on average only one neutron from each fission event goes on to cause more fission.
Nuclear fusion	•When two nuclei are forced together to produce a single, larger nucleus. •Energy is released as some of the mass of the small nuclei is converted into energy •The nuclei need to be moving very fast for fusion to occur. •Nuclear fusion happens in stars
Background radiation	•Natural sources: rocks and cosmic rays •Man-made sources: nuclear fallout and nuclear accidents •Varies due to location •Radon gas causes a lot of the background radiation in the air. It seeps into houses through the ground. It is an alpha source.