



Box 1: Keywords

Activity	The rate at which a source of unstable nuclei decays	Fission	The splitting of a large atomic nucleus into smaller nuclei.
Background Radiation	The radiation that is present all around in the environment. There is some radiation from natural sources such as: Rocks. Cosmic rays from space.	Fusion	When two small, light nuclei join together to make one heavier nucleus.
Beta	If the nucleus has too many neutrons, a neutron will turn into a proton and emit a fast-moving electron. This electron is called a beta (β) particle.	Gamma	High energy electromagnetic waves emitted from unstable nuclei.
Chain reaction	A process in which neutrons released in fission produce an additional fission in at least one further nucleus.	Geiger Muller tube	A device that detects radiation. It creates an electrical signal each time radiation is detected.
Contamination	Occurs when an object is exposed to a source of radiation outside the object.	Half Life	The time it takes for half of the unstable nuclei in a sample to decay or for the activity of the sample to halve or for the count rate to halve.
Count rate	Count-rate is the number of decays recorded each second by a Geiger-Muller tube.	Radioactive decay	The process of emitting particles or waves of energy from an unstable nucleus.

Type	Change in nucleus	Ionising power?	Range in Air	Stopped by	Decay Equation
Alpha particle: 2 protons, 2 neutrons	Loses 2 protons & 2 neutrons	Highest	A few cm	Sheet of paper	${}^A_ZX \rightarrow {}^{A-4}_{Z-2}Y + {}^4_2\alpha$
Beta particle: fast moving electron	Neutron changes into a proton and an electron	High	1 metre	A few mm of Aluminium	${}^A_ZX \rightarrow {}^A_{Z+1}Y + {}^0_{-1}\beta$
Gamma radiation: high frequency EM wave	Some energy transferred away from nucleus	Low	Almost no limit	Several cm of lead or thick concrete	${}^A_ZX \rightarrow {}^A_ZX + {}^0_0\gamma$

Activity & Count Rate:

Activity is the rate of decay of an unstable nucleus, measured in **Becquerels (Bq)**.

1 Bq = 1 decay / sec

Geiger-Muller tubes record a count rate (decays per sec).

Count rate after n half lives =

$$\frac{\text{Initial count rate}}{2^n}$$

Key skills: predict changes using decay equations; calculate half-life.



Half Life:

the time for half the number of unstable nuclei to decay, **or** for the count rate or activity to halve. This can be found from a graph of count rate against time.

Nuclear Radiation in Medicine:

Gamma emitting **tracers** are injected/swallowed by a patient. Gamma cameras can then create an image showing where the tracer has gone. The half-life of the tracer must be short enough so that most of the nuclei will decay shortly after the image is taken to limit the patient's radiation dose (normally about 6 hours).

Control/Destroy unwanted tissue:

Narrow beams of gamma radiation can be focussed to destroy tumour cells. Used as it can penetrate tumours from outside the body. Beta or gamma emitting implants can be placed inside/next to tumours. Half-life must be long enough to be effective, short enough to not irradiate the patient after treatment.

Irradiation v Contamination

Irradiation

When an object is exposed to nuclear radiation

Contamination

When atoms of a radioactive material are in or on an object

Cause harm through ionisation

Prevented by shielding, removing, or moving away from the source of radiation

Object remains exposed to radiation as long as its contaminated; contamination can be very difficult to remove.

Protecting:

Maintain a safe distance from the radiation source.

Limiting time near the source;
Shielding from the radiation.

Cross curricular links

Ionising Radiation:

Living cells can be killed or damaged by Ionising Radiation. Risk depends on the half-life of the source and the type of radiation.

Alpha radiation is very dangerous inside the body because it affects all the surrounding tissue. Outside the body it only affects the skin and eyes because it cannot penetrate skin. Beta and gamma are dangerous in and outside of the body as they penetrate tissue.

Radiation Dose:

Measured in Sievert (Sv), measures the health risk of exposure to radiation. It depends on the type and amount of radiation.

Background Radiation:

Radiation all around us: Rocks emit Radon gas; Cosmic rays from space penetrate the atmosphere. Nuclear weapons and accidents release harmful radiation.

Nuclear Fission:

When a large unstable nucleus absorbs an extra neutron it splits into two smaller nuclei of roughly equal size.

During nuclear fission:

gamma radiation is emitted and energy is released.

Two or three neutrons are emitted that can go on to cause a **chain reaction**.

The chain reaction in a power station is controlled by absorbing neutrons, Nuclear explosions are uncontrolled chain reactions.

On rare occasions an unstable nucleus splits apart without absorbing a neutron. This is called spontaneous fission.

Nuclear Fusion:

This is when two light nuclei join to make a heavier one.

Some of the mass is converted to energy and transferred as radiation.

Previous knowledge: atomic structure; EM radiation

Future links: The EM spectrum.

Careers: Radiology, Nuclear Engineer.