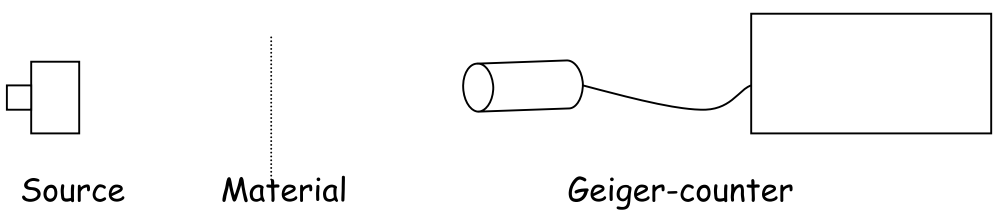
Radioactivity

1. Radioactive Emissions

- Radioactivity (alpha particles, beta particles and gamma rays)
- Some atoms have unstable nuclei. **(HIGHER ONLY The nucleus is unstable because of an imbalance between the numbers of protons and neutrons.)**
- Background radiation - all around us - from hospitals, industry, nuclear power stations, space, rocks, food
- Radioactive gas, radon, seeps out of rocks and builds up in the houses - causes lung cancer. A special space below the house, like cellar, is created. It has vents to the outside and fans inside blow the radioactive gas out of the space to prevent it building up. Also opening doors and windows prevents too much building up inside.
- Radioactivity - detected using a Geiger-Counter.
- Measured in counts per minute (cpm).
- Place a radioactive source or sample in front of a Geiger-Counter.



Make a note of the count rate, now place different thicknesses and types of material in between and observe the effect on the count rate.

Paper – count rate drops paper absorbs all alpha particles

A few mm of aluminium foil – count rate drops aluminium absorbs all beta particles

Several cm of lead – count rate drops lead absorbs some gamma particles

Summary – alpha least penetrating, then beta particles with gamma rays being most penetrating.

2. Properties of radioactive emissions

Type of emission	Penetrating Power	Charge	What its made of	Mass
Alpha	Few cm of air, stopped by paper	2+	4 particles (2 protons 2 neutrons)	Same as helium nucleus
Beta	Stopped by a few mm of aluminium	1-	Electron from the nucleus	Same as electron
Gamma	Reduced by several cm of lead	0	Electromagnetic wave	No mass

3. Ionising properties and penetration

Alpha particles –

- very ionising (charge of 2+)
- much damage to cells if absorbed
- most dangerous in direct contact with body eg., touched by hands, swallowed or inhaled
- protect yourself - step back so there is a few cm of air in between - cover yourself

Beta particles –

- less ionising (charge of 1-)
- some damage to cells if absorbed
- protect yourself –cover with foil several mm thick

Gamma rays –

- least ionising (no charge)
- very energetic rays so still
- cause some damage when absorbed
- very penetrating so fewer are absorbed by the body (a large amount pass through)
- very hard to shield yourself because even several metres of concrete will not completely stop gamma rays.

Remember damage to cells is only done when the radiation is absorbed. Deeper penetration means that the cells of internal organs can be damaged. Damage can lead to cancer.

4. **Protection for Medical Staff Using Radiation**
    - Limit time using the source
    - Keep source at arms length, handle with tongs
    - Wear clothing impregnated with lead
    - Wear gloves and face mask
    - Monitor exposure by wearing badges that detect amount of radiation

5. **Treatment for cancer**

    Gamma rays are used to kill cancer cells. It will also kill healthy cells and this can make the patient more ill. To minimise damage to healthy cells the gamma rays are focussed on the cancer. Then the beam is moved round the patient so it passes through the healthy cells for a short time but remains centred on the cancer cells all the time.

    The cancer cells receive a high dose that kills them, the healthy cells get a short dose that does not cause them to become cancerous. This still makes the patient quite ill. **Is it right to use this treatment on someone who has had surgery to remove some of the cancer but is feeling unwell?**

6. **Half Life of Radioactive Materials**

    This is the time it takes for the activity of a radioactive element to become half of its original value - learn this!

    The really strange thing about the half life is that it does not matter what the starting activity is, it always takes the same length of time for the activity to halve.

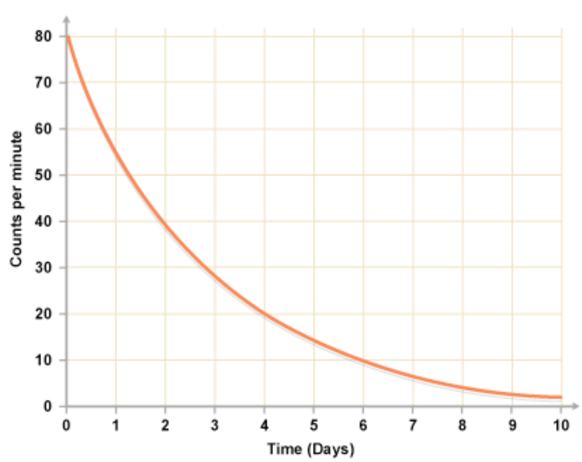
Example:

i) Technetium-99 has an activity of 800 counts per minute (cpm), after 6 hours the activity has become 400cpm, so the half life is 6hours. It will always become half after 6h, so 400 down to 200 takes 6h, 200 to 100 in 6h.

ii) If we include a background count (from rocks, cosmic rays, nuclear testing etc) of 100cpm then the actual readings above become 900cpm down to 500 cpm. To fond the activity due to the sample remove the background count first so 900-100=800, 500-100=400.

iii) A radioactive sample has an activity of 1800cpm and a half life of 3h. If the background count is 200cpm what is the activity after 3h? How long will it take to reach an activity of 100cpm?
For answer see bottom of next page.

A graph of the activity against time looks like this. Its known as a decay curve.



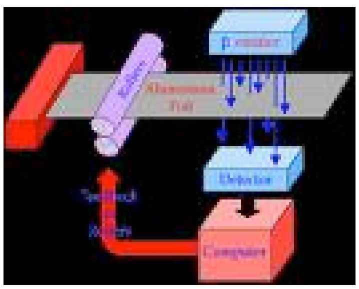
For the sample above what is the value of the half life?
ANSWER
Starting activity is 80cpm when the time is 0. To find the half life read the number of days it takes to get to 40cpm. **Answer=2days**

Try this for any pair of values eg., 60 and 30, 40 and 20, it should take 2 days each time.

Answer to previous page: 1800 – 200 = 1600cpm, after 3h it will half this or 800cpm, 1600 has to halve 4 times to get to 100cpm (1600 – 800, 800 – 400, 400 – 200, 200 – 100) therefore 4 times 3h = 12h

7. **Contemporary uses of radioactive materials – read the following, especially the first 4!**

Thickness Control



Eg paper mills,

- Beta particles pass through paper to detector.
- Thicker paper – fewer counts per minute(cpm) – increase pressure – paper thinner
- Thinner paper – more cpm – release pressure - thicker
- Paper, plastic, aluminium foil,
- beta rays are used
- alpha completely stopped
- all gamma passes through

Radioactive Dating

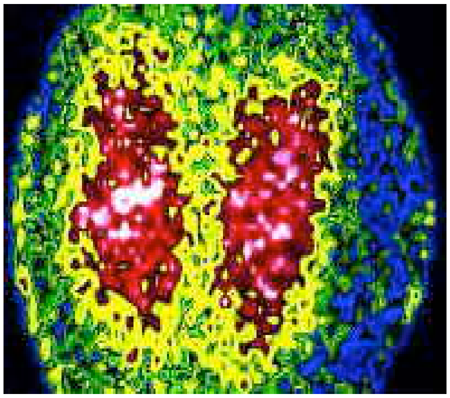
Animals and plants have a known proportion of Carbon-14 (a radioisotope of Carbon) in their tissues.

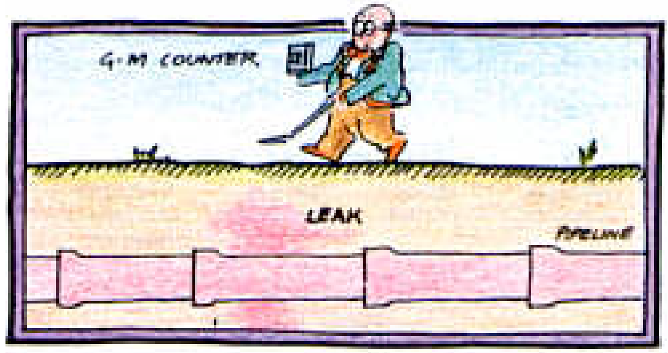
When they die they stop taking Carbon in, then the amount of Carbon-14 goes down at a known rate (Carbon-14 has a half-life of 5700 years).

The age of the ancient organic materials can be found by measuring the amount of Carbon-14 that is left.

If 1/2 is left then it has been dead 5 700 yrs, if _ then 11 400 yrs (twice as long)

Radioactive Tracers





The most common tracer is called Technetium-99 and is very safe because it only emits gamma rays and doesn't cause much ionization.

Radioisotopes can be used for medical purposes, such as checking for a blocked kidney.

To do this a small amount of Iodine-123 is injected into the patient, after 5 minutes 2 Geiger counters are placed over the kidneys.

Also radioisotopes are used in industry, to detect leaking pipes. To do this, a small amount is injected into the pipe. It is then detected with a GM counter above ground.

Smoke Detectors

Smoke alarms contain a weak source made of Americium-241.

Alpha particles are emitted from here, which ionize the air, so that the air conducts electricity and a small current flows.

If smoke enters the alarm, this absorbs the alpha particles, the current reduces, and the alarm sounds.

Am-241 has a half-life of 460 years.

Checking Welds

If a gamma source is placed on one side of the welded metal, and a photographic film on the other side, weak points or air bubbles will show up on the film, like an X-ray.

Sterilising

Even after it has been packaged, gamma rays can be used to kill bacteria, mould and insects in food.
This process prolongs the shelf-life of the food, but sometimes changes the taste.
Gamma rays are also used to sterilise hospital equipment, especially plastic syringes that would be damaged if heated.

8. **Disposing of Radioactive Waste**

Remember these key points

- The radioactive materials have long half lives – they emit radioactivity for hundreds and thousands of years
- Storage has to withstand earthquakes, corrosion due to weathering to prevent leakage
- Leaks can get into the water system and cause cancer to those living in the area
- Leaks can get into the soil and the food chain again causing damage to the cells of living things
- Can become a target for terrorism
- No one will want this stored near them