# Chapter 23. Radioactivity

**Contents:**



## 5.2 Radioactivity

### 5.2.1 Detection of radioactivity

Core

1 Know what is meant by background radiation

2 Know the sources that make a significant contribution to background radiation including:
(a) radon gas (in the air)
(b) rocks and buildings
(c) food and drink
(d) cosmic rays

3 Know that ionising nuclear radiation can be measured using a detector connected to a counter

4 Use count rate measured in counts / s or counts / minute

Supplement

5 Use measurements of background radiation to determine a corrected count rate

### 5.2.2 The three types of nuclear emission

Core

1 Describe the emission of radiation from a nucleus as spontaneous and random in direction

2 Identify alpha ($\alpha$), beta ($\beta$) and gamma ($\gamma$) emissions from the nucleus by recalling:
(a) their nature
(b) their relative ionising effects
(c) their relative penetrating abilities ($\beta^+$ are not included, $\beta$-particles will be taken to refer to $\beta^-$)

Supplement

3 Describe the deflection of $\alpha$-particles, $\beta$-particles and $\gamma$-radiation in electric fields and magnetic fields

4 Explain their relative ionising effects with reference to:
(a) kinetic energy
(b) electric charge

### 5.2.3 Radioactive decay

**Core**

1 Know that radioactive decay is a change in an unstable nucleus that can result in the emission of $\alpha$-particles or $\beta$-particles and/or $\gamma$-radiation and know that these changes are spontaneous and random

2 State that during $\alpha$-decay or $\beta$-decay, the nucleus changes to that of a different element

**Supplement**

3 Know that isotopes of an element may be radioactive due to an excess of neutrons in the nucleus and/or the nucleus being too heavy

4 Describe the effect of $\alpha$-decay, $\beta$-decay and $\gamma$-emissions on the nucleus, including an increase in stability and a reduction in the number of excess neutrons; the following change in the nucleus occurs during $\beta$-emission

neutron $\rightarrow$ proton + electron

5 Use decay equations, using nuclide notation, to show the emission of $\alpha$-particles, $\beta$-particles and $\gamma$-radiation

### 5.2.4 Half-life

**Core**

1 Define the half-life of a particular isotope as the time taken for half the nuclei of that isotope in any sample to decay; recall and use this definition in simple calculations, which might involve information in tables or decay curves (calculations will not include background radiation)

**Supplement**

2 Calculate half-life from data or decay curves from which background radiation has not been subtracted

3 Explain how the type of radiation emitted and the half-life of an isotope determine which isotope is used for applications including:

(a) household fire (smoke) alarms

(b) irradiating food to kill bacteria

(c) sterilisation of equipment using gamma rays

(d) measuring and controlling thicknesses of materials with the choice of radiations used linked to penetration and absorption

(e) diagnosis and treatment of cancer using gamma rays

### 5.2.5 Safety precautions

**Core**

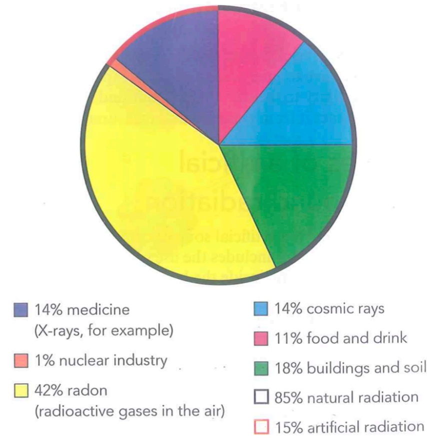
1 State the effects of ionising nuclear radiations on living things, including cell death, mutations and cancer

2 Describe how radioactive materials are moved, used and stored in a safe way

**Supplement**

3 Explain safety precautions for all ionising radiation in terms of reducing exposure time, increasing distance between source and living tissue and using shielding to absorb radiation

# 23.1 Radioactivity all around us



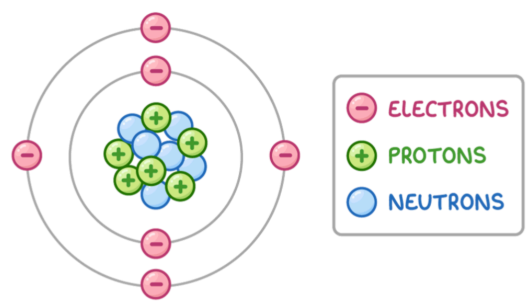

**Background radiation:**
Natural:

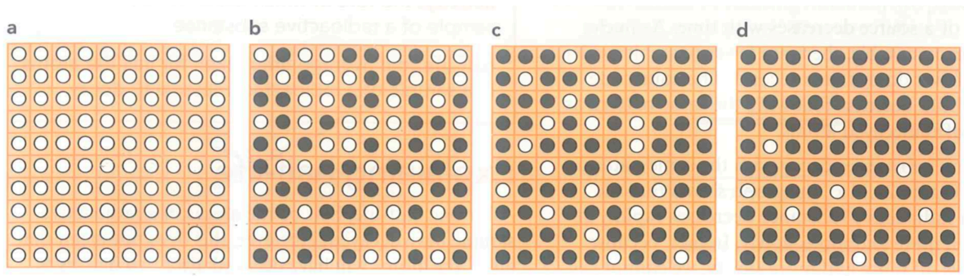
Measurement of radiation:
Unit:

# 23.2 Radioactive Decay

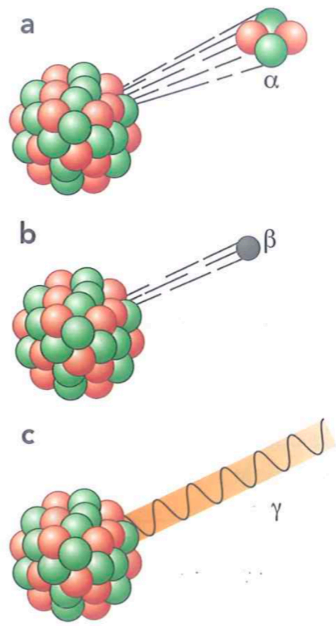
**Radioactive decay**:

**Random:**
**spontaneously:**

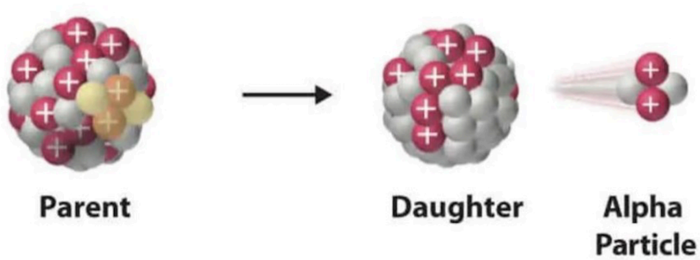


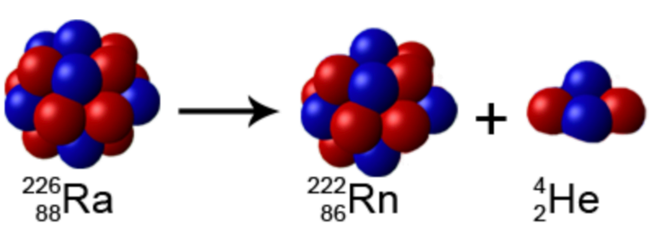
**Three types of radiation:** alpha particle, beta particle, gamma radiation




**a. Alpha Decay:** emits alpha particle(helium nucleus/ 2p + 2n)

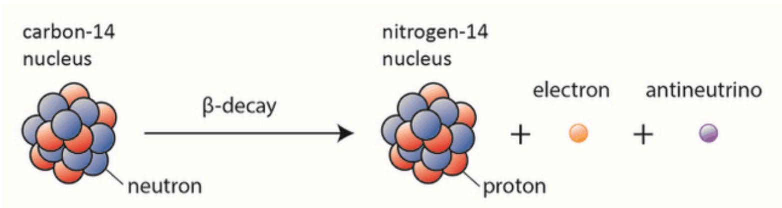



Nucleon number, proton number, charge are conserved.




- A new element is formed, with an atomic number 2 less than before, mass number is 4 less than before.

**b.beta decay(minus)**
A neutron in decaying **<u>nucleus</u>** turns into a proton, emitting an electron(beta particle) and an antineutrino.



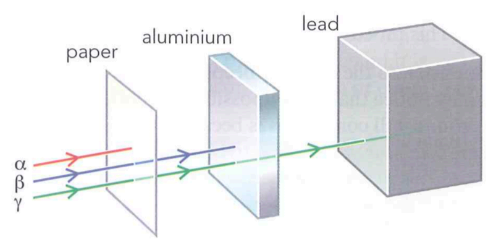

A new element is formed, with an atomic number 1 more than before. The mass number is unchanged.

**c. Gamma radiation**
Release energy in the form of EM wave(gamma ray);
along with alpha/beta decay.
no mass, no charge.

## Comparing three radiations

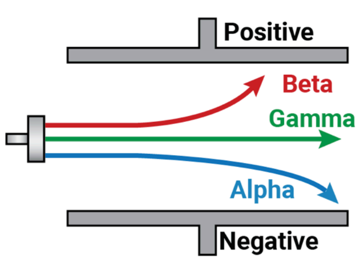
| Name | Symbol | Made of | Mass | Speed/m/s |
|---|---|---|---|---|
| alpha | α | 2 protons + 2 neutrons | approx. (mass of proton) × 4 | $\sim 3 \times 10^7$ |
| beta | β | an electron | approx. (mass of proton) ÷ 1840 | $\sim 2.9 \times 10^8$ |
| gamma | γ | electromagnetic radiation | 0 | $3 \times 10^8$ |

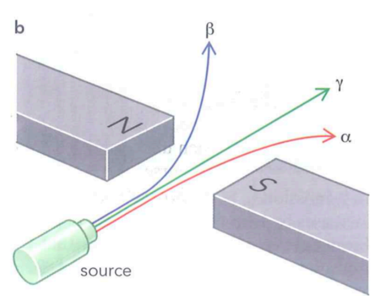
**Ionization:**
highest:
lowest:
**Penetration:**
highest:
lowest:




Using Geiger counter at different distance with different blockers to differentiate three radiations.

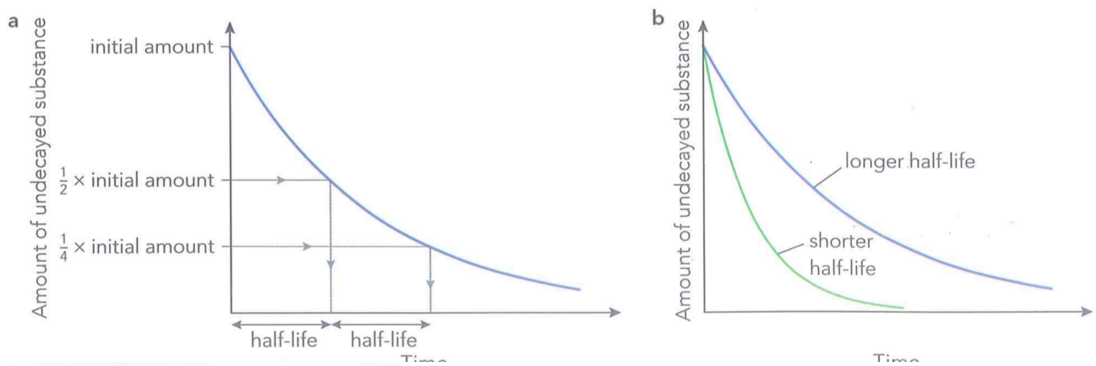
In Electric/Magnetic Field:



# 23.3 Activity and Half-life

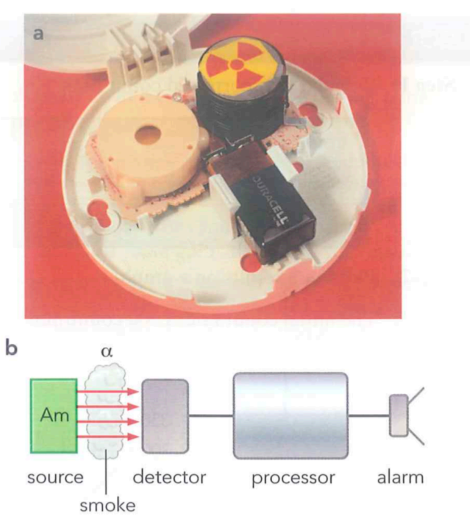
**half life:**



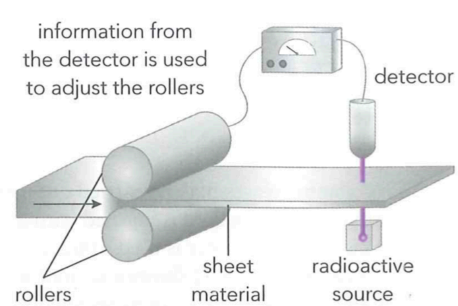

| Time / min | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|---|
| Count rate / count/min | 330 | 230 | 165 | 120 | 92 | 70 | 56 |
| Corrected count rate / count/min | 300 | 200 | 135 | 90 | 62 | 40 | 26 |

Corrected count rate =
Background radiation has to be **subtracted** before attempting to perform half-life calculations!!!

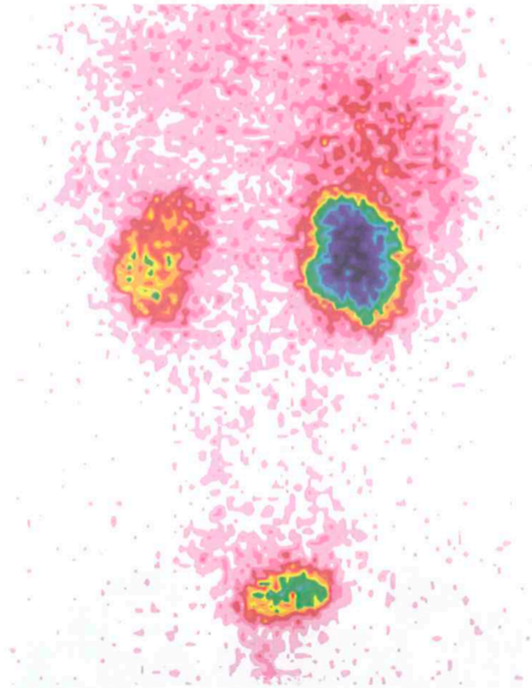
# 23.4 Using Radioisotopes




Smoke detectors

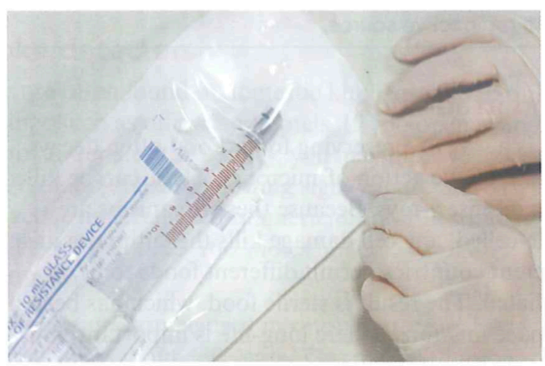



Thickness monitoring



Cancer treatment &
Diagnose


Food irradiation & Sterilization



Fault detection

Exposure to radiation can destroy living cell membranes by ionisation, causing the cells to die, or damage DNA which causes mutations that could lead to cancer.

**Safety measures include:**