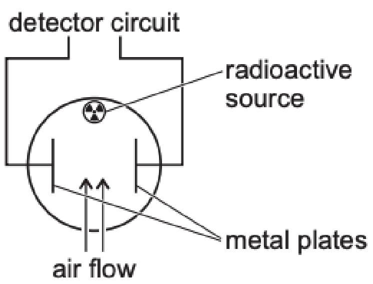
1. **Iodine-131 emits γ-radiation. It has a half-life of 8 hours. Explain why this emission and this half-life make iodine-131 a suitable material for a tracer in medical diagnosis.**
    - γ can be detected outside body
    - needs long enough half-life to be detected / reach part of the body required
    - needs short enough half-life to soon have very little activity
    - gamma weakly ionising or pass out of body without harm

2. **Describe composition and structure of neutral atom of uranium-235 (atomic no = 92)**
    - (very small) nucleus and surrounded by electrons (in orbit / shells) B1
    - 92 protons or 92 electrons or number of protons = number of electrons B1
    - protons and neutrons in nucleus B1
    - 143 neutrons

3. **How americium-241 used in smoke detectors ionises air**
    - alpha particles emitted from americium
    - move close to / hit molecules in the air between the metal plates
    - removing electrons out of the molecules



4. **Why smoke detectors use an isotope that emits α-particles rather than γ-radiation.**
    - alpha (particles) more highly ionising (than gamma) AND ionise air more easily
    - alpha not penetrating / short range AND alpha particles stopped by smoke particles
    - range of alpha particles is short / not penetrating AND alpha less harmful to humans

5. **Nuclear fission**
    - large unstable nucleus OR neutrons hit nucleus OR neutrons are released (from nucleus)
    - (large) nucleus splits (into smaller nuclei)
    - (large) release of energy

6. **Advantages of generating energy using nuclear power stations than wind turbines**
    - continuous supply of energy
    - not affected by the weather OR not affected by wind strength

- produces large amounts of energy

7. **Disadvantages of generating electricity using nuclear power stations than wind turbines**
   - resources finite / not renewable
   - cost / difficulty of building / cost / difficulty of decommissioning
   - danger if any leak of radiation
   - produces hazardous / dangerous waste OR difficulty of storage of used radioactive material OR nuclear waste must be stored for a long time

8. **Sources of background radiation**
   - rocks, buildings, soil, Earth,
   - space, cosmic rays, Sun,
   - radon, nuclear waste, weapons testing

9.

A radiation detector is set up in a laboratory where there are no radioactive samples.

On **six** separate occasions, the detector is switched on for 1.0 minute and the background count is recorded. The counts are:

23 27 25 24 20 25

State why the readings are not all identical.
Because background radiation is random

A sample containing only one radioactive isotope is brought into the laboratory. The half-life of the isotope is 15 hours. The sample is placed near to the radiation detector in this laboratory. The detector is switched on and, after 1.0 minute, a count of 440 is recorded. The sample is left next to the detector and the experiment is repeated 45 hours later. The detector is switched on for 1.0 minute. Predict the reading for the count obtained on this occasion.

- Background radiation = (23+27+25+24+20+25) / 6 = 24
- 440 - 24 = 416
- 45/15 = 3 half lives
- $416 (1 - ½)^3 = 52$
- 52 + 24 = 76 counts

10. **How radioactive isotopes are handled, used and stored in a safe way.**
    - Use of tongs & gloves while handling
    - Wear protective clothing

- Minimise exposure by time OR distance
- Monitor exposure
- Shielded storage: lead-lined boxes
- Secure storage
- Should be accessed only by approved personnel
- Must be disposed of securely

11. Economic & environmental consequences of producing radioactive waste with half lives of many thousands of years.

- expensive to store
- must be stored with shielding
- must be stored securely / safely
- expensive to transport
- must be transported with shielding
- must be transported securely
- in case of accident / terrorism could escape to environment / danger to people
- site of storage uninhabitable for thousands of years

12.

Fig. 9.1 shows a beam of α-particles moving towards a thin sheet of gold in a vacuum.

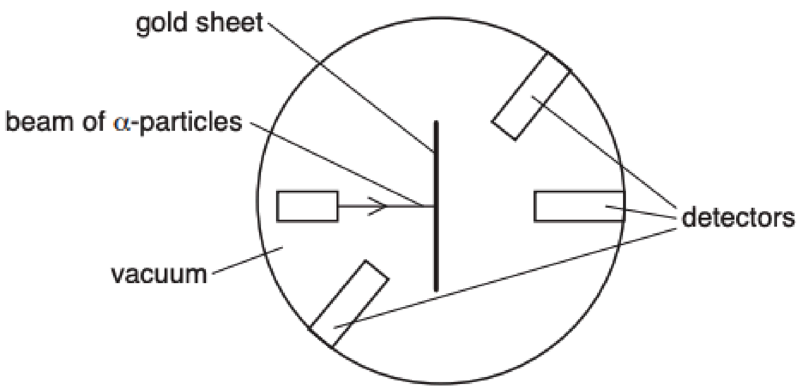


Fig. 9.1

Detectors in the region surrounding the thin gold sheet detect the α-particles and determine the number of particles that travel in various directions.

State and explain what can be deduced from the following observations.

The majority of the α-particles pass through the gold sheet undeflected and are detected on the far side.

Deduction: nucleus is very small

Explanation: very few α-particles hit or pass near to a nucleus

A small number of α-particles are deflected as they pass through the gold sheet.
Deduction: nucleus is charged
Explanation: (charged) α-particles experience a force

A very small number of α-particles are deflected through very large angles or return back the way they came.
Deduction: centre / (small) part of atom OR nucleus includes most of the mass of the atom / is (very) dense
Explanation: (α-particles move and) nucleus stays still

13. **A beam that consists of both α-particles and β-particles is passed through a region of space where there is a magnetic field perpendicular to the direction of the beam. State two ways in which the deflection of the α-particles differs from that of the β-particles.**
    - opposite direction
    - (much) smaller deflection
    - undergo deflections of similar magnitude

NOTE:
- Relative charge on alpha particle = 2+
- Magnitude of charge on alpha particle = $2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ C

14.

A cloud chamber can be used to detect α (alpha)-particles and β (beta)-particles. Alcohol in the cloud chamber exists as a vapour and condenses on ions produced in the air. This forms visible tracks.

Fig. 10.1 shows the tracks when a source of α-particles and β-particles is present in the cloud chamber.

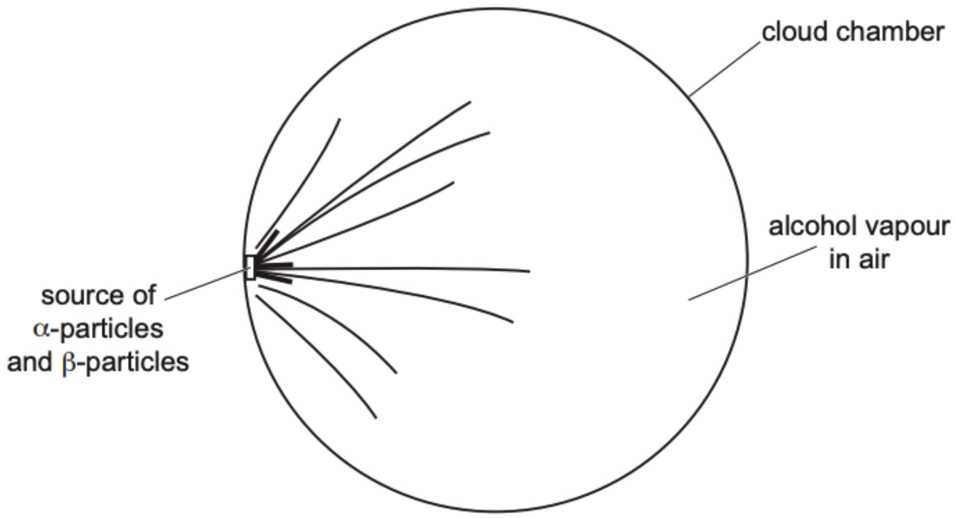


Fig. 10.1

Some of the tracks are short and thick. Other tracks are longer and thinner.

State and explain which tracks are produced by α-particles and which tracks are produced by β-particles.

- α particles are short and thick / β particles are long and thin

any two from:

- α particles are more ionising / β particles are less ionising
- α particles are less penetrating or have shorter range / β particles are more penetrating or have longer range
- α particles have more energy / β particles have less energy

15. In a nuclear fusion reactor, a nucleus of hydrogen-2 fuses with a nucleus of hydrogen-3 at an extremely high temperature. Explain why an extremely high temperature is needed when forcing these 2 nuclei together

- (high temperature produces) high (kinetic) energy / momentum / speed / ability to do large quantity of work
- they repel each other
- are positively charged / have like charges or need to come close together

16.

An experiment takes place in a laboratory shielded from all background radiation. A sample of radioactive material is wrapped in aluminium foil of thickness 0.1 mm. A detector of ionising radiation placed 1 cm from the foil records a reading.

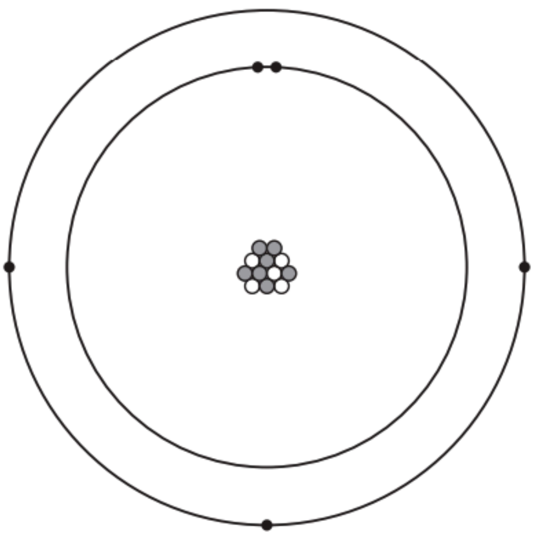
A piece of aluminium of thickness 5 mm is placed between the detector and the foil. The detector reading drops to zero.

State and explain any type of radiation passing through the aluminium foil.

- β
- β (would be) stopped by 5 mm / thick Al B1
- α (would be) stopped by 0.1 mm Al / Al foil AND γ – (would) not (be) stopped by 5 mm / thick Al

17.

Fig. 9.1 represents all the particles in a neutral atom of a radioactive isotope X1.



The radioactive isotope decays by beta emission to form X2

Describe how a nucleus of X2 differs from a nucleus of X1

(X2 has) one more proton more <u>and</u> one fewer neutron (than X1)

Suggest why isotope of X2 is stable whereas X1 is not stable

(X2) has fewer (excess) neutrons (in its nucleus)

18. Define the term half-life.

- time (taken)
- for number of (radioactive) nuclei / atoms (in a sample of X1) to halve OR for rate of decay to halve

19. **State a reason why isotopes with very short half-lives are especially hazardous**
large number of particles produced in short time OR high / large decay rate OR high dose (of radiation) in short time

20. **Explain why α are more strongly ionising than β particles**
    - They have more charge
    - They have more kinetic energy

21. **The isotope of neptunium produced by americium-241 is radioactive. The decay of this isotope of neptunium produces an isotope of protactinium which decays by β-emission. β-particles are more penetrating than α-particles. The half-life of neptunium is longer than two million years. Using this information, explain the advantage of this long half-life for the use and safe disposal of a household smoke alarm, which contains americium-241.**

    Benefits of using long half-life
    - Low(er) (initial) activity OR Few emissions per unit time
    - so smoke detectors are not hazardous to humans OR disposal of old detectors is cheap / easy