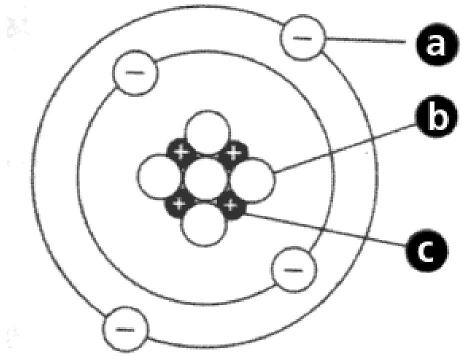
A. Atomic structure – Atoms and isotopes

1. a) The diagram shows an atom of Beryllium. Name the parts labelled a, b and c. (3)



electron (1)

neutron (1)

proton (1)

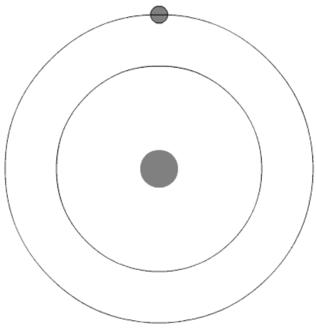
b) What is the atomic mass of this atom? (1)

Atomic mass = 9 (1)

c) Which parts make up the nucleus of the atom? (2)

b neutrons (1) **c protons (1)**

2. The diagram shows an electron orbiting the nucleus of an atom.



Under certain conditions the electron may fall into an orbit closer to the nucleus.

Explain what is likely to result from this event. (2)

Electron will release energy (1)

As a photon of radiation. (1)

3. The diagram represents an atom of sodium.

$^{23}_{11}Na$

   a. Use this information to calculate the number of:

   Protons, **11 (1)** Neutrons **12** (1) and Electrons **11 (1)** (3)

   b. What is the overall electrical charge of this atom? (1)

   Neutral (1)

4. Two isotopes of the element carbon are:

$^{12}_{6}C$ $^{14}_{6}C$

Complete the table of information for these two isotopes. (5)

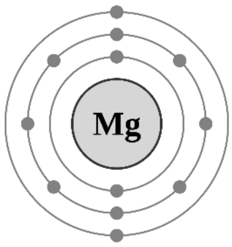
Isotope	Atomic Number	Mass Number	Number of Protons	Number of Neutrons
$^{12}_{6}C$	**6**	**12**	**6**	6
$^{14}_{6}C$	**6**	14	6	**8**

5. The diagram represents an atom of magnesium.

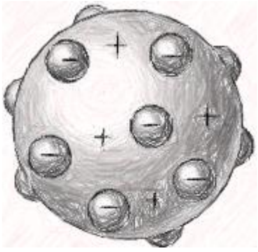
   What will happen to this atom if it is to become an ion of magnesium? **(1)**

   The magnesium must lose electrons. (1)

magnesium 2,8,2

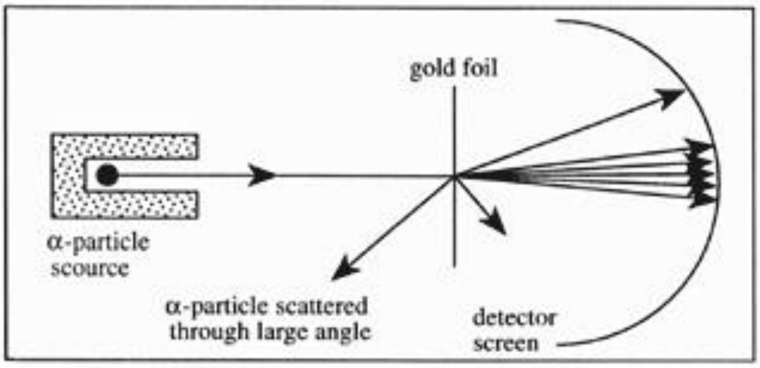


6. The diagram below represents the "plum pudding" model of the atom.
   Around 1911, this model of the atom was modified.
   How does the modern atomic model differ from this model of the atom? (3)



Modern atomic model is not a solid sphere. (1)
Most of the modern atom is empty space with a central nucleus. (1)
Electrons orbit the nucleus in clearly defined energy levels. (1)

7. The diagram shows Rutherford's experiment where alpha (α) particles are fired at a thin layer of gold atoms. The majority of the alpha particles pass straight through the gold foil without being deflected.



   a. Explain why the majority of alpha particles pass straight through the gold foil. (1)

      Alpha particles pass through the gold atom because atoms are mostly empty space. (1)

   b. A few alpha particles are scattered through a large angle. What is the cause of this large angle scattering? (1)

      An alpha particle directly collides with the (very) dense nucleus of the gold atom. (1)

B. Atomic structure – Atoms and nuclear radiation

8. Complete the table to show the nature of the different types of nuclear radiations. (6)

Radiation type	Composition	Charge
Alpha	**2 protons and 2 neutrons (a helium nucleus)**	**2+**
Beta	**An electron from the nucleus of the atom**	**1-**
Gamma	**Electromagnetic radiation from the nucleus**	**0**

9. When a water pipe is leaking under a road, a gamma emitting tracer is added to the water so the leak can be detected above ground.
Explain why alpha and beta emitting radiations are not used for this purpose. (2)

Alpha and beta would not penetrate the soil. (1)
Gamma would penetrate the pipe and soil to be detected above the surface. (1)

10. Explain why radioactive emissions are ionising. (2)

They are high energy. (1)
Have the ability to knock electrons off atoms/ forming ions. (1)

11. Complete the nuclear equation for the radioactive decay of Radon (Ra). (3)

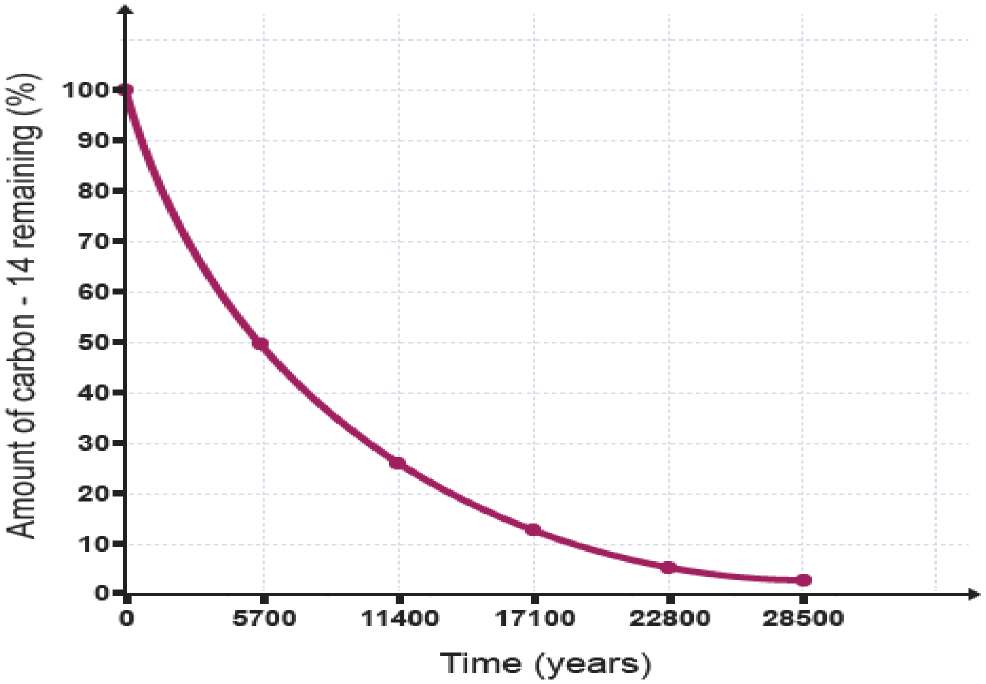
$$^{219}_{86}\text{Ra} \longrightarrow ^{215}_{84}\text{Po} + ^{4}_{2}\alpha$$

12. When a radioactive isotope decays by beta emission, what changes occur in the nucleus of the atom? (2)
A neutron decays to a proton and an electron in the nucleus. (1)
Therefore, the mass remains the same but the atomic number increases by one. (1)

13. What is meant by the half-life of a radioactive isotope? (1)

The time a radioactive isotope takes to lose half its activity.
Or the time it takes for the count rate to halve. (1)

14. a. Use the graph to determine the half-life of Carbon-14. (3)



(2 marks for use of graph to determine half-life)

Half-life = 5700 years (1)

b. The initial sample of Carbon14 had 6400 counts/min. When tested, the sample had a count rate of 800 counts/min.

(i) How many half-lives has the sample gone through? (2)

6400 → 3200 → 1600 → 800 (1) **3 half-lives (1)**

(ii) Use this information to calculate the age of the sample. (2)

3 x 5700 (1) = 17 100 years (1)

c. **(Physics only)** What is the net decline of this isotope over this number of half-lives? (2)

Net decline = 5600 / 6400 (1) = 7/8 (1)

15. Describe the difference between radioactive irradiation and radioactive contamination. (2)

Irradiation is where an object is exposed to radiation without being in contact with the radioactive source. (1)
Contamination is when the radioactive source is in contact or within the object or body. (1)

C. Atomic structure – Hazards and uses of radiation emission and background radiation (physics only)

16. Describe the precautions a medical worker should take if they are working with samples of beta emitting radioactive isotopes. (4)
Wear protective clothing e.g., lead apron, safety glasses, lab coat.
Avoid contamination by ingestion (eating, drinking, smoking etc).
Wear a dose-meter to monitor the amount of radiation received.
Limit exposure time. Use tongs to increase the distance from source. (any 4 relevant points)

17. The following sources of background radiation can be either naturally occurring or man-made. (2)

Cosmic rays **(N)** fallout from nuclear weapons **(MM)** radon from rocks **(N)**

Nuclear power waste **(MM)** Building materials **(N)** Medical tracers **(MM)**
(1 mark / three correct responses)

List these radioactive sources as natural or man-made.

18. Uranium has a half-life of thousands of years whereas Iodine has a half-life of a few days. Explain which you think will pose the greatest hazard to humans. (2)

Iodine will release its radiation very quickly and so poses a short-term threat.
Uranium is safer in the short term but will release its radioactivity for a long time.
(any 2 relevant points)

19. In a CT scanner, radioactive emissions are used to assess damaged or diseased organs.

a. Explain why these machines usually use gamma radiation. (1)
Will penetrate out of the body, less ionising than alpha and beta radiation. (1)
b. Radiation is dangerous for the body so why is this procedure carried out on patients? (1)
Safer than doing intrusive surgery even though there may be no medical problem. (1)
c. Describe how the radiation source used could lead to ionisation of cells in the body. (1)
Radioactive tracer could knock electrons off atoms in body cells. (1)

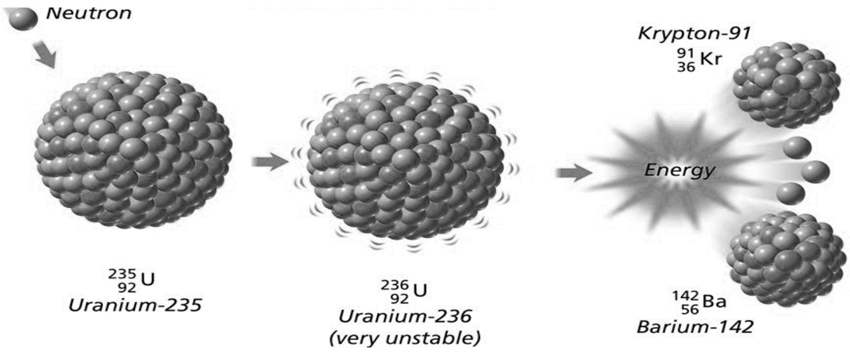
20. Radiation is used for the destruction of unwanted tissue. Describe how this process differs from the scanning process described above. (2)

Radiation source is outside the body and directed towards the tissue to be destroyed.

A number of low doses from different directions result in a high radiation dose striking the unwanted tissue. Therefore, reducing harm to healthy cells. (2 relevant points)

D. Atomic structure – Nuclear fission and fusion (physics only)

21. The diagram shows the nuclear fission of Uranium. Below the diagram write a nuclear reaction for this process. (3)



$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{91}_{36}Kr + {}^{142}_{56}Ba + 3\,{}^{1}_{0}n$$

(Max 3 marks. Lose a mark for any incorrect or omitted stage)

22. In the nuclear fission of uranium, the neutrons released by fission can go on to split further uranium atoms.

   a. What is this process called where one reaction leads to many others? (1)

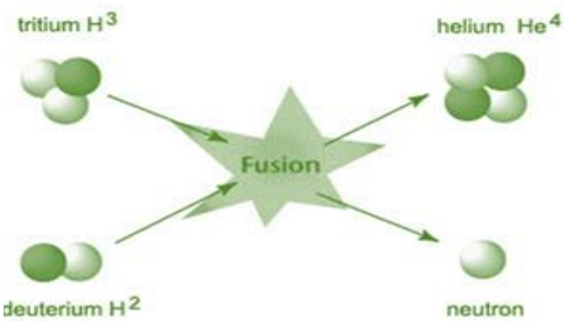
   Chain reaction. (1)

   b. How is this process controlled in a nuclear reactor? (2)

   Some of the neutrons released in the reaction are absorbed by (boron) control rods (1) to prevent them splitting further uranium atoms. (1)

23. The reaction below represents one stage of nuclear fusion in a star. Draw a diagram to show this process. (3)

$$^{2}_{1}H + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + {}^{1}_{1}H$$



(1 mark for each stage)
(Maximum 3 marks)