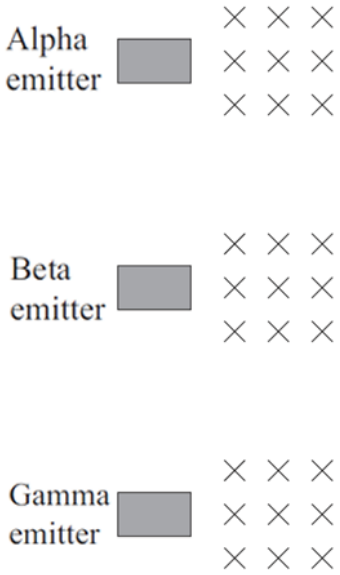
ATOMS: TYPES OF RADIOACTIVITY QUESTIONS

RADIOACTIVITY (2011;2)

(a) Three sources of radiation are shown. These sources emit radiation into a magnetic field that is directed **into the page**. On the diagrams, **draw arrows to show the path** of each type of radiation as it passes through the magnetic field. Although in reality alpha and beta radiation have different speeds, for the purposes of this question, assume they have approximately the same speed.

(b) Give detailed reasons for **each** of the shapes that you have drawn in the diagram.

(c) Describe what **each** of alpha, beta and gamma radiation is AND discuss what happens inside a nucleus when it produces each of the three types of radiation. In your answer, you will need to state what happens to the atomic (charge) number and the mass (nucleon) number.



RADIOACTIVE DECAY AND HALF LIFE (2011;3)

(a) Complete the equation showing alpha decay for radium-226.

$$^{226}_{88}\mathrm{Ra} \rightarrow \overset{\cdots\cdots}{\underset{\cdots\cdots}{\mathrm{Rn}}} + \ldots\ldots$$

NUCLEAR MEDICINE (2010;1)

Iodine 131 is a radioactive isotope used in medicine because it emits beta particles.

(a) Describe what is meant by the term "beta particles".

The equation for the reaction is shown. $^{131}_{53}\mathrm{I} \rightarrow {}^{Z}_{A}\mathrm{Xe} + {}^{0}_{-1}\beta$

(b) Write down the atomic number (A) and the mass number (Z) for the xenon.

(c) Name the conservation principle that you used to work out the atomic number.

Another useful isotope is Technetium 99m. The letter m stands for metastable, which means it does not decay into a *different* element. Technetium 99m can be introduced into the body. It emits gamma rays that are detected outside the body, and these are used to make images of various organs.

Technetium 99m decays with a half-life of 6 hours as follows: $^{99m}_{43}\mathrm{Tc} \rightarrow {}^{99}_{43}\mathrm{Tc} + {}^{0}_{0}\gamma$

The Technetium 99 then decays by emitting low energy beta particles. The half-life of Technetium 99 is 211 000 years. Its decay is as follows:

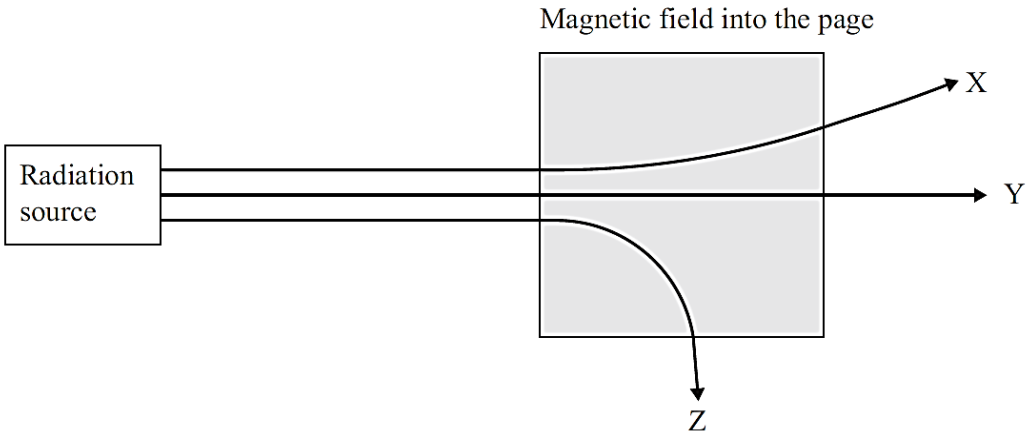
$$^{99}_{43}\mathrm{Tc} \rightarrow {}^{99}_{44}\mathrm{Ru} + {}^{0}_{-1}\beta$$

(d) Describe TWO important differences between the gamma emission and the beta emission.

(e) Explain why the properties of Technetium 99m make it ideal for making images of various organs.

RUTHERFORD'S EXPERIMENTS (2010;2)

(c) As a means of identifying the nature of alpha, beta and gamma radiation, Rutherford fired them through a magnetic field. The diagram below shows the results of his experiment.

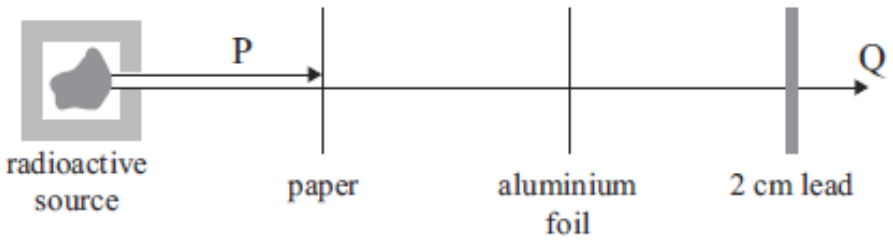


Identify the three unknown types of radiation. Give an explanation for your answer. (You may assume all the particles are travelling at a similar speed.)

RUTHERFORD AND RADIOACTIVITY (2009;2)

One of the first artificial nuclear reactions was carried out by Rutherford when he fired alpha particles into a jar of nitrogen gas $^{14}_{7}N$. He discovered that the products were oxygen $^{17}_{8}O$, and one other particle.

(b) Write a nuclear equation for the reaction.
(c) Name the other particle that was produced as a result of this nuclear reaction.
(d) State the TWO conservation laws that you used in order to write the equation in (b).
(e) The type of radiation emitted from a source can be determined using absorbers. The diagram below shows an example. Identify the radioactive emissions labelled P and Q in the diagram, giving reasons.



HALF-LIFE (2009;3)

$_{89}Ac$	$_{90}Th$	$_{91}Pa$	$_{92}U$	$_{93}Np$	$_{94}Pu$	$_{95}Am$	$_{96}Cm$	$_{97}Bk$	$_{98}Cf$

Plutonium-241 ($^{241}_{94}Pu$), which has a half-life of 14 years, is a typical product from a nuclear reactor. Plutonium-241 decays to americium-241($^{241}_{95}Am$).

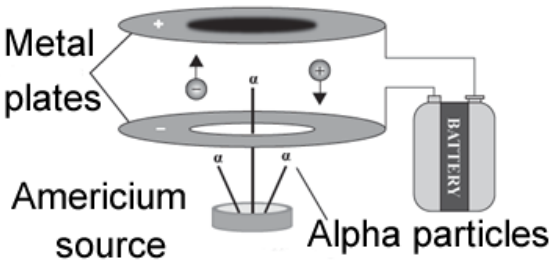
(a) Write a nuclear equation for the decay of plutonium-241 to americium-241.

Americium-241 has a half-life of 432 years and is widely used in smoke detectors. Americium-241 emits alpha particles and gamma radiation.

(c) Describe and explain the changes inside the nucleus of Am-241 when it emits an alpha particle and a gamma ray.
(d) Write a nuclear equation for the decay of Am-241 when it emits an alpha particle.

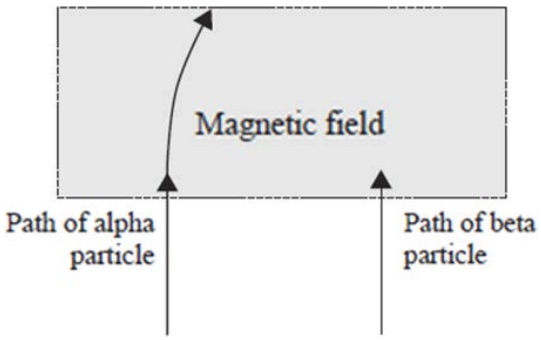
THE SMOKE DETECTOR (2008;1)

Common smoke detectors contain a small amount of the radioactive isotope Americium 241. Americium 241 is an alpha emitter, and decays with a half-life of 432 years. The alpha particles ionise the gases in the air between two metal plates.



(a) State another name for an alpha particle.
(b) Describe what is meant by the word "ionise" in this context.
(c) Describe why the radioactive source is not a health risk.
(d) The symbol for Americium 241 is $^{241}_{95}\mathrm{Am}$. How many protons and neutrons are there in the nucleus?
(e) Americium 241 decays to Neptunium (Np). Write the equation for the alpha decay of Americium 241.
(f) Name the important physics principle that helped you work out the atomic number of Neptunium.

The diagram shows an alpha particle travelling towards the top of the page and through a magnetic field.



(i) What is the direction of the magnetic field? Choose your answer from:

- towards the top of the page
- left
- into the page
- towards the bottom of the page
- right
- out of the page.

(j) Complete the diagram above to show the path of a beta particle travelling at the same speed. Explain how you worked out your answer.

NUCLEAR MEDICINE (2008;2)

Cobalt 60 ($^{60}_{27}Co$) is used in hospitals. It decays into Nickel 60 ($^{60}_{28}Ni$).

(a) Write the radioactive decay equation for Cobalt 60, and name the particle produced.

(b) Describe what has happened inside the Cobalt nucleus to produce this radioactive decay.

Technetium 99 ($^{99}_{43}Tc$) is another common isotope used in hospitals for imaging. Technetium 99 emits gamma rays when it decays.

(c) Write the radioactive decay equation for Technetium 99.

(d) Describe what gamma rays are, and use your description to justify your answer

RADIOACTIVITY (2007;2)

Platinum-195 and platinum-192 are both isotopes of the same element.

(a) State the difference between the nuclei of platinum-192 and platinum-195.

(b) What do the numbers 78 and 195 represent in the symbol $^{195}_{78}Pt$?

(c) Write an equation for the decay of iridium $\left(^{192}_{77}Ir\right)$ to platinum $\left(^{192}_{78}Pt\right)$ and name the particle emitted.

(d) What Physics principles did you use to write the above nuclear equation?

(e) Technetium-99 is sometimes injected into hospital patients. Technetium-99 decays by emitting gamma rays and low energy electrons. Technetium-99 has a half-life of 6 hours. Give two reasons why is it important for doctors to use a radioactive isotope that has a half-life of a few hours in patients.

(f) Explain why it is safer to inject radioisotopes that emit gamma rays rather than those that emit alpha particles.

(g) Describe and explain the changes which occur in the nucleus of a radioactive isotope, including changes of its atomic number and mass number when it decays by emitting:

(i) An alpha particle (ii) A beta particle

RADIOACTIVITY (2006;2)

(a) $^{220}_{86}Rn \rightarrow {}^{216}_{84}Po +$ _____ Type of radiation _____

(b) $^{24}_{11}Na \rightarrow {}^{24}_{12}Mg +$ _____ Type of radiation _____

Some nuclei are unstable and undergo radioactive decay in order to become more stable. This involves the nucleus giving off some radiation. Complete the equation for each of the following radioactive decays, and name the type of radiation.

Beta particles are created inside a nucleus by the decay of a neutron. Complete the equation to show how this occurs.

(c) $^{1}_{0}n \rightarrow$ _____ + _____

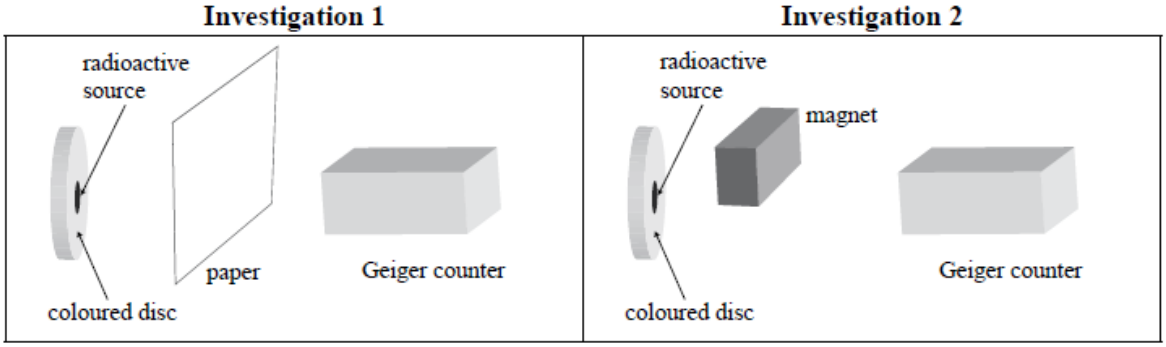
One isotope of cobalt is radioactive, and it decays producing a beta particle and a gamma ray. Complete the equation for this decay, and determine the atomic number and mass number of the cobalt.

(d) $Co \rightarrow {}^{60}_{28}Ni + \_\_\_\_\_ + \_\_\_\_\_$

A STUDENT INVESTIGATION (2006;3)

A student wanted to identify the type of radiation emitted from three unknown radioactive sources. She had a piece of paper, a strong magnet and a Geiger counter. The radioactive sources were attached to discs coloured red, blue and green.

In the investigations, she placed each radioactive source in the position shown, and measured the radiation received by the Geiger counter.



Results

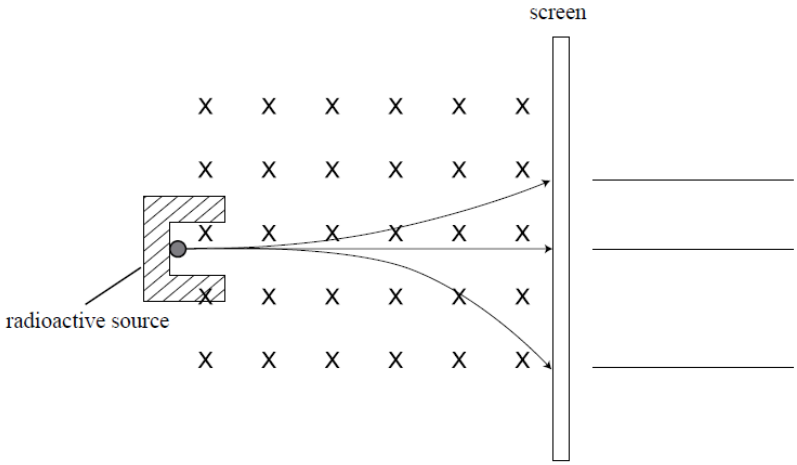
Red disc	Not stopped by paper	Not deflected by magnet
Blue disc	Stopped by paper	Deflected by magnet
Green disc	Not stopped by paper	Deflected by magnet

Deduce the type of radiation emitted from each radioactive source, giving a brief explanation in each case.

(a) Radioactive source on red disc emits
(b) Radioactive source on blue disc emits
(c) Radioactive source on green disc emits

QUESTION THREE (2005;3)

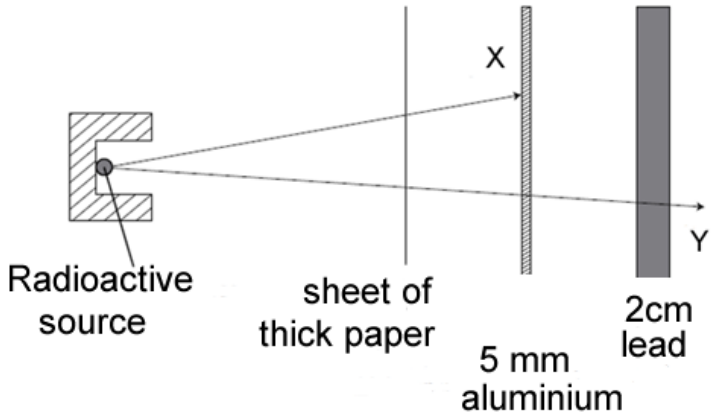
Radioactivity can occur in three distinct forms. The following diagram shows a radioactive source whose emission comprises all three forms. The three components are being separated as they pass through a uniform magnetic field directed into the page, as indicated by the crosses.



(a) Name each component on the appropriate line to the right of the screen.
(b) Explain why the component whose path was bent downwards was deflected further from its original path than the component whose path bent upwards. (Assume that both components had the same speed when they left the radioactive source.)

QUESTION FOUR (2005;4)

The following diagram shows a radioactive source decaying and giving off two types of radioactivity, X and Y. It shows how the two types of radioactivity behave when different materials are placed in their paths.



Identify the **types** of radioactivity *X* and *Y*.

QUESTION FIVE (2005;5)

Rutherford was also the first person to demonstrate artificial radioactivity and to "split the atom". He did this by firing helium nuclei at nitrogen atoms. The following is the nuclear equation of the reaction.

$$^{14}_{7}\mathrm{N} + ^{4}_{2}\mathrm{He} \rightarrow ^{17}_{8}\mathrm{O} + ^{b}_{a}X$$

Identify the numbers a and b and the particle X in the above equation.

QUESTION SIX (2005;6)

Technetium-99 is used as a radioactive tracer in medical diagnoses because it has a half-life of 6 hours, and therefore does not stay in the body for too long. It emits only gamma rays, which means that it has very little ionising ability and thus causes very little ionisation.

State clearly the meaning of the term ionisation.

QUESTION EIGHT (2005;8)

Smoke detectors/alarms provide an early warning of fire and allow people time to escape from a building. A suitable radioactive source for a smoke alarm is americium-241($^{241}_{95}\mathrm{Am}$).

The atomic numbers of elements near americium in the periodic table are given in the following table.

Atomic number	90	91	92	93	94	95	96	97	98	99	100
Element symbol	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm

(a) Americium is an alpha particle emitter. Write a nuclear equation for the decay of americium.

(b) A smoke detector works because the radioactive source ionises smoke particles that enter the detector. Explain TWO different reasons why an alpha particle emitter (rather than beta or gamma) is used as the radioactive source.

(c) Americium-241 has a half-life of 433 years. Why is an isotope with a long half-life used in a smoke detector?

TYPES OF RADIATION (2004;1)

Ernest Rutherford and his colleagues identified three different types of radiation emitted from radioactive nuclei.

(a) Complete the two nuclear equations below with appropriate symbols and numbers to identify the type of radiation emitted. State the name of the type of radiation

$$^{90}_{38}\mathrm{Sr} \rightarrow {}^{90}_{39}\mathrm{Y} + \ldots\ldots$$

$$^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{27}\mathrm{Co} + \ldots\ldots$$

(b) Uranium 238 decays to thorium (Th) by emitting an alpha particle.

$$^{238}_{92}\mathrm{U} \rightarrow \quad \ldots\ldots \quad + \quad \ldots\ldots$$

Complete the equation for this reaction using appropriate symbols and numbers.

(c) Which type of radiation is most strongly ionising?

(d) Describe what is meant by "ionise" in relation to radiation.

(e) An electron can be emitted from a radioactive nucleus even though it cannot exist inside the nucleus. Describe how an electron can be created in the nucleus.

(f) As part of an experiment, Rutherford placed an alpha particle emitter into a jar. When the jar was later tested it contained the gas helium that was not previously present. Explain how the helium was formed.

(g) The isotope radon 222 ($^{222}_{86}Rn$) undergoes two consecutive radioactive decays and turns into the isotope polonium 218($^{218}_{84}Po$).
Carry out calculations to determine the TWO separate emissions. Name the emissions.