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90256

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Level 2 Physics, 2005

90256 Demonstrate understanding of atoms and radioactivity

Credits: Two
2.00 pm Tuesday 29 November 2005

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions in this booklet.

For all numerical answers, full working must be shown. The answer should be given with an SI unit.

For all 'describe' or 'explain' questions, the answer should be in complete sentences.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–10 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

For Assessor's use only	**Achievement Criteria**		
Achievement	**Achievement with Merit**	**Achievement with Excellence**	
Identify or describe aspects of phenomena, concepts or principles.	Give descriptions or explanations in terms of phenomena, concepts, and/or principles.	Give concise explanations that show clear understanding in terms of phenomena, concepts, and/or principles.	
Overall Level of Performance			

You are advised to spend 20 minutes answering the questions in this booklet.

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MODELS OF THE ATOM AND RADIOACTIVITY

QUESTION ONE

For thousands of years, atoms were thought to be tiny solid spheres. Following his discovery of the electron in 1897, J J Thomson proposed a new model of the atom. A few years later, as a result of his "alpha particle scattering" experiment, Rutherford proposed an improved model.

(a) Describe the one way in which Thomson's and Rutherford's **models** of the atom were **similar**.

(b) Describe the **key difference** between Thomson's and Rutherford's models of the atom.

QUESTION TWO

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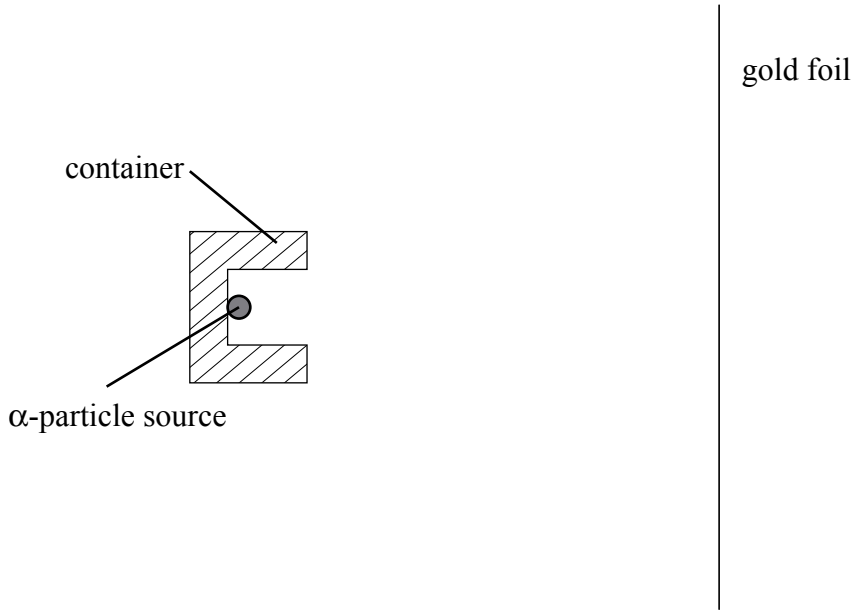
Rutherford's famous "alpha particle scattering" experiment fired alpha (α) particles at gold foil.



As predicted, most of the alpha particles were observed to go straight through the gold foil or were deflected only very slightly as they passed through. A very small percentage of the alpha particles bounced back towards the source or were deflected at very large angles.

Explain why only a very **small percentage** of the alpha particles bounced back or were deflected at very **large angles**.

QUESTION THREE

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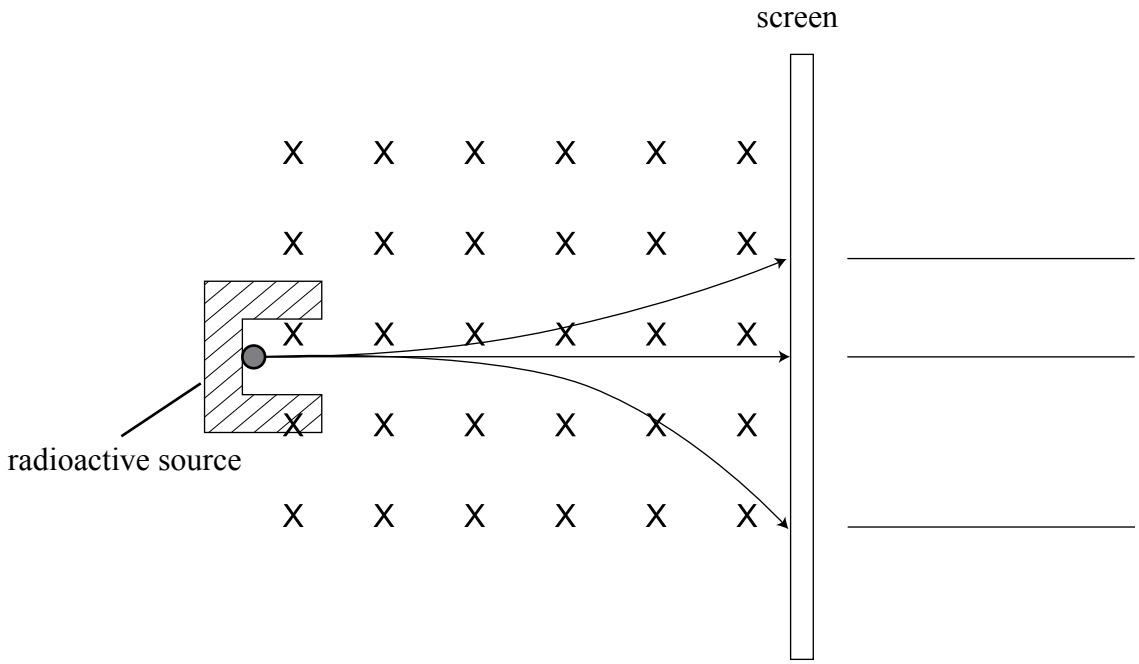
Radioactivity can occur in three distinct forms. The following diagram shows a radioactive source whose emission comprises all three forms. The three components are being separated as they pass through a uniform magnetic field directed into the page, as indicated by the crosses.



(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

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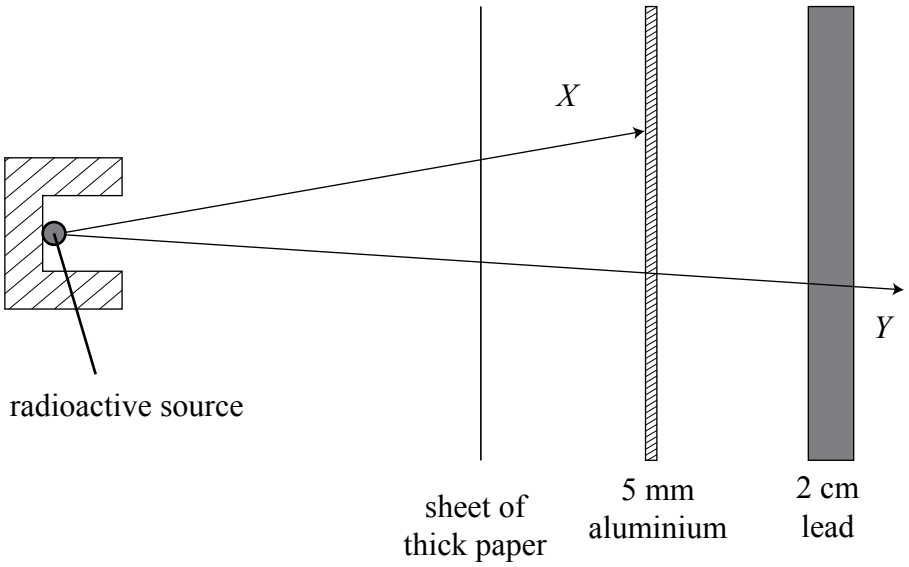
The following diagram shows a radioactive source decaying and giving off two types of radioactivity, *X* and *Y*. It shows how the two types of radioactivity behave when different materials are placed in their paths.



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

X is _____

Y is _____

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QUESTION FIVE

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.

a = _____ *b* = _____ *X* = _____

QUESTION SIX

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 SEVEN

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Radioactive material decays and becomes less radioactive over time. The rate of decay is not constant, so it is measured in terms of **half-life**.

(a) On the axes drawn below, **sketch** a graph that illustrates radioactive decay. Give the axes appropriate **labels**. **On** your graph draw two lines to show how you could determine the half-life of the material.

(b) State the meaning of the term **half-life**.

QUESTION EIGHT

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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 ($^{241}_{95}\text{Am}$).

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.

Reason 1:

Reason 2:

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

QUESTION NINE

All living plants and animals contain carbon. All carbon contains a known proportion of the radioactive isotope carbon-14. During the lifetime of a plant or animal, the carbon content is continually replenished, but the process stops once the plant or animal dies.

The half-life of carbon-14 is 5 730 years. This length of time makes the isotope appropriate for estimating the time-since-death of archaeological samples of items that were once living. This process is called radio-carbon dating.

A kauri tree trunk is discovered buried in a Northland swamp. A 10 g sample of the timber is sent to a laboratory and is found to have a measured activity of 25 counts per minute. A 100 g sample of timber from a branch that just fell off a living kauri tree is found to have an activity of 2 345 counts per minute.

Estimate the **age** of the buried specimen.

Extra paper for continuation of answers if required.
Clearly number the question.

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Question number	