

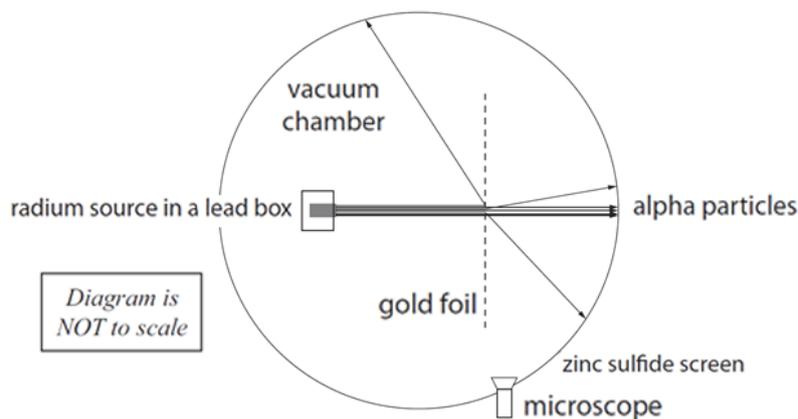
ATOMS: ATOMIC STRUCTURE QUESTIONS AND ANSWERS

QUESTION ONE: MODELS OF THE ATOM (2011;1)

At different times scientists have proposed various descriptions or models of the atom to match experimental evidence available.

- (a) The model that Thomson proposed was called the plum-pudding model. Describe this model.
Thomson's model had a number of negative particles / corpuscles / electrons embedded in a (solid) positive sphere / cloud.
Cloud of particles or energy not accepted.
The atom as a whole is neutral because the charges are balanced.
Term "nucleus" not accepted.

Geiger and Marsden performed a series of experiments under the direction of Ernest Rutherford which led to a new model of the atom. A model of the gold foil experiment is shown below.



- (b) For each of the conclusions given below, state which observation from the experiment provides evidence that:
- (i) Most of the mass of the atom is concentrated in a tiny region which Rutherford called the nucleus.
Most of the alpha particles went straight through and a very small number / a few bounced back / were reflected.
- (ii) The nucleus is positively charged.
Some of the alpha particles were deflected ("deflection" is an observation, "repulsion" is not).
- (c) Rutherford included several features in the experiment due to the characteristics of the alpha particles. Discuss the reason for each of the features below:
- (i) The source of the alpha particles is at the end of a narrow lead tube
Tube: To provide a narrow (or collimated) beam of alpha particle.
OR to direct the alpha particles
OR ensure alpha hits perpendicular to gold foil
OR to avoid stray alpha particles affecting the results
- (ii) Vacuum chamber
Vacuum chamber – Alpha particles would not travel far / be stopped / lose energy / path would change / be deviated / collide with the air particles (cannot accept "affect", "disrupt", "react", "interfere").
OR
Alpha would become a helium atom / alpha particles ionise the air.
- (iii) Zinc sulfide screen
Alpha particles are not visible to the naked eye. The ZnS coating will show / glow / fluoresce / flash / give off light when alpha particles strike it (this may be implied as opposed to directly stated) but do not allow "detected" or "located"

RUTHERFORD'S EXPERIMENTS (2010;2)

In 1905, Ernest Rutherford carried out an experiment to determine the nature of atoms. He fired alpha particles at a thin gold foil. After carrying out the experiment, he concluded that the atoms were mainly empty space, and that most of the matter was contained in a small, very dense, positively charged object that was more massive than the alpha particle. The object later became called the nucleus.

- (a) If there was air between the alpha source and the gold foil, the air would become ionised. Explain what is meant by the term "ionised".

Ionise describes the process where radiation knocks electrons out of atoms turning the atoms into (positive) ions.

- (b) Describe the results of the experiment and explain clearly how he linked his results to his conclusion.

1 Most of the alpha particles went straight through. Links to: atoms were mainly empty space.

2 Some of the alpha particles were deflected/deviated because the nucleus was positively charged and repelled the positively charged alpha particles. Links to: most of the matter was contained in a small, very dense, positively charged nucleus.

3 A few of the alpha particles were repelled straight back/at large angles because the mass of the atom was concentrated in the nucleus/the nucleus is very dense (not "large or heavy"). Links to: most of the matter was contained in a small, very dense, positively charged nucleus.

MODELS OF THE ATOM (2009;1)

- (a) Around 1800, James Dalton proposed a modern atomic model, based on experimentation rather than pure reason. Describe one aspect of Dalton's model of the atom.

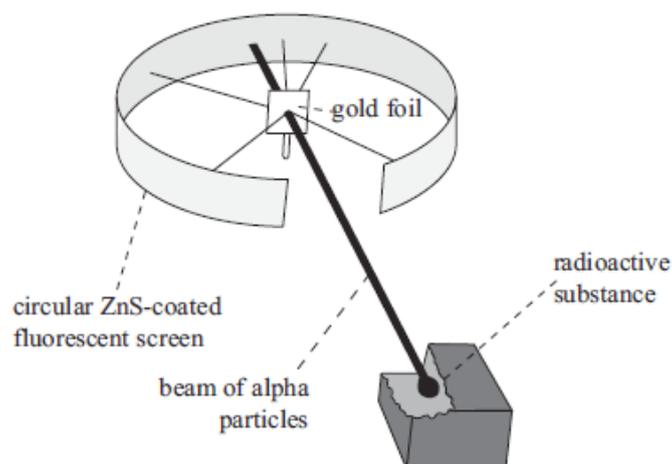
All matter is made up of atoms / atoms are indivisible / atoms are the building blocks of matter / atoms are indestructible / atoms are tiny / atoms are the smallest unit of matter / atoms of an element are unique.

- (b) Thomson's model is commonly referred to as the "Plum Pudding Model". Describe Thomson's model of the atom.

Thomson's model had a number of negative particles (electrons) embedded in a (solid) positive sphere / cloud.

The atom as a whole is neutral because the charges are balanced.

- (c) A diagram of Rutherford's gold foil experiment, which he performed with Geiger and Marsden, is shown below. The whole apparatus was in an evacuated chamber that is in a vacuum.



Give the purposes of the following in the experimental setup:

(i) zinc sulfide (ZnS) fluorescent coating on the circular screen

Alpha particles are not visible to the naked eye. The ZnS coating will **glow / fluoresce / flash / give off light** when alpha particles strike it (this may be implied as opposed to directly stated).

(ii) circular shape of screen

The circular screen **enabled the detection** of particles that may be deflected in any direction.

(iii) evacuated chamber

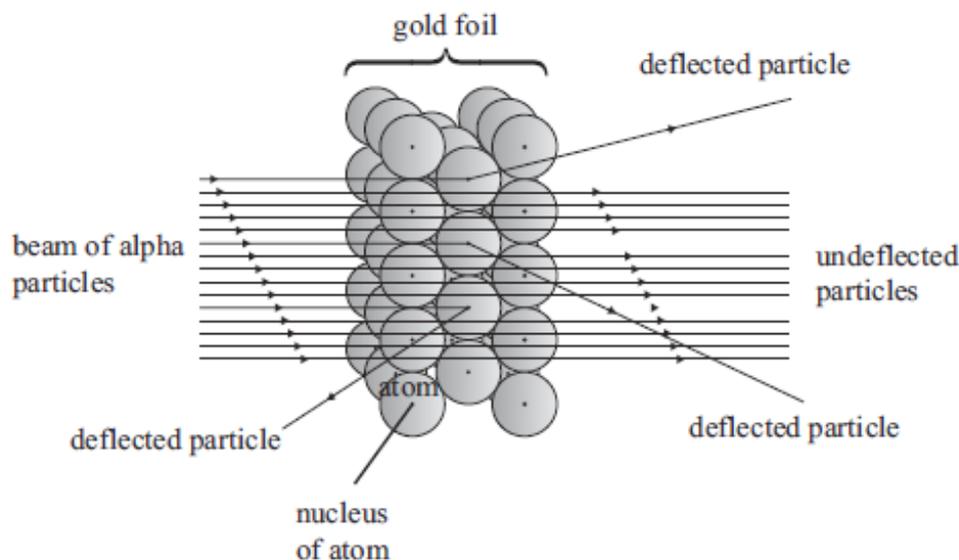
Alpha particles would **not travel far / be stopped / lose energy / path would change / be deviated** (do not accept "affect", "react", "interfere").

OR

Alpha becomes a helium atom / alpha particles ionise the air so the particles do not interact with the gold foil in the same way / are not detectable by the zinc screen.

RUTHERFORD AND RADIOACTIVITY (2009;2)

The observations that Rutherford made are shown in the diagram below:

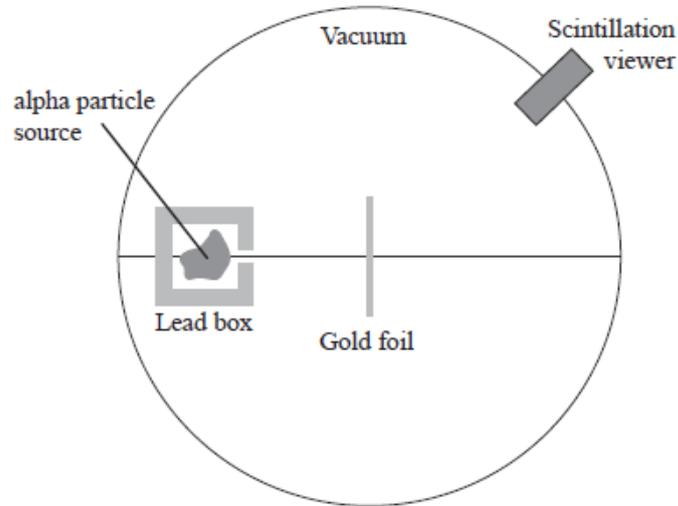


(a) Based on his observations, Rutherford came to certain conclusions about the structure of the atom. Explain Rutherford's THREE main conclusions about the structure of the atom.

1. Most of the **atom** was empty space **because most** of the **alpha particles** went **straight through**.
2. The **nucleus** was positively charged **because** the **positive** nucleus **repelled** the **positively charged alpha** particles.
3. The mass of the atom was concentrated in the nucleus / the nucleus is very dense (not "large or heavy") **because** the alpha particles were **repelled straight back / at large angles**. Electrons must be **very light** and **orbit the nucleus** in some way since most of the **mass** is in the **positive** nucleus **because** the alpha particles were **repelled straight back / at large angles** and the **positive** nucleus **repelled** the **positively charged alpha** particles.

RUTHERFORD'S EXPERIMENT (2008;3)

In 1910 Ernest Rutherford directed an experiment that involved firing alpha particles at a thin gold foil. From the results he developed a new model of the atom.

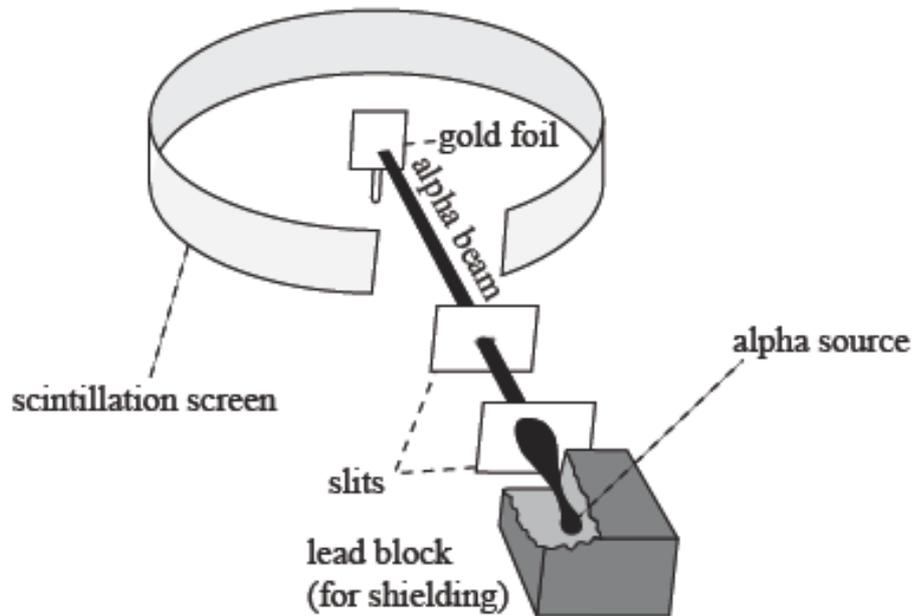


- (a) What part of the results did he find surprising?
Some alpha particles underwent large deflections OR bounced back.
- (b) Briefly describe the model Rutherford developed.
Atom is mainly empty space.
Tiny / dense / positive nucleus at centre.
Surrounded by (orbiting) electrons.

ATOMIC MODELS (2007;1)

- (a) Give a concise explanation that shows clear understanding of the development of the model of the atom from Dalton to Thomson to Rutherford.
 The Dalton model proposed that matter was made of **indivisible atoms / smallest building block of matter** (The Dalton model had no electrons or protons).
 The Thomson ("plum pudding") model proposed that the atom was a **positive sphere** with negatively charged **electrons embedded in it**. The atom as whole was neutral. (The Thomson model did not have protons.)
 The Rutherford model proposed that the atom had a **central positive nucleus**. The negatively charged **electrons were in orbit** around the nucleus of the atom. The atom as whole was neutral. The **atom was mainly space**. (The Rutherford model had electrons and protons.)
 (Thomson and Rutherford BOTH predicted the atom was mainly space.)

The following diagram shows Rutherford's gold foil experiment.



(b) What would Rutherford have expected to see in his experiment if Thomson's model was correct?

(Most of) the alpha particles would go straight through / alpha particles should only be deflected by small angles as they pass through / uniform scattering.

(c) Write three observations that Rutherford made in his gold foil experiment.

(Most of the) alpha particles went straight through.

(Some of the) particles were deflected away.

(A very few of the) particles were reflected right back / deflected through large angles.

(d) Rutherford's experiment was carried out in a vacuum. If the chamber contained air, describe the effect this would have had on the alpha particles and on the air.

If air were present in the chamber the alpha particles would not travel far (alpha particles can penetrate only 5cm in air) / be stopped / lose energy / path would change / be deviated **because** of collisions with air particles.

The air (particles) would be ionised / become positively or negatively charged / lose electrons / change from atoms to ions **because** alpha particles are highly ionising and they would ionise the air as they passed through it.

(e) Describe what would have been observed if Rutherford had used a beta emitter instead of an alpha emitter.

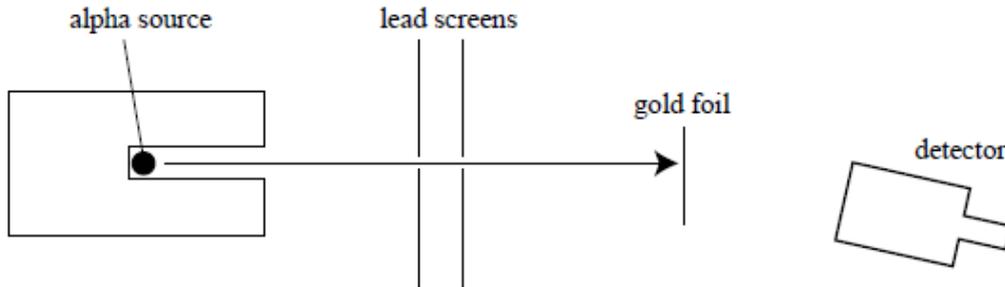
Beta particles (which are more penetrating) would almost all go straight through the gold foil.

OR
Greater scattering effect so more Beta particles deflected through large angles (very few would be scattered through small angles)

OR
greater backscattering.

RUTHERFORD'S EXPERIMENT (2006;1)

Ernest Rutherford carried out an experiment to investigate the structure of the atom. He fired alpha particles at a thin gold foil, and observed the path of the alpha particles. The whole apparatus was in a vacuum chamber.



(a) State what an alpha particle is.

A helium nucleus OR a doubly ionised helium atom OR two protons and two neutrons (joined) OR a helium atom with no electrons

(b) State why the apparatus was placed in a vacuum.

To prevent the alpha particles being stopped by gas molecules.

Accepted: stopped, deviated, can't travel long distance in air, air disrupts path.

Not Accepted: affect, react, interfere, prevent ionisation.

(c) State the purpose of the lead screens.

To provide a narrow (or collimated) beam of alpha particles OR ensure alpha hits perpendicular to gold foil.

Rutherford made the following observations:

Observation 1: Most of the alpha particles went straight through the gold atoms undeflected.

Observation 2: A few of the alpha particles rebounded (bounced back) from the gold atoms.

(d) State what Rutherford concluded about the structure of the gold atom from Observation 1.

Most of the gold **atom** is empty space.

(e) State and explain TWO of Rutherford's conclusions from Observation 2.

The nucleus must be **positively** charged to cause the **positive** alpha particles to **repel** (or rebound).

The nucleus must be **dense** to cause the alpha particles to **rebound**.

QUESTION ONE (2005;1)

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.

Thomson's and Rutherford's models both:

- contained (negative) electrons
- involve subatomic particles
- involve atoms with smaller particles inside
- contain positive charges
- contain negative charges
- contain (balanced) positive and negative charges
- atoms are neutral overall

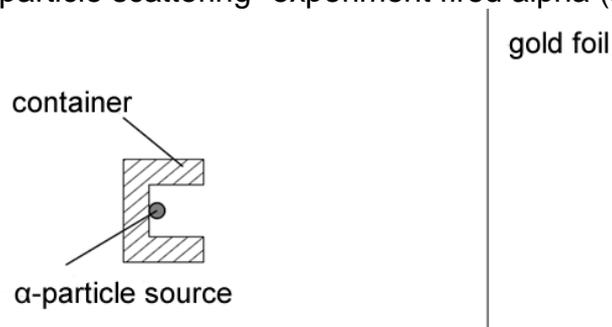
Accept any one of these – an answer that involves **protons** in both models **cannot be accepted**

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

Thomson's model consisted of negative electrons embedded in a sphere of positiveness/accept "solid" sphere; but Rutherford's electrons were in orbit around a (small) positive nucleus.

QUESTION TWO (2005;2)

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.

Only a few alpha particles bounced back because the nucleus is so small/atom is mostly empty space that few collided with the nucleus.

If they bounced back it was because both alpha particle and nucleus are positive: repulsion

If they bounced back it was because nucleus is massive/dense so alpha particles rebound.

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.

Ionisation occurs when **radiation**:

- causes **atoms** to become positively or negatively **charged**
- or
- **electrons** lost or gained from **atoms**
- or
- changes **atoms** into **ions**

ATOMIC MODELS (2004;2)

To find out more about the structure of the atom, Rutherford decided to fire alpha particles at a thin gold foil. The whole apparatus was in a vacuum.

- (a) Explain why the apparatus had to be in a vacuum.
- (b) What type of charge does an alpha particle have?
- (c) When the experiment was carried out, it was found that most of the alpha particles passed straight through the gold atoms, but a few were deflected through very large angles. Describe TWO conclusions possible from these observations. Give an explanation for your answers.