5 Atomic Physics

5.1 The Nuclear Atom

Syllabus points

1. Atomic Model
2. Nucleus

book p227-230

- Rutherford Scattering Experiment
- Radioactive Isotopes
- Nuclear Fission & Fusion

(1)$_{11}$ **(a)** A radioactive source emits α-, β- and γ-radiation.

For Examiner's Use

Which of these radiations

(i) has the shortest range in air, alpha or α

(ii) has a negative charge, beta or β

(iii) is not deflected in a magnetic field? gamma or γ

[2]

(b) In a famous experiment, carried out in a vacuum, a very thin sheet ofgold was placed in the path of alpha particles.

It was found that a large number of the alpha particles passed through the sheet with little or no deflection from their original path. A very small number of the alpha particles were reflected back towards the source.

(i) Explain, in terms of the force acting, why the direction of motion of an alphaparticle changes when it comes close to the nucleus of a gold atom.

repulsion

α particle and (gold) nucleus nucleus have positive charges

[2]

(ii) State **two** conclusions, about the nuclei of atoms, that were made from the results of this experiment.

1. Nucleus is very small (compared to size of atom) OR Most of atom is empty space

2. Nucleus is positive / contains protons OR Nucleus has (all) the positive charge of the atom

[2]

Nucleus is heavy OR Nucleus has most / all of the mass of the atom

[Total: 6]

(2)$_{10}$ There are two stable, naturally occurring isotopes of hydrogen.

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Common hydrogen (hydrogen-1) has a proton number of 1 and a nucleon number of 1.

Hydrogen-2 (deuterium) has a nucleon number of 2.

There is also a radioactive isotope of hydrogen called tritium (hydrogen-3), with a nucleon number of 3.

(a) Complete the table for neutral atoms of these isotopes.

	hydrogen-1	hydrogen-2 (deuterium)	hydrogen-3 (tritium)
number of protons	1	1	1
number of neutrons	0	1	2
number of electrons	1	1	1

[3]

(b) Two samples of tritium are stored in aluminium containers of different thickness.

Sample 1 is in a container of thickness 0.5 mm and radiation can be detected coming through the container.

Sample 2 is in a container of thickness 5 mm and no radiation comes through.

(i) State the type of radiation coming through the container of Sample 1.

Beta particles .....[1]

(ii) Explain your answer to **(b)(i)**.

Alpha stopped by paper and
Beta stopped by approx. 3mm Al

.....[2]

(c) Under conditions of extremely high temperature and pressure, as in the interior of the Sun, hydrogen nuclei can join together.

(i) Name this process.

Nuclear fusion .....[1]

(ii) State whether energy is released, absorbed or neither released nor absorbed during this reaction.

Energy released .....[1]

(d) When a nucleus of a certain isotope of uranium is bombarded by a suitable neutron, it splits into two smaller nuclei and energy is released.

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Name this process.

Nuclear fission .....[1]

[Total: 9]

Turn over for Question 11

(3)$_9$ In a laboratory experiment, the isotope uranium-238 is used as a source of α-particles.

For Examiner's Use

(a) State

(i) one feature of uranium-238 nuclei that is the same for the nuclei of other uranium isotopes,

atomic number ..... [1]

(ii) one feature of uranium-238 nuclei that is different for the nuclei of other uranium isotopes.

mass number-neutrons ..... [1]

(b) Fig. 9.1 shows the α-particles from the uranium source being directed at a very thin gold foil, in a vacuum.

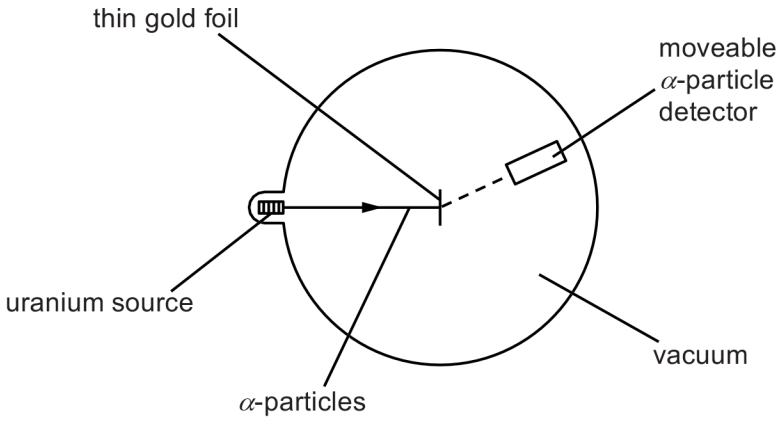

Fig. 9.1

To investigate the scattering of α-particles, a detector is moved to different positions around the very thin gold foil and measurements are recorded.

Describe the results from this scattering experiment and explain what they show about the structure of atoms.

Most alpha particles pass straight through .....

Very few are deflected off to the side, ...

even fewer deflect backwards .....

Atom mostly empty space .....

Most mass concentrated in dense nucleus .....

.....

..... [4]

[Total: 6]

(4) **11** Uranium-238 and uranium-234 are radioactive isotopes of the element uranium.

A uranium-238 nucleus is different from a uranium-234 nucleus but both decay by the emission of an α-particle.

(a) **(i)** In terms of the particles in each, state how a nucleus of uranium-238 differs from a nucleus of uranium-234.

Uranium 238 has 4 more neutrons

.....[2]

(ii) Although the two nuclei are different, they are both nuclei of uranium.

State a property that makes these isotopes the same element.

Same atomic no/proton no/electrons etc

.....[1]

(b) When α-particles pass through air, they are more strongly ionising than β-particles.

Suggest **two** reasons why this is so.

Larger mass and hence more energy

Greater charge .....[2]

(c) In an experiment, α-particles are allowed to strike a thin gold foil in a vacuum.

Almost all the α-particles pass straight through the gold undeflected. Only a very small number of α-particles are deflected from their original path.

This result reveals certain features of the atoms of the gold.

State what is shown about atoms by the fact that

(i) most α-particles pass straight through the gold undeflected,

Atom is mostly empty space/ big distances between nuclei

.....[1]

(ii) some α-particles are deflected back the way they came.

The charge is concentrated at center of nucleus

.....[1]

[Total: 7]