AQA GCSE Physics

Paper 1 (H) Revision

Topic 4: Radioactivity

Name: ______________________________

Form: 11 ___

AQA GCSE Physics
Paper 1 Revision
Topic 4: Radioactivity

Specification point	Notes ✓	☺		☹	Questions?
Describe, recognise and draw the basic structure of an atom					
Explain how results from the Rutherford and Marsden scattering experiments led to the 'plum pudding' model being replaced by the nuclear model					
Appreciate that new evidence can cause theories to be re-evaluated					
Appreciate that, according to the nuclear model, most of the atom (and therefore most of any form of matter) is empty space					
Compare the relative masses and relative electric charges of protons, neutrons and electrons					
Describe the numbers of protons and electrons in atoms, and explain why they have no overall electrical charge					
Describe how atoms may lose or gain electrons to become ions					
Define 'isotope'					
Define 'atomic number'					
Define 'mass number'					
Describe how radioactive substances randomly give out radiation from the nuclei of their atoms all of the time, whatever happens to them.					
Describe the origins of background radiation from rocks, cosmic rays, nuclear weapons tests and nuclear accidents					
Evaluate the effect of different jobs and/or locations on the level of background radiation and radiation dose					
Evaluate measures that can be taken to reduce exposure to nuclear radiations					
Identify an alpha particle, a beta particle and a gamma ray					
Write nuclear equations to show single alpha and beta decay					

AQA GCSE Physics
Paper 1 Revision
Topic 4: Radioactivity

Specification point	Notes ✓	☺		☹	Questions?
Compare the properties of alpha, beta and gamma radiations in terms of their ionising power, penetration through materials, and their range in air					
Compare how alpha, beta and gamma radiations are affected by electric and magnetic fields and explain in terms of their relative mass and charge					
Describe the uses and evaluate the dangers associated with each type					
Define 'half-life' for a radioactive isotope, in terms of the number of nuclei of the isotope in a sample, or in terms of the count rate from a sample					
Evaluate how appropriate different radioactive sources are for different users, including tracers, in terms of the type of radiation and half life					
Identify the two main fissionable substances commonly used in nuclear reactors					
Define 'nuclear fission' and describe what must first happen to the nucleus of an atom for fission to occur					
Describe what happens when a nucleus undergoes fission					
Describe or sketch a diagram to show how a chain reaction can happen					
Outline how nuclear fission can be used to generate electricity in a nuclear power station					
Define 'nuclear fusion' and identify it as the process that releases energy in stars					
Compare the uses of nuclear fusion and nuclear fission in generating electricity					

What are the overall charges of a beta and alpha particle?

The Atom

What are the atomic and mass numbers of an alpha and beta particle?

The nuclear model

Rutherford's scattering experiment determine todays nuclear model of the atom, which replaced the plum pudding model. Rutherford fired positive alpha particles towards gold foil. He found that most of the alpha particles passed straight through, thus concluding that the atom is mostly empty space.

He found that some alpha particles were deflected, which showed that the entre of the atom was positively charged. Very few alpha particles bounced straight back, leading Rutherford to conclude that the nucleus contained positive protons and neutrons which had electrons which orbit it.

Atoms

In an atom there are the same number of protons as there are electrons. The number is denoted by the atomic number. Chlorine has 17 of each. If an atom loses of gains an electron it becomes an ion.

The number of protons and neutrons in an atom is the mass number. Chlorines mass number is 35.

Radioactivity

An unstable atom becomes more stable by releasing radiation. There are 3 types of radiation:

Alpha:

An alpha particle is two protons and two neutrons. It is a helium nucleus.

Beta:

A beta particle is a fast moving electron emitted by a nucleus which has too many neutrons.

Gamma:

Gamma radiation is an electro-magnetic wave, therefore has no charge.

Particle	Relative mass	Relative charge
proton	1	+1
neutron	1	0
electron	0.0005	-1

Alpha, Beta & Gamma

Nuclear reactions

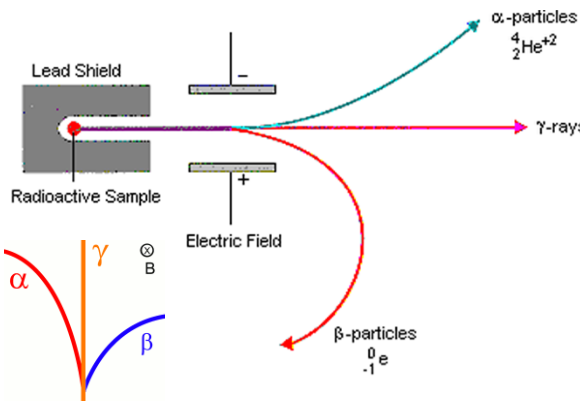
Alpha emission: $^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$

$$^{228}_{90}Th \rightarrow {}^{224}_{88}Ra + {}^{4}_{2}\alpha$$

Beta emission: $^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e$

$$^{40}_{19}K \rightarrow {}^{40}_{20}Ca + {}^{0}_{-1}\beta$$

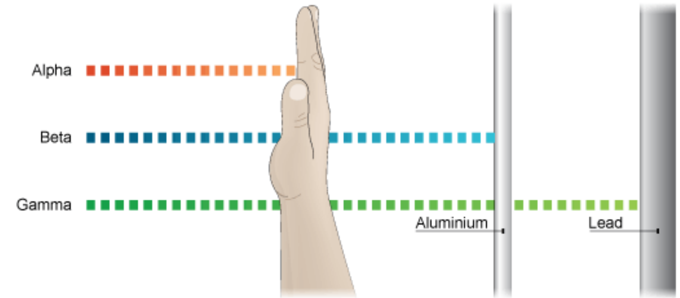
Deflection in a magnetic or electric field



The charged particles deflect in a magnetic or electric field. The beta particle deflects more than the alpha particle as it is lighter.

Penetrating and Ionisation

We can test absorbed materials by placing the material between the source and a Geiger-Muller counter. As you add the absorber material the count rate will drop to 0 i.e. all the radiation has been absorbed.



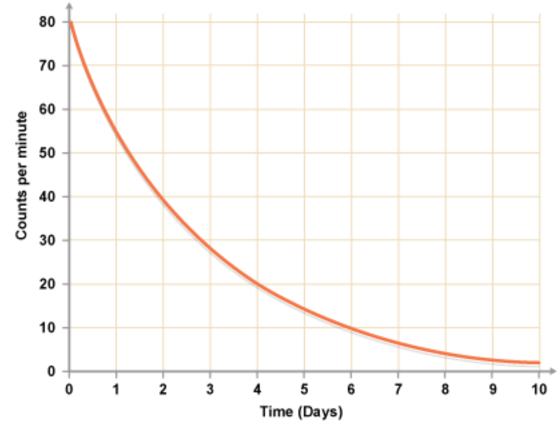
You can find the penetrating power in air by moving the source further from the counter. You find that alpha only travel a few centimetres, due to it being highly ionising, beta travels about 1m and gammas range is unlimited.

Half-Life & Uses

Half-life

There are two definitions for the half-life of a radioactive substance, either is just as valid as the other:

1. The time it takes for the count rate to half
2. The time it takes for half of the radioactive nuclei to decay



What is the first and second half-life of the radioactive isotope from the graph?

Uses of radioactivity

Here are some examples of how radiation is used:

- in smoke detectors
- for sterilising medical instruments
- for killing cancer cells
- for dating rocks and materials such as archaeological finds
- in chemical tracers to help with medical diagnosis
- for measuring the thickness of materials in, for example, a paper factory

How do you think radiation would be used in measuring the thickness of paper?

Evaluating the uses

- Medical Tracers

Doctors may use radioactive chemicals called tracers for medical imaging. Radiation detectors placed outside the body detect the radiation emitted and, with the aid of computers, build up an image of the inside of the body.

When a radioactive chemical is used in this way it is not normally harmful, because:

- it has a short half-life and so decays before it can do much damage
- it is not poisonous

Emitters of beta radiation or gamma radiation are used because these types of radiation readily pass out of the body, and they are less likely to causes ionisation of the cells compared to alpha radiation.

Fission & Fusion

What are the advantages and disadvantages of using nuclear ?

If 2 hydrogen with mass number of 2 and atomic number of 1 fuse together, what does it form?

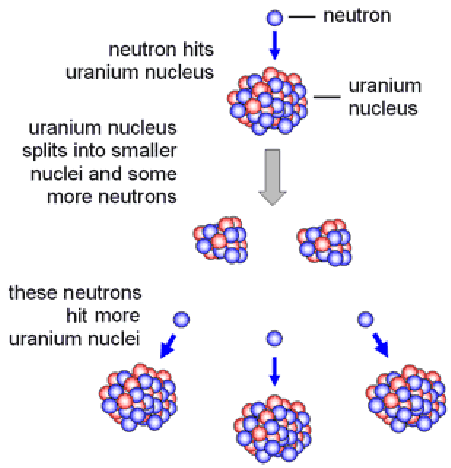
Fission

In a nuclear reactor, fission is sued to generate energy and hence electricity.

The two most common fissionable substances used in nuclear reactors are urnaium-235 and plutonium-239.

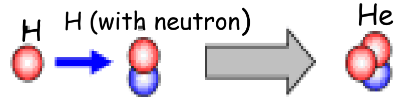
When either absorbs a neutron, the fissionable substance, uranium in the example below, splits into two smaller nuclei. When it does so, further neutrons are also released which can then be absorbed by other uranium nuclear, this creating a chain reaction. Control rods in a nuclear reactor absorb neutrons to control the rate of fission.

A moderating material slows down neutrons so that they can be absorbed. Fast moving electrons have little effect.



Fusion

Nuclear fusion is the joining together of smaller nuclei to form larger nuclei. This is the process which energy is released in stars. When the smaller nuclei fuse together there is a drop in mass compared to their separate masses. The difference in mass is released as energy.



The future

We are trying to create fusion generators on Earth but it is proving difficult to generate the conditions needed (high temperature and pressure).

Background radiation and radiation dose

Background radiation stems from nuclear fallout, rocks, medical, cosmic rays.

Air travel and occupation such as medicine increases the exposure.

Key Equations

On the Data Sheet

Not on the Data Sheet