AQA A-Level Physics

Topic 8: Nuclear Physics

Flashcards

Describe the Rutherford scattering experiment.

Describe the Rutherford scattering experiment.

- A beam of alpha particles was directed at a thin gold foil.
- Occurs in a vacuum so that no collisions between air particles and alpha particles can occur.
- The experiment was done in order to determine structure of an atom.

In the Rutherford scattering experiment it was observed that most of the alpha particles passed straight through. What can we infer from that?

In the Rutherford scattering experiment it was observed that most of the alpha particles passed straight through. What can we infer from that?

That most of the atom is made from empty space.

What evidence was there that suggested that the nucleus had a positive charge?

What evidence was there that suggested that the nucleus had a positive charge?

Because the the nucleus repels the alpha particles and caused it to deflect from its original path, some of them even bounced back.

Name 3 types of radiation?

Name 3 types of radiation?

- Alpha
- Beta (plus and minus)
- Gamma

Order Alpha,Gamma and Beta radiation starting with the most ionising?

Order Alpha,Gamma and Beta radiation starting with the most ionising?

- Alpha
- Beta
- Gamma

Order Alpha,Gamma and Beta radiation starting with the most penetrating?

Order Alpha,Gamma and Beta radiation starting with the most ionising?

- Gamma
- Beta
- Alpha

A sheet of paper can block which type of radiation?

A sheet of paper can block which type of radiation?

Alpha radiation.

This equation represents which process?

$$ {}^{A}_{Z}X + {}^{0}_{-1}e \rightarrow {}^{A}_{z-1}Y + V_e $$

This equation represents which process?

$$ {}^{A}_{Z}X + {}^{0}_{-1}e \rightarrow {}_{z-1}{}^{A}Y + V_e $$

Electron capture.

When a nucleus decays through gamma radiation, how does the atomic number and mass number change?

When a nucleus decays through gamma radiation, how does the atomic number and mass number change?

They remain the same as the number of protons and neutrons remain the same.

Why is ionising radiation seen as dangerous?

Why is ionising radiation seen as dangerous?

Because it can kill or mutate cells, which could lead to mutations and lead to things such as cancer.

Which radiation is more harmful inside a human body, alpha or gamma?

Which radiation is more harmful inside a human body, alpha or gamma?

Alpha radiation - because it has a high ionising power so it would damage more cells. It is also very poorly penetrating, therefore it is not be able to leave the body, whereas gamma radiation is highly penetrating.

Give an example of a real life use of Beta decay and explain why Beta is chosen for this.

Give an example of a real life use of Beta decay and explain why Beta is chosen for this.

Beta radiation can be used to measure the thickness of paper or aluminium foil. Alpha isn't used as it is less penetrative and wouldn't reach the detector on the other side of the sheet. Gamma radiation is too penetrative and would pass through everything.

Which type of radiation follows the inverse square law?

Which type of radiation follows the inverse square law?

Gamma radiation.

What does the inverse square law state?

What does the inverse square law state?

The intensity is inversely proportional to the square of the distance from the source.

What is intensity measured in?

What is intensity measured in?

Measured in watts per square meter (W/m^2).

Describe an experiment which be used to show the inverse square law and gamma rays.

Describe an experiment which be used to show the inverse square law and gamma rays.

- Firstly measure background radiation (using Geiger Muller tube), without the gamma source in the room
- Then put the gamma source at a set distance (1m) from the GM tube and measure the count rate per minute. Record 3 measurements for each distance and take an average.
- Do this for many distances going up in 10cm intervals
- Take away the background radiation from each reading
- Square each of the distances
- Plot a graph of the count rate per minute against 1 over distance squared ($1/d^2$)
- If it is a straight line through the origin then it confirms they are directly proportional

What is background radiation?

What is background radiation?

Radiation that is constantly in the surrounding from sources such as rocks and food.

What is the decay constant (λ)?

What is the decay constant?

The probability of a nucleus decaying per second.

What are the units for the decay constant (λ)?

What are the units for the decay constant?

s^{-1}

What is half life?

What is half life?

The time it takes for half of the unstable nuclei in a substance to decay.

What equation can you use to work out the half life of on object?

$T_{1/2} = \ln(2)/\lambda$

Complete the equation. λN =?

Complete the equation. λN =?

Activity.

What is activity measured in?

What is activity measured in ?

Bq (decays per second).

True or false. Radioactive isotope decay exponentially.

True or false. Radioactive isotope decay exponentially

True.

i.e . $N = N_0 e^{-\lambda t}$

Why is Technetium 99m useful in medicine?

Why is Technetium 99m useful in medicine?

- Because it releases gamma radiation
- It has a short half life therefore it doesn't stay highly radioactive for long
- Half life of 6 hours: long enough for it to be detected
- It can also be made near to the hospital
- Easy to detect outside the patient
- 'Clears away' after a few days

What does the graph of N against Z show?

What does the graph of N against Z show?

IT shows the relationship between proton number and neutron number. The graph shows a stability curve which starts as N=Z until N value of 20. After that the graph curves upward and becomes steeper.

Where on the curve does B- decay occur and why?

Where on the curve does B- decay occur and why?

Above the stability line, because the nuclei found there contains too many neutrons. Therefore when beta minus decay occurs the neutron turns into a proton and it becomes more stable.

What type of decay occurs below the stability line and why?

What type of decay occurs below the stability line and why?

Beta plus decay. As the isotopes found here often have too many protons. Therefore when beta plus decay occurs the proton turns into neutrons.

How does the heavier nuclei often decay?

How does the heavier nuclei often decay?

Through alpha decay. This is because alpha decay emits a helium nucleus (2 protons and two neutrons) therefore causing the nuclei to become less heavy and more stable.

A alpha particle is fired at a nucleus, with the kinetic energy at the start known. How can you use energy conservation to find closest approach of of particle?

A alpha particle is fired at a nucleus, with the kinetic energy at the start known. How can you use energy conservation to find closest approach of of particle?

We can work out how close a particle will get to a nucleus: we know the kinetic energy it heads to the nucleus and the electrostatic potential energy that repels it. At some point these equal and this is the closest approach the particle can get.

$$E_k = E_p$$

$$E_p = \frac{1}{4\pi\varepsilon_0}\frac{Q_\alpha Q_n}{r}$$

Ek = 1/2mv^2

r = qQ / 2πε₀mv^2

How is electron diffraction used to determine the diameter of a radius?

How is electron diffraction used to determine the diameter of a radius?

- An electron beam is fired at a thin sheet of the desired atom.
- A diffraction pattern is produced on a screen behind.
- Using the angle of a minimum we can use equations to calculate the diameter.

What is the relationship between nuclear radius(R) and nucleon number (A)?

What is the relationship between nuclear radius(R) and nucleon number (A)

$$R = r_0 A^{1/3}$$

Therefore nuclear radius is directly proportional to the cube root of the nucleon number.

True or false. The density of a nucleus is independent of its radius.

True or false. The density of a nucleus is independent of its radius.

True.

What equation is used to convert mass to its energy equivalent?

What equation is used to convert mass to its energy equivalent?

$$E = mc^2$$

What is the mass defect?

What is the mass defect?

The difference between the total mass of all the nucleons separately compared to the mass of the nucleus.

Why is there a mass defect?

Why is there a mass defect?

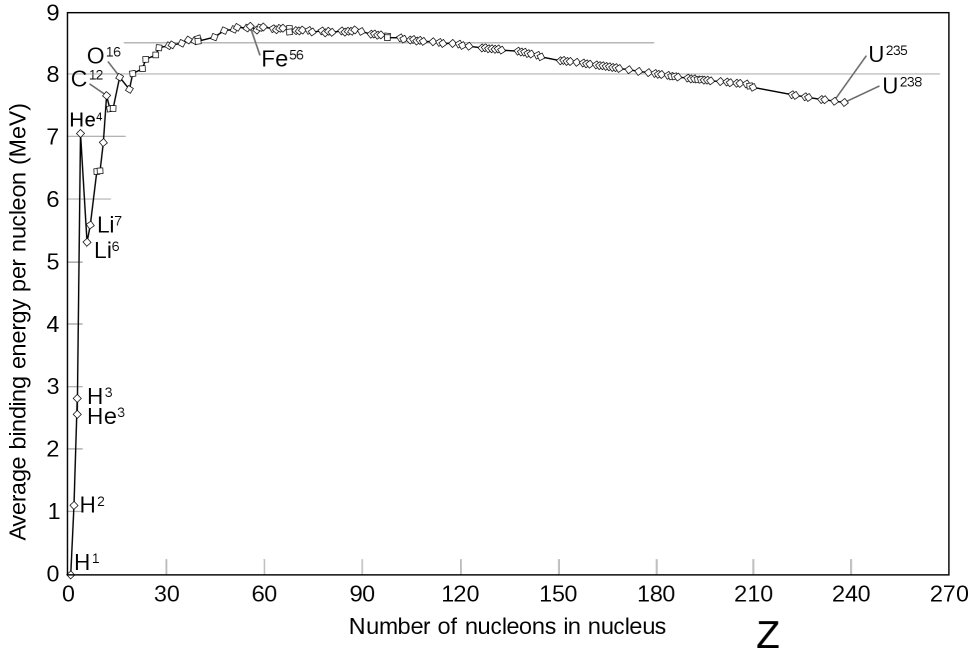
Because energy is needed to bring the constituent parts of a nucleus together, therefore the mass equivalent of the energy is lost and the total mass decreases.

What is binding energy? Draw a graph to show this.

What is binding energy? Draw a graph to show this.

The energy required to separate a nucleus into its constituent parts.

https://upload.wikimedia.org/wikipedia/commons/thumb/5/53/Binding_energy_curve_-_common_isotopes.svg/1920px-Binding_energy_curve_-_common_isotopes.svg.png



What is nuclear fission?

What is nuclear fission?

- Where a unstable nucleus splits into 2 smaller nuclei.
- Often occurs with the larger nuclei.
- The binding energy per nucleon increases when fission occurs therefore the overall process releases energy.

What is fusion?

What is fusion?

When two small nuclei fuse together to create a larger nuclei. The new nucleus has a larger binding energy per nucleon than the old nuclei therefore energy is released in the process.

Why is it difficult to make fusion occur on earth?

Why is it difficult to make fusion occur on earth?

There is a large repulsion between the two positively charged nuclei, therefore a lot of energy is required to overcome the repulsion and fuse them together.

It is hard to get a material that can withstand the heat and be cost effective.

How is fission used in nuclear reactors?

How is fission used in nuclear reactors?

Rods of uranium-235 absorb neutrons and become unstable and then split into two daughter nuclei. It also releases 2/3 more neutrons. These then go on to be reabsorbed by another uranium-235.

What is the purpose of a moderator?

What is the purpose of a moderator?

To slow down the neutrons so they travel slow enough to be absorbed by the uranium.

They do this through elastic collisions between the moderator and the nucleus.

Why is control rods essential for a nuclear power station?

Why is control rods essential for a nuclear power station?

They stop the chain reaction from being out of control.

They absorb neutrons so that only 1 of the neutrons released in each reaction can go on to be absorbed by another uranium.

If not then the nuclear reactor would overheat as too many reactions would happen at once.

Is Boron used as a control rod or a moderator?

Is Boron used as a control rod or a moderator?

Control Rods.

Give an example of a material that can be used as a moderator?

Give an example of a material that can be used as a moderator?

Water.

What is the purpose of using water as a coolant?

What is the purpose of using water as a coolant?

It allows heat from the nuclear reactor to escape, which stops the reactor from overheating.

What is the critical mass?

What is the critical mass?

The minimum mass of fuel needed for a chain reaction to occur.

Which waste products from a nuclear reactor cause the highest risk?

Which waste products from a nuclear reactor cause the highest risk?

Spent fuel rods.

How is high-level waste disposed of?

How is high-level waste disposed of?

- They are first stored in cooling ponds
- Then they are put in sealed steel containers and put deep underwater.

What is low level waste contained in?

What is low level waste contained in?

They are sealed in containers and put underground until it is safe again.