CAIE Physics A-level

11 - Particle Physics

Flashcards

How does the alpha-scattering experiment give evidence of a small and dense nucleus?

How does the alpha-scattering experiment give evidence of a small and dense nucleus?

A few alpha particles bounce back.

This wouldn't happen if the positive charge in the atom was distributed evenly throughout (as in the Plum Pudding Model), which suggests they must be hitting a dense positive charge. The fact it only happens to a very small number of alpha particles shows the nucleus must be small.

What are the main constituents of an atom?

What are the main constituents of an atom?

Proton

Neutron

Electron

How are atomic particles arranged within an atom?

How are atomic particles arranged within an atom?

Protons and Neutrons reside within the nucleus. Electrons orbit the nucleus in surrounding shells.

Which has a higher density: an atom or a nucleus?

Which has higher density: an atom or a nucleus?

A nucleus is much more dense than an atom since the atom includes a lot of empty space.

How many times more volume does an atom occupy compared to its nucleus?

How many times more volume does an atom occupy compared to its nucleus?

Approximately 100,000 times.

What is the letter associated with a proton number?

What is the letter associated with a proton number?

Z

What is a nucleon?

What is a nucleon?

A particle that makes up the nucleus: a proton or a neutron.

What is the unified atomic mass unit?

What is the unified atomic mass unit?

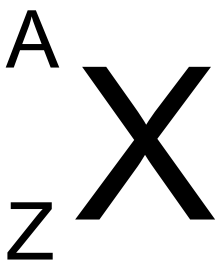
The unified atomic mass unit (u) is defined as 1/12 of the mass of a Carbon-12 atom. It is approximately equal to the average mass of a nucleon.

What letter represents nucleon number?

What letter represents nucleon number?

A

Which is the correct notation?



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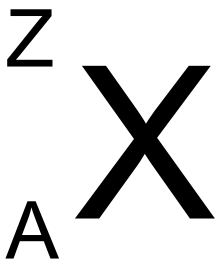

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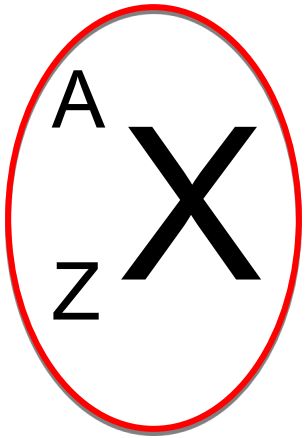

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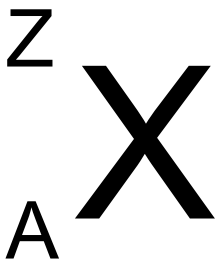

What is the definition of an isotope?

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Isotopes are atoms of an element (with the same number of protons) with a different number of neutrons (and therefore a different mass number).

What is an ion?

What is an ion?

Ions are similar to atoms but are charged, since they contain an unequal number of protons and electrons.

What is an alpha (α) particle?

What is an alpha (α) particle?

An alpha particle can be described as a fast moving Helium 2+ ion. It consists of a nucleus containing 2 protons and 2 neutrons.

What are beta (β) particles, including β^- particles and β^+ particles?

What are beta (β) particles, including β^- particles and β^+ particles?

Beta particles can be described as a fast moving electrons (β^-) and positrons (β^+) respectively. Both have negligible mass (9.11×10^{-31}kg). β^- particles have a relative charge of -1 (-1.6×10^{-19}C) and β^+ particles have a relative charge of +1 ($+1.6 \times 10^{-19}$C).

What are gamma (γ) rays?

What are gamma (γ) rays?

Gamma rays are short wavelength, high energy electromagnetic radiation, often emitted during radioactive decay. They have zero mass and zero charge.

Give an example of alpha (α) decay and represent this in a decay process in equation form?

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Uranium-238 decays to Thorium-234 in the following reaction:

$$^{238}_{92}U \Rightarrow {}^{234}_{90}Th^{2-} + {}^{4}_{2}\alpha^{2+} .$$

Give an example of β^- decay and represent this in a decay process in equation form?

Give an example of β^- decay and represent this in a decay process in equation form?

Carbon-14 decays to Nitrogen-14 in the following reaction:

$$^{14}_{6}C \Rightarrow ^{14}_{7}N^{+} + e^{-} + \overline{\nu}$$

Where $\overline{\nu}$ is an anti-neutrino

Give an example of β^+ decay and represent this in a decay process in equation form?

Give an example of β^+ decay and represent this in a decay process in equation form?

Carbon-10 decays to Boron-10 in the following reaction:

$$^{10}_{6}C \Rightarrow {}^{10}_{5}N^{-} + e^{+} + \nu$$

Where e^+ is a positron and ν is a neutrino.

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

Which type of radiation can only be stopped by a thick block of lead or concrete?

Which type of radiation can only be stopped by a thick block of lead or concrete?

Gamma radiation

How far does a beta particle typically penetrate in air?

How far does a beta particle typically penetrate in air?

50cm - 1m

A particle with nucleon number, A, and mass number, Z, undergoes alpha decay. What are the nucleon and mass numbers of the resulting particle? (In terms of A and Z)

A particle with nucleon number, A, and atomic number, Z, undergoes alpha decay. What are the nucleon and atomic numbers of the resulting particle? (In terms of A and Z)

Nucleon number = A - 4

Atomic number = Z - 2

In beta plus decay, how does the atomic number change?

In beta plus decay, how does the atomic number change?

It decreases.

(A proton turns into a neutron and a positron, so mass is ‘constant’ but atomic number decreases).

Why does beta plus decay have a very low penetration?

Why does beta plus decay have a very low penetration?

The positrons will be annihilated by electrons almost immediately.

What can electrons and positrons be described as relative to one-another?

What can electrons and positrons be described as relative to one-another?

They are antiparticles of one-another.

True or false?

‘Every particle has a antiparticle.’

True or false? ‘Every particle has a antiparticle.’

True.

Give a difference and a similarity between particles and their antiparticles.

Give a difference and a similarity between particles and their antiparticles.

They have a similar mass but opposite charges (eg. for protons/anti-protons).

Why do the electrons/positrons emitted in beta decay possess a continuous range of emitted energies, where alpha particles may only be emitted with distinct energies during alpha decay?

Why do the electrons/positrons emitted in beta decay possess a continuous range of emitted energies, where alpha particles may only be emitted with distinct energies during alpha decay?

During beta decay the decay output energy is shared between the electron and anti-neutrino (β^- decay) or the positron and the neutrino (β^+ decay), allowing for a continuous range of energies (within the total energy limit) to be possessed by the electron/positron. In alpha decay, only the alpha particle is emitted and it may only be emitted at distinct frequencies or energies.

What are quarks?

What are quarks?

They are the fundamental elementary constituents of matter: the basic unit from which all nuclear sub-atomic particles are constructed.

What are the six types of quark?

What are the six types of quark?

Up (u) and Down (d)

Strange (s) and Charm (c)

Top (t) and Bottom (b)

State the quark compositions of protons and neutrons.

State the quark compositions of protons and neutrons.

Protons are made up of two up quarks (+⅔ relative charge) and a down quark (-⅓ relative charge).

Neutrons are made up of one up quark (+⅔ relative charge) and two down quarks (-⅓ relative charge).

Do quarks have anti-particles?

Do quarks have anti-particles?

Yes they do. They are given the following notation:

$\bar{u}$ (anti-up), $\bar{d}$ (anti-down), $\bar{s}$ (anti-strange) etc...

What is a hadron?

What is a hadron?

A hadron sub-atomic particle comprising two or more quarks held together by the strong nuclear force.

What are the main classes of hadron?

What are the main classes of hadron?

- Baryons (three quarks)
- Mesons (one quark and one anti-quark)

Give two examples of baryons.

Give two examples of baryons.

Protons and neutrons.

What are leptons?

What are leptons?

Leptons are fundamental particles which are not subject to the strong nuclear force.

(They do still interact via the weak nuclear force)

Give some example of leptons.

Give some example of leptons.

Electrons

Muons

Neutrinos

And their corresponding antiparticles

Give the charges of the up, down and strange quarks (in terms of the electron charge, e).

Give the charges of the up, down and strange quarks (in terms of the electron charge, e).

Up = $+\frac{2}{3}e$

Down = $-\frac{1}{3}e$

Strange = $-\frac{1}{3}e$

(The charges of corresponding antiparticles have the same magnitude, but the opposite sign).

What is meant by beta minus decay?

What is meant by beta minus decay?

When a neutron turns into a proton and the atom releases an electron and an anti electron neutrino.

Which quark decays in beta minus decay?
What does it turn into?

Which quark decays in beta minus decay? What does it turn into?

A down quark turns into an up quark (emitting an anti-neutrino).

Which quark decays in beta plus decay? What does it turn into?

Which quark decays in beta plus decay? What does it turn into?

An up quark is converted to a down quark (emitting a neutrino).

What quantities must be conserved during the decay of particles?

What quantities must be conserved during the decay of particles?

Charge, mass, baryon and lepton numbers.

(And energy - but you can't show this in a symbol equation)

What are the defining features of radioactive decay?

What are the defining features of radioactive decay?

Radioactive decay is spontaneous and random - you can't predict when an individual nucleus will decay (or which nucleus will go next).

What features of a nucleus might cause it to radioactively decay?

What features of a nucleus might cause it to radioactively decay?

- Too many or too few neutrons.
- Too heavy (too many nucleons).
- Too much energy.