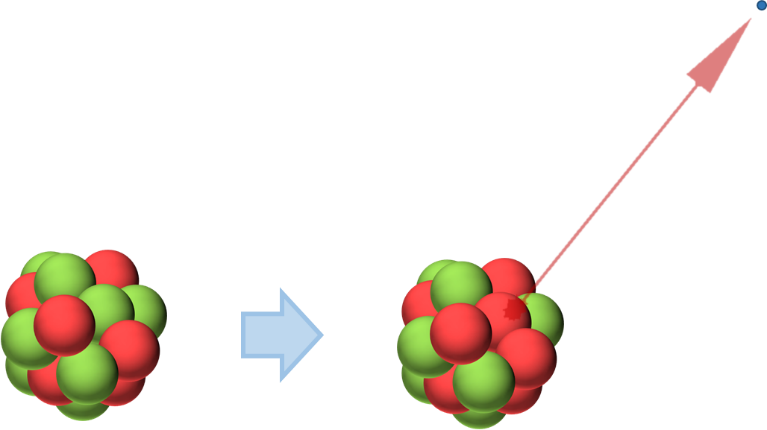
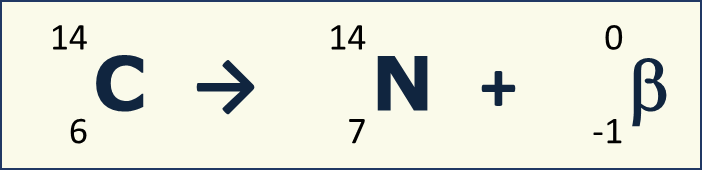
**Beta decay**

The nucleus on the left is carbon-14.

A carbon-14 nucleus is unstable.

It can decay by emitting a beta particle.

This is a nuclear equation that shows what happens:



What does the equation tell you about the beta decay of carbon-14?

*For each statement, tick (✓)* ***one*** *column to show what you think.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | A new nucleus is made that is a different element. |  |  |  |  |
| **B** | A beta particle is a type of proton. |  |  |  |  |
| **C** | A beta particle has a negative electric charge. |  |  |  |  |
| **D** | A proton turns into a neutron and a beta particle. |  |  |  |  |

*Some unstable nuclei undergo beta decay.*

*Others can decay by different sorts of radioactive decay.*

*Physics > Big idea PMA: Matter > Topic PMA5: Nuclear physics > Key concept PMA5.2: Radioactive decay*

|  |
| --- |
| **Diagnostic question** |
| **Beta decay** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Some nuclei, which are unstable because they have too many neutrons, decay spontaneously by beta radiation because neutrons are unstable away from the close proximity of protons. |
| Observable learning outcome: | Interpret nuclear equations to describe the beta decay of radioactive nuclei. |
| Question type: | Confidence grid |
| Key words: | Radioactive decay, nucleus, proton, neutron, beta particle, beta decay, stable, unstable |

**What does the research say?**

During beta decay, a neutron in the nucleus becomes a proton and a high-speed electron is created, which is emitted from the nucleus, leaving a nucleus of a different element. The valence electrons around the nucleus will be affected only indirectly, which is because after radioactive decay the proton number of the atom is changed and the way it attracts valence electrons is affected. The actual process of radioactive decay involves just the nucleus.

This does not appear to be understood by the majority of students. In a study in the USA, Prather (2005) found that just 26% of high school students (n=19) and 33% of first year undergraduate students, who were non-science majors studying physics (n=258), thought that radioactive decay involved just the nucleus of an atom. In the case of beta-decay, he found that it was common for them to think that electron emitted was one of the valence electrons.

**Ways to use this question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

Statements A and C are right; and statements B and D are wrong.

**How to respond - what next?**

A beta-particle is identical to a valence electron, but is emitted at a very high speed from an unstable nucleus.

During beta-decay, a neutron in an unstable carbon-14 nucleus transforms into a proton, and a beta particle is created that is emitted from the nucleus. What is left is a nitrogen-14 nucleus that has one extra proton, and one neutron less.

A It is common for students to describe beta decay as making an unstable nucleus more stable, which may imply that the *type* of nucleus is not changed. This can reinforce the misunderstanding that radioactive decay does not result in a nucleus of a different element.

It is also common for students to think that a radioactive nucleus disappears after it decays (Prather, 2005).

B. For nuclear equations, the atomic number can mean different things, depending on the context, and this can lead to confusion. For a nucleus, or for an alpha-particle, it signifies the number of protons. For other particles can signify the charge of a particle, relative to the charge of a proton. In nuclear equations it is sometimes referred to as the charge number.

Some students may think that the -1 on a beta particle signifies it is a proton, perhaps with a negative charge. However, the mass number of a beta particle is 0, which suggests it is not a proton. Instead it is an electron with a charge of -1.

C The beta particle has a ‘charge’ number of -1, which gives it a negative charge of -1.

D Students who think this statement is correct may be confusing protons and neutrons. In a nuclear reaction, the total charge is conserved. The positive charge of the proton and negative charge of the beta particle add up to zero, which is the charge on the original neutron.

If students have misunderstandings about Interpreting nuclear equations to describe the beta decay of radioactive nuclei, it can help to provide them with examples of nuclear equations and to give them the opportunity to describe each beta-decay in words, giving as much detail as possible.

Students working in pairs or in small groups to agree on group answers can help consolidate learning through the social construction of understanding.

*N.B. During beta decay a further particle, the anti-neutrino, is also created when a neutron decays into a proton. This particle is typically introduced at a later stage of learning, to students studying physics aged 16-19.*

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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