**Beta origin**

A beta particle is a high-speed electron.

Carbon-14 decays by beta-decay.

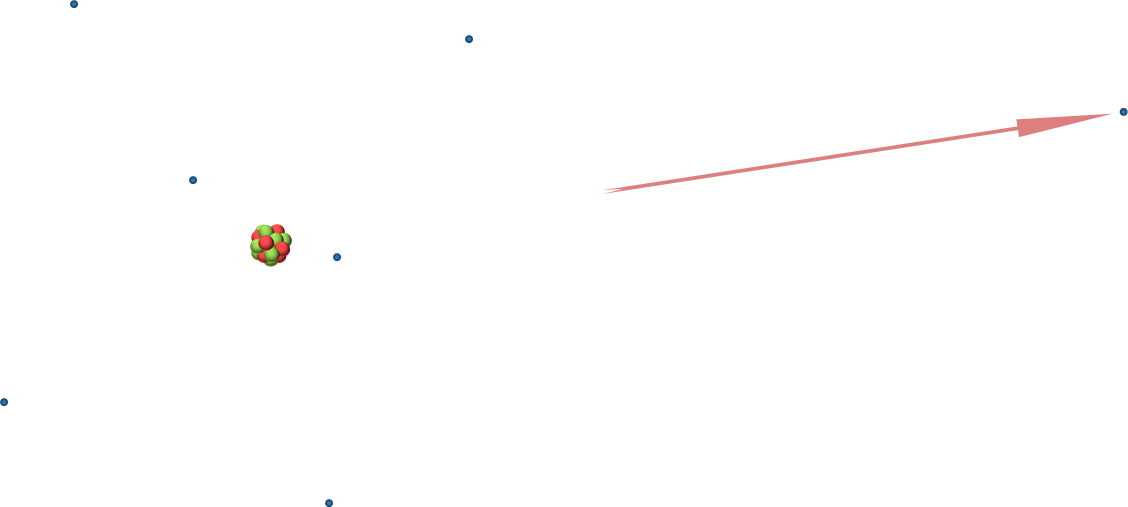
A beta particle is emitted.

Carbon-14 atom

*(not to scale)*

Beta particle

*(emitted during beta decay)*



Where does the beta particle come from?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | It shoots out of the nucleus of an atom. |  |
|  |  |  |
| **B** | It is one of the electrons around an atom that shoots out. |  |
|  |  |  |
| **C** | It is one of the electrons around an atom that the nucleus forces out when it decays. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Beta origin** |

**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: | Describe what happens to an atom and its nucleus during a beta decay. |
| Question type: | Simple multiple choice |
| Key words: | Radioactive decay, nucleus, proton, neutron, valence electrons, emitted |

**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 beta decay involved just the nucleus of an atom. He found that it was common for them to think that electron emitted was one of the valence electrons, either with or without the influence of the nucleus.

**Ways to use this question**

Students should complete the question 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.

The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

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 answer**

A

**How to respond - what next?**

In a study, carried out in the USA, Edward Prather (2005) used a mixture of open response questions, interviews and multiple choice questions to explore students’ beliefs about the role of atoms in radioactive decay. His results, recording which parts of an atom students thought were involved in radioactive decay, are shown in the table below.

|  |  |  |
| --- | --- | --- |
| Response type | Undergraduate students,  who were non-science majors studying a physics module (n=258) | High school students  (age 15-19, n=19) |
| RA decay involves only valence electrons. | 44% | 37% |
| RA decay involves only neutrons, protons, and the nucleus. | 33% | 26% |
| RA decay involves both valence electrons and the nucleus. | 21% | 37% |
| Other | 3% | 0% |

These results indicate that a majority of students may think that a beta particle originates from the valence electrons that are around the nucleus in an atom, either without the influence of the nucleus (option B in this diagnostic question) or with the influence of the nucleus (option C).

If students have misunderstandings about describing what happens to an atom and its nucleus during a beta decay, it can help to review the ‘mechanism’ of beta decay, which is caused by neutrons being unstable away from the close proximity of protons, such as in neutron rich nuclei. Diagnostic questions from towards the start of the learning progression in the BEST key concept*: radioactive decay (beta decay)* may be helpful.

It is quite possible that students develop misunderstandings about the origin of a beta particle because they have not learnt about the ‘mechanism’ of beta decay. Without an understanding of neutron instability, they may quite reasonably combine their understanding of the structure of an atom with a description of beta decay to conclude that a beta particle must originate as a valence electron.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Beta decay story.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Prather, E. (2005). Students' beliefs about the role of atoms in radioactive decay and half-life. *Journal of Geoscience Education,* 53(4)**,** 345-354.