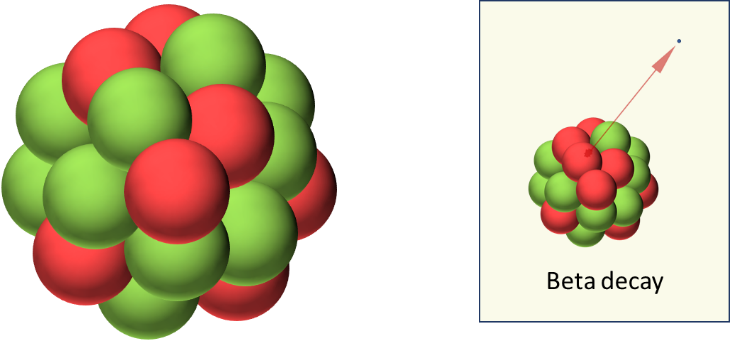
**Beta decay story**

This nucleus is unstable because it has too many neutrons.

An unstable nucleus like this can emit a beta particle.



Describe beta decay.

*Pick* ***one*** *statement in each row to explain how.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | Neutrons are unstable when they are not very close to protons. | | | |
| 2 | They are more likely to be away from protons in a large nucleus. | | They are more likely to be away from protons in a neutron rich nucleus. | |
| 3 | An unstable neutron is likely to decay. | | An unstable neutron will decay. | |
| 4 | A beta particle is emitted that pushes the nucleus backwards. | | A beta particle is emitted that destroys the nucleus. | |
| 5 | A beta particle is a high-speed electron created in the nucleus. | | A beta particle is a high-speed electron from outside the nucleus. | |
| 6 | The atom is now a different element. | The atom does not exist anymore. | | The atom is the same element and is more stable. |

**To answer:**

What else can you say about the nucleus that remains?

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

|  |
| --- |
| **Response activity** |
| **Beta decay story** |

**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.  Explain why a nucleus can often emit gamma radiation after a beta decay. |
| Activity type: | Explanation story |
| Key words: | Radioactive decay, nucleus, proton, neutron, valence electrons, emitted |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Beta origin
* Diagnostic question: After beta

**What does the research say?**

At ages 14-16, students are rarely taught about these ideas or that the causes of alpha, beta and gamma radiation are each different. By thinking about the mechanisms behind each of these types of radioactive decay, this key concept is designed to support the development of useful mental models that can help challenge students’ misunderstandings about radioactive decay and clarify gaps in understanding that could otherwise lead to some confusion or uncertainty.

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 activity**

This task is intended for discussion in pairs or small groups. It is best done as a pencil and paper exercise.

Students should read the statements and follow the instructions on the worksheet. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as the scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

**a.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | Neutrons are unstable when they are not very close to protons. | | | |
| 2 | They are more likely to be away from protons in a large nucleus. | | They are more likely to be away from protons in a neutron rich nucleus. | |
| 3 | An unstable neutron is likely to decay. | | An unstable neutron will decay. | |
| 4 | A beta particle is emitted that pushes the nucleus backwards. | | A beta particle is emitted that destroys the nucleus. | |
| 5 | A beta particle is a high-speed electron created in the nucleus. | | A beta particle is a high-speed electron from outside the nucleus. | |
| 6 | The atom is now a different element. | The atom does not exist anymore. | | The atom is the same element and is more stable. |

**b.** The nucleus recoils and its protons and neutrons are left jiggling about more vigorously. If the amount of energy the nucleus has because of its excited state is sufficiently large, the nucleus can emit gamma radiation (a gamma photon) to transfer its extra energy away.

**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.