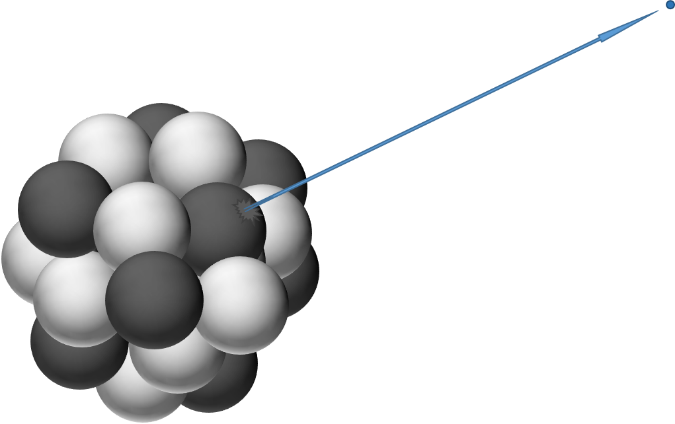
**The chances of beta**

The atoms of some radioactive isotopes have nuclei that are neutron rich.

These isotopes usually decay by emitting a beta particle.



Some students are discussing why a neutron rich nucleus is likely to emit a beta particle.

**Aidan:** If a neutron is far enough from a proton it will decay.

**Crystal:** The closer a neutron is to protons, the less likely it is to decay.

**Darcie:** A neutron is made of a proton and an electron.

**Billy:** The arrangement of protons and neutrons affects the probability that a neutron will decay.

**To answer**

1. Who is right about why a neutron rich nucleus is likely to emit a beta particle?

*Explain your answer*

1. Who is wrong about why a neutron rich nucleus is likely to emit a beta particle?

*What would you say to help them understand?*

|  |  |
| --- | --- |
| Cards for  **The chances of beta** |  |
| **Aidan:** If a neutron is far enough from a proton it will decay. | **Billy:** The arrangement of protons and neutrons affects the probability that a neutron will decay. |
| **Crystal:** The closer a neutron is to protons, the less likely it is to decay. | **Darcie:** A neutron is made of a proton and an electron. |

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| Cards for  **The chances of beta** |  |
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*Physics > Big idea PMA: Matter > Topic PMA5: Nuclear physics > Key concept PMA5.2: Radioactive decay*

|  |
| --- |
| **Response activity** |
| **The chances of beta** |

**Overview**

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| 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: | Explain why the chances of beta decay increase with the proportion of neutrons to protons in a nucleus. |
| Activity type: | Talking heads |
| Key words: | Radioactive, isotope, nucleus, proton, neutron, neutron-rich, beta particle, beta decay |

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

* Diagnostic question: Neutron rich

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| --- | --- |
| **B** | **BRIDGING**  This activity explores ideas that are usually taught at age 16-19, to build a bridge to later stages of learning. |

**What does the research say?**

At ages 14-16, students are rarely taught that the causes of alpha, beta and gamma radiation are each different. By thinking about the mechanisms behind beta decay students can develop of a useful mental model that can help challenge misunderstandings about radioactive decay and clarify gaps in understanding that could otherwise lead to some confusion or uncertainty.

Prather (2005) found that, even after tuition, 59% of the undergraduates believed that the mass or volume of a radioactive substance reduced by half after one half-life, when half the substance had decayed. This outcome is suggestive that the language used to describe what is happening: ‘half of it has decayed’ and ‘half-life’ is taken literally by students; which in turn suggests that many students do not have a clear mental model of radioactive decay that they can draw on.

This response activity gives students opportunity to discuss and to consolidate their understanding of what makes neutrons more unstable, in order to explain why neutron rich isotopes can decay by beta emission.

**Ways to use this activity**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. 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**

Billy and Crystal are right; and Aiden and Darcie are wrong.

The arrangement of protons and neutrons in a nucleus affects the probability that a neutron will decay, because the closer a neutron is to protons, the less likely it is to decay. This is because the close proximity of protons provides stability to a neutron. Neutron rich nuclei are likely to undergo beta decay, because the higher the ratio of neutrons to protons in a nucleus, the greater the mean distance between each neutron and the protons nearest to it.

Aiden is wrong because he thinks that there is a fixed distance, between a proton and a neutron, after which the neutron decays. This ignores the random nature of radioactive decay, and increasing the distance instead increases the *probability* of a decay.

Darcie is wrong because she imagines that a neutron is an electron attached to a proton, which is broken off during beta decay. Instead, the neutron decays into a proton and the electron is created from the energy released by this decay (according to E=mc2).

**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.