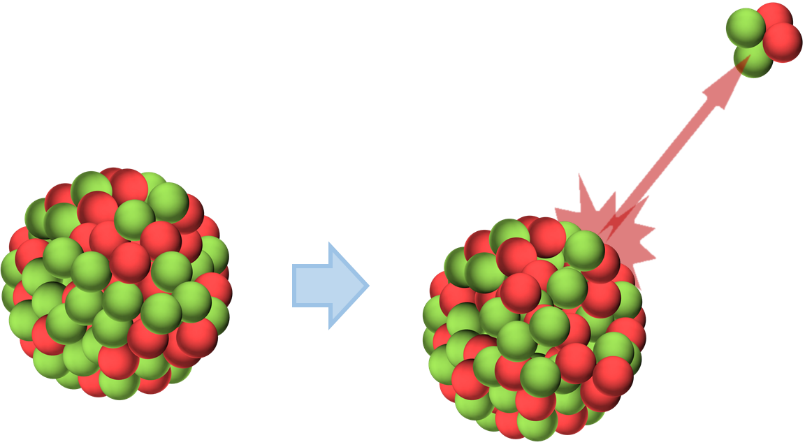
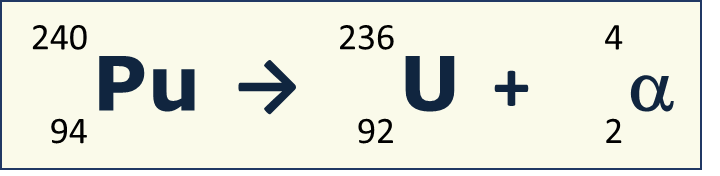
**Alpha decay**

The nucleus on the left is plutonium-240.

A plutonium-240 nucleus is unstable.

It can decay by emitting an alpha particle.

This is a nuclear equation that shows what happens:



What does this tell you about the alpha decay of plutonium-240?

*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 uranium nucleus is stable. |  |  |  |  |
| **C** | An alpha particle has a positive electric charge. |  |  |  |  |
| **D** | A plutonium nucleus loses 2 protons and  2 neutrons. |  |  |  |  |

*Some unstable nuclei undergo alpha 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** |
| **Alpha decay** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Some large nuclei, which are unstable because they contain too many protons, decay spontaneously by alpha radiation because of repulsive forces between protons. |
| Observable learning outcome: | Interpret nuclear equations to describe the alpha decay of radioactive nuclei. |
| Question type: | Confidence grid |
| Key words: | Radioactive decay, nucleus, proton, neutron, alpha particle, alpha decay, stable |

**What does the research say?**

Key to understanding the reasons for alpha decay, is an understanding of the repulsive electrostatic forces between protons in a nucleus. However, amongst students age 13-18, the level of awareness is low that an electrostatic force attracts electrons to a nucleus and causes electrons around a nucleus, or protons within a nucleus, to repel each other (Harrison and Treagust, 1996; Tabor, 2013). In his study, Taber (2013) found that it was more common for students aged 15-18 (N=105) to think instead, that gravity or magnetism attracts electrons towards a nucleus. These findings suggest it is likely that many students think about atomic structure in isolation from their thinking about electrostatic forces and need support to defragment their understanding of each concept.

During alpha decay, the nucleus of the radioactive atom loses two protons and two neutrons and therefore becomes an atom of a different element. The valence electrons around the nucleus will be affected indirectly because after radioactive decay the proton number of the atom is changed. However, the actual process of radioactive decay involves just the nucleus; and all alpha particles originate from a nucleus and account for a very small fraction of its mass.

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.

**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, C and D are right; and statement B is wrong.

**How to respond - what next?**

During alpha-decay, an unstable plutonium-240 nucleus loses an alpha particle that has two protons (proton number) and two neutrons (mass number minus proton number). What is left is a nucleus of uranium-236. The new nucleus is uranium because it now has 92 protons, which is the atomic number of uranium.

A It is common for students to describe alpha decay as making an unstable nucleus more stable. This way of speaking can imply that the new nucleus formed is a stable version of the same nucleus and 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. There is nothing to suggest in the nuclear equation that the nucleus formed is stable or unstable.

C The alpha particle has an atomic number of 2, which gives it a positive charge of 2+. Some students may consider it to be like a small atom, with two electrons and no overall charge. These students perhaps have the common misunderstanding that radioactive decay involves both the nucleus and the valency electrons.

D Some students may not have a clear understanding of how the atomic number and the mass number relate to the numbers of protons and neutrons in a particle.

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

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

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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