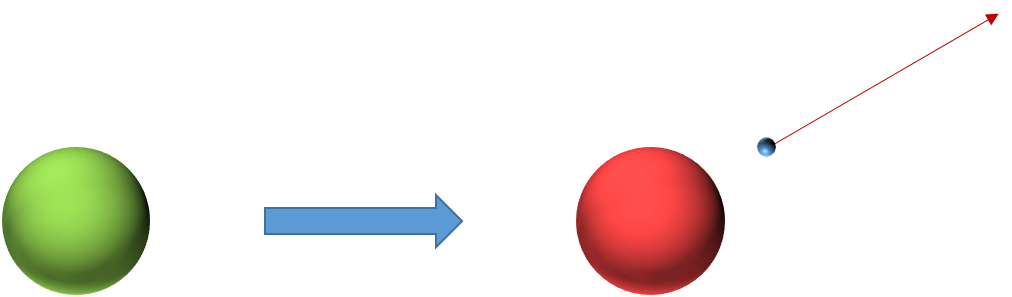
**A stable partnership**

On their own neutrons are unstable.

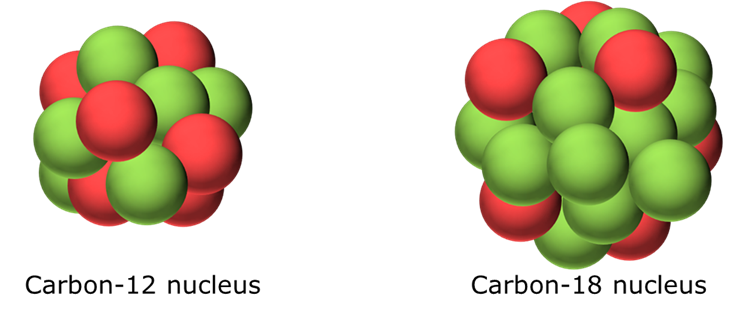
A neutron can change into a proton and shoot out an electron.

Inside a nucleus, neutrons are made more stable by the protons around them.



Compared to a carbon-18 nucleus,

what do you think about a carbon-12 nucleus?



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** | Its protons push apart with more force. |  |  |  |  |
| **B** | Its neutrons are more stable. |  |  |  |  |
| **C** | It’s more stable than a carbon-18 nucleus. |  |  |  |  |

*Physics > Big idea PMA: Matter > Topic PMA5: Nuclear physics > Key concept PMA5.1: Atomic nuclei*

|  |
| --- |
| **Diagnostic question** |
| **A stable partnership** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | There is a fixed number of positively charged protons in the nucleus of each atom of an element, but the number of neutrons can vary to make isotopes that are either stable or unstable. |
| Observable learning outcome: | Explain why some nuclei are stable and others are not. |
| Question type: | Confidence grid |
| Key words: | Stable, unstable, nucleus, strong nuclear force, electrostatic force, proton, neutron, nucleon |

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

**What does the research say?**

The level of awareness is low amongst students, age 13-18, 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).

To develop a deeper understanding of the structure of nuclei, Brock, Manning and Walsh (2021) suggest starting by reinforcing understanding of the structure and scale of an atom by modelling Rutherford’s scattering experiment. Their next step is to introduce the proton and neutron, and to use nomenclature to give students opportunity to explore the numbers of protons, neutrons and electrons in different atoms. This introduces students to ideas about isotopes and about what makes some nuclei stable and others unstable (radioactive).

This question checks students’ understanding about *why* different numbers of protons and neutrons make a nucleus more or less stable.

**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**

All three statements are right.

**How to respond - what next?**

A Both nuclei contain six protons, but in carbon-12 the repulsive electrostatic force is stronger because they are closer together.

A few students may have the misunderstanding that protons do not repel when they are in a nucleus.

B Without protons, neutrons have a half-life of about ten minutes. In carbon-18 there are 12 neutrons and 6 protons, which means that it is quite likely that the immediate neighbours of some neutrons will be mainly neutrons. These neutrons are more likely to decay into a proton and shoot out an electron, which makes the nucleus less stable.

Most students will be unfamiliar with neutrons being unstable. This understanding is necessary to explain why there are clear limits on the number of neutrons in a stable nucleus.

C Carbon-12 is a good compromise between having too few neutrons, with forces between protons being too big, and having too many neutrons, leading to the neutrons themselves becoming unstable.

Some students may deduce this from their knowledge of stable nuclei that are defined on the periodic table. It is more likely that this statement will raise questions and initiate a discussion about what makes a more stable nucleus.

At this stage, it is sufficient for students to understand that there are factors that limit how few or how many neutrons there can be in a nucleus that is stable.

If students have misunderstandings about explaining why some nuclei are stable and others are not, it can help to consider what happens at either extreme of having too few or too many neutrons:

* having too few neutrons results in protons that are so close the repulsion between them is very large and they are pushed apart
* and having too many neutrons results in isolated neutrons that are unstable.

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

* Response activity: Pushing apart

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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