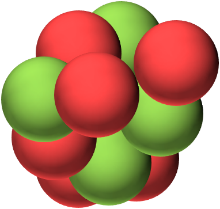
**Pushing apart**

There are six protons in the nucleus of **every** carbon atom.

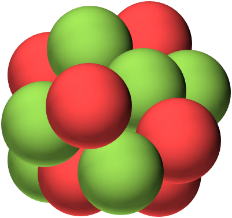
Below are the nuclei of some different isotopes of carbon.

Carbon-12 is stable; carbon-10 and carbon-18 are unstable.



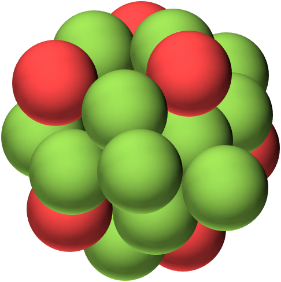
Carbon-10 nucleus

6 protons, 4 neutrons



Carbon-10 nucleus

6 protons, 4 neutrons



Carbon-10 nucleus

6 protons, 4 neutrons

***To do:*** *organise the following statements into two paragraphs.*

1. One to describe why carbon-10 is less stable than carbon-12.

2. Another to describe why carbon-18 is less stable than carbon-12.

Protons are closer together.

Neutrons are less stable.

On average, each neutron is closer to more protons.

On average, each neutron is closer to fewer protons.

The electrostatic force pushing them apart is smaller.

It is easier for the strong nuclear force to hold the nucleus together.

It is harder for the strong nuclear force to hold the nucleus together.

Protons are further apart.

The electrostatic force pushing them apart is bigger.

Neutrons are more stable.

**Pushing apart** cards

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

|  |
| --- |
| **Response activity** |
| **Pushing apart** |

**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. |
| Activity type: | Explanation story |
| Key words: | Stable, unstable, nucleus, strong nuclear force, electrostatic force, proton, neutron, nucleon |

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

* Diagnostic question: A stable relationship
* Diagnostic question: A stable partnership

|  |  |
| --- | --- |
| **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?**

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 activity extends students’ understanding to consider *why* different numbers of protons and neutrons can make a nucleus more or less stable.

**Ways to use this activity**

This task is intended for discussion in pairs or small groups, with cards provided that each group can organise into an appropriate order.

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**

**Carbon-10 is not as stable as carbon-12**

Protons are closer together.

The electrostatic force pushing them apart is bigger.

It is harder for the strong nuclear force to hold the nucleus together.

On average, each neutron is closer to more protons.

Neutrons are more stable.

**Carbon-18 is not as stable as carbon-12**

Protons are further apart.

The electrostatic force pushing them apart is smaller.

It is easier for the strong nuclear force to hold the nucleus together.

On average, each neutron is closer to fewer protons.

Neutrons are less stable.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Brock, R., Manning, A. and Walsh, K. (2021). Atomic physics. In de Winter, J. & Hardman, M. (eds.) *Teaching Secondary Physics.* 3rd ed. London: Hodder Education.

Harrison, A. G. and Treagust, D. F. (1996). Secondary students' mental models of atoms and moelcules: Implications for teaching chemistry. *Science Education,* 80(5)**,** 509-534.

Tabor, K. S. (2013). Upper secondary students' understanding of the basic physical interactions in analogous atomic and solar system models. *Research in Science Education,* 43**,** 1377-1406.