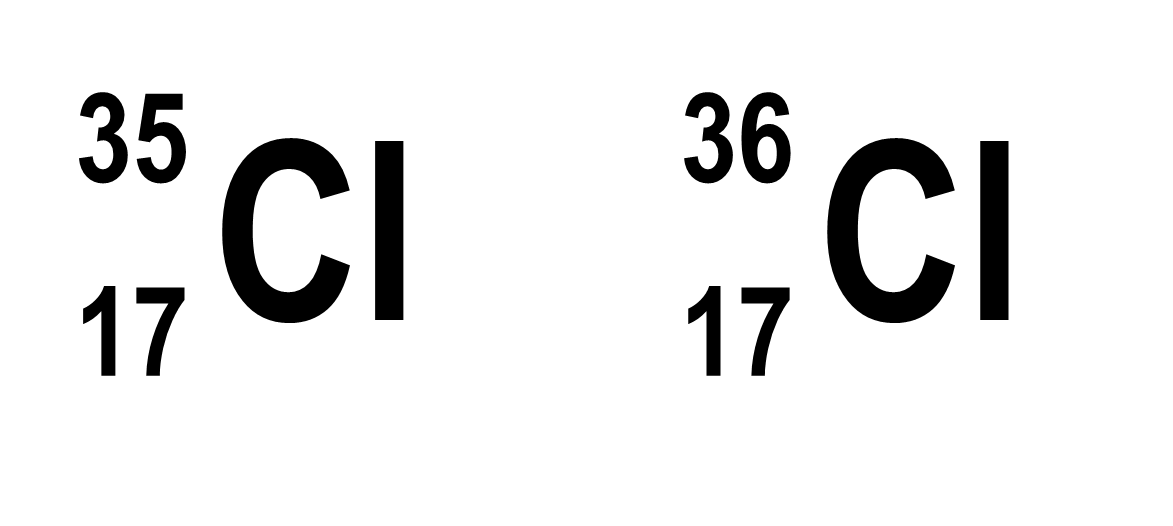
**Different but the same**

These atoms are both chlorine atoms.

They are **isotopes** of chlorine.



How do the particles in one **isotope** compare to those in the other?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | Same number of protons, neutrons and electrons. |  |
|  |  |  |
| **B** | Same number of protons and electrons, different number of neutrons. |  |
|  |  |  |
| **C** | Same number of protons, different number of neutrons and electrons. |  |
|  |  |  |
| **D** | Same number of neutrons, different number of protons and electrons. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Different but the same** |

**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 what isotopes of an element are. |
| Question type: | Simple multiple choice |
| Key words: | Isotope, element, atom, nucleus, proton, neutron, electron, mass number, atomic number |

**What does the research say?**

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 diagnostic question checks students understanding of an isotope and their understanding of the difference between the atomic structures of different elements.

**Ways to use this question**

Students should complete the question 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.

The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

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**

B

**How to respond - what next?**

Both isotopes of chlorine have the same number of protons and electrons, but the numbers of neutrons can vary. This is because it is the number of electrons around an atom (equal to the number of protons in its nucleus) that determine how it interacts with other atoms – its chemistry. The number of neutrons does not affect the number of electrons, but may affect how stable the nucleus is.

A Some students may have the misunderstanding that every atom of a particular atom is identical to every other atom and assume that isotopes of an atom are identical. It is possible that some students who pick the correct option (B) by working out the maths, may still hold this misunderstanding, which can lead to a sense of confusion.

C Students picking this option are likely to have confused the properties of protons and neutrons; or they may not understand how the number of protons in the nucleus of an atom determines the number of electrons around it.

D It is likely that students choosing this option believe the atomic number is the number of neutrons in an atom’s nucleus.

If students have misunderstandings about explaining what isotopes of an element are, it is important to first establish that they understand the properties of protons, neutrons and electrons, and the structure of an atom. Understanding of the link between the numbers of positively charged protons and negatively charged electrons in an atom needs to be clear; as does a knowledge of what particles are counted by the atomic number and the mass number.

Once these ideas have been consolidated, a discussion about how atoms interact with each other can follow. Careful questioning should elicit understanding that:

* The number of protons in a nucleus determines the number of electrons around an atom.
* That the nucleus of an atom is shielded from other atoms and it is their outer electrons that can interact.
* That the positive charge of a nucleus acts over a distance and can affect how an atom interacts.
* That changing the number of neutrons in a nucleus does not affect the number of electrons in an atom or the charge on the nucleus.
* That changing the number of neutrons in a nucleus does not affect how an atom interacts chemically with other atoms.
* An element can comprise of more than one type of atom, which all have the same number of protons and electrons (governing how the atom interacts) and a range of different numbers of neutrons.
* Each different atom of an element is called an isotope of that element.

(Isotope: from iso- meaning ‘equal’ and the Greek *topos*meaning ‘place’, because isotopes of an element occupy the same place in the periodic table.)

Giving students opportunity to work in pairs or small groups to develop their own definitions of what isotopes of an element are, and how the properties of different isotopes compare, can help to consolidate understanding.

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

* Response activity: Accounting for atoms

**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.