**Numbering nucleons**

The nucleus of an atom is made of protons and neutrons.

Together, protons and nucleons are called **nucleons**.

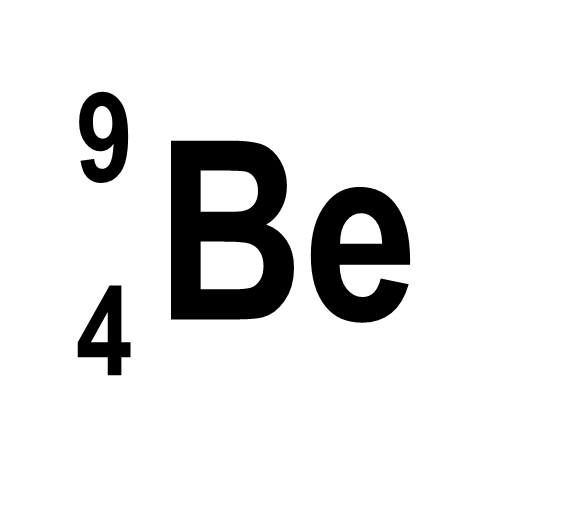
The structure of an atom can be described using just two numbers.

Atomic symbol

(for beryllium)

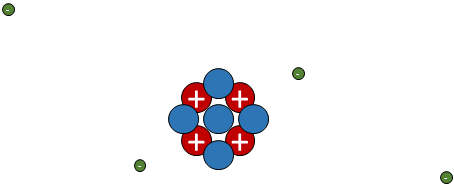
Mass number

(number of nucleons)



Atomic number

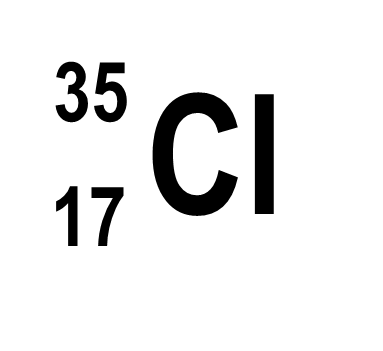
(number of protons)

Atomic number = 4, so 4 protons.

**Mass number = 9**, which is the total number of protons *and* neutrons.

9 – 4 protons = 5, so 5 neutrons.

**4 protons**, so 4 electrons to give the atom a total charge of zero.

**How many protons, neutrons and electrons are there in this atom of chlorine?

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

|  |  |  |
| --- | --- | --- |
| **A** | 17 protons 35 neutrons 17 electrons |  |
|  |  |  |
| **B** | 17 protons 18 neutrons 17 electrons |  |
|  |  |  |
| **C** | 17 protons 18 neutrons 18 electrons |  |
|  |  |  |
| **D** | 35 protons 17 neutrons 35 electrons |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Numbering nucleons** |

**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: | Determine the structure of an atom from its mass number and atomic number. |
| Question type: | Simple multiple choice |
| Key words: | 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 the nomenclature used as shorthand to describe the numbers of different particles in atoms.

N.B. the outer edge of the model beryllium atom shown is deliberately unclear.

**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 answer**

B

**How to respond - what next?**

This question requires students to apply understanding that the nucleus of an atom contains protons and neutrons and that the number of electrons around an atom’s nucleus is the same as the number of protons in the nucleus.

A Some students may confuse nucleons with neutrons.

C Others may not fully understand the difference between protons and neutrons. In particular that protons have a positive charge, which is balanced by the negative charge of electrons in an atom.

D Some students may get the mass number and atomic numbers back to front.

N.B. If students are not confident in their understanding there is a tendency for them to guess at an answer using numbers provided. Any of the wrong answers may have been chosen in this way.

If students have misunderstandings about how to determine the structure of an atom from its mass number and atomic number, it may be necessary to revisit learning about the structure of an atom, including the electric charge of protons, neutrons and electrons.

Giving students examples to practise can help to consolidate learning, but care must be taken to check if students understand how their answers relate to the structure of an atom and that they are not just learning a procedure by rote.

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.