Electronic structure

4.1.1.7 · Atomic structure and the periodic table · revision notes

How electrons are arranged in shells (energy levels), and how to write and draw the electronic structures of the first 20 elements. This is the basis for explaining the periodic table, bonding and reactivity, so it is used across both papers.

Key facts

- Shells for the first 20 elements: up to 2, then 8, then 8, then the fourth shell
- Electrons in an atom = atomic number
- Outer electrons = group number (Groups 1 to 7)
- Group 0: full outer shell (He 2; Ne 2,8; Ar 2,8,8)
- Innermost shells (lowest energy levels) fill first
- Number of occupied shells = period number
- Examples: O 2,6; Na 2,8,1; Cl 2,8,7; K 2,8,8,1; Ca 2,8,8,2

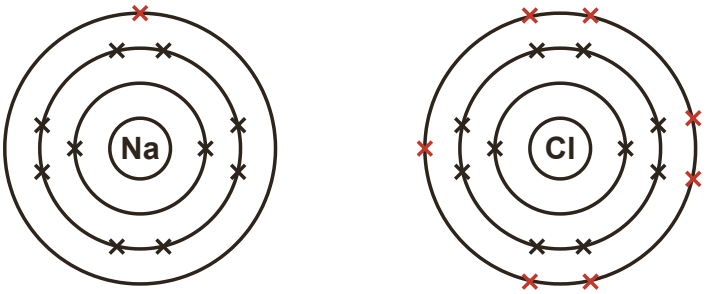
Notes

Shells (energy levels)

- Electrons are arranged in **shells**, also called **energy levels**, around the nucleus.
- Electrons occupy the **lowest available energy levels**: the innermost shells fill first.
- For the first 20 elements: the first shell holds up to **2** electrons, the second up to **8** and the third up to **8**. Then the fourth shell starts.

Writing and drawing electronic structures

- In an atom, the number of electrons = the atomic number.
- Fill the shells in order and write the numbers separated by commas: carbon (6) is 2,4; sodium (11) is 2,8,1; chlorine (17) is 2,8,7; calcium (20) is 2,8,8,2.
- In a diagram, draw the nucleus in the centre (often shown by its symbol), a circle for each shell and a dot or cross for each electron on the circles.



sodium 2,8,1 **chlorine 2,8,7**

Inner shells fill first. Outer shell electrons are shown in red.

- Check that the numbers add up to the atomic number.

Links to the periodic table

- The number of occupied shells equals the **period** (row). Sodium, 2,8,1, has 3 occupied shells, so it is in period 3.
- For Groups 1 to 7, the number of electrons in the outer shell equals the **group** number. Sodium has 1 outer electron, so it is in Group 1.
- Group 0 elements have a full outer shell: 8 electrons, or 2 for helium.
- Elements with the same number of outer electrons are in the same group and have similar chemical properties.

Ions Grade 6+ only

- Metal atoms lose their outer electrons to form positive ions: Mg (2,8,2) → Mg^{2+} (2,8).
- Non-metal atoms gain electrons to fill their outer shell, forming negative ions: O (2,6) → O^{2-} (2,8).

How to answer each type of question

Give the electronic structure of an atom

1 mark **Grade 4**

1. Find the atomic number: this is the number of electrons.
2. Fill shells in order: 2, then 8, then 8, then the rest.
3. Check the numbers add up to the atomic number.

Example. (a) Give the electronic structure of an aluminium atom (atomic number 13).
(b) Give the electronic structure of a potassium atom (atomic number 19).

Model answer.

(a) 2,8,3 (1)

(b) 2,8,8,1 (1)

Complete an electron shell diagram

1 mark | Grade 4

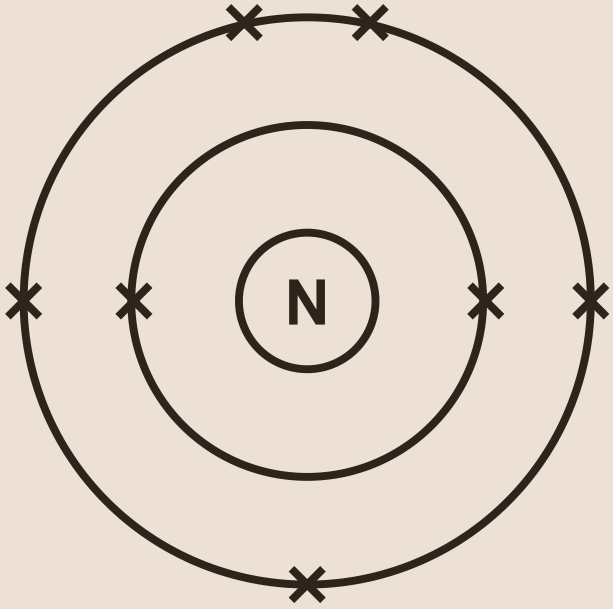
1. Count the electrons needed (the atomic number).
2. Put 2 on the inner circle, then fill the next circle.
3. Draw clear dots or crosses exactly on the circles.

Example. The diagram shows the nucleus of a nitrogen atom (atomic number 7) with two empty circles for its shells.



Complete the diagram to show the electronic structure of the nitrogen atom. Use a dot or cross for each electron.

Model answer.



2 electrons on the inner shell and 5 electrons on the outer shell (1).

Use electronic structure to find group, period and element

2 to 3 marks **Grade 5**

1. Last number = number of outer electrons = group number.
2. How many numbers there are = number of shells = period.
3. Add them all up to get the atomic number, then look up the element.

Example. An element has the electronic structure 2,8,6.
(a) Which group of the periodic table is it in?
(b) Which period is it in?
(c) Name the element.

Model answer.

(a) Group 6, because it has 6 outer electrons (1)
(b) Period 3, because it has 3 occupied shells (1)
(c) 2 + 8 + 6 = 16, so sulfur (1)

Explain similar properties using electronic structure 2 marks **Grade 6**

1. Give the number of outer electrons for each element and say it is the same.
2. Say that chemical reactions depend on the outer electrons.

Example. Fluorine has the electronic structure 2,7 and chlorine has 2,8,7.
Explain why fluorine and chlorine have similar chemical reactions.

Model answer. Both have 7 electrons in their outer shell (1). Reactions involve the outer electrons, so both atoms react in a similar way / both gain one electron (1).

Don't lose marks

- Writing potassium as 2,8,9. The third shell takes 8 at GCSE, then the fourth shell starts: 2,8,8,1.
- Using the mass number instead of the atomic number to count electrons.
- Putting more than 2 electrons in the first shell.
- Drawing electrons in the nucleus, or leaving out the inner shells.

More tips

Memory tricks

- Remember calcium, 2,8,8,2: it shows the whole pattern you need for the first 20 elements.
- Last number = group; how many numbers = period.
- Always check: the numbers add up to the atomic number.

Exam technique

- Use the form the question asks for: numbers with commas (2,8,1) or a diagram. 'Draw' or 'complete the diagram' means a diagram.
- When you explain trends or similar properties, always mention the electrons in the **outer shell**.
- Use the periodic table on the data sheet to find atomic numbers.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 **Recall how many electrons each shell holds**
For the first 20 elements: 2 in the first shell, then up to 8 in the second and 8 in the third.

Grade 4 **Write electronic structures of the first 20 elements**
Fill the innermost shells first, e.g. sodium (11 electrons) is 2,8,1.

Grade 4 **Draw electron shell diagrams**
Draw circles for the shells around the nucleus and dots or crosses for the electrons.

Grade 5 **Link electronic structure to group and period**
Outer electrons = group number (Groups 1 to 7); number of occupied shells = period.

Grade 5 **Identify an element from its electronic structure**
Add up the electrons to get the atomic number, e.g. 2,8,5 is 15, which is phosphorus.

Grade 6

Give the electronic structure of simple ions

Remove or add outer electrons, e.g. Na^+ is 2,8 and Cl^- is 2,8,8.

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