

Science

Atomic structure

Atoms consist of *electrons* [*electrons: Sub-atomic particles, with a negative charge and a negligible mass relative to protons and neutrons.*] surrounding a *nucleus* [*nucleus: The central part of an atom. It contains protons and neutrons, and has most of the mass of the atom.*] that contains *protons* [*protons: Sub-atomic particles with a positive charge and a relative mass of 1.*] and *neutrons* [*neutrons: Uncharged sub-atomic particles, with a mass of 1 relative to a proton.*]

Neutrons are neutral, but protons and electrons are electrically charged. Protons have a relative charge of +1, while electrons have a relative charge of -1.

The number of protons in an atom is called its atomic number. In the periodic table atoms are arranged in atomic number order.

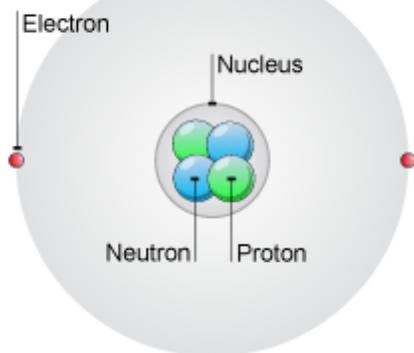
Electrons are arranged in energy levels or shells, and different energy levels can hold different numbers of electrons. The electronic structure of an atom is a description of how the electrons are arranged, which can be shown in a diagram or by numbers. There is a link between the position of an element in the periodic table and its electronic structure.

The structure of an atom

Although the word 'atom' comes from the Greek for *indivisible*, we now know that atoms are not the smallest particles of matter. Atoms are made from smaller **subatomic particles**.

At the centre of an atom is a *nucleus* [*nucleus: The central part of an atom. It contains protons and neutrons, and has most of the mass of the atom.*] containing *protons* [*protons: Sub-atomic particles with a positive charge and a relative mass of 1.*] and *neutrons* [*neutrons: Uncharged sub-atomic particles, with a mass of 1 relative to a proton.*]

particle relative charge



Sub-atomic particles with a positive charge and a relative mass of 1. and

neutrons: Uncharged sub-atomic particles, with a mass of 1 relative to a proton..

Electrons [electrons: Sub-atomic particles, with a negative charge and a negligible mass

relative to protons and neutrons.] are arranged around the nucleus in energy levels or shells. Make sure you can label a simple diagram of an atom like this one.

Both protons and electrons have an electrical charge. Both have the same size of electrical charge, but the proton is positive and the electron negative. The neutron is neutral.

The electrical charge of particles

particle relative charge

proton +1

neutron 0

electron -1

The total number of electrons in an atom is always the same as the number of protons in the nucleus. This means atoms have no overall electrical charge.

The number of protons in an atom is called its *atomic number***atomic number**: *The number of protons in the nucleus of an atom. Also called the proton number.* - also called the proton number. Atoms are arranged in the periodic table in order of increasing atomic number. You may need to re-visit the section in **AQA GCSE Science** on the **periodic table** to check you recall it.

Energy levels and shells

energy level or shell **maximum number of electrons**

Electrons [electrons: Sub-atomic particles, with a negative charge and a negligible mass relative to protons and neutrons.

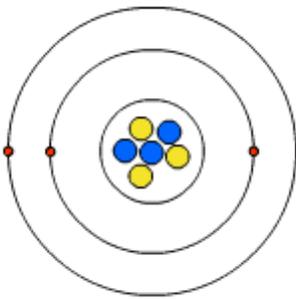
] are arranged in different shells around the nucleus [nucleus: The central part of an atom. It contains protons and neutrons, and has most of the mass of the atom.]. The innermost shell - or lowest energy level - is filled first. Each succeeding shell can only hold a certain number of electrons before it becomes full. The innermost shell can hold a maximum of two electrons, the second shell a maximum of eight, and so on. The table gives the maximum capacity of the first three shells.

Maximum capacity of the first three shells

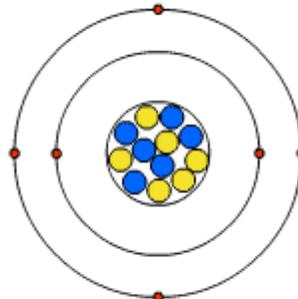
energy level or shell	maximum number of electrons
first	2
second	8
third	8

A lithium atom, for example, has three electrons. Two are in the first energy level, and one in the second.

A carbon atom has six electrons. Two are in the first energy level, and four in the second energy level.



Arrangement of electrons in a lithium atom



Arrangement of electrons in a carbon atom

Element **Numeric** **Electrons** **Periodic**
A calcium atom has 20 electrons. Two are in the first energy level, and eight in the second energy level, eight in the third energy level and two in the fourth energy level. **table**
format **group**

Electronic structure 1

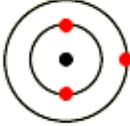
The electronic structure of an atom is a description of how the *electrons* [**electrons**: *Sub-atomic particles, with a negative charge and a negligible mass relative to protons and neutrons.*] are arranged. For your exam, you need to be able to describe the electronic structure of the first 20 elements in the periodic table. You may need to re-visit the section in AQA GCSE Science on the **periodic table** for this.

The first 20 elements in the periodic table run from hydrogen to calcium. Their electronic structures can be shown either as diagrams or numbers. You need to know how to do both.

Take lithium, for example. The drawing shows each energy level as a circle around the nucleus, with each electron represented by a dot. In the exam, do not worry about colouring in the electrons. Just make them clear and ensure they are in the right place. Sometimes you will be asked to use a cross rather than a dot. The numerical method is to write the chemical symbol (**Li**) followed by the number of electrons in each energy level, innermost first, **Li 2,1**.

Electronic structure of lithium

Element **Numeric** **Electrons** **Periodic**
format **table**
group

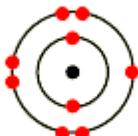
Element	Numeric format	Electrons	Periodic table group
	Li 2,1	Lithium atoms have three electrons. Two of these fit into the first energy level, with the third in the second energy level.	Group 1

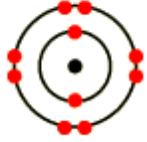
Electronic structure 2

Below are some more electronic structures. Remember - you need to learn the electronic structures of the first 20 elements.

The number of electrons in the highest occupied energy level of each atom is the same as the element's group number.

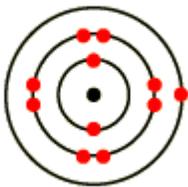
Electronic structures of elements

Element	Numeric format	Electrons	Periodic table group
	F 2,7	Fluorine atoms have nine electrons. Two of these fit into the first energy level. The remaining seven fit into the second energy level.	Group 7

Element**Numeric format****Electrons****Periodic table group**

Ne 2,8

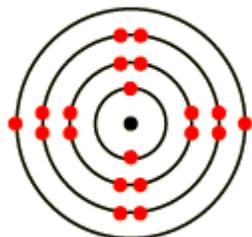
Neon atoms have ten electrons. Two of these fit into the first energy level. The remaining eight electrons fit into the second energy level. Because its highest occupied energy level is full, neon is **stable**: *Atoms are stable if their outer shell contains its maximum number of electrons.* and unreactive.

Group 0
- that is, the eighth group

Na 2,8,1

Sodium atoms have 11 electrons. Two of these fit into the first energy level, eight into the second energy level. The last one fits into the third energy level.

Group 1

Element**Numeric Electrons format****Periodic table group**

Ca
2,8,8,2

Calcium atoms have 20 electrons. Two of these fit into the first energy level, eight into the second energy level, another eight into the third energy level. The last two fit into the fourth energy level.

Group 2

Electronic structure and the periodic table

As you have seen, there is a link between an atom's electronic structure and its position in the periodic table. You can work out an atom's electronic structure from its place in the periodic table.

	Group								
	1	2	3	4	5	6	7	0	Number of occupied energy levels
Period 1								2 He 2	1
Period 2	3 Li 2,1	4 Be 2,2	5 B 2,3	6 C 2,4	7 N 2,5	8 O 2,6	9 F 2,7	10 Ne 2,8	2
Period 3	11 Na 2,8,1	12 Mg 2,8,2	13 Al 2,8,3	14 Si 2,8,4	15 P 2,8,5	16 S 2,8,6	17 Cl 2,8,7	18 Ar 2,8,8	3
Period 4	19 K 2,8,8,1	20 Ca 2,8,8,2							4
	1	2	3	4	5	6	7	8	
	Number of electrons in highest occupied energy level (except for helium)								

Periodic table related to electronic structure

The diagram shows a section of the periodic table, with the elements arranged as usual in the order of their atomic

number, from 2 to 20. The red numbers below each chemical symbol show its electronic structure.

Moving **across each period**, you can see that the number of occupied energy levels is the same as the period number.

As you go **across each period** from left to right, an energy level gradually becomes filled with electrons. The highest occupied energy level contains just one electron on the left-hand side of the table. It is filled by the time you get to the right-hand side.

Moving **down each group**, you can see that the number of electrons in the highest occupied energy level is the same as the group number.

Each element in a group therefore has the same number of electrons in its highest occupied energy level. Group 0 is a partial exception to this rule. Although it comes after Group 7, it is not called Group 8 - and it contains helium, which has only two electrons in its outer shell.

Working out an element's electronic structure

Here is how to use the periodic table to work out an electronic structure:

1. Find the element in the periodic table. Work out which period it is in, and draw that number of circles around the nucleus.
2. Work out which group the element is in and draw that number of electrons in the outer circle - with eight for Group 0 elements - except helium.
3. Fill the other circles with electrons. Remember - two in the first, eight in the second and third, and 18 in the fourth.
4. Finally, count your electrons and check that they equal the atomic number.

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