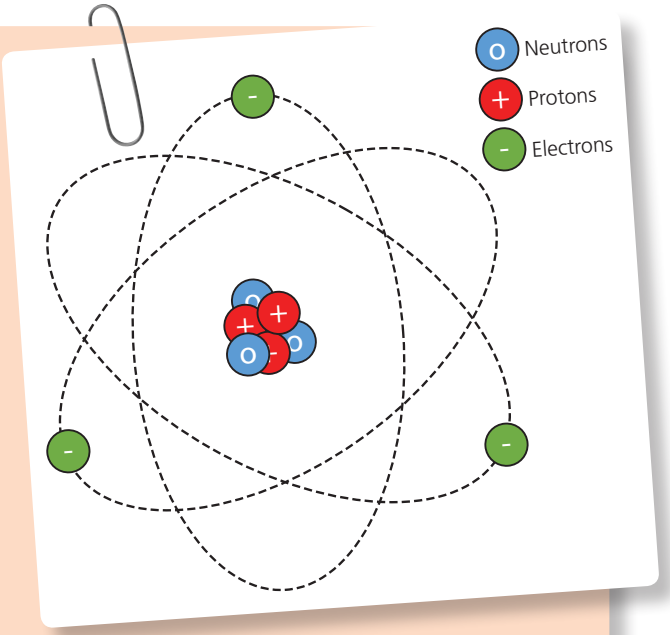
Atoms and Bonds

This resource can be used in support of the following KS4 curricula:
AQA: GCSE Chemistry 2 **OCR:** Gateway C2-C4, OCR 21st Century C4-6
Edexcel: Individual and Mixed sciences C2

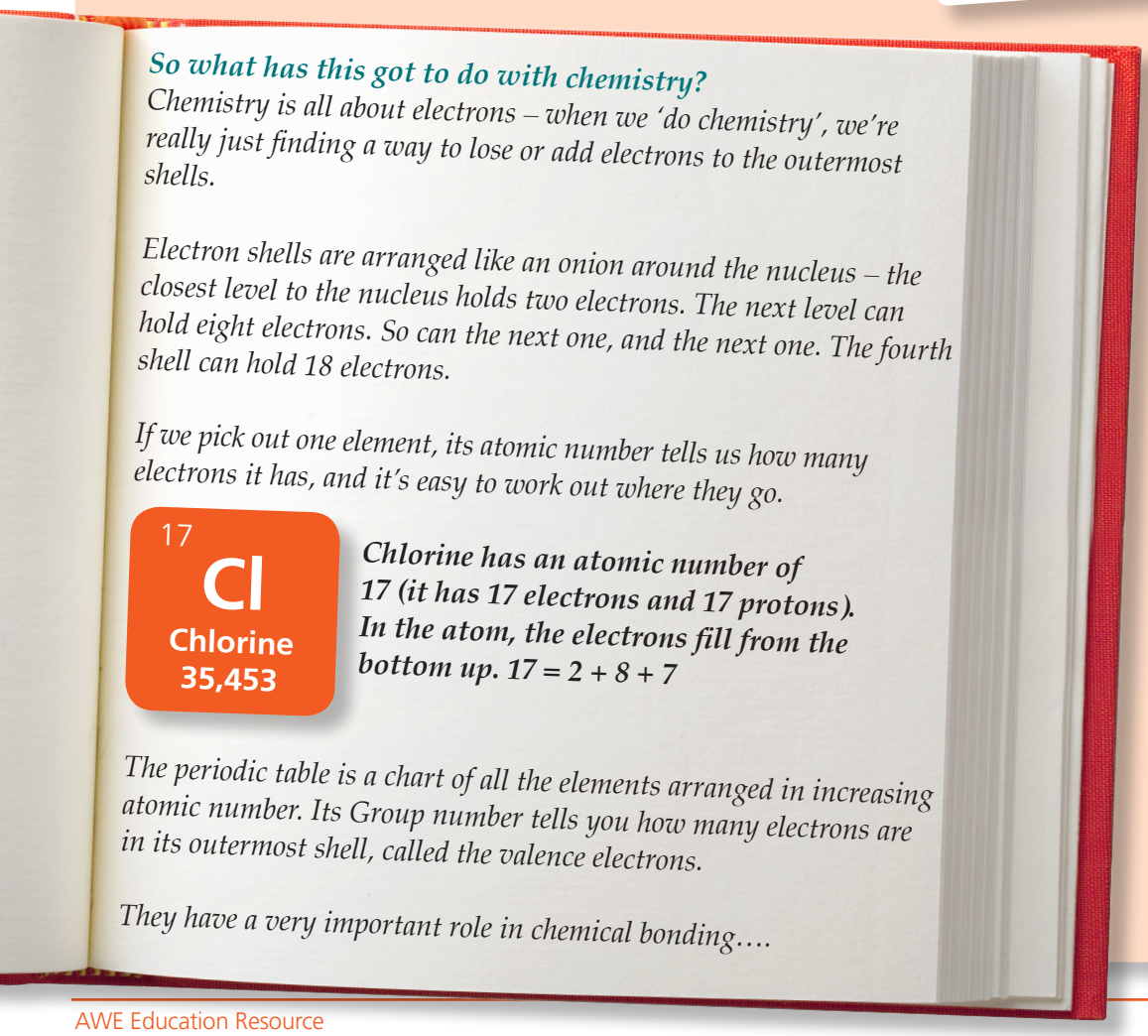
For Students:
Revision Notes



What is an atom?
Atoms make up everything – solids, liquids and gases of all types have atoms at their heart. All atoms contain protons, neutrons and electrons, with electrons arranged in shells around the nucleus (made up of tightly-bound protons and neutrons).

For atoms to also be neutrally charged there must be the same number of electrons (charge: -1) in the shells as there are protons (charge: +1) in the nucleus.

The number of protons (and, therefore electrons) in an atom is called its **atomic number**.



So what has this got to do with chemistry?

Chemistry is all about electrons – when we 'do chemistry', we're really just finding a way to lose or add electrons to the outermost shells.

Electron shells are arranged like an onion around the nucleus – the closest level to the nucleus holds two electrons. The next level can hold eight electrons. So can the next one, and the next one. The fourth shell can hold 18 electrons.

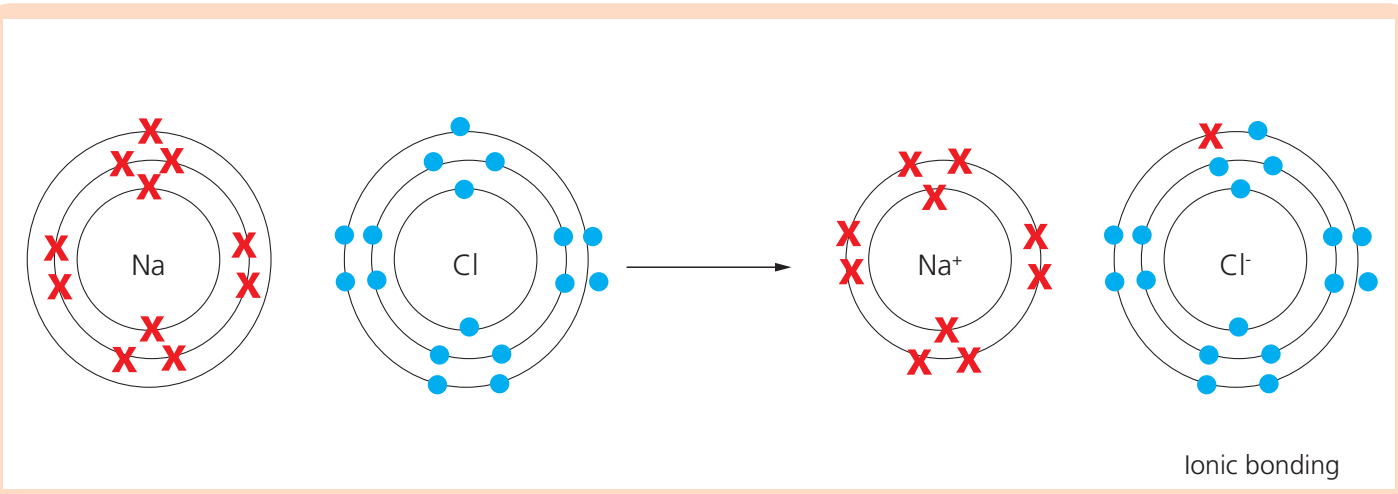
If we pick out one element, its atomic number tells us how many electrons it has, and it's easy to work out where they go.

17
Cl
Chlorine
35,453

Chlorine has an atomic number of 17 (it has 17 electrons and 17 protons). In the atom, the electrons fill from the bottom up. 17 = 2 + 8 + 7

The periodic table is a chart of all the elements arranged in increasing atomic number. Its Group number tells you how many electrons are in its outermost shell, called the valence electrons.

They have a very important role in chemical bonding….



Ionic bonding

Ionic bonding

Ionic bonding is all about losing or gaining valence electrons (the ones in the outermost shell). Ionic bonds occur when an atom with an almost-full level meets one that has electrons to spare! This causes a strong attraction between them – so strong, that electrons can move completely from one atom to the other. This way, both atoms can fill up their outer electron level. After the electron-movement has happened, you're left with charged particles, called ions…

- The atom that loses electrons becomes a positive ion.

- The atom that gains electrons becomes a negative ion.

Opposites attract! The positive ion and negative ion attract each other to form an ionic bond.

Each crystal of the **salt** that you add to food is made up of ionic sodium and chlorine.

Sodium has an atomic number of 11, so has **one electron** in its outer shell. It loses that electron, leaving it with 10 electrons. Because it has lost a (negatively-charged) electron, a sodium ion is left with a charge of +1 – it is a *positive* ion.

Chlorine has an atomic number of 17, **so needs one electron** to have a full outer shell. It gains that electron from sodium, filling its shell. A chlorine ion has a charge of –1, making it a *negative* ion.

When table salt (NaCl) is dissolved in water (H_2O) and has electricity passed through it (in a process called **electrolysis**), the **ionic bonds** between atoms of sodium and chlorine are broken. This gives a solution of Na+ and Cl- ions (along with OH- ions).

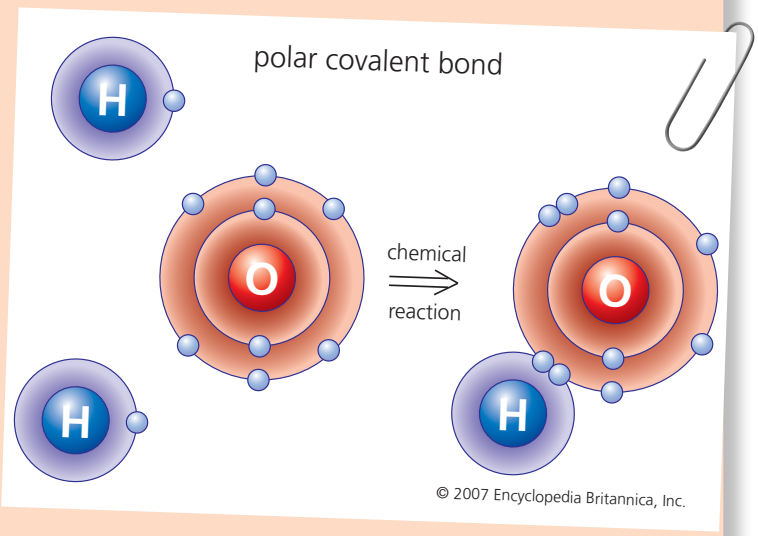
Negative ions move toward the positively charged anode, gaining electrodes - this is called r**eduction**. Positive ions move toward the cathode, losing electrons – this is called **oxidation**.

Covalent bonding

Covalent bonding is all about **sharing** electrons, and is the process that ties hydrogen and oxygen together to form **water**!

In water molecules, electrons are shared between the oxygen and hydrogen atoms. Because the bond involves sharing electrons, it is a **covalent bond**. These bonds hold the oxygen and hydrogen atoms together and form the H_2O molecule.

Hydrogen has just a single electron, so has space for one more. Oxygen has an atomic number of 16, so has 6 electrons in the outer shell, with space for two more. So, one oxygen atom bonds to two hydrogen atoms, tricking all of the atoms into thinking each one has a full outer shell.

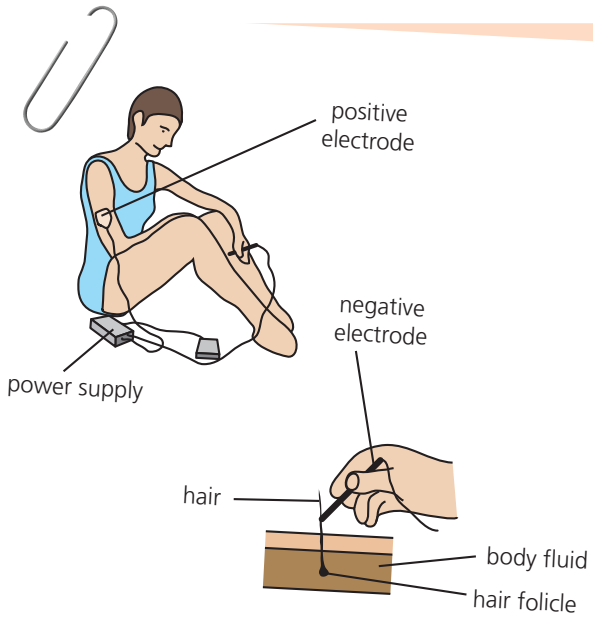


For Students:
Exam-style question

Electrolysis is about more than just breaking bonds in brine (salt + water) – it can also be used to remove unwanted hair from the skin

The hair is first coated with a layer of gel containing ions in solution. The positive electrode is connected by a patch to the skin.

The negative electrode is connected to the hair. Electricity flows through the gel and causes electrolysis of the body fluid around the hair follicle.



Q1. Metal wires conduct electricity to the electrodes. Explain how metals conduct electricity (2 marks)

.....
.....
.....
.....
.....

Q2. Explain why the gel containing ions in solution can conduct electricity (1 mark)

.....
.....
.....
.....
.....

Q3. The body fluid is a solution that contains sodium chloride (NaCl). The electricity causes the electrolysis of a small amount of this solution. This solution contains hydrogen ions that move to the negative electrode

(a). At the electrode, this is the equation $2H^+ + 2e^- \rightarrow H_2$ explain why this reaction is a reduction

.....
.....
.....
.....
.....
.....
.....

(b). Complete / balance the half-equation for the reaction at the anode: $Cl^- \rightarrow Cl_2 +$

.....
.....
.....
.....
.....
.....
.....

Did you know?

AWE don't just do chemistry in the lab. Their supercomputers can simulate the bonds that form between individual atoms, no beakers needed!

http://www.awe.co.uk/2015/04/new-supercomputing-capability-upgrade-for-awe/

Learn more!

- Interactive periodic table from Royal Society of Chemistry: http://www.rsc.org/periodic-table
- Periodic table of videos: http://www.periodicvideos.com/
- NASA's Aquarius page: http://aquarius.umaine.edu/cgi/ed_activities.htm

For Teachers: Experiment!

Covalent Bonding

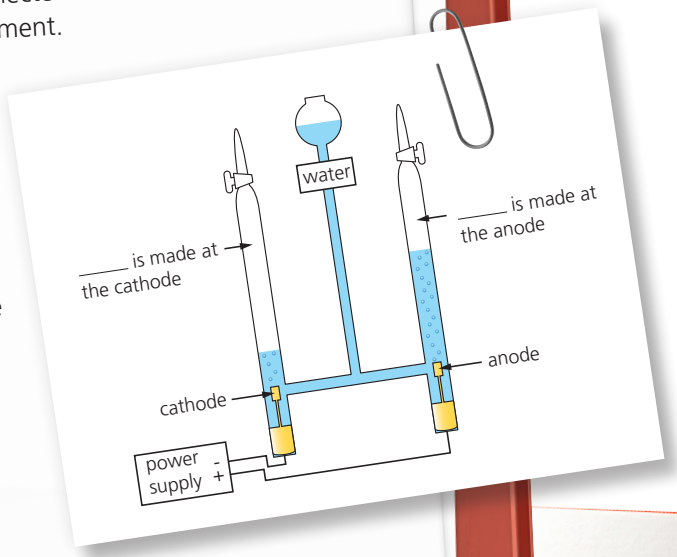
Teachers: This is the standard Hoffmann Voltameter set-up – it is possible to carry out this experiment with a power supply, acidified water and a pair of beakers, but the oxygen and hydrogen gas cannot be collected. This must be carried out as a demonstration, rather than a hands-on experiment.

Equipment

Power supply (set to 4V DC), Hoffmann Voltameter, acidified water (suggested acid: H_2SO_4), catalyst (where relevant)

Things to consider

- Why is a hydrogen molecule (H_2) more stable than two individual hydrogen atoms?
- Why can't a third hydrogen atom join the H_2 molecule to make H_3?



Students: Observe the experiment and answer the following questions

Q1: Describe your observations below. What do you see?

.....
.....
.....
.....

Q2: What gases are produced when the covalent bond in water molecules is broken?

.....
.....
.....
.....

Q3: How can you test for these gases?

Gas name: .....
Test: .....
Gas name: .....
Test: .....
.....

Q4: What does this tell us about the chemical formula for water?

.....
.....
.....

What's happening?

We used electrical energy to break the covalent bonds in water (H_2O) molecules. The bubbles you see must be either hydrogen gas (H_2) or oxygen gas (O_2). Each water molecule breaks into two hydrogen atoms and one oxygen atom. Two hydrogen atoms then bond to form hydrogen gas (H_2) and two oxygen atoms bond to form oxygen gas (O_2).