InfoChem
STUDENT SUPPLEMENT


ISSUE 112 SEPTEMBER 2008

# MEDICINES ON THE INTERNET

With growing prescription charges, some people may be tempted to look on the Internet for cheaper sources of those medicines which are classified as 'lifestyle' drugs. Drugs for treating baldness, obesity, and male impotence fall into this category. But according to Professor Tony Moffat, from the School of Pharmacy, University of London, there is a real chance that such drugs bought on the Internet will be counterfeit. They may or may not contain the correct active ingredient, they may even contain the wrong ingredients, and people who buy them are putting themselves at considerable risk.

Of perhaps more concern, he told *InfoChem*, is that in developing countries around the world, notably in Africa, counterfeit drugs are finding their way into the supply chain of life-saving medicines such as antimalarials, antibiotics and anti-HIV drugs – with fatal consequences. Children are particularly at risk since pain-killing medicines are being tampered with – the sweet tasting, but expensive, glycerol in these products is being replaced with the cheap and toxic diethylene glycol. Moffat said, 'Over the past 20 years literally hundreds, if not thousands, of children have died in places like Panama, Haiti, and China as a result of taking counterfeit analgesic mixtures'.

To address this problem, Moffat and his colleagues have developed a fast and portable analytical technique for identifying counterfeit medicines. The technique uses near infrared (NIR) spectroscopy. This region of the spectrum, explains Moffat, contains all the chemical information for identifying a compound that we need.

In a normal infrared spectrometer the sample has to be diluted by a factor of *ca* 100 to get the spectrum. Using the near infrared region, explains Moffat, allows them to put the whole tablet into the machine, making it faster since no sample preparation is required.

Together with an Australian instrument manufacturer, the London pharmacists have used a small light-weight NIR spectrophotometer that can be used at the wholesaler's, or airport, for example, without recourse to the laboratory.

The portable instrument originally used has been approved and is currently undergoing further trials, and is expected to put a big dent in the market of counterfeit medicines. The latter is estimated to be as high as 50 per cent of the global medicines' market in some developing countries.

JUPITERIMAGES

## Did you know?

***Cranberries have the highest levels of tooth decay- and cancer-fighting chemicals – plus, they help reduce the risk of heart problems and strokes. Healthier than the peach, the banana and the pineapple, cranberries contain the highest concentration of phenols – chemicals with antioxidant properties. Antioxidants mop up highly reactive free radical chemicals within the body which damage tissue and cause many diseases, as well as the signs of ageing. Research in 2002 by Professor Joe Vinson, from Scranton University in Pennsylvania, found that the uncooked berries are better for you than 19 other fruits. Good news then for cranberry growers.***

**Gabriel Webber, Tiffin School, Kingston-upon-Thames**

## IN THIS ISSUE



**Editor**
Kathryn Roberts
**Assistant editor**
James Berressem
**Design and layout**
Dale Dawson

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# Ozone – in the



**A UK chemical observatory situated on a remote island in Cape Verde in the tropical Atlantic Ocean is providing chemists with new information about ozone levels in the troposphere. The natural ability of this oceanic atmosphere to remove ozone, a greenhouse gas, could be compromised by NO emissions from the increasing numbers of ships in this region.**

Ozone – $O_3$ – is a Jekyll and Hyde compound. High in the stratosphere, *ca* 25 km from the Earth's surface, it has a beneficial role – it absorbs damaging uv radiation from the Sun, which can cause skin cancers, eye cataracts and damage to plants. In the lower part of the atmosphere – the troposphere – ozone is itself a damaging air pollutant and a greenhouse gas. It is its latter role that has recently brought this gas back in the headlines, but this time there's some good news.

Recent data from a UK chemical laboratory on the edge of São Vicente in Cape Verde suggest that larger quantities of this 'bad' ozone than had been previously estimated are being destroyed over the tropical Atlantic ocean. According to Professor Ally Lewis, director for composition research at the National Centre for Atmospheric Research (NCAS) based in York University, and a lead scientist on the Cape Verde, project told *InfoChem*, 'It's all thanks to iodine and bromine ions produced by sea-spray and tiny marine organisms'.

## Tropospheric ozone

Most ozone in the troposphere comes from a band of industrialisation that runs around the middle of the planet – from the US, across Europe, through Russia, and into China. Nitrogen monoxide (NO), a pollutant from cars, is oxidised to nitrogen dioxide, a brown gas, which absorbs sunlight and decomposes to produce NO and a highly reactive oxygen atom. This oxygen atom combines with molecular oxygen to form ozone. Ozone is a highly reactive oxidising species, which attacks hydrocarbons, such as unburnt fuels, in the atmosphere to give secondary pollutants, such as aldehydes and nitrites, in the form of an aerosol (photochemical smog) which can lead to a host of respiratory problems. Ozone also absorbs infrared radiation and is the third most important greenhouse gas generated from

**Sea-spray keeps the ozone at bay...**

JUPITERIMAGES

A nice bit of kit...

man's activities, after $CO_2$ and $CH_4$.

However, as Lewis explains, 'The tropical Atlantic has a natural mechanism for cleaning the atmosphere. The trade winds, which blow from north to south, from the UK into Cape Verde, effectively suck a proportion of these pollutants into the tropics where they are destroyed. Moreover, ozone is destroyed more efficiently when you have strong sunlight. Cape Verde was always likely to be a region where a lot of ozone is lost because there's a lot of sunlight there. But what we've discovered at the observatory is that about 50 per cent more ozone is being destroyed here than we thought and we can explain this by the presence of bromine and iodine compounds in the atmosphere'.

'Sea water', he continues 'contains chloride and bromide ions that enter the air as bromine ($Br_2$) and bromine monochloride (BrCl), which are then broken into atoms by sunlight. The bromine atoms can then react with ozone to form bromine oxide. At the same time, algae in the sea produce iodine-containing molecules that sunlight converts to iodine atoms, which also react with ozone to form iodine oxide.

## Sea view

The observatory – essentially a shipping container packed full of lab equipment – was set up in 2006 and is perfectly positioned for monitoring what happens in the atmosphere above the open ocean. 'It's essentially like being on a boat,' says Lucy Carpenter a lead researcher from the University of York. 'Strong trade winds come directly off the ocean, bringing pollutants with them'.

The observatory is run by local scientists, though the UK researchers go there regularly. On board are gas chromatographs, spectrophotometers, and meteorological instruments. A wide range of atmospheric compounds and weather conditions can be monitored. Measuring $O_3$, NO and the highly reactive halogen oxide radicals is fundamental to understanding what is going on in the atmosphere.

## How do they do it?

Ozone levels are measured using a photometric analyser. This is a spectrophotometer – uv light is passed simultaneously through a sample cell and a reference cell. The ozone in the sample cell absorbs uv light, which is proportional to its concentration. NO and halogen species are trickier to detect. The NO is detected via a chemiluminescence reaction. The NO molecule is first excited as it reacts with ozone and then falls back to a less excited state, releasing a photon in the process. The number of photons detected by a photonmultiplier is proportional to the concentration of NO.

The halogens are measured using a differential optical absorption spectrometer (Doas). This, explains Lewis, is like a giant spectrophotometer. 'A bright xenon lamp is used as a source of light, which is beamed out via a telescope to a mirror and then reflected back to the instrument, creating a giant sample cell containing air. Over the long path that the light travels – *ca* 8 km over the sea – certain wavelengths of light are absorbed by the halogen oxide molecules in the air. By taking the difference between the light that has passed through 8 km of air and a reference which hasn't, we can derive the concentration of the halogen oxide molecule'.

## In-flight entertainment

The team also took flight in an aircraft containing similar equipment to confirm their results. 'While it's fine to make measurements at the surface, we need to know for sure that what is happening over our heads is the same

Chemistry in the tropics...

UNIVERSITY OF LEEDS; UNIVERSITY OF YORK/SOLAS

# "... IF YOU DO SOMETHING NOW YOU'LL SEE A RESPONSE WITHIN WEEKS."



*Chemistry on high...*

as what we're measuring at the surface,' explains Lewis. The researchers discovered just how important the halogens are when they tried to recreate their Cape Verdean ozone measurements using a computer model. Without them, the model underestimated levels of ozone loss by up to 50 per cent and overestimated ozone concentrations by 12 per cent. 'Including halogens in global climate models is now absolutely essential for understanding what part ozone plays in our changing climate', says Lewis.

## Sunny climes

The team is delighted with its achievements so far, but recognises that more work needs to be done. Things that happen in Europe, North America and West Africa, such as increasing pollution levels or mass population movement, will affect what goes on in atmospheres of the tropical Atlantic.

Shipping, for example, releases large amounts of NO, and so key to keeping these tropical regions clean is to limit NO emissions. Lewis explains, 'Ozone tends to be destroyed when the NO concentration is less than about 20 parts per trillion but above that value ozone is made. If shipping increases, NO levels may go above the tipping point so we would lose the natural "cleaning" service that the tropical oceans have provided us with. One of the purposes of the observatory is to monitor how shipping is going to change over time and how it's going to affect the atmosphere'. But the good news, he says, is that even if NO emissions do take away the region's unique ability to scrub ozone, the damage is reversible. If the emissions are stopped, within a few weeks the atmosphere would return to its natural state. 'This is one of the reasons that we're interested in looking at ozone as a greenhouse gas; if you do something now, you'll see a response within weeks or months,' concludes Lewis.

**Emma Davies**

# that's chemistry!

*Simon Cotton, chemistry teacher at Uppingham School, looks at the molecules in our lives. In this issue:* **exploding ants**

### Insect bombers

Ants of the species *Camponotus saundersi*, found in Malaysia, have a remarkable chemical defence. When they are threatened, they rupture glands in their body and spray poison in all directions.

### How do they do that?

These ants have two enormous mandibular glands which run the length of the body. The ants are charged with the role of protecting the colony. When threatened by predators, *eg* arthropods such as other ants, the ant can contract its abdominal muscles violently, making the gland explode. This releases a sticky poisonous fluid.

### What does the fluid look like?

Its colour varies, sometimes it is white or cream, but richer colours such as yellow, orange and red are known.

***Ant attack***

### What is in the poison?

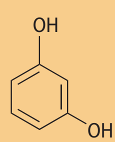
A cocktail of chemicals, such as phenols (*m*-cresol and resorcinol (*1*)), hydroxyacetphenones, such as 2,4-dihydroxyacetophenone (*2*), and even carboxylic acids like 2,6-dimethyl-2-octen-1,8-dioic acid. Some simple alkanes ($C_{11}$–$C_{17}$) and a few alcohols such as octadecanol are also found in the mix.

### What are the roles of the chemicals?

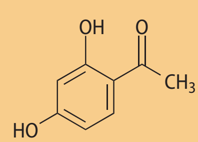
The phenols are acidic, so they will be irritating to the enemy, even corrosive, as will the carboxylic acids. The hydroxyacetophenones have pH-dependent colours, and are responsible for the variety of spray colours, but must also be present for some other purpose – at present unknown.

### So what does the spray achieve?

The fluid is sticky (possibly the viscous long-chain alcohols contribute to this property) so that the invading ants get stuck to the exploded soldiers. The invading bug can't get away even when more invaders come to rescue them, which may also get stuck. So the soldier ant sacrifices itself, but perhaps saves the nest. ■



(*1*) Resorcinol



(*2*) 2, 4-Dihydroxyacetophenone

FOTOLIA; PHOTODISC

*Jonathan Hare asks…*

# MURDER AHOY: *do all poisons kill instantaneously?*


In many films and TV thrillers someone gets poisoned and they die instantly. But could a poison really kill someone so quickly?

**Miss Marple investigates**

In the film *Murder ahoy* – Agatha Christie's Miss Marple classic – a woman is seen murdered instantly when she injures her hand on a mouse trap coated in curare. Curare, an extract of the South American plant *Chondodendrum tomentosum*, is a well-known poison. Centuries ago the native Indians used arrows coated with paste made from the plant to hunt animals. Once in the bloodstream curare acts quickly, blocking the transmission of nerve impulses to the muscles, which become paralysed and the animal dies of asphyxiation within minutes. However, the 'home-made' paste was impure so quite large quantities were required. To overcome this, rather than simply painting the poison on, the Indians cut long grooves into the arrow tips and filled them with the poisonous paste. As a result more poison entered the unfortunate animal and, because of the grooves, the poison did not get wiped off as it pierced the skin. In fact curare is only effective when introduced via the bloodstream through a cut but not when eaten. The Indians could therefore eat the kill without being killed themselves.

Back to Miss Marple's puzzle, and in fact there would probably not have been nearly enough of the poison transferred by the trap to kill the woman because much of the poison would have been wiped off as it entered her finger.

In films things are not always presented as they should be. In the TV series *Heroes*, for example, Sylar was allegedly drugged with a curare-laced drink. As we now know this poison is only effective when it enters the body via the bloodstream, so Sylar should not have been affected.

More recently, in the news, reporters suggested that Alexander Litvinenko was poisoned after a polonium-210 compound was slipped into his drink. Polonium emits α-particles, which when ingested would damage essential organs leading to a very painful and slow death (three weeks in his case). Yet even something apparently as 'powerful' as this is slow to respond – it doesn't kill instantly.

There are other poisons – certain varieties of mushroom and the plant deadly nightshade, for example. Even rhubarb has to be treated with respect because the leaves and other parts of the plant are rich in oxalic acid which is poisonous. But again, while these poisons would kill you, they do so only in certain circumstances – and not quickly enough for most Hollywood story-lines. ■

***Dr Jonathan Hare, The CSC Centre, Chemistry Department, University of Sussex, Brighton BN1 9ET (www.creative-science.org.uk/TV.html).***

## webwatch

*Emma Woodley, RSC assistant education manager, takes a look at some websites of interest to students*

**Is art the future of science?**

**http://www.mrs.org/s_mrs/doc.asp?CID=1803&DID=171434**

The latest technology for examining the surfaces of materials at a nanoscale is revealing a previously unseen world. Visualisation methods are an important tool in the analysis of materials. Occasionally these images have the aesthetic qualities of art. This is one such collection of images from the Materials Research Society.

**Small science, big deal**

**http://www.sciencemuseum.org.uk/antenna/nano/**

Some of the latest developments in nanotechnology are discussed here – sports equipment with enhanced properties, fabrics inspired by Nature, and additives to increase fuel efficiency. The facts and fears about nano-technology are explained, with images, videos, and animations. ■

# BACKYARD CHEMISTRY

DR HAL SOSABOWSKI PRESENTS EXPERIMENTS YOU CAN DO ON YOUR OWN

## IN THIS ISSUE: lemonade and Mentos: Henry's law and Boyle's law

### THE SCIENCE

Lemonade or any carbonated drink is a mixture of chemicals, one of which is dissolved carbon dioxide gas. When sparkling lemonade is made, the carbon dioxide is forced into solution under pressure and the bottle is sealed. The $CO_2$ stays dissolved as long as the pressure is kept constant – this is an example of Henry's Law which states:

> *the pressure of the gas determines the concentration of a gas dissolved in a liquid.*

When the bottle is opened the pressure is lowered and the $CO_2$ becomes less soluble, and comes out of solution – which is why if you look at the side of the bottle when you unscrew the cap, you see thousands of bubble appear apparently from nowhere.

The $CO_2$ comes out of solution gradually; if you look at a glass of lemonade, you see bubbles appearing at a fairly constant rate. What increases the rate of bubble production is the introduction of nucleation sites, *ie* any sharp edges or irregularities in the lemonade.

When you take a mouthful of lemonade you feel the bubbles form on your tongue because the rough texture of your tongue acts as a bed of nucleation sites. This also explains why you often see a constant stream of bubbles coming from one particular point on the inside of a glass of lemonade; there is likely to be a tiny scratch at this point and even if the glass is washed and refilled, the bubbles will still come from this point.

Scuba divers can get the 'bends' for the same reason – as they dive deeper, the pressure of air in their lungs increases and the nitrogen which they are breathing becomes more soluble in blood plasma. If they surface slowly, the dissolved nitrogen has a chance to come out of their blood plasma and slowly into their lungs, but if they surface too fast the nitrogen comes out of solution within the body and damages organs. The bends are treated by putting the diver in a decompression chamber which causes the nitrogen bubbles to redissolve temporarily and the pressure later released more slowly.

In this experiment, a whole packet of Mentos is put into a bottle of lemonade at once. Mentos have a rough surface, which means millions of nucleation sites. These allow all the $CO_2$ to come out of solution at once, causing a large change in the pressure inside the bottle which forces the liquid out in a spectacular fountain.

### MATERIALS

You will need:

- a 2 l bottle of lemonade (or any carbonated drink, the cheaper the better);
- a tube of Smarties;
- a playing card or piece of stiff card of the same dimensions;
- a packet of Mentos mints.

### HEALTH & SAFETY

There is a risk of eye splash from fast moving lemonade so do all the tasks at arm's length, and use safety glasses. The experiment should be done outside because it does produce a sticky mess.

### METHOD

Put all the Mentos into the Smarties tube. (The Smarties tube is used to add the Mentos to the lemonade.) Carefully unscrew the cap of the lemonade bottle and place it on a flat surface. Put the playing card over the open top of the Smarties tube and invert the tube directly over the open bottle top. The card should now be the only thing stopping the Mentos falling into the lemonade. When you are ready, **making sure your head is not directly over the bottle**, slide out the card from between the bottle and Smarties container, allowing all the Mentos to drop into the bottle. There will be a short delay of a second or so and then a spectacular 3–4 m fountain of lemonade followed by a shower. ■

GRAHAM TIBBLE

# FORENSIC SCIENTIST:

## *Tom Geddes*

Tom Geddes

**Tom Geddes has spent the past four years working for LGC Forensics, Culham, as a forensic scientist. He talks to Kathryn Roberts about his typical day.**

LGC Forensics, part of the 'analytical giant' LGC, provides forensic services to police forces and various other law enforcement agencies as well as to a few private clients. Tom is one of 20 scientists in the marks and traces team at Culham, where he specialises in footwear marks and glass evidence.

## Experience counts

Four years ago Tom, like all new recruits to the division, spent six months being trained in the basics of forensic work. Strict procedures have to be learnt, including cleaning and handling equipment, moving between different departments, and wearing the right clothes to avoid cross contamination. The recruits are also trained to present their findings under the scrutiny of the legal profession. For much of this time Tom worked on other people's research projects within the different teams, familiarising himself with what everyone did. He told *InfoChem*, 'It is vital that we are aware of what everyone else is doing at all times so that we never compromise someone else's evidence while doing our own work'.

Fully trained and now with four years' experience in footwear and glass, Tom will have many cases on the go at once. For each case he starts by reading through all the details provided by the police on the items in question. Packed and labelled will be: broken glass; clothing that might contain small fragments (*ca* a third of a mm in size) of glass; footwear; and photographs of any footwear marks taken at the scene of the crime. Tom looks at the evidence and decides what items need to be examined and what tests should be done.

Much of the experimental work he does himself, or it is done under his supervision. Glass, for example, found on clothing is tested for its refractive index to see if this matches the refractive index of glass fragments also found at the scene of the crime. If a match is found he will look at the samples in more detail. By using microprobe analytical techniques, such as scanning electron microscopy, he can determine the elemental composition of the glass samples. While some elements are present in all glass, others, for example impurities that have crept in during the manufacturing process, differ from one sample to another and therefore act as markers. Other tests can reveal whether a glass is toughened or not. With footwear, Tom is looking for unique features of a shoe that will set it apart from any other, in the form of footwear characteristics or damage features. He uses 'lifting techniques', *eg* gelatine lifts, to remove footprints from surfaces and enhances these digitally to compare with other shoes. All the experiments are done in a clean room, and can take several weeks to complete, especially if there is more than one suspect in the case. He cannot examine evidence from two suspects in the same case on the same day because there would be a risk of contamination.

Experimental work finished, Tom writes an 'opinion-based' statement on his findings, which will be read by the prosecution or defence later in court. Occasionally he is called to court as an expert witness to explain his findings. As part of his own professional development, he is able to go to crime scenes with a senior colleague to look at evidence from a different perspective. 'The benefit of working at LGC Forensics', says Tom, 'is that we cover many diverse areas and can therefore develop our expertise'.

## Communication skills, necessary

The diversity of the work attracts Tom to the job – there's always something new to see in every case, he says, which is always interesting and occasionally surprising. But the real challenge, beyond the benchwork, he admits, is taking highly technical scientific knowledge and translating it into something which can be understood by a jury. ■

### PATHWAY TO SUCCESS

- 2004–present, forensic scientist, LGC Forensics, Culham
- 2000–2004, MChem chemistry (first class), Hatfield College, University of Durham
- 1998–2000, chemistry, physics, maths A-levels, general studies, Codsall High School, Wolverhampton

£50 OF HMV TOKENS TO BE WON!

Benchtalk

ISSUE 112 SEPTEMBER 2008

# PRIZE WORDSEARCH No. 41

Students are invited to find the 34 words/expressions associated with insect repellents hidden in this grid. Words read in any direction, but are always in a straight line. Some letters may be used more than once. When all the words are found, the unused letters, read in order, will spell a further 10-letter word. Please send your answers to the Editor at the usual address to arrive no later than Friday 10 October. First correct answer out of the editor's hat will receive a £20 HMV token.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O | E | A | E | N | I | M | A | L | Y | H | T | E | I | D | E | D |
| R | V | M | C | I | N | E | G | A | T | U | M | X | N | T | I | M |
| G | O | I | R | T | N | E | L | L | E | P | E | R | S | M | N | O |
| A | L | N | B | E | G | E | R | A | N | I | O | L | E | U | S | L |
| N | C | E | O | E | D | S | E | A | S | O | N | T | C | C | E | E |
| I | I | N | G | D | E | M | I | D | G | E | H | A | T | O | C | C |
| C | T | O | M | R | T | D | T | C | Y | Y | T | C | R | U | T | U |
| C | R | L | Y | E | A | U | A | T | L | M | S | I | E | S | R | L |
| H | O | A | R | D | R | S | E | P | L | A | E | R | C | M | E | A |
| E | N | D | T | N | D | K | H | N | E | L | T | E | E | E | P | R |
| M | E | N | L | E | Y | T | U | I | M | A | S | M | P | M | E | T |
| I | L | I | E | V | H | S | A | R | S | R | E | R | T | B | L | A |
| S | L | K | G | A | R | L | I | C | O | I | M | U | O | R | L | R |
| T | A | S | L | L | R | A | D | E | C | A | A | T | R | A | E | G |
| R | L | A | C | H | R | Y | M | A | T | O | R | Y | S | N | N | E |
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| E | C | O | T | O | X | I | C | O | L | O | G | Y | T | E | S | T |

AMES TEST
AMINE
BOG MYRTLE
CEDAR
CITRONELLAL
CLOVE
DEET
DIETHYL AMINE
DIMETHYL PHTHALATE
DUSK
ECOTOXICOLOGY TEST
ENTOMOLOGIST
GARLIC
GERANIOL
HEAT
HYDRATED
INDALONE
INSECT RECEPTORS
INSECT REPELLENT
LACHRYMATORY
LAVENDER
MALARIA
MIDGE
MOLECULAR TARGET
MUCOUS MEMBRANE
MUTAGENIC
ORGANIC CHEMISTRY
RASH
REPELLENT
SEASON
SKIN
SMELLY
SUN
TURMERIC

## July PRIZE WORDSEARCH No. 40 winner

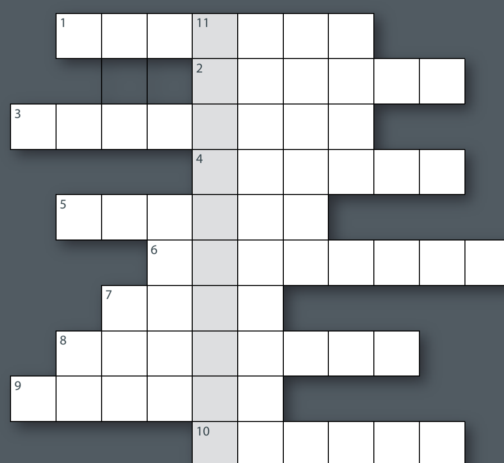
*The winner was Tsolofelo Swan of St Martha's Senior School, Hadley Wood, Hertfordshire. The 10-letter word was LABORATORY.*

# FIND THE ELEMENT No. 4

Students are invited to solve Benchtalk's *Find the element* puzzle, contributed by Dr Simon Cotton of Uppingham School. Your task is to complete the grid by identifying the 11 elements using the clues below.

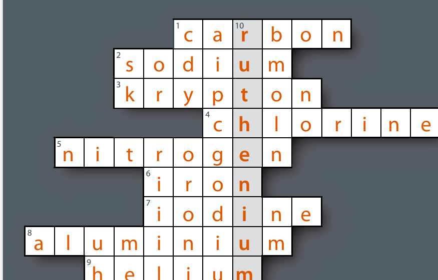
### ACROSS

1. Non-metal that forms a ring-shaped molecule of eight atoms.
2. Gaseous element that does not form molecules.
3. Positively charged ion (cation) of this element is largely found in solutions with pH below 7.
4. All the salts of this metal are soluble.
5. Metal that forms a coloured hydroxide insoluble in excess NaOH, but which dissolves in aqueous ammonia.
6. Very reactive non-metal which forms a single-charged anion.
7. This metal forms an insoluble brown hydroxide.
8. Non-metal that forms a gaseous oxide which turns brown on exposure to air.
9. Salts of this metal are used in the sulfate test.
10. This metal forms an insoluble chloride.




If you have found the correct 10 elements, in 11 down you will have generated the name of a non-metallic element. This is an essential element for plant growth.

Please send you answers to: the Editor, *Education in Chemistry*, the Royal Society of Chemistry, Burlington House, Piccadilly, London W1J 0BA, to arrive no later than Friday 10 October. First out of the editor's hat to have correctly completed the grid will receive a £30 HMV token.




## Find the element no. 3 solutions and winner

*The winner was Lucy Mapp from Colchester County High School, Colchester.*