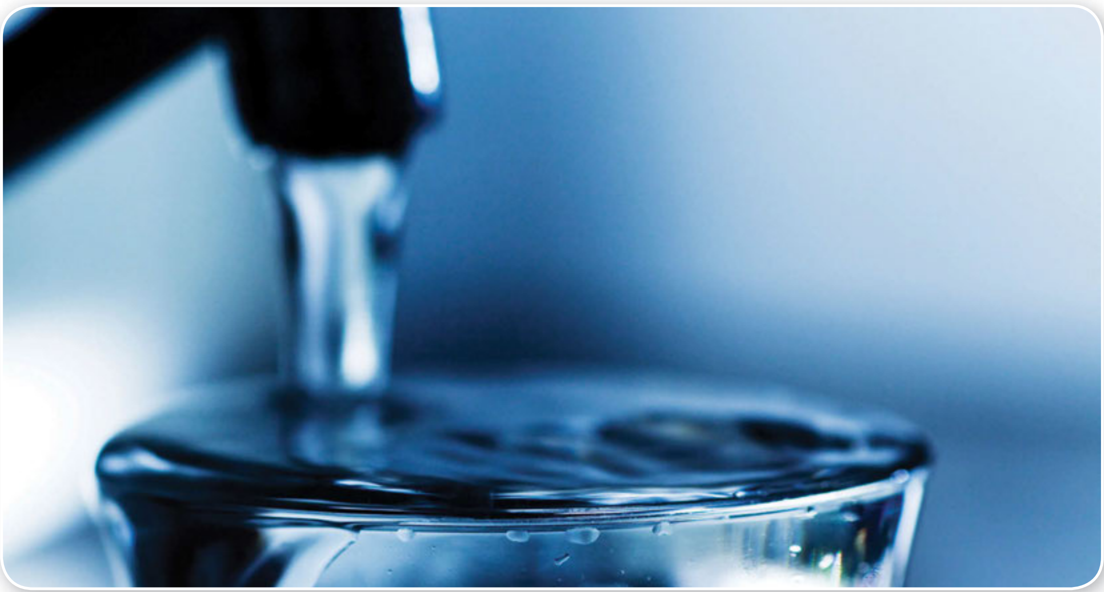
The Mole

... FOR ANYONE INSPIRED TO DIG DEEPER INTO CHEMISTRY

ISSUE 02 | MARCH 2014

From ground to tap

Sue Thompson leads us through the journey water takes from underground to our drinking glass



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Chemistry helps us to treat water and understand how it can be made safe

ChemNet, the Royal Society of Chemistry's network for 14–18 year olds, organised two events last year to inform students about the role of chemistry – and chemists – in the treatment of drinking water. The first was a tour around Affinity Water's water treatment works in Bushey, Hertfordshire, UK. The second was a visit to the company's laboratories in Staines-upon-Thames, Middlesex, UK. Both events included talks about careers for chemists in the water industry.

'The use of chemistry in the water industry is widespread,' says Richard Lake, process engineering science manager at Affinity Water. 'However, it's not just using chemistry to treat the water which is important, but also understanding the chemistry of emerging pollutants and how the water can be made safe.'

Affinity Water supplies 900 million litres of drinking water daily to 3.5 million people based in north-west London and the home counties. Their customers live in the London boroughs of Harrow, Hillingdon, Barnet, Brent, Ealing and Enfield, and in parts of Bedfordshire, Berkshire, Buckinghamshire, Essex, Hertfordshire, Surrey, Essex and Kent.

Digging down

60% of the tap water Affinity Water provides comes from groundwater. This water has filtered down through soil and rock layers, and may have been there from between two years and 60 million years. From here it is pumped out, through boreholes, and taken to a water treatment works such as the one run by Affinity Water in Bushey.

The works at Bushey were built in 1954 and are supplied by eight sites, some with multiple boreholes, situated along the Colne Valley in Hertfordshire. On an average day 118 million litres of water pass through these water treatment works, but it can increase to 160 million litres.

The first step in the water treatment process at Bushey is to disinfect the water using ozone. Ozone kills bacteria and viruses as well as breaking down any organic matter into smaller molecules. The machine used to produce the ozone operates at a very high voltage: 11,000 V. It contains multiple 3 m long glass tubes containing electrodes, which produce controlled lightning. This lightning turns the liquid oxygen (O_2) into ozone (O_3). The huge tank of liquid oxygen at the works

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Did you know?

Carl Rogers Darnell was a US Army medical surgeon and chemist. In 1910 he developed a 'chlorinator' to purify water for troops in the battlefield by dosing it with chlorine gas. Similar technologies are still in use today.

ChemNet events

Find out about forthcoming ChemNet events for 14–18 year old students:
http://rsc.li/1epjOWP

is kept at –185°C – so cold that it has ice coating its outside pipes.

The ozone enters the tank holding the water needing treating in a vortex. The water stays in this tank for seven minutes. There is a vacuum above the water level and any excess ozone is converted back into oxygen using thermal destruction to prevent it being released it in to the environment. Sodium hydrogensulfite is also added to remove ozone.

After treatment with ozone, the water is transferred into large, 3 m deep tanks containing 1.25 m of activated carbon at the bottom. The total surface area of the activated carbon is huge as just 2 g of activated carbon has a surface area the size of Wembley Stadium football pitch. Van der Waals forces attract dissolved substances onto the carbon and remove impurities via adsorption. The carbon retains micropollutants such as pesticides and the bits of organic matter that were broken down by the ozone. The water passes through the carbon and takes around 15 minutes to do so. Every five years the activated carbon is removed, taken away and regenerated by heating it to a very high temperature and washing with acid. It is estimated that the carbon itself will last for 25 years.

Further bug busting

The next stage is the addition of chlorine to prevent the growth of disease-causing pathogens. Cholera, typhoid fever and dysentery killed countless people before disinfection methods were employed routinely to water treatment. In 1854, John Snow proved the link between cholera and contaminated water in the Soho area of London from the now famous Broad Street pump.

Chlorine bleach was first added to municipal drinking water in 1897 in Maidstone, Kent. When the Bushey works were first built, chlorine gas was used to chlorinate the water. The buildings were on the flight path of Heathrow Airport, so the chlorine tanks had to be able to survive the impact of a 747 crash, as any release of chlorine would have been extremely dangerous. Chemists have now worked out safer ways of producing chlorine.

In 1854 John Snow proved the link between cholera and contaminated water from the Broad Street pump in London, UK

Affinity Water uses sodium hypochlorite, which decomposes in water to produce chlorine.

When chlorine is added to water, hypochlorous acid (HOCl) is generated and it is this that does the disinfecting. The process works best at lower pHs, as in a more alkaline environment the hypochlorus acid dissociates to hypochlorite (OCl^-). This is a less powerful disinfectant. The effectiveness of the chlorination process also depends on the water temperature.

The dose of chlorine added to the water is automatically controlled and the residual concentration is measured continually by on-line instruments. On the day we visited, the residual concentration was 0.39 mg dm^{-3}. There is often some chlorine in the water already as 85% of prescription-only medicines contain chlorine in some form.

The ultrafiltration plant at Bushey removes cryptosporidium

The clarity of the water – its turbidity – is also checked. The fewer particles present in the water, the clearer it appears and the lower the turbidity. This is assessed by passing light through a sample of the water and then measuring how much light is deflected. It is an important parameter because particles can shield bacteria from the effects of the disinfectants and consumers expect their water to be clear and bright.

At this point 15 years ago, the water from Bushey would have gone directly to houses and industries, but then the parasite cryptosporidium was identified in the water entering the site. Previously it was thought to only be an issue in works that treat surface water – as the parasite normally comes from faeces – and Bushey is a groundwater only site.

© AGE FOTOSTOCK / ALAMY

The analytical laboratory tests for chemical substances, physical properties and biological organisms

In 2000, a state-of-the-art ultrafiltration plant was installed at Bushey and the works became a world leader in removing cryptosporidium. This changed water treatment worldwide and many people have come to the Bushey works to look at this plant with a view to installing their own. Inside the ultrafiltration plant are long, filtering polymer 'straws'. Water is forced through these straws under pressure and bacteria and oocysts (protective capsules containing cryptosporidium spores) remain trapped on the outside. The equipment is washed every 45 minutes and replaced every 10 years. There is £10 million worth of equipment in the ultrafiltration plant alone. The clean water then goes to the storage reservoir and then into our homes.

The Affinity Water site at Staines-upon-Thames contains another water treatment plant: the Egham works. The water treated at this site is Thames river water (rather than groundwater) and so treatment starts with coagulation and flocculation, followed by filtration to remove any solid particles. This is followed by ozonolysis, and the remainder of the process is similar to that used at Bushey. There is no ultrafiltration at Egham.

Water testing

Affinity Water carries out all of its water quality testing at its central laboratory in Staines-upon-Thames. The laboratory has a floor area of 20,000 square feet and houses 33 laboratory staff consisting of 15 chemists, 10 microbiologists, three quality control scientists, two sample reception technicians, three management/admin staff and 23 samplers out on site.

The laboratory operates 24 hours a day, 365 days of the year. Over 50,000 individual water samples are collected and tested annually, with 600,000 individual analyses carried out each year for 200 individual contaminants. Many of these tests are on a 24 hour turnaround.

Tests include looking for biological organisms (for example *E coli*, *enterococci* and *coliforms*), chemical substances (including pesticides, hydrocarbons, solvents, metals and organophosphates) and physical properties (for example pH, colour, taste, turbidity and electrical conductivity). The most common metals found in water samples are copper and lead from water pipes and inorganic and organic particles contribute to the turbidity and colour of water.

Analytical quality control is also important. This consists of internal audits, participation in externally run proficiency testing schemes, internal calibrations and duplicates.

The techniques used in this lab are liquid chromatography mass spectrometry (LCMS), gas chromatography mass spectrometry (GCMS), inductively coupled plasma mass spectrometry (ICPMS) and ionic chromatography. A colorimetric autoanalyser analyser is also used, which measures hardness and alkalinity, as well as nitrate, ammonium, chloride, sulfate and phosphate ions.

So next time you go to the kitchen tap, raise your glass to all those chemists working behind the scenes to ensure you have a safe, clear and refreshing drink.

Did you know?

In 36BC the Roman scholar Marcus Terentius Varro advised his contemporaries to avoid marsh and swampland 'because there are bred certain minute creatures that cannot be seen by the eyes, which float in the air and enter the body through the mouth and nose and there cause serious diseases'.

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© SHUTTERSTOCK

The Egham plant treats water from the river Thames, so the purification process uses some different techniques

Magnificent molecules

Nitinol

Neil Withers explores an unusual phenomenon

Find out more

Check out the podcasts from *Chemistry World*. Each week a leading scientist or author tells the story behind a different compound.

www.chemistryworld.org/compounds

Have you ever seen those spectacles that can be screwed up, but then 'rebound' back to their original shape? If so, you've probably wondered how on earth they work. After all, it seems to go completely against anything you've learnt or experienced about how metals behave. Paperclips, for example, once bent out of shape, are more likely to fall apart than resume their old shape.

It might surprise you to discover that the shape memory effect, as it is known, goes back quite a few years – to the 1930s. But products incorporating materials that make use of this effect only came on the market a bit more recently, in the past few decades.

Alloys and missiles

Most of the materials known to have this shape memory are alloys – mixtures of two or more metals – and the most widely known one is a nickel–titanium alloy known as nitinol.

The story of its discovery is a classic. William Buehler, a researcher at the US Naval Ordnance Laboratory, was trying to make a better missile nose cone, one that was resistant to fatigue, heat and impact. A 1:1 alloy of nickel and titanium did the job, so he took some to show his colleagues at a meeting. The sample he passed around was folded up like an accordion. Someone, presumably trying to test its heat-resistant properties, held a lighter underneath it. To everyone's surprise, the accordion-like strip stretched out and took its previous shape.

Spectacle frames made from nitinol have shape memory and can bounce back into shape if they have been bent

Putting atoms in their place

So how does it work? The answer lies in the atomic structure. In nitinol, the titanium and nickel atoms occupy well-defined atomic positions relative to each other, whereas in many other alloys, the positions are random. When heated to around 500°C, it forms a very strong structure with cubic symmetry, similar to that of steel, which we all know is pretty strong. Making the spectacle frames at a high temperature 'locks' the metal in the frames into the right shape.

At lower temperatures, nitinol changes crystal structure to a monoclinic one that is much weaker and allows layers of atoms to slip past each other. So at room temperature the frames are flexible, but just a little bit of warmth gives them enough energy to spring back to their previous structure.

Price versus performance

Unfortunately, this structure is what hindered these miraculous materials from being used for so long. Making an alloy where the metal atoms are in defined positions is difficult, and costs a lot of money. And that's why the first uses for nitinol were in fighter jets and medical devices, which are both areas where price for once can take a back seat to performance.

The medical devices that make use of memory metals are stents and filters, which can be inserted in patients' blood vessels and 'inflated' to get back their original shape and prop open those weak or clogged veins. Nitinol is also used in dental braces: body heat is enough to make the wires strain to get back to their original shape, pulling the teeth nice and straight along with them.

And of course there are the glasses, magically springing back to their original shape after they've been sat on. One limitation though is the lifetime – over time and repeated bending cracks can develop. Also, dislocations in the crystal structure can pile up and prevent the alloy from returning to the correct shape. But recently a new shape memory alloy, a combination of zinc, gold and copper, has been discovered. This offers better reversibility, so perhaps in future, more and more metallic objects will have that magical memory effect.

Avogadro's lab

Speedy reactions

Stephen Ashworth investigates the catalysts inside us all

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How could you make a reaction go faster? Molecules need to bump into one another to react. In fact they have to be facing the right way and the collision has to have more than a minimum energy. If we raise the temperature of a reaction we make the molecules bump together more often and with more energy. If they are facing the right way more of them have enough energy to react, so the product of the reaction is formed faster.

Lots of chemical reactions take place in the human body and help to keep us alive. Most of them would normally be so slow at body temperature that it would be difficult to detect they were happening at all. Increasing the temperature of these reactions just isn't possible – we can't keep our bodies hot! Fortunately, heating up a reaction is not the only way to make it go faster – another option is to provide an alternative route for the reaction so it needs less energy.

Taking a different path

Imagine you need to get to the other side of a hill. You could go all the way to the top and down the other side, but that would take a lot of effort. Alternatively you could find a path that avoided going right to the top, perhaps round the side. Something that does this for a chemical reaction it is known as a catalyst.

Biological catalysts, called enzymes, are very specific and will generally only work with one chemical. Not only do they provide a low energy path for the reaction, but they also hold the molecules they work with in exactly the right place to react. The result is a much faster reaction without raising the temperature.

See for yourself

One thing that enzymes do in our bodies is to break down toxic substances. Just by breathing we produce hydrogen peroxide, H_2O_2. To prevent it building up, we have an enzyme called catalase that breaks it down quickly:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

You can see the effect that catalase has on hydrogen peroxide with a simple experiment using the enzymes found in yeast and potato.

Empty a sachet of dried yeast into a cup or glass and mix it with some tepid water. Put this to one side while you do the first part of the experiment.

Pour a little hydrogen peroxide solution into a saucer. Look at it carefully – it is breaking down into oxygen and water all the time, but too slowly to be seen. Cut a chip shaped piece of potato so that a fresh surface is exposed and carefully place it in the hydrogen peroxide solution. You should now clearly see bubbles of oxygen gas – evidence that the reaction is taking place more quickly.

IMAGE COURTESY OF STEPHEN ASHWORTH

Stephen Ashworth demonstrates the reactions in Herzlia High School, Cape Town, South Africa

Even faster!

Next place some more hydrogen peroxide, no more than 50 cm^3, in a tall container such as a large jar or glass vase (be careful if you choose a bottle or anything with a narrow neck). Add a dash of washing-up liquid and swirl it gently to mix. Place the container in a washing-up bowl, or the sink (to catch any overflow), and quickly add the yeast that you mixed with water earlier. You should now see an even quicker reaction – the enzymes in the yeast can mix more freely than those in the potato and the gas makes lots of bubbles, which are formed quickly. Wash the liquid waste down the sink with plenty of water.

You will need:

- Dried yeast (from a supermarket or baker)
- A cup
- Tepid water
- 3% (or 10 vol) hydrogen peroxide (from a pharmacist)
- A saucer
- A potato
- A tall jar or vase
- Washing-up liquid

Take care!

Hydrogen peroxide can be bought in different concentrations from most pharmacies. The concentration is quoted as either a percentage or volume: a 10 vol solution is approximately 3%.

Always take care when handling hydrogen peroxide and wear eye protection.

Cutting-edge chemistry

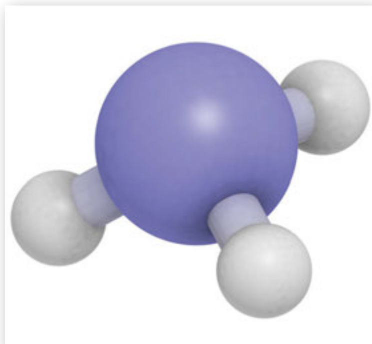
Ammonia freezes up under pressure

Emma Stoye looks at how 'hot ice' could be found at the cores of Neptune and Uranus

Did you know?

Neptune appears blue because methane in the atmosphere absorbs the red light from the sun and reflects the blue light back at us.

Researchers in France have shown that when molecular ammonia is put under enormous pressure, it becomes unstable and then forms a solid ionic ice. The change was first predicted in 2008 by theoretical calculations, but until now it had never been shown experimentally.



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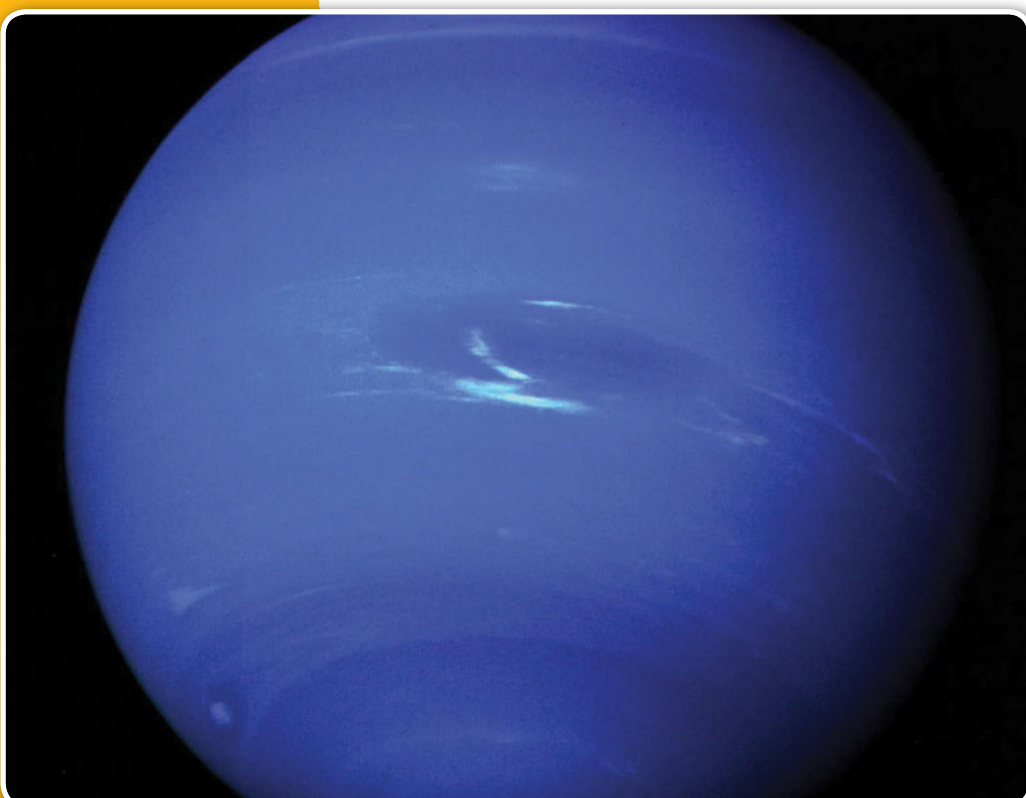
At room temperature and pressure ammonia (NH_3) is a gas. Its low temperature ice form is a typical molecular crystal, with weak hydrogen bonds between molecules, much like water ice. But ammonia behaves differently elsewhere in the universe where temperatures and pressures are extremely high, such as in the cores of the gas giants Neptune and Uranus. A team led by Sandra Ninet and Frederic Datchi at the institute of mineralogy and condensed matter physics recently showed that at temperatures above 750 K and pressures beyond 60 GPa, the molecules dissociate to form 'hot ice' – a superionic phase composed of NH_3, NH_4^+ and NH_2^- that behaves simultaneously as a solid crystal and a liquid.

In 2008, theoretical simulations predicted that low temperature ammonia could also enter an ice phase containing alternating layers of NH_4^+ and NH_2^- ions, at very high pressures. Now, Sandra and Frederic have found strong evidence that supports this theory. They used a diamond anvil cell to squash room temperature ammonia at pressures up to 194 GPa, over 1.5 million times atmospheric pressure.

'Above 150 GPa, strong changes in the experimental infrared (IR) and Raman spectra are observed, indicating a transition to another high-pressure phase,' they write in a paper published on the preprint server *arXiv*. 'The IR band around 2500 cm^{-1} cannot be due to molecular NH_3, which therefore implies the presence of NH_4^+ ions.'



© NASA

Ammonia behaves as 'hot ice' in the gas giants, Neptune and Uranus

The spectra agree only partly with previous theoretical predictions, however, as they confirm ammonia's ionicity but do not match up with the crystal structures suggested in the structural model. Further calculations, guided by the experiments, have helped the team refine the model and suggest that the high pressure ionic phase contains two different crystalline forms.

'It is pleasant that the prediction has been at least partly verified by experiment,' says Artem Oganov from the State University of New York in the US, whose group also study materials at high pressure. 'Spontaneous ionisation seems to be a rather common phenomenon under pressure – it probably happens to soften interatomic repulsions and reduce the average atomic volume.' He adds that these findings could help improve understanding of the conditions inside giant gas planets made of ammonia, methane and water.

Sandra, Frederic and colleagues now plan to refine ammonia's phase diagram by exploring the boundary between its ionic and superionic phases.

Fireworks and the spread of particulate matter

William Bergius investigates the pollution created by spectacular celebrations

A detailed study on the distribution of atmospheric pollutants arising from the wide scale use of fireworks has been carried out by scientists in China, with a view to highlighting related environmental and health concerns.

Fireworks and firecrackers are used extensively across the globe in all manner of celebrations, though few match the sheer scale of Chinese New Year. They generate a variety of contaminants, including gases such as carbon monoxide, sulfur dioxide and nitrogen oxide, in addition to aerosols of microparticles known as particulate matter.

Though research groups around the world have investigated various aspects of firework detonation on the local atmosphere, the study from Wei Gong's research group at Wuhan University is on a larger geographic scale, with more regular time intervals, than ever before. The team also present the first detailed data on the vertical atmospheric distribution of PM2.5 and PM10 levels (particulate matter with an aerodynamic diameter of less than or equal to 2.5 μm and 10 μm, respectively). These suspended particles are important as they can affect climate and are also respirable, affecting both heart and lung function. In 2010, the World Health Organisation's global burden of disease report indicated that ambient particulate matter ranked fourth out of the main risk factors relating to deaths in China.

Wei's team recorded data from 10 air monitoring stations around Wuhan, the capital of Hubei Province with a population of 8 million. They also used a remote sensing technique known as Lidar, which employs the detection of reflected laser light by aerosol particles, to monitor plumes of particulate matter emanating from fireworks displays. Wei's analysis of this data estimates that PM2.5 emissions from fireworks in Wuhan during the testing period totalled between 39.57 and 43.51 tons.

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'We have found that air quality is seriously affected by this human activity and the effects are much greater than we previously thought,' says Wei. 'The highest PM2.5 concentrations measured were up to seven times greater than on ordinary days. It is time to alert the public to the negative effects of our cultural customs.'

© SHUTTERSTOCK

Wei may find that the public don't take much convincing to give up fireworks. 81% of respondents to a Shanghai resident's survey were in support of a year-round fireworks ban to improve the city's air quality. And in January, Beijing's government sent text messages encouraging people to cut down on the number of fireworks they set off.

Dilip Chate, an expert in atmospheric aerosols at the Indian Institute of Tropical Meteorology, says this is an interesting study. 'The dispersion of human-induced emissions during any fireworks display mainly depends on weather parameters, and it would be interesting to see this discussed based on real time parameters,' he adds.

Wei intends to continue his research in the remote sensing of atmospheric pollutants, to investigate larger and more complex systems.

Did you know?

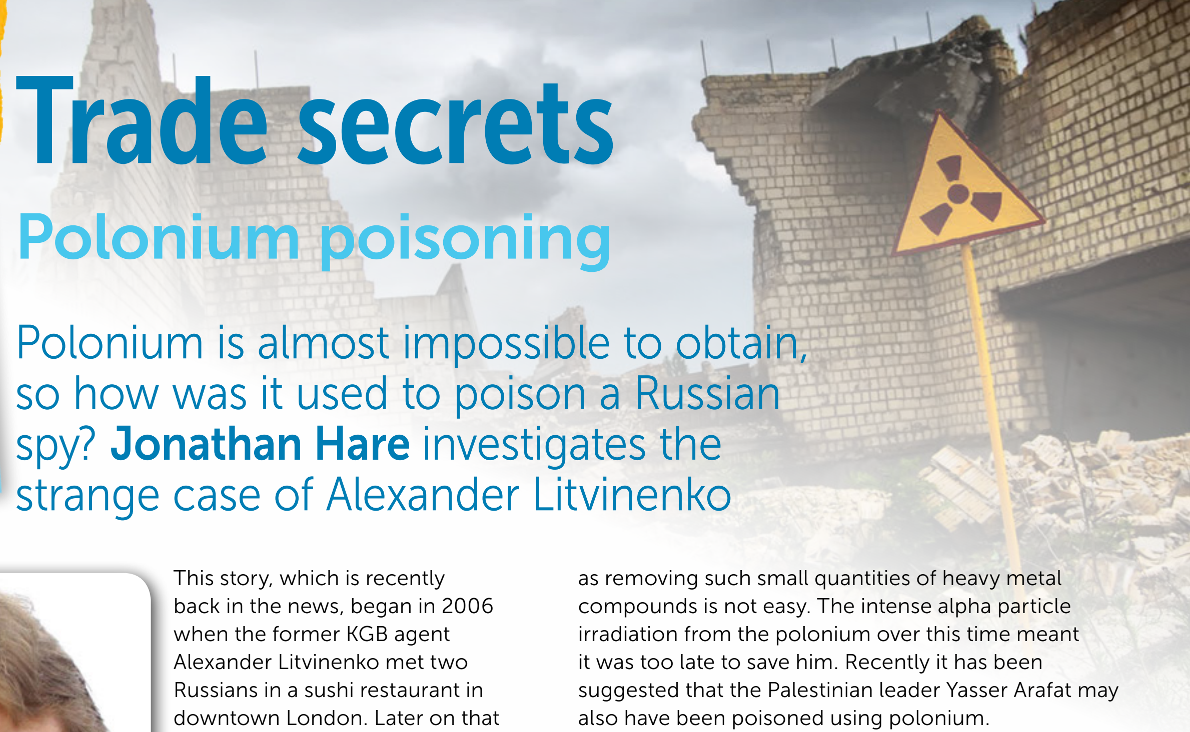
The world record for the largest firework display is held by the State of Kuwait. They let off 77,282 fireworks on 10 November 2012 to celebrate the 50th anniversary of their constitution. The display lasted 64 minutes!

Find out more

Learn more about the history and science of fireworks with this article from *Education in Chemistry*:

http://rsc.li/1fh50XK

Particulate matter from firework displays have a severe effect on the local atmosphere, which can lead to health risks



Trade secrets

Polonium poisoning

Polonium is almost impossible to obtain, so how was it used to poison a Russian spy? **Jonathan Hare** investigates the strange case of Alexander Litvinenko

Find out more

Learn more about radioactive isotopes and the man who put the word 'isotope' in the dictionary with this article from *Chemistry World*: **http://rsc.li/18aVFkX**

Alexander Litvinenko

This story, which is recently back in the news, began in 2006 when the former KGB agent Alexander Litvinenko met two Russians in a sushi restaurant in downtown London. Later on that day he reported feeling unwell and within two weeks he was dead. It is thought that he was poisoned with a radioactive material. The inquest showed Litvinenko was killed by ingesting polonium (^{210}Po). Polonium is an alpha particle emitting metal with a half life of 138 days. Amazingly it is thought that as little as one microgram is enough to kill someone.

Dangerous alpha particles

Radioactive materials need to be handled carefully. In the case of a nuclear power station radiation disaster (eg Three Mile Island in the US or Chernobyl in Russia) radioactive species dispersed by the accident may cause widespread irradiation of life. For example, dust fallout in the smoke from the burning power station contains radioactive species that are a major problem, especially if they are an alpha emitting species. Local people are often given iodine supplements to try and reduce their thyroid uptake of radioactive iodine. The safest option is usually to evacuate people far away from the danger area. Sometimes however even this will not guarantee safety. During the Russian Chernobyl disaster for example, considerable fallout was deposited as far away as northern Italy due to the peculiarities of the wind and rain patterns at the time.

Do not ingest!

Because alpha particles are so intensely ionising they only penetrate a few centimetres in air, and so a piece of paper or even your clothes will reduce the intensity very considerably. However if an alpha emitter happens to be ingested (either by breathing it in as a fine dust or perhaps drunk as a water soluble salt) then the material is in intimate contact with internal body parts. As it makes its way through the body the intense local irradiation can cause organ failure, leading to death.

In the case of Mr Litvinenko it appears that only a few micrograms of the alpha emitting polonium salt may have been added to his food. Once inside his body there would be very little that could be done, as removing such small quantities of heavy metal compounds is not easy. The intense alpha particle irradiation from the polonium over this time meant it was too late to save him. Recently it has been suggested that the Palestinian leader Yasser Arafat may also have been poisoned using polonium.

Handle with care

Polonium has to be handled very carefully and a spy would certainly need to use protective gloves. Being a strong alpha emitter, very little is required and so it could be safely transported in a small metal vial. Contained like this it would be very difficult for security teams to spot within luggage, for example.

If polonium was the poison how was it obtained? ^{210}Po can only be produced in a nuclear power plant and so it's the sort of material that only highly specialised personnel would have access and permission to use (or steal). As this material is very difficult to obtain, its use and abuse could only be authorised 'right from the top', making the use of polonium a politically sensitive issue.

An excellent little book is *Radioactivity: a very short introduction* by Claudio Tuniz: http://amzn.to/1iaTmzh

Did you know?

Sunflowers were planted after the Chernobyl disaster to help to remove radioactive pollutants from the land. This process is known as rhizofiltration: **http://rsc.li/1egpMaW**

Chernobyl nuclear power station

Jamie Gallagher

Chemist, public engagement officer, science communicator …

… electrical engineer, salsa dancer and comedian – Jamie Gallagher meets **Edwin Silvester** to explain how it all fits together

Jamie Gallagher is currently polishing off his PhD thesis at the University of Glasgow. Yet he was recently named in the UK Science Council's 100 leading scientists, chosen alongside such media luminaries as Alice Roberts and Maggie Aderin-Pocock for science communication. In Jamie's own words, 'it highlights the importance of public engagement in science and that all scientists must be able to communicate their work and its importance to truly make an impact.'

Public engagement

Jamie is certainly having an impact. Before even submitting his thesis he's already been signed up to a new role as public engagement officer for the University of Glasgow, coordinating, developing and measuring the impact of the university's public engagement. Jamie says he hopes 'to inspire students with the success I have had in taking my research out of the lab and making it interesting and accessible to all.

'It is great to see the help, support and reconnection that organisations like the Royal Society of Chemistry offer to those undertaking engagement activities and I look forward to encouraging more of our staff and students in undertaking a host of rewarding activities.'

Jamie's infectious enthusiasm for learning and communicating are bound to make him a success in the new job and it's a natural extension of his own energetic public appearances.

Linking salsa to science

Jamie has taught salsa in Glasgow for the last five years, running classes for both beginner and advanced dancers. 'I find there is actually a strong link between teaching dance and science communication', he explains. 'With both, the goals are the same – to take some fairly complicated information and share it in an understandable, accessible and fun way.'

His passion for explaining science to both expert and non-specialist audiences led to Jamie being named one of the RSC's 175 Faces of Chemistry – and the RSC also sponsored his excellent Periodic Success show at Cheltenham Science festival in 2013.

'I can get a little bit excited about science', he says. 'There are so many wonders to explore I just can't contain myself so I started telling people about it. 'I've had shows at the British Science Festival and also in Cheltenham, Manchester, Glasgow and Edinburgh. I've worked with the BBC and independent production companies; I've spoken at schools and universities; set fires in science centres and interpreted energy with dance troupes.

'Science has taken me from basement bars to the painted hall of the maritime museum via muddy fields and recording studios and what an adventure it has been! I always look forward to my next project.'

Diversity

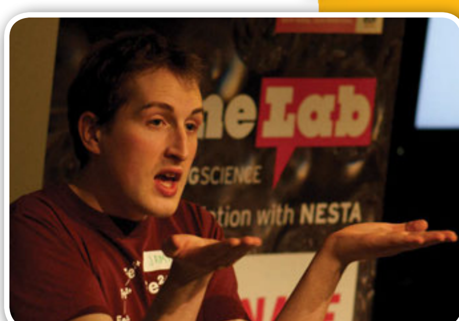
Jamie is outspoken on diversity in science, not least because one of his chemistry inspirations is Marie Curie, who came up against immense sexism in her illustrious career.

'She is the only person to win two Nobel prizes in different sciences and yet the prejudice and bigotry she encountered and battled through her life is staggering', he says. 'She was turned away from universities; she was hounded and vilified by the media and all for being a woman.

'Today it is all too easy to forget that her scientific quest was a daily fight, or to think that the issues she faced are long since gone, they are not. Let us learn from the mistakes of the past and ensure that no one needs to fight to justify their right to pursue their scientific dream.'

The thrill of discovery

And while Jamie is almost ready to hand in his thesis, this won't be his last foray into research. He says: 'There is a thrill to scientific discovery. It gives me a kick to know that when I investigate something I'm the first person in the world to know about it. If you're working in a field, it's yours – you feel very connected to your topic and passionate about it.



'You're the one person learning about it and then telling others about your discoveries. The scientific community is fantastic and the idea of discovery is extraordinary.'

Pathway to success

- **2013–present**
  Public engagement officer, University of Glasgow, UK
- **2012**
  Winner in the Scottish final, and runner-up in UK final, of the Famelab science communication competition
- **2011–present**
  Tour of the UK with self-written science shows
- **2009–2013**
  PhD in chemistry and electrical engineering, University of Glasgow
- **2004–2009**
  BSc (Hons) in chemical physics, University of Glasgow
- **2002–2004**
  Advanced Highers in mathematics and physics; Highers in mathematics, physics, chemistry, biology, english and modern studies at Hamilton Grammar School, South Lanarkshire, UK

175 Faces of Chemistry

Celebrating diversity in science, *175 Faces of Chemistry* recognises scientists who have achieved excellence in their field:

http://rsc.li/1eTr4Je

Francine Atkinson

Magda van Leeuwen introduces you to the newest member of the ChemNet team

Francine Atkinson is the latest addition to the ChemNet team. Having been captivated by chemistry at school, she's excited about helping you make the most of your ChemNet membership and showing you what chemistry has to offer.

Inspiration

Originally from Cornwall, Francine has a great passion for cooking, rugby and creative design and did not always think she would follow a career in chemistry. However, the imagination and enthusiasm of her A-level chemistry teacher had her sold on the idea of studying chemistry at university.

'Chemistry is full of curious characters, fascinating findings and serendipitous events,' she says. 'I found chemistry lessons captivating as our teacher told stories, describing treks through the Amazon rainforest as a metaphor for revision.' From this experience, it's clear to see why Francine found lessons so engaging, and she chose to explore chemistry further.

From student to teacher

Before university, Francine's inquisitive nature led her to a summer placement at Exeter Police Forensics. This gave her the opportunity to indulge her interests in problem-solving and gain some valuable work experience. 'It was fascinating to find out how chemistry can be used to solve crime,' Francine remembers. 'Scientists really do have an important and varied part to play in the police force.'

Francine studied chemistry as an undergraduate at the University of Nottingham – an institute she chose because of their excellent facilities and attractive green campus.

While at university, she taught A-level students during university holidays. 'Teaching is very rewarding. I loved helping young people to understand chemistry and use it to make sense of the world around them.' Francine enjoyed teaching so much that, after graduating, she returned to the south coast to pursue a PGCE (a teacher training qualification) at the University of Exeter.

How ChemNet can help you

Francine taught chemistry for seven years, and then a new opportunity arose that would let her use all her skills and passion in engaging young people with chemistry. She joined the ChemNet team in January and plans to develop it as a service that will bring with it lots of new and exciting opportunities to students, such as resources, events and support with career choices.

Keen to maintain her links to teaching, she feels that in her new role she can act as an advocate and ambassador for students: 'ChemNet offers a chance to thoroughly explore all that is on offer including the wide range of jobs that studying chemistry can lead to. I would really love to hear your ideas on how we can improve ChemNet further and support you with your studies.'

Francine's advice

Above anything else, Francine says that chemistry is very similar to her favourite passion, cooking. She has often seen students ready for an experiment with the same instructions, chemicals and equipment, yet with very varied results. Her advice is: 'Don't be frightened by practical sessions, be excited about them for the chemical adventure that they are and constantly question the results you see, whether they are the same as your lab partners' or entirely different. Unusual results can sometimes be the start of a new discovery.'

RSC ChemNet Events

Dates for your diary

▶ UCAS conventions
March to September
Across the UK
Thinking of university? Find out about university life, courses, gap years and the whole application process.
http://bit.ly/M9L6UF

▶ Chemistry of flavour
20 March 10:00–12:00
Great Blakenham, Ipswich
Everything you wanted to know about flavours but were afraid to ask. Come along for the opportunity to make a flavour yourself and see how it tastes in a drink or yoghurt.
http://rsc.li/18eNh1B

▶ Transition metals and electrochemistry
26 April 10:00-14:00
Jackfield, Shropshire
Find out how people have been using the chemistry of transition metals to make and decorate tiles since the time of the Egyptians. Explore the tile factory and museum while revising AS/A2 chemistry.
http://rsc.li/1bO8b9K

▶ Creating chemistry with BASF
28 May 2014 13:00–16:30
Somercotes, Derbyshire
Take part in a hands-on workshop at BASF. Explore real-life industrial chemistry and discover the science of polyurethanes.
http://rsc.li/1bNWujv

▶ Meet the Universities
28 June (*London*) and 12 July (*Leeds*)
10:00–12:30 and 13:30–16:00
Considering a degree in the chemical sciences? This is a fantastic opportunity to talk directly to staff and students from many of the UK's universities.
http://rsc.li/S4tKev

The Mole reader survey

This is your chance to help us improve ***The Mole*** and win one of three **£50 Amazon vouchers**

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We are on a mission to improve *The Mole* and we need to find out what you, the readers, really want. At the moment you can read the digital magazine online at **www.rsc.org/TheMole** or the printed copy that is sent to school. This is your chance to tell us how you want to read *The Mole*: On your phone or tablet? On a computer or in print?

Also, what do you like about *The Mole*? Is there anything you would change or would like to see more of?

Our aim is to bring you *The Mole* with articles that interest you in a way that you want to read it. Tell us what you think and as a 'thank you' we will enter you in a prize draw to win £50 of Amazon vouchers. There will be three lucky winners. Closing date for entries is 14 April 2014 (terms and conditions apply).

Scan here

Visit the survey online at **http://svy.mk/1epMOZ1** or scan the QR code

Enter the prize draw at http://svy.mk/1epMOZ1

£50 of vouchers to be won

Puzzles

Wordsearch

Find the 37 words/expressions associated with coprolites hidden in this grid (contributed by Bert Neary). Words read in any direction, but are always in a straight line. Some letters may be used more than once. When you have found all the words, use the remaining letters to make a nine-letter, two-word expression. Find out more about coprolites in *The Mole,* January 2013 (**http://rsc.li/TM0113**).

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

ABSORBED
ANALYTICAL SPECTRA
ANCIENT ANIMALS
ATE
BIG
BIOMARKERS
BONES
CARNIVORE
CHROMATOGRAPHY
CLUES
DIE
DIET
DIGESTIVE SYSTEM
DINOSAUR FOSSILS
EXTINCT
FAECES
FOSSIL RECORD
FUR
GUIDE
GUT
HERBIVORE
IDENTIFICATION
INHABITED
LAND
LIFE
MASS SPECTROMETRY
MICROBES
MUSEUMS
PALAENTOLOGISTS
PEAK
PLANTS
PRESERVED
PREY
RECONSTRUCTED
STOMACH
STONES
TEETH

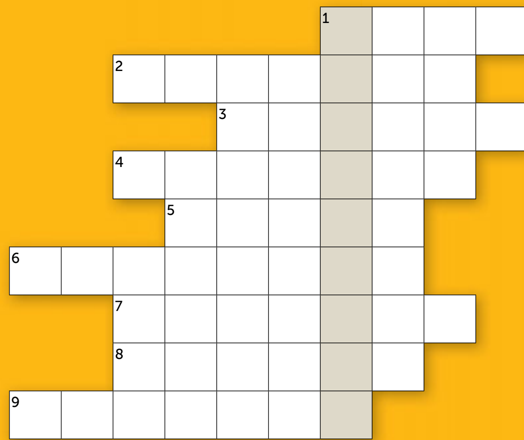
January wordsearch solution and winner

The winner was Tasha from Rushden The 9-letter word was MOLECULES.

Submit your answers online at **http://svy.mk/TM214ans** by **Monday 14 April.** A correct answer for each puzzle, chosen at random, will win a £25 Amazon voucher

Chemical acrostic

Complete the grid (contributed by Simon Cotton) by answering the nine clues to find the answer in the shaded box. This will spell out the name of a transition metal once used to make photographic flash bulbs.



1 Oysters are the richest food source of this metal

2 Cumulative poison, found in the same group as zinc

3 Radioactive isotope of this element is used to date archaeological specimens

4 Group 4 element essential to the electronic industry

5 Element with atomic number 5

6 This halogen has no stable isotopes

7 The halogen found in the natural dye Tyrian Purple

8 Group I metal, vital to the body in transmitting nerve impulses

9 Most abundant metallic element in the human body

Another clue...

This element is used (together with activated carbon) to reduce mercury pollution from coal-fired power stations.

	O	X	Y	G	E	N		
	S	U	L	F	U	R		
C	O	P	P	E	R			
		A	R	G	O	N		
		K	R	Y	P	T	O	N
	L	I	T	H	I	U	M	
U	R	A	N	I	U	M		
C	U	R	I	U	M			

January acrostic solutions and winner

The winner was Kevin Chang from Hereford.