InfoChem
STUDENT SUPPLEMENT
EDUCATION IN CHEMISTRY
ISSUE 118 SEPTEMBER 2009

HYDROGEN FUEL FROM URINE

Using hydrogen to power cars is an attractive alternative to fossil fuels because the only emission produced is water. But a major problem with this approach is the lack of a cheap, renewable source of the fuel. Researchers at Ohio University in the US may now have found the answer in an unexpected place, our urine.

Although hydrogen is the most abundant element in the universe, on Earth it tends to be locked away in molecules such as water (H_2O). To liberate hydrogen gas (H_2) from water the strong hydrogen–oxygen bonds must be broken. This can be achieved by passing an electrical current through water (the electrolyte) in a process called electrolysis. However, the energy required for this process makes it a prohibitively expensive way of making hydrogen fuel. The Ohio team, led by Dr Gerardine Botte, have shown that electrolysis can be used to produce hydrogen gas from human urine, at a fraction of the cost of producing hydrogen from water using the same method.

Urine contains urea, $(NH_2)_2CO$, which has four hydrogen atoms in each molecule. Importantly these are easier to remove than in water because nitrogen–hydrogen bonds are weaker than oxygen–hydrogen bonds. Reporting in the Royal Society of Chemistry's *Chemical Communications* journal, Botte and her colleagues designed an electrochemical cell with urine as the electrolyte. To break down one urea molecule and release the two molecules of hydrogen gas they applied 0.37 V across the cell. This is much lower than the 1.23 V needed to do the same to water.

During the electrochemical process, pure hydrogen is evolved at the cathode (negative electrode) and nitrogen is collected at the anode (positive electrode). Carbon dioxide is also generated during the reaction, but it is not released as a gas and instead reacts with the potassium hydroxide in the electrolyte to form potassium carbonate.

As well as producing an environmentally friendly fuel, this process could also be used to clean up wastewater. According to Botte, current methods to remove urine from water are expensive and not efficient. She plans to try and combine the two ideas, so that hydrogen can be collected for use as fuel during the cleanup of effluent from sewage works.

Matt Wilkinson

JUPITERIMAGES

Did you know?

You can find out what work goes on in university research labs through a series of short films available to watch online at www.chem.ucl.ac.uk/schools/lifeinchem/index.htm. The eight videos provide a glimpse into some of the research that chemists and their students in University College London's (UCL) chemistry department are doing to help meet the global challenges of the 21st century. Produced by UCL's* Chemistry for our future *teacher fellow Dr Cheryl Sacht, the videos show UCL chemists in their labs talking about their work, including how they are using nanotechnology to develop self-cleaning antimicrobial materials and how they simulate chemical reactions occurring in the Earth's atmosphere in the lab.

IN THIS ISSUE

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Pandemic swin

On 11 June 2009 the World Health Organisation officially declared a pandemic of swine flu following 30 000 cases in more than 70 countries. By August the number of new cases reported each week had peaked at 110 000 and there had been 36 deaths in England, but for most sufferers the symptoms seem to have been mild. So should we be worried by the pandemic this autumn and winter?

This year's outbreak of a new strain of influenza, more commonly known as swine flu, is the latest episode in the long history of mankind's struggle with this continually changing virus. To determine the threat this new outbreak poses as we enter the peak flu season we need to consider the chemistry of the virus, the historical precedent for pandemic flu and the drugs available to treat the illness.

What is influenza

Influenza is a highly contagious viral infection which causes fever, shivering attacks, muscle aches, headache and sore throat. The illness rarely lasts for more than three days and recovery is usually rapid, though there may be associated respiratory infections. The most serious of these is pneumonia, a bacterial inflammation of the lungs which if left untreated can be fatal particularly for the young and elderly.

Catch it, bin it, kill it…

JUPITERIMAGES

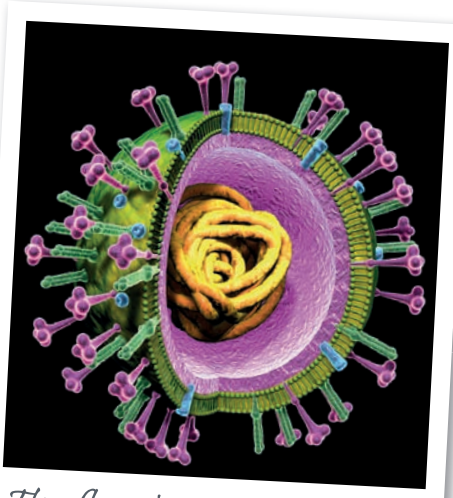
The influenza virus has a diameter of *ca* 0.1 μm (1×10^{-7} m) and is essentially a spherical, protein-based envelope containing genetic material (ribonucleic acid – RNA). On the surface of the virus particle are two protruding proteins (antigens). These are haemagglutinin (HA), which is a glycoprotein (*ie* a protein with attached sugar chains), and the enzyme neuraminidase (NA). Each flu particle is covered by *ca* 2000 HA and 500 NA spikes and these two proteins have key roles in the life cycle of the virus as it infects a host cell to replicate itself.

Haemagglutinin attaches the virus to the surface of the host cell by binding to specific sugar chains, in particular neuraminic acid, on proteins on the cell surface. Once bound, the virus membrane fuses with the host cell membrane incorporating the particle into the cell. A subsequent fall in pH within the cell results in a change in the three dimensional structure of HA, which causes the virus to rupture and release its viral RNA. This genetic material is then used by the cell to make new copies of the virus.

Neuraminidase plays its important role when the new virus particles are ready to leave the infected cell. The NA enzyme catalyses the cleavage of the neuraminic acid chain from surface proteins on the infected cell. This causes a change in shape of the cell surface which allows the new virus particles to escape and infect other cells in the body.

The structures of HA and NA can differ

E FLU



The flu virus particle

subtly from virus to virus. At present, at least 16 discrete subtypes of HA (H1–H16) and nine forms of NA (N1–N9) have been identified in Nature, some in people, but most in viruses affecting aquatic birds. These subtle variations and the possible HN combinations (144 in all) determine the type of virus (*eg* H1N1, H3N2, H5N1) and whether it attacks humans. The swine flu virus is a novel strain of H1N1, one of only a few combinations that are capable of infecting humans and causing a pandemic.

What is pandemic flu?

A pandemic is an outbreak of a new infectious disease that can spread easily among humans and is prevalent across a country, continent, or even worldwide. The influenza pandemic of 1918–19, which rates as the greatest pandemic of all time, caused more than 20 million deaths around the world in less than two years. The high mortality associated with this pandemic (>2.5 per cent) was caused by pneumonia, which so often followed the initial infection. This condition was sometimes caused by the influenza virus itself, which reproduced especially well in the lungs, but was more often the result of infection by the bacterium *Staphylococcus pyogenes*. This invaded the already damaged lungs and produced a sudden inflammatory condition, which led to respiratory collapse and death. With the availability of modern antibiotics, the likelihood of a similarly high mortality rate from bacterial pneumonia in any new pandemic is unlikely.

The influenza strain of 1918 appears to have been particularly virulent because it had an HA protein that was especially well adapted for human-to-human transmission along with a NA enzyme that allowed for efficient release of new virus particles. This allowed the virus to infect and spread rapidly throughout communities, limiting the opportunity for people to develop immunity to the illness.

JUPITERIMAGES

The new strain

Transmitted through air by coughs and sneezes or through contact with contaminated surfaces or body fluids, influenza viruses circulate widely in the human and animal (birds, pigs *etc*) environment and different strains are adapted specifically to cause disease in their hosts. However, if strains of the viruses are passed back and forth between hosts there is the potential for a host to be infected with two different viruses at the same time. During this period of infection the viruses can trade genetic material (mutate) which can lead to the development of a novel strain. This is a reason why so many new strains of influenza originate in the Far East, a region of the world where humans live in close proximity to aquatic birds and to pigs.

Although called swine flu, the new H1N1 strain appears to have acquired genetic material from human, swine and avian flu viruses. These genetic components have been combined into the new strain during a period of infection in a North American swine host.

The novel H1N1 strain currently causes infection mainly in the upper respiratory tract, which results in mild symptoms and a fatality rate similar to seasonal flu (0.1–0.35 per cent). However, the behaviour of viruses is unpredictable. For instance, over the next few months this swine flu virus could evolve by mixing with seasonal flu viruses or with the dangerous avian H5N1 virus, which has a mortality rate of >60 per cent. The resultant new strain could be more of a threat to humans during a pandemic and only a vast supply of effective flu treatments would limit its impact on the global population.

Flu treatments

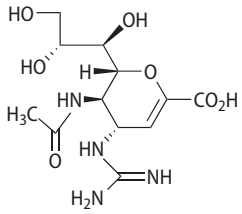
There are several influenza vaccines available, which are used to prevent the disease infecting those at most risk, *ie* the young, the elderly and those whose immune systems are compromised (*eg* patients receiving cancer chemotherapy, HIV/AIDs patients *etc*). Yearly flu vaccines introduce inactive flu strains into the body. This primes the immune system to recognise similar invading viruses, making it ready to fight infection. These vaccines are only useful against the known strains of the virus and the World Health Organisation (WHO) announced in August that a vaccine for the new H1N1 strain is likely to be licensed for use in September.

The development of drugs to treat influenza is fraught with difficulties, not least because infection is so rapid. To be effective drugs must either be given prior to any symptoms to prevent infection or immediately the first symptoms are recognised. Current influenza drug therapy focuses on a family of drugs known as neuraminidase inhibitors. Discovered by a team of Australian chemists, these compounds inhibit the actions of the viral neuraminidase enzyme, which reduces the infectiousness of the virus. In 1993 the Australian research group, led by Mark von Itzstein and Michael Pegg at Monash University in Melbourne, determined the three dimensional structure of the neuraminidase enzyme bound to neuraminic acid using x-ray crystallography. This allowed the team to use computational chemistry techniques to study how the sugar chain fitted into the active site of the enzyme. Using data from these studies, the researchers constructed drug molecules designed to occupy the active site, and thus inhibit the enzyme.

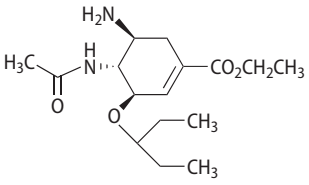
The Australian team prepared several

"... THE WORLD IS BETTER PREPARED FOR AN INFLUENZA PANDEMIC..."

Protection from a pandemic



(*1*) Zanamivir (Relenza)



(*2*) Oseltamivir (Tamiflu)

structural analogues of neuraminic acid that were effective neuraminidase inhibitors. One of these was zanamivir (*1*), a drug which was approved for use in 2000 and is now produced by GlaxoSmithKline (GSK) in the UK and marketed as Relenza. The drug is administered as a dry powder that is puffed into the lungs.

However, almost immediately after its launch, Relenza was eclipsed by another neuraminidase inhibitor oseltamivir (*2*). Produced by Roche and sold as Tamiflu, this drug is taken as a pill. Both drugs reduce the duration of the illness if administered within two days of the first symptoms of influenza.

The outlook

Antiviral drugs such as Tamiflu will help to control any new pandemic. In addition, the availability of antibiotics will ensure that any associated bacterial infections are treatable. As the WHO has recently stated, the world is better prepared for an influenza pandemic than at any time in history. So as long as the virus does not become dangerously virulent by picking up genes from the highly pathogenic H5N1 avain flu virus, we can be quietly optimistic that there will be no repeat of the disaster of 1918.

John Mann

magnificent molecules

John Johnston, freelance science writer, highlights his favourite molecules. In this issue: **EPO**

Erythropoietin (EPO) is one of several natural hormones that scientists have been able to isolate, synthesise and use as a medicine. However, EPO has also been shrouded in controversy because of its abuse by athletes.

Structure and uses

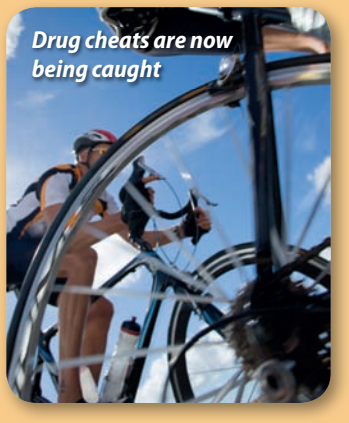
Erythropoietin is a protein with an attached sugar, *ie* a glycoprotein. EPO is produced by the kidneys and stimulates the production of oxygen-carrying red blood cells in bone marrow.

First isolated and later purified from urine in the 1970s, human EPO is a large protein molecule containing 165 amino acids, with four carbohydrate chains. By the mid-1980s scientists had identified the section of human DNA (gene) responsible for programming kidney cells to produce EPO. Several research groups then developed methods to combine this gene with DNA in cell cultures to provide a way of synthesising EPO in the lab. Synthetic EPO is used to treat patients suffering from low blood oxygen levels caused by kidney failure, cancer chemotherapy and drugs used to treat HIV infection.

Athletic abuses

Although synthetic EPO is used to improve the quality of life for many people with serious illnesses, the drug also has a dark side. Endurance athletes such as cyclists, runners and cross-country skiers have used EPO as a performance-enhancing drug. The drug is used to boost athletic performance by producing extra red blood cells to improve oxygen uptake and aerobic power. However, using EPO in this way can be fatal. The extra red blood cells thicken the blood and raise the risk of heart attacks and strokes. The deaths of some athletes have been linked to EPO since the 1980s.

With advances in testing procedures it is now easier to catch unscrupulous athletes. The World Anti-Doping Agency use a combined urine and blood test to detect EPO abuse. Cycling is now adopting a more organised regime of testing to catch drug cheats. Several competitors tested positive for EPO at the 2008 Tour de France and received lengthy bans from the sport. ■



Drug cheats are now being caught

JUPITERIMAGES; ROCHE

ON-SCREEN CHEMISTRY

Jonathan Hare asks…

FLOOD: *will all the land be covered by water if the polar ice caps melt?*

Land ahoy?

'The future. The polar ice caps have melted covering the Earth with water. Those who have survived have adapted to a new world'.[1] It's the start of the film *Waterworld* where we see the ice caps melt and the continents disappear under water. Could climate change lead to complete melting of the polar ice caps like we see in the film, how long will it take and what effect will it really have?

Meltdown at the Poles

The major ice sheets are found at the Poles (the Arctic and Antarctic), in Greenland and in the world's glaciers. Floating ice does not raise the sea level when it melts. You can demonstrate this by adding some ice cubes to a gas of water and marking the water level. When the ice has melted you will see that the water level is the same. Arctic ice is floating and so will not directly change the sea level, even if it all melts.

Around 60 per cent of all the fresh water on the Earth's surface is locked up in the enormous continental Antarctic ice sheet. If this ice melted it is estimated that it would cause the sea level to rise by *ca* 60 m, while the Greenland ice sheet would produce around a 7 m rise.[2] Some of the Antarctic ice sheet is more stable than other parts. The west Antarctic ice sheet (WAIS) is thought to be most at risk from collapse and melting which, if it all went, would lead to around a 5 m rise in sea level.

Just a few metres sea level rise would cause major havoc to all global coastlines and many major cities. For example Bangladesh, the Netherlands as well as island archipelagos such as the Maldives would be threatened by flooding. However even with a 70 m sea level rise, if all the ice melted, it would not cause all the land on Earth to be covered.

Hot water

Large increases in sea level can happen if the seas warm up – above 4 °C water expands with increasing temperature, taking up a larger volume. This can occur over a long time as a result of global warming or if changes in oceanic circulation and convection take place. The oceans are so vast (deep) that the expansion produced by even a slight rise in the average temperature will produce a large change in the sea level.

The Intergovernmental Panel on Climate Change (IPCC) has reported that the ice sheets are melting and that the seas are warming. The average sea level rise currently amounts to *ca* 1.8 mm per year, though recent data suggest its larger than this.[3] This figure has to be appreciated against a complicated set of natural, long-term, periodic variations. In reality this average includes some parts of the ocean becoming lower while others rise.

Currently, more than half of the average rise is the result of thermal expansion of water while the rest is from ice melting. Since the oceans are a vast mass they will take a long time to heat up significantly to any great depth. So large permanent changes in sea level caused by thermal expansion probably won't happen for many hundreds of years. Melting of the Greenland and massive Antarctic ice sheet will require much longer timescales, however once started it may be impossible to stop this process.

Overall, in the short term (~100 years) thermal expansion will dominate the changes in sea levels while over the longer term (~1000 years) melting of the Antarctic ice sheet will become more significant. The *Waterworld* scenario where all the land is covered by water is unlikely to occur, even if global warming and ice melting continues unabated for hundreds of years. But many fear that smaller changes in sea level will dramatically effect humans within the next 100–200 years.

REFERENCES

1. *Waterworld*, Universal Studios, 1995.

2. Intergovernmental Panel on Climate Change (IPCC), Fourth assessment report: *The physical science basis*, 2007, chap 5: http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter5.pdf

3. Sea level rise: http://en.wikipedia.org/wiki/Sea_level_rise

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

BACKYARD CHEMISTRY

DR HAL SOSABOWSKI PRESENTS EXPERIMENTS YOU CAN DO ON YOUR OWN

IN THIS ISSUE: Separating colours of sweets using chromatography

Sweets such as M&M's, Smarties or Skittles contain dyes. In this experiment we will compare dyes used in sweets using the separation science of chromatography.

MATERIALS

You will need:

- M&M's, Smarties or Skittles (three of each colour);
- coffee filter paper and a tall glass;
- water and table salt;
- a pencil, a ruler and a pair of scissors;
- six toothpicks and aluminium foil;
- an empty two-litre bottle with cap.

METHOD

Do the experiment using different coloured sweets of one brand, *eg* Skittles. Cut the coffee filter paper into a 8 cm × 8 cm square. Draw a faint pencil line 1 cm from one edge. Make six equally spaced pencil dots along the line, leaving 0.5 cm between the first and last dots and the edges. Below the line, label each dot for the different colours of sweet (*eg* Y = yellow *etc*).

Next you must make solutions of each colour of Skittles. Lay a 20 cm × 10 cm piece of aluminium foil flat and put six evenly-spaced drops of water on the foil. Put one of each colour sweet on each drop of water. Wait about a minute for the colour to dissolve from the sweet into the water then remove it. Repeat using two more Skittles.

To 'spot' the colour extracts onto the filter paper, dampen the tip of a toothpick in one of the coloured solutions and lightly touch it onto the corresponding dot on the filter paper. Use a light touch so that the dot is less than 2 mm in diameter. Repeat using a different toothpick for each colour. After the spots have dried, repeat the process to get more colour on each spot. Do this three times, waiting for the spots to dry each time. When the paper is dry, fold it in half so that it stands up, with the fold at the top and the dots at the bottom.

Next make a 1 per cent salt developing solution. Rinse the two-litre bottle, and add to it 10 g (5 cm^3) of salt and one litre of water. Shake the bottle to dissolve the salt. Pour the salt solution into the tall glass to a depth of about 0.5 cm. Put the paper in the glass with the salt solution. The level of the solution should come below the dots on the paper.

The salt solution will start to climb the paper by capillary action. As the salt solution passes through the colour spots it picks up the dyes, which also start to climb the paper. Some colours will start to separate into different dye bands. The colours of some sweets are made of several dyes, which will start to separate as the bands move up the paper because some dyes stick more to the paper while other dyes are more soluble in the salt solution. These differences will lead to different colour dyes ending up at different heights on the paper.

The salt solution is the 'mobile phase', and the paper is the 'stationary phase'. A dye's preference for one phase over the other is described as its 'affinity' for a phase. The dyes that travel the furthest have more affinity for the salt solution. The dyes that travel the least have more affinity for the paper, being less soluble in the solution.

When the salt solution is 1 cm from the top edge, remove the paper from the solution. Lay the paper on a clean, flat surface to dry. Compare the spots from the different Skittles, noting which Skittles contain mixtures of dyes and which seem to have just one dye.

You can repeat the experiment with M&M's or Smarties to see if you get the same results for different sweets of the same colour. For example, do green Smarties give the same results as green Skittles?

HEALTH & SAFETY

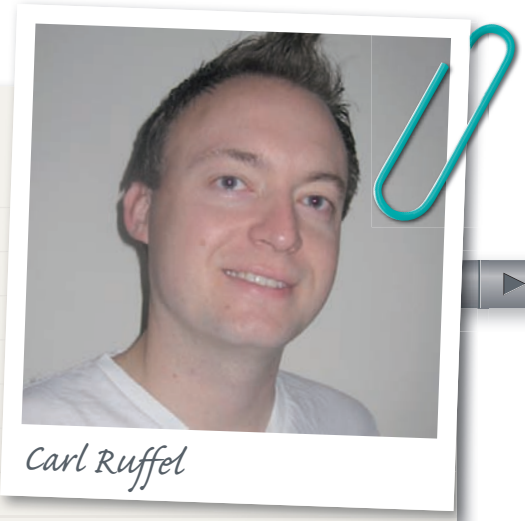
There are no particular hazards associated with this experiment.

Acknowledgment: *adapted by kind permission of Professor Bassam Z. Shakhashiri, University of Wisconsin–Madison, US.*

A DAY IN THE LIFE OF...

ANALYST:
Carl Ruffel

Carl has spent the past three years working as an analyst for the Medical Research Council. He talks to Nina Notman about his typical day.


Carl Ruffel

The Medical Research Council is a publicly-funded organisation that carries out research aimed at improving human health. Carl works in the human nutritional research unit, which looks into the relationship between what we eat and our health. He is part of a team that analyses markers of nutrition in human samples, and he specialises in vitamin analysis.

Detecting vitamins

Carl spends most of his day in the lab analysing blood plasma samples taken from people participating in nutritional surveys and intervention studies. He uses high-performance liquid chromatography (HPLC) to separate the components in blood plasma. Typically, Carl measures the levels of the fat-soluble vitamins (vitamins A and E) and up to six plant pigments (*eg* β-carotene – a precursor to vitamin A) in 25 to 30 samples a day.

Each day Carl makes up a series of known concentrations of solutions containing each of the vitamins he is measuring. To determine the precise concentration of each of these 'standard' solutions he uses ultraviolet–visible spectroscopy.

Next, Carl extracts the vitamins from the blood plasma samples. The first step is a protein precipitation, which denatures the blood proteins and releases vitamin A from the protein it is bound to. He then does an extraction between two solvents, where the proteins and other impurities stay in one solvent and the vitamins move into another. The solvent containing the vitamins is then evaporated to dryness and redissolved in another solvent that is suitable for use in HPLC analysis. Carl runs the vitamin samples and the standards side-by-side through the HPLC instrument. A third, quality control, sample is also analysed. This sample contains a known concentration of each vitamin.

Once the HPLC run is finished, Carl uses data from the standards to make a calibration curve from which the amount of each vitamin in each blood plasma sample is calculated. He also checks that the quality control sample has been analysed correctly, to ensure that the instrument is working properly. When he has all his results, they are used with dietary intake information to assess dietary health.

Surveying the national health

The blood samples analysed by Carl mainly come from people involved in nutritional surveys, who have been given dietary supplements, or who have been following special diets. Currently, Carl and his team are involved in the National Diet and Nutritional Survey, which is collecting data on the diet and nutritional status of the UK population. Commissioned by the Food Standards Agency, the survey involves taking blood samples from around 1000 adults and children each year. By assessing a cross section of the UK population Carl and his collaborators hope to gain a better understanding of what food makes us healthy and what doesn't.

Advancing technology

Carl particularly enjoys investigating ways to improve upon the technology and procedures he and his colleagues use in the lab. He is currently looking into replacing their HPLC instruments with liquid chromatography–mass spectrometers, which will help his team to improve the efficiency and accuracy of vitamin detection. ■

PATHWAY TO SUCCESS

- 2006–present, analyst, Medical Research Council, Cambridge
- 1997–2006, technician, forensic science and chemistry department, Anglia Ruskin University, Cambridge
- 1999–2002, BSc chemistry, Anglia Ruskin University (part-time)
- 1997–99, HNC chemistry, Anglia Ruskin University (part-time)
- 1995–97, biology, business studies and general studies A-levels, Hills Road Sixth Form College, Cambridge

£50 OF HMV TOKENS TO BE WON!

Benchtalk

ISSUE 118 SEPTEMBER 2009

PRIZE WORDSEARCH No. 47

Students are invited to find the 30 words/expressions associated with the changing atmosphere 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 eight-letter word. Please send your answers to the Editor at the usual address to arrive no later than Friday 9 October. First correct answer out of the editor's hat will receive a £20 HMV token.

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

AIR
AIR QUALITY
ATMOSPHERE
CARBON DIOXIDE
CARBON MONOXIDE
CLIMATE
DATA
FOSSIL FUELS
GAS PHASE RADICALS
GLOBAL WARMING
GREENHOUSE GASES
HUMIDITY
IODINE CHEMISTRY
LABORATORY STUDIES
METHANE
MOLECULAR DIOXYGEN
NITROGEN
OXIDISED
OXYGEN
OXYGEN ATOMS
OZONE
POLLUTION
SEAWEED BED
SHORT LIVED SPECIES
SUN
TRACE CONSTITUENTS
VAPOUR
WATER
WATER VAPOUR
WET

July PRIZE WORDSEARCH No. 46 winner

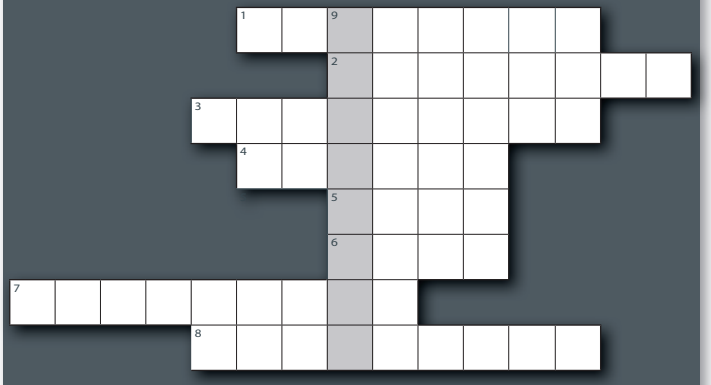
The winner was Matthew Pullen from Hertford.
The 12-letter word was EXPERIMENTAL.

FIND THE ELEMENT No. 10

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

ACROSS

1. Principal element in the atmosphere.
2. Gaseous element that is a reducing agent.
3. This reactive metal burns with a lilac flame.
4. Non-metal associated with volcanoes, and hell.
5. Soft and not very reactive metal, used to cover roofs.
6. This metal is produced in a blast furnace.
7. This metal is used in thermit reactions.
8. Alkaline earth metal with two electrons in the third shell of the atom.



If you have found the correct eight elements, in 9 down you will have generated the name of a poisonous heavy metal. This metal was used by the notorious poisoner Graham Young, and features in the Agatha Christie novel *The pale horse*. If ingested in trace amounts the element causes hair loss.

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 9 October. First out of the editor's hat to have correctly completed the grid will receive a £30 HMV token.

Find the element no. 9 solutions and winner

The winner was Laura Daubney from Toot Hill College, Nottingham.