BIONIC IONIC

LEGO BRICKS, CRISPS AND A BIT OF BLING – THEY ALL COME TOGETHER IN THIS SUPERB CHEMISTRY LESSON FROM DR JOANNA RHODES...

Ionic substances provide us with useful compounds that are both beautiful and functional. Ionic compounds are used in products from jewellery to batteries. They provide our bodies with essential electrolytes and they are essential for transmitting nerve impulses within the central nervous system. But how do we identify and make these compounds and explain their properties and uses?

WHY TEACH THIS?

In this lesson the aim is to help students appreciate the strong connection between chemistry and its importance within living systems covering ionic compounds, electrolysis, nerves and cells; topics which are usually separated into their respective subject specialism. Learners also explore social consequences, gaining an understanding of how electrochemical breathalysers for drug and alcohol testing and glucose sensors can protect and enrich lives. A novel application such as the heat of chilli peppers helps students to attempt relevant and interesting science in their own school laboratories – why not compete to see who can make the hottest curry?

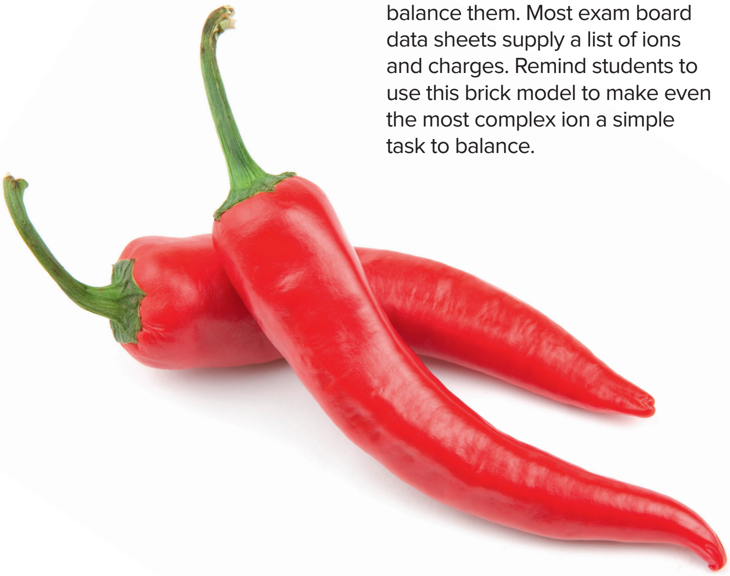
HOME LEARNING

Electrochemistry is a very broad and exciting field of research in chemistry. Students can apply their knowledge of electrode processes to understand other applications such as electroanalysis. Pioneering applications designed by the Compton Group in the Oxford University Chemistry department include electrochemical breathalysers for alcohol and drug detection and glucose sensors for diabetics [AR 7]. Students could begin by carrying out a web-quest to investigate these and other applications. My students have attempted the electrochemical determination of the heat of chilli peppers designed by the Compton Group [AR 8] on chilli peppers that they have grown themselves with great success!

STARTER ACTIVITY

Balancing act

Dot-cross diagrams of ionic compounds illustrate the transfer of electrons from the metal to the non-metal. A worksheet from the Royal Society of Chemistry will provide a quick reminder [Additional Resource 1]. A common difficulty for students is producing the formula of an ionic compound with the correct number of ions and charges. Lego brick ions are a useful strategy to help. I use different coloured bricks to represent metal cations or non-metal anions with red as the cation and blue as the anion. The number of bricks in the ion represents the charge and a sticky label on the brick tells the student the identity of the ion. To balance the formula students must end up with the same number of each colour of brick. Using this method they can work out for themselves that aluminium oxide must be Al2O3 because this is the only way to balance the Al3+ ion and the O2- ion so that you have the same number of red and blue bricks overall. To help students tackle complex cations and anions such as ammonium (NH4+) and sulfate (SO42-) use the same process with a single red brick representing ammonium and two blue bricks labelled with sulfate. Balancing (NH4)2SO4 then becomes a simple task of two red bricks to two blue. A common misconception that this avoids is for students to attempt to break apart these ions in order to balance them. Most exam board data sheets supply a list of ions and charges. Remind students to use this brick model to make even the most complex ion a simple task to balance.



MAIN ACTIVITIES

1. Salt and Vinegar or Ready Salted?

Students need to be able to describe different ways to prepare salts, and understanding the relationship between a salt and an acid is a good place to start. I use the term 'Salt and Vinegar' to represent using an acid to make a salt whereas 'Ready Salted' is used to describe making a salt from other salts using precipitation.

In the 'Salt and Vinegar' approach students first have to consider which acid they will need to make the salt of their choice. A nitrate will require nitric acid, a chloride will require hydrochloric acid and a sulfate will require sulfuric acid. Once students have decided which acid they need for their salt they need to decide the source of the metal ion. A rule of thumb is that if it is a group-one metal it is the metal hydroxide. If it is a group-two metal or transition metal it is from the metal oxide. Variants include use of a carbonate, which fizzes and produce carbon dioxide and use of the metal itself, which will bubble as it produces hydrogen.

Students should also be able to describe the experimental method used. This lends itself well to practical work. Students can perform a titration using hydrochloric acid and sodium hydroxide with indicator and then repeat the titration using the same volumes to produce sodium chloride solution, which can be evaporated if desired. When dealing with an insoluble base they should describe how to react an acid such as sulfuric acid with excess base such as copper oxide followed by filtration and evaporation to make copper sulfate crystals, this approach also works for carbonates which can be added to the acid until they stop fizzing.

In the 'Ready Salted' approach students need to be able to spot the use of two soluble salts to make an insoluble salt. Students should be on the lookout for the state symbols given in exam questions to identify the presence of soluble (aqueous) salts. Examples you can use to illustrate this include lead nitrate and potassium iodide to make lead iodide, a bright yellow solid and barium chloride and sodium sulfate

to make white barium sulfate. Students find it interesting to know that barium sulfate is so insoluble it can pass through the body without poisoning you even though soluble barium salts are toxic. This is harnessed in the use of barium sulfate in a barium meal that is ingested to show up soft tissue on an X-ray [AR 2].

As a follow up activity or homework ask students to work in teams to create a flowchart or a key based on yes/no questions to link the different methods of making salts.

2. Bling-Bling

Your students work for a start-up company called Bling-Bling, which custom electroplates copper and silver mobile phones. Bling-bling's clients are very fussy and students have to investigate a method for ensuring the same amount of metal is plated onto each mobile phone to ensure a perfect finish. In their preparatory work students should identify the appropriate independent variable, dependent variable and control variables. Their independent variable could either be time or voltage on the power supply and the dependent variable should be the mass of metal plated onto the electrode.

Suitable solutions for electroplating include copper sulfate solution and silver nitrate solution [AR 3]. Use a bulb in the circuit to demonstrate to students that dissolved ionic compounds conduct electricity due to the movement of charged ions through the solution.

After their electroplating exercise ask students to predict the products of electrolysis of a solution of sodium chloride. Using their knowledge of electrolysis it is likely that most will predict sodium and chlorine. Use a Hoffmann Voltameter to demonstrate that the products are in fact hydrogen gas and chlorine gas. Both are very useful gases extracted using electrolysis of seawater and then bottled and sold. If you do not have a gas voltameter one can be improvised using burettes as described in this Nuffield practical worksheet [AR 4] or get pupils hands on by investing in a class set of low cost mini gas voltammetry cells supplied with graphite electrodes and graduated test tubes [AR 5]. To challenge higher ability students ask them to use the reactivity series (including hydrogen) to predict which solutions will yield the metal and which will yield hydrogen gas.

A demonstration of the electrolysis of molten lead bromide [AR 6] to produce lead and bromine shows how ionic compounds cannot conduct when solid but do conduct when molten and the ions can move freely. Higher ability students should be encouraged to construct half equations for the processes taking place at the anode and the cathode in each of the three electrolysis experiments carried out during the lesson.

+KEY RESOURCE

The Royal Society of Chemistry's education website, Learn Chemistry, is a free, award-winning online platform of resources designed to enhance chemistry teaching and learning.

Through Learn Chemistry, you and your students can explore thousands of resource downloads, substance pages, articles and activities. These free-to-access teaching materials relate to everyday life and real-world challenges in areas such as pharmaceuticals; lifestyle; scarce natural resources; air quality; agricultural productivity; and energy. And resources are added and updated every month.

Created for use with pupils of varying levels of ability, the materials encourage students to approach challenges through problem solving and analytical thinking.

Royal Society of Chemistry, learn-chemistry@rsc.org, www.rsc.org/learn-chemistry

INFORMATION CORNER

ABOUT OUR EXPERT

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ADDITIONAL RESOURCES

[1] RICHARD DAWKINS TINYURL.COM/TSAPE1
[2] CLIP BIRDS ACTIVITY TINYURL.COM/TSAPE2
[3] BUILD-A-BEAST TINYURL.COM/TSAPE3
[4] NHM EVOLUTION – DOWNLOADABLE FROM THE APPLE APP STORE
[5] NATURAL HISTORY MUSEUM WEBSITE TINYURL.COM/TSAPE5
[6] BBC BANG GOES THE THEORY TINYURL.COM/TSAPE6
[7] CREATION MYTHS – NUFFIELD FOUNDATION TINYURL.COM/TSAPE7
[8] CHARLES DARWIN – CHRIST'S COLLEGE CAMBRIDGE TINYURL.COM/TSAPE8

SUMMARY

ARE YOU NERVOUS?

Transmission of nerve impulses across a synapse would not take place if electrolytes including Na+, K+ and Ca2+ ions were not present. To demonstrate the speed of the central nervous system ask the whole class to stand in a circle and join hands. While closing their eyes they 'pass' an impulse around the circle by squeezing the hand of the person standing next to them with the time for the 'impulse' to travel around the circle being measured. Dividing by the number of people in the class gives and average response time which can be improved by a few attempts. Students can then begin to appreciate how fast a reflex action is and how fast the electrochemical transmission of an impulse across the synapse must be.