# Chemistry PAG 2: Electrolysis

# Combined Science PAG C1: Electrolysis

# Suggested Activity 3: Some gas tests

## Instructions and answers for teachers and technicians

These instructions cover the learner activity section which can be found on [page 13](#_Learner_Activity). This Practical activity supports OCR GCSE Chemistry and Combined Science.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

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| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/), [SSERC](http://www.sserc.org.uk/)and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this activity, learners can produce a variety of gases using ‘kitchen chemistry’. Carrying out practical work in this manner can help facilitate discussions about the role of chemistry in our everyday life, from cooking to cleaning to health-care. The suggested equipment and methods can be adapted to use standard laboratory equipment.

This activity can be modified to reduce the number of observations the learners are making, allowing them to focus on less chemistry at with greater depth. For example, Method 1 and 2 are stand alone. The red cabbage indicator can be tested with standard laboratory reagents such as 0.1 mol dm–3 sodium hydroxide and/or hydrochloric acid. Method 4 could be carried out using universal indicator solution rather than the red cabbage solution.

Further activities to do with cabbage indicators can be found at <http://www.rsc.org/learn-chemistry/resource/res00001214/outreach-red-cabbage-ph-indicator>.

### Aims

To carry out ‘kitchen chemistry’ preparations of oxygen, carbon dioxide and chlorine, and to analyse the products formed.

### Intended class time

30–45 minutes

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Chemistry**](http://www.ocr.org.uk/Images/323481-gcse-chemistry-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

By doing this experiment, learners have an opportunity to develop the following skills:

**6** [*11*]: Safe use and careful handling of gases, liquids and solids, including: i) careful mixing of reagents under controlled conditions; ii) using appropriate apparatus to explore chemical changes and/or products

**7** [*12*]: Use of appropriate apparatus and techniques to: i) draw electrochemical cells for separation and production of elements and compounds; ii) set up and use electrochemical cells for separation and production of elements and compounds

**8**: Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including: i) gas tests

### Links to Specifications:

### Gateway Science (Suite A) – including Working Scientifically (WS)

C3.3f recall that carbonates and some metals react with acids and write balanced equations predicting products from given reactants

C3.4a recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

C3.4d describe electrolysis in terms of the ions present and reactions at the electrodes

C3.4e describe the technique of electrolysis using inter and non-inert electrodes

C4.1a recall the simple properties of Groups 1, 7 and 0

C4.2a describe tests to identify selected gases

W1.3a presenting observations and other data using appropriate methods

W1.3e interpreting observations and other data

W1.3f presenting reasoned explanations

W1.4a use scientific vocabulary, terminology and definitions

WS2a carry out experiments

WS2b make and record observations and measurements using a range of apparatus and methods

WS2c presenting observations using appropriate methods

### Twenty First Century Science (Suite B) – including Ideas about Science (IaS)

C1.4.2 describe a test to identify chlorine (using blue litmus paper)

C2.2.6 recall the simple properties of Group 7 elements including their states and colours at room temperature and pressure, their colours as gases, their reactions with Group 1 elements and their displacement reactions with other metal halides

C2.2.7 describe experiments to identify the reactivity pattern of Group 7 elements including displacement reactions

C3.2.5 explain why electrolysis is used to extract some metals from their ores

C3.3.1 describe electrolysis in terms of the ions present and reactions at the electrodes

C3.3.3 recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

C3.3.4 use the names and symbols of common elements and compounds and the principle of conversation of mass to write half equations

C3.3.5 explain reduction and oxidation in terms of gain or loss of electrons, identifying which species is oxidised and which are reduced

C3.3.8 describe the technique of electrolysis of an aqueous solution of a salt

C6.1.1 recall that acids react with some metals and with carbonates and write equations predicting products from given reactants

IaS2.1 present observations and other data using appropriate formats

IaS2.11 in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions

### Mathematical Skills covered

No defined mathematical skill is covered in this experiment.

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| Technical Requirements – PER GROUPChemicals  | **Identity** | **Approximate quantity required or produced PER GROUP** | **Hazard information** | | **Risk information** | | --- | --- | --- | --- | --- | | sodium chloride (table salt), NaC*l*(s) | c. 2 g | Not classified as hazardous | |  | | calcium carbonate (indigestion tablets), CaCO3(s) | c. 1 g | Not classified as hazardous | |  | | 0.8 mol dm–3 ethanoic acid (white vinegar)  CH3COOH(aq) | c. 10 cm3 | Currently not classified as hazardous at this concentration. | |  | | pieces of liver (e.g. calf) | c. 2 g | Not classified as hazardous | | Ensure hands are thoroughly washed after use. | | 3% (w/w) hydrogen peroxide solution (contact lens cleaner), H2O2(aq) | c. 5 cm3 | Not classified as hazardous | |  | | saturated calcium hydroxide solution (limewater), Ca(OH)2(aq) | c. 10 cm3 | Currently not classified as hazardous – however treat as an irritant (skin, eye) | | Eye protection should be worn. | |  |  |  |  |  | | hydrogen gas, H2(g) **PRODUCED** | c. 5 cm3 |  | DANGER: Extremely flammable. | Wear eye protection. Ensure laboratory is well ventilated. Ensure there are no naked flames in close proximity to electrolysis apparatus. | | chlorine gas, C*l*2(g) **PRODUCED** | c. 5 cm3 | HSE toxic warning symbol | DANGER  May cause or intensity fire; oxidiser. Causes skin irritation. Causes serious eye irritation. Toxic if inhaled. May cause respiratory irritation. Very toxic to aquatic organisms. | Work in a well-ventilated laboratory. Remind learners NOT to sniff the gas.  Ensure the electrolysis is **turned off** as after the 1–2 minutes – this will minimise release of chlorine into the laboratory. Be particularly aware of class members with respiratory problems. | | sodium hydroxide solution, NaOH(aq) **PRODUCED** | c. 20 cm3 at <0.1 mol dm–3 | Currently not classified as hazardous at this concentration | |  |  Equipment 3 × 30 cm3 plastic ‘shot glasses’  3 × polystyrene cup  teaspoon  grater  sieve  access to a kettle  2 × pencils  pencil sharpener  splints and lighter  9V battery  2 × wire with crocodile clips on either end  washing up liquid  red cabbage |

### Notes

Check the ingredients of the indigestion tablet carefully ensuring it contains calcium carbonate.

f regular laboratory equipment is available, red cabbage indicator can be made following this activity: <http://www.rsc.org/learn-chemistry/resource/res00000422/making-a-ph-indicator>. Alternatively, grate red cabbage can be soaked in just boiled water in a cup for a few minutes, then filtered through a sieve.

Limewater can be made up using CLEAPSS Recipe 20 (<http://www.cleapss.org.uk/attachments/article/0/RBPrint.pdf>). Small quantities could be made up by shaking a small amount of hydrated (builder’s) lime in a sealed jar of water and allowing to settle. **Suitable risk assessment should be carried out and personal protective equipment used when handling the solid (DANGER: Corrosive and irritant).**

The reaction between the contact lens solution and liver can be quite slow – if available, a demonstration of the reaction with laboratory grade hydrogen peroxide and a catalyst such as manganese dioxide can be used: <http://www.rsc.org/learn-chemistry/resource/download/res00002144/cmp00002415/pdf>

While aimed at teachers of primary school children, the ‘G5p Using chemicals safely’ document from CLEAPSS includes a range of useful information for carrying out practical work with commonly available materials around the home: <http://www.cleapss.org.uk/attachments/article/0/G5p.pdf?Primary/Resources/Guides/?New%20teachers/>

Release of chlorine can be minimised using a cardboard lid over the cup, which the pencil electrodes can be pushed through.

### Health and Safety

Learners should wear eye protection during all practical work.

Ensure the room/laboratory is well ventilated, especially during the electrolysis reaction.

Ensure learners wash their hands thoroughly after all practical work.

### Method

This activity is intended to be used by those with limited access to a regular secondary school laboratory, perhaps those in an alternative provision school. Should regular equipment/reagents be available they could be used.

Learners will produce oxygen by the catalytic decomposition of hydrogen peroxide, then test with a glowing splint. They will produce carbon dioxide by the decomposition of calcium carbonate with acid, then test with lime water. They will produce a pH indicator from red cabbage, electrolyse brine solution and test for chlorine gas and sodium hydroxide solution.

### Images from trials

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| --- | --- |
| STAGE 1: Decomposition of hydrogen peroxide. The washing up liquid helps trap the oxygen in bubbles which can relight a glowing splint STAGE 1: Decomposition of hydrogen peroxide. The washing up liquid helps trap the oxygen in bubbles which can relight a glowing splint | STAGE 2: Effervescence of carbon dioxide in the left hand tube – the dense CO2 spills over into the limewater (right hand tube) causing the precipitation of CaCO3  STAGE 2: Effervescence of carbon dioxide in the left hand tube – the dense CO2 spills over into the limewater (right hand tube) causing the precipitation of CaCO3 |
| STAGE 3: Red cabbage contains anthrocyanins which change colour in acid and alkali solutions  STAGE 3: Red cabbage contains anthrocyanins which change colour in acid and alkali solutions. | STAGE 4: Electrolysis of salt water with a 9V battery and two pencils  STAGE 4: Electrolysis of salt water with a 9V battery and two pencils |

### Analysis of results – trial results

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| **Test carried out** | **Observation** |
| glowing splint in oxygen bubbles | the splint relights |
| carbon dioxide into lime water | a white precipitate forms |
| boiling red cabbage | a blue/green solution forms |
| passing current through brine – positive electrode | bubbles form |
| passing current through brine – negative electrode | bubbles form |
| damp blue litmus paper near positive electrode | paper turns briefly pink/red then white |
| red cabbage indicator in remaining brine solution | solution turns paler green |

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| **1.** | For a flame to form you need the three components of the fire triangle, fuel, heat and oxygen. Describe and explain the evidence you have for the production of oxygen gas. **[3 marks]** |  |
|  | The glowing splint provides the heat and fuel for the fire ✓. As the splint relights ✓, indicating the bubbles contain concentrated oxygen ✓. | |
|  |  | |
| **2.** | Carbon dioxide forms an insoluble substance in limewater. Describe and explain the evidence you have for the production of carbon dioxide. **[3 marks]** |  |
|  | A white precipitate ✓ forms when the gas produced in the indigestion tables/vinegar shot glass spills into the lime water solution ✓, indicating the gas contains carbon dioxide ✓. | |
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| **3.** | Chlorine is an acidic gas. Describe and explain the evidence you have for the production of chlorine gas **[3 marks]** |  |
|  | Chlorine gas dissolves in to the water forming hydrochloric acid and a chlorate bleach ✓. Blue litmus paper tests turns red in the presence of acids ✓, and turns white in the presence of a bleach ✓. | |

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| **4.** | Sodium hydroxide forms an alkaline solution. Describe and explain the evidence you have for the production of sodium hydroxide **[2 marks]** |  |
|  | The remaining solution after the electrolysis of brine turned the red cabbage indicator blue/green ✓, indicating an alkaline solution ✓. | |
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### Extension opportunities

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| **1.** | Write a word and symbol equation for the different reactions that have occurred:  **[14 marks]** |  |
|  | * 1. catalytic decomposition of hydrogen peroxide (H2O2)   hydrogen peroxide → hydrogen + water ✓  2H2O2(aq) → O2(g) + 2H2O(l) ✓   * 1. combustion of the splint (assume wood has the formula C6H12O6)   wood + oxygen → carbon dioxide + water ✓  C6H12O6(s) + 6O2(g) → 6CO2(g) + 6H2O(g) ✓   * 1. carbon dioxide in lime water   carbon dioxide + calcium hydroxide → calcium carbonate + water ✓  CO2(g) + Ca(OH)2(aq) → CaCO3(s) + H2O(l) ✓   * 1. Half equation at the positive electrode (anode)   chloride ions → chlorine + electrons ✓  2C*l*–(aq) → C*l*2(g) + 2e– ✓   * 1. Half equation at the negative electrode (cathode)   2H+(aq) + 2e– → H2(g) ✓  hydrogen ions → hydrogen + electrons ✓   * 1. Full redox equation in the sodium chloride solution   chloride ions + hydrogen ions → chlorine + hydrogen ✓  2H+(aq) + 2C*l*–(aq) → H2(g) + C*l*2(g) ✓   * 1. Squeaky pop test in the hydrogen tube   hydrogen + oxygen → water ✓  2H2(g) + O2(g) → 2H2O(g) ✓ | |

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| **2.** | Identify which of the two half equations is a reduction and which an oxidation. Explain what these terms mean. **[4 marks]** |  |
|  | Reduction: The reaction at the cathode (negative electrode) is a reduction reaction, i.e. gain of electrons by the species reacting.  Oxidation: The reaction at the anode (positive electrode) is an oxidation reaction, i.e. loss of electrons by the species reacting. | |

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| **3.** | Draw a diagram showing the electrochemical cell you used in Stage 4 **[3 marks]** |  |
|  | Diagram showing the electrochemical cell you used in Stage 4  Battery correctly shown ✓, two electrodes shown ✓ electrolyte solution shown ✓ | |

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| **4.** | Research the uses of the product of electrolysis of sodium chloride solution. Give at least two examples for each product and make sure say where you found the information. Try to use at least one offline (text book / encyclopaedia) and one online (web page) source. |  |

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| Product | Use | Source |
| sodium hydroxide | cleaning product  making soap | <https://hpd.nlm.nih.gov/cgi-bin/household/search?tbl=TblChemicals&queryx=1310-73-2>, accessed on 26/04/2016  Modern Organic Chemistry by ROC Norman and DJ Waddington, (Mills and Boon , 1972) |
| chlorine | making bleaches  making plastics | <https://en.wikipedia.org/wiki/Bleach>, accessed on 26/4/2016  Chemistry in Context, Graham Hill and John Holman (Nelson Thornes Ltd, 2000) |
| hydrogen | rocket fuel  making margarine | <http://www.nasa.gov/topics/technology/> hydrogen/hydrogen\_fuel\_of\_choice.html , accessed on 26/04/2016  Essential Science for GCSE, Susanne Lakin and John Patefield (Nelson Thornes, 1998) |

### Document updates

v0.1 May 2016 Original – published on the OCR community

v1.1 February 2017 Consolidated labelling and formatting of activities

v1.2 June 2017 Updated hazard and risk assessments

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If you are looking for examination practice materials, you can find Sample Assessment Materials (SAMs) on the qualification webpages: [here](http://www.ocr.org.uk/qualifications/by-type/gcse/chemistry/)

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# Chemistry PAG 2: Electrolysis

# Combined Science PAG C1: Electrolysis

# Suggested Activity 3: Some gas tests

## Learner Activity

### Introduction

Some simple gas substances can be produced relatively easily, and their indicative tests carried out. In this experiment, you will synthesis chlorine, oxygen and carbon dioxide and carry out the tests.

Contact lens solution, which contains hydrogen peroxide solution, can be decomposed with liver and the **oxygen** gas collected in washing up liquid bubbles. The gas can be tested with a glowing splint which will relight in the presence of oxygen.

Indigestion tablets contain calcium carbonate, which can be decomposed with vinegar, which contains acetic acid, to produce gaseous **carbon dioxide**. Lime water, which is saturated calcium hydroxide solution, will turn cloudy in the presence of carbon dioxide.

Brine, which contains sodium chloride in solution, can be electrolysed using a 9 V battery and two pencils as electrodes, producing **hydrogen** and **chlorine** gas. The chlorine can be tested with damp blue litmus paper, and the resultant alkaline solution, containing sodium hydroxide, can be tested with red cabbage indicator.

### Aims

To make chlorine, oxygen and carbon dioxide gases and carry out simple tests on them.

### Intended class time

30-45 minutes

### Chemicals and equipment (per group)

3 × 30 cm3 plastic ‘shot glasses’

3 × polystyrene cup

teaspoon

grater

sieve

access to a kettle

2 × pencils

pencil sharpener

splints and lighter

9V battery

2 × wire with crocodile clips on either end

washing up liquid

red cabbage

table salt (sodium chloride)

indigestion tablets (contains calcium carbonate)

vinegar (contains ethanoic acid)

calf liver (contains catalase)

contact lens cleaning solution (contains hydrogen peroxide;

limewater (irritant to skin and eyes)

blue litmus paper

### Health and Safety

Learners should wear eye protection during all practical work.

Ensure the room/laboratory is well ventilated, especially during the electrolysis reaction.

Ensure learners wash their hands thoroughly after all practical work.

### Method

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| **Method 1 – Making a testing oxygen**   1. About one-third fill a plastic shot glass with the contact lens / hydrogen peroxide solution. 2. Add 1-2 drops of washing up liquid and stir thoroughly with a splint. 3. Add the piece of liver to the liquid.   **👓*You should observe bubbles forming from the liver surface and being trapped in bubbles.***   1. Light a splint, allow to burn for 10 seconds, then blow it out.   **👓*Ensure the end of the splint is still glowing red*.**   1. Place the glowing red end of the splint in the oxygen bubbles.   **👓*The splint should relight***. | Method 1 – Making a testing oxygen |
| **Method 2 – Making and testing carbon dioxide**   1. Half fill one shot glass with lime water. 2. Half fill a second shot glass with vinegar. 3. Add two indigestion tablets to the vinegar.   **👓*You should see the tablets fizzing****.*   1. Tip the tablet/vinegar shot glass to about 45° and hold the top close to the top of the lime water glass. ***The carbon dioxide formed as the tablet reacts with the vinegar is denser than air so ‘spills’ out of one glass into the other.*** 2. Gently swirl the lime water shot glass.   **👓*You should observe white precipitate forming due to the reaction of carbon dioxide with the limewater.*** | Method 2 – Making and testing carbon dioxide |

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| **Method 3 – Making the red cabbage indicator**   1. Grate about a quarter of a red cabbage into a cup. 2. Fill to cup with just boiled water to the level of the top of cabbage, and leave for 30 minutes. 3. Pour the liquid through a sieve into another cup.   **👓*You should have a purple solution.*** | Method 3 – Making the red cabbage indicator |
| **Method 4 – Making and testing chlorine**   1. One quarter fill a polystyrene cup with tap water. 2. Add half a teaspoon of table salt to the water and mix thoroughly until completely dissolved.   ***You have made brine solution.***   1. Sharpen both ends of two pencils – these are your electrodes. 2. Place both pencils into your brine solution. 3. Use one wire with crocodile clips to connect the top end of one pencil to the positive terminal on the 9 V battery. ***This is your anode.*** 4. Use the other wire to connect the other pencil to the negative terminal of the battery. ***This is your cathode.***   **👓*You should now observe bubbles forming at two pencil leads in the solution.***   1. Dampen a piece of blue litmus paper, and hold close to the bubbles forming at the anode (positive electrode).   **👓*Write down your observations****.*   1. Allow electrolysis to run for about 1-2 minutes, then remove the pencils from the cup and disconnect from the battery. 2. Pour about half your cabbage indicator into the solution   **👓*You should observe a change in colour of the indicator from purple to blue.*** | Method 4 – Making and testing chlorine |

### Analysis of results

You can draw your own table, or use the one below:

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| --- | --- |
| **Test carried out** | **Observation** |
| glowing splint in oxygen bubbles |  |
| carbon dioxide into lime water |  |
| boiling red cabbage |  |
| passing current through brine – positive electrode |  |
| passing current through brine – negative electrode |  |
| damp blue litmus paper near positive electrode |  |
| red cabbage indicator in remaining brine solution |  |

Your ability to analyse your observations may depend on how much of the GCSE Chemistry/Combined Science course you have studied. Your teacher will let you know which questions you should focus on:

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| **1.** | For a flame to form you need the three components of the fire triangle, fuel, heat and oxygen. Describe and explain the evidence you have for the production of oxygen gas. **[3 marks]** |  |
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|  |  |  |
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| **2.** | Carbon dioxide forms an insoluble substance in limewater. Describe and explain the evidence you have for the production of carbon dioxide. **[3 marks]** |  |
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| **3.** | Draw a diagram showing the electrochemical cell you used in Stage 4. **[3 marks]** |  |
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| **4.** | Chlorine is an acidic gas. Describe and explain the evidence you have for the production of chlorine gas. **[3 marks]** |  |
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| **4.** | Sodium hydroxide forms an alkaline solution. Describe and explain the evidence you have for the production of chlorine gas. **[2 marks]** |  |
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### Extension Opportunities

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| **1.** | Write a word and symbol equation for the different reactions that have occurred:  **[14 marks]** |  |
|  | 1. catalytic decomposition of hydrogen peroxide (H2O2) 2. combustion of the splint (assume wood has the formula C6H12O6) 3. carbon dioxide in lime water 4. Half equation at the positive electrode (anode) 5. Half equation at the negative electrode (cathode) 6. Full redox equation in the sodium chloride solution 7. Squeaky pop test in the hydrogen tube | |

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| **2.** | Identify which of the two half equations is a reduction and which an oxidation. Explain what these terms mean. **[4 marks]** |  |
|  | Reduction:  Oxidation: | |

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| **3.** | Research the uses of the product of electrolysis of sodium chloride solution. Give at least two examples for each product and make sure say where you found the information. Try to use at least one offline (text book / encyclopedia) and one online (web page) source. |  |
|  |  | |

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Chemistry**](http://www.ocr.org.uk/Images/323481-gcse-chemistry-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chemistry** | | | |  | ***Combined Science*** | | | |
| 6–i | 6–ii | 7–i | 7–ii |  | *11–i* | *11–ii* | *12–i* | *12–ii* |
| 8–i |  |  |  |  |  |  |  |  |