5.1 Some chemical changes

At the end of this activity students will be able to:

- describe a range of observable changes that occur during chemical reactions.

What ideas might your students already have?

Because the range of chemical reactions is so vast students have difficulty recognising any common theme. This is dependent on some level of understanding of what is happening at the molecular level.

Key vocabulary:

Chemical change

Equipment list

Each GROUP will require:

Test 1: Limewater test • test tube • drinking straw • lime water • test-tube rack	**Test 2: Burning magnesium ribbon (Teacher demonstration)** • magnesium ribbon • metal tongs • Bunsen burner • Evaporating basin • safety mat	**Test 3: Starch test** • test tube • starch in a dropper bottle • iodine in a dropper bottle • test-tube rack
Test 4: Steel wool and copper sulfate • test tube • copper sulfate solution • small piece of steel wool • test-tube rack	**Test 5: Precipitation of lead iodide** • small reagent bottle of 0.1 M potassium idode. • Dropper bottle with 0.01 M lead II iodide • Large test tube and test tube rack.	

Each STUDENT will require:

- *Science by Doing* ***Notebook***

Things to consider and hints for success

It is easiest to give each group a complete set of equipment to reduce movement around the room and to ensure students can find all they need. The burning of magnesium ribbon is indicated as a teacher demonstration, and is obviously clearly visible. There may be some variation between different jurisdictions as to whether Year 8 students are permitted to carry this out themselves. Traditionally all students experienced this activity but more recent guidelines may have added more restrictions. If carried out as a teacher demonstration it is still important for students to observe the white ash product so that they can easily observe that a new substance has been created.

Understanding 'chemical change' as a unified concept requires consideration at the particle level. It is worth discussing the actual chemical rearrangements that have taken place with the class, either through word equations or balanced equations as appropriate. Each of the reactions is provided below. While balancing chemical equations is not part of this activity, students can still benefit from seeing the chemical equations and noting that the number of atoms before and after are the same, and that chemical reactions involve a rearrangement of the atoms.

According to Science Assist guidelines students are allowed to handle lead nitrate solution at levels below 0.5 M. However, make sure that students do not touch the tubes at the end or attempt to wash out the solutions or lead iodide precipitate themselves. This should be included in the *Risk Assessment* for this activity.

Teacher content information

Test 1

Carbon dioxide passed into limewater gives a milky precipitate as calcium carbonate is formed

$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

Test 2

Magnesium burnt in air produces a white ash. It is a highly exothermic reaction.

$2Mg + O_2 \rightarrow 2MgO$

Test 3

When starch is mixed with iodine in water (or a potassium iodide solution), an intensely coloured starch/iodine complex is formed. This reaction is not fully understood. Somehow the iodine ions get stuck in the some of the coiled sections of the starch molecules. It is probably somewhat academic as to whether this is a chemical or a physical change, depending on how the iodine is actually bonded to the starch, but it is a clearly observable, and commonly used, reaction.

Test 4

This is a displacement reaction, where the copper comes out of solution and displaces the iron. Because the iron sulfate is not very soluble are rusty coloured precipitate might be observed.

$CuSO_4(aq) + Fe \rightarrow FeSO_4(s) + Cu(s)$

Test 5

This is a straight precipitation reaction, producing the colourful (yellow) lead iodide precipitate. It is worth pointing out to students that lead salts used to be commonly used in paints, but were toxic.

$Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$

Lesson plan

Step 1: Explain to students that they will perform a series of tests involving chemical reactions and will record their observations in their Notebooks. They should first copy the table in the **Student Guide** into their ***Notebooks***.

Step 2: Groups conduct each test and record observations. Show Test 2 to the class.

Step 3: When testing is completed, students will answer the discussion questions in their Notebooks, and share their observations with the rest of the class. They may like to include the chemical reactions in their Notebooks.

5.2 Observing reactions

At the end of this activity students will be able to:

- describe a range of observations that provide evidence for chemical changes.

What ideas might your students already have?

Students know that a new substance is formed but the range of observations that might indicate this are so varied that they will still be confused about the unified concept of 'chemical change'.

A 'chemist's' view is likely to revolve around an understanding of molecular rearrangements and bonding and the latter is beyond the scope of this unit.

Key vocabulary:

Precipitate, reaction

Equipment list

Each GROUP will require:

Test 1	Test 2	Test 3
• 250 mL beaker • copper strip • zinc strip • copper sulfate solution • 2 electric leads with alligator clips • LED (light emitting diode)	• test tube • hydrochloric acid in a dropper bottle • small piece of magnesium ribbon	• test tube • dropper bottle of lead nitrate • dropper bottle of potassium iodide

Test 4	Test 5
• test tube • vinegar in a dropper bottle • sodium hydrogen carbonate • popstick	• test tube • copper sulfate solution • sodium hydroxide solution

Each STUDENT will require:

- *Science by Doing* ***Notebook***
- safety glasses

Things to consider and hints for success

It is easiest to give each group a complete set of equipment to reduce movement around the room and to ensure students can find all they need.

Teacher content information

Evidence for chemical changes:

1. produces electricity (**Test 1**)
2. produces a gas (**Test 2**)
3. produces a colour change (**Test 3**)
4. produces a change in temperature (**Test 4** – exothermic)
5. produces a precipitate (**Tests 5** and **3**)

Lesson Plan

Step 1: Explain students will conduct a series of tests and record their observations. They should first copy the table in the *Student Guide* into their ***Notebooks***.

Step 2: Groups conduct the tests and record their observations

Step 3: Discuss students' observations for each test and identify the evidence demonstrated. Students record evidence in their ***Notebooks***.

Discussion

How can you tell if a chemical change has taken place?

5.3 Reactants and products

At the end of this activity students will be able to:

- identify the reactants and products in a chemical reaction
- write the word equations for chemical reactions.

What ideas might your students already have?

Students may have been introduced to word equations for chemical reactions in earlier activities. They may not have extended this thinking in terms of reactants and products; i.e. a before and after point of view.

Key vocabulary:

Reactant, product

Equipment list

Each GROUP will require:

Pop test: • test tube • hydrochloric acid in a dropper bottle • small piece of magnesium ribbon • matches		
Test 1 • test tube • hydrochloric acid in a dropper bottle • calcium carbonate	**Test 2** • test tube • hydrochloric acid in a dropper bottle • granulated zinc	**Test 3** • test tube • cobalt chloride solution in a dropper bottle • sodium carbonate solution in a dropper bottle

Each STUDENT will require:

- *Science by Doing* ***Notebook***

Things to consider and hints for success

It is easiest to give each group a complete set of equipment to reduce movement around the room and to ensure students can find all they need.

Teacher content information

Pop test

magnesium (s) + hydrochloric acid (aq) → magnesium chloride (aq) + hydrogen (g)

Test 1

calcium carbonate (s) + hydrochloric acid (aq) → calcium chloride (aq) + water (l) + carbon dioxide (g)

Test 2

zinc (s) + hydrochloric acid (aq) → zinc chloride (aq) + hydrogen (g)

Test 3

Cobalt chloride (aq) + sodium carbonate (l) → sodium chloride (aq) + cobalt carbonate (s)

Lesson Plan

Step 1: Students read the information at the beginning of the activity, conduct the first experiment and complete the discussion questions.

Step 2: Discuss students' answers to ensure they have the correct understanding of products and reactants.

Step 3: Students complete the remaining three tests and discussion questions.

Step 4: Students share results with the class.

5.4 Some natural reactions

At the end of this activity students will be able to:

- identify some naturally occurring reactions.
- explain why photosynthesis is one of the most significant chemical reactions.

What ideas might your students already have?

Students will be aware of photosynthesis through previous units in biology, but may not appreciate its chemical nature, or its importance.

Key vocabulary:

Photosynthesis

Equipment list

Each GROUP will require:

- access to **Student Digital**

Each STUDENT will require:

- *Science by Doing* ***Notebook***

Things to consider and hints for success

To ensure students are on track, you could discuss their responses after each ***Notebooking*** task, rather than at the end of the activity. If they work in ***Learning Partners*** when using the *Student Digital*, you could ask one partner to work on the first ***Notebooking*** task (photosynthesis) and the other to work on the second (corrosion). Alternatively, half the class could complete the first task and the other half, the second. They then share responses.

Teacher content information

Oxygen is highly reactive and cannot survive long in the atmosphere without reacting with other chemicals. Its presence in the Earth's atmosphere is totally dependent on its replacement through photosynthesis, a highly energy demanding reaction powered by light. All the oxygen currently in the atmosphere came from photosynthesis. Astronomers believe that if oxygen is ever detected in the atmosphere of another planet, probably through spectral analysis, it will provide strong evidence for the existence of life on that planet.

Lesson Plan

Step 1: Explain students will investigate some natural chemical reactions.

Step 2: Students work through the activity, completing all questions in their ***Notebooks***.

Step 3: Discuss student responses as a class.

5.5 Investigating some useful reactions

At the end of this activity students will be able to:

- give an example of a useful reaction and describe the properties that make it so.

Key vocabulary:

Synthetic, plastic.

Equipment list

Each GROUP will require:

Investigation 1:	**Investigation 2:**	**Investigation 3:**
• 10 mL of latex • 10 mL syringe • 100 mL beaker • glass stirring rod • Pasteur pipette • 2M hydrochloric acid • metre rule	• 50 mL of milk • 10 mL vinegar • 10mL measuring cylinder • 50 mL measuring cylinder • 250 mL beaker • thermometer • water bath set to 50-70 °C • glass dropper • stirring rod • filter funnel • filter-funnel stand • coffee-filter paper • paper towel	• two 250 mL beakers • 2 teaspoons • stirring rod • filter funnel • filter-funnel stand • coffee-filter paper • 2 tablespoons powdered non-fat milk • 20 mL vinegar • sodium hydrogen carbonate • set of measuring spoons • measuring cup • hot water • 2 small pieces of paper • 2 wooden pop sticks

Each STUDENT will require:

- *Science by Doing* ***Notebook***
- safety glasses

Things to consider and hints for success

Students can do one or more investigations. They could compete to see whose rubber ball bounces the highest or test the ball in **Investigation 1** against the ball in **Investigation 2**. It is easiest to give each group a complete set of equipment for each investigation, to reduce movement around the room and ensure students can find all they need. Students could first complete a *Risk Assessment*.

Teacher content information

Whether or not sublimation occurs depends on a substance's triple point, the conditions of temperature and pressure at which the substance can coexist as solid, liquid and gas. Interestingly under very low pressure, for example, in outer space water ice will also sublime rather than melt.

Lesson Plan

Step 1: Students complete each investigation and answer discussion questions in their ***Notebooks***.

Step 2: Students complete the *Digital activity* and the related ***Notebook*** exercise.

Step 3: Share student responses with the class.

5.6 A rusty problem

At the end of this activity students will be able to:

- define rust and what causes it.

What ideas might your students already have?

Students will be aware of rust in some contexts but will not be aware of its chemical nature.

Key vocabulary:

Rust

Equipment list

Each GROUP will require:

- 4 test tubes
- 1 stopper to fit test tube
- test-tube rack
- calcium chloride
- 4 small pieces of steel wool
- boiled water
- vegetable oil

Each STUDENT will require:

- *Science by Doing* ***Notebook***
- safety glasses

Things to consider and hints for success

Students could use thumbs up/thumbs down to indicate their predictions e.g. '*Do you agree with Katie?*'

Group members may disagree.

It is easiest to give each group a full set of equipment, to reduce movement around the room and ensure all students find what they need. Students could first complete a *Risk Assessment*.

This experiment must be observed and results recorded over four or five days. It should start early in the week, with observations made each lesson. Meanwhile, students can move on to the investigation of the effect of salt on rusting.

Teacher content information

Rusting involves the oxidation of iron (Fe). The products are generally some form or hydrated iron oxide ($Fe_2O_3.nH_2O$) and hydroxides of iron III. Hence rusting occurs most vigorously in environments rich in oxygen and water, which acts as a catalyst. The presence of salt (NaCl) can speed up the process of rusting as it enhances the electrochemical reactions taking place.

As rust is produced it tends to expand, possibly causing severe damage to the surrounding structures, and forms a flaky and friable layer. Unlike what happens when several other metals corrode (including copper, zinc and aluminium) the surface layer of rust does not tend to protect the underlying layers, so that rusting can continue until the whole iron structure totally disintegrates.

Lesson Plan

Step 1: Ask: '*Where have you seen rust?*' Students record answers in their ***Notebooks*** or you can write them on the board.

Step 2: Ask students to consider a selection of rusty objects (if available) and the images in their *Student Guide*. Ask what they have in common.

Step 3: Ask students to consider what causes rust. A list of suggestions may be used to prompt ideas and discussion.

Step 4: Explain that students will conduct an investigation to identify what causes rusting and to test their predictions.

Step 5: Groups conduct the investigation, record their observations and answer the discussion questions.

Step 6: Students compare their results to those of Katie, Joshua, Olivia and Iggy, and complete the discussion questions.

Step 7: Discuss students' results and the cause of rust. Ask them to complete the question at the end of the activity.

Step 8: Students plan and conduct their experiment to test how salt affects the rusting reaction.

Follow up:

Students could investigate rusting in steel wool by varying its exposure to air and water.

5.7 Preventing rust

At the end of this activity students will be able to:

- describe some methods of preventing corrosion of iron.

What ideas might your students already have?

Students will be aware, from **Activity 5.2**, that electricity can be involved in chemical reactions.

Key vocabulary:

Corrosion, control, sacrificial anode.

Equipment list

Each GROUP will require:

- 6 test tubes
- test-tube rack
- salt solution
- 4 iron nails
- 1 nail painted with rust-proof paint
- 1 galvanised nail
- vaseline
- copper wire
- magnesium ribbon

Each STUDENT will require:

- *Science by Doing* ***Notebook***

Things to consider and hints for success

This experiment must be left for at least three days. Students can complete all or some of the questions. They could research the questions at the end of the activity while they await their results.

Suggested research questions:

How do sacrificial anodes work?

How is corrosion managed for the Sydney Harbour Bridge (or a similar large steel structure in your state or territory)?

Teacher content information

Whether or not sublimation occurs depends on a substance's triple point, the conditions of temperature and pressure at which the substance can coexist as solid, liquid and gas. Interestingly under very low pressure, for example, in outer space water ice will also sublime rather than melt.

Lesson Plan

Step 1: Explain students will investigate different ways to prevent corrosion of iron.

Step 2: Groups set up their investigations.

Step 3: Students make and record observations in their ***Notebooks*** over three days.

Step 4: Students complete the discussion questions and research the final two questions if necessary.

5.8 Do other metals corrode like iron?

At the end of this activity students will be able to:

- demonstrate their ability to design and conduct an investigation to answer a question.

Equipment list

Each GROUP will require:

- single strips of metals such as aluminium, copper, iron, lead, magnesium and zinc
- steel wool (or emery paper)
- students select their own equipment.

Each STUDENT will require:

- *Science by Doing* ***Notebook***

Things to consider and hints for success

Students design and conduct an investigation. If they have not done this previously or recently, you could use this investigation to model the process. This activity could also be used for assessment. Try to get strips of metal of similar sizes. You don't have to provide all those suggested. Students should first complete a *Risk Assessment*.

Teacher content information

Whether or not sublimation occurs depends on a substance's triple point, the conditions of temperature and pressure at which the substance can coexist as solid, liquid and gas. Interestingly under very low pressure, for example, in outer space water ice will also sublime rather than melt.

Lesson Plan

Step 1: Explain to students that they will design and conduct an investigation to investigate the question 'Do other metals corrode like iron?' Explain that they will be provided with strips of different metals, but must decide on their own equipment.

5.9 Chemical hazards

At the end of this activity students will be able to:

- describe some safety precautions required when in danger of being exposed to hazardous particles in the air.

Equipment list

The CLASS will require:

- computer access
- internet access
- *Student Digital*

Each STUDENT will require:

- *Science by Doing* ***Notebook***

Things to consider and hints for success

This activity explores safety precautions for hazardous particles in the air. It can be done at any time in the unit.

As you teach:

Step 1: Students work through the activity, answering the questions in their ***Notebooks***.

5.10 Sample test

A sample **summative test** and a **marking scheme** have been developed and are available to teachers from *Science by Doing* at sbd@science.org.au. Both are editable versions, so you can adapt them to your students' needs.

Note - *Science by Doing* provides sample assessment items and whilst every effort has been made, the security of these items cannot be guaranteed. *Science by Doing* encourages teachers to modify the items to suit individual teaching programs.

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This resource was revised in 2017 by Dr Jim Woolnough.

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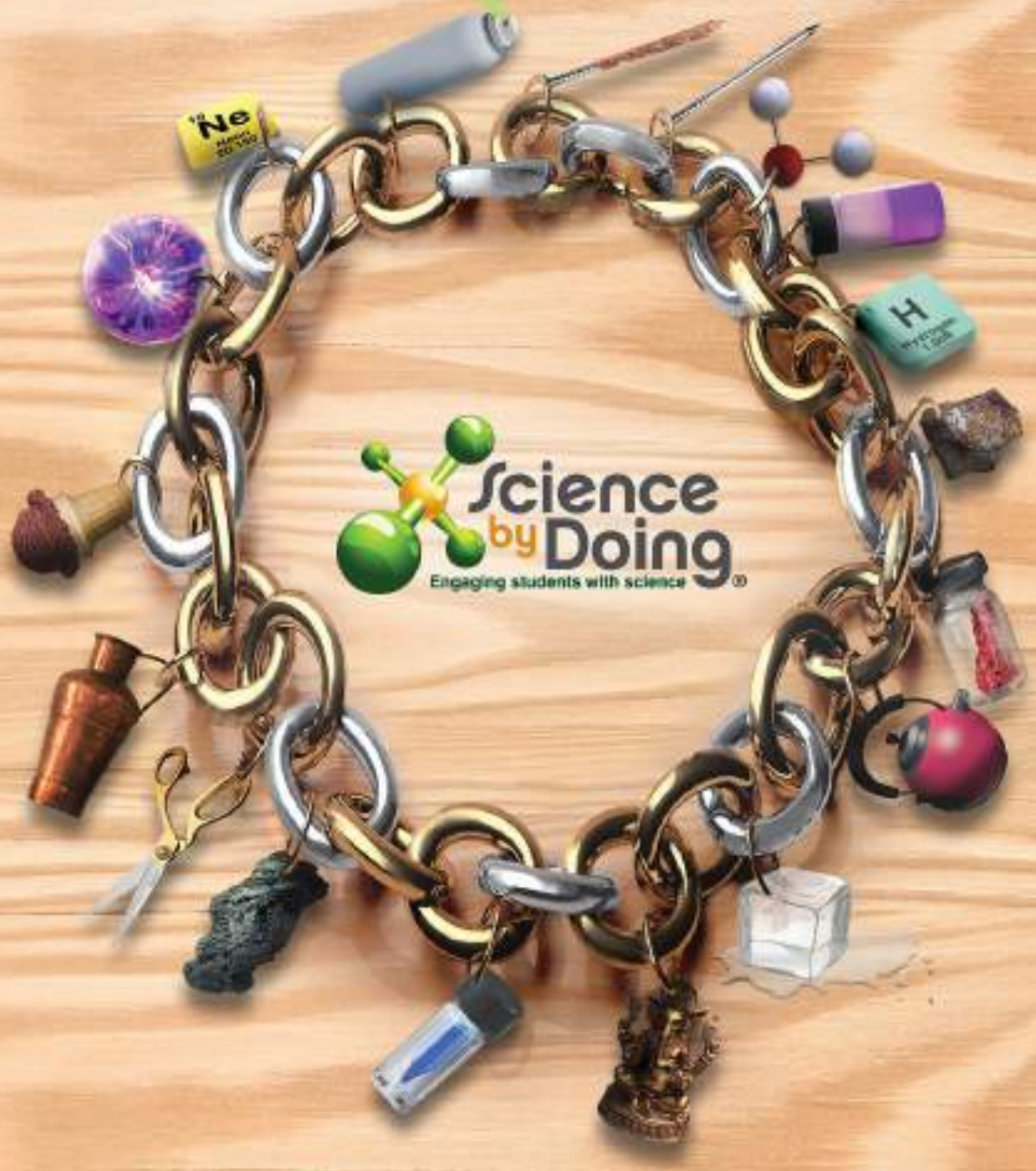

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