# *Chemical reactions* Teaching and learning plan

## Learning intentions

Students will be able to:

* observe and identify different types of chemical reactions;
* identify the reactants in a chemical reaction and relate them to the reaction type;
* predict the products formed for a given chemical reaction type;
* write word and balanced symbol equations for reactions;
* construct conclusions based on evidence.

## Suggested time for this CLE

The time needed to complete the *Chemical reactions* CLE will depend on the depth of the students’ prior knowledge, the time to perform the five investigations and follow up with any further extension activities. Allow 2–3 hours.

[**Planning ahead and equipment list**](http://assist.asta.edu.au/sites/assist.asta.edu.au/files/Planning%20and%20equipment%20list_yr10_Chemical%20reactions.docx)

## Safety considerations

When you and your class are completing your Risk Assessment consider the following safety points and add any other relevant ones to the list.

### Investigation 1: Synthesis reaction (e.g., between acid and metal).

* Wear suitable Personal Protection Equipment (PPE) such as laboratory coats, closed in shoes and safety glasses.
* Magnesium is flammable, so keep it away from ignition sources.
* Hydrochloric acid is harmful and causes skin and lung irritation. Avoid contact with skin and do not inhale.
* In case of a spill:
* If exposed, wash affected skin with soap and water and flush eyes with fresh running water for at least 20 minutes. Seek medical advice if necessary.
* Dam the spill and neutralise it with sodium bicarbonate. Sweep up the dammed spill into a bucket. Test contents of the bucket with universal indicator and dispose of the wastes down the sink.
* Hydrogen gas generated during the reaction is highly flammable.
* Use Borosilicate test tubes as they are more resistant to thermal shock. Inspect and discard any damaged test tubes.
* Stand the test tube in the test tube rack before adding the acid.
* The inverted test tube used to collect the hydrogen gas is safe to be held with the hand.
* Hold the curved base of the test tube when inserting the lighted splint.
* Be prepared for a ‘pop’ and hold onto the base of the test tube so as not to drop it.
* At the end of the reaction, pour all generated chemical wastes into the general wastes disposal container.

### Investigation 2: Decomposition reaction (e.g., decomposition of copper (II) carbonate).

* Wear suitable PPE such as laboratory coats, closed in shoes and safety glasses.
* Copper (II) carbonate is toxic and a strong irritant so use in a well-ventilated room. Avoid contact with skin and wash hands thoroughly after working with it.
* Use Borosilicate test tubes as they are more resistant to heat. Inspect and discard any damaged test tubes.
* Bunsen burner flame is very hot and can cause severe burns. Ensure that hair is tied back and does not catch alight.
* Check the gas supply and Bunsen burner to gas tap connections.
* Point the test tube of copper carbonate away from everyone while heating
* Keep the test tube moving in the flame to ensure even heating.
* At the end of the reaction, place the black residue (copper (II) oxide) in a clean, clearly labelled chemical waste container.

### Investigation 3: Single displacement reaction (e.g., between iron and copper (II) sulfate solution).

* Wear suitable PPE such as laboratory coats, closed in shoes and safety glasses.
* Copper (II) sulfate solution may cause skin irritation so avoid any contact with skin.
* The sharp point of an iron nail can cause injury to skin.
* Sandpaper can cause abrasion to skin and must be handled with care.
* At the end of the reaction, the copper-coated iron nail can be disposed of as general waste. The iron (II) sulfate solution can be converted into insoluble iron carbonate by a reaction with sodium carbonate. The precipitate can be collected and stored with inorganic solids or with mixed heavy metal waste or iron waste.

### Investigation 4: Double displacement reaction (e.g., between barium chloride and sodium sulphate solutions).

* Wear suitable PPE such as laboratory coats, closed in shoes and safety glasses.
* Barium chloride solution (0.1 M) is slightly toxic and may be harmful if swallowed.
* Inspect and discard any damaged test tubes.
* At the end of the reaction, the barium sulphate precipitate should be disposed of with toxic inorganic solid waste (unless it can be used at a later time, e.g. as a flocculent).

### Investigation 5: Chemical reactions test.

* Wear suitable PPE such as laboratory coats, closed in shoes, safety glasses and gloves.
* Carry out all reactions in a well-ventilated room.
* Copper (II) chloride solution (0.5 M) can cause mild skin irritation and serious eye damage.
* Manganese (IV) oxide is harmful, so avoid inhalation of fine particles.
* Hydrogen peroxide is toxic, so avoid skin or eye contact and do not inhale.
* Sulphuric acid is corrosive and can cause serious eye and skin irritation.
* In case of a spill:
* If exposed, wash affected skin with soap and water and flush eyes with fresh running water for at least 20 minutes. Seek medical advice if necessary.
* Dam the spill and neutralise it with sodium bicarbonate. Sweep up the dammed spill into a bucket. Test contents of the bucket with universal indicator and dispose of the wastes down the sink.
* Steel wool may cause abrasion to fingers so handle with care.
* Inspect and discard any damaged glassware and crucibles.
* Bunsen burner flame is very hot and can cause severe burns. Ensure that hair is tied back and does not catch alight.
* Check the gas supply and Bunsen burner to gas tap connections.
* Be prepared for the steel wool to catch alight in the Bunsen flame.
* Allow the burnt steel wool to cool completely before examining it.
* Stand the test tubes in a test tube rack before adding the liquids.
* Sulfur can produce a dangerous gas when heated, so use a fume cupboard.
* Allow the crucible to cool down before examining the contents.
* Chemical wastes disposal advice.
* Burning of iron: collect the iron (II) oxide formed and place in a clearly labelled container. Store with waste inorganic solids or with mixed heavy metal waste or iron solids.
* Reaction between calcium chloride and sodium phosphate: the calcium phosphate can be recovered by filtration. The small quantity can be disposed of as general waste.
* Decomposition of hydrogen peroxide: once the bubbling ceases, put a large amount of water in the wastes container and pour down the sink.
* Reaction between zinc and sulphuric acid: the resulting solution, in small quantities, can be poured down the sink.
* Reaction between aluminium and copper (II) chloride: recover the copper by filtration.

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## Introduction

This CLE focuses on different types of chemical reactions and links to the Year 10 Australian Curriculum: Science.

Revise the chemical reactions that students should know from Year 9—particularly combustion and reactions of acids with metals, bases and carbonates that should have been studied in Year 9. Explain that there are many other types of reactions and that reactions can be grouped into different types.

The reaction between **potassium permanganate and glycerol** can be used to illustrate spontaneous, exothermic and redox reactions. *Note: A video is the most suitable demonstration of this reaction as this reaction produces extreme amounts of heat and is quite dangerous, especially if it is unfamiliar to the teacher*.

Show students the video of this experiment. ‘Potassium permanganate and glycerol’, *YouTube* (1:25 min) <https://youtu.be/IdpqxrMdio0>

For further information for teachers on this reaction, see ‘Potassium permanganate and glycerol – teacher version – ECCNvideos’, *YouTube* (2:34 min) <https://youtu.be/onn_aox3ziU>. ECCN have also produced an accompanying teacher handout [http://bit.ly/1fn2f4v](http://bit.ly/1fn2f4v" \t "_blank)

## Core

### Investigation 1: Synthesis reaction

In this investigation, students will perform a synthesis reaction involving hydrogen and oxygen gas to produce water. They will model the reaction using atomic model kits and comprehend how to balance the equation.

### Equipment needed

Per group:

* safety glasses
* 2 Borosilicate test tubes
* test tube rack
* 2 M hydrochloric acid (3 mL)
* 5 mL measuring cylinder
* 2 cm magnesium ribbon
* Bunsen burner
* matches
* wooden splint
* cobalt chloride paper (optional)
* atomic model kit (or just the parts required: 8 x balls with one hole, 4 x balls with 2 holes, 8 bonds)

### Procedure

1. To capture some hydrogen gas (i.e., H2) for this reaction, place an empty test tube in a test tube rack and add 3 mL of 2 M hydrochloric acid solution. Drop the 2 cm piece of magnesium ribbon into the test tube.
2. Collect the resulting gas in a second test tube positioned upside down over the first one.
3. Light a wooden splint, turn over the test tube containing the gas and hold the flame to the mouth of the test tube.
4. A ‘pop’ sound will be heard. This confirms the presence of hydrogen gas.
5. Examine the inside of the test tube carefully. (Cobalt chloride paper can be used to test for the presence of water.)
6. Use the atomic model kit to build a model of a hydrogen molecule H2 using two balls with one hole in each and one bond between them.
7. Also build a model of an oxygen molecule using two balls with two holes in each and two bonds between them.
8. Model a water molecule using the same balls as for the hydrogen and oxygen molecules but arranged to form one molecule of H2O.
9. With the H2 and O2together on one side of the desk and the H2O on the other side, work out how to make the total number of each coloured ball the same without changing anything about the models apart from how many there are of each model.
10. Once the two ‘sides’ are balanced, use the number of each model to construct a balanced chemical equation using the formulas of hydrogen, oxygen and water instead of the models. See if the final balanced equation follows the rules of balancing equations. Models won’t always be available to do this, so it is important to know how to use the rules instead.

### Expected results and explanations

As the acid reacts with the magnesium ribbon, hydrogen gas is produced and collected in another test tube. When the lighted wooden splint is placed at the mouth of the test tube this hydrogen gas reacts with oxygen in the air and an audible ‘pop’ should be heard. Small droplets of water should form and might be visible along the inside of the test tube. Cobalt chloride paper could be used as an option if no droplets are visible. It will change from blue to pink in the presence of water.

With the models laid out on the desk, students will realise that 2 x hydrogen atoms + 2 x oxygen atoms on one side does not equal 2 H and 1 O on the other. The ‘equation’ of their models needs to be balanced and so another H2 and another H2O are needed for equivalence:

2 H2(g) + O2(g) → 2 H2O(l)

Other simple synthesis equations can be given to students to allow them to predict the product and practice their balancing skills: Answers:

copper + oxygen → copper (II) oxide 2 Cu(s)+ O2(g) → 2 CuO(s)

sodium + chlorine → sodium chloride 2 Na(s) + Cl2(g) → 2 NaCl(s)

hydrogen + bromine → hydrogen bromide H2(g) + Br2(g) → 2 HBr(g)

In addition to teaching balancing, and possibly more importantly, this simple activity shows students that to turn H2 gas and O2 gasinto H2O, bonds are broken, atoms rearrange and new bonds are formed. This is fundamental to ***ALL*** chemical reactions and cannot be understated. See the common student misconceptions in the [Teacher Background Notes](http://assist.asta.edu.au/sites/assist.asta.edu.au/files/Teacher%20Background%20Notes_yr10_Chemical%20reactions.docx) to quiz students thoroughly at this stage on their understanding and to correct any misunderstandings.

### Investigation 2: Decomposition reaction

In this investigation, students will perform a decomposition reaction of copper (II) carbonate.

### Equipment needed

Per group:

* safety glasses
* small spatula
* copper (II) carbonate solid
* test tube
* test tube rack
* Bunsen burner
* matches
* test tube tongs
* heatproof mat
* taper or wooden splint

### Procedure

1. Add a 1/4 of a spatula of copper (II) carbonate to a test tube.
2. Holding the test tube with test tube tongs heat strongly over a blue Bunsen flame until a colour change is observed.

**Keep the test tube moving in the flame and ensure the mouth of the test tube is pointed away from everyone while heating.**

1. Push a lit taper or wooden splint into the opening of the test tube to test for any gas produced. Try to write a balanced chemical equation for this reaction using the rules for balancing equations.

### Expected results and explanations

The green copper (II) carbonate decomposes to give black copper (II) oxide. Bubbles of carbon dioxide gas are evolved which extinguish the lit taper or wooden splint.

Instead of models, this time students should write a formula equation and will notice that it is already balanced, as sometimes happens:

CuCO3(s) → CuO (s) + CO2(g)

Other decomposition equations can be given to students to allow them to predict the products and practice their balancing skills:

Answers:

silver sulfide → silver + sulfur Ag2S(s) → 2 Ag(s) + S(s)

ammonia → nitrogen + hydrogen 2 NH3(g) → N2(g) + 3 H2(g)

iron (III) oxide → iron + oxygen 2 Fe2O3(s) → 4 Fe(s) + 3 O2(g)

### Investigation 3: Single displacement reaction

In this investigation, students will perform a single displacement reaction involving iron and copper (II) sulfate solution.

### Equipment needed

Per group:

* safety glasses
* 100 mL beaker
* 1.0 M copper (II) sulfate solution (25 mL)
* iron nail
* 50 mL measuring cylinder
* tweezers
* sandpaper
* paper towel

### Procedure

1. Pour 25 mL copper (II) sulfate solution into the beaker.
2. Clean the iron nail by rubbing it with sandpaper to remove dust, grease or rust.
3. Using the tweezers carefully place the nail into the beaker and observe the reaction over time.
4. Using the tweezers remove the nail from the beaker and place on the paper towel. Examine the surface that was under the solution.
5. If possible, leave this equipment set up and allow the reaction to continue until the following day.
6. Carefully compare the colour of the remaining liquid with that of fresh copper (II) sulfate solution.

### Expected results and explanations

As iron is more reactive than copper, it will ‘displace’ or ‘take the place of’ the copper (II) ions from the copper sulfate solution. A brown coating of copper (not rust!) will appear on the surface of the nail that was under the solution. Some of the iron will have entered the solution as iron (II) ions to take the place of the copper ions and form iron (II) sulfate solution, which is greenish. The reaction is:

CuSO4(aq) + Fe(s) → FeSO4(aq) + Cu(s)

Other single displacement equations can be given to students to allow them to predict the product and practice their balancing skills:

copper (II) + silver nitrate → silver + copper (II) nitrate

magnesium + hydrochloric acid → magnesium chloride + hydrogen gas

chlorine gas + sodium bromide → sodium chloride + bromine gas

Answers:

Cu(s) + 2 AgNO3(aq) → 2 Ag(s) + Cu(NO3)2(aq)

Mg(s) + 2 HCl(aq) → H2(g) + MgCl2(aq)

Cl2(g) + 2 NaBr → 2 NaCl + Br2(i)

### Investigation 4: Double displacement reaction

In this investigation, students will perform a double displacement reaction involving aqueous barium chloride and aqueous sodium sulfate solutions, which will also form a precipitate.

### Equipment needed

Per group:

* personal protective equipment
* 2 test tubes
* test tube rack
* 0.1 M barium chloride solution (1 mL)
* 0.1 M sodium sulfate solution (1 mL)

### Procedure

1. Combine 1 mL of aqueous barium chloride solution with 1 mL of aqueous sodium sulfate solution in a test tube.
2. Observe the result and try to identify any precipitate.
3. Leave the reaction for a while and come back to observe any changes over time.

### Expected results and explanations

The reactants will ‘swap partners’ and form insoluble white barium sulfate solid and sodium chloride solution. The barium sulfate precipitate will sink to the bottom of the test tube over time.

BaCl2(aq) + Na2SO4(aq) → 2 NaCl(aq) + BaSO4(s)

Other double displacement equations can be given to students to allow them to predict the product and practice their balancing skills:

calcium bromide + potassium hydroxide

silver nitrate + potassium phosphate

lead nitrate + sodium iodide

Answers:

CaBr2(aq) + 2 KOH(aq) → 2 KBr(aq) + Ca(OH)2(s)

3 AgNO3(aq) + K3PO4(aq) → Ag3PO4(s) + 3 KNO3(aq)

Pb(NO3)2(aq) + 2 NaI(aq) → PbI2(s)  + 2 NaNO3(aq)

### Investigation 5: Chemical reactions tests

In this investigation, students will predict the products of a series of six chemical reactions without knowing beforehand what the products are. They will use their knowledge from investigations 1–4 to assign each reaction to a particular type and to write word and/or balanced chemical equations for each one.

### Equipment needed

Per group:

* safety glasses
* gloves
* small piece of steel wool
* pair of tongs
* heatproof tile
* Bunsen burner
* matches
* 0.1 M calcium chloride solution (1 mL)
* 0.1 M sodium phosphate solution (1 mL)
* manganese dioxide powder
* 3% hydrogen peroxide solution (2 mL)
* zinc granules
* 1 M sulfuric acid (2 mL)
* small piece of aluminium foil
* 0.5 M copper (II) chloride solution (10 mL)
* measuring cylinder or disposable pipettes
* 2–5 large test tubes
* test tube rack
* small spatula
* taper
* sulfur powder
* crucible
* tripod
* pipe clay triangle
* small piece of aluminium foil
* stirring rod
* [Student investigation sheet](http://assist.asta.edu.au/sites/assist.asta.edu.au/files/Student%20investigation%20sheet_yr10_Chemical%20reactions.docx) (per student)

### Procedure

1. Hand out the [Student investigation sheet](http://assist.asta.edu.au/sites/assist.asta.edu.au/files/Student%20investigation%20sheet_yr10_Chemical%20reactions.docx).
2. Brief students on their task and expectations emphasising the safety and disposal requirements for chemicals.
3. Allow students time to complete all six reactions. **Note:** Reaction 5 is a teacher demonstration.

### Expected results and explanations

Reaction 1: Synthesis

Observations: The steel wool ignites and burns slowly with a bright orange light to form black iron (II) oxide. Note: this is different to red rust, which is iron (III) oxide.

Explanation: Oxygen from the air has combined with the iron to form the compound iron oxide.

iron + oxygen → iron oxide

2 Fe(s) + O2(g) → 2 FeO(s)

Reaction 2: Double displacement—precipitation

Observation: The two reactants are aqueous colourless solutions and, when added together, a white insoluble precipitate forms. This slowly sinks to the bottom of the test tube leaving a colourless solution above it.

Explanation: The two reactants were soluble hence they formed colourless solutions. When reacted, the calcium ions join with the phosphate ions to form the white insoluble solid calcium phosphate. This leaves the soluble sodium chloride in the remaining colourless solution.

calcium chloride + sodium phosphate → calcium phosphate + sodium chloride

3 CaCl2(aq) + 2 Na3PO4(aq) → Ca3 (PO4)2(s) + 6 NaCl(aq)

Reaction 3: Decomposition

Observation: On adding the catalyst, the solution rapidly fizzes, giving off a colourless and odourless gas. A glowing taper relights, indicating that the gas is oxygen.

Explanation: Even at room temperature, hydrogen peroxide will slowly decompose into oxygen and water. Adding the manganese dioxide as a catalyst rapidly speeds up the decomposition. The catalyst is not involved in the reaction and is not included in the chemical equation. It can, however, be written on top of the arrow to indicate this.

hydrogen peroxide → oxygen + water

2 H2O2(l) → O2(g) + 2 H2O(l)

Reaction 4: Single displacement (acid + metal)

Observation: The reaction fizzes, giving off a gas. The test tube increases in temperature. Testing the gas with a lit taper gives a ‘pop’ or ‘squeak’ revealing it to be hydrogen.

Explanation: Zinc is a reactive metal and so it displaces the hydrogen ions from the acid and combines with the sulfate ions.

zinc + sulfuric acid → hydrogen gas + zinc sulfate

Zn(s) + H2SO4(aq) → H2(g) + ZnSO4(aq)

Reaction 5: Synthesis (teacher demonstration only)

Observation: The sulfur reacts with the zinc and emits a lot of heat and a bright flame. The product is white in colour.

Explanation: The two elements have combined to form the white compound zinc sulfide.

zinc + sulfur → zinc sulfide

Zn + S → ZnS

Reaction 6: Single displacement

Observation: A brown coating very slowly forms on the surface of the aluminium foil. The beaker gets slightly warm.

Explanation: The aluminium displaces the copper ions from the solution. The brown coating on the foil is solid copper.

aluminium + copper chloride → copper + aluminium chloride

2 Al(s) + 3 CuCl2(aq) → 3 Cu(s) + 2 AlCl3(aq)

## Conclusion

Chemistry involves a wide range of different reactions that produce different products. If the main types of reactions are studied thoroughly, it is possible to predict the products of those reactions.

When identifying various gases: hydrogen explodes in a flame to produce a ‘pop’ or ‘squeak’, oxygen causes a glowing splint to relight, carbon dioxide extinguishes a burning splint.

Balanced equations are important because mass cannot be created or destroyed and they also show the ratios of each substance that are required to react fully.

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### Assessment opportunities

Investigation 5 provides an opportunity to assess student understanding of the concepts related to chemical reactions and could be undertaken as an assessed prac with a full report required for grading.