Level

F	1	2	3	4	5	6	B6

SCIENCE

Patterns of interactions

Strand
Natural and Processed Materials

Key concept
Patterns of interactions between materials can be identified and used to predict and control further interactions.

Purpose

Activities in this module are designed to help students understand that there are factors that affect the nature and rate of reactions; and that scientific ideas about the structure of the particles which make up matter can be used to explain the different types of changes that can take place between materials. Students will have opportunities to:

- identify patterns of change in substances that are being mixed or dissolved;
- describe the patterns identified and justify the inferences made about these patterns;
- generalise about the patterns of interactions using word equations;
- predict changes that may occur when materials such as metals, aqueous solutions and indicators interact.

Overview of activities

The following table shows the activities in this module and the way in which these are organised in **introductory**, **developmental** and **culminating** phases.

Introductory ▶	Developmental ▶	Culminating
Water, water Dry ice	Acids and metals Acids and metal carbonates Neutralisation pH and universal indicator Metals: The activity series Precipitates from salts Characteristics of oils	Make and test your own indicator Place an unknown metal in an activity series

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Core learning outcomes

This module focuses on the following core learning outcomes from the Years 1–10 Science Syllabus:

Natural and Processed Materials

5.2 Students make inferences about the effect of various factors (including temperature of the reaction and surface area of the reactants) on the nature and rate of reactions.

6.2 Students use identified patterns of change to predict interactions between materials.

Discretionary learning outcome

Activities in this module also focus on the following discretionary learning outcome:

DB6.2 Students explain and use chemical formulae and equations to describe the reactions and energy changes that take place between materials.

Core content

This module incorporates the following core content from the syllabus:

Natural and Processed Materials

- nature of change — fast/slow, requires heat/releases heat, physical, chemical;
- rate of change is affected by surface area, temperature, concentration and catalysts;
- predicting and controlling changes;
- word equations;
- theories of structure/organisation — the Periodic Table of the Elements.

Assessment strategy

Suggestions for gathering information about student learning are provided in each of the activities in this module. Once sufficient information has been collected, judgments can be made about students' demonstrations of outcomes. Typical demonstrations of this module's intended outcomes are provided here to indicate the pattern of behaviour to look for when making judgments.

Natural and Processed Materials

5.2 Students make inferences about the effect of various factors (including temperature of the reaction and surface area of the reactants) on the nature and rate of reactions.

Students may:

- plan and participate in investigations into the relationship between the rate of reaction and the factors that affect the rate;
- infer from data that the rate of reaction is affected by factors such as temperature, concentration and surface area;
- generalise about factors that affect a particular reaction or group of reactions.

Natural and Processed Materials

6.2 Students use identified patterns of change to predict interactions between materials.

Students may:

- design and perform experiments that explore the nature of interactions between materials such as metals and salts, metals and acids, and oils and detergents;
- describe the interactions in terms of particles — for example, salts dissociate into ions in water;
- make and explain inferences, predictions and conclusions using the data from investigations;
- make generalisations about types of interactions — for example, oils float on water, acid–metal reactions generate hydrogen;
- use generalisations from patterns they have observed to make predictions about changes in simple interactions, and then design and perform experiments to test their predictions.

Natural and Processed Materials

DB6.2 Students explain and use chemical formulae and equations to describe the reactions and energy changes that take place between materials.

Students may:

- write formulae for reactants used and products formed in their investigations;
- write balanced equations representing a range of reactions related to their investigations;
- describe the pattern of energy changes they have observed — for example, that heat is produced.

Background information

Current scientific conceptions

Patterns of reactions

Patterns that are related to reactions of acids, metals, water and salts, and that are investigated in this module, include:

- acid + most metals ⟶ salt + hydrogen gas;
- acid + metal carbonate ⟶ salt of the acid + water + carbon dioxide;
- acid + base ⟶ salt + water;
- indicators respond to changes in acidity by changing colour;
- some acids react more vigorously than others;
- more reactive metals displace less reactive metals in solution;
- insoluble salts precipitate out of solution;
- ionic substances dissociate in solution.

Patterns reflected in the Periodic Table of the Elements

The Periodic Table lists all the elements, organised in horizontal periods and vertical groups, according to their characteristics. Properties of elements down a group and across a period show both commonalities and progression. The table is useful to researchers and students who are searching for specific combinations of elements with particular properties.

The reactivity of metals generally decreases across a period from left to right and up a group in the Periodic Table. The reactivity of non-metals generally increases across a period and up a group in the Periodic Table, except for the inert (noble) gases, the group on the far right of the table.

Students' prior understandings

Students' prior understandings may differ from current scientific conceptions in many ways. Some students may think that:

- metals are heavy solids;
- all metals are shiny and hard;
- all metals are strong and enduring;
- 'salt' means table salt;
- all salts are soluble;
- all acids/alkalis are dangerous and destructive;
- oils are not natural substances;
- oils are heavy;
- oils sink if added to water.

Teachers could provide students with opportunities to refine their understandings about natural and processed materials — for example:

- there are metals that differ from students' conceptions;
- metals display a range of reactivities with water;
- there are many different kinds of salts of varying degrees of solubility;
- oils are extracted from natural substances;
- oils are usually less dense than water.

Teaching strategies

This module offers a wide range of contexts in which patterns can be explored. Some other contexts include fibres, extraction of minerals and metals, and the chemistry of carbon and its compounds.

This module is based on the following pattern of teaching strategies:

- students discuss and reflect on the topic, and the teacher discovers their current understandings of the topic;
- the teacher presents students with discrepant events or hands-on activities to extend their understandings;
- students reflect on the topic and form a generalisation that can be tested.

Terminology

Terms that classify materials into categories according to their properties and the processes of their formation are essential to the activities in this module — for example:

acid	ion	pH	reactant	salt
alkali	neutralisation	precipitate	reaction	series
base	oil	product	reactivity	solution
indicator	pattern			

Students may already be aware of some of this terminology. If so, the activities provide opportunities for them to evaluate current usage.

School authority policies

Teachers need to be aware of and observe school authority policies that may be relevant to this module.

Safety policies are of particular relevance to the activities that follow. It is essential that demonstrations and student activities are conducted according to procedures developed through appropriate risk assessments at the school.

Teachers should refer to Material Safety Data Sheets on the chemicals used in this module. Teachers should also consider safety issues relating to:

- experimental procedures;
- handling of and exposure to mineral oils and other chemicals;
- exposure to fumes and cold air (such as that around dry ice).

Support materials and references

Garton, A. 1996–1997, *Science Moves 1–4*, Rigby Heinemann, Port Melbourne.

James, M. & Parsons, M. 1995–1996, *Science 1–3*, Rigby Heinemann, Port Melbourne.

Lofts, G. & Evergreen, M. J. 1995–1998, *Science Quest 1–4*, Jacaranda Wiley Ltd, Milton, Q.

Parsons, M. 1996, *Science 4*, Rigby Heinemann, Port Melbourne.

Queensland Department of Education 1996, *Aspects of Science Management: A Reference Manual for Schools*, Brisbane.

Shadwick, B. 1998–1999, *Science Skills in Perspective 1–4*, Science Press, Marrickville, NSW.

Shadwick, B. & Barlow, S. 1991–1994, *Science in Perspective 1–4*, Science Press, Marrickville, NSW.

Stannard, P. & Williamson, K. 1991–1993, *Science Alive 1–3*, Macmillan Education Australia, Melbourne.

Watson, G. 1995–1997, *Science Works 1–4*, Oxford University Press, Melbourne.

ACTIVITY

Water, water

Introductory

Focus

This activity provides opportunities for students to observe and reflect on their current knowledge and understanding of the reactivity of metals and the use of indicators.

Students observe demonstrations and conduct investigations to identify the pattern of reactions between metals and water.

Materials

For each student:

- Resource Sheet 1, 'Useful tables'

For the teacher:

- Resource Sheet 2, 'Calcium and sodium in water: Teacher demonstration'
- materials listed on Resource Sheet 2

For each group of students continuing to 'Additional learning':

- magnesium ribbon
- aluminium
- zinc
- iron nail
- 5 test tubes and test-tube rack
- water

Teaching considerations

Indicators

The indicator phenolphthalein is used to gather evidence about the change of metal to metal hydroxide when sodium or calcium are added to water. Phenolphthalein is pink in alkaline solutions.

Additional learning

The samples of metals used in the additional learning activity need to be cleaned of corrosion and to be of comparable size and surface area.

The additional learning activity involves longer-term observations and may be set up at another time suitable to the learning program.

Safety

In this activity, the following precautions apply to activities using the metals calcium and sodium:

- Eye protection is essential for any person handling calcium or sodium, as are implements to transfer and cut the metals.
- Perform the calcium and sodium activities as demonstrations for students.
- To ensure that the demonstrations are safe but effective, test the reactions before demonstrating them to students.
- A safety area needs to be defined around the demonstration area. Students must observe the demonstrations from outside the safety area.

Working scientifically

Time: 50 minutes

Clarifying and challenging
Hypothesising
Looking for patterns and meanings
Making and judging observations
Making comparisons
Reflecting and considering
Discussing thinking

▶ As an introduction, students discuss their experiences and perceptions of metals. Discussion questions could include:

- How do you know when a material is a metal?
- What is one common metal that you know?
- How would you describe this metal?
- For what purposes is this metal used?
- What are some characteristics or properties of metals in general?
- Which metals are liquid at room temperature?
- Which metals are heavy? Which are not heavy?
- If paint on the metal parts of cars/toys/sports equipment is missing and these objects are left in the rain, what happens to them?
- Which metals are used to make boats? kitchen sinks? laboratory sinks?

As discussion progresses, students create their own concept map (see the initial in-service materials, Module 5) from the terms and ideas discussed. They then share their maps in groups. The discussion and the concept maps will demonstrate students' prior understandings about metals.

The teacher leads the discussion into a consideration of the reactive properties of the metals calcium and sodium. These metals are so reactive that their storage and handling require special protective measures. Students predict what might happen when each metal is put into water.

Resource Sheet 2

▶ The teacher follows the instructions on Resource Sheet 2 to demonstrate how calcium reacts with water. The temperature of water in the beaker is recorded; then the teacher adds a small piece of calcium to the water. Students describe what appears to be happening and offer some explanation.

After a minute or two when the reaction slows, any change in temperature is noted and students are challenged to explain where the calcium went. Questions to support observation could include:

- What changes did you observe during the reaction?
- How could you explain these changes?
- What difference in the reaction would you expect to see if two smaller pieces of calcium were put in instead of one larger piece?
- How could you speed up the reaction?
- How could you slow down the reaction?

▶ Gathering evidence is an important part of identifying a pattern. The indicator phenolphthalein is used to gather evidence about the change of the metal to metal hydroxide.

Students discuss indicators and how they are used. Discussion questions could include:

- What is phenolphthalein?
- What types of indicators do you know or have you used?
- What do indicators show?

The teacher shows the students a beaker of water with a few drops of phenolphthalein added. The water should remain clear and colourless.

The beaker in which the calcium has reacted with water is then placed on a white background and the diluted phenolphthalein added. Students record the colour change, and then discuss and record what this means about the acidity or alkalinity of the solution.

Resource Sheet 2

▶ The teacher then demonstrates what happens when sodium is added to water, following the instructions on Resource Sheet 2. Before the demonstration, students make hypotheses about the nature of the reaction. If possible, students observe and describe a freshly cut surface of sodium in paraffin.

Students record their observations after viewing the demonstration and note the temperature change after the reaction has stopped. Discussion questions could include:

- How would you describe the reaction that occurs?
- Apart from using the thermometer to measure temperature increase, are there any other indications that the reaction produces heat?
- Where does the sodium go?
- How could you speed up the reaction?
- How could you slow down the reaction?

▶ The teacher repeats the demonstration, this time adding phenolphthalein to the beaker of water before adding the sodium. Discussion questions could include:

- What does the colour indicate about the acidity of the water?
- Is using phenolphthalein an accurate way of establishing the degree of acidity of a solution?

After the sodium has been added to the water, students observe the change of colour. Further discussion questions could include:

- How does the colour of the solution change as the reaction progresses?
- Is heat generated or absorbed?
- Do you think a new substance is formed? If so, what is the evidence of this?

▶ After the demonstrations, students reflect on the reactions of calcium and sodium with water. Discussion questions could include:

- How do the reactivities of the two metals compare?
- What aspects of the reactions are the same?
- What aspects of the reactions are different?
- What steps can be taken to slow down the reactions?
- Have the demonstrations changed your ideas about metals?

Resource Sheet 1

Students record some of their ideas about how sodium and calcium react with water. These ideas can be compared with the original concept map, and, later, with comments about reactions of other metals in water (see 'Additional learning' on the next page). Students could also annotate the copy of the Periodic Table on Resource Sheet 1 with comments about the reactivity of the metals.

Additional learning

▶ To explore the reactions between water and other metals, students could set up test tubes of water each containing a sample of a different metal — for example, an iron nail or a piece of aluminium. Gradual changes in the metals can be observed only over an extended period.

Resource Sheet 1

Students record their observations of these reactions and compare the reactions with those between water and calcium, and water and sodium. They can make further annotations about the reactivity of the metals on the Periodic Table on Resource Sheet 1.

Gathering information about student learning

Some sources of information could include:

- anecdotal records of students' discussions of factors affecting the rate of reactions; and their ability to identify a pattern;
- students' written notes about the reactions of metals with water, and factors affecting the reactions.

ACTIVITY

Dry ice

Introductory

Focus

This activity provides opportunities for students to discuss and reflect on their current knowledge and understanding of acids, bases, indicators and changes of state.

Students observe a demonstration of dry ice turning from a solid to a gas in water.

Materials

For the teacher:

- Resource Sheet 3, 'Dry ice: Teacher demonstration'
- materials listed on Resource Sheet 3
- several soft drinks (optional)

Teaching considerations

Practical points

Dry ice can be kept for several days in double insulation. Newspaper is an excellent insulating material. A 5 kg block of dry ice lasts longer than pellets — about 2–3 days in an Esky.

Consider ways to improve the visibility of the demonstration — for example, by using a white background.

Safety

Dry ice should not be touched. Its temperature is -78°C, and if it comes into contact with skin or other tissue, it can cause severe tissue damage. Cold air may initiate an asthma attack.

Working scientifically

Time: 30 minutes

Clarifying and challenging
Hypothesising
Looking for patterns and meanings
Making and judging observations
Inferring from data
Making comparisons
Discussing thinking

▶ Before the demonstration, the class discusses the characteristics of water. Discussion questions could include:

- What are some words you could use to describe the characteristics of water?
- What are the properties of water?
- Is water acidic, basic or neutral?

Students can be asked if they have any experience of using universal indicator and, if so, where and for what purpose. The colour of the indicator indicates the acidity of a solution. A key pattern in the investigation is the pattern of the indicator changing colour over a range of acidity. Acidity is one of the properties of aqueous solutions. (Other properties include odour and colour.)

▶ Students are shown the dry ice and how it is kept. Questions that support discussion and observation could include:

- What do you think dry ice is?
- How is the dry ice changing as it is brought out of the insulated container?
- When ice made from water melts, how does it change?
- What is different about the behaviour of dry ice?

- Have you seen dry ice used in theatrical performances to create misty or smoky effects?
- What is being given off from the dry ice when it is taken out of its insulated container?
- What do you think you are seeing around the dry ice at room temperature?
- As the gas comes off the dry ice, is it falling or rising?
- What can you infer about the density of this gas compared to the density of air?
- In what process is carbon dioxide constantly produced by living things?
- Is carbon dioxide visible at room temperature?
- Do you know how to test whether a gas is carbon dioxide?
- What makes the bubbles in soft drinks?

Resource Sheet 3

▶ The teacher then performs the demonstration on Resource Sheet 3.

As the dry ice is added to a dilute solution of sodium hydroxide, students observe what is happening to the solution and to the indicator in the solution. Some discussion questions could include:

- What is happening in the solution?
- What is happening to the colour of the indicator?
- How is the acidity changing?
- How would the reaction progress if the amount, or the size of the pieces, of dry ice were changed?
- At what point does adding more dry ice stop having more effect on the indicator?

(If students already understand the concept of pH, then questions can relate to pH rather than to acidity generally.)

▶ After the reaction ceases, students discuss what has happened. Discussion questions could include:

- What do you think caused the acidity to change?
- How could the reaction be slowed down?
- Do you know what carbonic acid is?

Now that students have reflected on the nature of the reaction, it is recommended that the teacher repeats the demonstration. Students then write about their understanding of what happened.

▶ After the demonstration, students can hypothesise what the acidity or pH of soft drinks might be and then test their hypothesis.

Gathering information about student learning

Sources of information could include:

- anecdotal records of the way that students contribute to group discussion; the way that they observe, hypothesise, infer, explain; and their knowledge about factors affecting the rate of reaction, and reactions between materials;
- students' notes on their observations and on the inferences that they draw from these observations.

ACTIVITY

Acids and metals

Developmental

Focus

This activity provides opportunities for students to develop understandings about the patterns in reactions of acids with metals and to use word equations to describe them.

Students review their knowledge of acids and perform experiments to observe reactions, look for patterns and test predictions.

Materials

For each group of students:

- Resource Sheet 1, 'Useful tables'
- planning and reporting worksheets (see the sourcebook guidelines, Appendix 3)

Testing for hydrogen, carbon dioxide and oxygen

- Resource Sheet 4, 'Testing for gases with a taper'
- materials listed on Resource Sheet 4

Investigation of acids and metals

- 6 Pyrex test tubes and test-tube rack
- iron filings
- zinc pieces
- aluminium pieces
- lead pieces
- 1 M hydrochloric acid
- spatula
- taper
- matches
- magnesium pieces

Additional learning

- 1 M citric acid
- 1 M acetic acid
- 1 M hydrochloric acid
- pieces of magnesium ribbon 3 cm long
- 1 M sulfuric acid
- saturated solution of tartaric acid (optional)

Teaching considerations

Practical points

If students already understand about tests for substances and have experience of the tests for hydrogen, carbon dioxide and oxygen, there is no need to do the activities on Resource Sheet 4.

Comparisons of metals to assess their relative activity are most reliable when all pieces of metal used are of similar size and surface area, with corrosion removed.

Copper is not included in this activity, as it does not fit into the trend displayed by metals either side of it in the Periodic Table.

As hydrogen peroxide spontaneously decomposes into oxygen and water, it is best to use a freshly opened bottle. Manganese dioxide is a catalyst which increases the rate of decomposition of hydrogen peroxide.

Safety

Use Pyrex test tubes because heat is generated in the reactions.

Working scientifically

Time: 90 minutes

Clarifying and challenging
Designing and performing experiments
Hypothesising
Identifying
Looking for patterns and meanings
Making and judging observations
Predicting
Making comparisons
Inferring from data
Illustrating
Negotiating

Resource Sheet 4

▶ The teacher discusses with students what a 'test' for a substance is, and how it is used to check for the presence or absence of the substance. Discussion questions to elicit students' current understandings could include:

- How can you be sure you have the substance you think you have?
- How is the presence of hydrogen gas identified?
- How is the presence of carbon dioxide gas identified?
- How is the presence of oxygen gas identified?
- Can you identify any common properties of hydrogen, oxygen and carbon dioxide?

Students then carry out the preparatory activity to practise tests for carbon dioxide, hydrogen and oxygen (see Resource Sheet 4).

▶ In the next part of the activity, students explore the way metals react with acids. As an introduction, they discuss what they know about acids and the reactions between acids and metals. Discussion questions could include:

- What do you know about acid–metal reactions?
- What are you not sure of with respect to acid–metal reactions?
- Is there anything you would like to know about acid–metal reactions?

▶ Following the discussion, students design and perform an investigation to find a pattern in the way metals react with acids. Each group of students uses the materials listed above, or other materials they suggest. Students negotiate with the teacher to establish what they can safely and appropriately investigate.

Students who need more direction could be guided by a series of prompts. For example, they could investigate the question: Do all metals react the same way with one particular acid? Other questions to guide their planning could include:

- What will you change in each test?
- What will you keep the same in each test?
- What will you measure?

Questions to support students' observations could include:

- What are the similarities in the ways the metals react?
- What are the differences in the ways the metals react?
- How could you change the rate of the reactions?

Students devise their own way of assessing and recording the nature and intensity of the reactions. For those who need support in this area, a table like the one below could be used.

Metal	Reaction with hydrochloric acid **Rating:** 0 none; ✓ some; ✓✓ moderate; ✓✓✓ a lot	
	Heat generated	**Gas**
Iron		
Zinc		
Aluminium		
Lead		

Students may complete and share a range of investigations. The planning and reporting worksheets in the sourcebook guidelines support students in this process.

▶ Following the investigation, the teacher models for the students a word equation representing one of the reactions in the investigation. With the teacher's guidance, students then practise writing word equations for each of the other reactions tested.

After students have practised writing the word equations of individual reactions, they should be guided to write a general equation representing all the reactions. They need to substitute a general name for the specific names in the equations, resulting in the generalisation:

metal + acid ⟶ metal salt + hydrogen gas

Resource Sheet 1

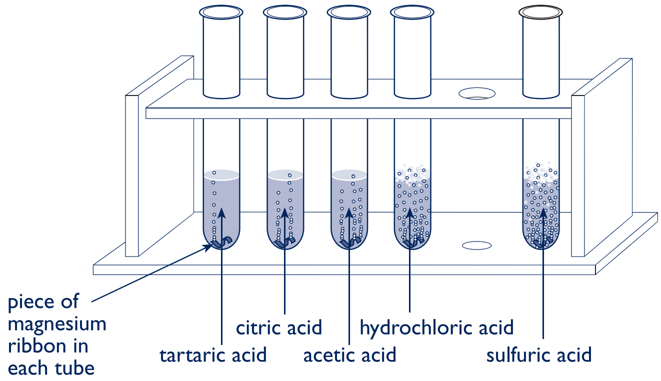
▶ The teacher can model for the students or lead them in reflection in judging the relative activity of the metals tested. Students compare the order of activity of the metals with their place in the Periodic Table (see Resource Sheet 1).

Finally, students predict and test where magnesium will fit in the order of activity of all the metals tested.

Additional learning

▶ If the products of the acid–metal reactions are neutral solutions, some of them can be set aside to form crystals. The formation of crystals is an example of a pattern of change. The crystals can be compared with crystals from commercial preparations.

▶ Students could also investigate the reactions of the metal magnesium with various acids to form magnesium salts. After observing the reactions, students identify the pattern of the reactions and record a generalisation about them. While tartaric acid is not soluble enough to make a 1 molar solution, students may hypothesise about the nature of a reaction between tartaric acid and magnesium and suggest ways of collecting enough gas to test.



Questions to guide students' observations could include:

- What is happening in the test tubes?
- Which reaction is the most vigorous?
- Which reaction is giving off the most heat?
- Is the same thing happening in all the test tubes?
- What gas is being given off?
- How could you be sure of what the gas is?
- What factors could change the rate of reaction?
- Can you make a general statement about all the reactions?

Students could adapt this activity to work out the order of acids in an activity series. They could then predict and test the place of sulfuric acid in the acid activity series.

Gathering information about student learning

Some sources of information could include:

- anecdotal records of students' planning for investigations and their generalisations about the reactions;
- students' notes on planning the investigations, and their data records;
- the investigation process that students use.

ACTIVITY

Acids and metal carbonates

Developmental

Focus

This activity provides opportunities for students to design investigations to identify the patterns of reactivity between acids and metal carbonates, and to use word equations to describe them.

Materials

For each group of students:

- 8 test tubes in 2 test-tube racks
- 0.1 M citric acid
- 1 M acetic acid
- 0.1 M hydrochloric acid
- sodium carbonate (powder)
- potassium carbonate (powder)
- magnesium carbonate (powder)
- barium carbonate (powder)
- taper
- matches
- water
- marble chips
- planning and reporting worksheets (see the sourcebook guidelines, Appendix 3)

Teaching considerations

Marble

Limestone and marble are both calcium carbonate. Marble is formed when limestone is subjected to heat and pressure in the Earth's crust.

The white cliffs of Dover in southern England, the Jenolan Caves in New South Wales, and Carnarvon Gorge and Mount Etna Caves in Queensland are all made of limestone. Marble is quarried at Chillagoe in Queensland.

Practical points

The materials listed are only a guide to what might be used. Other materials may be suggested by students.

Students should use acids of the same molarity, and equal small amounts of each carbonate. The amounts of carbonate and the strength of the acids need to be sufficient to generate enough carbon dioxide to provide a positive test result for the gas.

Safety

Students must use only small amounts of reactants since the reactions can be very vigorous.

Working scientifically

Time: 50 minutes

Designing and performing experiments
Identifying
Hypothesising
Looking for patterns and meanings
Predicting
Drawing conclusions
Generalising
Inferring from data

► The teacher leads a discussion about how we use marble (for example, for bench surfaces, cutting boards, floors and sculptures) and the composition of marble. If pictures of marble are available, these can be shown to students. Discussion questions to elicit students' current understandings could include:

- Why is marble used as a construction material?
- How does marble form?
- How is limestone related to marble?
- How is limestone used?
- What is the chemical composition of limestone and of marble?

A class concept map (see the initial in-service materials, Module 5) about marble and limestone can be generated from the discussion.

The teacher guides the discussion on to the formation of limestone caves. Discussion questions could include:

- Which natural events cause a cavity to form under the ground?
- What does the washing away of material imply about that material?
- What are stalactites and stalagmites? How do they form?
- What are the usual carrying agents of eroded and deposited material?
- Which kinds of factors affect the rate of erosion?

► The teacher explains that establishing patterns of interactions between materials allows predictions to be made about results of other interactions. Students then plan an investigation to rank the metal carbonates provided according to:

1. their solubility in water;
2. their reactivity with acids.

Students may find the planning and reporting worksheets in the sourcebook guidelines useful. Questions to guide students in their investigation could include:

- Can you estimate whether the carbonates are readily soluble, barely soluble or insoluble in water?
- What is the gas produced in the reaction of metal carbonates with acid?
- Is there a pattern to the vigour of the reactions with acid?
- If you need to slow the reactions down, what factors would you change?
- Can a generalisation be made about all the reactions between metal carbonates and acids?

► Following the investigation, the teacher models writing a word equation representing one of the reactions in the investigation. With the teacher's guidance, the students then practise writing word equations for each of the other reactions tested.

After students have practised writing the word equations of individual reactions, they should be guided to write a general equation representing all the reactions. They need to substitute a general name for the specific names in the equations, resulting in the generalisation:

metal carbonate + acid ⟶ metal salt + carbon dioxide + water

► The teacher can model for the students or lead them in reflection about the activity of the carbonates tested. The teacher then links the concept of carbonate activity to the previous discussion of limestone and marble and puts the following questions to students:

- What effect would you predict acid rain to have on buildings constructed from marble?
- What effect would you predict run-off from acid soil to have on deposits of limestone or marble?

Students test their predictions by adding acids to samples of calcium carbonate (either in powdered form or as marble chips). They then answer the following questions:

- Are your predictions confirmed?
- Does the following generalisation hold for the reactions of acids with calcium carbonate?

metal carbonate + acid ⟶ metal salt + carbon dioxide + water

Students record their findings and their conclusions.

Gathering information about student learning

Sources of information could include:

- anecdotal records of students' planning for investigations and their generalisations regarding the nature of changes that take place during their investigations;
- students' notes about their investigation plans and their data records;
- anecdotal records of students' investigations.

ACTIVITY
Neutralisation

Developmental

Focus

This activity provides opportunities for students to explore the pattern of reaction between an acid and a base to form a salt and water, and to use word equations to describe the pattern.

Students construct meaning about strong and weak acids by neutralising a range of acids with sodium hydroxide.

Materials

For each group of students:

- discs marked H^+
- discs marked OH^-
- 0.1 M tartaric acid
- 0.1 M citric acid
- 0.1 M acetic acid
- 0.1 M hydrochloric acid
- 0.1 M sodium hydroxide
- 0.1 M potassium hydroxide
- 6 measuring droppers
- 6 test tubes and test-tube rack
- universal indicator or pH meter
- Resource Sheet 5, 'Practising patterns' (for each student)
- planning and reporting worksheets (see the sourcebook guidelines, Appendix 3)

Teaching considerations

Acids and pH

Students need to be aware that:

- acids are ionic;
- the ions making up an acid dissociate in solution;
- the concentration of hydrogen ions in an acid is reflected by its pH;
- acids and bases change the colour of indicators.

Materials

The materials listed are only a guide to what might be used. Other materials may be suggested by students. If students have a good knowledge of acid–base reactions, they may be able to plan their own investigations using the planning and reporting worksheets in the sourcebook guidelines.

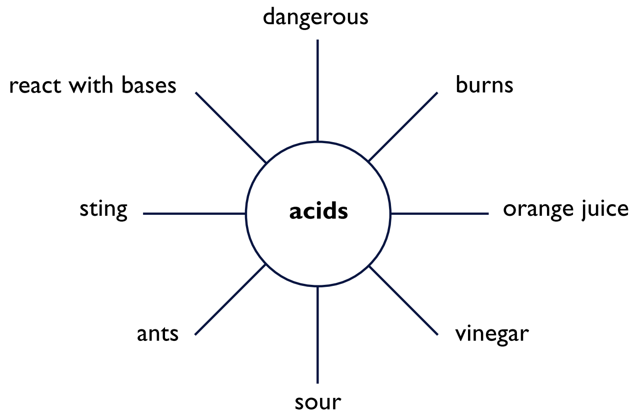
Working scientifically

Designing and performing experiments
Looking for patterns and meanings
Identifying
Making and judging observations
Hypothesising
Predicting
Constructing meaning
Inferring from data

Time: 60 minutes

► Students undertake a brief introductory activity to help develop a mental model of the ionic structure of acids and bases. They are provided with a random number of flat discs marked with either H^+ or OH^-. They match as many pairs of H^+ and OH^- discs as possible to make neutral 'water molecules'. Students then decide whether the discs make up an acidic solution (in which there remain unpaired H^+ discs), a basic solution (in which there remain unpaired OH^- discs) or a neutral solution (in which all discs are paired). (For the visually impaired, the discs can be marked with textured paint.)

Individually or in groups, students make a word wheel (see the initial in-service materials, Module 5) about neutralisation or about acids, depending on their level of understanding. Data from students' word wheels can be collated on a board or an overhead transparency.



Example of a word wheel about acids

► Next, students devise an experiment to identify or confirm the pH of an acid, and to determine the amount of strong alkali (sodium hydroxide) required to neutralise each acid. (They can plan to use the materials listed, or may negotiate the use of other materials with the teacher. The following description assumes that the listed materials are used.) Such an experiment will give the students the information they need to be able to deduce the strength of the respective acids.

Directions and questions to guide students in planning their experiments could include:

- How can the range of acids be described? (The following direction can be used instead if students are familiar with the concept of pH.)
- Suggest the range of pH of the acids provided.
- Rank the acids in order from greatest to least acidity.
- Why did you suggest that order?
- What can you do to check the order?
- In your investigation what variables are you going to change?
- How are you going to record your results?
- How are you going to determine the acidity of solutions?

With teacher guidance, students decide how to perform their experiments so that the results can be validly compared. They will need to decide what they will change in each experiment, what they will keep the same in all experiments, and what they will measure in each experiment.

Students may need assistance to recognise that, for valid comparisons of tests:

- the same volume of acid of the same concentration should be used in each test;
- the same quantity and type of indicator should be used in each test;
- when adding varying volumes of sodium hydroxide to acid, the concentration of sodium hydroxide should be constant.

Students design their own data table in which to record their results. The planning and reporting worksheets in the sourcebook guidelines may be a useful reference for this.

▶ Students then perform their experiments. They record the pH of each acid and the amount of alkali required to neutralise it. Before drawing any conclusions, they must examine their results for inconsistencies and work out how to refine their experiments if necessary.

Questions to guide students in evaluating their experiments could include:

- Which variables did you keep constant?
- Which was the independent variable — that is, the one you chose to change?
- Which variable did you measure?
- Was the concentration of any of the reactants varied for any reason?

Students write a brief summary of what they did and identify any patterns they observed. From the patterns they observed, they draw conclusions about the strength of the acids tested and rank them by strength.

▶ The teacher uses the understandings developed in the earlier activities to lead students to an understanding that, in water:

hydrochloric acid ⟶ hydrogen ions + chloride ions

sodium hydroxide ⟶ sodium ions + hydroxyl ions

The teacher then combines the above two equations to model the reaction between hydrochloric acid and sodium hydroxide:

sodium ions + hydroxyl ions + hydrogen ions + chloride ions ⟶ sodium ions + chloride ions + water

Resource Sheet 5

Some sections of Resource Sheet 5 provide examples of similar equations that students can complete. Students can practise writing word equations representing the reactions between other acids and bases.

After students have practised writing the word equations of individual reactions, they should be guided to write a general equation representing all the reactions. They need to substitute a general name for the specific names in the equations, resulting in the generalisation:

acid + base ⟶ salt + water

Gathering information about student learning

Sources of information could include:

- the investigation process that students used;
- anecdotal records of students' discussion and their generalisations regarding the nature of changes that take place during their investigation;
- students' summaries of their investigation and data records;
- the patterns students identified in their investigation and the conclusions they drew.

ACTIVITY

pH and universal indicator

Developmental

Focus

This activity provides opportunities for students to identify the pattern of an acid dissociating in water to form hydrogen ions, and the degree of dissociation as measured by pH.

Students perform a serial dilution of hydrochloric acid and of sodium hydroxide to illustrate the full pH range.

Materials

For each group of students:

- Resource Sheet 6, 'Indicating pH 1–14'
- materials listed on Resource Sheet 6
- coloured pencils to represent pH range 1–14

Teaching considerations

Necessary prior understandings

Students need to be aware that:

- ionic substances readily dissociate into their component ions in water;
- the hydrogen ion is represented as H^+;
- the hydroxyl ion is represented as OH^-.

Practical points

This activity is recommended as a closed investigation to construct the concept of pH — that is, it follows a set procedure to demonstrate a particular result.

This experiment requires accurate measurement. Pre-test it before students attempt it.

Liquid universal indicator shows colour changes over the pH range of 3–11. Universal indicator paper shows colour changes over the pH range of 1–14. Although the paper indicator will show changes at the extremes of the range, it is harder to read in the middle range than the liquid is.

Where equipment is a limiting factor, the task could be divided between two groups. One group does pH 1–7 and the other does pH 8–14.

Working scientifically

Handling materials
Hypothesising
Looking for patterns and meanings
Making and judging observations
Measuring
Reflecting and considering
Illustrating

Time: Part 1, 30 minutes; Part 2, 40 minutes

Part 1

▶ Students discuss how pH reflects the number of hydrogen ions in solution. In 0.1 M hydrochloric acid, the hydrogen and chloride ions are fully dissociated. In 1 M sodium hydroxide, the sodium ions and the hydroxyl ions are fully dissociated. This solution is described as alkaline. In both solutions the number of positive ions exactly balances the number of negative ions.

In their notebooks, students prepare a scale with 14 segments that can be coloured or annotated to represent the pH in each test tube as the investigation progresses. The left end of the scale is marked as acidic and the opposite end alkaline. The seventh segment is marked neutral.

Resource Sheet 6

Part 2

▶ Students now follow the instructions on Resource Sheet 6 to demonstrate the full pH range. Precise measurement of 1 mL at each dilution is critical to the result. The desired result is that a change in the colour of the indicator is evident through the range of dilution.

Questions to help students clarify their understanding could include:

- What is the initial concentration of the hydrochloric acid?
- What is the initial concentration of the sodium hydroxide?
- How much of the initial solution is transferred to the next test tube?
- How much water was there in the second test tube?
- How much has the original acid/alkali been diluted in the second test tube?
- Will there be fewer or more acid/alkali particles in each test tube as the dilution proceeds?
- What would this do to the rate of any reaction for which the acid/alkali is used?
- Which tubes of acid and alkali would you expect to react the fastest? Why?

▶ After the procedure, students reflect upon the dilutions, the colour changes of the indicator, and the changes in the ionic composition of the solutions. The teacher should draw students' attention to the seventh test tube and encourage them to formulate hypotheses about the nature of the ions in this test tube. Students need to accommodate the idea that the number of the test tube corresponds to the pH of the solution in it. Through reflecting on recent investigations, students may be able to see that pH is a useful property of solutions.

Students then reflect on their current understanding of pH and what causes pH to change. They can annotate their pH scale and summarise what they believe has occurred during the procedure.

Additional learning

▶ A similar investigation can be carried out to establish the pH at which other commercial indicators change. The results can be compared with the results for universal indicator.

Gathering information about student learning

Sources of information could include:

- anecdotal records of students' discussion and reflection;
- students' records — for example, the annotated pH scale;
- students' summaries of what happened in the investigation.

ACTIVITY

Metals: The activity series

Developmental

Focus

This activity provides opportunities for students to develop understandings about reaction patterns of metals.

Students observe what happens when metals are combined with solutions of metal salts. They then deduce an order of activity for the metals.

Materials

For each group of students:

- 8 test tubes in 2 test-tube racks
- zinc
- steel wool or iron filings or iron nail
- lead
- zinc nitrate (solid)
- ferric nitrate (solid)
- lead nitrate (solid)
- magnesium
- magnesium nitrate (solid)
- planning and reporting worksheets (see the sourcebook guidelines, Appendix 3)

Teaching considerations

Introductory activity

As an introductory activity, students could investigate the solubility of metal salts. Salts could be ranked as soluble, partially soluble or insoluble.

Combining salts and metal salts

Model the ranking of three metals in order of reactivity. (Do this by guiding students' thinking as they process the initial data from their investigation.) Then extend the ranking to include a fourth metal and salt so that students can practise assigning the new metal a relative position.

When a less reactive metal is placed in a solution of the salt of another more reactive metal, nothing happens. However, when a more reactive metal is placed in a solution of a salt of another less reactive metal, the pattern of the reaction is that the more reactive metal will give up electrons and go into solution. The ions of the less reactive metal accept the electrons and the less reactive metal then settles out of solution.

Practical points

The materials listed are suggestions only. Choose metals with salts readily available from the chemical store; however, sulfates are preferable. If lead or silver is investigated, then nitrates will need to be used (nitrates are the only soluble salts of lead and silver).

The surfaces of the metals must be clean (that is, not oxidised) and the salt solutions must be freshly prepared.

To minimise the use of test tubes, each group could test a single metal with the various salts and the results of all groups can then be collated.

Some of these reactions between metals and metal salts are slow, and results may not be discernible for some hours, or even days.

Safety

The materials in this activity must be handled with care, as some are toxic.

Working scientifically

Time: 40 minutes

Designing and performing experiments
Hypothesising
Identifying
Describing
Looking for patterns and meanings
Making and judging observations
Predicting
Inferring from data
Interpreting data
Making and judging deductions

▶ As a class, students discuss what they know about the relative activity of metals. Discussion questions to help students reflect and to allow the teacher to assess students' current understandings could include:

- In recent investigations, which metal have you found to be the most reactive?
- Can you identify a metal that is less reactive than others? Which one? Why did you decide on that one?
- Can you predict what might happen if a more reactive metal is put into a solution of a salt of a less reactive metal? Why do you think that?
- If a more reactive metal is put into a solution of a salt of a less reactive metal, what are some of the factors that would influence the rate of the reaction?

▶ Working in groups, students then devise an investigation to find the relative reactivity of three metals: zinc, iron and lead. The level of assistance students require during their investigation depends on their experience.

The planning and reporting worksheets in the sourcebook guidelines may be useful to students when they are planning their investigations. Students familiar with open investigations may be able to suggest ways of testing the metals' reactivity using the materials provided. More confident students may suggest other materials they would prefer to use.

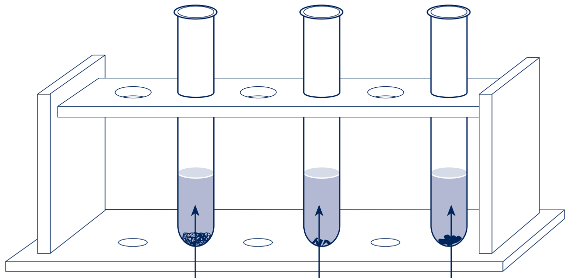
Questions to help students design their investigations could include:

- To assess the reactivity of a metal placed in the solution of a salt, what will you keep the same in every test?
- Which metal will you test first?
- With which salt will you test this metal?
- What will you change in every test?
- What will you measure in every test?
- What problems might arise if the salt solutions are not all the same concentration?
- What factors will influence the choice of concentration? What will the concentration be?

Students need to nominate which combinations of metals and metal salts will be set aside for extended observation. The class needs at least two full sets of long-term observations for the purpose of comparison.

If students are using the materials listed on the previous page, the following combinations should be observed:

- zinc fragments in zinc nitrate, ferric nitrate, lead nitrate;
- steel wool in zinc nitrate, ferric nitrate, lead nitrate;
- lead fragments in zinc nitrate, ferric nitrate, lead nitrate.



▶ When students have completed their observations and collated their data, they consider the following questions for each metal:

- When the metal was put in the various salt solutions, which solution(s) did it react with?
- What does this suggest about the metal?
- Are there any other factors affecting the reaction rate that have not been kept constant?

▶ Students now look at the position of magnesium in the Periodic Table. They predict how reactive magnesium is compared to the other metals they have just tested. They then test the reactivity of magnesium.

Additional learning

▶ Students could research the commercial applications of the different reactivity of different metals.

Gathering information about student learning

Sources of information could include:

- anecdotal records of students' planning of investigations and their generalisations regarding the nature of changes that take place during their investigations;
- the investigation process that students use;
- students' data records, their notes about the inferences they drew from their observations, and their predictions.

ACTIVITY

Precipitates from salts

Developmental

Focus

This activity provides opportunities for students to develop an understanding of precipitates and to make predictions about the reactions that may occur when two salts in solution are mixed.

Materials

For each group of students:

- 6 test tubes and test-tube rack
- dropper dispensers (one for each solution)
- Resource Sheet 1, 'Useful tables' (for each student)
- Resource Sheet 5, 'Practising patterns' (for each student)
- planning and reporting worksheets (see the sourcebook guidelines, Appendix 3)

A selection of the following in solid form and in dilute solution if they are soluble (concentrations are suggested):

- sodium iodide (0.1 M)
- sodium carbonate (0.5 M)
- sodium sulfate (1 M)
- potassium nitrate (0.1 M)
- calcium carbonate (insoluble)
- copper carbonate (insoluble)

A selection of the following in dilute solutions (concentrations are suggested):

- potassium iodide (0.1 M)
- lead nitrate (0.1 M)
- barium nitrate (0.1 M)

Teaching considerations

Prior understandings

For this activity, students' understandings of the solubility of salts and the formation of ions in solutions are fundamental for identification of the patterns.

Practical point

The decision on concentrations should be made before the investigation, informed by the optimum results found in pre-testing.

Safety

The materials used in this activity must be handled with care, as some are toxic.

Solubility testing should be performed only on the salts provided in solid form.

All solutions must be dilute.

Material Safety Data Sheets, including information on methods of disposal, must be read and acted upon.

Working scientifically

Time: 50 minutes

Designing and performing experiments
Looking for patterns and meanings
Hypothesising
Predicting
Inferring from data

Resource Sheets 1, 5

▶ If students have not recently done any solubility testing, they should first test the solubility of a selection of the substances provided in powder form. The salts can be categorised as soluble, sparingly soluble or insoluble.

Students discuss the dissociation of ions. Through discussion, they develop an understanding that this dissociation occurs only when salts dissolve in water. The teacher models the use of Resource Sheet 1 to select a soluble salt, such as sodium chloride, and then writes a sample dissociation equation for this salt. Students can then complete the equations on Resource Sheet 5 (in the section 'Ions associated with salts') as guided practice.

▶ Following the preliminary activities, students design an investigation to establish which pairs of ions will form a precipitate when salt solutions are mixed. Students may find the planning and reporting worksheets in the sourcebook guidelines useful.

The investigation should include at least two pairs of reactants: one pair which is predicted to produce a precipitate; and one pair which is predicted to remain in solution. Each salt could then be tested against every other salt provided for this activity. A simple pattern should emerge: some metal salts are insoluble and form precipitates; others are soluble, and all ions will remain in solution.

Students who need assistance can be encouraged to plan their investigation using a matrix showing all the possible combinations of solutions to be tested. Students who already have clear ideas about patterns may choose to omit some tests.

▶ Students record the results of their tests, and justify their method. In conclusion, they make one or more generalisations about some of the ions tested. Some generalisations, such as that all silver salts except silver nitrate are insoluble, can be made from the solubility table on Resource Sheet 1.

Gathering information about student learning

Sources of information could include:

- anecdotal records of students' planning for investigations and observations regarding the nature of changes that take place during their investigations;
- students' data records, their notes explaining why they chose to use particular salts, and their predictions;
- the investigation process that students use and the generalisations they make from their results.

ACTIVITY

Characteristics of oils

Developmental

Focus

This activity provides opportunities for students to explore the physical characteristics of oils (mineral or vegetable or both).

Students investigate how oil spills on water may be cleaned up.

Materials

- Resource Sheet 7, 'Characteristics of oils: Interview about instances' (for each student)
- paraffin oil
- kerosene
- lubricating oil
- vegetable oil(s)
- sand, sawdust
- flour
- detergent
- absorbent cloth or paper
- water
- small, wide-mouthed glass container or pie dish
- plastic syringe (without needle) for drawing oil up into the barrel, or disposable plastic Pasteur pipette

Teaching considerations

Covalent (non-ionic) materials

For some students, this activity may be a suitable extension to activities featuring ionic substances, in that it explores the behaviour of a covalent, or non-ionic, substance when added to water.

The chemistry of carbon or oils

This activity could also be used as an introduction to various patterns associated with the chemistry of carbon or oils — for example, fractional distillation of mineral oil, distillation of fragrant oils, and the combustion of oils.

A unit based around this activity might focus on using the Earth's resources wisely, or on safe disposal of waste. Inferences about factors affecting the rate of reaction are particularly applicable to techniques of cleaning up oil spills.

Safety

The specific safety issues for this activity relate to the flammability of materials used and the fumes of mineral oils:
- Only small quantities of materials should be used.
- There must be no source of heat or electrical sparks in the workroom.

Working scientifically

Time: Part 1, 60 minutes; Part 2, 40 minutes

Designing and performing experiments
Hypothesising
Looking for patterns and meanings
Making and judging observations
Predicting
Assessing and reassessing
Developing possible, probable and preferred options
Examining and evaluating
Inferring from data

Resource Sheet 7

Part 1

▶ Students consider the illustrations on Resource Sheet 7 and suggest answers to questions such as:

- How are the objects in the pictures associated with some type of oil?
- What type of oil is associated with these objects?
- What is the origin of each type of oil?
- Is the amount of oil (or of products derived from oil) used in the situations shown in the drawings a threat to the environment — for example, during transport or disposal?

Students can put a copy of the pictures in their notebooks and annotate the illustrations with comments. These annotations can be used later for reflection.

After this introduction, students discuss what they know about oils. Discussion questions could include:

- What do you know about oils?
- What are you not sure about with regard to oils?
- What do you want or need to know about oils?

During the discussion, issues are listed for investigation. The list can be divided into two parts: one of items for library and Internet research; and one of issues that can be investigated by carrying out experiments in class. One sample research activity and one sample experimental activity are outlined below.

▶ Students can research the physical properties of oils. The task should be quite specific — for example, for each oil researched, students find its chemical name, its uses, its boiling point, density and flammability.

Guided by the teacher, students share the data they have found. Discussion questions to guide students' reflection about patterns of change could include:

- What do you know about the way oils are transported?
- What happens when there is an accidental oil spill?
- What are the options for dealing with the spill?
- What are the consequences of the spill if it is not cleaned up?
- What are the consequences of the clean-up?
- Are there other ways that the spill could have been dealt with?

The most important property for the following experiment in Part 2 is the density of the oil. If students do not have this information, they should note, when carrying out experiments, whether an oil is heavier or lighter than water.

Part 2

▶ Some materials are provided for students to investigate why spills of oil on water are undesirable and how they can be cleaned up. Students organise groups so that each of the oils is tested with the range of clean-up techniques when they have been spilled on water. (Each group could test one oil with all the clean-up techniques, or each group could test all the oils with one clean-up technique.)

The aim of the experiment is to find out what effects the clean-up techniques have. All the groups need to have the same understanding of variables in the experiment, and need to follow the same procedure so that results can be compared between groups. Students need to agree on:

- which variables will change;
- which variables will be measured and how;
- which variables will be kept constant.

Students also need to record results in an agreed format so that they can share and compare data.

When students are writing about their conclusions from the experiment, they need to consider these questions:

- What options were explored in the experiments?
- What are the consequences of each clean-up technique?
- How do factors that affect the rate of reaction affect clean-up results? (Consider the methods that use oil dispersal versus those that use oil absorption.)
- Is there a range of practical alternative methods to consider when cleaning up oil spills?

Additional learning

▶ As a follow-up activity, students could make inquiries with the relevant authorities about the current clean-up practices used to deal with oil spills, and the current state of research into clean-up of oil spills. They can draw inferences from both their experimental and their research data.

Gathering information about student learning

Sources of information could include:

- anecdotal records of students' discussion about oils, their experiment planning, and their observations and reflections on the nature of changes involved when oils are spilled on water in the open air, and when they are cleaned up;
- the investigation process that students used;
- students' notes, their annotated illustrations, their collected data, the options they considered and the conclusions they drew.

ACTIVITY

Make and test your own indicator

Culminating

Focus

This activity provides opportunities for students to demonstrate their understanding of the pattern of interaction between an indicator and aqueous solutions.

Students design and perform an investigation in which they make, calibrate and use an indicator to establish the pH of household solutions.

Materials

For each student:

- notes and data from earlier activities related to acids and pH
- water
- beaker
- heat source
- mortar and pestle
- a large quantity of petals from the same kind of flower (red or purple ones usually give good results)
- tea bags
- red cabbage
- a selection of commercial indicators
- universal indicator
- test tubes and rack
- 0.1 M hydrochloric acid
- 1 M sodium hydroxide
- 0.1 M acetic acid
- 1 M sodium bicarbonate

Teaching considerations

Concepts

An understanding of the following patterns is required in this activity:

- acid–base reactions;
- indicator changes.

Throughout the activity, guide students in reflection about the concepts and thinking processes they have developed. Level 5 students will be able to explain the effect of varying the concentrations of their indicator solution and the test solutions.

Practical points

The materials listed are suggestions only. Discuss choices of materials with the students, particularly the household materials.

This is a largely independent activity. It can be done alone or in groups, depending on the type of evidence required of the student to demonstrate the outcome.

Working scientifically

Time: 60 minutes

Designing and performing experiments
Hypothesising
Looking for patterns and meanings
Predicting
Making and judging observations
Dealing in an orderly manner with the parts of a complex whole
Inferring from data

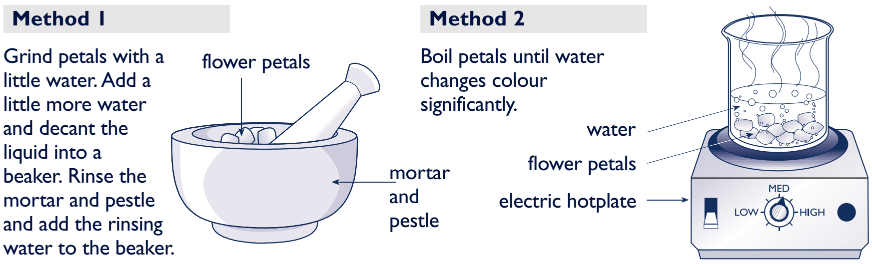
▶ With the teacher's guidance, students discuss their earlier investigation of pH, using universal indicator. Discussion questions could include:

- What property of the solution does pH measure?
- What does a low pH indicate?
- What is the pH of a neutral solution?
- What pH range signifies alkaline solutions?
- What are some everyday uses of indicators?

▶ Students are then given the following task:

- make an indicator;
- find out what colour it turns in standard laboratory solutions — for example, hydrochloric acid, water and sodium hydroxide;
- assess the pH of the standard solutions using universal indicator;
- compare the colours of their new indicator with the colours that universal indicator shows when added to the same solutions;
- use the new indicator to establish the pH of some household solutions.

Students can make their indicator from flower petals, cabbage leaves, tea bags or mixes of commercially available indicators. Each kind of indicator will require a different approach to its manufacture.



Making an indicator from flower petals

▶ Students should discuss their plans for the manufacture and testing of their indicators and submit them to the teacher for a response before they put the plans into action. They document their work for assessment according to guidelines that the teacher considers appropriate to their experience. A criteria sheet detailing how the investigation will be assessed is essential.

Gathering information about student learning

Sources of information could include:

- anecdotal records of students' discussion about pH and indicators, of their experiment plans and observations, and of their reflections on the patterns of pH and the nature of changes involved in using indicators;
- the investigation processes that students use;
- students' documentation of their work.

ACTIVITY

Place an unknown metal in an activity series

Culminating

Focus

This activity provides opportunities for students to demonstrate their understanding of the patterns of metal activity by placing copper in its position in the series already identified (see 'Metals: The activity series', page 24).

Students observe metal–salt reactions and gather evidence about copper to decide where to place it in the series of metals tested.

Materials

For each group of students:

- freshly made solutions of:
  - zinc nitrate
  - ferric nitrate
  - lead nitrate
  - magnesium nitrate
  - copper nitrate
- for each salt solution, 6 test tubes in a test-tube rack
- magnesium
- zinc
- steel wool
- lead
- copper
- planning and reporting worksheets (see the sourcebook guidelines, Appendix 3)

Teaching considerations

Concepts

Throughout the activity, guide students in reflection about the concepts and thinking processes they have developed. Level 5 students will be able to make inferences from their data about factors affecting the rate of reaction.

Practical points

The pieces of metals used in the activity should have clean, shiny surfaces of similar area.

Copper is used as the test metal in this activity because its pink colour makes it easy to distinguish from other grey metals.

Solutions must be freshly made. Concentrations should be decided by pre-testing to make sure that readable results will be obtained in an appropriate time span.

The activity could be done alone or in groups, depending on the type of evidence required of the student to demonstrate the outcome.

Working scientifically

Time: 60 minutes

Designing and performing experiments
Looking for patterns and meanings
Making and judging observations
Making and judging deductions
Explaining ideas and decisions

▶ The teacher leads students in a review of the earlier activity, 'Metals: The activity series' (p. 24). Discussion questions could include:

- Which metals are likely to be found as pure metals in the natural state?
- Why do you think this is so?
- Why do you think other metals are not found naturally in a pure state?
- If two positive ions, each one from a different metal, compete for one negative ion in solution, which one do you expect will be successful?
- What will happen to the unsuccessful metal ion?

▶ Students design an experiment that will use the materials provided to identify the position of copper in the metal activity series. They may find the planning and reporting worksheets in the sourcebook guidelines useful.

Students record their plans, their observations, their conclusions, and the evidence supporting their choice of the position of copper in the series. Questions to assist students in drawing conclusions include:

- Which metals did the copper displace?
- Which metals did it not displace?
- What can you deduce from this?
- What were the factors affecting the rate of reactions in your investigation?
- What measures did you take to ensure a fair test?

Gathering information about student learning

Sources of information could include:

- anecdotal records of students' discussion and inferences from earlier data, their experiment plans and observations, and their reflections on the order of the metals;
- students' records of their plans, conclusions and the evidence to support their decisions;
- the investigation process that students use.

Useful tables

Extract from the Periodic Table of the Elements — rows 1 to 6

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 xPo	85 At	86 Rn

↑ Lanthanides 57–71

Al	aluminium	Cl	chlorine	I	iodine	N	nitrogen
Ag	silver	Cu	copper	K	potassium	Na	sodium
Ba	barium	Fe	iron	Mg	magnesium	O	oxygen
Ca	calcium	H	hydrogen	Mn	manganese	Zn	zinc
C	carbon						

Solubility reference table

	NO_3^+ nitrate	Cl^- chloride	OH^- hydroxyl	$SO_4^=$ sulfate	$CO_3^=$ carbonate
Na^+ sodium	✓	✓	✓	✓	✓
K^+ potassium	✓	✓	✓	✓	✓
Ba^{++} barium	✓	✓	✓		
Cu^{++} copper	✓	✓		✓	
Ca^{++} calcium	✓	✓			
Pb^{++} lead	✓				
Ag^{++} silver	✓				

✓ indicates the salt of the metal is soluble

Calcium and sodium in water: Teacher demonstration

Safety *Great heat is generated in these reactions, but in the volume of water used, the temperature change is minimised. Sodium and calcium must be handled with the appropriate implements. Follow the recommendations for disposal provided in the Material Safety Data Sheets.*

Materials

- a piece of calcium
- a piece of sodium
- tongs
- sharp knife
- 2 x 100 mL beakers
- 2 L beaker
- safety glasses
- water
- mercury thermometer
- phenolphthalein
- white background for beaker

Method

The properties of calcium

1. Using tongs and a sharp knife, cut the piece of calcium to reveal a fresh surface for students to observe.

2. Put about 30 mL of water into a 100 mL beaker. Note the temperature of the water.

3. Place the beaker against a white background.

4. Using tongs and a sharp knife, cut a small piece of calcium no larger than a green pea.

5. Using tongs, place the small piece of calcium in the middle of the water in the beaker and allow students to observe what happens.

6. After the calcium has reacted for a minute or more, take the temperature of the liquid in the beaker.

7. Place a few drops of phenolphthalein in a small amount of water in the other 100 mL beaker.

8. Place this beaker against the white background so that students can see the colour of the solution. (Phenolphthalein is colourless below pH 8.)

9. Add the colourless solution of phenolphthalein and water to the solution remaining in the other beaker after the calcium has reacted with the water. Students take note of the colour change.

The properties of sodium

10. Using tongs and a sharp knife, cut the piece of sodium to reveal a fresh surface for students to observe.

11. One-third fill the 2 L beaker with water. Note the temperature of the water.

12. Place the beaker against a white background.

13. Using tongs and a sharp knife, cut a small piece of sodium no larger than a green pea.

14. Using paper towel, wipe as much paraffin as possible from the small piece of sodium so that it reacts quickly.

15. Using tongs, place the small piece of sodium in the middle of the water in the beaker and allow students to observe what happens.

16. After the vigorous reaction has slowed down significantly, take the temperature of the liquid in the beaker.

17. Repeat steps 11–15, adding a few drops of phenolphthalein to the water before adding the sodium. Students take note of the colour change.

Dry ice: Teacher demonstration

R3

Resource Sheet 3

Materials

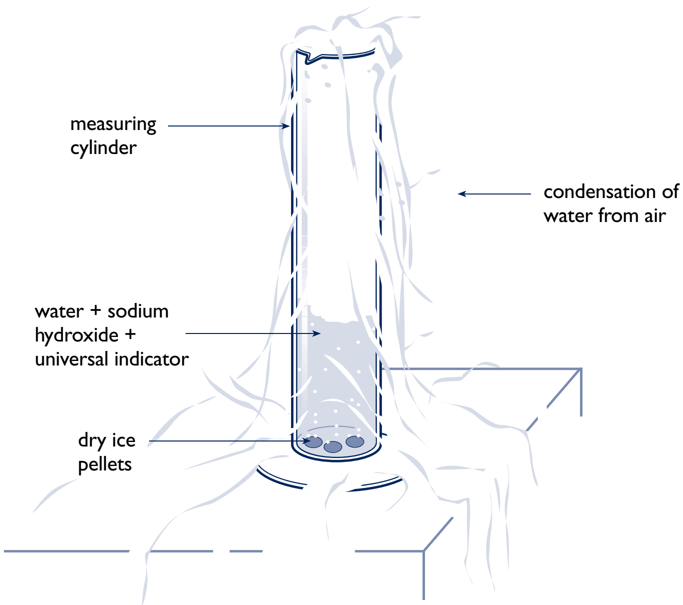
- 3–5 L measuring cylinder
- tongs
- water
- 1 M sodium hydroxide
- universal indicator (liquid and tape)
- pellets of dry ice kept in double insulation
- white background
- detergent (optional)

Method

1. One-third fill the measuring cylinder with water.
2. Add a few drops of universal indicator.
3. Add some dilute sodium hydroxide to give the solution a pH in the extremely alkaline range (as shown by the colour of the indicator).
4. Using tongs, add pellets of dry ice slowly until the colour of the solution cannot be altered by adding more dry ice.

Optional

5. Adding some detergent along with the universal indicator (and before the dry ice) will generate suds. The suds rise up the measuring cylinder, providing a different focus for discussion.



Testing for gases with a taper

R4 Resource Sheet 4

*Some reactions appear vigorous, but only slowly generate enough gas to register a positive test. A stopper placed lightly in the mouth of the test tube (**NOT** inserted tightly) increases the amount of gas retained in the test tube. Pre-test to see which reactions need more time to generate enough gas to test.*

Materials

For each group of students:

- 3 small test tubes and test-tube rack
- 3 cm of magnesium ribbon
- 1 M hydrochloric acid
- 3% hydrogen peroxide (6% if not freshly opened)
- matches
- taper
- manganese dioxide (catalyst)
- marble chips

Method

Generating and testing hydrogen

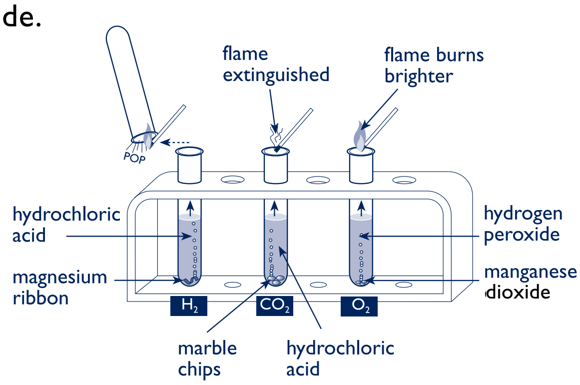
1. In the first test tube, place the 3 cm piece of magnesium and add about 10 mL of hydrochloric acid.
2. Using an inverted test tube, collect the hydrogen that is given off. Bring a lit taper to the mouth of the test tube, keeping the test tube in the inverted position. The hydrogen makes a squeaky pop as it explodes.

Generating and testing carbon dioxide

3. In the next test tube, place some marble chips and add about 10 mL of acid.
4. When the reaction has bubbled vigorously bring a lit taper to the mouth of the test tube. The carbon dioxide produced by the reaction extinguishes the flame.

Generating and testing oxygen

5. In the last test tube, place some manganese dioxide (an amount comparable to 2–3 rice grains).
6. Add about 10 mL of hydrogen peroxide.
7. When the reaction has bubbled vigorously, bring the lit taper to the mouth of the test tube. Oxygen will cause it to burn brighter.
8. From a safe distance, blow out the flame and immediately put the glowing end of the taper into the top of the test tube. Oxygen will relight it.



PATTERNS OF INTERACTIONS • LOWER SECONDARY

Practising patterns

Resource Sheet 5

Salts of acids

Acid	Salt
tartaric acid	tartrate
citric acid	citrate
acetic acid	acetate
carbonic acid	carbonate
hydrochloric acid	chloride
iodic acid	iodide
phosphoric acid	phosphate
sulfurous acid	sulfite
sulfuric acid	sulfate
nitrous acid	nitrite
nitric acid	nitrate

Ions associated with acids

tartaric acid → hydrogen ion + tartrate ion

citric acid → _______________ ion + _______________ ion

acetic acid → _______________ ion + _______________ ion

hydrochloric acid → _______________ ion + _______________ ion

sulfuric acid → _______________ ion + _______________ ion

Ions associated with alkalis

sodium hydroxide → sodium ion + hydroxyl ion

potassium hydroxide → _______________ ion + _______________ ion

barium hydroxide → _______________ ion + _______________ ion

calcium hydroxide → _______________ ion + _______________ ion

(continued)

Practising patterns *(continued)*

R5 Resource Sheet 5

Ions associated with neutralisation

acid + base ⟶ salt + water

hydrochloric acid + sodium hydroxide ⟶ hydrogen ion + chloride ion + sodium ion + hydroxyl ion

⟶ sodium ion + chloride ion + water

hydrochloric acid + potassium hydroxide ⟶ __________ + __________ + __________ + __________

⟶ __________ __________ + water

Ions associated with salts

sodium iodide ⟶ _______________ ion + _______________ ion

sodium carbonate ⟶ _______________ ion + _______________ ion

sodium sulfate ⟶ _______________ ion + _______________ ion

potassium nitrate ⟶ _______________ ion + _______________ ion

potassium iodide ⟶ _______________ ion + _______________ ion

lead nitrate ⟶ _______________ ion + _______________ ion

barium nitrate ⟶ _______________ ion + _______________ ion

Why would copper carbonate not be included in this list?

____

____

____

____

____

Indicating pH 1–14

R6 Resource Sheet 6

Materials

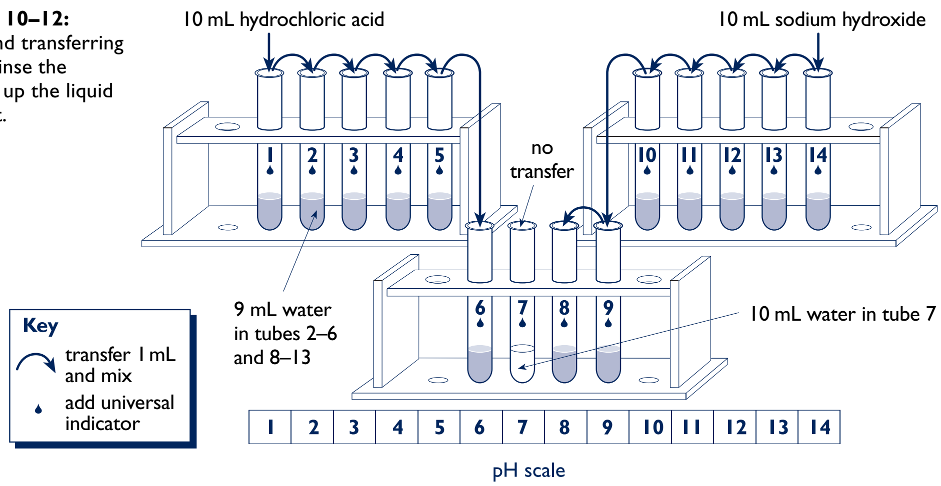
For each group of students:

- 14 test tubes in test-tube racks
- universal indicator, both liquid and tape
- 0.1 M hydrochloric acid
- 1 M sodium hydroxide
- 1 mL measuring dropper
- 10 mL measuring cylinder
- distilled water

Method

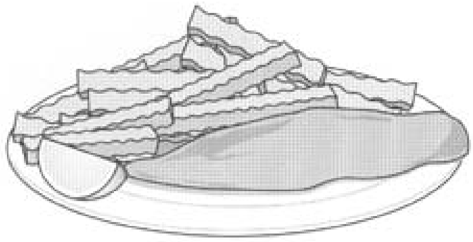
1. Number test tubes from 1 to 14 and put in order in racks, starting from the left.
2. To test tubes 2–6 and 8–13 add 9 mL of water. To test tube 7, add 10 mL of water.
3. To all test tubes, add a drop of universal indicator.
4. To test tube 1, add 10 mL of hydrochloric acid.
5. From test tube 1, take 1 mL of hydrochloric acid, add it to test tube 2 and mix.*
6. From test tube 2, take 1 mL of the mixed acid, add it to the next test tube and mix.
7. Repeat the process until 1 mL of acid has been taken from tubes 1 to 5 in order and added to tubes 2–6. This means that each of test tubes 2–6 contains a 1 in 10 dilution of the acid in the previous tube.
8. Do not add anything to test tube 7 other than water.
9. To test tube 14, add 10 mL of sodium hydroxide.
10. From test tube 14, take 1 mL of sodium hydroxide, add it to test tube 13 and mix.
11. From test tube 13, take 1 mL of the mixed sodium hydroxide, add it to test tube 12 and mix.
12. Repeat the process until 1 mL of sodium hydroxide has been taken from tubes 14–9 in order and added to tubes 13–8.
13. Note the colour of the solution in each test tube.
14. Discuss the main pattern evident in the range of colours.

* **For steps 5–7 and 10–12:** Before measuring and transferring the 1 mL amounts, rinse the dropper by drawing up the liquid and then expelling it.



Characteristics of oils: Interview about instances

Resource Sheet 7



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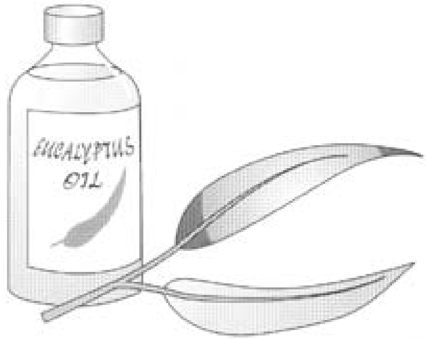

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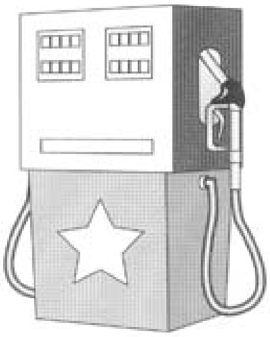

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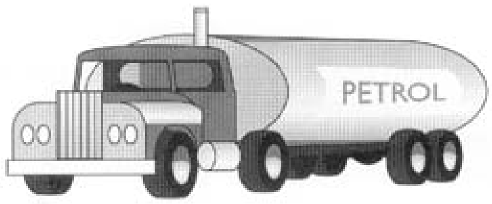

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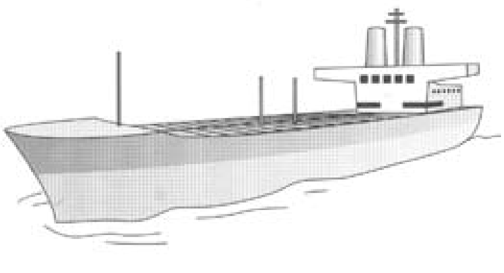

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This sourcebook module should be read in conjunction with the following Queensland School Curriculum Council materials:

Years 1 to 10 Science Syllabus
Years 1 to 10 Science Sourcebook: Guidelines
Science Initial In-service Materials

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