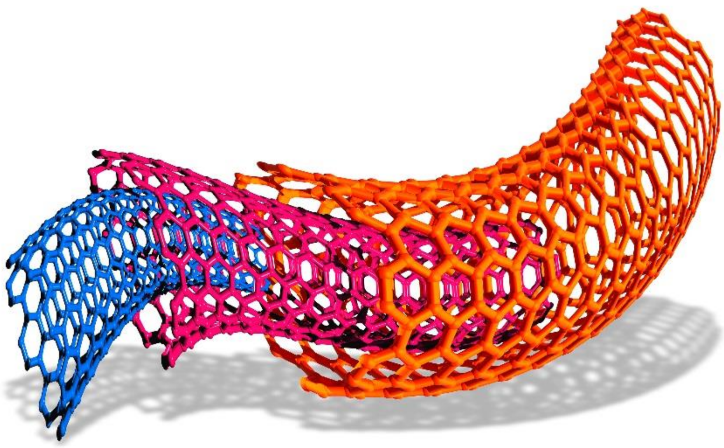
Cambridge Assessment International Education

Teaching Pack

Types of oxides – reactions with acids and bases

Cambridge IGCSE™ Chemistry 0620

This Teaching Pack can also be used with the following syllabuses:
- Cambridge IGCSE™ (9–1) Chemistry **0971**
- Cambridge IGCSE™ Chemistry (US) **0439**
- Cambridge IGCSE™ Combined Science **0653**
- Cambridge IGCSE™ Co-ordinated Sciences (Double Award) **0654**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge IGCSE™ Physical Science **0652**
- Cambridge O Level Chemistry **5070**
- Cambridge O Level Combined Science **5129**



Version 2.0

Cambridge Pathway

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Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1: run the experiment	**Option 2: virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases this also includes the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Types of oxides – reactions with acids and bases

This *Teaching Pack* focuses on soluble oxides that dissolve in water to form acidic, basic or amphoteric solutions. These solutions can then become involved in a neutralisation reaction, which involves moving the pH of the solution towards pH 7.

pH is usually measured using pH paper/Universal Indicator solution and the pH scale, which classifies solutions as acidic, basic or neutral.

This experiment has links to the following syllabus content (see syllabus for detail):

- 7.2 Oxides

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- make and record observations
- interpretation of experimental observations
- plan experiments and investigations, including equipment selection
- evaluate methods and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 7.1 The characteristic properties of acids and bases

Going forward

The knowledge and skills gained from this experiment will be useful for when you introduce learners to pollutant gases and their effects on global warming.

Briefing lesson: Planning the experiment

Resources	• Worksheets A, B, C, D, E and G
Learning objectives	By the end of the lesson: • ***all*** learners should have completed the planning sections of their experimental report. • ***most*** learners should have detailed information in the planning sections of their experimental report. • ***some*** learners will have compared their experimental set-up to the ideal and have made adjustments.

Timings	Activity
10 min	**Starter/Introduction** Start with a formative assessment activity to assess some of the following prior learning points: neutrality and relative acidity and alkalinity in terms of pH measured using Universal Indicator paper (whole numbers only), describe the meaning of weak and strong acids and bases, describe the characteristic properties of acids as reactions with metals, bases, carbonates and effect on litmus and describe the characteristic properties of bases as reactions with acids and its effect on litmus.
10 min	**Loop game** (whole class) Print out Worksheet A and cut out the individual cards containing a question and answer (these could be printed out and laminated). 1. Divide the class into groups of four and give each group **three** of the cards. 2. Ask one group to start the game by having one group member ask the question on their card. 3. The rest of the class has to check their own card to see if they get the correct answer on their card. 4. The group who has the correct answer on their card has one group member to read out the answer. 5. The group member then reads out the question on the lower half of the card. 6. The game continues until all questions are asked and answered.
30 min	**Main lesson** Divide learners into groups of four (they will stay in these groups for all activities) and give them the following background information: *Soluble oxides can dissolve in water to form acidic, basic or amphoteric solutions. These solutions can then become involved in neutralisation reactions, which involve moving the pH of these solutions towards 7.* Explain to learners that in these experiments they will explore the changes in pH that occur when soluble metal oxides (metal oxide and water solutions) are reacted with an acid and also when soluble non-metal oxides gases are reacted with a base (alkali). Learners should be given Worksheet B and Worksheet C to help scaffold their learning. Ask the learners to come up with, in their group, the two aims of the experiment. Then get learners to discuss, within their group what are the important variables involved in this experiment. They should record this on Worksheet C. *Continues on next page …*

Timings	Activity
	Ask learners to discuss, within their group, what equipment they would choose and how they would set it up. They should use Worksheet D to help with this. Remind them they will not need to use all of the equipment, and they need to think about reagents and other tests that might be needed. You should display all of the equipment required to carry out the experiments at the front of the class so learners can come and have a look. They must remember to accurately draw their equipment set-up, which should be annotated. Important questions they need to consider • How will volumes be measured out? • How will pH values be worked out? Learners should be told that soluble metal oxide solutions will be supplied and that non-metal oxides will be produced from a series of reactions that must take place within a fume cupboard. At this stage access to the experimental method(s) Worksheet G may be helpful. It is important that the teacher offers guidance during this phase, as the production of the three non-metal oxide gases needs to be controlled.
10 min	**Plenary** Give the learners the experimental set-up for the two parts of the experiment: neutralisation reactions involving metal and non-metal oxides. (Worksheet G). Ask learners to compare their illustrations with and get them to identify similarities and differences. Get the learners to adjust their experimental set-up in Worksheet D.

Lab lesson: Option 1 – run the experiment

Resources

- Teacher notes
- *Teacher Walkthrough video*
- Worksheets E, G and H
- Equipment as outlined in the notes

Learning objectives

By the end of the lesson:

- ***all*** learners should be able to carry out reactions involving metal and non-metal oxides.
- ***most*** learners should be able to generate and record data from their experiments.
- ***some*** learners will be able to start to evaluate the data from their experiments.

<table>
<tr><th>Timings</th><th>Activity</th></tr>
<tr><td>5 min

5 min</td><td>Starter/Introduction
Start by giving learners some general instructions. Learners should be in the same groups as they were for the briefing lesson. Within these groups they should quickly decide which pair will carry out the reactions of metal oxide and water solutions with an acid and which pair the reactions of non-metal oxide gases with a base (alkali).

Give out Worksheet E, Worksheet G and Worksheet H to each learner. Tell them the approximate timings for each part of the experiment:
preparation (10 min)
testing and results (20 min)
clean-up (10 min).
You could project these timings on the board at the front of the class.

Before learners start their experiments, ensure that they are all wearing fastened lab coats. They should also wear goggles throughout the experiment and learners with long hair should tie it up safely. Remind learners about spillages and the safe movement around the lab.</td></tr>
<tr><td>10 min

20 min</td><td>Main lesson
Preparation
Learners should use Worksheet G to allow them to collect the correct materials and equipment.

Testing and results
Learners should follow the appropriate method on Worksheet E.

Safety
Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate. Additionally, the following safety point should be noted and the learners warned as appropriate: the reactions of non-metal oxide gases with a base MUST take place in a fume cupboard.

Remind learners that they need to use the pH scale provided. Alternatively, the teacher could project a pH scale onto the board.
Continues on next page …</td></tr>
</table>

Timings	Activity
10 min	All group members should use Worksheet H to record the results for their group. *Clean-up* Make sure that the learners tidy up after themselves, clean up any bench spills, empty the contents of their test-tubes and empty their 'chemical waste' into a 'chemical waste' bottle or down the sink. Finally, they should wash their hands.
10 min	**Plenary** Ask learners to complete the sections in Worksheet H covering the conclusion and evaluation. The suggested answers can be used as guidance if required.

Teacher notes

Watch the *Teacher Walkthrough video* for types of oxides and read these notes.

Each group will require:

Part 1 – Reaction of metal oxide and water solutions with an acid:

- 3 × 100 cm^3 beakers
- sticky labels for beakers
- labelled 'potassium oxide and water' solution [potassium hydroxide solution 0.2 mol/dm^3]
- labelled 'sodium oxide and water' solution [sodium hydroxide solution 0.2 mol/dm^3]
- labelled 'lithium oxide and water' solution [lithium hydroxide solution 0.2 mol/dm^3]
- 200 cm^3 of hydrochloric acid [0.1 mol/dm^3]
- magnetic hot plate
- Universal Indicator solution
- 5 cm^3 syringe
- 50 cm^3 measuring cylinder
- small magnetic flea
- pH scale (coloured and laminated).

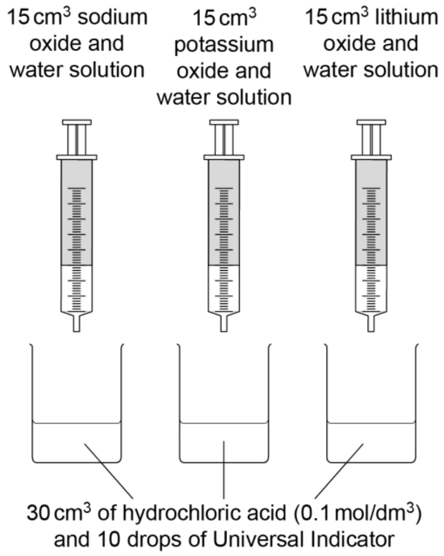
Part 2 – Reaction of soluble non-metal oxides with a sodium hydroxide (alkali) base:

- 10 cm^3 of sodium hydroxide [0.01 mol/dm^3]
- Universal Indicator
- solid sodium nitrite
- solid sodium carbonate (or hydrogen carbonate)
- 10 cm^3 of hydrochloric acid [1 mol/dm^3]
- solid sodium hydrogen sulfate
- test-tube rack
- 2 × 5 cm^3 syringes (one labelled HCl and the other NaOH)
- 1 × 10 cm^3 syringe with 18 cm^3 PVC tubing (or rubber tubing) for gas extraction
- 6 × small test-tubes
- 3 × test-tube bungs
- spatula
- sticky labels
- access to a fume cupboard*
- pH scale (coloured and laminated)

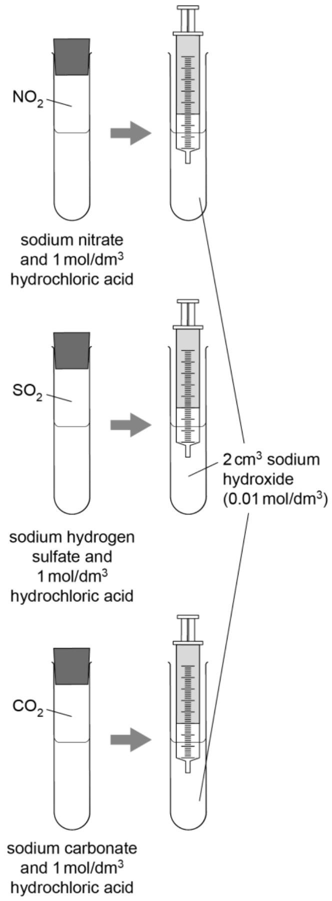
**if no fume cupboard is available; this part of the experiment should be done virtually by watching the video.*

Experiment set-up

1. Reaction of metal oxide and water solutions with acids



2. Reaction of non-metal oxides with alkalis



Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
Sodium carbonate (solid)	 GHS07 (*moderate hazard* **MH**)	**In the eye:** flood the eye with gently-running tap water for at least 10 min. See a doctor. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Dust breathed in:** remove the casualty to fresh air. See a doctor if breathing is difficult. **Spilt on the skin or clothing:** remove contaminated clothing and rinse it. Wash off the skin with plenty of water. **Spilt on the floor, bench, etc.:** scoop up solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Sodium nitrite (solid – also known as sodium nitrate(III))	 GHS03 (*oxidising* **O**)  GHS09 (*hazardous to the aquatic environment* **N**)  GHS06 (*acutely toxic* **T**)	**In the eye:** flood the eye with gently-running tap water for at least 10 min. See a doctor. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Dust breathed in:** remove the casualty to fresh air. See a doctor if breathing is difficult. **Spilt on the skin or clothing:** remove contaminated clothing and rinse it. Wash off the skin with plenty of water. **Spilt on the floor, bench, etc.:** scoop up solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Dilute hydrochloric acid [0.1 mol/dm^3] [0.5 mol/dm^3] [1.0 mol/dm^3]	 GHS07 (*moderate hazard* **MH**) [below a concentration of 2.7 mol/dm^3]	**In the eye:** flood the eye with gently-running tap water for 10 min. See a doctor. **Vapour breathed in:** Remove to fresh air. Call a doctor if breathing is difficult. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** remove contaminated clothing, then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.

Substance	Hazard	First aid
		Spilt on the floor, bench, etc.: for large spills, and especially for (moderately) concentrated acid, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water. Wipe up small amounts with a damp cloth and rinse it well.
Sodium hydrogen sulfate (solid)	LOW HAZARD	**In the eye:** flood the eye with gently-running tap water for at least 10 min. See a doctor. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Dust breathed in:** remove the casualty to fresh air. See a doctor if breathing is difficult. **Spilt on the skin or clothing:** remove contaminated clothing and rinse it. Wash off the skin with plenty of water. **Spilt on the floor, bench, etc.:** scoop up solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Dilute potassium hydroxide solution [0.2 mol/dm^3]	 GHS05 (*corrosive* **C**)  GHS07 (*moderate hazard* **MH**)	**In the eye:** flood the eye with gently-running tap water for at least 20 min. See a doctor. If a visit to hospital is necessary, continue washing the eye during the journey in an ambulance. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. **Spilt on the floor, bench, etc.:** wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated solutions, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with citric acid. Rinse with plenty of water.

Substance	Hazard	First aid
Dilute lithium hydroxide solution [0.2 mol/dm^3]	 GHS05 (*corrosive* **C**)  GHS07 (*moderate hazard* **MH**)	**In the eye:** flood the eye with gently-running tap water for at least 20 min. See a doctor. If a visit to hospital is necessary, continue washing the eye during the journey in an ambulance. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. **Spilt on the floor, bench, etc.:** wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated solutions, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with citric acid. Rinse with plenty of water.
Dilute sodium hydroxide solution [0.01 mol/dm^3] [0.2 mol/dm^3]	 GHS05 (*corrosive* **C**)  GHS07 (*moderate hazard* **MH**)	**In the eye:** flood the eye with gently-running tap water for at least 20 min. See a doctor. If a visit to hospital is necessary, continue washing the eye during the journey in an ambulance. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. **Spilt on the floor, bench, etc.:** wipe up small amounts with a damp cloth. For larger amounts, and especially for (moderately) concentrated solutions, cover with mineral absorbent (e.g. cat litter). Neutralise with citric acid.

Teacher method

This is your version of the method for this experiment that accompanies the teacher video.

Do not share this method with learners. Give them Worksheet D.

Before you begin
Plan how you will group your learners during the experiment.

Think about:
- the number of groups you will need (group size 2–4 learners)
- the amount of equipment/chemicals required.

Experiment
Circulate during the experiment in case learners encounter any difficulties.

Part 1: Reaction of metal oxide and water solutions with an acid

Steps	Notes
1. Learners should collect all the equipment they need from the front of the class.	
2. They should label the three beakers: ‘potassium oxide and water’, ‘sodium oxide and water’ and ‘lithium oxide and water’.	
3. Learners should measure out 30 cm^3 of 0.1 mol/dm^3 hydrochloric acid using a measuring cylinder and add this to the beaker labelled, ‘potassium oxide and water’.	*Remind learners to measure the liquid out accurately. Their eyes should be horizontal to the measuring cylinder and the volume should be read from the bottom of the meniscus.*
4. Learners need to repeat this procedure for the ‘sodium oxide and water’ and ‘lithium oxide and water’ beakers.	
5. Learners then add ten drops of Universal Indicator to each beaker, note the colours, and use the pH scale to turn these into pH numbers. The pH numbers should be recorded in their results table.	
6. Learners should add a magnetic stirrer to the beaker labelled ‘potassium oxide and water’, place the beaker on the magnetic hot-plate and gently stir.	*Remind learners to make sure the heating function of the hot plate is off. Also, if not hot plate stirrer is available; a stirring rod can be used.*

7. Using a clean 5 cm^3 syringe, learners should measure out and transfer 15 cm^3 of the 'potassium oxide and water' solution to the hydrochloric acid in the beaker marked 'potassium oxide and water'.

   Remind the learners to measure the liquid out accurately. Their eyes should be horizontal to the syringe and the volume should be read from the bottom of the syringe plunger.

8. Learners should record the pH once all of the 'potassium oxide and water' solution has been added to the beaker.

9. Learners now wash out the 5 cm^3 syringe with water so that it can be reused.

   Remind learners that this is to stop cross-contamination between alkali solutions.

10. Learners need to repeat the same procedure for the other two 'metal oxide and water' solutions and fill in the results in their table.

Part 2: Reaction of soluble non-metal oxides with a sodium hydroxide (alkali) base

<u>**Steps**</u> / <u>**Notes**</u>

1. Learners should collect all the equipment they need from the front of the class.

   If the various syringes are not going to be labelled in advance, then get the learners to do this right at the start.

2. They should then label three test-tubes: NO_2, SO_2 and CO_2 and place these in a test-tube rack.

3. Using a 5 cm^3 syringe, learners need to measure out 2 cm^3 of 0.01 mol/dm^3 sodium hydroxide solution and transfer it into one of the test-tubes. This should be repeated so that all three test-tubes contain sodium hydroxide solution.

   Remind learners to measure the liquid out accurately. Their eyes should be horizontal to the syringe and the volume should be read from the bottom of the syringe plunger.

4. Learners need to add two drops of Universal Indicator to each test-tube and use the pH scale to record the pH numbers of each of the solutions, in a suitable table.

5. Learners should now move the test-tube rack into a fume cupboard.

   Remind learners that the next steps must take place in a fume cupboard.

   Producing NO_2 gas

6. In the fume cupboard, learners should add half a spatula of sodium nitrite to a small test-tube.

7. Using a syringe labelled 'HCl', learners should add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the test-tube.

   Remind learners to look out for effervescence and/or the formation of a brown gas in the test-tube.

Learners should immediately place a bung onto the test-tube.

8. After a few minutes, learners should remove the bung from the reaction test-tube and extract any brown gas formed using the 10 cm^3 syringe with the long tubing.

Run the reaction until brown NO_2 gas is visible.

9. Once the gas has been extracted, learners should place the tubing into the NaOH solution in the NO_2 labelled test-tube, and slowly bubble in all the brown gas.

10. Learners should now measure the pH of the sodium hydroxide solution and note the value down in their results table.

11. Before being used again, learners should dry the end of the tubing, as well as draw in and expel the air from the syringe a few times.

Remind learners to do this so that no gas remains in the syringe and tubing.

Producing SO_2 gas

12. Learners should add half a spatula of sodium hydrogen sulfate to a small test-tube.

13. Then they should use the syringe labelled 'HCl' to add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the reaction test-tube. Learners should immediately place a bung onto the reaction test-tube.

Learners should see bubbles of gas being produced. Remind them that SO_2 is a colourless gas.

14. Learners should repeat steps **8–11** for transferring all the gas and measuring the pH value of the sodium hydroxide solution, this time in the SO_2-labelled test-tube.

Producing CO_2 gas

15. Learners should add half a spatula of sodium carbonate to a test-tube.

16. Then they should use the syringe labelled 'HCl' to add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the reaction test-tube. Learners should immediately place a bung onto the reaction test-tube.

Learners should see bubbles of gas being produced. Remind them that CO_2 is a colourless gas.

17. Learners should repeat steps **8–11** for transferring all the gas and measuring the pH value of the sodium hydroxide solution, this time in the CO_2-labelled test-tube.

Clean-up

After the experiment learners should:

- clean all glassware
- tidy up their work space
- ensure any spillages have been mopped up
- empty their chemical waste into the main chemical waste bottle in a central location
- return all equipment and any unused chemicals to you
- wash their hands with soap and water.

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual Experiment video* for metal oxides • Worksheets F, G, H, K and L. • Suggested answers as appropriate
Learning objectives	By the end of the lesson: • ***all*** learners should be able to carry out reactions involving metal and non-metal oxides • ***most*** learners should be able to generate and record data from their experiments • ***some*** learners will be able to start to evaluate the data from their experiments.

Timings	Activity
15 min	**Starter/Introduction** Instruct learners that they need to have a look at their Worksheet C from the previous planning lesson to remind themselves of what they planned. Give out Worksheet F and Worksheet G so the learners can have a look at the experimental set-up and method before the *Virtual Experiment video* is shown. Get learners to complete the missing parts of the method for the experiment. Remind them it should be written like the instructions in a recipe, so that they can be repeated by someone else.
25 min 10 min	**Main lesson** Introduce the video by stating: 'Soluble oxides can dissolve in water to form acidic, basic or amphoteric solutions. These solutions can then become involved in neutralisation reactions, which involve moving the pH of a solution towards 7.0. Today you will explore the changes in pH that occur when metal oxide and water solutions are reacted with an acid, and non-metal oxides are reacted with a base (alkali)'. Tell the learners that by the end of the lesson they will have watched a video that will allow them to complete all of the sections in Worksheet F and Worksheet H. Learners need to fill in the results, conclusion and evaluation sections of Worksheet H as they watch the video. The suggested answers can be used for guidance if required.
10 min	**Plenary** Give out Worksheet K and Worksheet L to the learners and get them to complete the statements about the experiment and answer the questions on the theory and practice behind the experiment. They should use the information in their report, as well as a glossary from a textbook. Answers can be checked using the suggested answers.

Debriefing lesson: Analysing and evaluating a report

Resources	• Completed report of the experiment • Worksheets I and J • Suggested answers for Worksheet I • Sticky notes

Learning objectives	By the end of the lesson: • ***all*** learners should have finished their write-up of their experiment. • ***most*** learners should be able to evaluate and offer feedback on a scientific report. • ***some*** learners will be able to suggest improvements to a report marking scheme and possibly evaluate their own report.

Timings	Activity
10 min	**Starter/Introduction** Ask learners to complete and review their findings from the experiment – you may want to encourage them to share their findings with other learners.
15 min 20 min	**Main lesson** Ask the learners (in pairs or groups) to discuss the characteristics of a good scientific report. Get them to write out the suggestions and stick these onto one side of the classroom board using sticky notes. Use this as the focal point of a classroom discussion. They are likely to suggest things like: explains processes, uses clear language; writing is concise, uses technical language or presents data clearly. Give out Worksheet I, which is a marking scheme for a report. Give learners (in pairs or groups) a report to assess (Worksheet J) using the success criteria in the marking scheme. They should fill in Worksheet I as they go through the report. Once finished the learners can write out the main points they have found onto sticky notes and place them on the other side of the classroom board.
15 min	**Plenary** Discuss the deficiencies found within the report as a class. Use the sticky notes on the board as the focus for this activity. Learners can check their answers using the suggested answers provided. If time permits, learners can suggest improvements to the marking scheme.

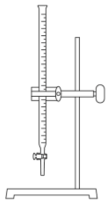
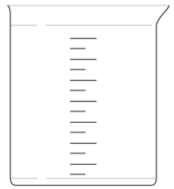
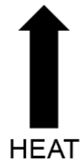
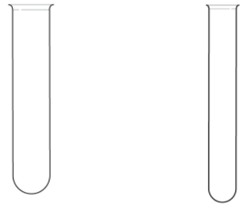
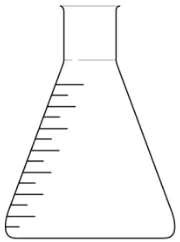
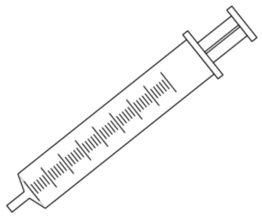
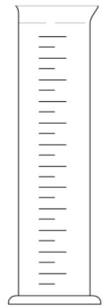
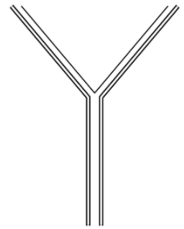
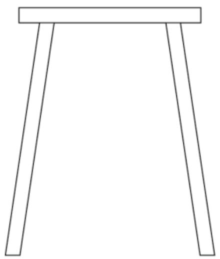
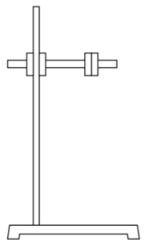
Worksheets and answers

Worksheet A: Acid/alkali loop game

START	*red*	*red cabbage*	*above 7*
What colour does Universal Indicator show in strong acid?	What everyday substance can be used to make an indicator?	What are the pH values of all alkaline substances?	Name a household substance that is neutral.
distilled water	*salt and water*	*oven cleaner*	*alkali*
What completes this reaction? acid + alkali → ?	Name a household substance that is strongly alkaline.	Is toothpaste an acid or alkali?	Indigestion tablets work by ……?
neutralising stomach acid	*corrosive*	*salt*	*vinegar*
What hazard is associated with acids and alkalis?	What is made when an acid is neutralised with a base?	Which is more acidic: soft drink or vinegar?	Acids have a pH …..?
below 7			
FINISH			

Worksheet B: Choosing the correct equipment

Here is a range of some common lab equipment.

			
burette	**beaker**	**a heat source**	**boiling-tube and test-tube**
			
conical flask	**syringe**	**measuring cylinder**	**filter funnel**
			
tripod	**thermometer**	**boss, clamp and stand**	**pipette**

Worksheet C: Experiment report – Introduction

Title	…………………………………………………………………………………………
Background information	………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………
Aims	**Aim 1:** ………………………………………………………………………………………… ………………………………………………………………………………………… **Aim 2:** ………………………………………………………………………………………… …………………………………………………………………………………………

Worksheet C: Experiment report – Introduction

Experimental variables	**Changed (independent) variables** …………………………………………………………………… …………………………………………………………………… **Measured (dependent) variables** …………………………………………………………………… …………………………………………………………………… **Fixed variables** …………………………………………………………………… ……………………………………………………………………
What will happen? (hypothesis)	…………………………………………………………………… ……………………………………………………………………

Worksheet D: Your experiment set-up and method

Materials and method: In the space provided, draw your experiment set-up. Make sure you annotate your diagram showing the decisions you have made.

Experimental set-up – part 1

Worksheet D: Your experiment set-up and method

Experimental set-up – part 2

Worksheet E: Method

Part 1: Reaction of 'metal oxide and water' solutions with acid

1. Collect all your equipment from the front of the class.
2. Label three beakers, 'potassium oxide and water', 'sodium oxide and water' and 'lithium oxide and water'.
3. Using a measuring cylinder, measure out 30 cm^3 of 0.1 mol/dm^3 hydrochloric acid and add to the beaker labelled, 'potassium oxide and water'.

Remember to measure the liquid out accurately. Your eyes should be horizontal to the measuring cylinder and read from the bottom of the meniscus.

4. Repeat this same procedure with the 'sodium oxide and water' and 'lithium oxide and water' beakers.
5. Add ten drops of Universal Indicator to each beaker, note the colours, and use the pH scale to turn these into pH numbers. Record these pH numbers in your results table.
6. Add a magnetic stirrer to the beaker labelled 'potassium oxide and water', place on the magnetic hot-plate and gently stir.

Make sure the heating function of the hot plate is turned off. If you don't have a magnetic hot-plate, use a stirring rod.

7. Use a clean 5 cm^3 syringe to measure out and transfer 15 cm^3 of the 'potassium oxide and water' solution to the hydrochloric acid (HCl) in the beaker marked 'potassium oxide and water'.

Make sure that the volume in the syringe is read from the bottom of the plunger.

8. Record the pH once all of the 'potassium oxide and water' solution has been added to the beaker.

9. Wash out the 5 cm^3 syringe with water so that it can be reused.

Remind the learners that this is to stop cross-contamination between alkali solutions.

10. Repeat the same procedure for the other two 'metal oxide and water' solutions and fill in the results into your table.

Worksheet E: Method

Part 2: Reaction of non-metal oxides with a sodium hydroxide (alkali) base

1. Collect all your equipment from the front of the class.
2. Label three test-tubes: NO_2, SO_2 and CO_2 and place these in a test-tube rack.
3. Using the 5 cm^3 NaOH-labelled syringe, measure out 2 cm^3 of 0.01 mol/dm^3 sodium hydroxide solution and transfer it into one of the test-tubes. Repeat this so that all three test-tubes contain the sodium hydroxide solution.
4. Add two drops of Universal Indicator to each test-tube and use the pH scale to record the pH numbers of each of the solutions, in a suitable table.
5. Move the test-tube rack into a fume cupboard.

Carry out the next steps in a fume cupboard.

Producing nitrogen dioxide (NO_2) gas

6. In a fume cupboard, add half a spatula of sodium nitrite to a small test-tube.
7. Using a HCl-labelled syringe, add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the test-tube. Immediately place a bung onto the test-tube.

You should see bubbles of gas being produced or that a brown gas is formed.

8. After a few minutes, take the bung off the reaction test-tube and extract any brown gas formed using the 10 cm^3 syringe with the long tubing.
9. Once the gas has been extracted, place the tubing into the NaOH solution in the NO_2 labelled test-tube, and slowly bubble in all the brown gas.
10. Once (all) the gas has been added withdraw the tubing.
11. Measure the pH of the sodium hydroxide solution and note the value down in your results table.
12. Before using again, dry the end of the tubing, as well as draw in and expel air from the syringe a few times.

Producing sulfur dioxide (SO_2) gas

13. Add half a spatula of sodium hydrogen sulfate to a small test-tube.
14. Use the HCl-labelled syringe to add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the reaction test-tube. Immediately place a bung onto the reaction test-tube.

You should see bubbles of gas being produced. Sulfur dioxide is a colourless gas.

15. Repeat the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution-this time in the SO_2-labelled test-tube.

Producing carbon dioxide (CO_2) gas

16. Add half a spatula of sodium carbonate to a test-tube.
17. Use the HCl-labelled syringe to add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the reaction test-tube. Immediately place a bung onto the reaction test-tube.

You should see bubbles of gas being produced. Carbon dioxide is a colourless gas.

18. Repeat the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution-this time in the CO_2-labelled test-tube.

Worksheet F: Your method (part 1)

Method: Watch the virtual experiment video and fill in the gaps to the method.

Part 1: Reactions of 'metal oxide and water' solutions with an acid

1. Label three beakers, 'potassium oxide and water', 'sodium oxide and water' and 'lithium oxide and water'.

2. ………………………………………………………………………………………………………

………………………………………………………………………………………………………

3. Repeat this same procedure with the 'sodium oxide and water' and 'lithium oxide and water' beakers.

4. Add ten drops of Universal Indicator to each beaker, note the colours, and use the pH scale to record the pH numbers.

5. ………………………………………………………………………………………………………

………………………………………………………………………………………………………

6. Transfer 15 cm^3 of the 'potassium oxide and water' to the HCl in the beaker marked 'potassium oxide and water'.

7. ………………………………………………………………………………………………………

………………………………………………………………………………………………………

8. ………………………………………………………………………………………………………

………………………………………………………………………………………………………

9. Repeat the same procedure for the other two 'metal oxide and water' solutions and record the results.

Worksheet F: Your method (part 2)

Method: Watch the virtual experiment video and fill in the gaps to the method.

Part 2: Reactions of non-metal oxides with a base (alkali)

1. Label three test-tubes: NO_2, SO_2 and CO_2 and place these in a test-tube rack.

2. ……

……

3. Add two drops of Universal Indicator to each test-tube and use the pH scale to record the pH numbers of each of the solutions.

4. Move the test-tube rack into a fume cupboard.

***********************Carry out the next steps in a fume cupboard***********************

Producing nitrogen dioxide (NO_2) gas

5. Add half a spatula of sodium nitrite to a small test-tube.

6. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the test-tube and immediately place a bung onto the test-tube.

7. ……

……

8. Once the gas has been extracted, place the tubing into the NaOH solution in the NO_2 labelled test-tube, and slowly bubble in all the brown gas.

9. Once (all) the gas has been added withdraw the tubing.

10. Measure the pH of the sodium hydroxide solution and note the value down in your results table

11. Before using again, dry the end of the tubing, draw in and expel air from the syringe a few times.

Producing sulfur dioxide (SO_2) gas

12. ……

……

13. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to and immediately place a bung onto the reaction test-tube

14. Repeat the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution-this time in the SO_2-labelled test-tube.
Note: SO_2 is a colourless gas.

Producing carbon dioxide (CO_2) gas

15. ……

……

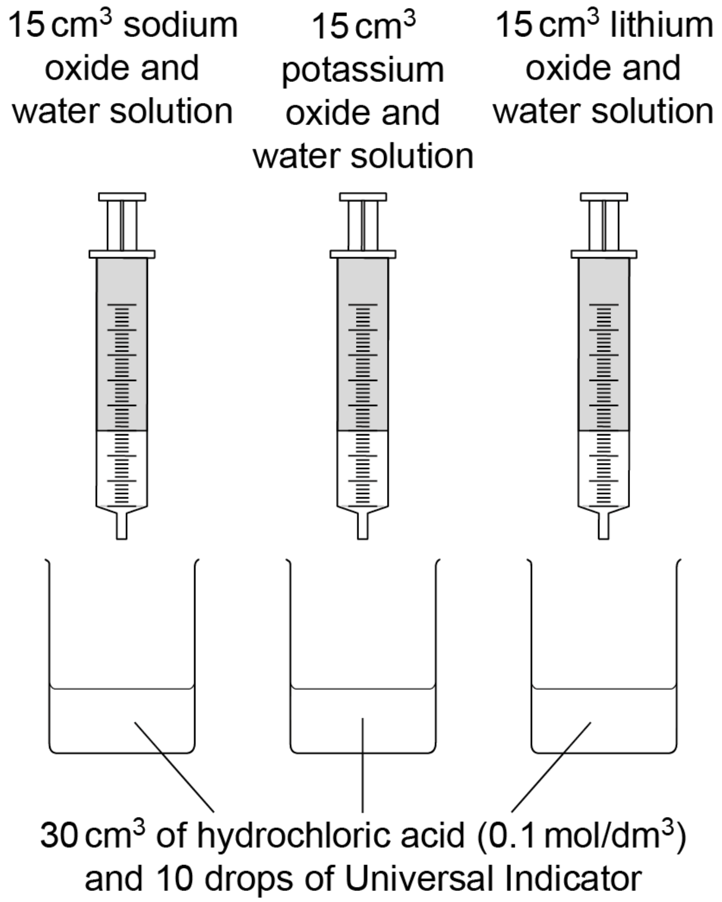
16. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to and immediately place a bung onto the reaction test-tube.

17. Repeat the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution-this time in the CO_2-labelled test-tube.
Note: CO_2 is a colourless gas.

Worksheet G: Experimental set-up

Make sure that you follow the diagram carefully.

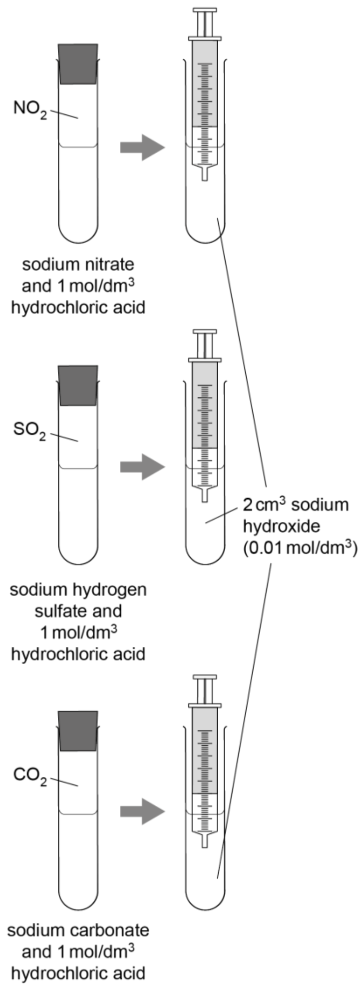
Part 1: Reaction of metal oxide and water solutions with acids



Worksheet G: Experimental set-up

Make sure that you follow the diagram carefully.

Part 2: Reaction of non-metal oxides with alkalis



Worksheet H: Experimental report

Results:

Table 1: Reactions of ‘metal oxide and water’ solutions with an acid

‘Metal oxide and water’ solution	pH of hydrochloric acid solution	
	Before addition	After addition
potassium oxide and water		
sodium oxide and water		
lithium oxide and water		

Table 2: Reactions of non-metal oxides with a base (alkali)

Non-metal oxide	pH of sodium hydroxide solution	
	Before addition	After addition
sulfur dioxide		
nitrogen dioxide		
carbon dioxide		

Worksheet H: Experimental report

Conclusion(s): What were the results of your experiment? Mention the aim of the experiment in your answer.

………

………

………

………

………

………

Worksheet H: Experimental report

Evaluation: Assess whether the experiment you carried out was fair and whether you can make a reliable conclusion based on the data collected.

Overall fairness of experiment	…………………………………………………………………………………………………… ……………………………………………………………………………………………………
Accuracy and reliability of results	…………………………………………………………………………………………………… ……………………………………………………………………………………………………
Sources of error/uncertainties	…………………………………………………………………………………………………… ……………………………………………………………………………………………………
Improvements	…………………………………………………………………………………………………… ……………………………………………………………………………………………………

Worksheet I: Assessing a scientific report

Report section	Success criteria	✓ or ✗	Comments
Title	Does the report contain a simple and informative title?		
Background	Is there a brief explanation of a theory or concept linked to the experiment?		
Aim(s)	Does this section say what will be investigated?		
Variables	Does the report state what variables were changed, what variables were measured and what were fixed?		
Hypothesis	Does the report contain a clear hypothesis? For example, 'vitamin C in orange juice oxidises over time when exposed to the air'.		

Worksheet I: Assessing a scientific report

Report section	Success criteria	✓ or ×	Comments
Materials and method(s)	• Is there a list of equipment and chemicals used? • Does this section have a sequence of steps or commands that show how a task should be carried out? • Is it written using impersonal language? • Is there a clear labelled diagram of the experiment? • Is the language clear so that someone could repeat the experiment without mistakes?		
Results	This section should be made up of what can be measured or observed, not guessed. For example, if you bubbles were observed, then this is all that can be stated in this section (unless gas produced was tested). • Is this section well presented, and clear? • Have observations been made as accurately as possible? • Is the data in the form of a table and /or graph? • Have correct headings and units been used? • Has an average mean been worked out from repeat readings?		
Conclusion(s)	• Have the results been described? • Are any conclusions related to the aims? • Are there any comments on whether the results agree with the hypothesis?		

Worksheet I: Assessing a scientific report

Report section	Success criteria	✓ or ×	Comments
Evaluation	The evaluation is an opportunity to discuss both the strengths and weaknesses of an experiment. It should be specific and explain why the experiment did or did not work well and how it could be improved. • Has the fairness of the experimental design been evaluated? • Is there any mention about the accuracy and reliability of the results? • Does the report mention possible sources of error/uncertainty? • Does the report contain **three** improvements?		
Overall quality of the report	Look at the whole of the report and decide on its quality. • Does the report follow clearly from start to finish? • Is the vocabulary used in the report precise? • Has technical language been used throughout? • Has impersonal language (no ‘I’ or ‘we’) been used?		

Worksheet J: Assessing a scientific report

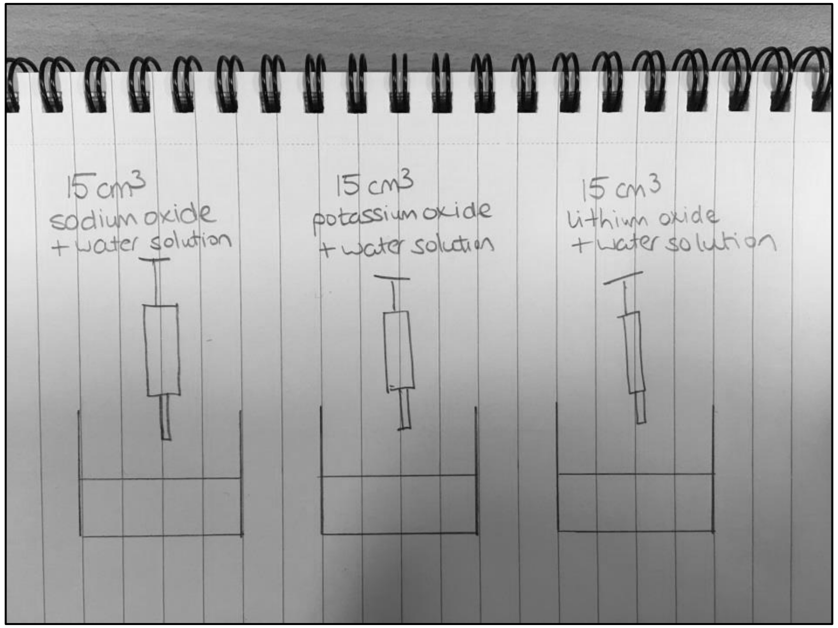
Title	Types of oxides
Background information	Soluble oxides can dissolve in water to form acidic, basic or amphoteric solutions. These solutions can then become involved in a neutralisation reaction, which involves moving the pH of a solution towards 7.0. pH can be measured using pH paper/Universal Indicator and the pH Scale which classifies solutions as acidic, basic or neutral.
Aims	**Aim 1:** To find out what happens when metal oxides react. **Aim 2:** To find out what happens to the pH of an alkali solution when it is reacted with soluble non-metal oxide gases.
Experimental variables	**Changed (independent) variables** Type of metal oxide and water solution. Type of non-metal oxide gas. **Measured(dependent) variables** pH of hydrochloric acid before and after reaction with metal oxide and water solutions. pH of sodium hydroxide before and after reaction with non-metal oxide gas. **Fixed variables** Final volume of reaction solutions/Temperature.
What will happen? (hypothesis)	Addition of metal oxide and water solutions to an acid will lead to a rise in their pH. Addition of metal oxide and water solutions to an alkali will lead to a fall in their pH.

Worksheet J: Assessing a scientific report

Materials and method(s):

Experimental set-up (labelled diagram)

Part 1: Reactions of 'metal oxide and water' solutions with an acid

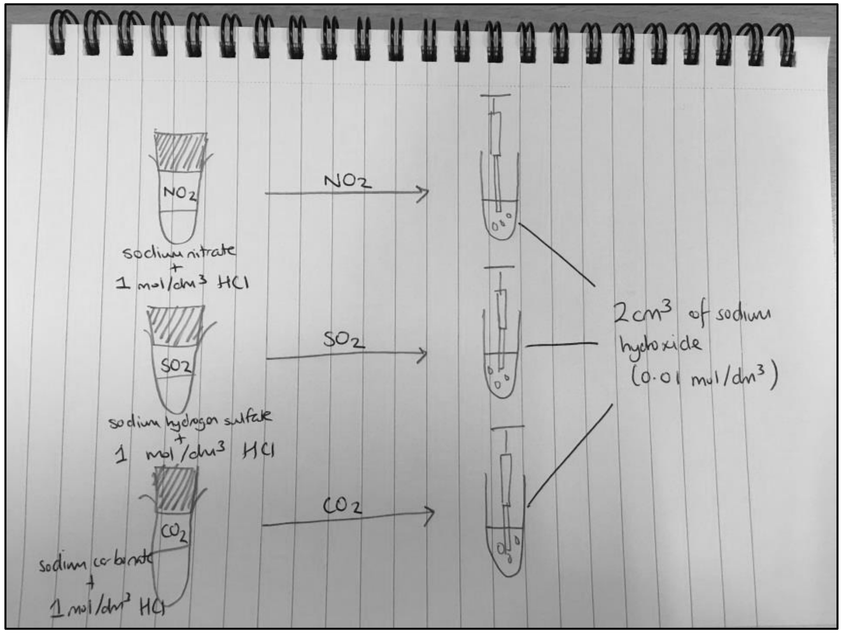


Materials (list of chemical and equipment)

- *3 x 100 cm³ beakers*
- *sticky labels for beakers*
- *labelled 'potassium oxide and water' solution (potassium hydroxide solution 0.2 mol/dm³*
- *labelled 'sodium oxide and water' solution (sodium hydroxide solution 0.2 mol/dm³)*
- *labelled 'lithium oxide and water' solution (lithium hydroxide solution 0.2 mol/dm³)*
- *200 cm³ of hydrochloric acid (0.1 mol/dm³)*
- *magnetic hot plate*
- *Universal Indicator*
- *5 cm³ syringe*
- *50 cm³ measuring cylinder*
- *small magnetic flea*
- *pH scale (coloured and laminated)*

Worksheet J: Assessing a scientific report

Part 2: Reactions of non-metal oxides with a base (alkali)



Materials (list of chemical and equipment)

- 10 cm^3 of sodium hydroxide (0.01 mol/dm^3)
- Universal Indicator
- solid sodium nitrite
- solid sodium carbonate (or hydrogen carbonate)
- 10 cm^3 of hydrochloric acid (1 mol/dm^3)
- solid sodium hydrogen sulfate
- test-tube rack
- 2 x 5 cm^3 syringes (one labelled HCl and the other NaOH)
- 1 x 10 cm^3 syringe with 18 cm^3 PVC tubing (or rubber tubing) – for gas extraction
- 6 x small test-tubes
- 3 x test-tube bungs
- spatula
- sticky labels
- access to a fume cupboard
- pH scale (coloured and laminated)

Worksheet J: Assessing a scientific report

Method(s)

Part 1: Reactions of 'metal oxide and water' with an acid

1. Firstly I labelled three beakers, 'potassium oxide and water', 'sodium oxide and water' and 'lithium oxide and water'.
2. Then I measured out 30 cm^3 of 0.1 mol/dm^3 hydrochloric acid and added it to the beaker labelled, 'potassium oxide and water'.
3. Repeated this same procedure with the 'sodium oxide and water' and 'lithium oxide and water' beakers.
4. Add ten drops of Universal Indicator to each beaker, note the colours, and use the pH scale to record the pH numbers.
5. Add a magnetic stirrer to the beaker labelled 'potassium oxide and water', place on the magnetic hot-plate and gently stir.
6. Transfer 15 cm^3 of the 'potassium oxide and water' solution to the hydrochloric acid (HCl) in the beaker marked 'potassium oxide and water'.
7. We recorded the pH of the reaction solution once all of the 'potassium oxide and water' solution that had been added to the beaker.
8. Wash out the 5 cm^3 syringe with water so that it can be reused.
9. Repeat the same procedure for the other two 'metal oxide and water' solutions and record the results.

Part 2: Reactions of non-metal oxides with a base (alkali)

1. Label three test-tubes: NO_2, SO_2 and CO_2 and place these in a test-tube rack.
2. Measure out 2 cm^3 of 0.01 mol/dm^3 sodium hydroxide solution and transfer into one of the test-tubes. Repeat this so that all three test-tubes contain the sodium hydroxide solution.
3. Add two drops of Universal Indicator to each test-tube and use the pH scale to record the pH numbers of each of the solutions.
4. Move the test-tube rack into a fume cupboard.

Carry out the next steps in a fume cupboard

Worksheet J: Assessing a scientific report

<u>Producing nitrogen dioxide (NO_2) gas</u>

1. My lab partner added half a spatula of sodium nitrite to a small test-tube.
2. She then added 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the test-tube and immediately placed a bung onto the test-tube.
3. After a few minutes, take the bung off and extract any brown gas formed using a 10 cm^3 syringe with attached tubing.
4. Once the gas has been extracted, I placed the tubing into the NaOH solution in the NO_2 labelled test-tube, and slowly bubble in all the brown gas.
5. Once all the gas has been added withdraw the tubing.
6. Measure the pH of the sodium hydroxide solution and note the value down in your results table.
7. Before using again, dry the end of the tubing, draw in and expel air from the syringe a few times.

<u>Producing sulfur dioxide (SO_2) gas</u>

1. Add half a spatula of sodium hydrogen sulfate to a small test-tube.
2. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to and immediately place a bung onto the reaction test-tube.
3. Repeat the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution – this time in the SO_2-labelled test-tube. Note: SO_2 is a colourless gas.

<u>Producing carbon dioxide (CO_2) gas</u>

1. Add half a spatula of sodium carbonate to a test-tube.
2. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to and immediately place a bung onto the reaction test-tube.
3. We repeated the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution – this time in the CO_2-labelled test-tube. Note: CO_2 is a colourless gas.

Worksheet J: Assessing a scientific report

Results

Table 1: Reactions of 'metal oxide and water' solutions with an acid

metal oxide and water solution	pH of hydrochloric acid solution	
	before addition of metal oxide	after addition of metal oxide
potassium oxide and water	2	7
sodium oxide and water	2	7
lithium oxide and water	2	7

Table 2: Reactions of non-metal oxides with a base (alkali)

non-metal oxide	pH of sodium hydroxide solution	
	before addition of non-metal oxide	after addition of non-metal oxide
sulfur dioxide	13	7
nitrogen dioxide	13	
carbon dioxide	13	7

Worksheet J: Assessing a scientific report

Conclusion(s):

All soluble metal oxide solutions can neutralise acidic solutions.
Soluble non-metal oxides, when added in the correct quantity, can neutralise an alkali. If too much non-metal oxide is added then the solution becomes acidic.

Evaluation:

Overall fairness of experiment	• Metal oxide solutions and acid part – Only one variable changed, so experimental results are valid. • Non-metal oxide gases and alkali part – Only one variable changed, so experimental results are valid.
Accuracy and reliability of results	• Accuracy – Results were obtained through correct and careful measurement of volumes and pH values. • Reliable – Results were reliable as several over groups in the class got the same type of results.
Sources of error/uncertainties	• Reliance on the interpretation of pH from the colours of solutions. • The volume of non-metal oxide gases was not controlled, but this was not required.
Improvements	• Change the method to state that the non-metal oxide gases should be added slowly until the solution turns green. • Each individual experiment should be carried out a minimum of three times and an average taken.

Worksheet K: Virtual experiment statements

Complete the following statements and questions using the word bank below.

fume cupboard	sodium carbonate	sulfur dioxide
brown	pH scale	too much
nitrogen dioxide	Universal Indicator	below seven

1. The …………………………….. was used in both reactions to measure whether a solution was acidic, neutral or basic.
2. When sodium nitrite was reacted with hydrochloric acid a …………………………….. gas was observed.
3. …………………………….. was produced during when hydrochloric acid is reacted with sodium hydrogen sulfate.
4. Carbon dioxide gas was produced when hydrochloric acid was reacted with

   ……………………………..
5. The production of non-metal oxide gases must take place in a ……………………………..
6. The colour of the sodium hydroxide solution did not change to green because

   ……………………………..non-metal oxide gas was added to the solution and the pH fell

   ……………………………..

Worksheet L: Virtual experiment questions

1. What is the effect on the pH of an acid when it is reacted with a soluble metal oxide?

………

2. What is the name of the reaction that occurs when a metal oxide reacts with an acid?

………

3. Some metal oxides, like aluminium oxide and zinc oxide can act as both an acid and a base. What name is given to this type of chemical behaviour?

………

4. What is the effect on the pH of a base (alkali) when it is reacted with a soluble non-metal oxide?

………

5. What is the name of the reaction that occurs when a non-metal oxide reacts with an alkali?

………

6. What kind of environmental damage is caused by the pollutant gases, nitrogen dioxide and sulfur dioxide?

………

7. Carbon dioxide gas dissolves in water to form the weak acid, carbonic acid. What is the definition of weak and strong when referred to acids and bases?

………

Worksheet A: Acid/alkali loop game

START	*red*	*red cabbage*	*above 7*
What colour does Universal Indicator show in strong acid?	What everyday substance can be used to make an indicator?	What are the pH values of all alkaline substances?	Name a household substance that is neutral.
distilled water	*salt and water*	*oven cleaner*	*alkali*
What completes this reaction? acid + alkali → ?	Name a household substance that is strongly alkaline.	Is toothpaste an acid or alkali?	Indigestion tablets work by ……?
neutralising stomach acid	*corrosive*	*salt*	*vinegar*
What hazard is associated with acids and alkalis?	What is made when an acid is neutralised with a base?	Which is more acidic: soft drink or vinegar?	Acids have a pH …..?
below 7			
FINISH			

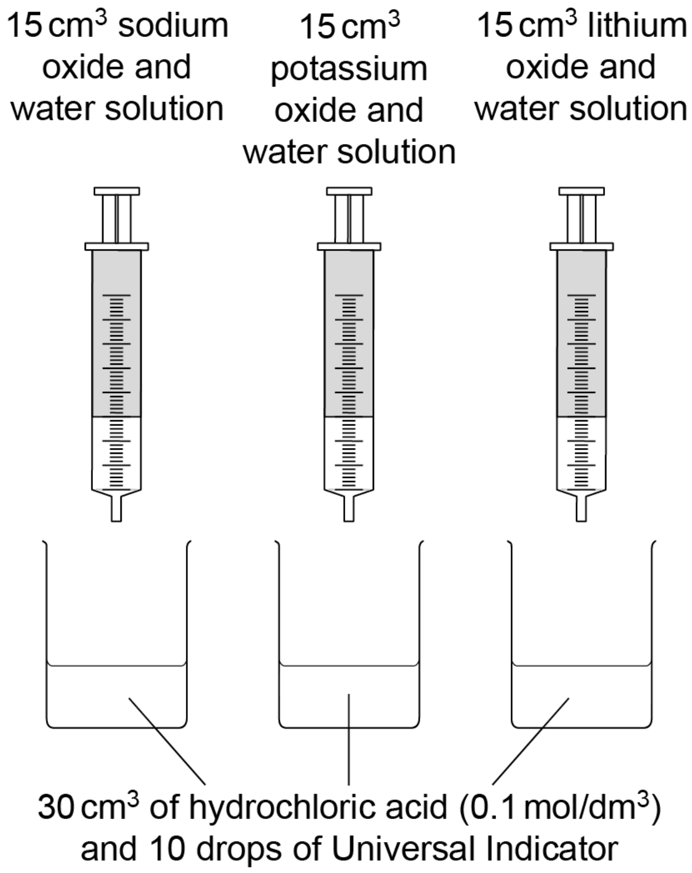
Worksheet C: Suggested answers (ideal report)

Title	Types of oxides: reactions with acids and bases	
Background information	Soluble oxides can dissolve in water to form acidic, basic or amphoteric solutions. These solutions can then become involved in a neutralisation reaction, which involves moving the pH of a solution towards 7.0. pH can be measured using pH paper/Universal Indicator and the pH scale that classifies solutions as acidic, basic or neutral.	
Aims	**Aim 1:**	To find out what happens to the pH of an acid when it is reacted with metal oxide and water solutions.
	Aim 2:	To find out what happens to the pH of an alkali solution when it is reacted with soluble non-metal oxide gases.
Experimental variables	**Changed (independent) variables**	Type of metal oxide and water solution. Type of non-metal oxide gas.
	Measured (dependent) variables	pH of hydrochloric acid before and after reaction with metal oxide and water solutions. pH of sodium hydroxide before and after reaction with non-metal oxide gas.
	Fixed variables	Final volume of reaction solutions/Temperature.
What will happen? (hypothesis)	(1) Addition of metal oxide and water solutions to an acid will lead to a rise in their pH. (2) Addition of metal oxide and water solutions to an alkali will lead to a fall in their pH.	

Worksheet D: Suggested answers (ideal report)

Materials and methods:

Part 1: Experimental set-up (labelled diagram)



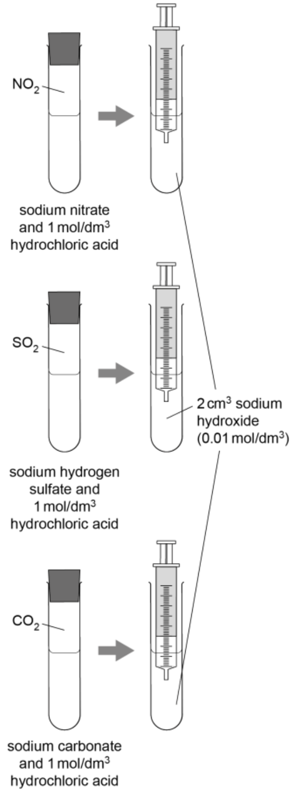
Materials (list of chemical and equipment)

- *3 × 100 cm^3 beakers*
- *sticky labels for beakers*
- *Labelled 'potassium oxide and water' solution (potassium hydroxide solution 0.2 mol/dm^3*
- *Labelled 'sodium oxide and water' solution (sodium hydroxide solution 0.2 mol/dm^3)*
- *Labelled 'lithium oxide and water' solution (lithium hydroxide solution 0.2 mol/dm^3)*
- *200 cm^3 of hydrochloric acid (0.1 mol/dm^3)*
- *magnetic hot plate*
- *Universal Indicator*
- *5 cm^3 syringe*
- *50 cm^3 measuring cylinder*
- *small magnetic flea*
- *pH scale (coloured and laminated)*

Worksheet D: Suggested answers (ideal report)

Materials and methods:

Part 2: Experimental set-up (labelled diagram)



Materials (list of chemical and equipment)

- 10 cm^3 of sodium hydroxide (0.01 mol/dm^3)
- Universal Indicator and pH scale
- Solid sodium nitrite
- Solid sodium carbonate (or hydrogen carbonate)
- 10 cm^3 of hydrochloric acid (1 mol/dm^3)
- Solid sodium hydrogen sulfate
- test-tube rack
- 2 × 5 cm^3 syringes (one labelled HCl and the other NaOH)
- 1 ×10 cm^3 syringe with 18 cm^3 PVC tubing (or rubber tubing) for gas extraction
- 6 × small test-tubes
- 3 × test-tube bungs
- spatula
- sticky labels
- access to a fume cupboard
- pH scale (coloured and laminated)

Worksheet F: Suggested answers

Part 1: Reactions of 'metal oxide and water' solutions with an acid

1. Label three beakers, 'potassium oxide and water', 'sodium oxide and water' and 'lithium oxide and water'.
2. *Measure out 30 cm^3 of 0.1 mol/dm^3 hydrochloric acid and add to the beaker labelled 'potassium oxide and water'.*
3. Repeat this procedure with the 'sodium oxide and water' and 'lithium oxide and water' beakers.
4. Add ten drops of Universal Indicator to each beaker, note the colours, and use the pH scale to record the pH numbers.
5. *Add a magnetic stirrer to the beaker labelled 'potassium oxide and water', place on the magnetic hot-plate and gently stir.*
6. Transfer 15 cm^3 of the 'potassium oxide and water' solution to the hydrochloric acid in the beaker marked 'potassium oxide and water'.
7. *Record the pH of the reaction solution once all of the 'potassium oxide and water' solution has been added to the beaker.*
8. *Wash out the 5 cm^3 syringe with water so that it can be reused.*
9. Repeat the same procedure for the other two 'metal oxide and water' solutions and record the results.

Worksheet F: Suggested answers

Part 2: Reactions of non-metal oxides with a base (alkali)

1. Label three test-tubes: NO_2, SO_2 and CO_2 and place these in a test-tube rack.
2. Measure out 2 cm^3 of 0.01 mol/dm^3 sodium hydroxide solution and transfer into one of the test-tubes. Repeat this so that all three test-tubes contain the sodium hydroxide solution.
3. Add two drops of Universal Indicator to each test-tube and use the pH scale to record the pH numbers of each of the solutions.
4. Move the test-tube rack into a fume cupboard.

************************Carry out the next steps in a fume cupboard************************

Producing nitrogen dioxide (NO_2) gas

5. Add half a spatula of sodium nitrite to a small test-tube.
6. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to the test-tube and immediately place a bung onto the test-tube.
7. After a few minutes, take the bung off and extract any brown gas formed using a 10cm^3 syringe with attached tubing.
8. Once the gas has been extracted, place the tubing into the NaOH solution in the NO_2 labelled test-tube, and slowly bubble in all the brown gas.
9. Once all the gas has been added withdraw the tubing.
10. Measure the pH of the sodium hydroxide solution and note the value down in your results table.
11. Before using again, dry the end of the tubing, draw in and expel air from the syringe a few times.

Producing sulfur dioxide (SO_2) gas

12. Add half a spatula of sodium hydrogen sulfate to a small test-tube.
13. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to and immediately place a bung onto the reaction test-tube.
14. Repeat the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution -this time in the SO_2-labelled test-tube. Note: SO_2 is a colourless gas.

Producing carbon dioxide (CO_2) gas

15. Add half a spatula of sodium carbonate to a test-tube.
16. Add 2 cm^3 of 1 mol/dm^3 hydrochloric acid to and immediately place a bung onto the reaction test-tube.
17. Repeat the same procedure for transferring all the gas and measuring the pH value of the sodium hydroxide solution -this time in the CO_2-labelled test-tube. Note: CO_2 is a colourless gas.

Worksheet H: Suggested answers (ideal report)

Results:

Table 1: Reactions of 'metal oxide and water' solutions with an acid

'metal oxide and water' solution	pH of hydrochloric acid solution	
	Before addition	After addition
potassium oxide and water	2	7
sodium oxide and water	2	7
lithium oxide and water	2	7

Table 2: Reactions of non-metal oxides with a base (alkali)

Non-metal oxide	pH of sodium hydroxide solution	
	Before addition	After addition
sulfur dioxide	13	6
nitrogen dioxide	13	5
carbon dioxide	13	3

Conclusion(s):

Part 1: The soluble metal oxide solutions (sodium oxide, potassium oxide and lithium oxide) used in the experiment neutralised a solution of hydrochloric acid by moving the pH from 3 up to 7. These results agreed with the stated hypothesis.

Part 2: Nitrogen dioxide changed the pH of the sodium hydroxide solution from 13 to 5, sulfur dioxide changed it from 13 to 6 and carbon dioxide lowered it from 13 to 3. The soluble non-metal oxide gases didn't neutralise a sodium hydroxide

(alkali) solution. This was different from the hypothesis.

Worksheet H: Suggested answers (ideal report)

Evaluation:

Overall fairness of experiment	• *Metal oxide solutions and acid part – Only one variable changed, so experimental results are valid.* • *Non-metal oxide gases and alkali part – Only one variable changed, so experimental results are valid.*
Accuracy and reliability of results	• *Accuracy – Results were obtained through correct and careful measurement of volumes and pH values.* • *Reliable – Results were reliable as several over groups in the class got the same type of results.*
Sources of error/uncertainties	• *Reliance on the interpretation of pH from the colours of solutions.* • *The volume of non-metal oxide gases was not controlled, but this was not required.*
Improvements	• *Change the method to state that the non-metal oxide gases should be added slowly until the solution turns green.* • *Each individual experiment should be carried out a minimum of three times and an average taken.* • *Use a pH meter to measure the pH of the various solutions.*

Worksheet J: Identified deficiencies in report

Report section	Success criteria	✓ or ×	Comments
Title	Does the report contain a simple and informative title?	×	Too vague and not informative. Need to state that you are looking at their reactions with acids and bases.
Background	Is there a brief explanation of a theory or concept linked to the experiment?	✓	
Aims	Does this section say what will be investigated?	×	Aim 1 is not specific enough. Need to mention 'metal oxide solutions' are being used and the effect on pH is being investigated.
Variables	Does the report state what variables were changed, what variables were measured and what were fixed?	×	Missing information on the changed (independent) variables.
Hypothesis	Does the report contain a clear hypothesis? For example, 'vitamin C in orange juice oxidises over time when exposed to the air'.	✓	
Materials and method(s)	• Is there a list of equipment and chemicals used?	✓	
	• Does this section have a sequence of steps or commands that show how a task should be carried out?	✓	
	• Is it written using impersonal language?	×	Personal language used: Part1, lines 1, 2, 7 and Part 2, lines 5, 6, 8 and 17.
	• Is there a clear labelled diagram of the experiment?	×	The contents of the beakers in Part 1 are and Universal Indicator information from Part 2 are missing.
	• Is the language clear so that someone could repeat the experiment without mistakes?	✓	

Worksheet J: Identified deficiencies in report

Results	This section should be made up of what can be measured or observed, not guessed. For example, if bubbles were observed, then this is all that can be stated in this section (unless gas produced was tested). • Is this section well presented, and clear? • Have observations been made as accurately as possible? • Is the data in the form of a table and /or graph? • Have correct headings and units been used? • Has an average mean been worked out from repeat readings?	✓ × ✓ × ×	Missing data in Table 2. Missing heading for Table 1. Single measurements taken.
Conclusion(s)	• Have the results been described? • Are any conclusions related to the aims? • Are there any comments on whether the results agree with the hypothesis?	× × ×	Conclusions are not specific to aims and inaccurate e.g. 'All soluble metal oxide solutions can neutralise acidic solutions'. No mention of hypothesis.

Worksheet J: Identified deficiencies in report

Evaluation	The evaluation is an opportunity to discuss both the strengths and weaknesses of an experiment. It should be specific and explain why the experiment did or did not work well and how it could be improved. • Has the fairness of the experimental design been evaluated? • Is there any mention about the accuracy and reliability of the results?	 ✓ ✓	
	• Does the report mention possible sources of error/uncertainty? • Does the report contain three improvements?	✓ ✗	Should mention the use of a pH meter instead of Universal Indicator.
	Look at the whole of the report and decide on its quality. • Does the report follow clearly from start to finish? • Is the vocabulary used in the report precise? • Has technical language been used throughout? • Has impersonal language (no 'I' or 'we') been used?	 ✓ ✗ ✓ ✗	 See the 'Conclusion(s)' section. See 'Materials and Method(s)' section.

Worksheet K: Suggested answers

1. The *pH scale* was used in both reactions to measure whether a solution was acidic, neutral or basic.

2. When sodium nitrite was reacted with hydrochloric acid a *brown* gas was seen.

3. *Sulfur dioxide* was produced during when hydrochloric acid is reacted with sodium hydrogen sulfate.

4. Carbon dioxide gas was produced during when hydrochloric acid is reacted with *sodium carbonate*.

5. The production of non-metal oxide gases must take place in a *fume cupboard*.

6. The colour of the sodium hydroxide solution did not change to green because *too much* non-metal oxide gas was added to the solution and the pH fell *below seven*.

Worksheet L: Suggested answers

1. *increases it*
2. *neutralisation*
3. *amphoteric*
4. *decreases it*
5. *neutralisation*
6. *acidification of soil and lakes due to acid rain*
7. ***strong*** = *completely ionised when dissolved in water;* ***weak*** = *partially ionised when dissolved in water.*

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