We are surrounded by substances. Some of the substances we use every day are hazards. Warning signs tell you the kind of harm a hazard can cause.

- Cut out the warning signs at the bottom of this sheet.
- Each of the boxes describes a substance that may be found at home. Stick in the correct warning sign.

Quick-light
Fuel for lighting barbecues. Burns easily.

Drain-clear
Dissolves away everything that clogs up drains such as fat and hair. It will also burn skin.

Pest-gone
When added to water will get rid of insects and fungi that damage plants. Kills plants and animals if spilt.

Super-clean
Used to clean work surfaces, baths and wash-basins. May irritate the skin.

Home-fresh
Spray can that gives a clean smell to your home. Explodes if heated.

Germs-away
Wipe surfaces to kill germs. Poisonous if swallowed.

I can…
- recall the purpose of hazard symbols.






Name ______________________ Class ____________ Date ____________

Your teacher may watch to see if you can:
- follow instructions accurately
- handle solutions safely.

Aim

To compare the hazards of some acids by comparing how they react with marble.

Introduction

The acids are substances that may be found at home. Marble is a rock that is used for floor tiles, work surfaces, chopping boards or pestles and mortars.

Apparatus
- eye protection
- 3 test tubes
- a test tube rack
- 3 marble chips
- acids X, Y and Z

⚠ Wear eye protection when carrying out practical work.

Method

A Fill a test tube about one-third full with acid X, as shown in the diagram.

B Put *one* of the marble chips in the tube.

C Watch what happens for about two minutes. Write your observations in the table.

D Do the same with acid Y in the second test tube and with acid Z in the third test tube.

E When the tests are finished pour the liquids away (do not let marble chips go down the drain).

Recording your results

Acid	What did you see happening?
X	
Y	
Z	

Considering your results

1 I think the most hazardous acid was ______________________

2 The least hazardous acid was ______________________

3 I thought this because ______________________

____

I can…
- make observations of a reaction
- identify acids that are hazardous.

Your teacher may watch to see if you can:

- follow instructions accurately
- handle solutions safely
- measure volumes of liquids accurately
- record observations accurately.

Aim

To compare the hazards of some acids at different dilutions by comparing how they react with marble.

Introduction

The acids are substances that may be found at home. Marble is a rock that is used for floor tiles, work surfaces, chopping boards or pestles and mortars.

Apparatus

- eye protection
- 3 test tubes
- a test tube rack
- measuring cylinder
- 3 marble chips
- acids X, Y and Z

⚠ Wear eye protection when carrying out practical work.

Method

A Measure out 10 cm^3 of acid X into a test tube.

B Put *one* marble chip in the test tube.

C Watch what happens for about two minutes. Make a note of your observations in a table.

D Pour 5 cm^3 of acid X into the measuring cylinder. Fill it up to the 10 cm^3 mark with water. Pour the diluted acid solution into a clean test tube and repeat parts B and C.

E Pour 1 cm^3 of acid X into the measuring cylinder. Fill it up to the 10 cm^3 mark with water. Pour the diluted acid solution into a clean test tube and repeat parts B and C.

F When the tests are finished pour the liquids away (do not let marble chips go down the drain) and wash out the tubes.

G Repeat steps A to F with acids Y and Z.

Recording your results

Draw a suitable table to record your observations and measurements.

Considering your results

1 Put the acids in order of hazard, with the most hazardous first, and explain your order.

2 Describe the effect diluting acids has on their level of hazard.

3 Explain why hazard warnings are necessary when using some acids.

4 Suggest suitable safety precautions for handling the most and least hazardous of the acids.

I can…

- make and record observations of a reaction
- compare the hazards caused by different substances and the effect of dilution
- describe the precautions needed to reduce risk when using hazardous substances.

Hazard symbols

Cut out the boxes on the sheet along the dotted lines.

Match each warning symbol to its hazard and an example of a substance that has that hazard.

Stick the boxes in your notebook or on to a sheet of paper in groups of three boxes.

I can…

- recognise some hazard symbols and some substances that are hazards, including some acids.

	***Hazard:*** **Corrosive**	*Example:* dilute sulfuric acid
Hazard: **Flammable**	*Example:* concentrated sulfuric acid	
Example: cyanide		***Hazard:*** **Toxic**
	*Example:* petrol	***Hazard:*** **Caution**

Design a label

CleanCo have produced a new cleaning material, *Pipeclear!*, for clearing waste pipes from showers and baths. *Pipeclear!* contains a substance that can attack hair and fatty deposits that often block pipes. It is poured straight down the pipes to clear them. Unfortunately *Pipeclear!* will also attack skin and cause painful burns.

CleanCo would like you to design the safety label to go on the *Pipeclear!* bottle.

Work in groups to design your labels and use coloured pens to make them eye-catching.

The label should show:

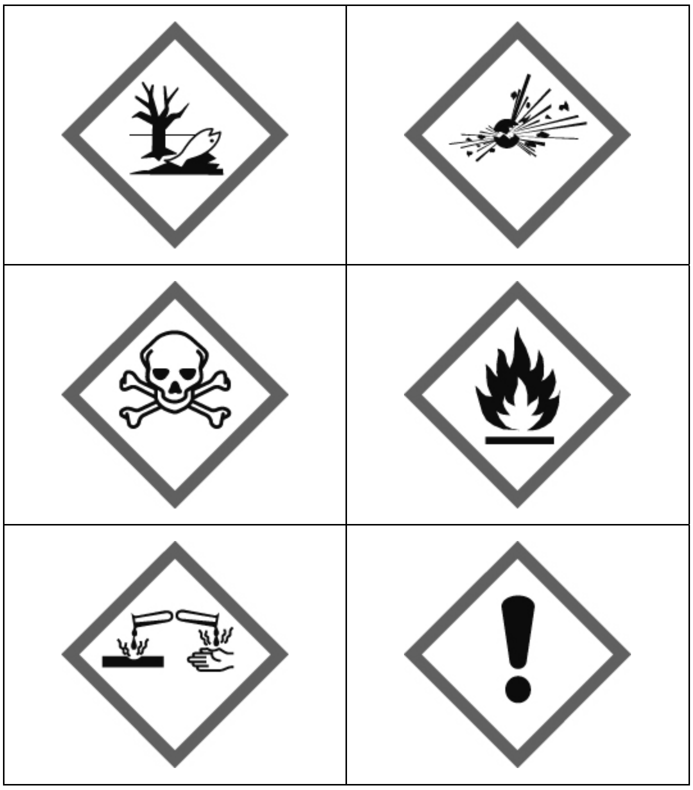
- the correct hazard symbol
- explain what the hazard symbol means
- how to safely clear up a spill of *Pipeclear!*

Explain why there is only a low risk of harm if *Pipeclear!* is used correctly.

CleanCo also wants to sell a dilute version of *Pipeclear!* that can be used to clean baths and showers.

Design a label for this product and explain why it is a less serious hazard.

The symbols used for various types of hazard are shown below.



I can…

- tell the difference between substances that are corrosive and irritant
- explain how to reduce the risk of a substance by dilution
- tell the difference between hazard and risk.

The Hazchem code

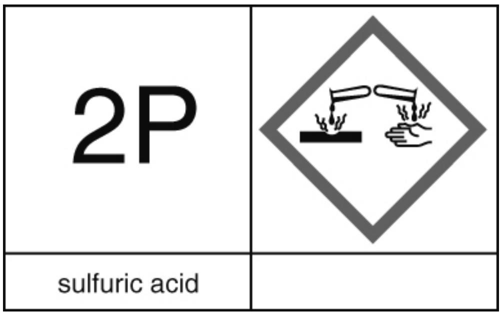
Name ________________________________ **Class** _____________ **Date** ______________

The Hazchem code tells the police and fire services about the hazards of a substance in a tanker.

Work in groups to use the Hazchem symbol and the code table to answer the questions.

This table shows what the code letters mean: V = violent reaction possible.

<table>
<tr><td colspan="4">1 Jets   2 Fog   3 Foam   4 Dry agent</td></tr>
<tr><td>P</td><td>V</td><td rowspan="2">Full</td><td rowspan="4">Dilute</td></tr>
<tr><td>R</td><td></td></tr>
<tr><td>S</td><td>V</td><td rowspan="2">BA</td></tr>
<tr><td>T</td><td></td></tr>
<tr><td>W</td><td>V</td><td rowspan="2">Full</td><td rowspan="4">Contain</td></tr>
<tr><td>X</td><td></td></tr>
<tr><td>Y</td><td>V</td><td rowspan="2">BA</td></tr>
<tr><td>Z</td><td></td></tr>
<tr><td colspan="4">E Consider evacuation</td></tr>
</table>



1 **a** What hazard is shown by the symbol in the diamond?

b Look at the number on the Hazchem warning sign. Use the code chart to decide how the fire service should put out a fire on this tanker. Choose from:

A use jets of water

B use a fine spray mist of water

C use a special foam

D use dry powder or carbon dioxide gas.

2 In each case say whether the following statements are ‘true’ or ‘false’. Explain your answers in each case by linking the letter on the Hazchem warning to the code letters in the chart.

a There could be a problem of a violent reaction of other substances with the sulfuric acid.

b The fire service only need to wear breathing apparatus and gloves (BA) – there is no need for a full protective suit.

c If the acid spills, it can be diluted and washed away down the drains. It is not necessary to contain the acid.

d The police and fire service need to evacuate the area immediately.

3 Use the Hazchem code to recommend the appropriate safety precautions for the following substances:

a methanol: code 2PE

b phosphorus: code 2WE.

4 Suggest why it is an advantage to use a system of code letters and numbers rather than having the full safety advice printed on the side of the tanker.

I can…

- describe the use and importance of the Hazchem code.

Name ______________________ Class __________ Date __________

Acid tastes

Many foods and drinks contain acids. Acids have a sharp or sour taste.

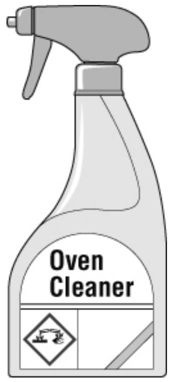
1 List 6 drinks, foods and other substances that contain acids.

1 ____________________ **2** ____________________

3 ____________________ **4** ____________________

5 ____________________ **6** ____________________

Hazards



2 Look at the diagram showing a bottle of oven cleaner.

Complete the following sentence by circling the correct word or phrase after it.

The label shows that the contents of the bottle are (an acid / corrosive / toxic).

3 Draw a line from the hazard symbol to the hazard it is warning of.

Flammable Toxic Caution (irritant) Explosive

4 While doing an experiment in a laboratory, Sam spilled some liquid marked with a corrosive symbol on the bottle. What could Sam do to reduce the risk of harm from the liquid he spilled?

____

____

I can…

- recall some substances that contain acids
- recall a reason why hazard symbols are used
- recognise some hazard symbols
- describe what to do to reduce the risk from a hazard.

1 Read the following descriptions of substances. Write down what type of hazard, if any, is described in the sentences and write down the letter of the most suitable hazard symbol shown needed for warning about the substance. If there is no risk from the substance write ‘no hazard’.

- Concentrated nitric acid can burn through skin and cause painful sores.
- Ammonium nitrate is used as a fertiliser and is sometimes used in bombs.
- Tartaric acid is used in sauces put on food.
- Dilute nitric acid can cause redness in skin.
- Concentrated ammonium nitrate kills plants and can harm animals in habitats.
- Copper sulfate is used as a weedkiller. It is poisonous if swallowed.
- Alcohol can be lit by a flame.

A **B** **C** **D** **E** **F**

2 A laboratory technician wants to prepare some dilute nitric acid, starting with concentrated nitric acid.

a Describe how the technician can change concentrated nitric acid into dilute nitric acid.

b Describe what safety precautions the technician should take.

c Concentrated nitric acid is usually kept in a locked chemical store room. Dilute nitric acid may be kept in small bottles in a laboratory.

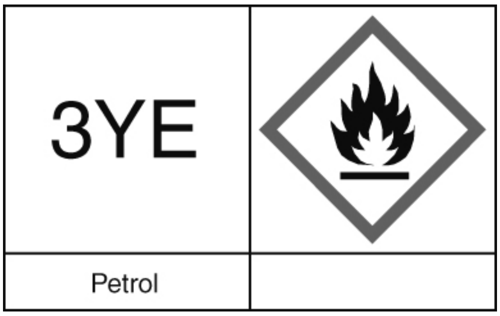
i Explain the different storage arrangements for concentrated and dilute nitric acid.

ii Explain why a risk assessment will suggest that if these arrangements are followed then there is a Low Risk of serious harm to people from both the concentrated nitric acid and the dilute nitric acid.

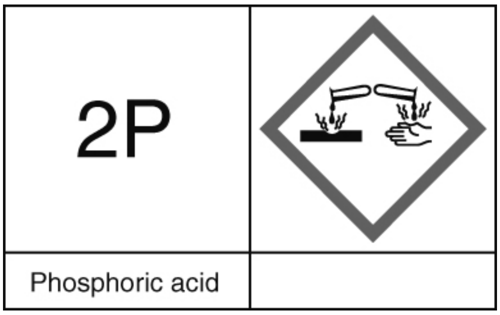
I can…

- recognise the difference in hazard between substances that are corrosive and irritant
- describe how to reduce the risk of hazards by dilution
- explain the difference between hazard and risk.

Two lorries have been involved in a collision on a motorway. They are both carrying hazardous substances. One lorry is a tanker carrying a liquid. It has the Hazchem sign on it shown below.



The other lorry is carrying a solid and has the Hazchem sign shown below.



You are a news reporter who arrives on the scene as the Fire and Rescue Service are dealing with the collision. Write an article for a newspaper or an internet item in which you:

- Explain the risks to other drivers and passengers on the motorway from the spilled chemicals.
- Describe how the two lorries were being dealt with by the Fire Service to make them safe.

The Hazchem Code

1 Jets of water **2** Water mist **3** Foam **4** Dry agent			
P	V	Full protective clothing	dilute (with water)
R			
S	V	BA (breathing apparatus)	
T			
W	V	Full protective clothing	contain (stop substance escaping into environment)
X			
Y	V	BA (breathing apparatus)	
Z			
E Consider evacuation			

V = violent reaction possible

I can…

- explain the difference between hazard and risk
- explain and use the Hazchem Code.

Name ______________________________ Class ____________ Date ______________

Acids turn litmus red. Alkalis turn litmus blue.

Cut out names of substances at the bottom of the page. In your group, discuss which substances belong in which box. Stick each substance into *one* of the boxes.

Turn litmus solution red	Turn litmus solution blue	Do not affect litmus

I can…

- recall the names of some acids and alkalis
- recall the colour changes of litmus.

sulfuric acid	toothpaste	sodium hydroxide	vinegar	soap
salt	baking soda	sugar	citric acid	lemon juice
bleach	hydrochloric acid	oven cleaner	yogurt	alcohol

Red cabbage indicator

Name ______________________________ **Class** ____________ **Date** _____________

Part 1: Making the indicator

Apparatus
- mortar and pestle
- boiling tube or conical flask
- filter paper and a filter funnel
- hot water
- red cabbage leaves

⚠ Wear eye protection.

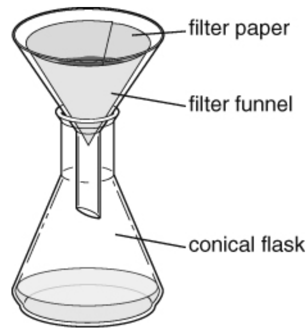
Method

A Wear eye protection. Put some red cabbage leaves into the mortar.

B Add a little hot water.

C Grind up the leaves so that you get as much of the colour out as possible.

D Filter the mixture and collect the liquid in a tube or flask.



Part 2: Using your indicator

Apparatus
- red cabbage juice
- spotting tile
- dropping pipette
- substances to test

⚠ Wear eye protection. Nothing should be tasted, not even food and drink.

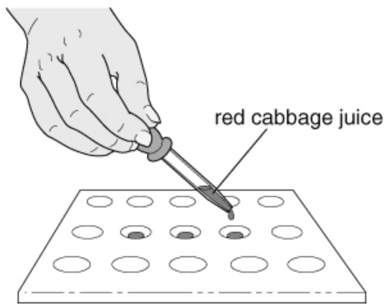
Method

A Put *one* of the substances into a circle on the spotting tile. Write the name of the substance in a table.

B Add a few drops of your cabbage juice.

C Write the colour in your table.

D Do this again with another substance.



Recording and considering your results

Name of the substance	Colour of cabbage juice	Acid or alkali? If you can't tell put a '?' in the box

I can…
- make an indicator and use it to identify acids and alkalis.

Your teacher may watch to see:
- that you can record the colours you observe correctly.

Aim

To prepare a colour chart for an indicator in acids and alkalis.

Part 1: Making the indicator

Apparatus
- mortar and pestle
- boiling tube or conical flask
- filter paper and a filter funnel
- hot water
- plant matter (leaves, flowers, fruits, roots)

⚠ Wear eye protection.

Method

A Wear eye protection. Put some of *one* type of plant material into the mortar.

B Add a little hot water.

C Grind up the plant material so that you get as much of the colour out as possible.

D Filter the mixture and collect the liquid in a tube or flask.

Part 2: Using your indicator

Apparatus
- plant juice indicator
- dropping pipette
- spotting tile
- substances to test

⚠ Wear eye protection.
Nothing should be tasted, not even food and drink.

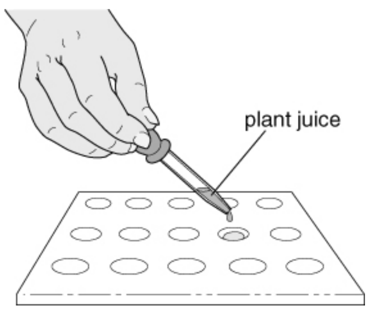
Method

A Put *one* of the substances into a circle on the spotting tile.

B Write the name of the substance in a table.

C Add a few drops of your plant juice indicator.

D Write the colour in your table.



Recording your results

1 Draw a results table like this and fill it in as you test your indicator. Make enough rows to fit in all the test substances you are using.

Plant material: ______________________	
Name of test substance	**Colour of plant juice**

2 Repeat Part 2 using litmus indicator solution instead of your own plant juice indicator.

3 If you have time, repeat the experiment with a different plant material or copy the results of other groups in your class. Draw a separate results table for each plant material used.

Considering your results/Conclusions

1 Make lists of the acids and alkalis that you have tested.

2 Make a colour chart for each of the plant juice indicators and litmus, showing their colour in acids and alkalis.

I can…

- make an indicator
- describe how to work out a colour chart for an indicator.

Aim

To determine the colours of litmus and other indicators in acidic, alkaline and neutral solutions and to compare the effectiveness of the indicators.

Part 1: How do the colours of litmus change?

Apparatus

- litmus indicator
- dropping pipette
- spotting tile
- substances to test (labelled acid, alkali, neutral)

⚠ Wear eye protection.
Caution! The test substances are irritants.

Method

A Put *one* of the substances into a circle on the spotting tile.

B Write the name of the substance in a table.

C Add a few drops of litmus indicator.

D Write the colour in your table.

E Do this again with another substance.

Considering your results/Conclusions

1 What is the colour of litmus in

a an acid

b an alkali

c a neutral solution?

2 What do you notice about the colour of litmus in a neutral solution?

3 Why do you think the litmus is this colour in a neutral solution?

Planning

1 Plan an experiment to test your idea. If there is time, carry out your test and report your findings.

Part 2: Which indicator is best?

Use the method in part 1 to compare a number of different indicators and record their colours in acids, alkalis and neutral solutions. Make sure you record the name of each indicator.

Considering your results/Conclusions

2 Draw a colour chart for each indicator, showing its colour in acid, alkali and neutral solutions.

3 What do you think is meant by 'the best' indicator? Decide on criteria for choosing your 'best' indicator.

4 Use the criteria you have decided on to compare the indicators you tested. Write a report justifying your choice of the best indicator.

I can…

- explain why litmus is purple in neutral solutions
- evaluate the effectiveness of an indicator.

Indicator colours

Name ______________________ **Class** __________ **Date** ___________

1 Complete the sentence using some of the words below.

purple	indicator	red	alkali	neutral

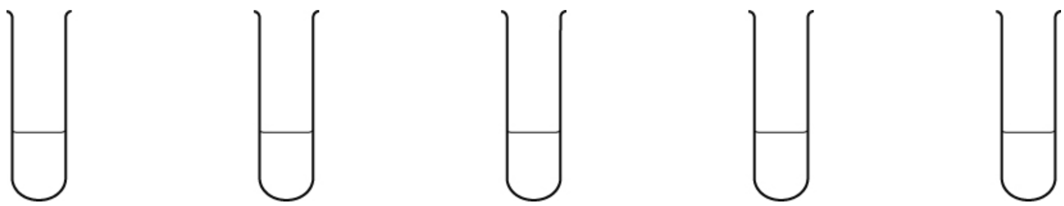
a Litmus is an ______________

b Litmus turns ______________ in an acid and blue in an ______________

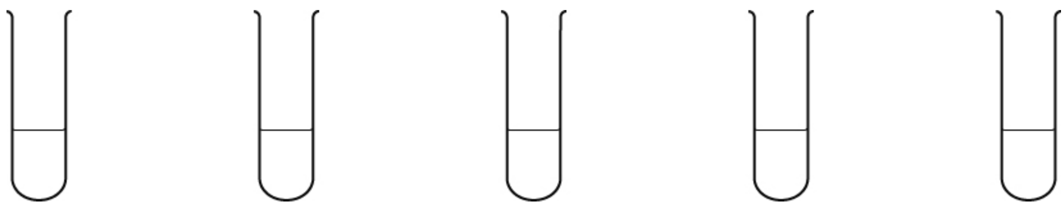
Some scientists added litmus to test tubes containing solutions of acids, alkalis and neutral substances.

2 Colour the solutions in the test tubes below the colour that the litmus would be in the named solution.

If you do not have coloured pens or pencils use a pen or pencil. Shade or dot the test tubes to represent the colours. Show what your shading means using a key.



sodium hydroxide	salt	sulfuric acid	soap	vinegar



bleach	citric acid	sugar	pure water	limewater

3 The scientists added the litmus to an unknown solution. The litmus turned blue. What does this tell the scientists about the unknown solution?

____

I can…

- recall examples of acids and alkalis and the colour changes they make to litmus solution
- describe how to use indicators to tell the difference between acid, alkalis and neutral solutions.

LoCost Supermarket is redesigning all its 'own label' packaging for food and household goods. They have heard that acids and alkalis are hazards so they have decided that all the products that are acids or alkalis should carry a warning. The warning should be colour coded.

First of all the products must be tested to see if they are an acid, an alkali or neutral.

- Suggest a suitable indicator for LoCost to use to test its products.
- Design a colour chart for the indicator you have suggested, which can be used on the packaging to show shoppers whether the product is an acid, an alkali or neutral.
- Design a poster or a leaflet for the supermarket to explain the scheme to shoppers, giving examples of products that are acids, alkalis and neutral.

Examples of LoCost products

Vinegar, toothpaste, table salt, oven cleaner, lemon juice, cola, soap, white sugar, disinfectant, yogurt, barbecue lighter fuel.

Planning

- In your group discuss what tasks have to be carried out and whether you are all going to work on each task in turn or split up into smaller groups to share out the tasks.
- Decide what each member of the group will do.
- Discuss where you can get information from.
- Discuss how you will check how each task is progressing.
- Discuss how you will make sure that all the tasks are finished in time.

Evaluation

When you have finished the tasks answer these questions.

1 Which indicator did you choose? Explain why this indicator was the most suitable.

2 What did you notice about the colour of the indicator in neutral solutions? Explain why the indicator has this colour in a neutral solution.

3 Do you think it would be a good idea for all products to be colour coded in this way? Give reasons for your answer.

I can…

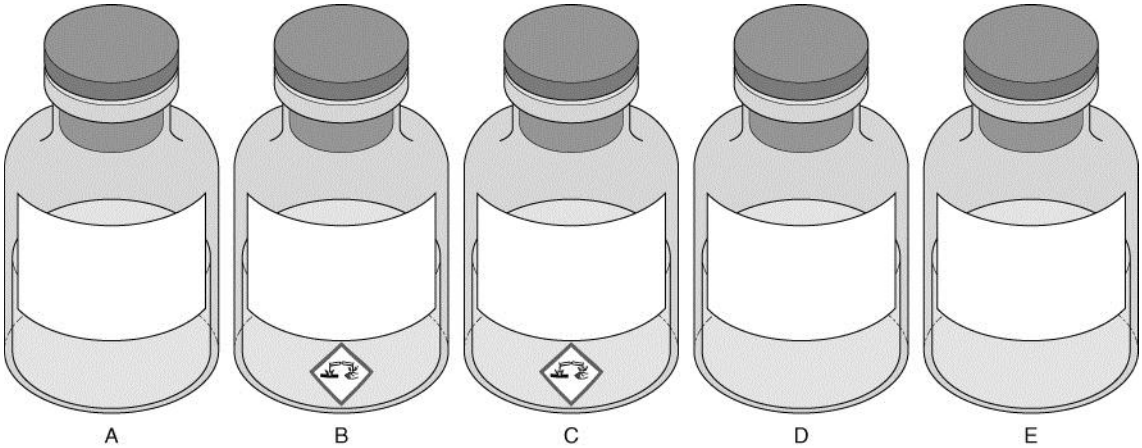
- explain the colour of indicators in neutral solution
- evaluate the effectiveness of indicators.

What a disaster! Mr Muddle's kitchen is such a mess that he has bottles of solutions with the labels missing. Luckily some of them still have warning stickers on them. Mr Muddle knows that some of the solutions were acids and some were alkalis, so he has tested a few drops of each with litmus solution. He has also sniffed some of the solutions that did not have warnings on the bottles (**Do Not Try This Yourself!**). Help him put the correct name labels back on the bottles.

The solutions were:

battery acid (sulfuric acid) (Corrosive!)	**citric acid for making lemonade**	**drain cleaner (sodium hydroxide) (Corrosive!)**	**baking soda (sodium hydrogen carbonate)**	**vinegar (ethanoic acid)**

Write the correct names onto the bottles below.



Mr Muddle's tests

Bottle	A	B	C	D	E
Litmus test	red	red	blue	blue	red
Notes	Sharp smell				Strong smell

Key

(light grey)	red
(dark grey)	blue

I can…

- recall examples of acids and alkalis
- recall the colour of litmus in acids and alkalis
- use indicators to distinguish between acids and alkalis.

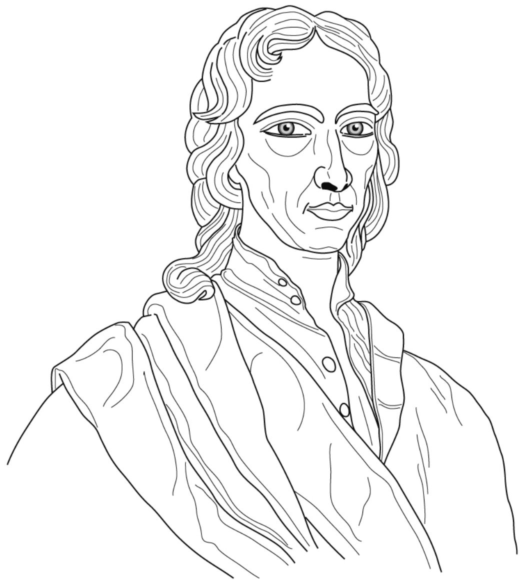
Robert Boyle's indicator

In the Middle Ages people knew of many substances that had sharp or sour tastes. They called them 'acids', from the Latin word for 'sour'. They also knew of substances that had a slippery feel to them. These were called 'alkalis' from the Arabic word for the ashes that some of these substances were obtained from.

Cloth makers coloured silk and wool with dyes obtained from plants and animals. They used other substances to help the dye stick to the cloth. They noticed that some of these substances changed the colours of the dyes. Some people carried out experiments and found that some alkalis fizzed when they were put in acids.

In 1664 Robert Boyle published a book in which he studied the colour of many substances. He described experiments he had done with coloured plant materials such as violets. He found that these coloured substances turned one colour in acids and another colour in alkalis. He said all acids and alkalis would act in the same way so indicators could be used to identify which substances were acids or alkalis. He found that a purple dye from a kind of lichen was very successful. He soaked this dye into pieces of paper that he then dipped into solutions to test them. This substance was called litmus and he had invented indicator papers.

Robert Boyle 1627–1691



Robert Boyle was born in Ireland to a very wealthy family. His book *The Sceptical Chymist* is famous for being one of the first to describe substances and chemical reactions in ways that we use today.

Boyle suggested that acids had a sharp taste because they were made up of tiny particles with spikes. Alkalis, however, were made up of soft slippery balls. When acids reacted with alkalis the acid spikes stuck into alkali balls so they didn't taste sharp anymore.

Questions

1 Explain how vinegar was known to contain an acid.

2 Explain how it was known that some lakes contain an alkali in the water.

3 Explain why some substances produced different colours when cloth was dyed with them.

4 Pick out examples where Boyle

- **a** made observations
- **b** stated a conclusion
- **c** suggested a hypothesis.

5 Describe how Boyle could have worked out a colour chart for his solution of violets.

6 Explain why Boyle's book on acids and alkalis was important.

7 Boyle found that sometimes when he mixed solutions the litmus paper turned purple. Suggest a reason why this happened.

I can…

- describe how to use indicators to tell the difference between acid, alkalis and neutral solutions.

Indicators at home

In this experiment you will be looking to see if there are any things that you can find around your home that could be used as indicators. Remember that an indicator will:

- be coloured
- change colour when mixed with acid or alkali.

Check with an adult before doing the experiment.

Planning

1 Suggest some coloured substances that you have in your home that you could test to see if they could be good indicators.

2 You will need an acid and an alkali to test your indicator. From the work you have done in class, suggest some acids and alkalis that you have at home that would be safe to use in this experiment. Will you also need to test your indicator using a neutral substance? What would you use for this?

3 How will you carry out your test to show if each of the coloured substances that you are trying behaves as an indicator?

Recording your results

1 You should design a table or chart to show:

- the name of the substance that you are testing
- if it changes colour when you mix it with chemicals that are acidic, alkaline or neutral.

Conclusion/Considering your results

1 Which of the substances that you tested is the best indicator? How have you reached this decision?

2 Which other substances would also work as indicators?

3 Are there any substances that you have tested that are no good as indicators? Why not?

I can…

- use solutions of known acidity/alkalinity in order to deduce a colour chart for an indicator.

Comparing indicators

Some scientists recorded the colour of various dyes when added to a variety of solutions. Their results are shown in the table below.

Test solution	Dyes				
	Litmus	Red cabbage	Daffodil	Phenolphthalein	Onion skins
Sodium hydroxide	blue	green	yellow	purple	yellow
Vinegar	red	red	yellow	colourless	colourless
Salt	purple	purple	yellow	colourless	colourless
Soap	blue	blue-green	yellow	colourless	yellow
Ammonia	blue	green	yellow	purple	yellow
Dilute hydrochloric acid	red	red	yellow	colourless	colourless
Sugar	purple	purple	yellow	colourless	colourless
Lemon juice	red	red	yellow	colourless	colourless

1 Which of the dyes is not an indicator? Explain your answer.

2 Draw a simple colour chart showing the colour in acids, neutral substances and alkalis, for each of the dyes that are indicators. Explain how you were able to work out the colour charts.

3 Which indicators are best for identifying:

a acids

b neutral substances?

Explain your answers.

4 What evidence is there that some substances are more alkaline than others?

5 Suggest a reason why litmus is purple in neutral solutions.

6 Which indicator do you think is best for identifying whether a substance is an acid, an alkali or neutral? Give your reasons.

I can…

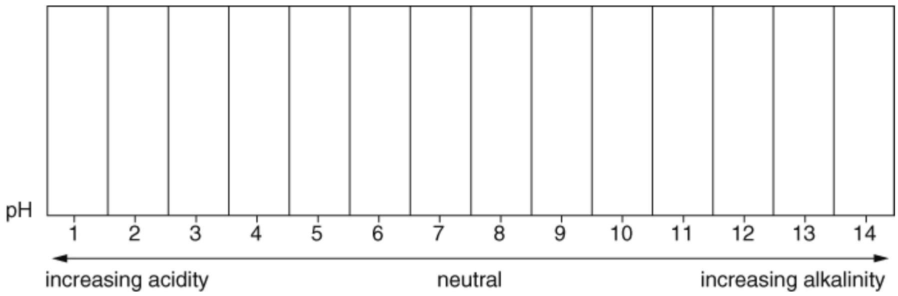
- explain why litmus is purple in neutral solutions
- evaluate the effectiveness of different indicators.

Indicator rainbow

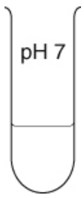
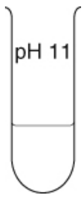
Name ______________________ **Class** ____________ **Date** ____________

1 Universal indicator can tell us how acidic or alkaline a substance is.

Colour in the chart.



2 What is it? Acid, alkali or neutral?

		
Substance A	**Substance B**	**Substance C**
It is ______________	It is ______________	It is ______________
Its colour is __________	Its colour is__________	Its colour is __________

3 Draw lines to match each substance with its pH and its colour in universal indicator.

Substance	**pH**	**Colour**
stomach acid	pH 5–6	green
skin	pH 1	yellow
soap	pH 10	red
pure water	pH 9	green-blue
toothpaste	pH 7	dark green

I can…

- describe how universal indicator shows whether a solution is acidic, alkaline or neutral
- describe the main features of the pH scale.

Name ________________________________ Class _____________ Date ______________

Method

A Put *one* of the substances into a circle on the spotting tile. Write the name of the substance in the table.

B Add two drops of universal indicator.

C Write the colour in the table.

D Look up the pH number using the colour chart. Write it in the table.

E Do this again with another substance.

Apparatus

- universal indicator or solution
- pH colour chart
- spotting tile
- dropping pipette
- substances to test
- eye protection

⚠ Wear eye protection.
Nothing should be tasted, not even food or drink.

Name of substance	Colour of universal indicator	pH number	Type of substance

Considering your results/conclusion

1 Decide whether each substance is acidic, alkaline or neutral and write it in the column headed 'Type of substance'.

2 Which substance is

a the most acidic: ____

b the most alkaline: ____

I can…

- use universal indicator to find the pH number of solutions
- use my results to state that a solution is neutral, acidic or alkaline.

Aim

To use universal indicator and pH meters to measure the pH of solutions and determine how acidic or alkaline the substances are.

Your teacher may watch to see if you:
- can use a pH meter correctly and record the colours of universal indicator and pH numbers accurately.

Apparatus
- Part 1: universal indicator solution, dropping pipette, spotting tile, pH colour chart.
- Part 2: test tube rack, test tubes, dropping pipette, pH meter.

⚠ Wear eye protection.
Nothing should be tasted, not even food or drink.

Part 1: Measuring pH using universal indicator solution

A Use a dropping pipette to put *one* of the solutions into a circle on the spotting tile.

B Add a few drops of universal indicator solution.

C Write the name of the solution and the colour in your results table.

D Use a pH colour chart to find the pH number of the solution and write it in the table.

E Repeat with another test solution.

Part 2: Measuring pH using a pH meter

A Pour the test solution into a test tube until it is about one-third full.

B Put the probe of the pH meter into the solution and stir it in the solution gently.

C Read the pH number from the meter.

D Write the pH meter reading into your table. Make sure you write it in the correct row for the test solution.

E Take the pH probe out of the solution and wash it with clean water.

F Repeat with another test solution.

Recording your results

Copy the headings below in your results table.

Name of solution	Colour of universal indicator	pH number	pH meter reading	Type of substance

Considering your results/Conclusion

1 Decide if each substance is neutral, acidic, alkaline, the most acidic or most alkaline. Write in your decision in the last column of your results table.

2 Explain why it is useful to have *two* ways of determining the pH of a solution.

3 Which method of determining pH is best? Explain your answer.

I can…
- use universal indicator and a pH meter to determine the pH of a solution
- use pH colours and numbers to describe solutions as neutral or as more or less acidic or alkaline.

Design a pH indicator

Universal indicator is a mixture of dyes each of which changes colour at various pH numbers. The mixture produces a distinct pattern of colour across the whole pH range.

Your task is to design your own pH indicator:

- either for the whole pH range (0–14)
- or a part of the range e.g. 0–6 or 8–14 or 4–10.

You have a number of indicators, some of which you may not have used before. You also have a variety of test solutions with known pH numbers or a pH meter is available for you to measure the pH number.

Planning

Working in your group decide the questions you need to ask to complete your task and how you will find the answers.

For example:

- What type of indicator shall we make?
- What colour is each indicator in the test solutions across the pH range you are investigating?
- How should you test mixtures of the indicators?
- How will you decide if your indicator is a good one?

Carrying out your plan

Collect the apparatus and materials you need and carry out the activities you decided on in your plan. Follow safety precautions and try to be as well organised as you can.

⚠ Wear eye protection. Nothing should be tasted, not even food or drink.

Recording your results

Design a table to record the observations and measurements you take.

Considering your results/Conclusions

1. Draw a pH colour chart for the indicator.
2. Does your indicator give an accurate pH number across the range it was intended for? Explain your answer.
3. Write a report of your investigation.

I can…

- use universal indicator and pH meters to measure pH
- use information about indicators to design a pH indicator.

Using pH

Name ______________________________ **Class** ____________ **Date** _____________

Some scientists measured the pH of solutions of substances that may be found around your home. The substances and their pH numbers are shown in the boxes below.

A Use a pH colour chart to work out what colour universal indicator would be in each substance.

B Colour in the strip of indicator paper in each box to show this colour.

C Cut out the boxes and sort them into three groups – acids, alkalis and neutral solutions.

D Write a title and your name at the top of a clean sheet of paper. Copy out the sentences below filling in the gaps with the words from the box. (You will not need to use all the words or numbers.)

Universal _______________ is used to work out the pH _______________ of solutions.

If the pH is less than _______ the solution is an acid; if it is over 7 it is an _________ and if it is equal to 7 it is a _______________ solution.

acid	**alkali**	**neutral**	**0**	**7**	**14**	**number**	**indicator**

E Divide the rest of your sheet of paper into three columns headed 'Acids', 'Alkalis' and 'Neutral solutions'.

F Stick each of the boxes in the correct column.

Toothpaste **pH 9**	Washing powder **pH 10**	Vinegar **pH 3**	Pure water **pH 7**
Fizzy drinks **pH 4.5**	Oven cleaner **pH 13**	Soap **pH 8**	Salt water **pH 7**
Stomach acid **pH 2**	Hair dye **pH 11**	Sea water **pH 8**	Rainwater **pH 5.5**
Sugar solution **pH 7**	Lemon juice **pH 2.5**	Milk **pH 6.5**	Baking soda **pH 9**

I can…

- state the colour of universal indicator for solutions with particular pH numbers
- use the pH scale to state if a solution is acidic, alkaline or neutral.

pH applications

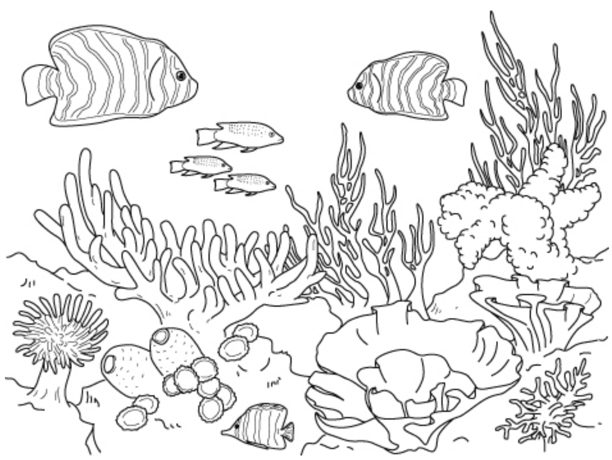
Scientists in lots of different areas make use of the pH scale.

1 Read the information in the boxes below.

2 Pick out the key words from each box. Write a title for each item.

3 Use the titles you have written to design a poster about pH. You could add pictures from magazines or from the internet.

4 Illustrate each item with the colours of universal indicator for the pH numbers mentioned and state how acidic or alkaline the substances are.



Marine scientists are seeing changes in the pH of seawater as the amount of carbon dioxide in the air increases. This could have a harmful effect on sea creatures such as corals.

Ecologists have seen a slow improvement in the quality of water in lakes since the 1960s. The dirty coal that used to be used in power stations produced sulfuric acid, which made some lakes as low as pH 2. This killed most fish.

Many streams are back to normal. Chalk streams have a pH of about 7.5 while streams is peaty areas can be about pH 6.

Farmers are very interested in the pH of their soils. Wheat and barley prefer a pH just below 7 but potatoes grow well in soils with a pH as low as 5.5. Sugar beet on the other hand, grows in soils at pH 8.

Hairdressers use many different substances on your hair. Shampoos can have a pH as high as 9. Some makes are 'pH balanced' to be the same pH as your skin, about pH 5.5. This is done by adding citric acid with a pH of about 3 to the shampoo. Liquids used to dye hair have a pH of 11.

The drinks that we like have a variety of pH numbers. Mineral water has a pH of about 8. Milk is pH 6.5 but yogurt drinks are around 4.5.

Lemonade is around pH 5. Cola is the lowest of the lot because of the phosphoric acid added to it. It has a pH of 3. It seems we like the sharp taste.

What about beer, the drink for which pH was invented? It has a pH of about 4.

A variety of substances are used to clean metals. Dirt and rust can be removed from iron and steel with sulfuric acid at a pH of 1. Aluminium needs cleaning materials that are close to pH 7 while the alloys used for car wheels and exhausts can be cleaned with liquids that have a pH of 12.

I can…

- use universal indicator and pH numbers to describe solutions as being more or less acidic or alkaline
- I can identify the key points in text and write clear titles to present ideas.

Inventing indicators

Although Peder Sorenson invented the pH scale in 1909 it required a lot of skill to calculate the pH of solutions. Simple indicators like litmus change colour at a particular pH so their colour indicates if the pH of the solution is above or below that pH. They do not give a precise pH number.

In 1923 a Japanese chemist called Yamada had the idea of mixing a number of indicators together to produce a mixture that produced a pattern of colours across the whole range of pH numbers. His recipe was patented in 1934 and is still used today for universal indicator.

Indicator	Amount in 1 litre of universal indicator solution (g)	Colour 1	Colour 2	pH at which colours changes from 1 to 2
Thymol blue	0.025	yellow	blue	8–9.5
Methyl red	0.060	red	yellow	4–6.5
Bromothymol blue	0.300	yellow	blue	6–7.5
phenolphthalein	0.500	colourless	red	8–10

1 Which of the indicators used by Yamada shows different colours in test solutions that are:

a more and less acidic

b slightly acidic and slightly alkaline

c more and less alkaline?

2 Why do you think that Yamada's mixture contains only a small amount of thymol blue compared to the amount of phenolphthalein?

3 Universal indicator is often called 'full-range' indicator but what range of pH numbers does it actually show different colours for?

Scientists often need a pH indicator that shows a colour change over a different range to Yamada's universal indicator.

4 Use the data in the box below and Yamada's recipe above to design an indicator that shows various colours over the range pH 0 to pH 7. You don't have to use all the indicators. Write down the indicators you think may work and draw a pH colour chart that you predict for your indicator.

Indicator	Colour 1	Colour 2	pH of colour change
Methyl violet	yellow	blue	0–1.5
Methyl yellow	red	yellow	3–4
Bromocresol green	yellow	blue	4–5
Phenol red	yellow	red	7–8.5

5 The pH meter was invented in 1935 by Arnold Beckmann. It was the first electronic instrument used in chemistry. Find out more about Beckman and his invention and write a short magazine article suggesting why his invention was important.

I can…

- describe solutions as more or less acidic or alkaline by comparing their pH
- use information about indicator colour changes to design indicators.

The pH test

Here are the results from an experiment using pH indicator paper. Some dry green pH indicator paper was touched on to a number of different substances. Look at the results and then answer the questions.

Experiment number	Substance	Colour of indicator paper
1	salt crystals	stayed green
2	salt water	stayed green
3	vinegar	turned orange
4	toothpaste	turned blue-green
5	citric acid crystals	stayed green
6	citric acid solution	turned orange
7	dilute sulfuric acid	turned red
8	tap water	stayed green
9	washing soda crystals	stayed green
10	washing soda solution	turned blue
11	sugar crystals	stayed green
12	sugar solution	stayed green

1 Decide whether you think each of the conclusions below is 'true' or 'false', based on the evidence in the table.

A Acids turn pH indicator blue.

B Vinegar is an acid.

C All crystals are neutral.

D All solutions are acids.

E You need to have water present to see if something is an acid or an alkali.

2 Explain which pieces of evidence help you reach your answers.

3 Suggest some extra pieces of evidence that might help you check the conclusions.

4 Which substance was the most acidic? Explain how you know your answer.

5 Is the pH of toothpaste higher or lower than washing soda solution? Explain how you know your answer.

I can…

- use universal indicator and the pH scale to state if a solution is acidic, alkaline or neutral
- draw conclusions
- explain the importance of evidence in drawing conclusions.

A day of pH

Name ______________________ **Class** ____________ **Date** ____________

You use a lot of substances during the day. Many of these substances are acids or alkalis or they are neutral.

The table gives the pH of some substances that you may meet during your day.

Write a diary of a day using the colours of universal indicator (UI) to show the pH of the substances. State whether they are neutral or more or less acidic or alkaline.

Substance	pH	Substance	pH	Substance	pH
Oranges and orange juice	3.5	Egg white	9.0	Lemonade	5
Cola	3	Kitchen cleaner	11	Milk	6.5
Mineral water	8	Oven cleaner	13	Tap water	7
Toothpaste	9.5	Vinegar	3	Washing up liquid	5
Wasp sting	10	Bee sting	3.5	Hair dye	11
Soap	8	Rainwater	5.5	Washing powder	10
Shampoo	9	pH balanced shampoo	5.5	Yogurt	4.5
Tea	5	Tartar sauce	5	Nail polish remover	7

You can use the grid below for your diary and continue on the back of this sheet or make up your own style. If you do not have coloured pens or pencil write in the colour the indicator would be.

Put a star next to the most acidic and most alkaline substances you meet during the day.

Time	Name of substances used	UI colour	Acid, alkali or neutral substance

I can…

- use universal indicator and pH numbers to describe solutions as being more or less acidic or alkaline.

pH colour changes

There are many different substances that can be used as indicators. Different indicators change colour at different pH numbers. This table shows the pH numbers at which some indicators change colour.

Indicator	First colour (more acid)	pH number when it changes colour	Second colour (more alkaline)
Methyl violet	yellow	1	blue
Methyl orange	red	4	yellow
Litmus	red	7	blue
Thymol blue	yellow	9	blue
Phenolphthalein	colourless	9	red
Alizarin yellow	yellow	12	red

1 What colour is:

a methyl orange in alkali

b thymol blue in acid

c methyl violet in acid of pH 5?

2 Copy and complete the following chart to show what would happen to a mixture of indicators.

pH number	Colour of methyl orange	Colour of thymol blue	Colour of a mixture of the two indicators
3			
7			
10			

3 What colour would a mixture of thymol blue and phenolphthalein go if the following solutions were added:

a hydrochloric acid

b salt water

c sodium hydroxide?

4 **a** Explain how a mixture of methyl orange, litmus and phenolphthalein could be used as a type of universal indicator.

b How many different colours would this indicator go? Name them.

c Make a colour chart for the mixture, writing in the colour at each pH number.

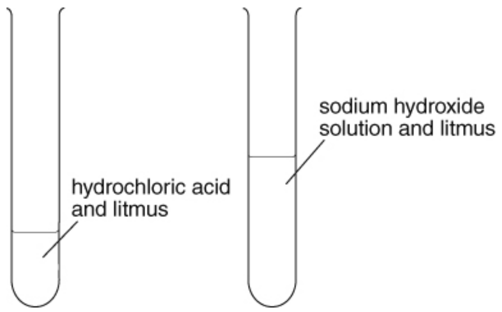
5 Explain why a mixture of indicators, as used in universal indicator, is more useful than a single indicator.

I can…

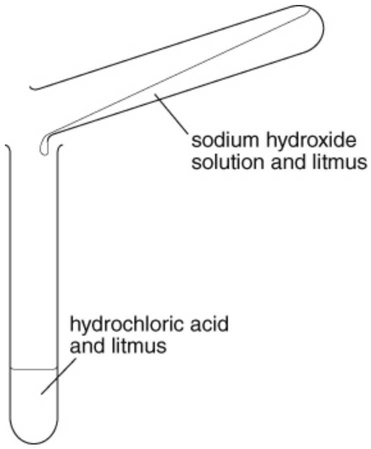
- explain how the colour of an indicator varies with the pH of the solution it is in
- use information about indicator colour changes to design indicators.

Name ______________________ **Class** __________ **Date** __________

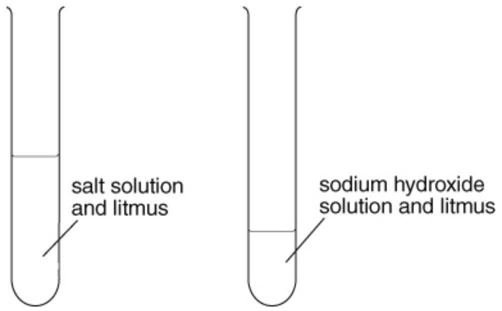
1 Colour in the solutions in the test tubes below with the colour that the litmus indicator would be.



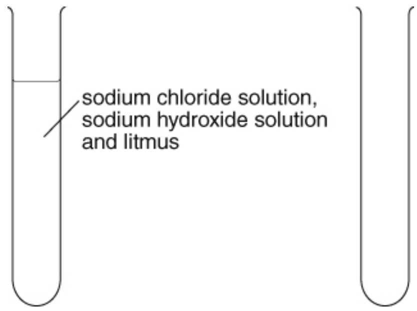
1 One test tube contains an acid and the other an alkali.



2 The alkali is being poured into the acid.



3 The acid has been neutralised.



4 More alkali has been added to the salt solution.

2 Look at the word equation below. Complete the sentences that follow using words from the box. You will not need to use all the words in the box.

hydrochloric acid + sodium hydroxide solution → sodium chloride solution + water

acid	alkali	chemical	neutralisation	neutralised	physical
		products	reactants		

a Sodium hydroxide solution has a pH of 13 so it is an ______________.

b When sodium hydroxide is mixed with hydrochloric acid a ______________ reaction takes place.

c Hydrochloric acid and sodium hydroxide are the ______________ in the reaction.

d When only sodium chloride and water are left the alkali has ______________ the ______________.

e The reaction between an acid and an alkali is called ____________________.

f One of the ______________ of the reaction is a salt.

I can…

- recall that the chemical reaction between acids and alkalis is called neutralisation
- identify the reactions and products in a word equation.

Acids and alkalis react

Name ______________________ **Class** __________ **Date** __________

Aim

To investigate the changes to indicator colours when acids and alkalis react.

Your teacher may watch you to see if you can:

- measure solutions carefully, and observe and record colours accurately.

Method

A Add a drop of the indicator to the test tube containing the acid. Record the name and the colour of the indicator on the line above the table below.

B Add 1 cm^3 of the sodium hydroxide solution from the measuring cylinder into the test tube containing the acid. Shake the test tube gently. Record the colour of the solution in the table.

C Add another 1 cm^3 of the sodium hydroxide solution to the test tube. Shake and record the colour the colour. Continue doing this until all the sodium hydroxide has been used up.

Apparatus

- test tube containing 5 cm^3 of dilute hydrochloric acid
- measuring cylinder containing 10 cm^3 of sodium hydroxide solution
- indicator solution

⚠ Wear eye protection.

Recording your results

Name of indicator: ______________________ Colour in acid: ______________________

Volume of sodium hydroxide solution added (cm^3)	**1**	**2**	**3**	**4**	**5**
Colour of indicator					
Volume of sodium hydroxide solution added (cm^3)	**6**	**7**	**8**	**9**	**10**
Colour of indicator					

Considering your results/Conclusions

1 How do you know a neutralisation reaction happened?

____

2 How much sodium hydroxide had to be added to neutralise the hydrochloric acid? ____ cm^3

The word equation for the reaction is

hydrochloric acid + sodium hydroxide → sodium chloride + water

3 Name the products of the reaction.

____

4 How do you know that this neutralisation reaction is a chemical change?

____

I can…

- recall that the chemical reaction between acids and alkalis is called neutralisation
- identify the reactants and products in a word equation.

Aim

To determine how much sodium hydroxide is needed to neutralise a sample of hydrochloric acid.

Your teacher may watch you to see that you can:
- measure solutions and follow instructions accurately; observe and record the colour of an indicator accurately.

Part 1: Neutralisation

A Measure out 10 cm^3 of hydrochloric acid (CARE! Corrosive) into the boiling tube.

B Add a few drops of the indicator solution. Record the name of the indicator and its colour in the acid.

C Use a clean measuring cylinder to measure out 15 cm^3 of sodium hydroxide solution (CARE! Corrosive).

D Add the sodium hydroxide 1 cm^3 at a time to the acid in the boiling tube. Shake gently after each addition and record the colour of the indicator.

E When you have used up all your sodium hydroxide solution collect another 10 cm^3 in the measuring cylinder and continue to add it 1 cm^3 at a time to the boiling tube.

F Wash out your apparatus and repeat the experiment.

Apparatus
- boiling tube
- 10 cm^3 and 25 cm^3 measuring cylinders
- dropping pipette
- hydrochloric acid 
- sodium hydroxide solution 
- indicator

⚠ Wear eye protection.

Recording your results

1 Copy and complete the table shown below

Volume of sodium hydroxide solution added (cm^3)	Colour of indicator

Considering your results/Conclusions

1 What volume of sodium hydroxide solution was needed to just neutralise the hydrochloric acid?

2 Describe the reaction that took place in the boiling tube.

Aim

To prepare a pure sample of common salt (sodium chloride)

Your teacher may watch you to see if you can:

- heat a solution safely.

Part 2: Collecting the salt

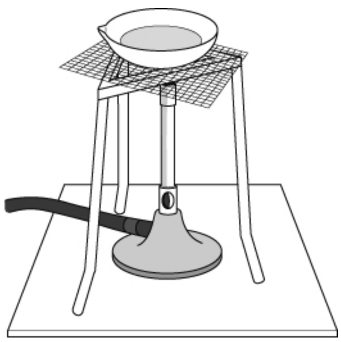
A Measure out 10 cm^3 of hydrochloric acid into an evaporating dish.

B Measure out the volume of sodium hydroxide solution that you found in Part 1 just neutralised the acid. Add this to the evaporating dish.

C Place the evaporating dish on a tripod and gauze and heat it to evaporate the water off.

D Remove the heat when you start to see crystals forming.

E Leave the evaporating dish overnight on a window sill to evaporate fully.



Apparatus

- 10 cm^3 and 25 cm^3 measuring cylinders
- dropping pipette
- evaporating dish
- tripod and gauze
- Bunsen burner
- bench mat
- hydrochloric acid
- sodium hydroxide solution

⚠ Wear eye protection.

Considering your results/Conclusions

1 Describe and name what you see in the dry evaporating dish.

2 Write the word equation for the reaction.

I can…

- describe reactions between acids and alkalis
- write word equations for simple reactions.

Aim

To investigate the effect on pH of diluting an acid and neutralising it with an alkali.

Your teacher may watch you to see if you can:
- measure solutions accurately
- use a pH meter correctly.

Method

⚠ Wear eye protection.

Apparatus
- 100 cm^3 beaker
- boiling tubes
- boiling tube rack
- measuring cylinders
- dropping pipette
- pH meter and probe
- hydrochloric acid
- sodium hydroxide solution
- universal indicator solution
- distilled water

Part 1: How does dilution affect pH?

A Put 20 cm^3 of hydrochloric acid into a boiling tube.

B Add a few drops of universal indicator, swirl gently and record the colour and the pH.

C Dip the probe of a pH meter in the solution and record the pH.

D Add 10 cm^3 of distilled water. Shake gently. Record the volume of water added, colour and pH.

E Repeat D until you have added 60 cm^3 of distilled water.

Considering your results

1 What was the change in pH for the total volume of water added in the experiment?

Part 2: How does pH change in neutralisation reactions?

A Repeat stages A, B and C from Part 1 above.

B Add 2 cm^3 of sodium hydroxide solution to the acid. Swirl gently. Record the colour and the pH.

C Repeat step B until you have added a total of 30 cm^3 of sodium hydroxide solution to the acid.

Considering your results/Conclusions

1 Draw a graph with 'pH' as the vertical axis and 'Volume of sodium hydroxide added' as the horizontal axis. Plot your results. Draw a smooth line that passes through or close to your points.

2 What volume of sodium hydroxide solution was needed to make the mixture neutral?

3 What substances were in the beaker when the mixture was neutral?

4 Write a word equation for the reaction.

5 Describe the shape of your graph.

6 Which is the most effective at changing pH – diluting or neutralising? Explain your answer.

7 Suggest the best way of clearing a spillage of an acid.

I can…
- apply ideas about the pH scale to the chemical changes that happen in neutralisation
- plot and interpret line graphs.

Neutralisation equations

An **acid** and an **alkal**i react together. The reaction is called **neutralisation**. The products of the reaction are a **salt** and **water**.

The word equation for the chemical change has the pattern:

acid + alkali → salt + water

1 In the table below there are the names of five acids, five alkalis and five salts.

Cut out all the cards and sort them into acids, alkalis and salts. You should also be left with five 'water' cards.

Copy the names down into a table with the headings, 'acids', 'alkalis' and 'salts'.

Next, sort the cards, including the water cards into reactants and products, of five neutralisation reactions.

Stick the cards onto a sheet of paper in the form of the word equations and write in the 'and' symbol (+) and the 'react to form' symbol (→).

Water	Hydrochloric acid	Sodium hydroxide	Water	Potassium citrate
Lithium chloride	Potassium hydroxide	Nitric acid	Sodium ethanoate	Ammonium hydroxide
Calcium hydroxide	Ammonium nitrate	Water	Sulfuric acid	Calcium sulfate
Ethanoic acid	Water	Water	Lithium hydroxide	Citric acid

2 Neutralisation reactions are used every day. Describe reactions that take place in the following situations, including (where appropriate) the reactants and products, if you can, and why the neutralisation is useful. Write word equations if you know the names of all the substances.

a Ammonium nitrate is a useful fertiliser. How can it be manufactured?

b Lakes affected by acid rain contain sulfuric acid. Lime (calcium hydroxide) is added to the lakes.

c If farmers add too much fertiliser to soils it can contain nitric acid. Calcium hydroxide is sometimes spread on the soil.

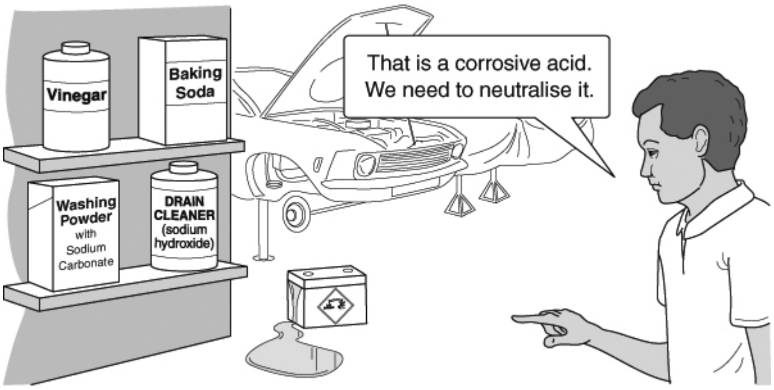
d Potassium citrate is a food additive. How can it be made?

I can…

- write word equations for neutralisation reactions
- name the products when a named acid reacts with a named alkali
- explain some everyday uses of neutralisation reactions.

Using neutralisation

Name ______________________ **Class** __________ **Date** __________



1 Look at the picture. What type of substance will neutralise an acid?

____

Another mechanic suggests using *one* of the other substances in the picture to neutralise the acid.

2 **a** Which of the materials shown in the diagram would not neutralise the spilt acid?

____

b Explain why this material cannot be used.

____

3 The car mechanics decide to use the sodium hydroxide drain cleaner. The word equation for the reaction is

sulfuric acid + sodium hydroxide → sodium sulfate + water

Each sentence below contains a mistake. Cross out the incorrect word and write in the correct one.

a Neutralisation is a physical change because new substances are formed.

____

b They could use an adjudicator to show when the acid has been neutralised.

____

c When the neutralisation is complete there is only sodium hydroxide left in the water.

____

d Sodium sulfate is one of the reactants in the reaction.

____

4 Find out about some other uses of neutralisation reactions and describe them.

I can…

- recall that neutralisation is the chemical change when acids react with alkalis
- identify the reactants and products in a word equation
- explain some uses of neutralisation.

Changing soil pH

Name ______________________ **Class** __________ **Date** __________

Maisie and Ben went for a walk in the countryside. They saw a farm tractor spraying a ploughed field.

'What's the farmer doing?' Ben asked.

'I expect he's putting some alkali on the soil,' Maisie replied.

'Oh, I expect that is to react with acid in the soil,' Ben said.

'Yes,' Maisie agreed. 'The crops won't grow in acid.'

Answer the following questions.

1 **a** Put a circle around the most likely pH of the field that Maisie and Ben saw before it was sprayed.

1 **5** **7** **9** **14**

b What should be the pH of the soil after the farmer has sprayed it ? ____________________

2 Write the name of the reaction that Maisie and Ben described.

____

The farmer may have been spraying calcium hydroxide solution on the soil. A word equation for the change could be

nitric acid + calcium hydroxide → calcium nitrate + water

3 Underline the reactants and (circle) the products in the word equation.

4 Complete the following sentence:

The word equation shows a chemical change because ________________________ are formed.

I can…

- recall the name of the reaction between acids and alkalis
- explain why it is a chemical change
- identify the reactants and products in a word equation
- recall that reactions between acids and alkalis are used to control the pH of soils.

Sorting word equations

Name ______________________ **Class** __________ **Date** __________

1 Sort the anagrams below into the correct words and link them with a line to the clue.

Clues	**Anagrams**
A product of the reaction of an acid and an alkali.	A dirt coin ______________
Substances that react with acids.	late side run ______________
The pH when all of an acid and alkali react.	last ______________
The salts formed by sulfuric acid.	evens ______________
It happens to an acid when alkali is added.	all I ask ______________
Shows when an acid and alkali have reacted.	use flats ______________

2 Fill in the gaps in the word equations below.

a hydrochloric acid + potassium hydroxide → ______________________ + water

b ______________ + lithium hydroxide → lithium sulfate + ______________

c nitric acid + __________________ → sodium nitrate + water

d __________________ + __________________ → calcium chloride + water

3 A farmer is finding that his crop of barley isn't growing well. He finds that his soil is pH 5 while barley prefers a pH between 6 and 7.5.

Write a letter to the farmer explaining what is wrong with his soil and what he should do about it.

____

____

____

____

____

____

I can…

- name the salts formed in neutralisation reactions and write word equations
- explain how to use acids and alkali to change the pH of soils.

Note

Solutions with a pH below 2 and above 12 are classed as corrosive. Between pH 2 and 5 and between pH 9 and 12 they are irritants.

Dilution

A student poured some hydrochloric acid into a beaker and measured the pH. It was pH 1.

The student took 1 cm^3 of this solution, put it in another beaker and added 99 cm^3 of water. He measured the pH again. It was 3.

The student took 1 cm^3 of this diluted solution and again added 99 cm^3 of water to it. The pH was now 5.

1 Show that there was just 0.01 cm^3 of the original hydrochloric acid in the final solution.

2 The acid must be at pH 5 to be non-hazardous. Discuss how effective diluting the acid is as a way of reducing risk.

Neutralisation

Another student measured 10 cm^3 of the same hydrochloric acid into a beaker. She placed the pH meter in the solution and recorded the pH. Then she added sodium hydroxide solution 1 cm^3 at a time and recorded the pH after each addition. Her measurements are shown below.

Volume of sodium hydroxide added (cm^3)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
pH	1	1	1	1	1	1	1	1	1.3	2	7	12	12.7	13	13	13

1 Plot the student's measurements on a graph, with 'Volume of sodium hydroxide added' on the horizontal axis and 'pH' on the vertical axis. Draw a line through the points. Don't forget to give your graph a title.

2 Describe the shape of your graph.

3 Describe what happens in the beaker when the sodium hydroxide is added to the hydrochloric acid.

4 Explain why this is a chemical change.

5 Write a word equation for the reaction.

6 Name the substances that were in the beaker when:

a 8 cm^3 of sodium hydroxide had been added

b 10 cm^3 of sodium hydroxide had been added

c 12 cm^3 of sodium hydroxide had been added.

7 Litmus is an indicator that is purple in neutral solutions. What volume of sodium hydroxide needed to be added to the hydrochloric acid to turn litmus purple? Explain your answer.

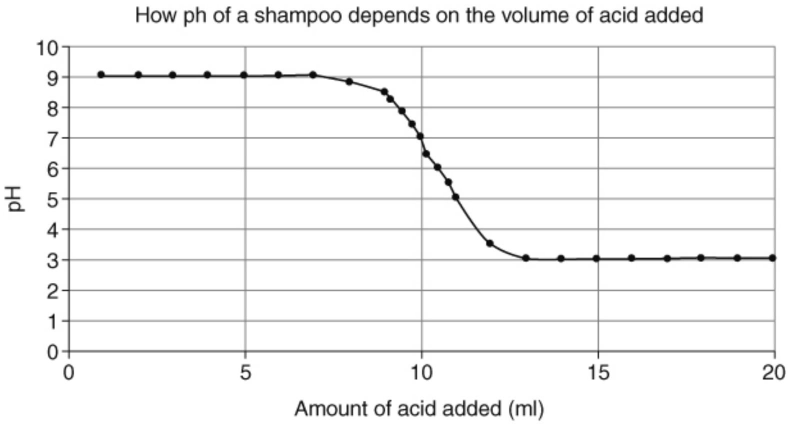
8 The student suggests that adding sodium hydroxide is a good way of making a spill of hydrochloric acid safe. Discuss whether she is correct.

I can…

- explain the changes when acids and alkalis are diluted or neutralised using the pH scale
- plot and interpret graphs for the changes in pH in neutralisation reactions.

The cosmetics company Splash! is looking to launch a new range of shampoos. A company scientist finds that one shampoo has a pH of 9. She decides that the pH of the shampoo should be about the same as skin which has a pH between 5 and 7. The scientist mixes a sample of the shampoo with water and slowly adds citric acid to it, measuring the pH as she does so.

The graph below shows the results the scientist collected.



1 Describe how the pH changes as the acid is added to the shampoo sample.

2 Explain how the scientist can work out the volume of acid needed to neutralise the alkali in the sample of shampoo.

3 Explain why it is important for the scientist to work our exactly how much citric acid is needed to get the pH of a batch of shampoo correct.

4 Explain why it may be safer to use citric acid to pH balance the shampoo instead of hydrochloric acid.

Splash! need to add potassium nitrate to some of their cosmetics. They decide to make the potassium nitrate themselves.

5 Suggest the reactants required to make potassium nitrate.

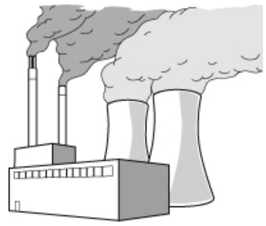
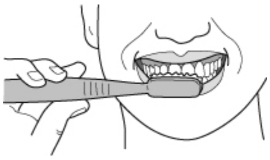
6 Write a word equation for the reaction.

7 Describe how the Splash! scientists can make sure that the potassium nitrate is not contaminated by left-over reactants.

I can…

- interpret graphs of pH against volume of reactants in an reaction between acids and alkalis
- use ideas about pH to explain the changes that take place in these reactions.

Name ______________________ Class ____________ Date ____________

1  ______	2  ______
3  ______	4  ______

The pictures show examples where a reaction between an acid and a base gives a way of solving the problem.

Cut out the ovals below that state the problems and stick them on the picture they describe.

Cut out the rectangles below that contain the solutions to each problem and stick them in the box at the bottom of the correct picture.

Lime (calcium oxide) is a base that is mixed with the gases.

Indigestion means there is too much hydrochloric acid in the stomach.

Burning fuels makes acidic gases.

Toothpaste contains aluminium hydroxide, a base.

Rust-repair kits contain sulfuric acid.

Steel becomes coated with rust (iron oxide), a base.

Food leaves acids in the mouth which cause tooth decay.

Indigestion remedies contain magnesium hydroxide, a base.

I can…

- recall examples of the uses of reactions between acids and bases.

Name ______________________ Class __________ Date __________

Aim

To find the best indigestion remedy out of the samples provided.

Your teacher may watch you to see if you can:
- follow instructions carefully
- use universal indicator paper to measure pH and record observations accurately.

Introduction

If you have too much hydrochloric acid in your stomach it can give you indigestion pains. Remedies for indigestion, sometimes called antacids, contain a base, magnesium hydroxide.

Method

Apparatus
- 4 large test tubes
- test tube rack
- measuring cylinder
- 4 samples of indigestion remedies
- stirring rod
- universal indicator paper
- hydrochloric acid

⚠ Wear eye protection. Do not put any substances in your mouth

A Measure out 10 cm^3 of hydrochloric acid into each of the large test tubes. Stand the test tubes in the test tube rack.

B One at a time, put the small amount of each antacid you have been given into a separate test tube. After adding each amount, record the name of the remedy in the table.

C Stir the mixture in each test tube.

D After two minutes, dip a piece of pH paper in the first test tube and record the colour and pH number. Record what the mixture looks like. Do the same with the other test tubes.

Recording your results

Tube	Name of antacid	Colour of pH paper	pH	Appearance
1				
2				
3				
4				

Considering your results/Conclusions

1 In which test tubes was the acid neutralised? ______________________

2 Which test tubes were cloudy at the end? ______________________

3 Which remedy do you think is best? Explain your answer.

____

____

I can…
- recall that antacids are bases that neutralise acids that cause indigestion
- carry out an experiment to find the best antacid.

Aim

To find the best indigestion remedy from the samples provided.

Your teacher may watch you to see if you can:
- plan an experiment that you can carry out safely to collect evidence and achieve the aim.

Introduction

Indigestion remedies, sometimes called antacids, react with acid in our stomachs and cancel it out. We can test different indigestion remedies by reacting them with some dilute acid and measuring the pH of the mixture after it stops reacting. You will be given a number of indigestion remedies to test.

Planning

1 When you plan your experiment you should think about these things and keep a record of your responses.
- What apparatus will you use?
- Which variable(s) will you keep the same in each test?
- What will you measure each time?
- How will this tell you which is the best indigestion remedy?
- Will you add the solid to the acid, or the acid to the solid?
- How much of the indigestion remedy will you use?
- How much acid will you use?
- When will you test the pH – before adding the remedy, after adding it, or both before and after?
- What are the hazards in this experiment?
- How can you reduce the risks?

Recording your results

1 Design a results table to record your results.

Considering your results/conclusions

1 What happened to the pH when the antacids reacted with the acid?

2 **a** Which remedy worked best?

b How do you know?

Evaluation

1 Can you suggest improvements to the way the experiment was done, to give results that you can be more sure about.

I can…
- describe the reactions of acids with bases
- explain how neutralisation is used to cure indigestion
- plan, carry out and evaluate an investigation.

Making crystals

Aim

To prepare crystals of copper(II) sulfate.

You teacher may watch you to see if you can:

- handle apparatus and substances safely, follow instructions and plan how to separate the products.

Introduction

Bases are substances that react with acids to form a salt and water. Many bases are insoluble in water but do react with acids. Copper(II) oxide is one such base.

1 Name the acid that copper(II) oxide reacts with to form copper(II) sulfate.

2 Write a word equation for the reaction.

Part 1: Making the salt

Apparatus

- small beaker
- measuring cylinder
- tripod
- gauze
- Bunsen burner
- spatula
- stirring rod.
- dilute sulfuric acid 
- copper(II) oxide 

⚠ Wear eye protection.
Avoid touching the reactants and product.

A Wear eye protection. Measure out about 25 cm^3 of dilute sulfuric acid into the small beaker.

B Place the beaker on the tripod and gauze and heat the solution until it is hot but not boiling.

C Scoop up a small amount of copper(II) oxide on the tip of a spatula and add it to the acid in the beaker.

D Stir the mixture gently while keeping it hot but not boiling.

E If the mixture goes clear go back to step C and repeat parts C and D. If it remains cloudy, continue stirring for a couple of minutes and then turn off the heat and allow the beaker to start to cool. WARNING! Do not allow the final solution to evaporate to dryness. The apparatus will stay hot for some time, so be careful not to touch it.

Considering your results/Conclusions

1 Explain how you know a chemical change has taken place.

2 Explain how you know when all the sulfuric acid has been neutralised.

3 Suggest a way of checking that the solution is neutral.

4 List the substances present in the mixture at the end of step E.

Part 2: Separating the salt

Planning

Copper(II) sulfate is a soluble salt.

1 Plan a method of separating copper(II) sulfate solution from the unreacted copper oxide. List the apparatus you need and write down what will you do. Show your teacher your plan.

2 Explain how you will know that the copper(II) sulfate solution is pure.

3 Plan a method of removing some of the water from the copper(II) sulfate solution. List the apparatus you need and write down what will you do. Show your teacher your plan.

A Carry out your approved plan.

B Leave your final solution of copper(II) sulfate somewhere safe for a day or two for the remaining water to evaporate. Put your name with your sample with a warning that it is toxic.

I can…

- describe how to make a pure solution of a salt by reacting an insoluble base with an acid.

Manufacturing fertiliser

Farmers may need to boost natural fertilisers such as manure by adding manufactured fertiliser to the soil. A commonly used fertiliser is ammonium nitrate. Sometimes crops need extra iron so iron sulfate can also be added to the soil.

You are the chemists advising a new company manufacturing fertilisers.

Find how ammonium nitrate and iron sulfate could be made.

You can use the internet or books to find information to help you.

Write a brief report or presentation suggesting how to make ammonium nitrate and iron sulfate.

You should state:

- the reactants required,
- the method you would use,
- how you would control the amounts of reactants needed,
- how you would separate the products.
- Any safety precautions.

You should also explain the reactions and give word equations.

Useful facts:

Ammonium hydroxide is an alkali. Unless very dilute it is an irritant.

Nitric acid and sulfuric acid are corrosive unless very dilute.

Iron oxide is insoluble in water.

Ammonium nitrate and iron sulfate are soluble in water.

I can…

- describe how to produce salts by reacting acids and bases.

Protecting teeth

Eating leaves bits of food stuck to your teeth, which bacteria change into acids. The acids can attack your teeth leaving cavities, which a dentist has to fill.

You can protect your teeth by brushing with toothpaste. Brushing gets rid of the bits of food but the toothpaste contains substances that kill the bacteria and react with the acids. One of the substances used to react with acids is aluminium hydroxide. Aluminium hydroxide does not dissolve in water.

1 Read the passage above and answer the following questions using *one* of the answers given.

a Which of the following statements is true?

A Aluminium hydroxide is an alkali but not a base.

B Aluminium hydroxide is an alkali and a base.

C Aluminium hydroxide is a base but not an alkali.

D Aluminium hydroxide is neither a base nor an alkali.

b Which of the following is the correct explanation?

A Aluminium hydroxide dissolves in water and neutralises acids.

B Aluminium hydroxide does not dissolve in water but neutralises acids.

C Aluminium hydroxide does not dissolve in water but neutralises alkalis.

D Aluminium hydroxide dissolves in water and neutralises alkalis.

c What happens to the pH in your mouth when you brush your teeth with toothpaste?

A The pH rises.

B The pH stays constant.

C The pH falls.

D Your mouth doesn't have pH.

2 Design an advert for the toothpaste, showing why it is good for teeth.

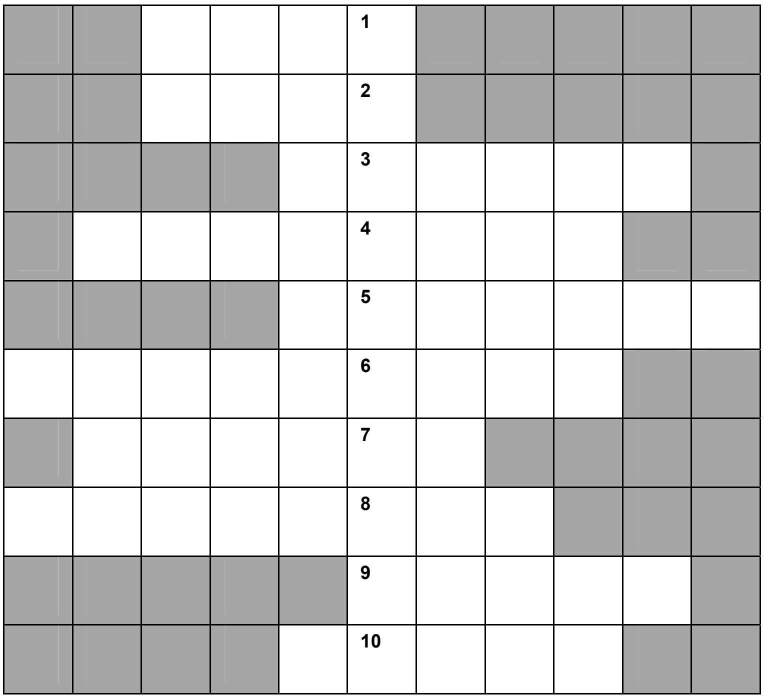
3 Describe some other examples of reactions between acids and bases in daily life.

I can…

- use the term 'base' correctly
- recall a use of neutralisation in everyday life.

Name ______________________________ **Class** ____________ **Date** _____________

Write the answers to the clues in the rows.



Clues

1 Sulfuric acid removes rust from steel because rust is ____________ oxide.

2 A substance that reacts with an acid to form a salt and water

3 The colour that litmus would turn if there were just enough indigestion powder to neutralise the stomach acid.

4 A substance that reacts with another.

5 A substance formed in a chemical reaction.

6 A substance used to test whether a solution is acidic or alkaline.

7 A base that dissolves in water.

8 The name of the salts formed when hydrochloric acid reacts with a base.

9 Substances made up of part of a base and part of an acid.

10 The pH when a base neutralises an acid.

Write down the word that forms the vertical line in the boxes ______________________________

Write a clue for this word:

____

I can…

- use the terms acid, base, alkali, salt and neutralisation
- recall some uses of acids and bases.

Which plan works best?

Indigestion remedies react with the acid in our stomachs and cancel it out. We can test different indigestion remedies by reacting them with some dilute acid. Several students worked out a plan for doing their experiments, and each one used a different method. They were all told to crush tablets into powder before they started. There were a number of indigestion remedies to test.

Here are some extracts from their plans. Read the extracts and then answer the questions.

Amy's plan

I'm going to put the same amount of acid in each beaker (20 cm^3). I'm then going to take a spatula of powder at a time and add it to the acid. I'll test the liquid with universal indicator paper. I'm going to keep going until it changes to pH 7 and I'm going to count the number of spatulas of powder I need. I'll do it again to make sure it was a fair test.

Byron's plan

A Fill up four tubes half full with acid.
B Add two spatulas of indigestion remedy to each one.
C Measure the pH at the end of the experiment.
D Decide which remedy has been the best at neutralising the acid.

Conrad's plan

I'm going to put 2 g of the powder into a beaker. Then I'm going to add some water to help it dissolve a bit. Then I'll put some universal indicator in (and it should go blue or purple). I'm going to put the acid in a burette (I'm using this because it's very accurate and you can get readings down to 0.1 cm^3, which is better than a measuring cylinder). Then I'm going to add acid a little bit at a time and watch the colour of the indicator. As soon as it goes green I'll stop and write down how much acid I've used (unless it goes orange or red, in which case I might take a bit off my reading because I'll have gone too far). I'll repeat all the tests again and take an average of the two results.

1 How will all the students know that indigestion remedies are bases?

2 Describe what happens when the indigestion remedy is mixed with acid.

3 Which variable did Amy and Byron keep constant?

4 Which variable was measured by:
- **a** Byron?
- **b** Conrad?

5 Compare Amy's plan with Conrad's.
- **a** What do the two plans have in common?
- **b** How is Conrad's plan different from Amy's?

6 Compare Amy's method with Byron's. Do you think one is likely to give better results or are they both equally good? Explain your reasons.

7 Give *three* reasons why Conrad's test is likely to give the best results overall.

I can…
- describe the reaction of acids with bases
- explain why bases are useful at curing indigestion
- explain why one plan for an investigation is better than another.

Name ______________________ **Class** ____________ **Date** ____________

Sulfuric acid – hero or villain?

Sulfuric acid is one of the most important industrial chemicals. Over two hundred million tonnes of it are produced every year worldwide. It is used in a lot of processes and products from making dyes to filling car batteries. One use of sulfuric acid is for cleaning steel. It reacts with rust, which is iron oxide. It is effective because unless it is very dilute it is very acidic.

Unfortunately, sulfuric acid can also be a problem. It is formed when fossil fuels such as coal are burned in power stations. The waste gases release sulfuric acid into the air and this helps to form acid rain. Acid rain lowers the pH of rivers and lakes so that plants and animals cannot live in them. One solution to the problem is to react a mixture of calcium hydroxide and water with the sulfuric acid in the waste gases.

Read the passage above and answer the questions below.

1 Explain what is meant by describing sulfuric acid as 'very acidic'.

____

a Name *two* bases referred to in the article.

____

b One of these bases is an alkali. Explain what makes a base an alkali.

____

2 **a** Complete the word equations for the two reactions referred to in the article.

sulfuric acid + iron oxide → ______________ + ______________

b Write a word equation for the other reaction referred to in the article.

____

3 Explain why these reactions are called neutralisation reactions.

____

4 State *two* more examples of useful neutralisation reactions and explain why they are useful.

____

____

I can…

- describe reactions of acid and bases
- explain examples of the uses of neutralisation.

Use the information in the boxes to carry out the tasks that follow.

Making soluble salts 1: acid + alkali
Add acid a little at a time to a measured amount of the alkali until the pH is neutral. Evaporate the water off to leave the salt.

Insoluble bases
copper(II) oxide
aluminium hydroxide
magnesium hydroxide
iron oxide

Alkalis
sodium hydroxide
potassium hydroxide
ammonium hydroxide
calcium hydroxide

acid + base → salt + water

Making soluble salts 2: acid + insoluble base
Add the base a little at a time to a measured amount of the acid until no more reacts. Filter off the unused base. Evaporate the water from the filtrate to leave the salt.

1 Describe how to make the following salts:

a potassium sulfate

b magnesium chloride

c iron nitrate

For each salt:

- name the reactants
- write a word equation for the reaction
- state the method that needs to be used
- explain how you will know that neutralisation has been achieved
- explain why the method you have chosen works.

2 Explain the following statements, with word equations where appropriate.

a Sulfuric acid is used to clean rusty steel. (*Hint*: rust is iron oxide.)

b It is safer to use magnesium hydroxide as an indigestion remedy than sodium hydroxide.

c The waste gases from burning coal in power stations are passed through a mixture of calcium hydroxide and water. (*Hint*: the waste gases include nitric acid and sulfuric acid.)

d Tooth decay is caused by acids made by bacteria in the mouth. Toothpastes contain aluminium hydroxide.

I can…

- describe how salts and water are formed by neutralisation reactions.