Science in the Kitchen

Name:____________

Everyone here has an understanding of what a chemical reaction is, we have all seen the movie of the scientist pouring acid on a metal and the metal disappearing in a smouldering, fizzing reaction. Not all-chemical reaction take place in the laboratory, most chemical reaction we see happen in my favourite place, the kitchen.

Before we can start to understand the nature of the chemical reaction in the kitchen we need to start to understand the nature and practices of science to describe chemical reactions.

The substances that you begin with in a chemical reaction are called the **reactants**; the substances that are produced are called the **products**.

Investigation

Before you will be able to complete this investigation you need to appropriately colour in and find the missing words on the following ph scale used by universal indicators and PH paper.

← ________ Solution ← ______________ → ____________Solution →

1	2	3	4	5	6	7	8	9	10	11	12	13	14

Collect various household substances; e.g. lemon juice, lemonade, detergent, milk, disinfectant, baking soda, toothpaste, cleaning solution, oven cleaner, vinegar. You could also try some laboratory acids and bases.

Tear off a small piece of pH paper (about 1 cm). Use a clean stirring rod to put a drop of solution onto the paper. (Rinse the stirring rod between tests.) Compare the colour of the wet spot on the paper with the colour chart on the dispenser.

- Record your results.

Substance	Colour	PH

- Which was the most acidic substance you tested (lowest pH)?

  ____.

- Which was the most basic (highest pH)?____________________________________.

- What happens to the pH of an acid when you dilute it (add water to it)? Is it more or less acidic?____.

Activities
Complete the following

- An acidic solution has a pH __________ than 7.
- A _________ solution has a pH of more than 7.
- A neutral solution has a pH of ___________.
- A substance, which is not an acid or a base, is said to be _____________.
- An example of a neutral liquid is ____________________.

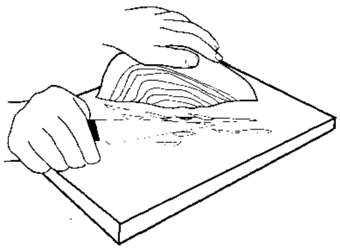
Red Cabbage Experiment
Aim
To extract the coloured substance from red cabbage, and use it as an acid-base indicator.
Materials

- 2 or 3 large leaves from a fresh red cabbage
- sharp knife and chopping board
- two 250 mL beakers
- Bunsen burner, tripod and gauze
- stirring rod
- Safety glasses
- 6 test tubes and test tube rack
- dilute hydrochloric acid (0-5M)
- dilute ammonia solution (0-5M)
- various household substances (for Step 6)

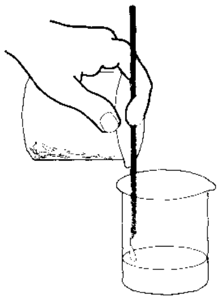
Stop

Before you can start an experiment you need to get your teacher's signature, Beware you may be asked some questions so you will have to read it before starting

Method
1 Cut up 2 or 3 large red-cabbage leaves into small pieces. Put them in *a* beaker.



2 Add water to just cover the cabbage pieces.
3 Boil the cabbage mixture for 5 to 10 minutes. The water should turn a dark colour, and the leaves should almost lose their colour.
4 Let the mixture cool. Then carefully decant the coloured solution into another beaker. Alternatively, you could strain the mixture through a sieve.



- What colour is the extract? ____.

5 Add a small amount of dilute hydrochloric acid to a test tube and label it. Add some ammonia solution to another test tube. Now add a few drops of red-cabbage extract to each tube.

- What colours are the solutions?

____

6 In the same way test various household substances.

For each substance record any colour change.

Substance	Colour

Questions and conclusions

1 What colour is your indicator in acidic solutions. And what colour is it in basic solutions?

____

____

2 Which household substances are the most acidic? Which are the most basic? How do you know?

Acidic	**Basic**

____

____

____

____

Scientist are always truing to enhance experiments, can you think of any problems you had and how these could be fixed.

____

____

____

Acids and Bases

Acids are substances that have a sour taste (never taste acids in the laboratory or workshop) and are very corrosive — they react with solids, eating them away. Acids are found in citrus fruits, car batteries and even ant and bee stings (formic acid). Vinegar contains acetic acid.
Acids are said to corrosive, they corrode or eat 'away many' things.

Bases are substances that taste bitter, feel slippery and may also be corrosive. Ammonia, sodium bicarbonate and lime (a white powder used in building materials and gardening) are examples of bases. Some bases are soluble in water and are called alkalis.
Many reactions involving acids and bases occur in water. These reactions are said to occur in solution.

One very important reaction involving acids and bases is **neutralisation.** Neutralisation is the name given to the chemical reaction in which an acid and a base react with each other to produce a neutral substance (a salt) and water. Acid from food attacks your teeth, so toothpastes are usually slightly alkaline.

Your stomach contains hydrochloric acid, which helps to break up food for digestion. If too much acid is produced, you get indigestion. Indigestion tablets are alkaline and they neutralise the acid

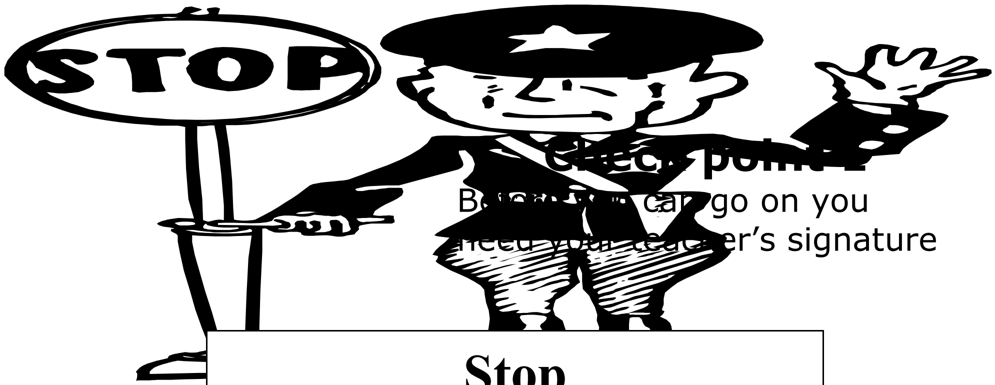
$$\underset{\text{Base}}{MgO} + \underset{\text{acid}}{2HCl} \rightarrow \underset{\text{salt}}{MgCl_2} + \underset{\text{water}}{H_2O}.$$

When an insect bites you it injects a small amount of chemical into your skin. This is why it stings. Bees inject an acid. Bee stings can be treated with calamine lotion or baking soda, which neutralise the acid. Wasps are different. They inject an alkali, which can be neutralised by applying a dilute acid, e.g. vinegar.

Activities

Put a tick in each cell of the table if the sentence formed is true.

Acids	Bases	
		are very common substances
		taste sour
		may be strong or weak
		are often used to clean things at
		have a pH of less than 7
		can burn through solid objects
		taste bitter
		have a pH of more than 7
		can be eaten and drunk when
		feel soapy
		are poisonous when strong



Check point 2
Before you can go on you
need your teacher's signature

Stop

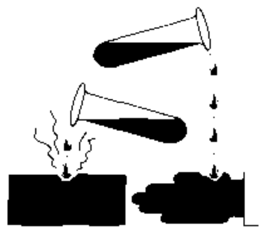
Before you can start an experiment you need to get your teacher's signature, Beware you may be asked some questions so you will have to read it before starting

Properties of Acids Experiment

Aim

____

Materials



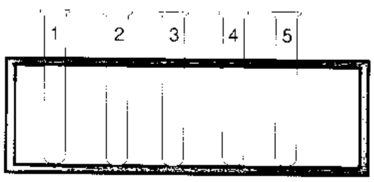
What does this sign indicate?
____
____
____

- 5 small test tubes
- a stopper to fit a test tube
- a test tube rack
- safety glasses
- dropper bottles containing: dilute hydrochloric acid (1M)
  - dilute sulphuric acid (1M)
  - vinegar
  - lemon juice
  - water
- blue litmus paper
- 5 small marble chips (calcium carbonate)
- 5 pieces of magnesium ribbon (each no more than 1 cm long)
- a large petri dish
- a felt pen
- a taper or birthday candle

Method

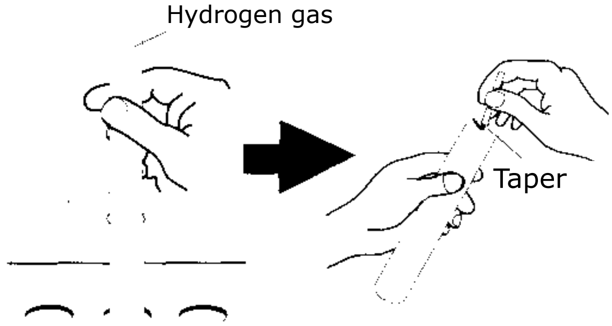
PART A: REACTION WITH MAGNESIUM

1 Put 5 test tubes in a test tube rack, and use a felt pen to number them 1 to 5.
2 Add a small amount of dilute hydrochloric acid to test tube 1. Similarly, add a small amount of dilute sulphuric acid to tube 2, and so on.



1. dilute hydrochloric acid
2. dilute sulphuric acid
3. vinegar
4. lemon juice
5. water

3 Put a small piece of magnesium ribbon in the hydrochloric acid in tube 1. To trap the gas released, hold an empty tube upside down over the mouth of the tube, as shown.



4 When the magnesium has reacted, light a taper. Carefully remove the top test tube, and tilt it upwards. Immediately put the burning taper near its mouth. A 'pop' indicates that the gas in the tube is hydrogen.
5 Feel the test tube.
• What do you observe?

____

____

____

____

• How do you know that there has been a chemical reaction?

____

____

____

Add a piece of magnesium to each of the other liquids in turn (repeating steps 3-5).

• Record your observations in the data table.

• Which liquid produced the fastest reaction?

____

____

____

____

PART B: REACTION WITH MARBLE CHIPS

1 Tip out the used liquids in the test tubes, and add fresh samples of the same liquids.
2 Add a marble chip (calcium carbonate) to tube 1. After a minute or two light the taper and put it into the mouth of the tube.

• Does the taper go out?__________ If it does, the gas in the tube is probably carbon dioxide.
3 Repeat step 2 with the other liquids.
• Record your observations in the data table.

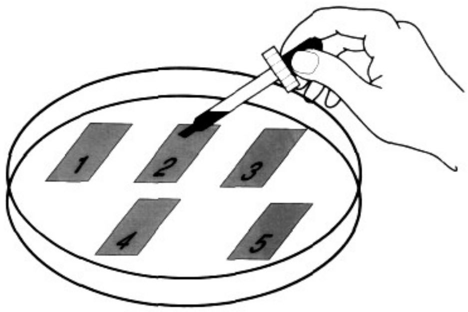
• Which was the fastest reaction?______________________________.

4 You may be able to repeat the experiment with pieces of eggshell or cuttlefish, which are both made of calcium carbonate. You could also try copper carbonate.

• Do you get the same results?

PART C: BLUE LITMUS TEST

1 Tear off 5 *small* pieces of blue litmus paper and put them in a petri dish, as shown.



2 To the first piece of litmus add *one drop* of dilute hydrochloric acid.

- Record the colour change (if any) in the data table.

3 Test the second piece of litmus paper with dilute sulphuric acid, and so on.

Results

Solution	**Observation of reaction with**		
	Magnesium	**Marble chips**	**Blue litmus paper**
Hydrochloric acid			
Sulphuric acid			
Vinegar			

Lemon juice			
water			

Questions and conclusions

Look at your data table. Two of the liquids you tested are common laboratory acids (dilute hydrochloric and sulphuric acids).

1 What properties do these two acids have?

____

____

____

2 Infer which of the other liquids are also acids.

____

____

____

3 Suggest a reason for testing water (tube 5).

____

____

Activities

Complete the following sentences.

a. Laboratory acids are dangerous, and will ________ your skin and clothes.

b. Acids have a __________ taste.

c. Acids turn _____ litmus paper red.

d. Acids react with metals such as__________ to produce the gas ___________.

e. Acids react with _____________ to produce carbon dioxide.

Of the following chemicals→ blue litmus, water, marble chips, hydrochloric acid, magnesium

(a) which two react to produce hydrogen gas?

____

____

(b) which two react to produce carbon dioxide?

____

____

Indicators

Universal indicator is a mixture of indicators having colours across the entire range of pH values. Litmus is another indicator that shows whether or not a substance is acidic or basic, but does not give the same degree of accuracy as universal indicator. There are many other indicators which change colour depending on the pH of the solution being tested. You may even have made your own indicator using plant material. Look carefully at the chart below which shows colour changes for various indicators, then answer the questions. You may like to colour this table in.

<table>
<tr><td>PH</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td></td><td></td></tr>
<tr><td>Universal Indicator</td><td colspan="2">Red</td><td colspan="2">Orange</td><td colspan="2">Yellow</td><td colspan="2">Green</td><td colspan="2">Blue/ Green</td><td>Blue</td><td colspan="2">Indigo</td><td colspan="2">Purple</td><td></td></tr>
<tr><td>Litmus</td><td colspan="7">Red (Blue Litmus Paper turns red in an acid)</td><td colspan="9">Blue (Blue Litmus Paper stays blue in a base)</td></tr>
<tr><td>Bromothymol blue</td><td colspan="2">Orange</td><td colspan="4">Yellow</td><td colspan="4">Green</td><td colspan="2">Blue/ Green</td><td colspan="4">Blue</td></tr>
<tr><td>Methyl orange</td><td colspan="3">Red</td><td colspan="13">Orange</td></tr>
<tr><td>Phenolphthalein</td><td colspan="7">Colourless</td><td colspan="3">Pink</td><td colspan="4">Deep Pink</td><td colspan="2">Red</td></tr>
</table>

Activities

For some of these questions it may not be possible to give an exact answer. If this is the case, give a range of pH values.

1 Is it possible to use methyl orange to indicate a neutral solution? Explain your answer.

____

____

2 Solution X turns blue with litmus and solution Y turns blue with bromothymol blue. Which solution is more basic? Why?

____

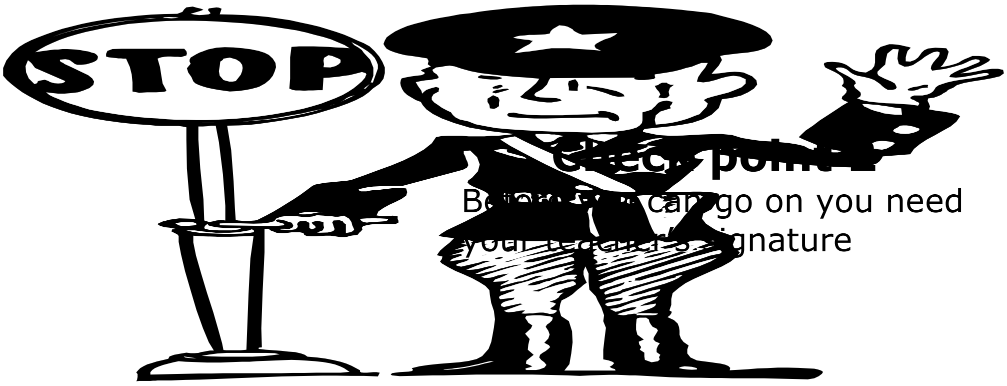
____

____

3 sea water which turns pink with phenolphthalein, and green with bromothymol blue?

____

4 battery acid which turns red with methyl orange, and orange with bromothymol blue?



Check point 2

Before you can go on you need your teacher's signature

Word and Symbol equations

A chemical equation shows the reactants and products in a chemical reaction, and the proportions in which they react. The names of the reactants and products can be written in a word equation. The formulae for the reactants and products can also be written in a symbol equation. Numbers may also appear in front of the formulae in symbol equations. These show the proportions in which the reactants combine to form the products. For example, consider the following word and symbol equations for a neutralisation reaction

zinc oxide + hydrochloric acid -> zinc chloride + water

$$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$$

The following table shows a list of these common types of reactions.

Be very careful when you use this list. There are many, many exceptions, for very good chemical reasons. It is always best to observe the reaction itself, just to be certain that the reaction does proceed as you would expect.

Reactant(s)	Likely product(s)
acid + metal	salt + hydrogen
acid + base (Neutralisation reaction)	salt + water
acid + carbonate	salt + carbon dioxide + water
acid + metal oxide	salt + water
combustion with oxygen	common oxide (s)

Activities (Hint: page 5 might help)

1. Explain the meaning of the words 'acid', 'base' and 'neutralisation'.

2. What does the expression 'reaction in solution' mean?

3. What is a salt?

4. What substance is produced in all neutralisation reactions?

Investigation

Add 20 drops of dilute sodium hydroxide to a test tube. Add a drop of bromothymol blue indicator.
Add dilute hydrochloric acid a drop at a time. Shake the tube gently after each drop. Keep adding drops until the colour changes from blue to yellow.

- How many drops of acid did you add?

- How can you explain the colour change?

Use pH paper to check whether the final solution is acidic, basic or neutral.

- Try and write an word equation for this experiment (hint: it's a neutralisation reaction)

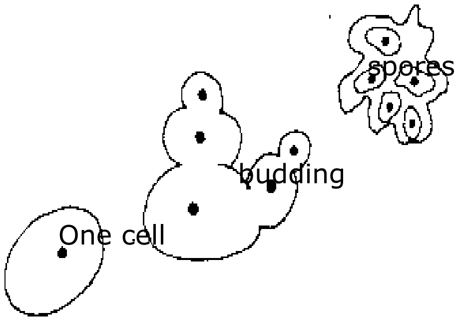
How Does Baking Soda Make a Cake Rise?

If we do not put yeast or baking soda in dough, the cake or bread we are making will not rise. It is 'unleavened'. Of course, 'self raising' flour already contains baking soda.

If we examine bread or cake closely, we will see tiny bubbles in it. Where do these bubbles come from?

Yeast

Nearly all-living things use oxygen and produce carbon dioxide to produce energy. Some, however, do not need air. These are called anaerobic organisms. Yeast is such an organism. It is really a type of fungus or mould. It reacts with sugars in the dough- producing alcohol and carbon dioxide. It is these bubbles of carbon dioxide that make the dough rise. However, making bread with yeast is slow, as the dough has to be left to 'rise' for about four hours as the yeast grows.



Yeast cells reproduce by budding or by producing spores (as in 'dried' yeast)

Dough before rising 'Risen Dough'

Baking soda
Baking soda, also known as 'bicarb soda', is chemically known as sodium bicarbonate, $NaHCO_3$. The atoms in its molecules are bound together by weak and strong forces, those between carbon and oxygen being the strongest ('covalent bonds') and between sodium and oxygen the weakest ('ionic bonds'). On heating, the weaker bonds break and the substance decomposes into carbon dioxide and steam.

$$\text{Sodium Bicarbonate} \xrightarrow[\textbf{Heat}]{} \text{Sodium carbonate} + \text{Water} + \text{Carbon dioxide}$$

Baking powder
In baking powder, sodium bicarbonate is mixed with a weak acid (usually tartaric acid) with which it reacts to give off carbon dioxide.

Activities

1. What is 'self raising' flour?

____

2. What is yeast? What is it used for?

____

____

3. What is meant by an anaerobic organism?

____

4. Write down what you understand is the difference between atoms and molecules.

____

____

____

5. What is meant by a chemical 'bond'? Can it be broken?

____

____

____

____

6. What is carbon dioxide, a solid, liquid or gas? Does it burn? Is it poisonous?

Stop

Before you can start an experiment you need to get your teacher's signature, Beware you may be asked some questions so you will have to read it before starting

Making Carbon Dioxide

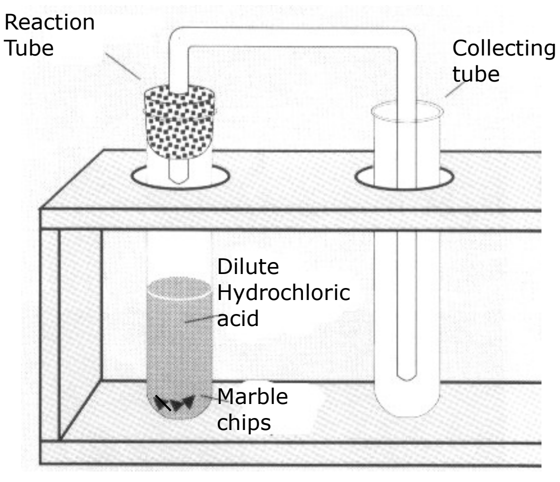
Aim

Materials

- 2 or 3 marble chips
- dilute hydrochloric acid (1M)
- 3 test tubes
- safety glasses
- a stopper
- a test tube rack
- a one-holed stopper fitted with a U-shaped piece of glass tubing (see diagram below)
- a taper
- a drinking straw
- limewater (calcium hydroxide solution)

Method

1 Set up the apparatus shown below. Make sure the collecting tube is dry. Put two or three marble chips into the reaction tube.

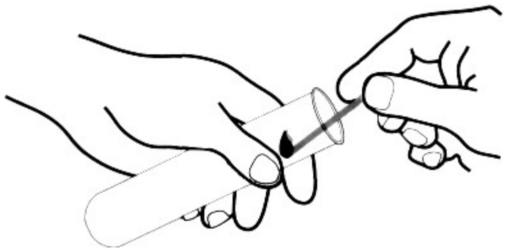


2 Add a dropperful of hydrochloric acid to the reaction tube, and then quickly fit the stopper and tubing.

3 Bubbles of carbon dioxide gas will form. This gas will go to the collecting tube.

4 After about three minutes remove the collecting tube and put a stopper in it. Replace it with another tube half full of limewater. (Allow the gas to bubble through the limewater while you do Step 5.)

5 Light a taper, remove the stopper from the collecting tube, and carefully put the taper into the tube as shown.



• Record what happens

____

6 Go back and observe the limewater from Step 4.

• Record your observations.

____

____

____

____

• Has there been a chemical reaction? How do you know?

____

____

7 Tip out the limewater. Wash out the test tube and pour in some fresh limewater. Blow gently through a straw into the limewater.

• What do you observe?

____

____

Activities

Complete these sentences.

a) Plants use carbon dioxide gas to make _________________.

b) Reacting marble chips with _________________acid can make carbon dioxide.

c) A glowing taper _____________________ when placed in carbon dioxide.

d) Carbon dioxide bubbled through _______________________ turns it milky.

e) Humans breathe in ___________________, and breathe out __________ __________.

Check point 3

Before you can go on you need your teacher's signature

So far we have looked at many different reaction that can take place in the laboratory or even the kitchen, now we are going to look at every day chemical reactions that you take for granted.

Combustion — *A* burning Question

Combustion reactions are those in which a substance reacts with oxygen and heat is released. Examples of combustion reactions include the burning of petrol in a motorcycle engine, wax vapour in a candle flame and natural gas in a kitchen stove. In each of these cases **hydrocarbons** (compounds containing only the elements carbon and hydrogen) combine with oxygen in the air to form carbon dioxide gas and water vapour. This is shown in the following equation for the burning of methane (natural gas) in a gas stove

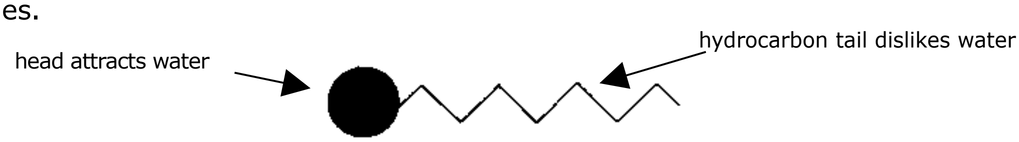
CH_4	+	20_2	$\longrightarrow$	$C0_2$	+	$2H_20$
methane molecule		oxygen molecule		carbon dioxide molecule		water molecule

Detergents – Getting to the bottom of things

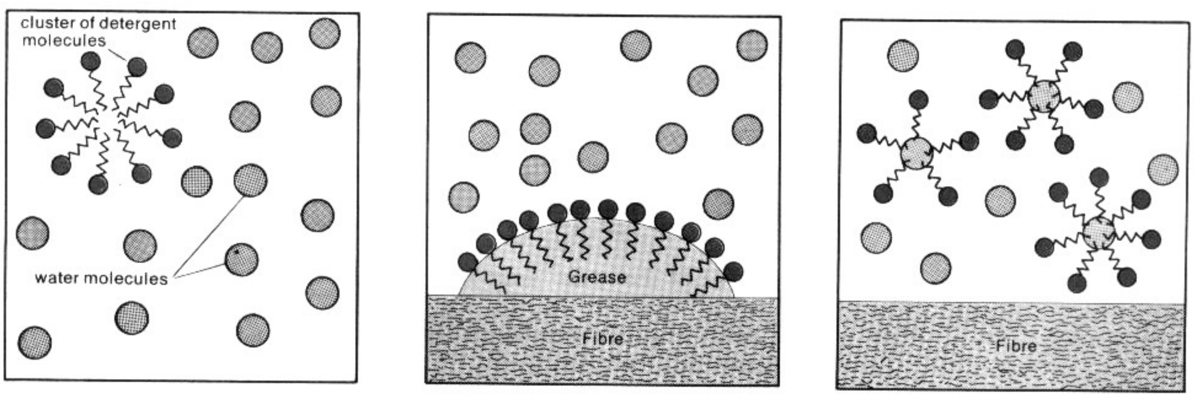
A detergent is a cleaning agent, soap is a common detergent but was made from animal fats recent research has led to the development of synthetic detergents from sugar. Synthetic detergents are used in washing powders and washing-up liquids. Detergents are usually made by the action of fuming sulphuric acid on an alkyl benzene (from petroleum). Early synthetic soap detergents caused a problem of foaming in rivers but bacteria in the river break down modern detergents. They are said to be **biodegradable.**

Structure of Detergents

Detergent molecules consist of a long hydrocarbon chain that repels water molecules (the tail) and a charged group of atoms forming a 'head', which readily attracts water molecules.



The diagram below shows you how a soap detergent cleans: the tails of the detergent molecules stick into the grease. Because the heads of the detergent molecules are attracted towards the water molecules, the grease is lifted from the material. Grease is suspended in the solution. Repelling forces between droplets of grease prevent them coming together and reattaching to the fibres.



CORROSION – Rusting away

When a metal reacts with air, water or other substances in its surroundings its properties change. This process is called corrosion. Iron and steel corrode in damp air to form rust (brown iron oxide), which has properties different from the metals.
When left exposed to the weather for many years copper becomes coated with a greenish compound. Aluminium becomes coated with white aluminium oxide, but this coating protects the metal from further corrosion. Metals like gold, silver and brass slowly become dirty or tarnished, especially in cities where there are acidic gases in the air. This is why they need to be cleaned regularly.

Most methods of slowing rusting down put some kind of non-reactive barrier between the iron and the air and water. For example:
- turning iron into stainless steel (stainless steel sinks). This material is more expensive.
- painting the iron (garden furniture).
- coating the iron with oil or grease (bike chains and car engines).
- coating the iron with plastic (dish racks, wire).
- coating with other metals, like zinc (roofs, garden sheds) and tin (steel food cans are coated in tin) which are not as reactive as iron. This process is called galvanising.

The less reactive a metal is, the less likely it is to corrode.
Other metals also corrode:
- Copper can become coated with a greenish compound.
- Aluminium becomes coated with white aluminium oxide
- Silver and brass become dirty or tarnished.

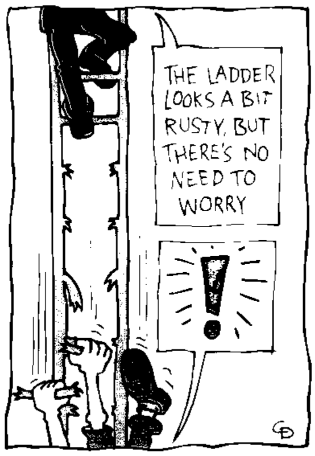
Sacrificial protection

Zinc is more reactive than iron. When a bar of zinc is attached to the side of a steel ship, it corrodes instead of the steel. When it is nearly eaten away it is replaced by a fresh bar. The zinc is sacrificed to protect the steel.

Stop

Before you can start an experiment you need to get your teacher's signature, Beware you may be asked some questions so you will have to read it before starting

Corrosion of Iron



Aim

____

____

Materials

- sodium chloride (salt) solution
- iron nails
- test tubes in a rack
- copper wire
- magnesium ribbon
- distilled water
- marking pen

Method

1. Number the four test tubes. Place clean bright nails in tubes 1 and 2.

Salt solution

water

Magnesium

Copper

2 Twist a clean piece of magnesium ribbon tightly around the third nail. Place this magnesium-covered nail in tube 3.

3 Similarly, twist some copper wire around the fourth nail. Put it in tube

4 Cover the nail in tube 1 with distilled water. Cover the nails in tubes 2, 3 and 4 with salt solution.

5 Leave the tubes in the test tube rack and observe what happens over a period of about three days.

• Use a data table to record the amount of metal corrosion in each tube.

6 After the third day, tip the liquids out of the tubes and examine the nails.

• Record your observations.

Results

Day \ Nail	1	2	3	4
1				
2				
3				

Questions and conclusions

1. Compare the amount of corrosion of the nails in tubes 1 and 2. Make an inference to explain the difference.

2. Where would you expect iron to rust more rapidly in a river or in the ocean? Explain.

3. Did the magnesium ribbon stop the nail rusting? Explain in terms of sacrificial protection.

4. Did the copper stop the nail rusting? Explain.

5. *Predict* what would happen to copper screws in a steel boat in salt water. Explain your prediction.

Activities

1 What is corrosion?

2 What two substances cause rusting?

3 Iron that is tin-plated does not rust. Why?

4 What is the process of galvanising? How does this prevent iron from rusting?

5 Oilrigs often have big lumps of magnesium attached to their legs underwater. Suggest a reason for this.

Find each of the following words.

DETERGENT	BASE	NEUTRALISATION	REACTANT
PRECIPITATION	WATER	SALT	PAINTING
PRODUCTS	FUSE	CORROSION	SOAP
ACID	GALVANISING	CARBON DIOXIDE	

I	N	G	O	I	P	N	S	I	P	P	T	P	A	I	N	T	I	N	G	B	S	I
R	O	O	T	V	N	R	O	A	S	E	D	W	A	O	L	S	A	L	T	N	A	E
O	I	I	I	O	A	N	E	E	D	E	I	L	D	S	E	I	R	A	W	A	T	C
E	C	I	I	T	I	T	I	A	R	I	N	I	N	C	R	N	N	W	O	E	P	O
S	N	O	R	A	A	O	N	E	U	T	R	A	L	I	S	A	T	I	O	N	O	T
I	O	O	R	E	I	T	D	E	T	E	R	G	E	N	T	O	D	I	N	T	S	L
S	N	E	L	R	A	R	I	I	E	A	D	N	P	R	O	D	U	C	T	S	O	I
E	D	D	S	D	O	C	C	P	S	A	P	A	A	A	A	R	T	T	I	O	C	T
S	D	A	S	U	S	S	T	T	I	E	A	R	I	C	L	T	N	E	A		T	S
A	E	I	R	T	F	E	I	A	U	C	R	E	I	C	R	E	N	D	N	E	A	N
B	S	D	E	E	A	C	C	O	N	A	E	D	U	R	O	I	I	E	T	P	R	N
S	R	I	T	T	T	S	O	I	N	T	T	R	C	N	S	G	E	P	G	A	P	T
G	S	S	A	C	T	E	A	T	T	E	S	E	P	S	S	N	I	P	I	O	A	
N	O	U	W	A	A	C	A	R	B	O	N		D	I	O	X	I	D	E	S	C	T
G	T	B	L	L	F	O	C	G	A	L	V	A	N	I	S	I	N	G	I	D	C	N
D	P	T	S	C	C	T	T	T	D	O	A	I	O	O	T	T	I	R	C	N	N	N