Energy and change

A project funded by the Nuffield Foundation

Theme C

Gases, liquids, solids

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Theme C - Gases, liquids, solids

What is this theme about?

Matter tends to spread out - this was the essential idea behind the activities in Theme A. This theme continues with this idea, but puts more emphasis on changes involving gases. Changes involving gases are more difficult to think about than those with solids and liquids, so early activities focus on the nature of gases and changes involving gases. The main ideas are that gases can be manipulated (e.g. squashed and poured) and that they tend to spread out (e.g. smells and pollution).

Changes happen when there are temperature differences - this was an important idea in Theme B (Hot and cold). This theme looks at changes of state of substances (melting, freezing, evaporation and condensation) and how they are caused by temperature differences. This is also an appropriate point to look at the nature of a *substance* - it is important for pupils to think about what changes and what stays the same during different kinds of changes (e.g. cutting a candle in half, melting it, burning it).

The activities

C1 Air - squeezing, stretching, pushing and pulling

C2 Moving gases around

C3 Smells and pollution

C4 Objects and substances

C5 Putting changes into groups

C6 Melting, freezing, evaporation, condensation

C7 Evaporation and condensation

C8 Evaporation - speeding it up and slowing it down

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Activity C1 - Air - squeezing, stretching, pushing and pulling

The activity is about the way in which air is distributed in containers. It is concerned with thinking about amounts, volumes and pressure of air in different situations.

Sheets 1-2 show 4 situations, and ask pupils to choose the best 'before' and 'after' pictures. Children should be led to an understanding that the amount of air is conserved, and that it can be 'squashed in' and 'stretched out' (i.e. it can be at different pressures). They also need to think about the way that air is distributed in containers, and understand that it spreads out to fill the container.

Answers:

A Blowing more air into a plastic bag B -> A (more air, bigger volume, same pressure)
B Squashing air in a syringe B -> C (same amount of air, smaller volume, bigger pressure)
C Blowing up a balloon B -> C (more air, bigger volume, bigger pressure)
D Letting the air out of a car tyre C -> B (less air, smaller volume, smaller pressure)

At the end is some extension work, in which pupils are asked to draw their own pictures.

Activity C2 - Moving gases around

The aim of this activity is to give pupils experience of handling a gas and appreciating that although it is invisible, it can be manipulated in a similar way to a liquid.

The pupil activity involves manipulating carbon dioxide gas. Before starting the pupil activity the point should be made that there are many different gases. Most of these are invisible, so it can be difficult to appreciate this. Some gases are coloured, however, and this could be demonstrated, for example by making nitrogen dioxide from copper and nitric acid.

Apparatus for each group:
Access to a gas jar filled with carbon dioxide, 20cm^3 plastic syringe with 10cm length of plastic tubing attached, 5 test-tubes and 2 bungs, limewater.

If there is time, the activity could be followed up by collecting the gas breathed out from the lungs, and investigating the effect on limewater. The point can be made that it does not turn the limewater as cloudy as the pure carbon dioxide - it is a mixture of gases including a small amount of carbon dioxide. This can be used as an introduction to the work on mixtures of gases in the next activity.

Activity C3 - Smells and pollution

This activity is concerned with thinking about the idea that there are different *gases, and that they can spread out into each other and mix together.*

In the previous activity, it was stressed that there are different gases with different properties. In this activity, we look at how, since there are different gases, they can mix together. It introduces the idea that gases mix spontaneously, 'by themselves'. The activity should be introduced by some demonstrations which show gases 'spreading out':

1. Use a long cardboard tube with holes along it at intervals. Pupils put their noses into the holes. Crush some garlic at one end. Pupils should move their noses away as soon as they smell the garlic.

2. Use a syringe with a length of plastic tubing to remove a little carbon dioxide from a gas jar (as pupils did in activity 2). Inject the carbon dioxide into the *middle* of a gas jar containing air. Replace the lid and leave it for a minute or two. Now, using the syringe, remove samples from different parts of the gas jar - top, middle, bottom, etc. - and test with limewater. All the tests should be positive - the carbon dioxide spreads throughout the jar. (This happens even though it is heavier than air - though it is not necessary to discuss density of gases with pupils at this stage.)

3. Watch the diffusion of a coloured gas in a container or from one container to another.

In the worksheet, pupils are asked to *draw their own* pictures, rather than *match* them as in previous activities. The point to be brought out in discussion after they have done the activity is that all these changes are essentially the *same*. Do their pictures show this similarity?

The worksheet also encourages them to think back to earlier ideas about 'mixing and unmixing', and to relate these to gases. Again, mixing happens more easily than unmixing.

This, of course, is why pollution is a problem - it spreads out by itself, and then it is difficult to remove. Examples of air pollution could be discussed, e.g. lead, carbon monoxide, sulphur dioxide and oxides of nitrogen from car exhausts; sulphur dioxide also from coal-burning power stations, and oxides of nitrogen from aircraft; CFCs from refrigerators and 'old-style' aerosol cans.

Activity C4 - Objects and substances

This activity provides a starting point for a discussion of the idea of 'substance' and distinguishes this from 'object'.

In all the changes with which we have so far been concerned (i.e. mixing and 'unmixing'), substances do not change into new substances. In the remaining activities, we shall be looking at melting, freezing, evaporation and condensation - processes in which substances change state, but do not change into new substances. In later themes we shall be looking at chemical reactions - processes in which substances change into new substances. So this activity is about clarifying the idea of a *substance.* The activity distinguishes between objects and substances. The term 'chemical' is not introduced, but this could be an appropriate place to discuss it. The point could be made that a chemical is a pure substance, and that all substances are either single chemicals or mixtures of chemicals. Chemicals are all around us (and in us) and not just in laboratories.

Activity C5 - Putting changes into groups

This activity is intended as a starting point to stimulate class discussion about the nature of changes of state - melting, freezing, evaporation, condensation.

There are twelve changes which illustrate some examples of melting (A, D, F, G), freezing (B, H, J), evaporation (E, I, L) and condensation (C, K). However, the aim is not to direct pupils towards this grouping - it is intended that the activity be done before changes of state are explicitly taught. At this stage, pupils should be encouraged to think about their own groupings; these can form the basis of a class discussion. They could make posters to illustrate their ideas.

Pupils' groupings often use various kinds of features, for example:

- the nature of the change (e.g. melting, drying)
- the nature of the substances involved (e.g. changes which involve air, or changes which involve liquids)
- the temperature of some part of the picture (e.g. hot things, cold things)
- superficial features (e.g. changes which happen in a kitchen)

It is worth discussing the *differences* between changes which pupils have put in the same group - this can encourage them to think more deeply about the changes. For example, 'soup in a freezer' and 'ice cream' may have been put in a group 'cold things'. One difference is that the soup is turning to a *solid,* while the ice cream is turning to a *liquid.* Another difference is that the soup is *warmer* than the air around it while the ice cream is *colder* than the air around it. Discussion of these kinds of differences leads into the ideas taken up the next activity.

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Activity C6 - Melting, freezing, evaporation, condensation

This activity is intended to make explicit to pupils the nature of changes of state, and the temperature differences which make them happen.

Pupils circle words on the sheets so that the sentences make sense. The first two sentences for each change are about the nature of the change to the substances involved and the name of the change (something which has always been part of teaching at this level). The third sentence is about *the temperature difference which makes the change happen* (something which commonly has had less attention paid to it).

At the end of the second sheet, there are 6 changes which pupils are asked to describe in their own words. Though this only takes up a small amount of space on the worksheet, it is an important part of the activity - pupils should be encouraged to use these ideas in their own descriptions.

Activity C7 - Evaporation and condensation

In this activity, pupils explore in more detail he nature of evaporation and condensation.

Sheet 1 is an activity which discusses in more detail the nature of evaporation, and its reverse process, condensation. Note that condensation, being a rather more difficult idea than evaporation, is not pursued further at this stage. This OHP is intended to encourage class discussion about the nature of evaporation and condensation (e.g. where is it coming from or going to, is it spreading out, etc.).

Sheet 2 is the pupil activity. They are asked to identify changes which involve evaporation, and then to give reasons why they chose to include and exclude some of the examples. They should be encouraged to write about these changes using the ideas from the OHP (it could be left on so that they can see the questions they discussed).

Pupils should first make their own grouping of the situations and write about as many as they can. Then there can be a class discussion of the correct answers.

Answers:
Something evaporates: B, C, F, G, I, L
Nothing evaporates: A, D, E, H, J, K

Activity C8 - Evaporation - speeding it up and slowing it down

The activity is about the factors which affect the rate of evaporation. Again, it emphasises evaporation as a process of 'spreading out'.

It would be appropriate to do this activity after the pupils have done some related experimental work. The ideas developed are very similar to those in the earlier activity about dissolving (A3), and this link should be made explicitly.

Sheet 1 is an OHP which introduces the idea of speeding up evaporation by helping the liquid to spread out. Sheet 2 can be used as an OHP to introduce four factors which affect the rate of evaporation, in addition to being used as the pupil activity.

Answers:

1 Slowly - too cold.
2 Slowly - too much water vapour already in the air.
3 Quickly - warm, plenty of air for the water to spread into and the air is moving.
4 Slowly - no room for the water to spread into.
5 Quickly - warm.
6 Even quicker - warm, plenty of air outside the window for the water to spread into (and the air is moving).
7 Slowly - not much room for the water to spread into.
8 Slowly - too much water vapour already in the air.

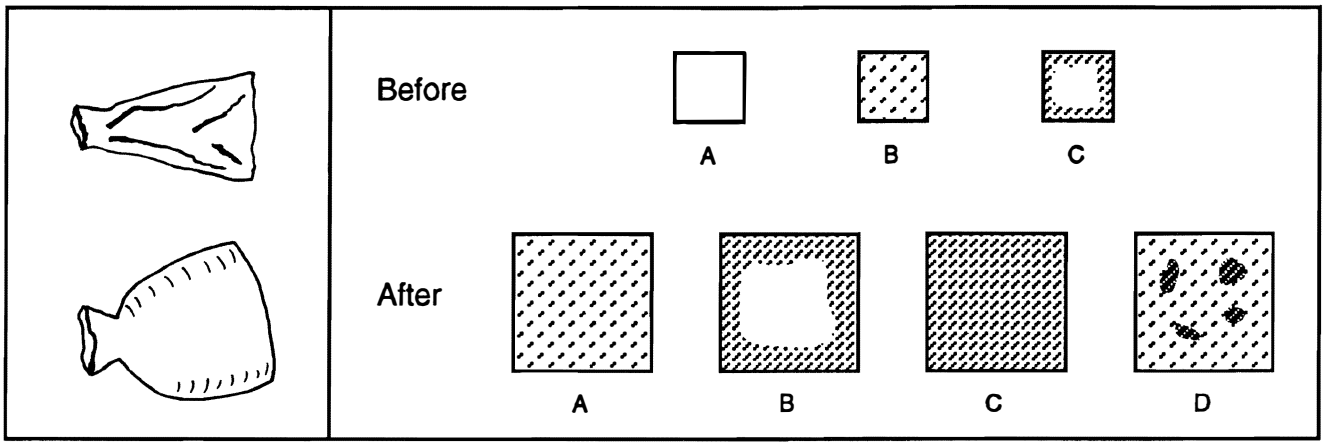
Air - squeezing, stretching, pushing and pulling

Sheet 1

1 Put circles around the pictures you think show these changes best. Put one circle around a 'Before' picture. Then put one one circle around an 'After' picture.

2 Explain why you chose these pictures.

A Blowing more air into a plastic bag

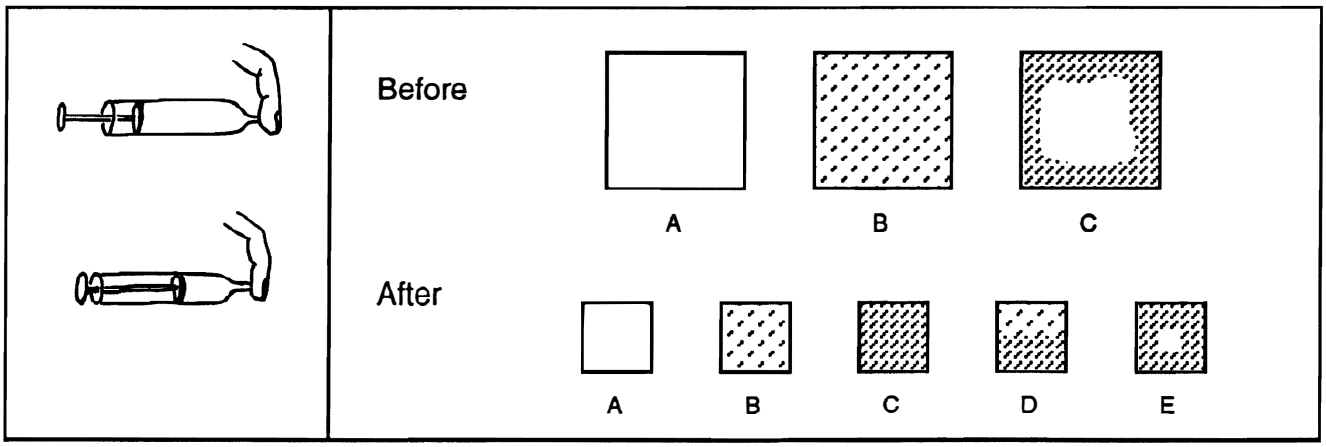


Explain why you chose these pictures. _____

_____

_____

B Squashing air in a syringe



Explain why you chose these pictures. _____

_____

_____

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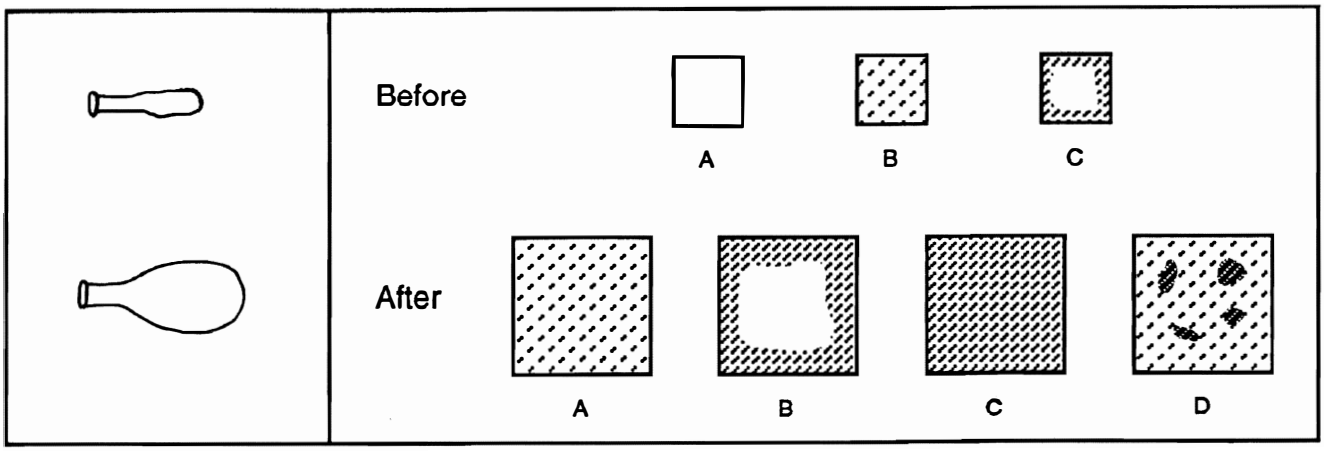
C Blowing up a balloon

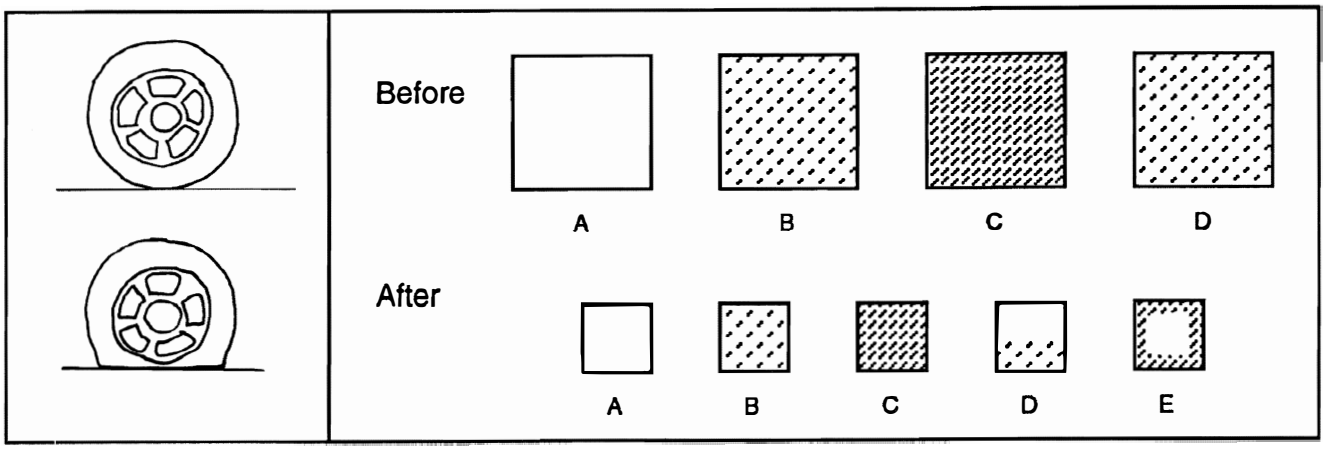


Explain why you chose these pictures. _____

_____

_____

D Letting the air out of a car tyre



Explain why you chose these pictures. _____

_____

_____

Your own pictures

Try drawing your own pictures to show these:
letting the air out of a blown-up balloon
pumping the air out of a can

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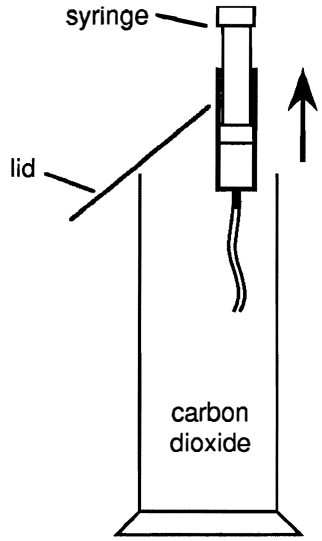
Moving gases around

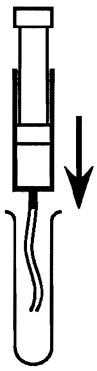
Sheet 1

1 In your jar, you have a gas called carbon dioxide. Put some of this gas into a test-tube using a syringe:

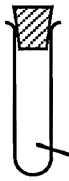


Carefully take some carbon dioxide out of the jar.

Put the lid back on the jar.

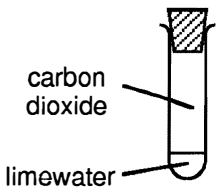


Carefully put the carbon dioxide into a test-tube.



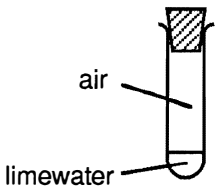
Put a bung in the test-tube.

2 Carbon dioxide is invisible, like air. So, how do you know this gas is really there? Here is a test:



Put a little limewater in the test-tube.

Give it a good shake.



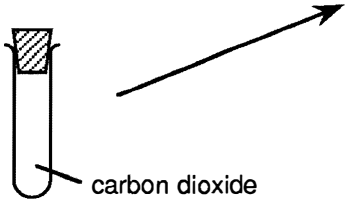
Do the same thing with a test-tube of air.

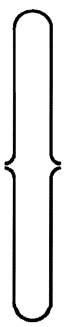
Is there any difference?

We can use limewater to test for carbon dioxide. With carbon dioxide, limewater turns cloudy.

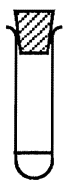
3 You have moved carbon dioxide with a syringe. Here is another way. This is harder, so be careful!

Use a syringe to put some carbon dioxide in a test-tube.





Turn it upside down over another test-tube. Give it a good shake.



Test the bottom test-tube with limewater.

Did you manage to move the carbon dioxide?

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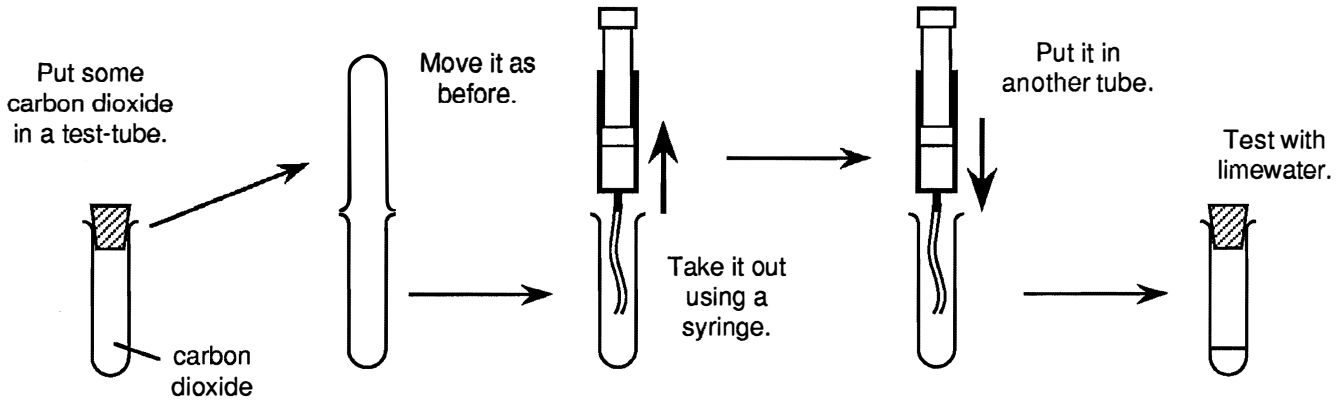
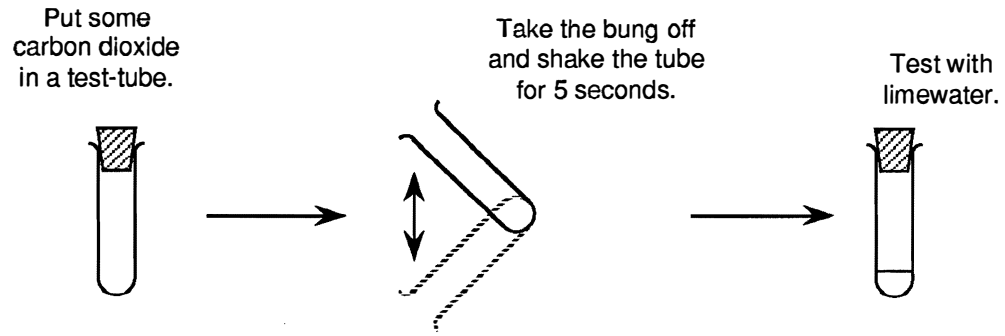
4 This is really hard! You need to be extra careful.



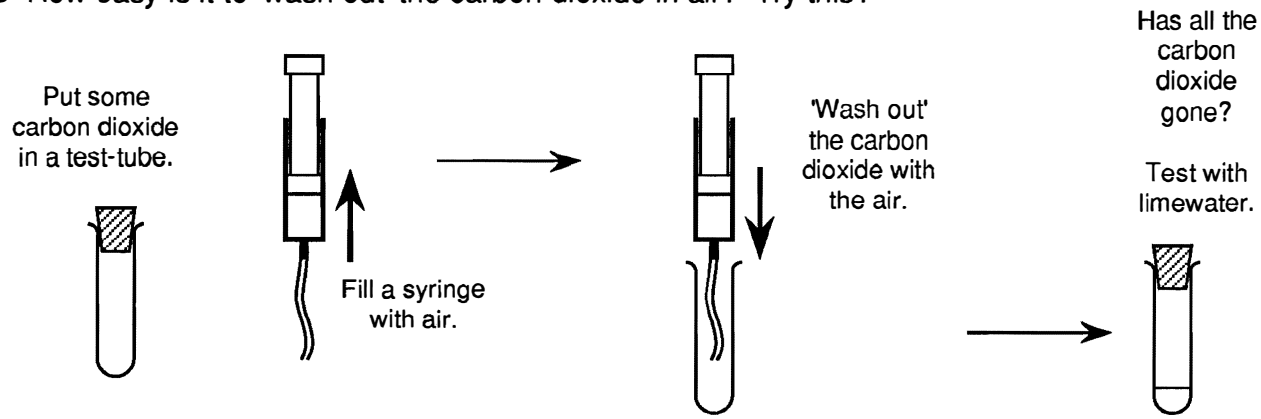
Did you manage to move the carbon dioxide?

5 How easily does 'carbon dioxide' leak away? Try this.



Do the same thing again, but shake the tube for 1 minute.

6 How easy is it to 'wash out' the carbon dioxide in air? Try this?



Was all the carbon dioxide 'washed out'? If not, do it again, 'washing out' the tube more than once. How many syringes of air do you need?

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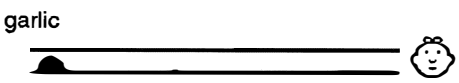
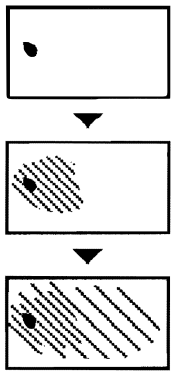
Smells and pollution

1 Here is a tube with some garlic at one end. Eventually, you will be able to smell it at the other end.



This is because the garlic slowly gives off a smelly gas. The gas spreads down the tube. These pictures show what is happening.



a) Explain why you can eventually smell the garlic.

2 Now draw your own pictures to show what is happening in these:

a) You spray some air freshener in the middle of a room. This is enough to 'freshen' the whole room.

b) You put a little carbon dioxide into a large container of air.

c) Pollution from a factory travels for many miles around.

Explain what is happening in each of these changes. Ask yourself: Is anything spreading out? Bunching together? Mixing? Unmixing or separating?

3 a) Think about these changes. Are they similar in any way? In what ways are they different? Write what you think.

- a spoonful of sugar dissolving in a cup of tea
- pollution from a factory spreading out into the air

b) Which of these changes do you think happens more easily? Why?

- a spoonful of sugar dissolving in a cup of tea
- getting sugar back from a cup of sweet tea

c) Which of these changes do you think happens more easily? Why?

- pollution from a factory spreading out into the air
- removing pollution from the air

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Objects and substances

Sheet 1

1. Cut up the list at the botom of the sheet.

2. For each one, ask yourself:

   Is it a thing? (an *object*)
   Or is it something that things are made of? (a *substance*)

Put them into two groups - objects and substances

3. Now match each object with the substance it is made from.

4. Write your answers in the table.

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Object	Substance

aluminium | book | building | cotton | door | drinks can | glass | knife | leather | paper | plastic | rubber | shirt | shoe | steel | limestone | tennis ball | waterproof hat | window | wood

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Putting changes into groups

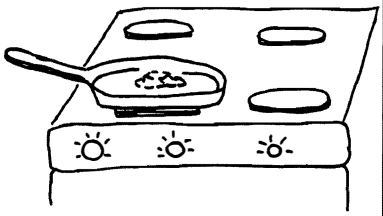
Sheet 1

1 Here are some changes. Cut them out.

2 Sort them into groups showing similar changes. You can have as many or as few groups as you like.

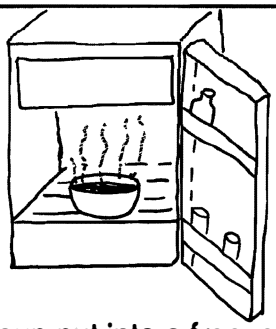
3 For each group, write a sentence explaining why these changes are similar.

A



butter in a hot frying pan

B



hot soup put into a freezer

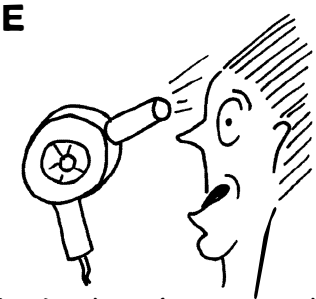
C

breathing out on a cold day

D

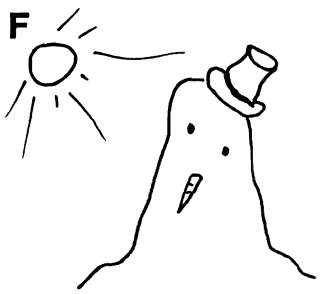
an ice cream on a hot day

E



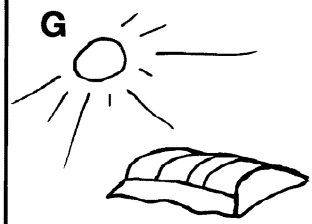
blowing hot air onto wet hair

F



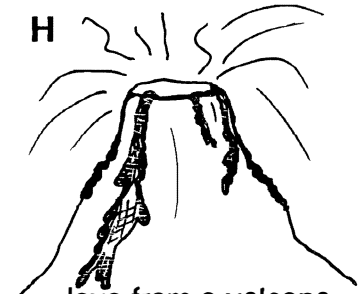
a snowman on a warm day

G



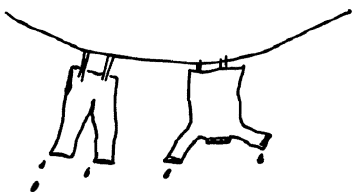
chocolate left in the Sun

H



lava from a volcano turning solid

I

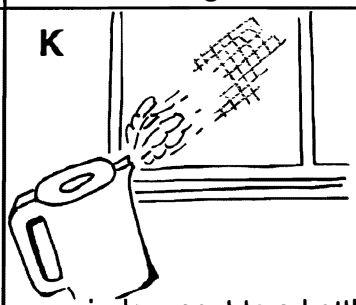


wet clothes left outside

J

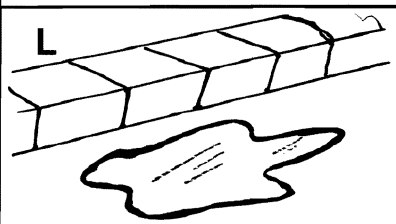
ice forming on a lake

K



a window next to a kettle 'misting up'

L



a puddle drying out

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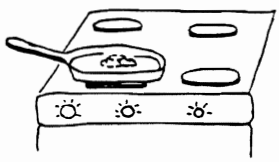
Melting, freezing, evaporation, condensation

Sheet 1

Put circles around the words, so that the sentences make sense. The first one has been done for you.

You need to think about:
- the state of matter before and after the change
- what the change is called
- the temperature difference which makes the change happen

A



butter in a hot frying pan

The change is from	vapour liquid solid	to	vapour liquid. solid	
This is called	melting freezing	evaporation condensation		
It happens because the	butter pan	is	cooler warmer	than the butter pan .

B

hot soup put into a freezer

The change is from	vapour liquid solid	to	vapour liquid. solid	
This is called	melting freezing	evaporation condensation		
It happens because the	freezer soup	is	cooler warmer	than the freezer soup .

C

breathing out on a cold day

The change is from	vapour liquid solid	to	vapour liquid. solid	
This is called	melting freezing	evaporation condensation		
It happens because the	air breath	is	cooler warmer	than the air breath .

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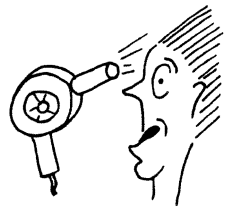
D

an ice cream on a hot day

The change is from	vapour / liquid / solid	to	vapour / liquid. / solid	
This is called	melting / freezing	evaporation / condensation		
It happens because the	ice cream / air	is	cooler / warmer	than the ice cream / air .

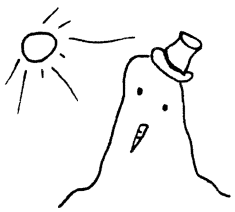
E



blowing hot air onto wet hair

The change is from	vapour / liquid / solid	to	vapour / liquid. / solid	
This is called	melting / freezing	evaporation / condensation		
It happens because the	wet hair / hot air	is	cooler / warmer	than the wet hair / hot air .

F



a snowman on a warm day

The change is from	vapour / liquid / solid	to	vapour / liquid. / solid	
This is called	melting / freezing	evaporation / condensation		
It happens because the	snowman / air	is	cooler / warmer	than the snowman / air .

Now write your own sentences to describe what is happening in these changes:

G chocolate left in the Sun
H lava from a volcano turning solid
I wet clothes left outside
J ice forming on a lake
K a window next to a kettle 'misting up'
L a puddle drying out

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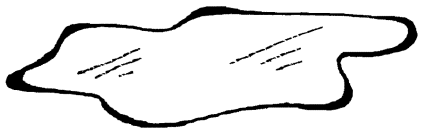
Evaporation and condensation

Evaporation If you spill some water on the floor, it will eventually dry up. It **evaporates.**



What do you think is happening to the water?

Is it disappearing?

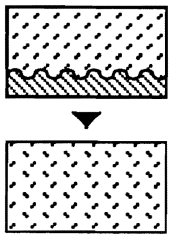
Is it pushing the air away?

Is it mixing with the air?

Is it spreading out?

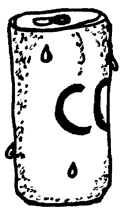
Is it getting squashed together?

Is it bunching together?



What do you think this picture is showing?

Condensation If you take a cold can of drink from a fridge, water forms on the outside. The water vapour in the air **condenses.**



What do you think is happening to the water?

Is it appearing from nowhere?

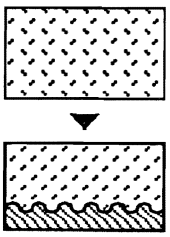
Is it coming from the can?

Is it separating from the air?

Is it spreading out?

Is it getting squashed together?

Is it bunching together?



What do you think this picture is showing?

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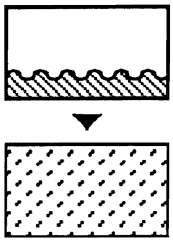
Evaporation

Something **evaporates** when it changes from a liquid into a **vapour** (or gas).



1 Cut out the boxes at the bottom showing different changes.

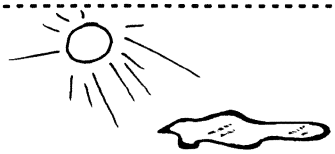
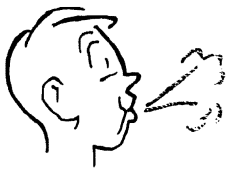
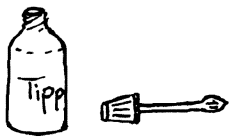
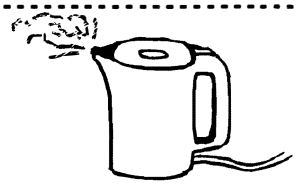
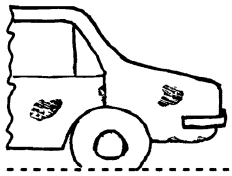
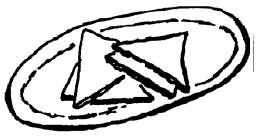
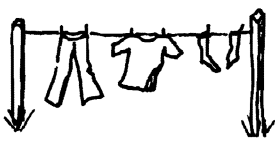
2 Sort them into two groups:

Group 1: something evaporates Group 2: nothing evaporates

3 Choose an example from the first group. Explain why you put it in that group.

4 Choose an example from the second group. Explain why you put it in that group.

5 Do the same thing for some more examples.

A dissolving sugar in water 	G leaving some salt solution until crystals appear 
B a puddle drying in the Sun 	H breathing out 
C a bottle of Tipp-ex left without the lid on it 	I boiling some water in a kettle 
D using a sponge to soak up some spilt water 	J a light bulb shining 
E a candle burning 	K a car rusting 
F some sandwiches left on a plate and drying up 	L clothes on a washing line 

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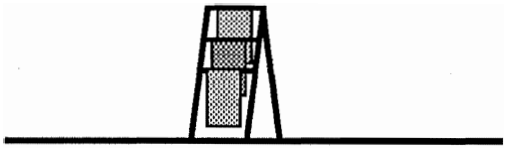
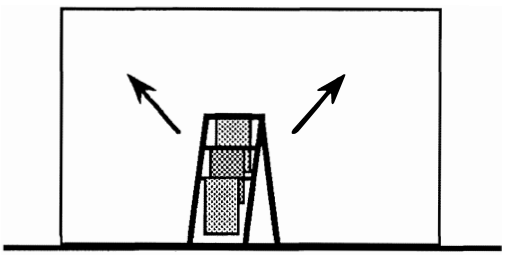
Evaporation - speeding it up and slowing it down

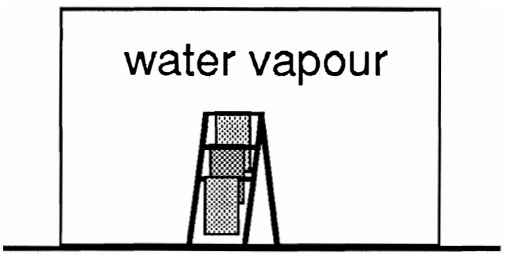


Here is some washing hanging out to dry.



The washing is in a room. The water starts to evaporate.

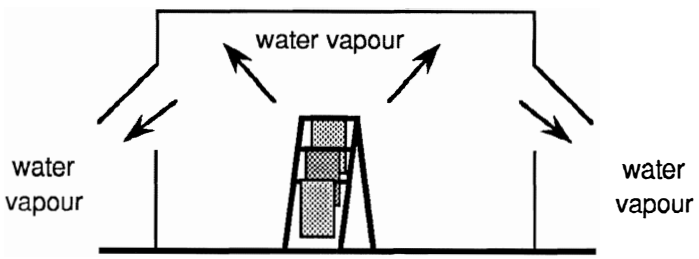
The water vapour **spreads out** through the room.



After a while, the room is full of water vapour.

The water vapour **cannot spread out** any more.

No more water evaporates from the clothes, and so they stop drying out.



When the windows are opened, the water vapour starts to **spread out again.**

So, more water can evaporate from the clothes.

Eventually, the clothes dry out.

So, to speed up evaporation:	help the water to spread out
to slow down evaporation:	stop the water spreading out

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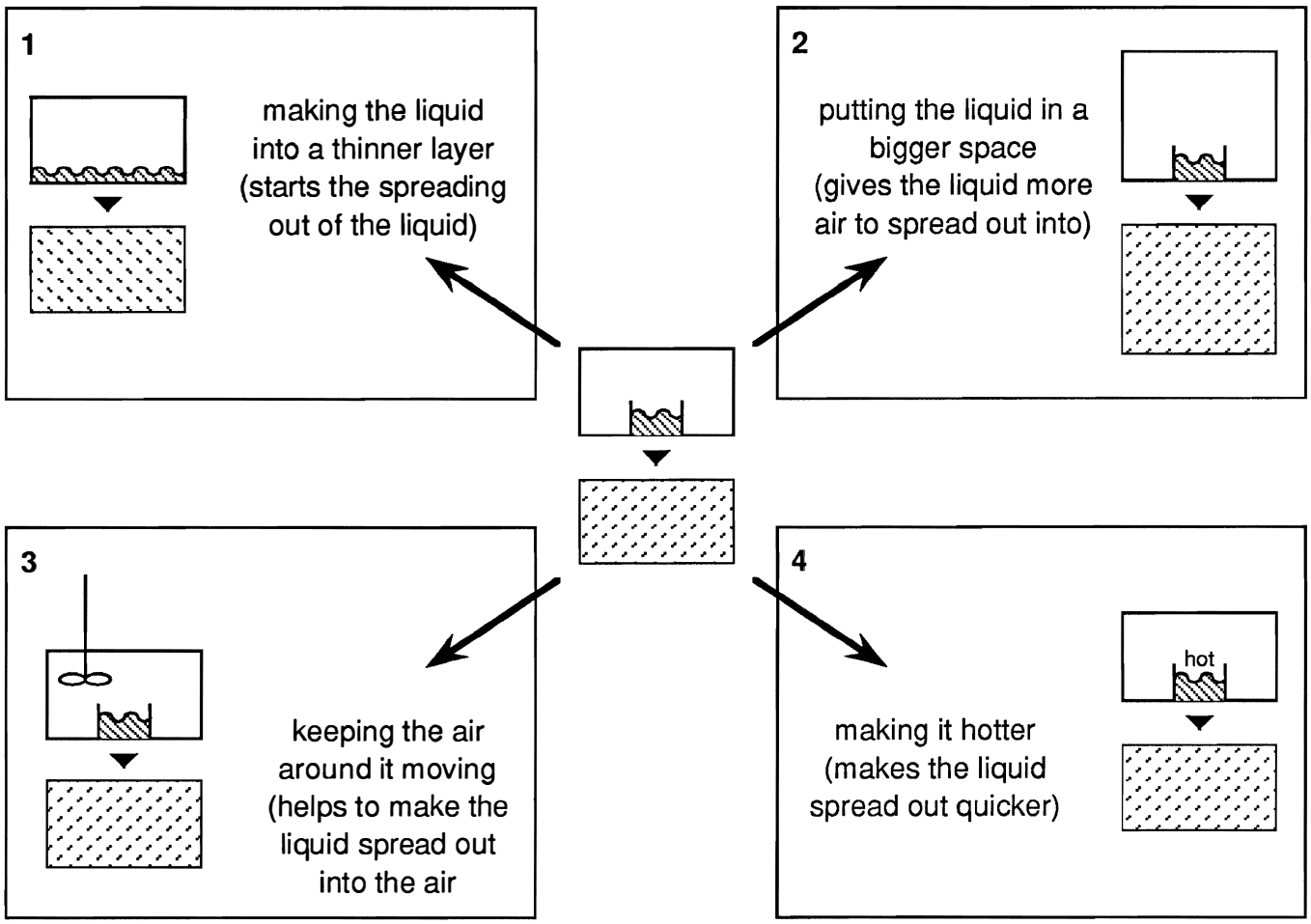
Evaporation - speeding it up and slowing it down

Sheet 2

Here are four ways of making things evaporate faster (for example, drying a paper towel).

Example: a paper towel dries quicker if you unfold it

Example: a paper towel dries quicker outside than in a plastic bag



Example: a paper towel dries quicker if you blow air over it

Example: a paper towel dries quicker if you warm it up

Questions

Here is a list showing some places you could leave washing to dry. Some are silly and some are sensible. For each place, answer these questions:

Do you think that the water will evaporate quickly or slowly?
Why do you think that?

1 In a fridge
2 In a steamy bathroom
3 Outside on a sunny windy day
4 In a plastic bag
5 On a radiator
6 On a radiator next to an open window
7 In a cupboard
8 Outside on a misty day

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