

Energy and change

A project funded by the Nuffield Foundation

Theme F

Particles and change

Teaching notes

Theme F - Particles and change

What is this theme about?

Understanding particles is central to the understanding of the nature of change. We need to distinguish two different kinds of change:

- those in which the particles themselves do not change (e.g. squashing a piece of plasticene, chocolate melting, sugar dissolving in a cup of tea)
- those in which particles form new particles - by splitting, joining, re-combining (e.g. hydrogen and oxygen reacting to form water, starch being broken down to glucose)

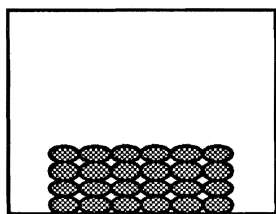
All changes tend to go in the direction in which particles become more spread out or more mixed together. Not all changes do this because energy is also an important part of the story too - especially in changes in which new particles are being made by splitting and forming chemical bonds.

In this theme, we shall focus on using particles pictures to represent different kinds of changes, and how particles may become more spread out or mixed together. Chemical changes in which new substances are formed will be represented, but the idea that chemical change involves splitting and forming bonds will be left until Theme G 'Up and down in complexity'. Energy changes in chemical reactions will be looked at in Theme H 'Food and fuels'.

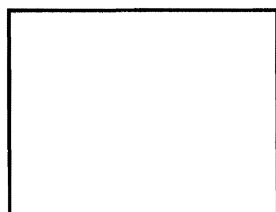
The activities

- F1 What are substances like?
- F2 Wearing out
- F3 Substances and changes
- F4 Changes in test-tube reactions
- F5 Everyday changes
- F6 Spreading out and mixing
- F7 Which way is easier?

Conventions used in this theme



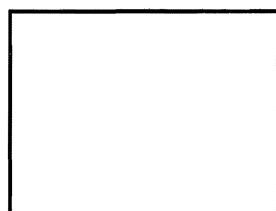
substances are represented by arrangements of oval-shaped particles, e.g. this is a solid



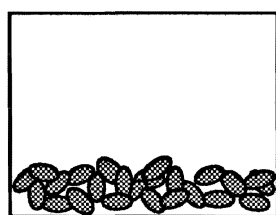
before



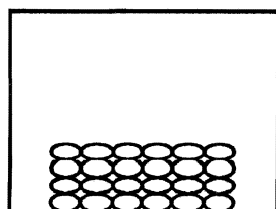
changes are represented by pictures showing 'before' and 'after'



after



different substances are represented by particles of different shading, e.g. this shows a liquid changing a different substance which is a solid



Activity F1 - What are substances like?

The activity introduces pupils to the 'particle pictures' which are used throughout this theme, and the arrangements of particles in a variety of substances.

This activity may appropriately be done after pupils have learned about the description of solids, liquids and gases in terms of particles. Many everyday substances are mixtures, however, and do not fit into this classification. This activity is intended to give pupils experience in considering the structures of everyday substances. A circus of the examples on display may be useful.

The pupils will require both sheets 1 and 2 for the activity, though sheet 2 can also be used as an OHP to introduce the different arrangements of particles. The pupils should initially work in groups cutting up the examples of substances and matching them to the arrangements of particles. Note that the instructions say which match they think is *best* (not necessarily exact) and this should be stressed.

One common conception that pupils have is that the spaces between particles are not empty but are filled with *air*. One point that these sheets make is that some substances (e.g. foam) *do* contain air, but that in others the space between particles *is* empty space. Other issues which could be raised are to think about the definition of a liquid of taking the shape of its container - flour, sand, sugar do this - are they then liquids? Looking at some substances under the microscope can reveal interesting things about their composition (e.g. milk as an emulsion).

Activity F2 - Wearing out

The activity makes the distinction between changes to objects and changes to substances, as a way of introducing the essential nature of a chemical reaction.

The particle pictures introduced in the previous activity are used, as well as the convention which represents 'before and after'. This convention needs to be explained if this has not already been done in other activities. Changes to substances are represented by changes in the shading of particles.

The activity could either be done individually or by groups on pupils. It is intended to encourage the distinction to be made between mechanical changes to objects and chemical changes to substances. An earlier activity (C4 'Objects and substances') made the distinction between objects and substances. Clarifying this essential feature is necessary to the understanding of the nature of a chemical reaction.

Since all of the changes here are those in which something becomes degraded in some way, it could also lead to a discussion about how easy it would be to reverse these changes. Reversibility is taken up in later activities in this theme.

Activity F3 - Substances and changes

The activity is intended to encourage discussion about the differences between various kinds of changes, and to give pupils experience in thinking about changes in terms of particles.

As in activity F1, this is best done as a group activity, with pupils matching the changes to the pictures they think are *best*. The pictures represent mechanical changes (e.g. cutting, stretching), changes of state (melting and freezing) and chemical reactions. Again, sheet 2 can be used as an OHP for class discussion to introduce the activity. It is important to note that these pictures should not be taken too literally - e.g. counting relative numbers of particles, or paying attention to the details of the kinds of particles involved. They should be interpreted, not as necessarily showing what is really happening (i.e. in terms of molecules), but as merely suggestive of a way of representing them.

Answers:

- | | |
|---------|---------|
| 1 A M | 2 E I N |
| 3 C G | 4 F K |
| 5 B D L | 6 H J |

Activity F4 - Changes in test-tube reactions

The activity gives pupils further experience in thinking about changes in terms of particle, and gives them the opportunity to interpret their observations in reactions they carry out.

In the other activities in this theme, pupils match changes that they know from their own experience to particle pictures. Using these pictures can be particularly successful when used alongside a practical task, in encouraging pupils to pay attention to the nature of the changes that they observe. The reaction chosen happens to be neutralisation (which could be set in the context of curing indigestion or clearing up an acid spill), but many other types of reactions could be investigated in the same way.

In choosing which pictures are the best matches, pupils need to pay attention to the following features:

- whether the substance added to the acid is a solid or a liquid
- whether the solids or liquids dissolve or mix
- whether a gas is given off
- whether a new substance is formed (from observing changes to the pH)

Answers:

- | | |
|------------------|---|
| ammonia solution | B |
| chalk | F |
| salt | D |
| water | A |

Activity F5 - Everyday changes

Seeing what is essentially similar in superficially different changes is important in understanding the nature of change. Pupils are encouraged to do this in this activity with the support of particle pictures.

This could be done as a poster activity. As before, pupils match changes (on sheet 2) to pictures (sheet 3) - making these up as posters allows them to be used to promote class discussion amongst groups. It may help pupils to 'navigate' the set of pictures if they are told that pictures 1-5 all start with a single substance and pictures 6-10 all start with two substances.

The second part of sheet 1 is particularly important - it asks pupils to compare selected changes in order to identify similarities and differences between them. For example, in 'bending a metal spoon' and 'a glass bottle breaking', a similarity is that the substances they are made of do not change. Seeing similarities between what appear to be superficially very different situations is essential to understanding the nature of changes. By focusing on the particle pictures, pupils may be helped to make these abstractions and pay less attention to superficial features of the changes.

An additional activity would be for pupils to try to put the changes into groups, with similar changes together (they could make up a second poster by cutting up another copy of sheet 2). They should be told that they can have 2, 3, 4 or as many groups as they want, and that they should give a reason for each group. Again they are being encouraged to pay attention to broad similarities between changes. (They could also be asked to think about this before matching them the particle pictures - do the particle pictures help them to see features that they had not seen before?)

This activity (along with the previous activities using particle pictures) can be used to introduce pupils to standard scientific terminology such as physical change and chemical change, effervescence, corrosion, and so on.

Activity F6 - Spreading out and mixing

Changes in which substances spread out or mix tend to happen more easily than the reverse. This activity extends this idea to chemical reactions.

Before starting this activity it would be useful to discuss with pupils ideas about mixing and 'unmixing' and why mixing happens more easily than the reverse. These ideas are introduced in the OHP from activity A4 'Mixing and unmixing'.

Sheet 1 in this activity can be used as an OHP, and extends the discussion to why some chemical changes may go more easily in one direction than another, by considering particle pictures of these changes. The reasons why these changes are difficult to reverse is that matter is spreading

out, or mixing. In the case of sulphur burning in air, another reason is that *energy* is spreading out - energy is not explicitly introduced in the pupil activity at this stage, but for some groups of pupils it may be appropriate to introduce this idea as well. (Energy changes in chemical reactions are introduced in Theme H 'Food and fuels'.)

Note that without knowledge of the precise changes occurring at the molecular level it is difficult to choose between some pictures. For example, is dissolving '3' or '4'? If we understand the process of dissolving in terms of the particles involved, we know that '3' is right, but this is not possible to deduce from the *appearance* of dissolving. Does zinc remain unchanged when it 'dissolves' (5) or does it react (6)? Pupils choices should be taken up in class discussion - where there are disagreements between pupils they should be asked to think about how they could test these practically.

Pupils could also be asked to draw their own pictures of changes which have not been included before. Examples might be using a dry cleaning fluid to remove a stain or dynamite exploding. Drawing particles with different shadings is clearly not easy - in their pictures, pupils should represent different substances by different colours or different shapes.

Activity F7 - Which way is easier?

This activity develops from the previous activity, considering reversibility in a wider range of changes.

Pupils are asked to consider the direction of different kinds of changes - physical and chemical - and reasons for this, but without the support of the particle pictures. However, they could be encouraged to draw their own particle pictures of these changes to support their explanations.

Many of these changes involve energy transfers as well as changes in the nature or arrangement of particles (note that change 2 *only* involves energy transfer). If energy has been discussed in the previous activity, then pupils could be encouraged to include ideas about energy in their explanations here.

What are substances like?

Sheet 1

Many substances we can group into 'solids', 'liquids' or 'gases'. However, there are many other examples which are none of these things, but which are 'in between'. For example, a sponge is made of a solid with air trapped in it.

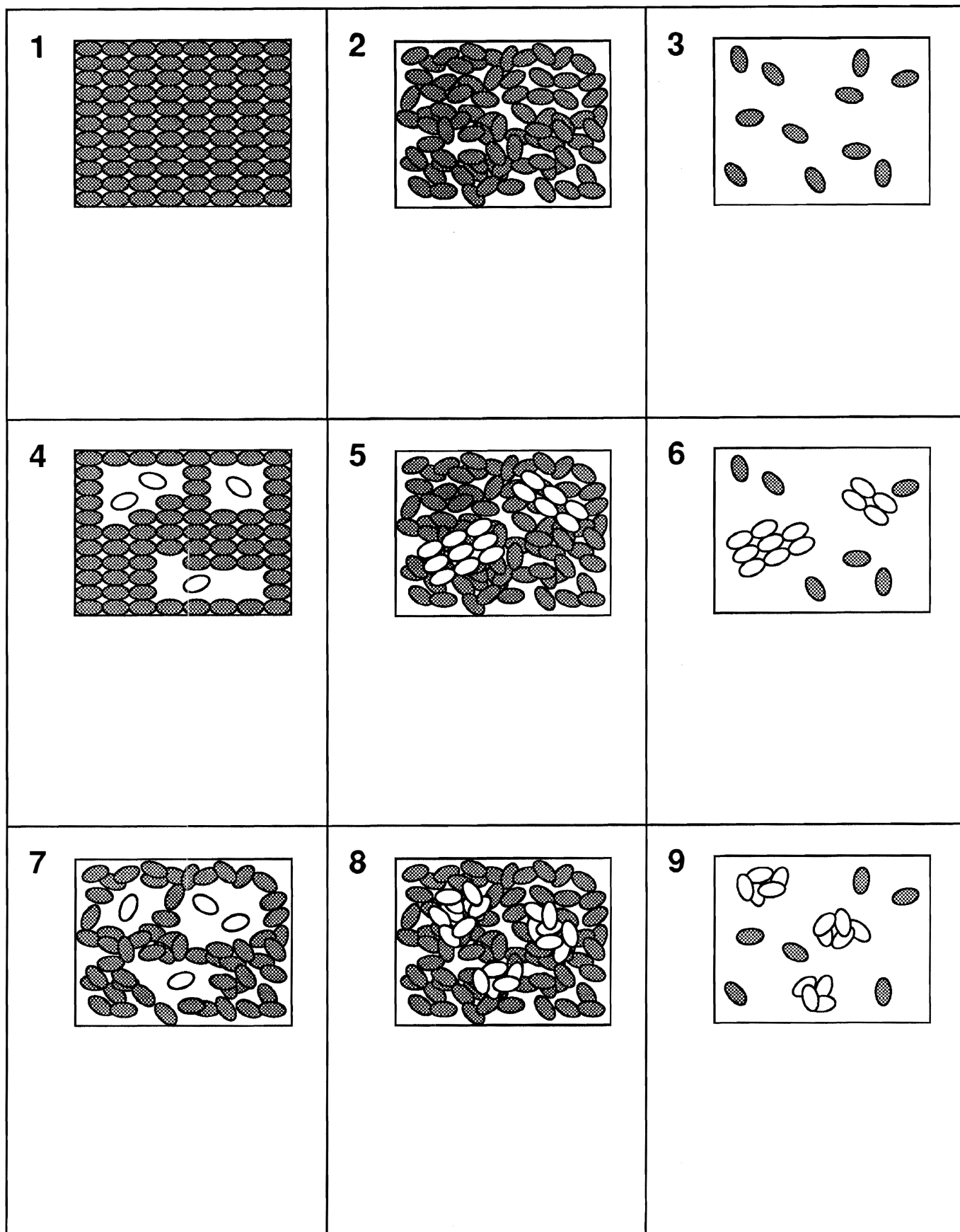
1 On sheet 2 are some pictures which show how particles are arranged in substances. Match each substance below to the picture which you think is best. (You can match more than one substance to a picture, or none at all.)

air	natural gas
cloud	orange juice
copper	petrol
expanded polystyrene	smoke
ice	water

2 Which picture have you used most? Explain why you have matched the substances to this picture. Do this for some of the other pictures.

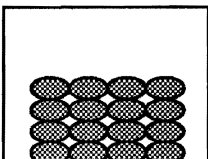

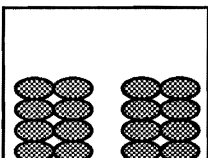
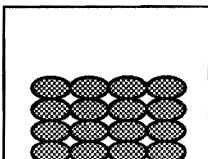

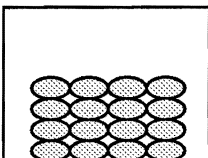
3 If you have time, you could try matching these as well.

air freshener spray	shaving foam
brick	toothpaste
dust	treacle
milk	water vapour
salt	whipped egg white



When we buy things, we do not expect them to last forever. When they get older they tend to wear out, break, become useless, etc.

Sometimes this happens because the *object* changes in some way. Sometimes it happens because the *substance* it is made of changes. For example:

<p>Here, the object changes, but the substance stays the same.</p> <div style="text-align: center;">    </div> <p><i>Example</i> a glass window breaks (it is still glass)</p>	<p>Here, the substance changes to a different substance.</p> <div style="text-align: center;">    </div> <p><i>Example</i> a steel knife rusts (steel changes to rust)</p> <p style="text-align: right;">This is a <i>chemical reaction.</i></p>
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Questions

1. Here are some other changes. Try to group them.

- | | |
|--|--|
| <ul style="list-style-type: none"> a wooden door rots a page is torn from a book the paper in a book turns yellow a cotton shirt is ripped a leather shoe becomes brittle | <ul style="list-style-type: none"> an aluminium can is crushed a plastic waterproof hat gets a hole a rubber ball perishes rain erodes a limestone building a building falls down |
|--|--|

the object changes, but the substance stays the same	the substance changes to a different substance

2. Now think about each change in the first column of the table. Could you get the object back to the way it was at the start? How could you do this? Would it be easy or difficult?

3. Now think about each change in the second column of the table. Could you get back the same substance you had at the start? How could you do this? Would it be easy or difficult?

Substances and changes

Sheet 1

In some changes, the substances stay the same. In other changes, new substances are formed.

Look at the pictures on sheet 2. They show what happens to particles in different kinds of changes:

In pictures 1 and 2, the particles stay the same.

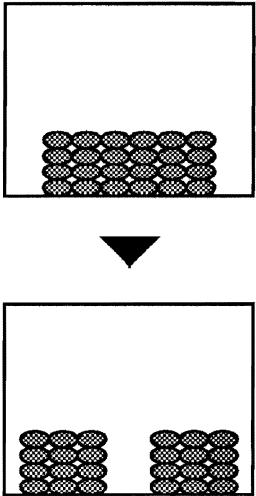
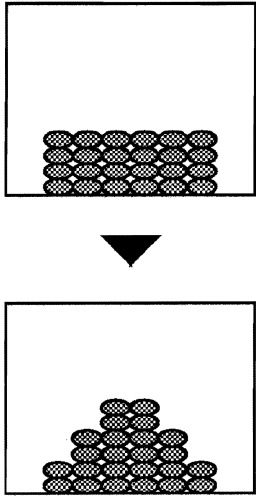
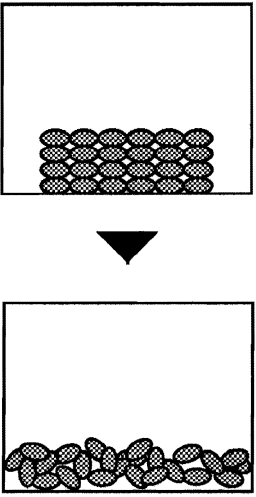
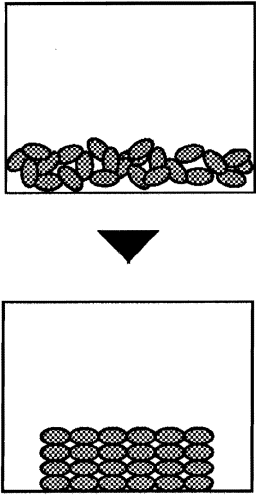
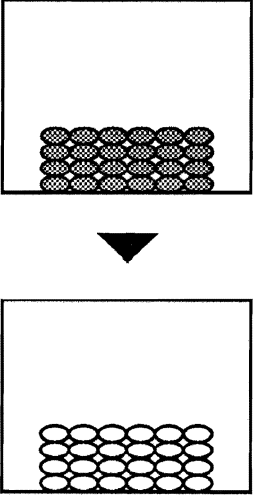
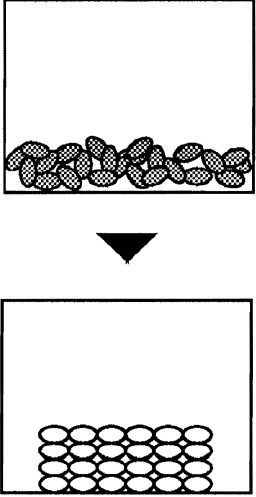
In pictures 3 and 4, there is a change in the state of the substance (liquid, solid) but the particles stay the same.

In pictures 5 and 6, new particles are formed.

1 Below are some different changes. Match each change to the picture you think best shows what happens to the particles. (You can match more than one change to a picture.)

2 Which picture have you used most? Explain why you have matched the changes to this picture. Do this for some of the other pictures.

A tearing up some paper	H cooking an egg
B a piece of wood rotting	I crushing an aluminium can
C a snowman turning to water	J glue becoming hard
D baking a potato	K making ice in the freezer
E bending a sheet of metal	L making toast from bread
F lava from a volcano turning solid	M sawing a piece of wood in half
G chocolate melting in the Sun	N stretching an elastic band

<p>1</p> 	<p>2</p> 
<p>3</p> 	<p>4</p> 
<p>5</p> 	<p>6</p> 

Changes in test-tube reactions

Sheet 1

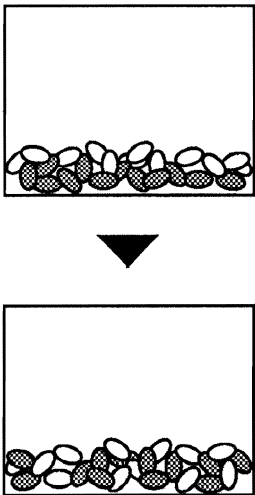
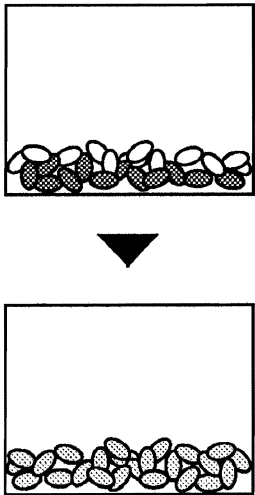
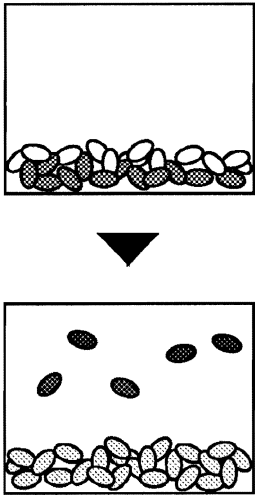
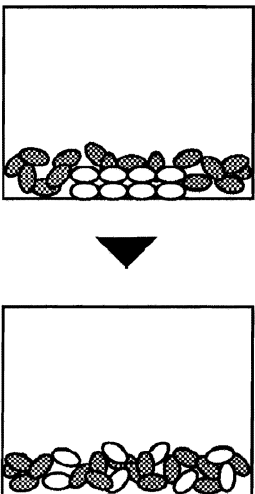
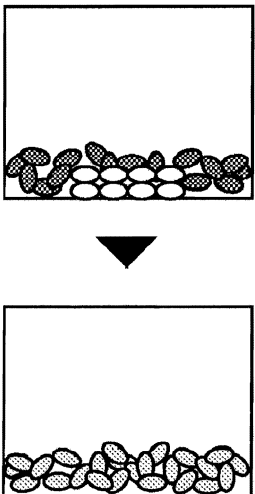
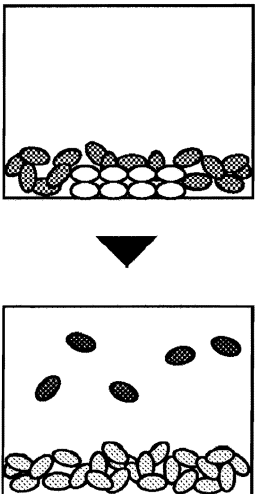
Which of these substances can neutralise an acid?

ammonia solution
chalk
salt
water

1 Put a small amount of dilute hydrochloric acid in a test-tube. Add one of the substances above. Observe carefully. Add some universal indicator to test the pH.

2 From you results, work out which of the pictures below best shows what is happening to the particles in this change. Explain.

3 Repeat for the other substances.

<p>A</p> 	<p>B</p> 	<p>C</p> 
<p>D</p> 	<p>E</p> 	<p>F</p> 

Everyday changes

Sheet 1

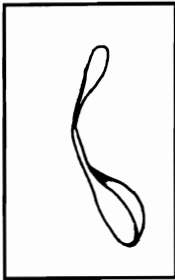
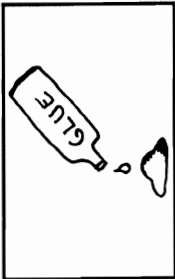
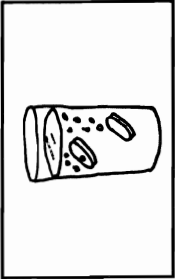
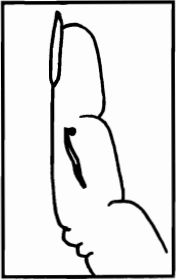
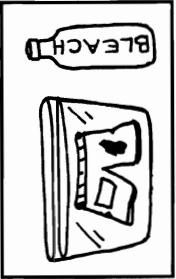


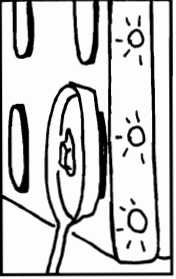
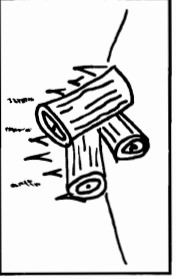



1 You have two sets of pictures. Sheet 2 shows a set of everyday changes, and Sheet 3 shows a set of 'particle pictures'.

Make up a poster, matching the 'changes' to the 'particle pictures'. (Note that some pictures may have more than one change matched to them, others may have none.)

Next to each matching, write a reason why you made the match.

2 Think about the following pairs of changes. For each pair, work out one thing that the changes have in common, and one way in which they are different. Look at the 'particle pictures' to help you think about this.

	One thing they have in common	One thing which is different
a) bending a metal spoon a glass bottle breaking		
b) some wood burning a metal bracelet tarnishing		
c) butter melting in a hot pan bending a metal spoon		
d) washing the dirt off your hands some wood burning		

<p>A</p>  <p>bending a metal spoon</p>	<p>B</p>  <p>glue becoming hard</p>	<p>C</p>  <p>putting Alka Seltzer in water</p>
<p>D</p>  <p>blood forming a blood clot</p>	<p>E</p>  <p>using bleach to get rid of a stain on clothing</p>	<p>F</p>  <p>a glass bottle breaking</p>
<p>G</p>  <p>using rust remover on an old car</p>	<p>H</p>  <p>butter melting in a hot pan</p>	<p>I</p>  <p>some wood burning</p>
<p>J</p>  <p>ice forming on a lake in winter</p>	<p>K</p>  <p>washing the dirt off your hands</p>	<p>L</p>  <p>a metal bracelet tarnishing</p>

<p>5</p>	<p>10</p>
<p>4</p>	<p>9</p>
<p>3</p>	<p>8</p>
<p>2</p>	<p>7</p>
<p>1</p>	<p>6</p>

Spreading out and mixing

Sheet 1

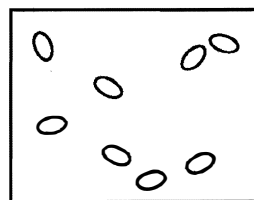
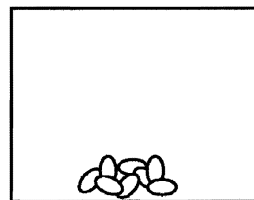
There are many changes in which substances spread out or mix. It is often difficult to make these changes 'go backwards'. To do this, the substances would need to 'bunch together or 'un-mix'.

1

For example, water evaporating

Here, a substance is spreading out.

This is not a chemical reaction - the substance stays the same.

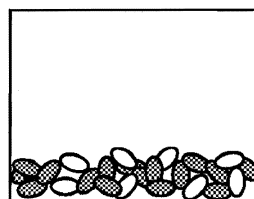
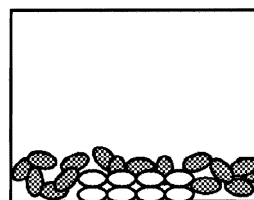


2

For example, salt dissolving in water

Here, substances are mixing together.

This is not a chemical reaction - the substances stay the same.

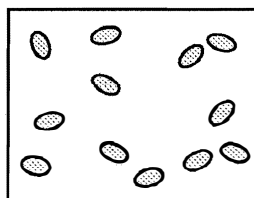
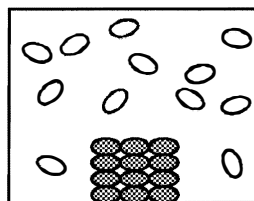


3

For example, sulphur burning in air

This is a chemical reaction - the substances are changing.

The substances are also spreading out.



Spreading out and mixing

Sheet 2

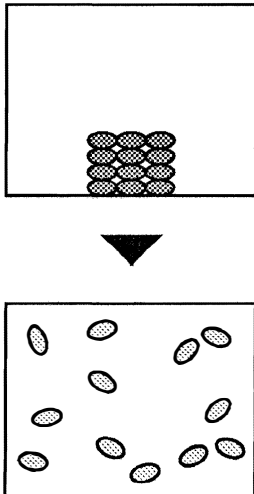
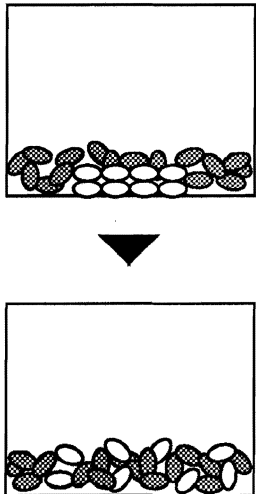
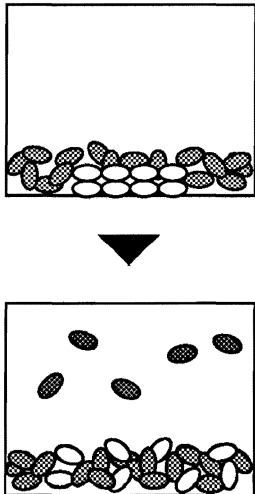
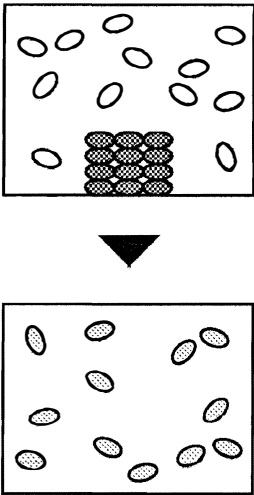
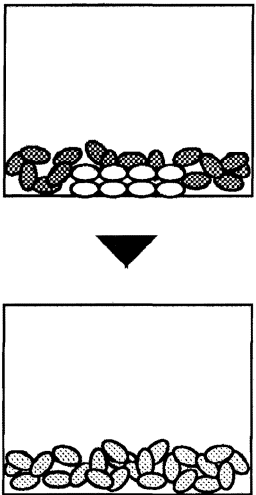
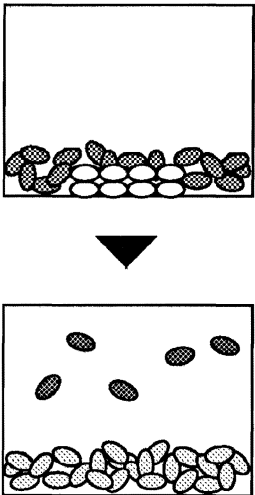
1 Here are some changes:

- A dissolving some sugar in water
- B a candle burning
- C zinc reacting with acid to make hydrogen gas

2 Look at the pictures below. For each change, choose which picture you think is best to show what is happening.

3 For each change:

- Is a substance spreading out?
- Are substances mixing?
- Is a new substance being formed?

<p>1</p> 	<p>3</p> 	<p>5</p> 
<p>2</p> 	<p>4</p> 	<p>6</p> 

Which way is easier?

Sheet 1

1 Look at each change. Think about which way is easier for it to go. Put a circle round the answer you think.

2 Then give your reasons - think about whether anything is spreading out or mixing, and whether new substances are being formed.

<p>1</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">coffee powder and hot water</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">hot coffee</div> </div>	<p>2</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">cold coffee</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">hot coffee</div> </div>
<p>3</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">a glass bottle</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">a broken glass bottle</div> </div>	<p>4</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">clean water and dirty hands</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">dirty water and clean hands</div> </div>
<p>5</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">ashes</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">wood</div> </div>	<p>6</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">wet paint</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">dry paint</div> </div>
<p>7</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">water vapour</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">water</div> </div>	<p>8</p> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 0 auto;">snowman</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="text-align: center;"> ↓ this way is easier </div> <div style="text-align: center;"> they are about the same </div> <div style="text-align: center;"> ↑ this way is easier </div> </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: 100px; margin: 10px auto;">water</div> </div>