

Using models and analogies in the teaching of chemistry at KS3: Unit 8I Heating and Cooling

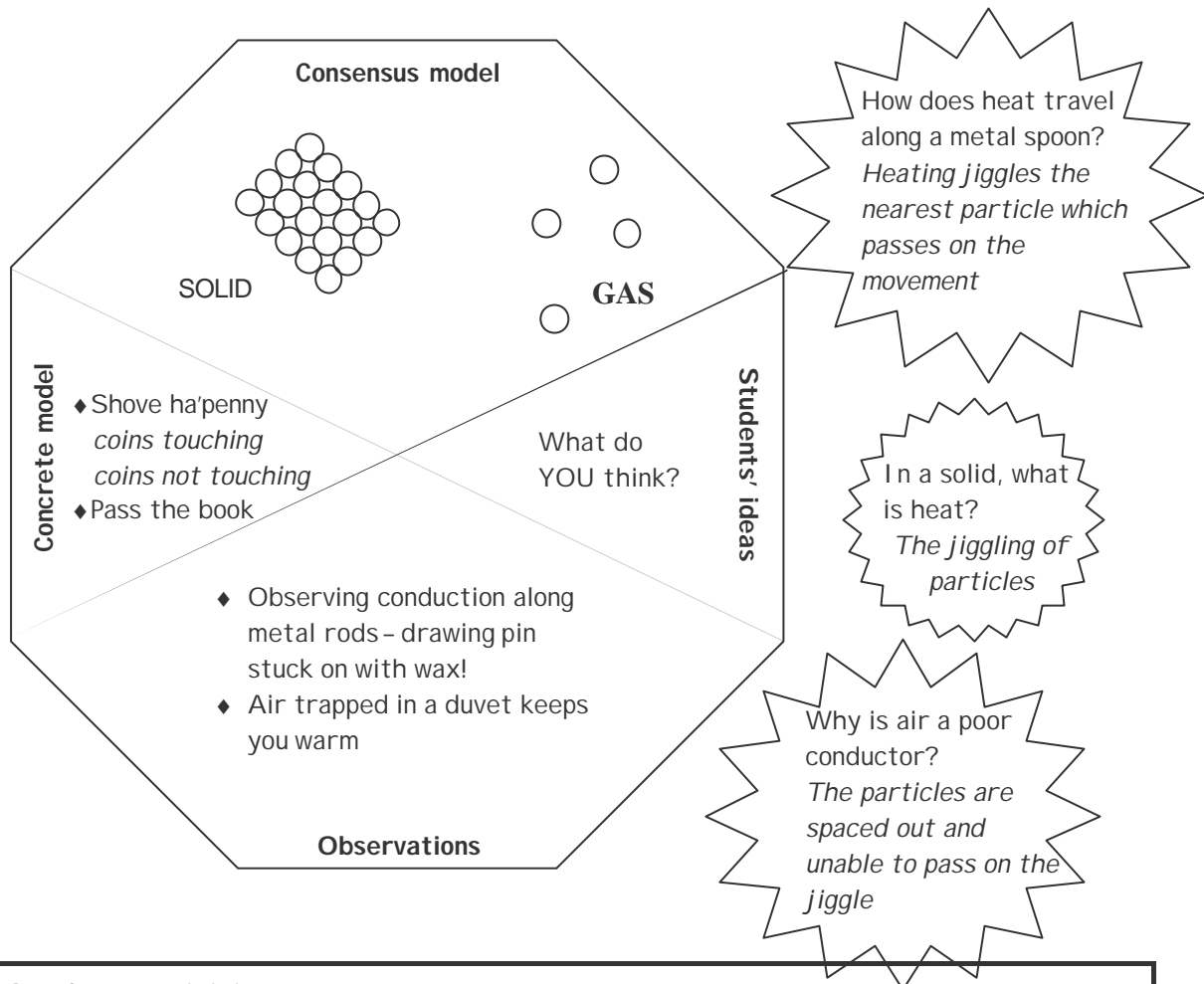
Key concepts	Phenomena that can be explained	“Visualisations” - Concrete models or analogies used by teachers
<ul style="list-style-type: none"> • Particles can act as energy carriers • Transferring energy to a material makes the particles move more quickly • When heating a solid the particles vibrate more rapidly about a “fixed position”. The amplitude of this vibration increases with increasing energy. • The increased amplitude of vibration results in the expansion of the solid • Energy from a heat source is transferred through solids by conduction, here particles pass on their energy to neighbours • Conduction will travel through a material in any direction • Good conductors such as metals have particles that can “vibrate” freely • In a liquid and in a gas particles move freely away from a heat source because they are not held so tightly together • Particles move freely in all directions resulting in a locally less dense medium that then rises upwards • This upwards movement is called convection. Convection currents can be seen in liquids and gases 	<ul style="list-style-type: none"> • Conduction takes place in all directions • Heat travels incrementally along a bar (pins stuck on with wax gradually dropping off) • Some solids are better conductors than others because their particles can vibrate freely • Generally solids are better conductors than liquids because their particles are “held” closely together • Convection currents move in an upwards direction • When substances are heated they expand 	<ul style="list-style-type: none"> • Spring connected polystyrene balls in the form of a cube can show the increased movement of particles carrying energy illustrating expansion and conduction • Be the model, link arms and pass on energy, for conduction • Pupils can hold hands and see that it is more difficult to transfer energy than when linking arms because they are further apart/held more loosely together (compare solid/liquid as good poor conductors) • Shove ha’penny can be used to illustrate transfer of energy in conduction and convection • 3D Kinetic model or CD Rom can show expansion
<p>Commentary: Pupils take readily to the notion of conduction as being energy transferred by increased vibrational energy that gradually passes through the solid. Drude’s theory of heat conduction (1904) helps explain why metals conduct heat better than some other materials. This theory uses the idea of electrons being free to move transferring energy more quickly. This model, expected by some GCSE boards (not all), does have its problems. If the question arises as to why metals are better conductors it would be appropriate to say at this stage that the way the particles are held together in a metal means that they can more easily vibrate than the particles in other materials such as plastics, wood etc. Convection currents move upwards because the particles move away from each other near the heat source so the material, is less dense in this region. This “less dense” region then moves upwards.</p>		

8I Heating and Cooling : Conduction

National Curriculum learning objectives

Explain conduction in terms of particle model

- ◆ Apply the particle model to explain why metals are good conductors and why fluids are poor conductors of heat



Student Activities

- ◆ Observe the experiments - see pins drop off metal rod - compare the insulation of a fluffed up and flattened duvet
- ◆ Explain the process - the metal particles pass on the jiggle one to another
- ◆ Be the model - pass the book/link arms and pass the jiggle (transfer the energy)
- ◆ Devise your own model - it's like.....

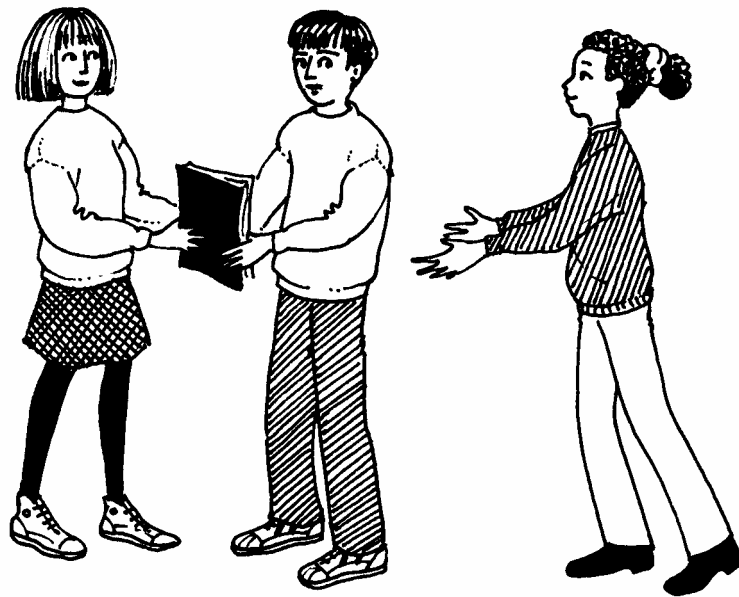
Student Evaluation e.g. Pass the book

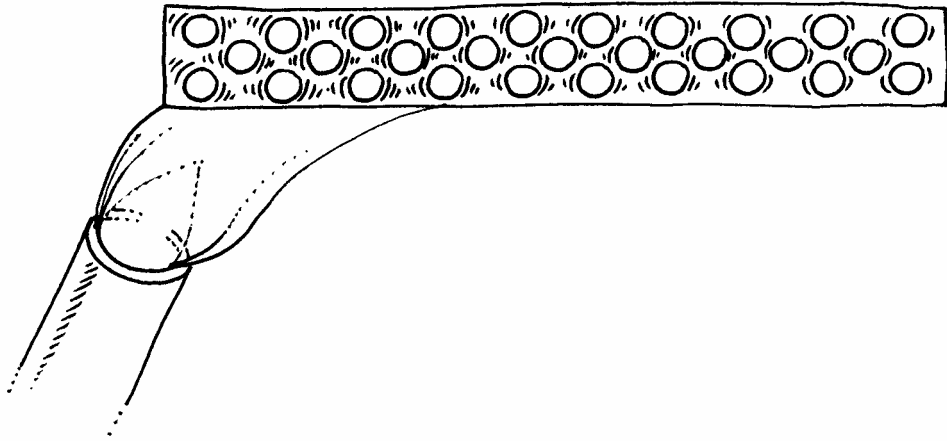
In what ways is the model good at helping you understand about particles?

Helps you imagine the way in which energy is passed from one particle to the next

In what ways is the model not good at helping you understand about particles?

Using the book as an energy packet does not help you imagine the jiggle!



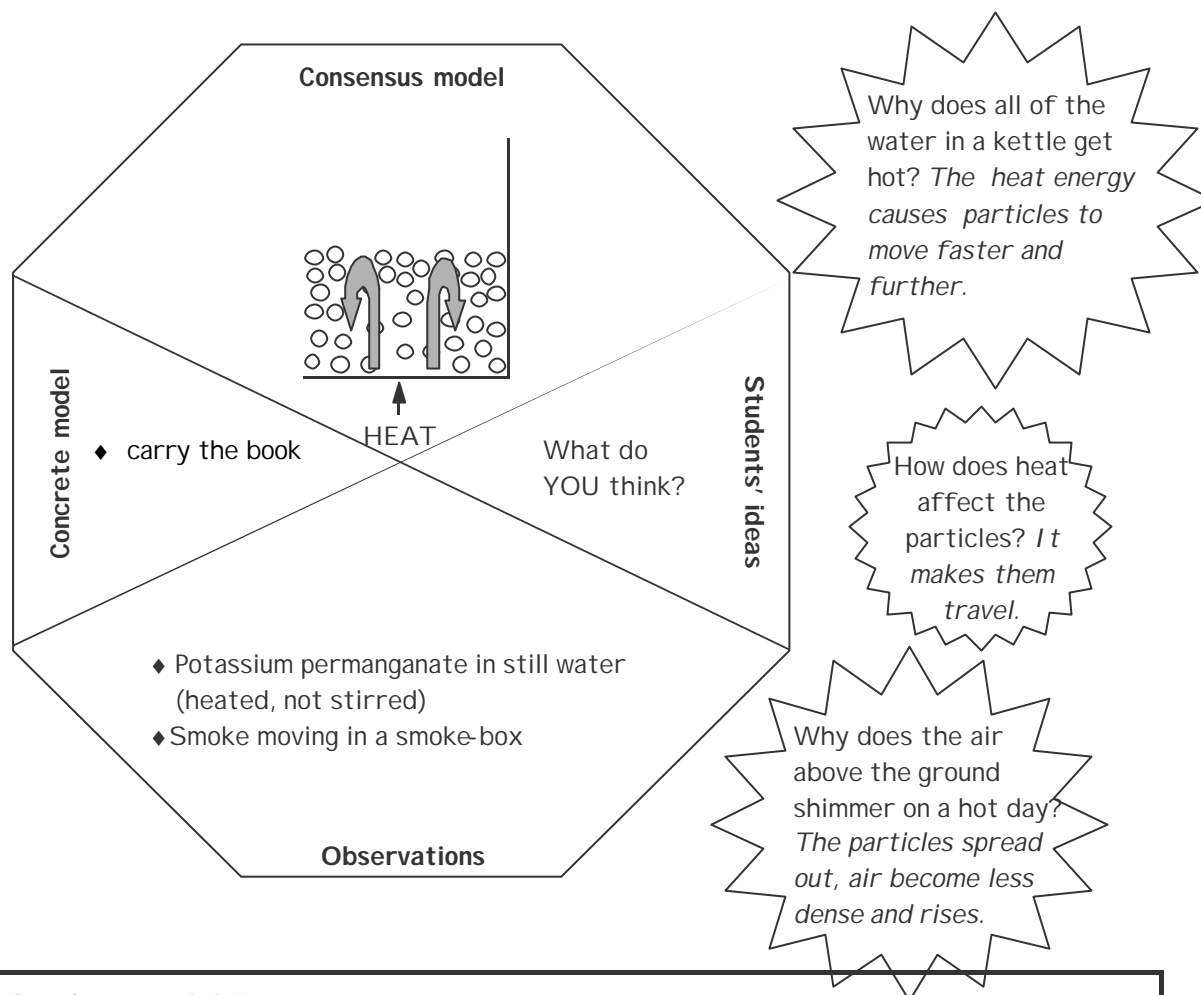


8I Heating and Cooling : Convection

National Curriculum learning objectives

Explain convection in terms of particle model

- ◆ Changes in movement due to energy transfers
- ◆ NB the **particles** don't expand, they spread out



Student Activities

- ◆ Observe the experiments – track movement of heated air with smoke particles and coloured dye in heated water
- ◆ Explain the process – the heated air/water particles spread out, the air/water becomes less dense and rises.....etc
- ◆ Be the model – carry a book from A to B
- ◆ Devise your own model – it's like.....

Student Evaluation e.g. Carrying a book

In what ways is the model good at helping you understand about particles?

Helps you imagine that particles move and don't expand.

In what ways is the model not good at helping you understand about particles?

The book is an object unlike energy. Carrying the book does not show how the spacing of particles changes.

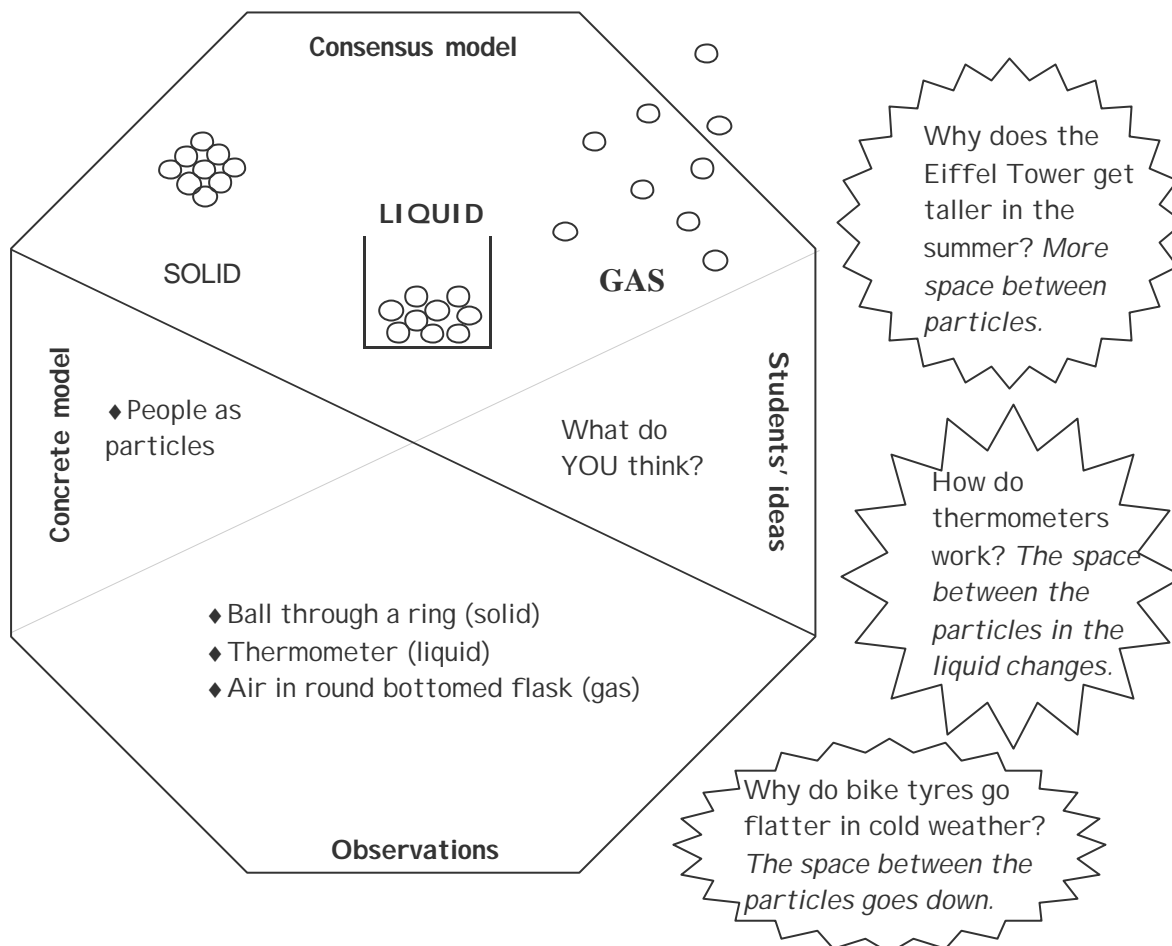


8I Heating and Cooling : Expansion

National Curriculum learning objectives

Explain expansion in terms of particle model

- ◆ Changes in movement, arrangement and bonding of particles due to energy transfers
- ◆ NB misconception - particles do not expand



Student Activities

- ◆ Observe the experiments - put the cold ball through the ring and then heat it up! Watch a thermometer change! Make bubbles in water by just holding a round bottomed flask
- ◆ Explain the process - if the substance is heated it expands, because the distance between the particles increases as they get more energy
- ◆ Be the model - act out being a solid, a liquid or a gas that is heated
- ◆ Devise your own model - it's like.....

Student Evaluation e.g. People as particles

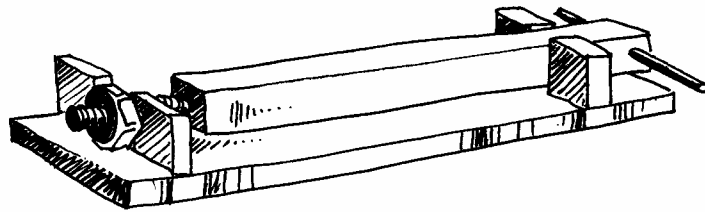
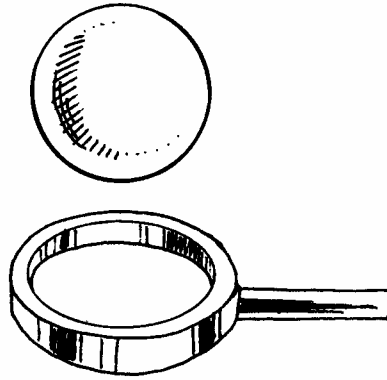
In what ways is the model good at helping you understand about particles?

*It helps you see that it's the **space** that gets bigger or smaller*

In what ways is the model not good at helping you understand about particles?

It's difficult to show the empty space between particles!



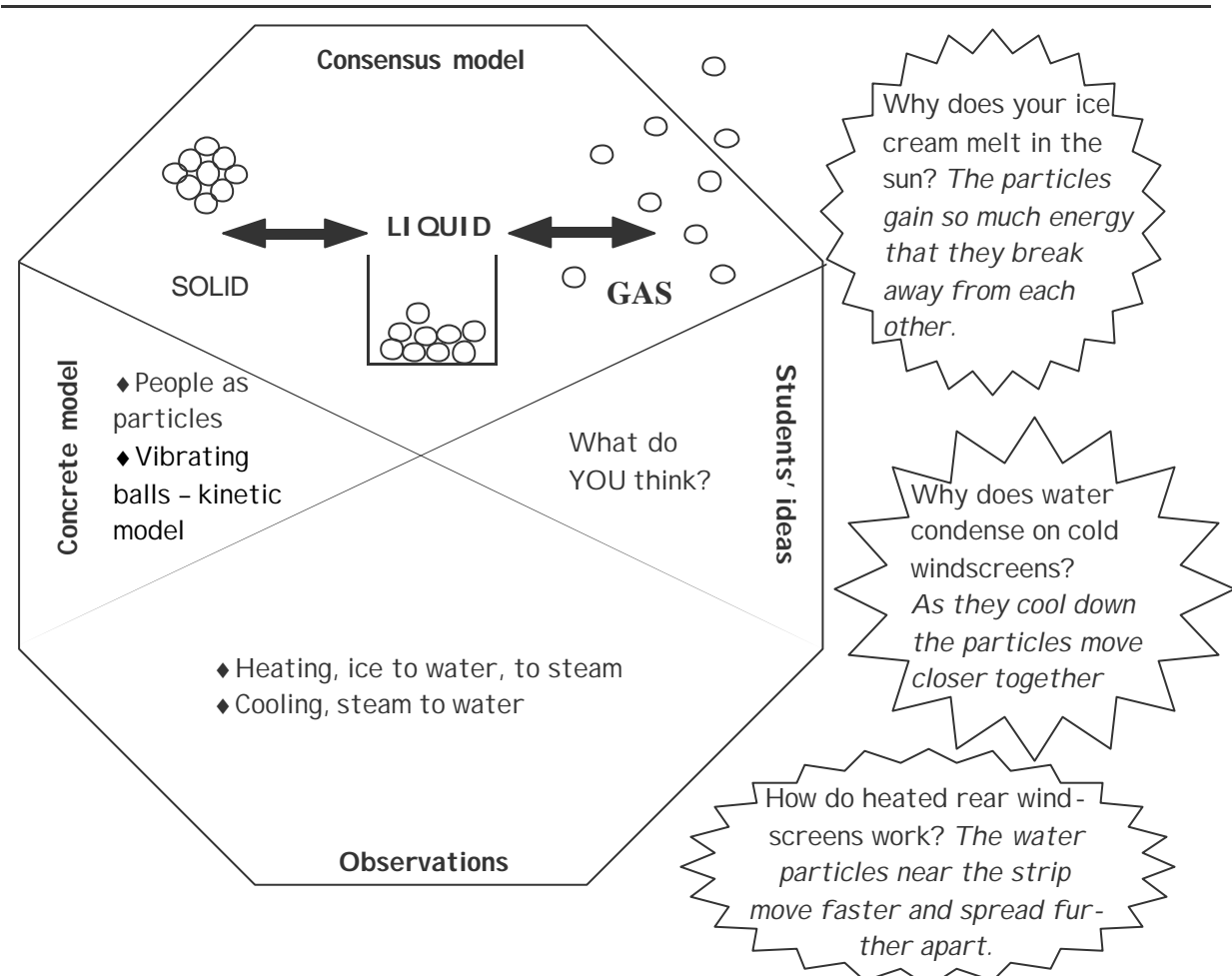


8I Heating and Cooling : Change of State

National Curriculum learning objectives

Explain change in state in terms of particle model

- ◆ Changes in movement, arrangement and bonding of particles due to energy transfers
- ◆ NB misconception - particles do not expand



Student Activities

- ◆ Observe the experiments - heating and cooling ice/water/steam - observe the spacing between vibrating balls in kinetic model
- ◆ Explain the process - if the solid/liquid is heated a lot, it melts/evaporates, because the particles have enough energy to move further away from each other
- ◆ Be the model - act out being the particles changing state
- ◆ Devise your own model -it's like.....

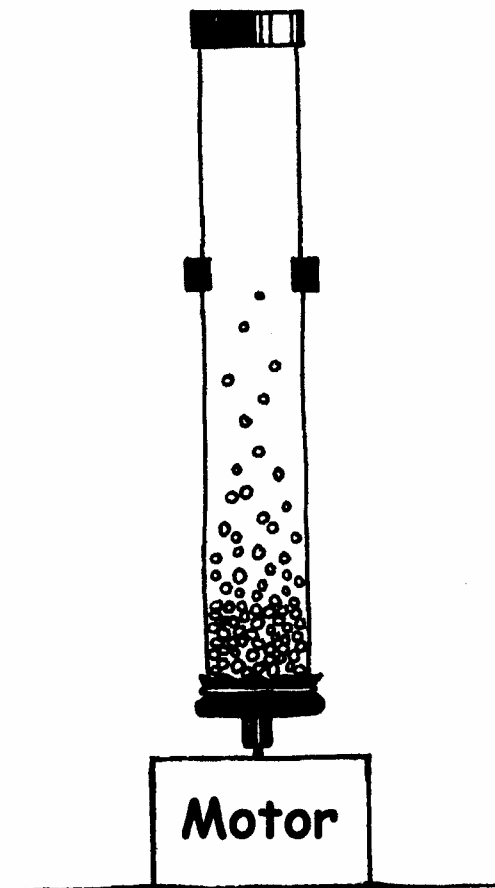
Student Evaluation e.g. People as particles

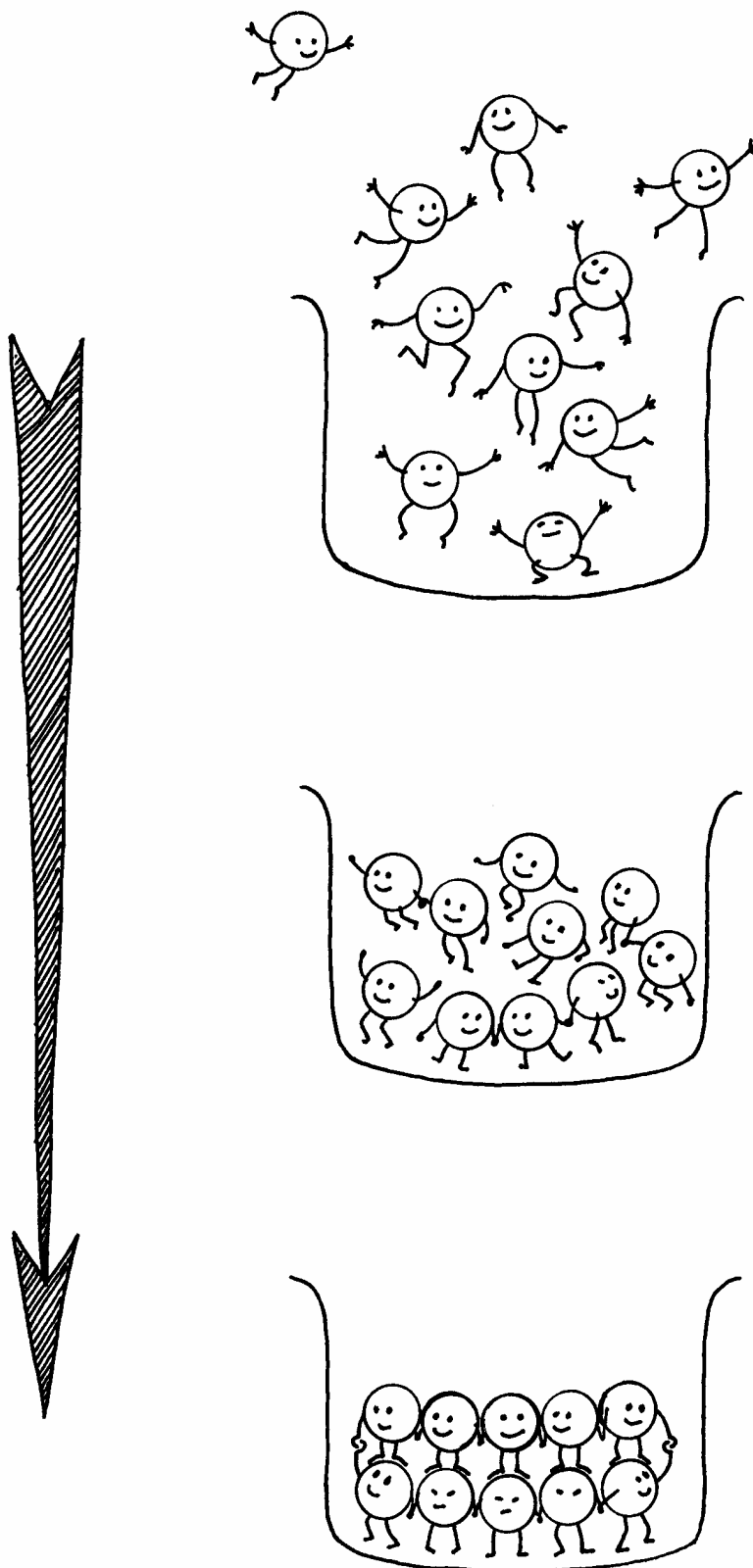
In what ways is the model good at helping you understand about particles?

It helps you see that the particles can gain enough energy to escape each other

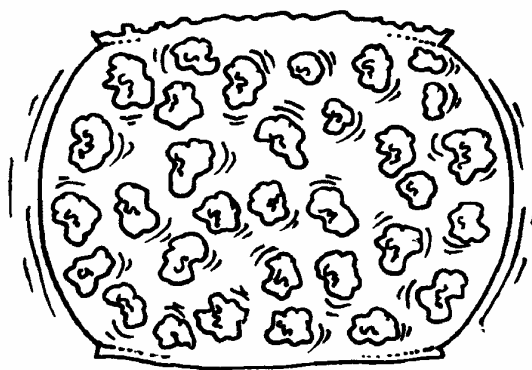
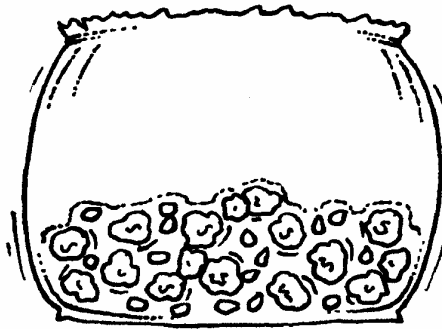
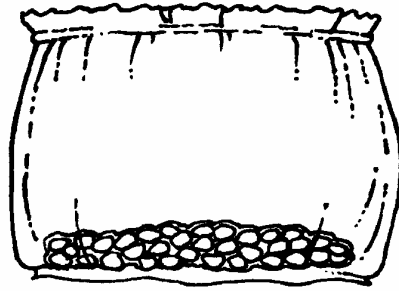
In what ways is the model not good at helping you understand about particles?

Particles move about randomly - people choose where they go!





What's good about the model?



What's bad about the model?

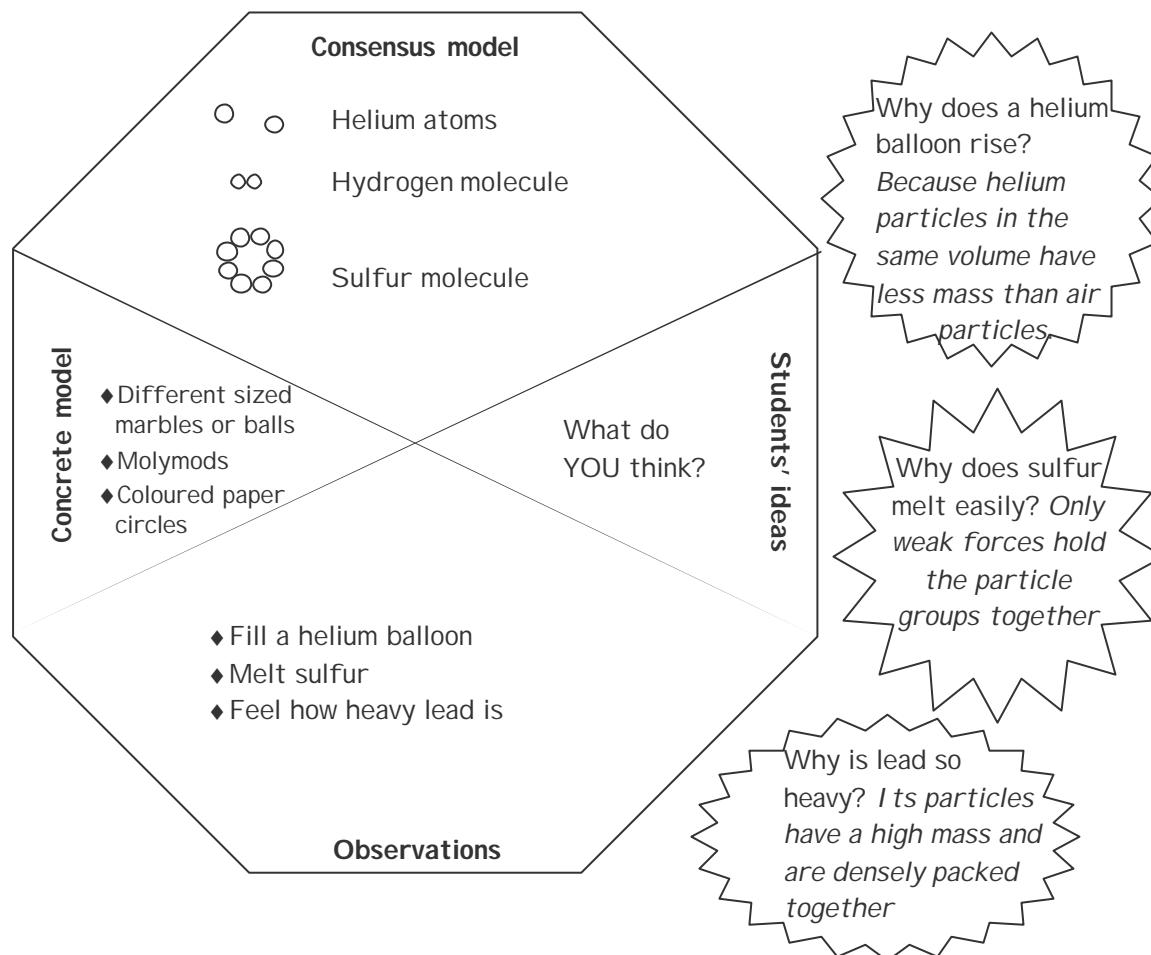
Using models and analogies in the teaching of chemistry at KS3: Unit 8E Atoms and elements

Key concepts	Phenomena that can be explained	“Visualisations” - Concrete models or analogies used by teachers
<p>The atom is the basic building block of matter; and there are a relatively small number of different atoms</p> <p>Different substances arise as a result of different combinations of atoms;</p> <p>Elements consist of only one type of atom;</p> <p>Compounds consist of fixed combinations of different types of atoms;</p> <p>Atoms that are bonded together in a compound cannot easily be separated</p> <p>Atoms and combinations of atoms can be represented by symbols and formulae.</p> <p>Molecules are two or more atoms joined together</p> <p>Substances can be divided into elements, compounds and mixtures</p> <p>Chemical reactions can be represented in word equations and by models and diagrams</p> <p>There are 4 types of reactions:-</p> <p>Combination $A+B \rightarrow AB$</p> <p>Decomposition $AB \rightarrow A+B$</p> <p>Swapping partners $AB + CD \rightarrow AC + BD$</p> <p>Displacement $A + BC \rightarrow AC + B$</p>	<p>Compounds are formed from elements in predictable ways</p> <p>How chemical reactions take place and why mass is conserved</p> <p>Why energy transfers are always associated with chemical change and this is how we can recognise a chemical reaction</p>	<p>Use different sizes marbles or balls to show different atoms</p> <p>Use atomic models such as Molymod to model combinations of compounds, molecules</p> <p>Use Lego bricks to model combining atoms or types of reactions</p> <p>Use toffee/mint and mint toffee analogy to illustrate combination as in oxidation of metals or difference between compounds and mixtures</p> <p>Act out recombination of particles in reactions to “track” a reaction</p> <p>Make models of atoms using cards and track reactions</p>
<p>Commentary: We need to rehearse with pupils the terms atom and molecule, although it would also be appropriate to mention giant structures or ions. When dealing with chemical reactions it is important to stress that there are only a certain number of ways in which particles can rearrange themselves Pupils need to see reactions modelled with particles such as Molymod or Lego bricks as they carry them out, so they can see the particles being broken apart and reassembled. This needs to happen frequently rather than once or twice. In many ways it is easier for pupils to move from particles to drawings to symbols and equations and THEN to word equations rather than the other way. Stress the 4 types of reaction, then match to type to reaction.</p>		

8E Atoms and Elements : Elements

National Curriculum learning objectives

- ◆ Elements are made up of one sort of particle and these are called atoms
- ◆ Models can be used to illustrate phenomena that cannot be observed
- ◆ That atoms can combine to form molecules



Student Activities

- ◆ Observe the experiments - watch the balloon rise - watch melting sulfur in fume cupboard - feel lead and measure its density
- ◆ Explain the process - helium has particles with a small mass, sulfur melts as it has groups of particles with weak forces holding them together, iron has particles of a high mass, densely packed together.
- ◆ Be the model - act out particle groupings - people or objects of different mass
- ◆ Devise your own model - it's like.....

Student Evaluation e.g. Molybds

In what ways is the model good at helping you understand about particles?

It helps you see how elements are arranged in different ways

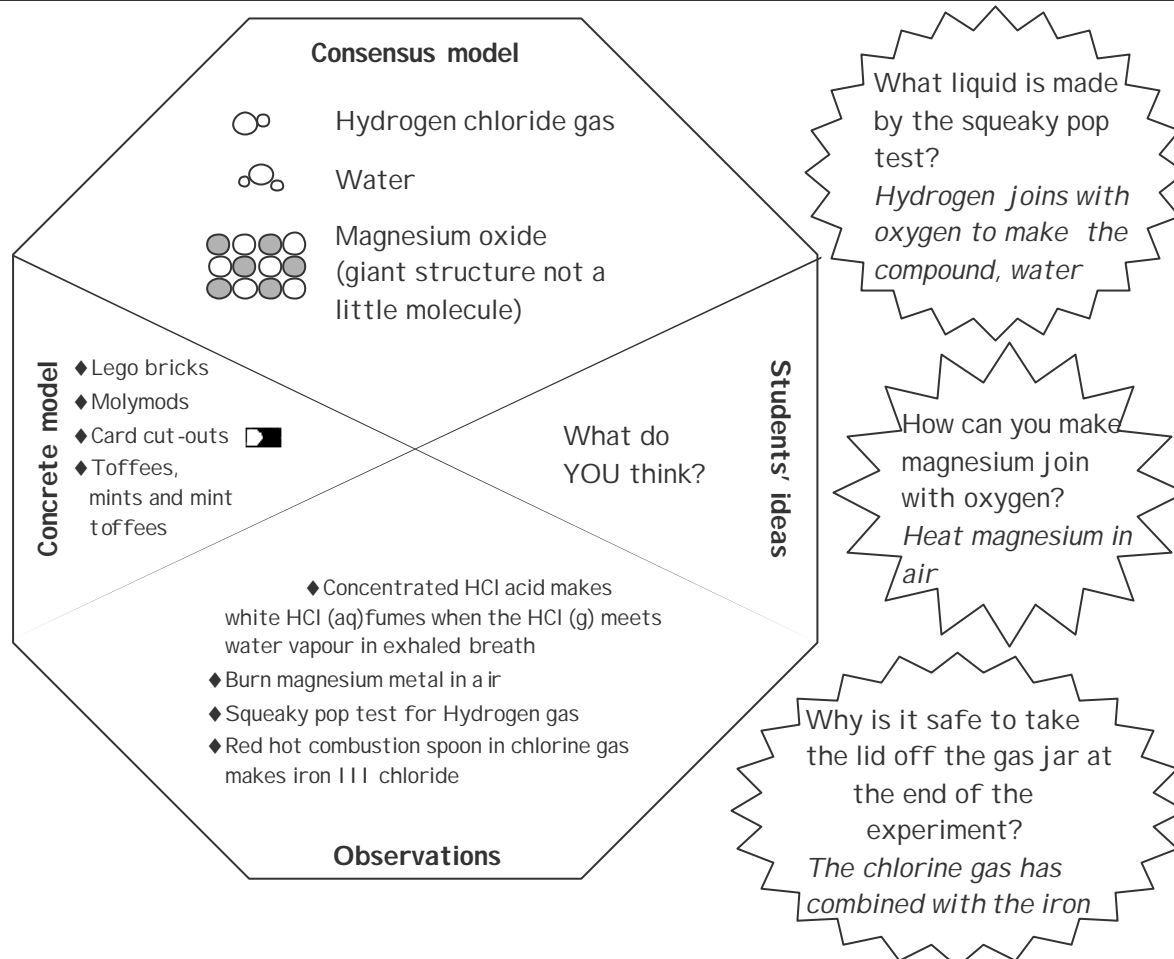
In what ways is the model not good at helping you understand about particles?

Atoms are so small you can't handle them individually

8E Atoms and elements : Compounds

National Curriculum learning objectives

- ◆ That new materials are formed when atoms join together in different ways
- ◆ That compounds are formed when different kinds of atoms combine
- ◆ That atoms can combine to form molecules
- ◆ That atoms of elements combine to form molecules of compounds



Student Activities

- ◆ Observe the experiments – a shiny metal forms a white solid – 2 colourless gases combine to form a colourless liquid – a green/yellow toxic gas combines with hot iron to form a brown solid
- ◆ Explain the process – particles are finding new 'partners' - (see 7F)
- ◆ Be the model – act out the recombination of the particles
- ◆ Devise your own model – it's like.....

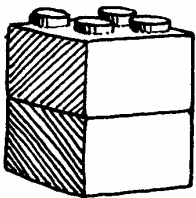
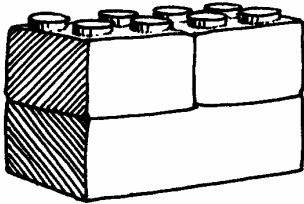
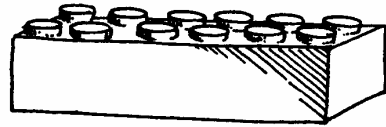
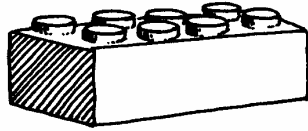
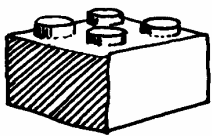
Student Evaluation e.g. Lego bricks

In what ways is the model good at helping you understand about particles?

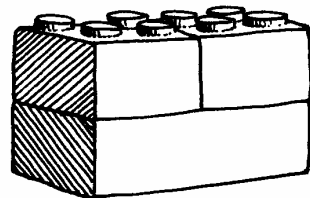
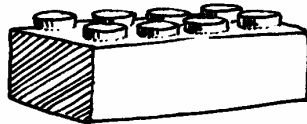
It shows the way that the molecule is made up

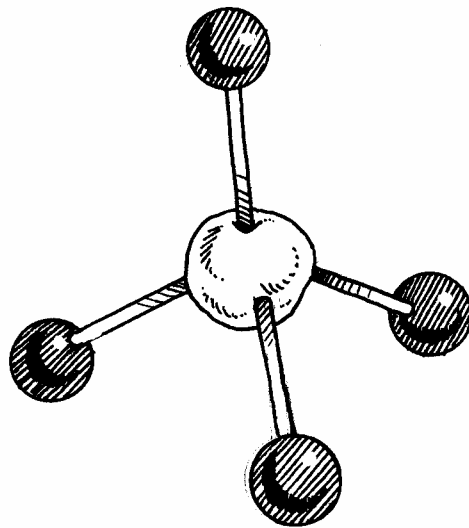
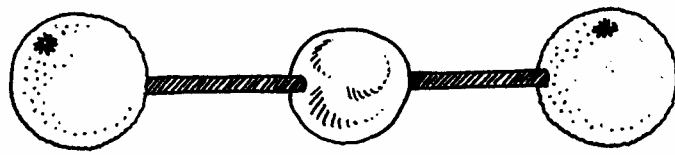
In what ways is the model not good at helping you understand about particles?

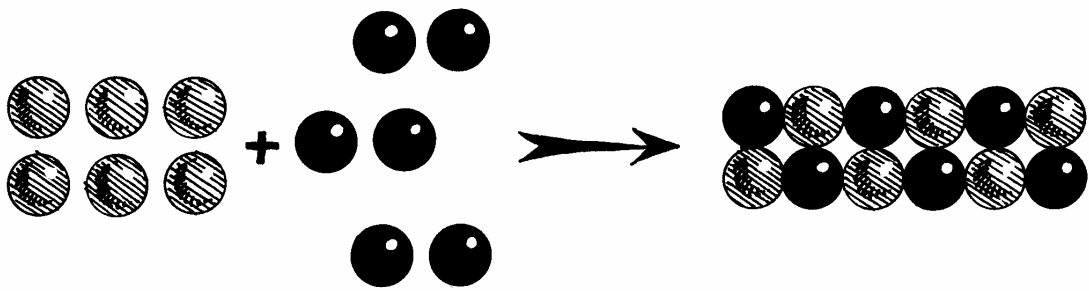
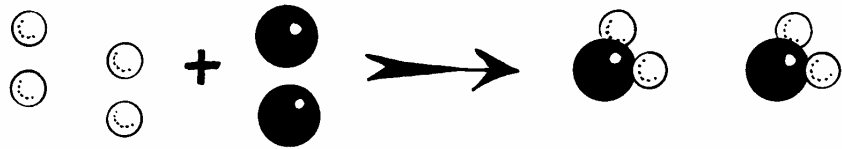
It doesn't show how the particles are held together or which elements will react



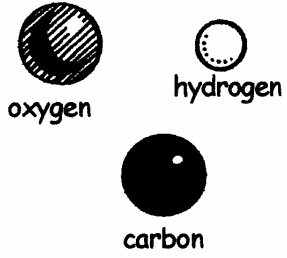
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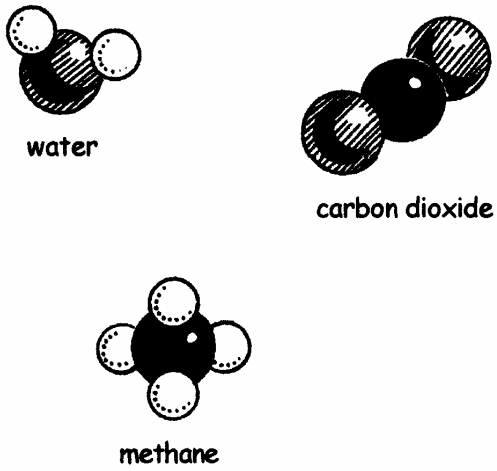


elements



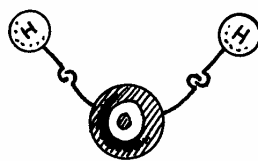
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compounds

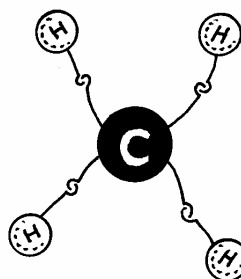


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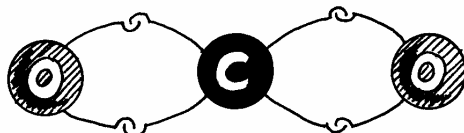
water



methane



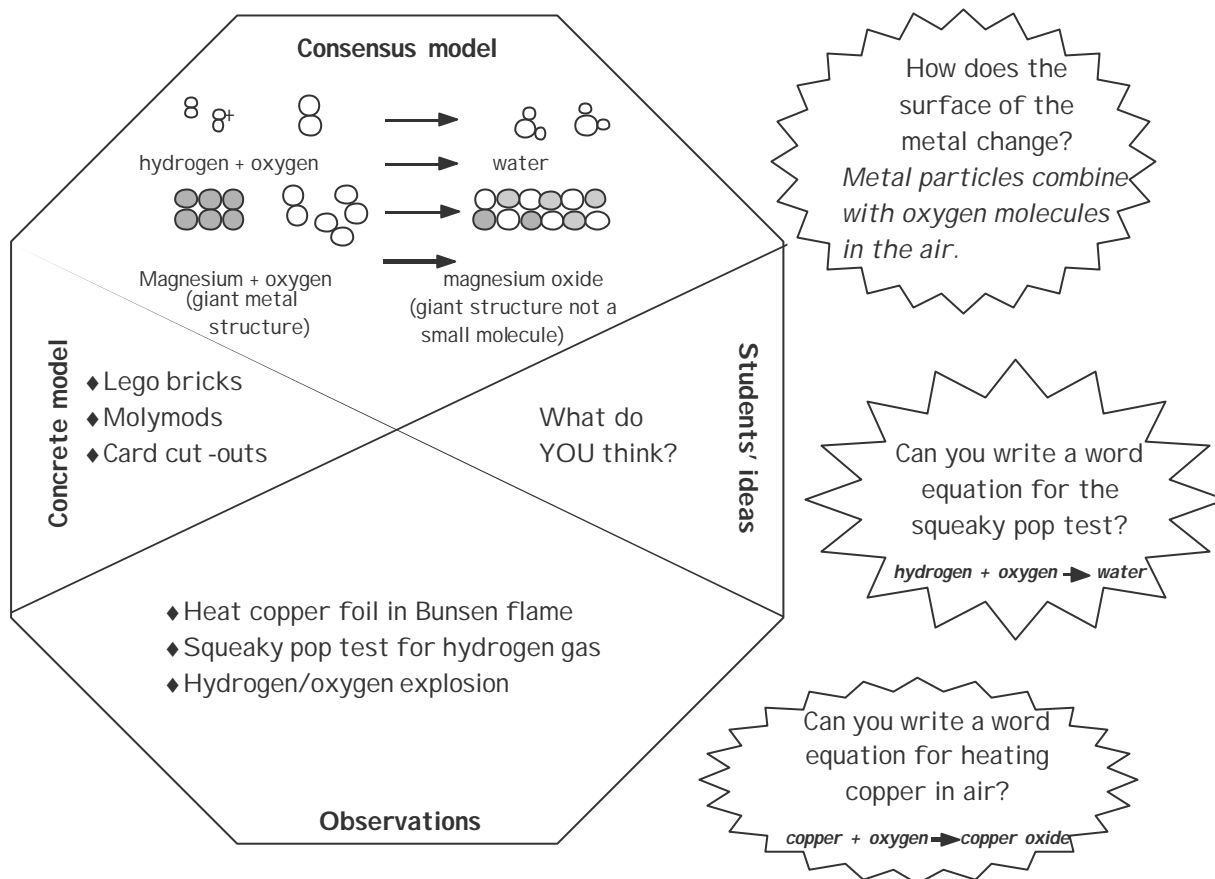
carbon dioxide



8E Atoms and elements : Representing word equations

National Curriculum learning objectives

- ◆ In chemical changes new substances are formed
- ◆ To represent and explain chemical reactions by word equations, models or diagrams



Student Activities

- ◆ Observe the experiments - copper metal becomes black - 2 colourless gases combine to form drops of a colourless liquid
- ◆ Explain the process - particles combine with different particles to make new substances
- ◆ Be the model - act out the recombination of the particles
- ◆ Devise your own model - it's like.....

Student Evaluation e.g. The consensus model

In what ways is the model good at helping you understand about particles?

It shows the 'correct' combination of particles to be able to write word equations

In what ways is the model not good at helping you understand about particles?

It doesn't show how the particles are linked together

Using models and analogies in the teaching of chemistry at KS3: Unit 8F Compounds and mixtures

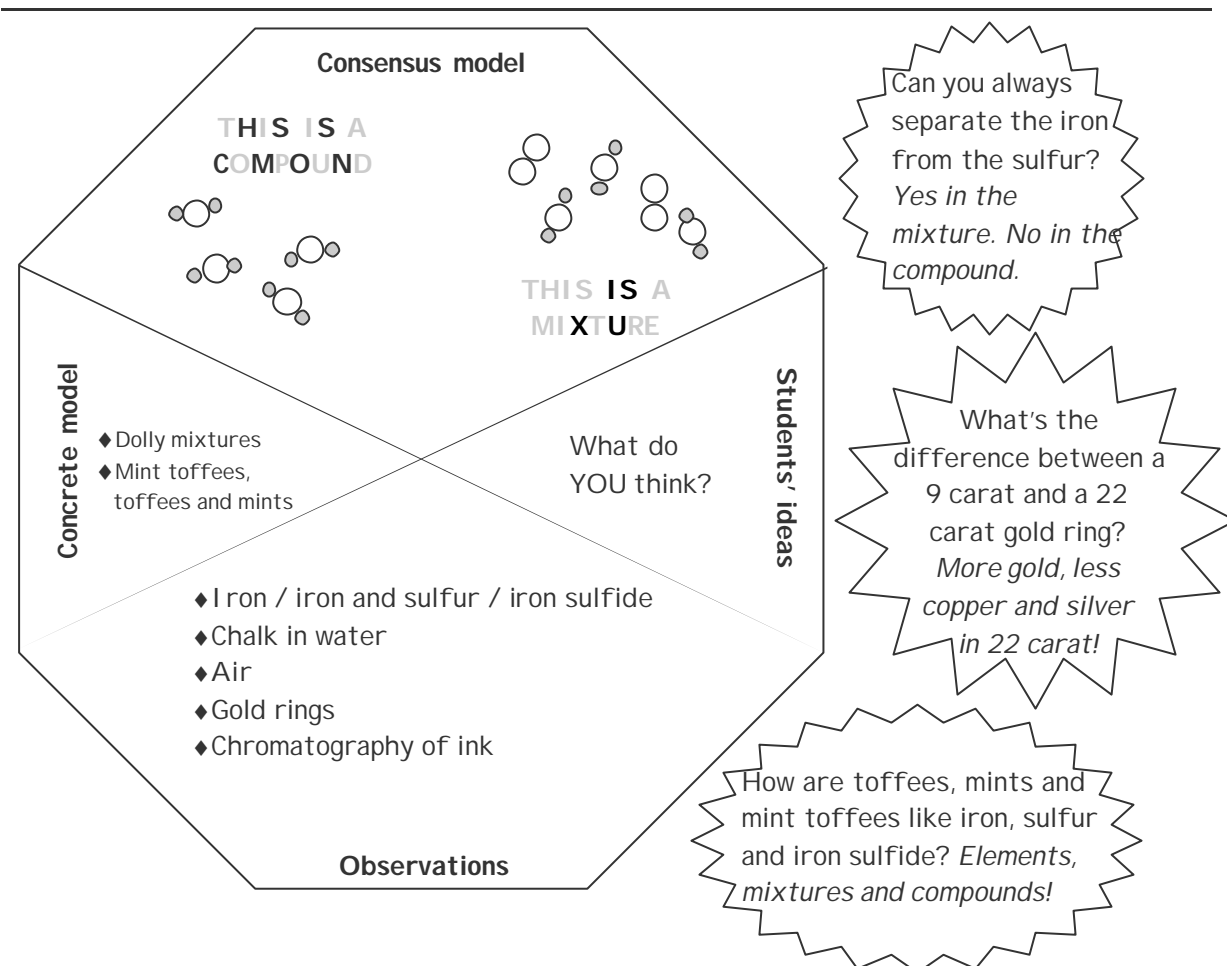
Key concepts	Phenomena that can be explained	“Visualisations” - Concrete models or analogies used by teachers
<ul style="list-style-type: none"> • Compounds are pure substances and mixtures are not • Compounds contain atoms of more than one kind joined together in fixed proportions. • Particles in a compound can be represented by formulae • Compounds are different from their elements because the atoms are chemically joined • Mixtures can exist in any proportion • Types of particles in a mixture can be separated relatively easily by physical means • Compounds can only be separated with relatively high energy inputs (e.g. by heating or electrolysis) 	<ul style="list-style-type: none"> • Compounds melt at specific, fixed temperatures as do elements • Compounds are very different to the elements from which they are made • Mixtures (such as chocolate) do not melt at specific temperatures but over a temperature range • Chromatography (which relies on the extent to which substances dissolve) separates materials 	<ul style="list-style-type: none"> • Lego Bricks or Molymod type atomic models can be used to create compounds and assist pupils in writing formulae • The use of Mints and Toffees and Mint toffees can be used to model the formation of compounds such as Iron Sulphide and Magnesium Oxide • Raft analogy can be used to explain chromatography, rafts = mixtures, current = solvent, riverbed/stumps cause snags (selective absorption/stationary phase e.g. the filter paper) some rafts get snagged more easily than others
<p>Commentary: Pupils do not always recognise compounds as pure substances because they contain different sorts of atoms. They need to see that every molecule in a compound is like any other. Physically modelling with sweets, beads, Lego bricks or chemical models can help enormously to give pupils “pictures in their heads”. Modelling of physical and chemical processes using bricks, beads and models is vital to help pupils visualise and root the idea of the particulate nature of matter. It is a good idea to use a variety of types models (beads, Molymod, Lego and discuss what the models can explain and what they cannot. As with all cases it is important that pupils are made aware that we are modelling ideas and that different models have strengths and weaknesses.</p>		

8F Compounds and Mixtures : Mixtures

National Curriculum learning objectives

Mixtures are 2 or more elements or compounds

- ◆ These can exist in any proportion



Student Activities

- ◆ Observe the experiments - look at iron and sulfur/separate the mixture/make the compound/try to separate the compound - see the chalk mix in water/separate it - separate inks - find out what 9 'carat' gold is!
- ◆ Explain the process - compounds are chemically joined/cannot easily be separated mixtures are not chemically joined/can be easily separated
- ◆ Be the model - act out the linking of particles in a compound
- ◆ Devise your own model - it's like.....

Student Evaluation e.g. Mints, toffees and mint toffees

In what ways is the model good at helping you understand about particles?

It helps you imagine that the particles in compounds are chemically linked

In what ways is the model not good at helping you understand about particles?

It doesn't help you understand which particles will chemically combine



