To do

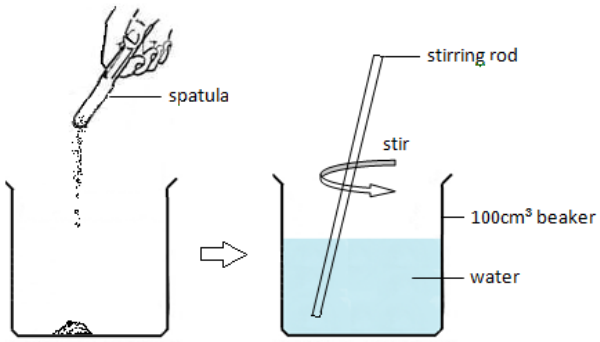
Carry out the following tests on your samples and record the results on the separate results tables. You will gather more data if you work as a team and exchange information with other people in your group.

SAFETY: Wear eye protection for all tests

Appearance

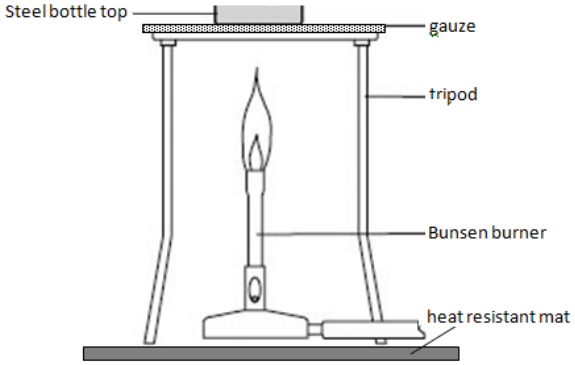
Describe the chemical. Include the colour, if it is shiny or dull, and if it looks crystalline.

Dissolving in water



Place a small amount of the chemical into a small beaker and add some water. Stir to see if it dissolves.

Effect of heat



Place a small sample of the chemical in a bottle top and heat very gently with a Bunsen burner. If it melts, stop heating immediately. If it does not, then it can be heated more strongly.

If any samples catch fire, it is easiest to put out the fire by placing a heatproof mat over the bottle top.

Do NOT heat samples H or J like this.

There are other properties which could be tested and you will be given the results of these tests.

Hardness – This can be tested by trying to bend the piece, if it is big enough, or scratch it with a nail. It can be difficult to test the hardness of a powder.

Conduction of electricity – This can be tested by placing a small amount of the chemical onto a piece of paper, and touching it with two graphite electrodes in a circuit with a power pack and a bulb. If it is a powder it can be difficult to test.

Dissolving in cyclohexane – This can be done in a similar way to the test for dissolving in water. Cyclohexane is HIGHLY FLAMMABLE and so this will be demonstrated at the end of the practical work when all the Bunsen burners have been turned off.

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Complete the tables with the results of your experiments.

Name _____

Substance A

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Solution in water conducts electricity and bubbles of gas appear at each electrode
Hardness	Very hard and brittle

Substance B

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very hard not brittle

Substance C

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Solid conducts electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Quite easy to bend as a sheet, very hard as a lump. Can be beaten into sheets.

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Substance D

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Solution in water conducts electricity and bubbles of gas appear at each electrode
Hardness	Difficult to test as it is a powder

Substance E

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Solution in water does not conduct electricity
Hardness	Easy to crush to a powder

Substance F

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Solid conducts electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Hard. Can be bent

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Substance G

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very soft

Substance H

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very brittle

Substance I

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very hard

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Substance J

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very brittle

Substance K

Description	
Effect of heat	
Solubility in water	
Solubility in other solvent – cyclohexane	
Conduction of electricity as solid	Conducts electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very hard

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To answer

Chemists put chemicals into particular groups.

Put the letter of the chemicals you tested next to the group you think they fit in best. If there are any chemicals which are really difficult to place try to explain why. Which of their properties do not seem to fit the groups?

Typical properties

Giant covalent • Have very high melting and boiling points • Do not dissolve • Hard • Do not conduct electricity	**Giant ionic** • Crystalline solid • Have high melting and boiling points • Many dissolve in water • Does not conduct electricity as a solid • Conduct electricity when molten or dissolved • Hard and often brittle
Metallic • Have a shiny appearance • Have high melting and boiling points • Do not dissolve in water or cyclohexane • Hard and malleable • Conduct electricity when solid	**Small molecular** • Typically gases, liquids or soft solids • Have low melting and boiling points • May dissolve in non-polar solvents such as cyclohexane • Do not dissolve in water • Do not conduct electricity

Chemical _____ is hard to place because_____

_____

_____

I think it should be placed in the group _____ because _____

_____

_____

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Assessing learning

Look at the descriptions of the chemicals below, and the typical properties of giant covalent, giant ionic, metallic and small molecular substances (on previous sheet).

Lithium chloride	**Water**	**Diamond**
Dissolves in water High melting point Conducts electricity when dissolved	Conducts electricity at high voltage Melts at 0 ˚C	Very hard Very high melting and boiling point Does not conduct electricity

In your answers to these questions, use *evidence* both to back up your answers and to argue against any of the statements that you disagree with.

1 Amy says that lithium chloride must be a giant covalent structure because it has a high melting point. Is she right?

2 Beth says diamond must be giant covalent because it does not conduct electricity. Is she right?

3 Connor says that water must be ionic because it conducts electricity. Is he right?

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Putting chemicals into groups – Teacher guidance

Learning structure of the lesson

The big picture

This lesson sequence is designed to exemplify an argumentation approach to practical work, using a 'classification' framework.

In these lessons students see for themselves that it is possible to group chemicals with similar properties and that there are some chemicals that do not fit easily into a group. Students carry out a practical activity in one lesson and in the next try to group the chemicals according to the results of their investigations. The lessons finish with students being told the four main groups that chemists use to classify chemicals. They try placing the chemicals they have been using into these groups.

Age range: 14–16
(or 16–18 as revision / re-introduction)

Timing: 2 x 50 minutes
(ideally as a double lesson)

1: Learning episode 1 (teacher-led) 15 mins

Introduce the idea of grouping chemicals. Show students that salt and sugar look similar but have different physical properties.

1: Learning episode 2 (student-led) 30 mins

Students collect data on the properties of 'unknown' chemicals. They look for patterns in the properties as they work and think about how the chemicals might be grouped. Some tests are demonstrated.

1: Learning episode 3 (teacher-led) 5 mins

Students consider whether any patterns are beginning to emerge from the data.

2: Learning episode 4 (student-led) 20 mins

Students use collected data to categorise the chemicals into groups of their choosing. They must justify their choices. They produce a poster to display their work.

2: Learning episode 5 (teacher-led) 5 mins

A mock scientific conference is held and groups present their arguments to each other. They are given the opportunity to change their thinking based on what they have heard.

2: Learning episode 6 (teacher-led) 15 mins

Scientists group chemicals according to their structure and bonding. There are four main groups and these are presented to students, who then try using these to classify the 'unknown' chemicals.

Learning outcomes

Students will be able to:

- make close and careful observations of chemical and physical phenomena
- discuss their ideas in a small group context
- put forward their arguments for why particular chemicals should be grouped in a particular way and justify their claims carefully
- understand that there are patterns in properties of chemicals which allow them to be placed in groups

Equipment and materials

Teacher guidance
Practical guidance
Slide presentation
Student sheets

Eye protection
Bunsen burners
Tripods and gauzes
Heat-resistant mats
Bottle tops or other small container for heating
Beakers 100 cm^3 (or smaller)
Small spatulas
Stirring rods
Test tubes and bungs
Mineral wool
Filter papers
Circuit tester – or power pack, crocodile clips, electrodes, leads and light bulb in holder
Table salt (NaCl), sugar, silicon, copper, washing soda/sodium carbonate, aluminium, wax, iodine, sand (silicon dioxide), sulfur, carbon
Iron nail
Cyclohexane
Access to a fume cupboard (optional)

Refer to the health and safety advice and practical guidance

Key words

Melting , solubility, electrical conduction, hardness, justify/justification

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Prior knowledge

It is assumed that students know the following.

- The particle model provides explanations of properties of chemicals.
- There are patterns in the properties and behaviour of chemicals.

Background information

At GCSE, students are expected to be able to group chemicals according to their structure: giant ionic, metallic, giant covalent, and small molecular or small covalent. They are also expected to understand that some chemicals, such as graphite, do not have the exact combination of properties that are typical of the group they are in.

In this lesson sequence, students use primary and secondary data about the properties of various chemicals to place the chemicals into groups. There are one or two chemicals included whose properties do not seem to fit well into any of the groups. For example, graphite is not a metal but it conducts electricity.

Terminology

The terms which students need to understand and use in this lesson are:

melting – turning from a solid into a liquid usually by heating

solubility – how much of a substance can dissolve in a solvent

electrical conduction – whether electricity will pass through a substance

hardness – the property of being rigid and resistant to pressure; not easily scratched (measured on Mohs scale)

justify / justification – in the context of scientific argument, a claim (for example how chemicals should be grouped) should be supported by some evidence (properties of those chemicals) and a statement linking the claim to the evidence. The evidence and the linking statement together are the justification.

The following terms are introduced during the lesson. They are used just as group names at this stage and the full explanation for the bonding and structure of each group is not needed.

- metallic
- giant covalent
- giant ionic
- small molecular

Differentiation

- To introduce why structure and bonding are important, the practical ‘Chocolate and structure’ could be used. (See link below to activity on Practical Chemistry.).
- For classes where behaviour management is likely to be an issue, the mock scientific conference in Lesson 2 could be managed differently. Just a few groups could present to the whole class instead.

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- Some groups may find it easier to have the practical work given to them in a more structured format. This could stretch to three lessons and students have the time to find out each property separately (possibly for only two or three different chemicals and then combine results as a class).
- Any group could be given longer to do the practical work if three lessons were given to this. They could then test for conductivity themselves too. Check CLEAPSS Hazcards for the various solutions.

Taking it further

- This lesson could be followed by more detailed teaching about the structure and bonding within each group – metallic, giant ionic, giant covalent and small molecular. (See link below to activity on Practical Chemistry.)
- When these have been introduced, then the practical 'Three colours from the same dye bath' could be used. (See link below to activity on Practical Chemistry.)
- For 16–18s, this Structure and Bonding card matching activity may be useful: www.rsc.org/education/teachers/resources/aflchem/resources/59/index.htm
- For 14–16s, Bonding Bingo may be useful: www.rsc.org/education/teachers/resources/aflchem/resources/33/index.htm
- For 16–18s, Chemistry in Your Cupboard provides some good examples of where an understanding of structure and bonding is useful in industry: www.chemistryinyourcupboard.org/index.php

Related practical activities on Practical Chemistry

Chocolate and structure:
www.nuffieldfoundation.org/practical-chemistry/chocolate-and-structure

Three colours from the same dye bath:
www.nuffieldfoundation.org/practical-chemistry/dyeing-three-colours-same-dye-bath

Allotropes of sulfur – this demonstration allows students to see that the properties of sulfur change as its structure changes:
www.nuffieldfoundation.org/practical-chemistry/allotropes-sulfur

Electrolysis of zinc chloride – this experiment allows students to see that ionic chemicals conduct when molten:
www.nuffieldfoundation.org/practical-chemistry/electrolysis-zinc-chloride
There is also a training video for teachers available for this demonstration:
www.rsc.org/learn-chemistry/resource/res00000826/practical-chemistry-demonstration-videos-electrolysis-of-molten-zinc-chloride

Electrolytes and non-electrolytes – this experiment allows students to see that ionic substances conduct when molten and covalent substances do not:
www.nuffieldfoundation.org/practical-chemistry/which-substances-conduct-electricity

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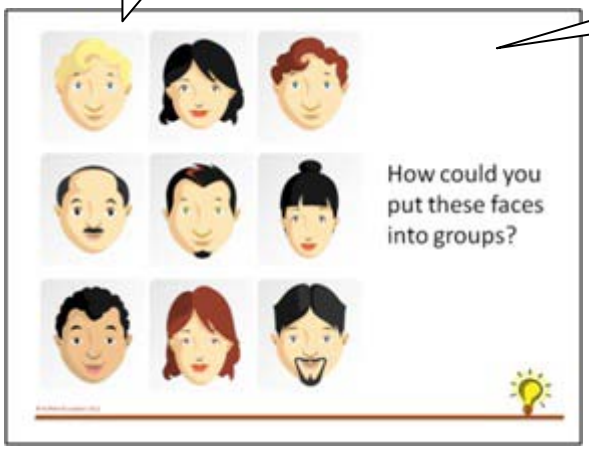
Lesson details – Lesson 1

Slide 2



Task: Show **slide 2**, and ask 'How could you put these faces into groups?'

There are many ways of grouping these faces; e.g. male/female, hair colour, eye colour, face shape. The central character has hair that is both black and red/brown – how would you decide which hair colour group to place this character in? (there is no right answer).

You could prepare a slide of alternative images based on the interests of your class; e.g. clothing or celebrities or mobile phones.

Explain: Explain that groups in chemistry are really important. This lesson is about using *properties* to group chemicals. Chemists have always been interested in patterns in properties. They found that chemicals seemed to fit into groups according to their properties, and so carried out systematic experiments to try to group them.

One way of grouping materials, which students will have previously come across, is element, compound, and mixture. Others are metal and non-metal, or natural and man-made. These are also valid ways of grouping materials.

Demonstration

Procedure

Introduction: heating salt and sugar

SAFETY: Wear eye protection

1 Place a small sample of sugar in a bottle top or small metal dish.

2 Place the bottle top on a tripod and gauze over a Bunsen burner on a heat resistant mat.

3 Heat the underside of the bottle top very gently. The sugar will melt and caramelise. If it does not, then it can be heated more strongly. Once it has melted stop heating immediately. You could dip a spoon or similar into the sugar and pull out long strands of it (spun sugar) if you wish.

4 Repeat with a small sample of table salt (NaCl) in place of sugar. Nothing happens – the salt does not melt. If you have a very hot Bunsen burner the sodium chloride may begin to melt if you heat it strongly enough. Its melting point is about at the limit of Bunsen burner temperatures. For the purposes of this introduction it is better not to melt it.

Task: Carry out the teacher demonstration (see **Practical guidance**). Salt and sugar look similar and are both used widely in food and cooking. However, they taste very different (do not eat anything in the laboratory). Some of their other properties are very different too.

Nothing happens when salt is heated, but sugar melts and caramelises.

A visualiser would be useful here to help students to see clearly what is happening.

As well as being an interesting introduction to the topic, this is a good way to demonstrate to students how to heat solids safely in the lab.

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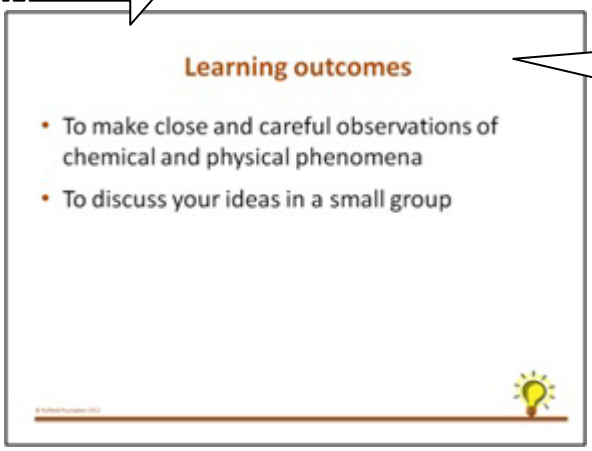
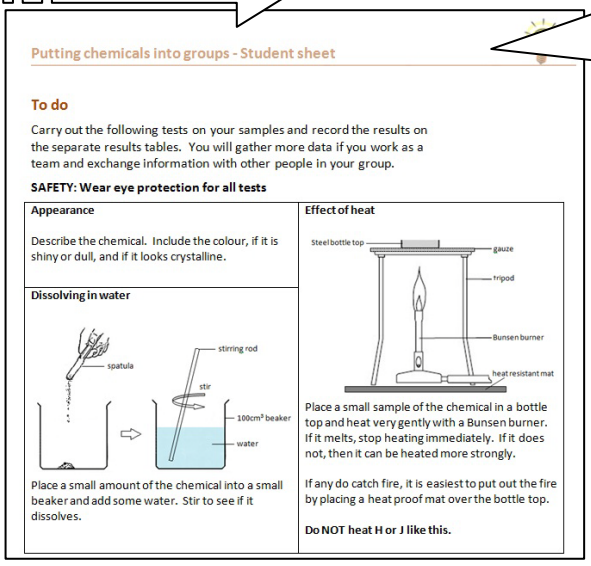
Slide 3



Explain: In this lesson, students will study the properties of various substances and try to put them into groups based on these *properties*. Use **slide 3** to share the learning outcomes.

Student sheet



Task: Students use the **student sheet** and work in groups of four to collect data about the properties of various chemicals (see also **Practical guidance**). They will use their data to decide what groups to put the chemicals in. They should look for patterns in the properties whilst they are working and think about how the chemicals might be grouped.

There are 11 chemicals, labelled only by a letter. There are three tests to be done on each. Students will collect more data if they work as a team. In each group, one pair should carry out the appearance and dissolving in water practical and the other should carry out the effect of heat practical. Dissolving in cyclohexane will be carried out by the teacher at the end; the data for conductivity and hardness is provided.

Explain: Warn students that heating 'H' (iodine) and 'J' (sulfur) should be carried out using a different method and explain how (see **Practical guidance**). Remind them to treat all unknowns as hazardous.

Differentiation: Depending on time available and how fast the students can do the practical work, you may want them to work as a class so each group carries out only one or two tests. he disadvantage of this approach is that it is harder for them to get a 'feel' for which of the chemicals are similar.

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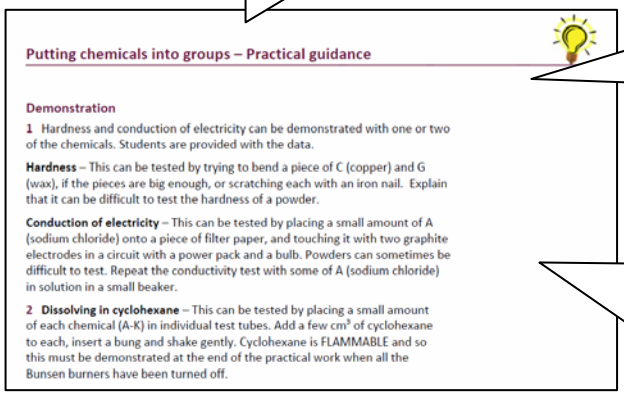
Demonstration



Putting chemicals into groups – Practical guidance

Demonstration

1 Hardness and conduction of electricity can be demonstrated with one or two of the chemicals. Students are provided with the data.

Hardness – This can be tested by trying to bend a piece of C (copper) and G (wax), if the pieces are big enough, or scratching each with an iron nail. Explain that it can be difficult to test the hardness of a powder.

Conduction of electricity – This can be tested by placing a small amount of A (sodium chloride) onto a piece of filter paper, and touching it with two graphite electrodes in a circuit with a power pack and a bulb. Powders can sometimes be difficult to test. Repeat the conductivity test with some of A (sodium chloride) in solution in a small beaker.

2 **Dissolving in cyclohexane** – This can be tested by placing a small amount of each chemical (A-K) in individual test tubes. Add a few cm^3 of cyclohexane to each, insert a bung and shake gently. Cyclohexane is FLAMMABLE and so this must be demonstrated at the end of the practical work when all the Bunsen burners have been turned off.

Task: Ensure all the Bunsen burners are switched off. Demonstrate dissolving each of the chemicals in cyclohexane (see **Practical guidance**) and get students to record the results.

A visualiser would be useful here to help students to see clearly what is happening.

Task: Show the equipment for the hardness test and test a piece of copper (hard) and wax (soft). Explain that the test works well on larger pieces of a substance, but is difficult to carry out on powders.

Show how the conduction of electricity test is carried out, by testing salt as a solid and in solution.

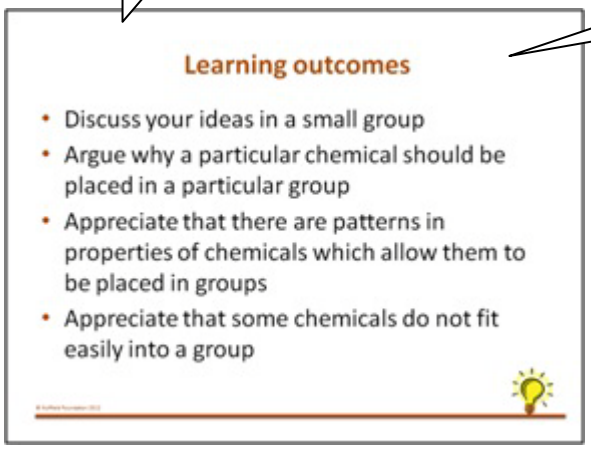
Explain: Students are provided with the data for the hardness and conductivity tests. In the next lesson they will use the all the data collected and provided.

Collect in the results tables in case of absence in the next lesson.

Task: Ask students whether they have begun to see any patterns in the properties of the chemicals.

Lesson details – Lesson 2

Slide 5



Task: Recap the previous lesson, then use **slide 5** to introduce the learning outcomes for this lesson.

Depending on how much they got done in the previous lesson, you may want to check that they have enough data to work with. Data cards containing the necessary data are available for those who do not have their own.

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Interactive

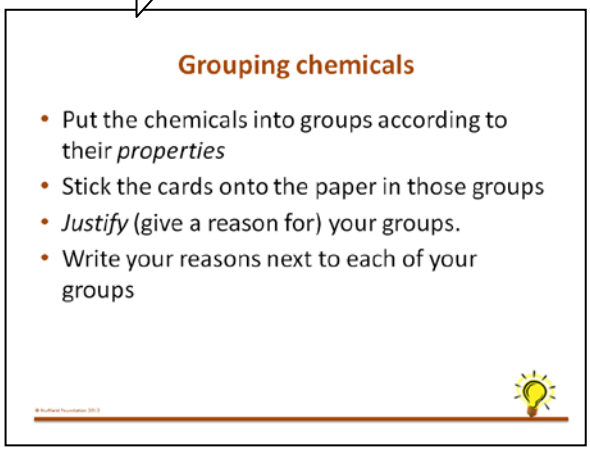
Task: Get students into the same groups of four as in previous lesson.

Either use the **interactive**, or give each group a large piece of paper and ensure that they have a complete set of results tables or data cards, or combination of these.

Students put the chemicals into groups according to their *properties* (the results from the previous lesson). They can have as many or as few groups as they wish. They should Blu-tack the results cards to the large sheet in the groups they have chosen.

It is critical for the success of this activity that students are aware that there is a time limit to this section and are clear what they have to achieve in the time available.

Slide 6



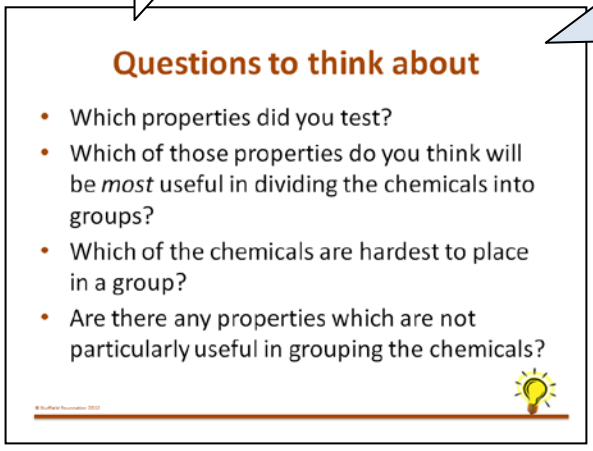
Task: Once students have decided on their grouping they have to *justify* their decisions. They should write their reasons onto the large sheet of paper next to each of their groups.

They will need to prepare to present their groups to other members of the class and explain and justify their groupings.

Differentiation: Use prompt questions (**slide 7**) to help groups finding it difficult to group the chemicals.

For some students it may be appropriate to split this activity into two halves; about 6 or 7 minutes to decide the groups and then the same again for writing their justifications.

Slide 7



Task: Display the groups' posters.

Explain: Explain that students will be carrying out a mock scientific conference. Each group of four will present their posters to other members of the class, and justify their choice of groupings.

To run the scientific conference split the class in half. One half of the class will present their poster: explaining and justifying groupings and the other half will act as the audience. You could mention that PhD students and early career researchers often present their research in a similar way.

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Task: In their groups of four, initially half the groups are presenters and the other half audience. The presenters set themselves up and each 'audience' group goes to hear from one 'presenter' group. Presentations take place simultaneously. After 2 minutes the 'audience' groups swap around and they listen to a different presentation. After another 2 minutes the 'audience' becomes 'presenters' and the 'presenters' become 'audience' and the process

This is a good opportunity to circulate and listen to students' responses and ask questions to deepen learning. For example:

- What are the properties that this group have in common?
- What properties does this chemical have that makes you include it in this group?
- (For a difficult to place chemical) What surprising combination of properties does this chemical have that makes it hard to place?
- Why didn't you choose to group them like this…(suggest different way)?

Push them to explain and justify how they chose to group the chemicals. They are likely to have picked some properties as more important for grouping than others – and again they could justify why they have chosen the ones that they have, and why other choices are not as good as theirs. Emphasise that there is no one 'right' answer.

Task: Ask students if any of them would like to change how they have grouped the chemicals based on what they have heard from others. Explain that this is how science develops: as people discuss their ideas their thinking becomes clearer.

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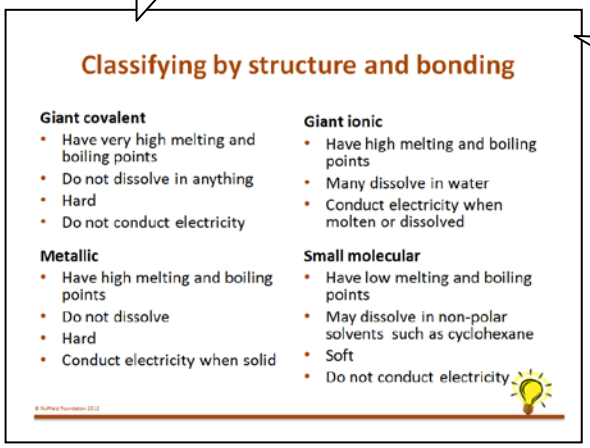
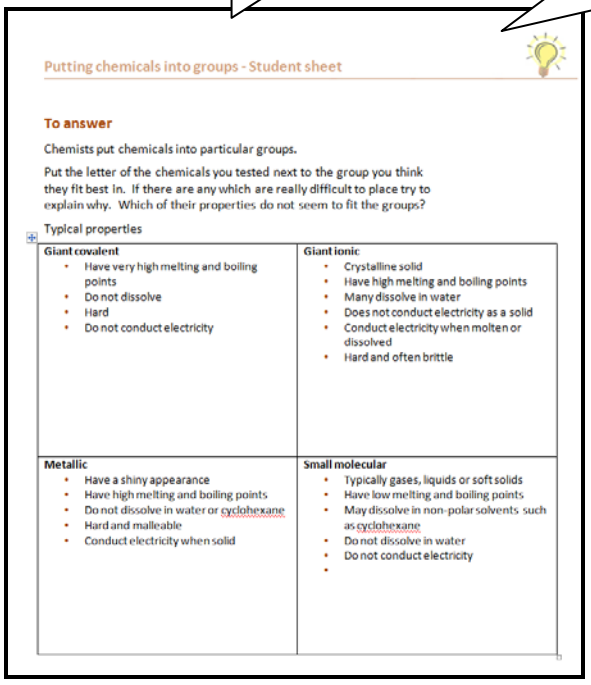
Slide 8



Explain: One way that scientists group chemicals is by their structure and bonding. This divides chemicals into four main groups. Use **slide 8** to present the *properties* of each of the groups.

Emphasise again that there is no single correct way to group the chemicals. Students' groupings may be different to what is about to be presented but they are not 'wrong.'

Student sheet



Task: Ask students to look again at the properties of the chemicals. Can they group them using these classifications? Use **Student sheet** page 6.

Give each group of students one or two chemicals to place into the groups. After about 5 minutes have a mini-plenary, briefly discussing each chemical and which group they placed it – pushing students to *justify* their choices.

To generate more discussion you could give the harder to place chemicals to more than one group (carbon, graphite (K) and sugar (E) are the hardest to place).

Task: Ask these questions.

- Which of the chemicals are very difficult to place into one of these groups?
- (for a difficult to place chemical) What unusual combination of properties does this chemical have that makes it hard to place?
- How do the groupings presented here differ from the groupings that you have chosen?

The chemicals used here can be grouped as follows:

Metallic – C, copper; F, aluminium

Giant ionic – A, sodium chloride; D, washing soda / sodium carbonate

Giant covalent – B, silicon; I, sand; K, carbon

Small molecular – E, sugar; G, wax; H, iodine; J, sulfur

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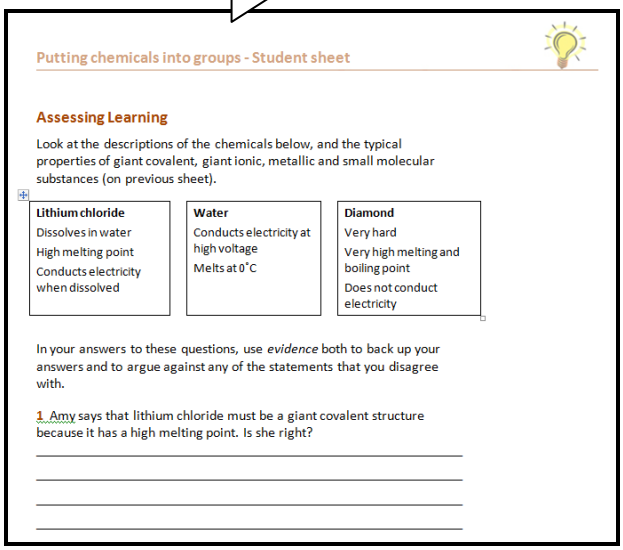
If students query why there are more in the small molecular group than any other, you can tell them that there are more chemicals which are small molecular in the Universe than in any of the other groups – virtually all gases including hydrogen are small molecular.

B (silicon), E (sugar) and K (carbon) are all difficult to place. Students may make varying suggestions about where to place them. The important thing is that they justify their choices using the data.

Explain: Chemists know the chemicals belong to the groups they do because they have collected more data and have found out more about the structure and bonding of these chemicals. This extra evidence gives them confidence in knowing which group they belong to.

Student sheet



Putting chemicals into groups - Student sheet

Assessing Learning

Look at the descriptions of the chemicals below, and the typical properties of giant covalent, giant ionic, metallic and small molecular substances (on previous sheet).

Lithium chloride	**Water**	**Diamond**
Dissolves in water High melting point Conducts electricity when dissolved	Conducts electricity at high voltage Melts at 0°C	Very hard Very high melting and boiling point Does not conduct electricity

In your answers to these questions, use *evidence* both to back up your answers and to argue against any of the statements that you disagree with.

1 Amy says that lithium chloride must be a giant covalent structure because it has a high melting point. Is she right?

Homework: Students carry out the **assessing learning** task on the **Student sheet**.

Differentiation: As an alternative homework, if not completed in the lesson, students could be asked to complete **Student sheet** page 6, deciding which group each of the chemicals should go into. Some additional chemicals not met in the lesson could be given to more able students (e.g. hydrogen, sodium, magnesium chloride).

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Assessing learning: Answers

1 Amy is wrong. Lithium chloride has a high melting point, but the giant covalent, giant ionic and metallic groups all contain chemicals with high melting points. Lithium chloride also dissolves in water and conducts electricity when dissolved. These properties are typical of giant ionic substances. The evidence suggests that lithium chloride is giant ionic.

2 Diamond does not conduct electricity, and giant covalent substances typically do not conduct electricity, but neither do small molecular substances. Beth is right but needs to use more evidence to support her claim. Diamond also has a very high melting point, and is very hard. All these properties together suggest it is giant covalent rather than small molecular.

3 Connor is probably wrong. Water also has a low melting point, but giant ionic substances have high melting points. Water could be giant ionic or small molecular. Because water only conducts at high voltages it is probably small molecular.

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Data cards

Substance A

Description	White crystalline solid
Effect of heat	Very high melting temperature
Solubility in water	Dissolves in water to give colourless solution
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Solution in water conducts electricity and bubbles of gas appear at each electrode
Hardness	Very hard and brittle

Substance B

Description	Grey shiny solid
Effect of heat	Very high melting temperature
Solubility in water	Does not dissolve in water
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very hard not brittle

Substance C

Description	Shiny pink solid
Effect of heat	Melts at high temperature
Solubility in water	Does not dissolve in water
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Solid conducts electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Quite easy to bend as a sheet, very hard as a lump. Can be beaten into sheets.

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Substance D

Description	White powder
Effect of heat	Melts at high temperature
Solubility in water	Dissolves in water to give colourless solution
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Solution in water conducts electricity and bubbles of gas appear at each electrode
Hardness	Difficult to test as it is a powder

Substance E

Description	White crystalline solid
Effect of heat	Low melting temperature
Solubility in water	Dissolves in water to give colourless solution
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Solution in water does not conduct electricity
Hardness	Easy to crush to a powder

Substance F

Description	Silver shiny solid
Effect of heat	High melting temperature
Solubility in water	Insoluble in water
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Solid conducts electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Hard. Can be bent

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Substance G

Description	White waxy solid
Effect of heat	Low melting temperature
Solubility in water	Does not dissolve in water
Solubility in other solvent – cyclohexane	Dissolves in cyclohexane
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very soft

Substance H

Description	Purple crystalline solid
Effect of heat	Turns to gas on heating at a low temperature
Solubility in water	Does not dissolve in water to any appreciable extent
Solubility in other solvent – cyclohexane	Soluble in cyclohexane to give purple solution
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very brittle

Substance I

Description	White crystalline solid
Effect of heat	Impossible to melt in a Bunsen flame
Solubility in water	Does not dissolve in water
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very hard

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Substance J

Description	Yellow crystalline solid
Effect of heat	Low melting temperature
Solubility in water	Does not dissolve in water
Solubility in other solvent – cyclohexane	Dissolves in cyclohexane
Conduction of electricity as solid	Does not conduct electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very brittle

Substance K

Description	Black solid
Effect of heat	Impossible to melt in a Bunsen flame
Solubility in water	Insoluble in water
Solubility in other solvent – cyclohexane	Does not dissolve in cyclohexane
Conduction of electricity as solid	Conducts electricity
Conduction of electricity in solution in water for those that are water soluble	Not tested
Hardness	Very hard

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Putting chemicals into groups – Practical guidance

There are three practical activities in this piece of work, an introductory demonstration, a class practical, and finally a second demonstration to show students the techniques that they will not be using for themselves.

Equipment and materials

For introduction: heating salt and sugar

Eye protection
Bunsen burner
Tripod, gauze, heat-resistant mat
Bottle tops or other small container for heating small amount of substance
Table salt (NaCl)
Sugar

For class practical:

Per group

Eye protection
Bunsen burner
Tripod, gauze, heat-resistant mat
Bottle tops or other small container for heating small amount of substance (these should have any plastic inner part melted off beforehand in a fume cupboard)
Beakers 100 cm^3 (or smaller)
Small spatulas
Stirring rod
Test tubes
Mineral wool
Access to a fume cupboard (optional)

Access to the following chemicals: These should be in small bottles, labelled with the given letter only. Students must be told not to heat H or J except in very small quantities in the fume cupboard. This will need close supervision to control amounts used. Refer to Hazcards for more information.

A salt – sodium chloride
B silicon
C copper
D washing soda/sodium carbonate
E sugar
F aluminium
G wax
H iodine
I sand (silicon dioxide)
J sulfur
K carbon

For demonstration 2:

Filter papers
Circuit tester – or power pack, leads, crocodile clips, graphite electrodes and light bulb in holder
Iron nail

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Cyclohexane 50 cm^3 (Refer to CLEAPSS Hazcard)
Test tubes and bungs
Small spatulas

Health and safety and technical notes

1 Before carrying out this practical, users are reminded that it is their responsibility to carry out a risk assessment in accordance with their employer's requirements, making use of up-to-date information.

Read our standard health & safety guidance.

2 Iodine (H) and sulfur (J) should ideally be heated in the fume cupboard.

3 Iodine can be heated by students in the open laboratory so long as no more than 0.25 g iodine is used in a test tube which has a mineral wool plug. Alternatively a teacher demonstration should use no more than 0.25 g iodine in a long test tube. Consult CLEAPSS *Hazcard* 54A.

4 Sulfur can be heated by students in the open laboratory so long as no more than 2 g of powdered roll sulfur is used in a test tube which has a mineral wool plug, and the Bunsen is adjusted to a small flame with the collar half-open; heating must be gradual because sulfur is a poor conductor of heat. Consult CLEAPSS *Hazcard* 96A.

5 Cyclohexane is highly flammable and should not be used while students are heating chemicals with Bunsen burners. It should be left until the end and then all the chemicals can be tested as a demonstration. This can be demonstrated by the teacher.

6 Bottle tops are made of steel. Do not use aluminium tops. Before use, the bottle top needs to be heated strongly in a fume cupboard to burn out the plastic insert.

Procedure

Demonstration 1: heating salt and sugar

Wear eye protection

1 Place a small sample of sugar in a bottle top.

2 Place the bottle top on a tripod and gauze over a Bunsen burner on a heat-resistant mat.

3 Heat the underside of the bottle top very gently. The sugar will melt and caramelise. If it does not, then it can be heated more strongly. Once it has melted stop heating immediately. You could dip a spoon or similar into the sugar and pull out long strands of it (spun sugar) if you wish.

4 Repeat with a clean bottle top containing a small sample of table salt (NaCl). Nothing happens – the salt does not melt. If you have a very hot Bunsen burner the sodium chloride may begin to melt if you heat it strongly

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enough. Its melting point is about at the limit of Bunsen burner temperatures. For the purposes of this introduction it is better not to melt it.

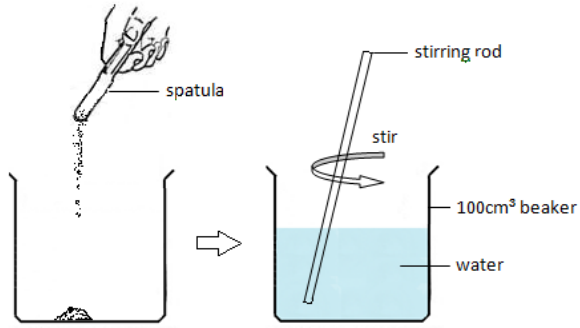
Class practical

1 Students carry out the appearance, dissolving in water and effect of heat tests on samples A–K and record the results on the separate results tables.

SAFETY: Wear eye protection for all tests

Appearance - Describe the chemical. Include the colour, if it is shiny or dull, and if it looks crystalline.

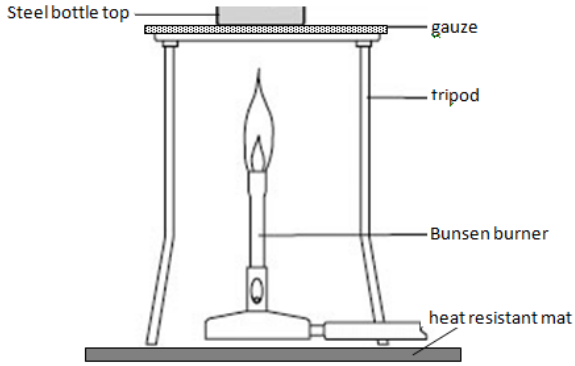
Dissolving in water - Place a small amount of the chemical into a small beaker and add some water. Stir to see if it dissolves.



Effect of heat - Place a small sample of the chemical in a bottle top and heat very gently with a Bunsen burner. If it melts, stop heating immediately. If it does not, then it can be heated more strongly.

If any of the samples catch fire, it is easiest to put out the fire by placing a heatproof mat over the bottle top.

Do NOT heat H or J like this – see Health and safety and technical notes.



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Demonstration 2

1 Hardness and conduction of electricity can be demonstrated with one or two of the chemicals. Students are provided with the data.

Hardness This can be tested by trying to bend a piece of C (copper) and G (wax), if the pieces are big enough, or scratching each with an iron nail. Explain that it can be difficult to test the hardness of a powder.

Conduction of electricity This can be tested by placing a small amount of A (sodium chloride) onto a piece of filter paper, and touching it with two graphite electrodes in a circuit with a power pack and a bulb. Powders can sometimes be difficult to test. Repeat the conductivity test with some of A (sodium chloride) in solution in a small beaker.

2 **Dissolving in cyclohexane** This can be tested by placing a small amount of each chemical (A–K) in individual test tubes. Add a few cm^3 of cyclohexane to each, insert a bung and shake gently. Cyclohexane is HIGHLY FLAMMABLE and so this must be demonstrated at the end of the practical work when all the Bunsen burners have been turned off.

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