Unit 7H Solutions

About the unit

In this unit pupils:
- extend their knowledge of dissolving and the separation of the components of a solution and relate this to particle theory
- begin to distinguish between a 'pure' substance and a mixture
- apply the particle model of solids, liquids and gases in a range of contexts

In scientific enquiry pupils:
- make measurements of temperature and mass
- describe and interpret patterns in graphs and chromatograms
- make predictions from graphs and data about solubility
- investigate how a sample of pure salt can be obtained from a sample of rock salt, evaluating the method in terms of salt obtained

This unit is expected to take approximately 8 hours.

Where the unit fits in

This unit develops work on solids, liquids and separating mixtures in the key stage 2 programme of study. It builds on unit 4D 'Solids, liquids and how they can be separated', unit 5C 'Gases around us', unit 5D 'Changing state', unit 6C 'More about dissolving' and unit 6D 'Reversible and irreversible changes' in the key stage 2 scheme of work.

The unit builds on ideas introduced in unit 7G 'Particle model of solids, liquids and gases'.

Pupils will have many opportunities in later units to try to explain phenomena in terms of particles, *eg changes of state in unit 8I 'Heating and cooling', digestion in unit 8A 'Food and digestion', crystal size related to rate of cooling in unit 8H 'The rock cycle', the behaviour of gases in unit 9L 'Pressure and moments'*.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: make measurements of temperature and mass; present experimental results as line graphs, pointing out patterns; describe observations and explain these; identify patterns in data about solubility, and make predictions from these; interpret data from chromatograms; use scientific knowledge and understanding to plan how to separate pure salt from rock salt

some pupils will not have made so much progress and will: make measurements of temperature and mass; produce simple line graphs of results and point out patterns in these; separate a sample of salt from rock salt

some pupils will have progressed further and will: make measurements of temperature and mass; interpret and explain the significance of data from chromatograms; evaluate their method for obtaining pure salt in terms of the mass obtained

in terms of materials and their properties

most pupils will: classify some solids as soluble or insoluble and explain the meaning of the term 'saturated solution'; describe how mixtures can be separated by distillation and chromatography and begin to use the particle model to explain what happens when a solid dissolves in water, explaining why mass is conserved

some pupils will not have made so much progress and will: name some soluble and insoluble solids; describe how pure water can be obtained from sea water and how different colours can be separated from some inks

some pupils will have progressed further and will: use the particle model to explain a range of phenomena

Prior learning

It is helpful if pupils:

- have had experience of dissolving solids in water and know that not all are soluble
- have separated mixtures of solids and liquids
- know that not all liquids contain water
- know that all materials are made up of very small particles

Health and safety

Risk assessments are required for any hazardous activity. In this unit pupils:

- plan and carry out an investigation of their own
- use highly flammable and harmful substances

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly:

- words and phrases relating to dissolving, *eg solution, solute, solvent, soluble, insoluble, saturated solution*
- words and phrases relating to the separation of mixtures, *eg filtration, distillation, chromatography, chromatogram*
- words and phrases relating to explanations using the particle model, *eg particle, attracted, mixing, mingling*
- words and phrases relating to scientific enquiry, *eg prediction, evaluate, interpret*
- words with similar spelling but different meanings, and use them in a consistently correct way, *eg affect, effect*

Resources

Resources include:

- prepared data about:
  - the solubility of different solids in water
  - the solubility of solids in different solvents
  - the variation of solubility of solids in water with temperature (as tables and graphs)
- chromatograms for interpretation
- software simulation of particles in mixtures
- secondary sources showing uses of chromatography, *eg caffeine determination in drinks, identifying traces of photoallergens (causing irritation) in germicides and soaps, identification of sugars in urine, identification of traces of drugs in horses*

Out-of-school learning

Pupils could:

- find out where distilled water is used and about other uses of distillation
- look at labels of household liquids to find out whether they are pure liquids or mixtures

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How can we tell whether a liquid is a mixture?			
• that some solids dissolve in liquids and others do not • that many common materials are mixtures • that mixtures can be separated	• Present pupils with a selection of liquids, *eg distilled water or deionised water, seawater, a suspension of chalk in water, ethanol, copper sulfate solution,* and ask pupils about them, *eg Is it water? Is it pure?* Ask pupils to describe work they did on solutions and on separating solids from liquids in key stage 2. Challenge them to devise techniques, *eg filter, evaporate to dryness*, to find out whether the liquid is a mixture or not. Ask them to record their observations and explain what their method showed. Help the class to summarise different approaches used and introduce the terms 'soluble', 'insoluble' and 'solute'.	• name some solids that dissolve in water and some that do not • identify the components of some mixtures, *eg seawater is water with salt and other solids dissolved in it* • describe one way of separating the components of a mixture	• This activity is designed to find out what pupils already know about solid/liquid separation. In the light of this, teachers may wish to put more emphasis on making mixtures and separation techniques with some pupils and on particle explanations with others. • Extension: pupils could investigate the labels on packaging of household items and food to find out which are mixtures and which are not. ⚠ **Safety** – teachers will need to check pupils' plans for health and safety before practical work begins. Ethanol is highly flammable, so there should be no naked flames in the room if ethanol is used. Copper sulfate solution is harmful if the concentration is greater than 1.0 mol dm^{-3}. Eye protection should be worn
How much salt can we get from rock salt?			
• to use knowledge about separating mixtures to obtain a sample of salt from rock salt • to evaluate methods used in terms of the mass of salt obtained • that salt comes from a variety of sources and has many uses	• Present pupils with a sample of rock salt and say that pure salt can be obtained from this. Ask them to plan a way of obtaining a sample of pure salt. Extend this for some pupils by asking them how they could find out how much of their rock salt is pure salt and to compare their results with those of others. Ask pupils to produce an account of what they did, describing and explaining each stage. Emphasise that, although the salt dissolves, it doesn't disappear. • Show a video about the occurrence, extraction and uses of salt. Relate this to the processes pupils have used in extracting their sample.	• plan a method for obtaining a sample of salt from rock salt • obtain a sample of salt • explain why the mass of the salt sample was less than the mass of rock salt • explain in terms of the original sample or in terms of techniques why results of different groups differ	• The activity could be set in the context of comparing the salt content of different rock salts used on icy roads in winter, or of comparing the efficiency of different pupils' methods of obtaining a sample of salt. • Extension: pupils could be asked to use secondary sources to find out more about salt, *eg its importance in diet and possible hazards, sources and history of use.* ⚠ **Safety** – teachers will need to check pupils' plans for health and safety before practical work begins – pupils should not taste the salt after it has been purified

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What happens to the solute when a solution is made?			
• that when a solute dissolves, mass is conserved • that when a solute dissolves, the solute and solvent particles intermingle	• Show pupils a beaker of water of a particular mass, *eg 100g,* and ask them to predict what the total mass will be if some salt, *eg 4g*, is dissolved in the water, and to test their predictions by weighing. Ask them to explain why the mass remains the same and to say how much salt they would expect to get if they evaporated the water. • Remind pupils of work they did on particles in solids and liquids in unit 7G 'Particle model of solids, liquids and gases', referring back to the annotated diagrams drawn at the end of the unit. • Show a model or models, *eg ICT simulation, mixing rice and peas,* to illustrate the mixing of particles when a solid dissolves in a liquid, asking pupils to put in their own words what is happening. • Ask pupils to draw the water particles before and after the addition of salt and to use these to explain, *eg that mass is conserved, why filtering will not separate the salt.*	• state that the mass of a solution is the same as the mass of the solute and solvent, *eg if you dissolve 5g of salt in 200g of water, you'll get 205g of salt solution* • describe, *eg using annotated diagrams,* how solute and solvent particles mix • explain that as the particles mix no matter is lost, so the mass remains the same	• Extension: some pupils could explore mixing two liquids, *eg ethanol and water.* • In unit 7K 'Forces and their effects' pupils are introduced to the difference between mass and weight and to the use of balances. ⚠ **Safety** – ethanol is highly flammable, so there should be no naked flames in the room when it is being used
How can we separate solvents from solutes?			
• that distillation can be used to separate a liquid from the solids which are dissolved in it • that distillation is a process in which evaporation of a liquid is followed by condensation	• Explain to pupils that work so far has concentrated on the solute in a mixture but that it is often very important to separate and collect the liquid, *eg in purifying water.* • Remind pupils of work done on evaporation and condensation at key stage 2, *eg by showing them a sample of blue ink and asking them to predict the colour of the water obtained when it was evaporated and then condensed.* If necessary, carry out a quick demonstration. Ask them how they could obtain drinkable water from seawater, *eg in an area where there is a lot of seawater, but no fresh water.* Discuss pupils' ideas with them and introduce the term 'distillation'. Help pupils to test their ideas by carrying out a simple distillation process. • Ask pupils to explain the process, *eg by using a flow chart, annotated drawing.*	• describe how the solvent could be separated from the solute by heating the solution, followed by cooling • explain that separation works because the solvent changes to a gas and back to a liquid, but the solute does not	• In key stage 2, pupils are likely to have seen colourless water collected from the evaporation of blue ink. • Extension: pupils could be asked to find out about desalination plants or how distillation is used to separate liquids, *eg crude oil.* At this stage it is not necessary to draw distinctions between distillation and fractional distillation. ⚠ **Safety** – teachers should check pupils' plans for health and safety before practical work begins. Pupils should be taught safe procedures for using glassware and fitting bungs into it

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How can chromatography separate and identify substances in mixtures?			
• that a mixture of two or more solutes which are soluble in a particular solvent can be separated by chromatography • to separate and identify materials using chromatography	• Remind pupils of work they did earlier on showing whether a liquid was pure or not. Explain that they are going to explore some other techniques for this. • Demonstrate how to separate the different coloured compounds in an ink mixture on blotting or filter paper, using a wick of the paper dipped into the solvent (water). Discuss and establish with pupils why different coloured ink solids travel different distances, perhaps using the analogy of the solvent particles giving the solute particles 'piggyback rides', so those which attach more firmly to the solvent particles can be carried further than those which do not, in a given amount of time.	• use chromatography to separate and identify different solutes • use particle ideas to explain how chromatography works	• Extension: pupils could be asked to find out at home whether food colourings, inks in felt-tip pens or markers are single dyes or mixtures of dye. ⚠ **Safety** – if solvents other than water are used, pupils should be taught to handle them safely
• how chromatography can be used to compare mixtures of solutes • how scientists use evidence from chromatography	• Ask pupils to use chromatography to compare the components of dyes, *eg the colouring on sugar-coated chocolate sweets,* to find out whether different colours include the same dyes and to explain what they found, *eg using drawings and annotated diagrams.* Extend by providing pupils with prepared chromatograms and information about the contexts in which these might be needed, *eg in forensic science, in identifying traces of substances in urine or medical preparations*, and asking them to interpret the evidence from each chromatogram.	• interpret chromatograms, explaining what the evidence shows • describe a situation in which chromatography provides useful evidence	• Many pupils think that chromatography can only be used with coloured solutes. It is helpful to illustrate how chromatography is used with non-coloured solutes.
Checking progress			
• how particle theory can be used to model changes that take place when solutions are formed or components of solutions are separated	• Use ICT simulation to show pupils how to model a change, *eg some solid dissolving in water,* by representing the particles themselves, making sure that those representing the solid are clearly distinguishable from those representing the water. Ask groups of pupils to work out how to model other changes, *eg adding an insoluble solid to water, the formation of a suspension, separation by chromatography of two solutes, the evaporation of a solution.* Help pupils to write a brief description of each change.	• show by modelling how particles behave in some changes • describe what the models show, *eg when marble is added to water it doesn't break up into smaller particles, so the particles can't mix together*	• At this stage it is not necessary to distinguish between atoms and molecules.
Is there a limit to the amount of solid that will dissolve in a liquid?			
• that when a solid is added to a liquid, eventually no more will dissolve • that different masses of different solids dissolve in the same volume of a particular solvent • that solids can dissolve in liquids other than water	• Present some pupils with a selection of solids, *eg salt, bicarbonate of soda, potassium nitrate,* and ask them how they could find out whether there is a limit to how much will dissolve in water at room temperature. Ask other pupils to find out whether there is a limit to the amount of solid, *eg salt*, that will dissolve in different liquids, *eg water, ethanol*. Discuss with them how they will decide when no more dissolves and suggest that different groups use different volumes of solvent. Bring together results for the same solvent and look for patterns in these. Introduce the terms 'saturated solution' and 'solubility'.	• state that there is a limit to the amount of solid that dissolves in a particular volume of water • describe differences between the amounts of different solids that dissolve in the same volume of water • state that some solids dissolve more in some liquids than others	• It is important to clarify with pupils that they are finding out how much of something dissolves, not how fast it dissolves. They are likely to have investigated the latter at key stage 2. ⚠ **Safety** – ethanol is highly flammable, potassium nitrate is oxidising. Teachers should make sure pupils can handle these and other substances carefully. This activity is not intended to explore variation in solubility with temperature and there is no need to heat the solvents

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What else affects solubility?			
• that many solutes are more soluble at higher temperatures • to use tables of data to calculate quantities of material to use • to make comparisons, identify patterns and make predictions from graphs	• Ask pupils to suggest what else affects how much solid dissolves in a liquid, perhaps showing them a saturated solution, *eg of benzoic acid,* which forms crystals as it cools. Provide pupils with a table of data showing approximate solubilities of solutes at different temperatures. Help them to work out how much they would need to dissolve in 10g of water to make a saturated solution at a particular temperature. Ask pupils to prepare a warmed solution with a suitable amount of solid and to cool it down to identify the temperature at which crystals appear. Put together class results and help pupils to draw a graph showing how solubility varies with temperature and to describe what the graph shows and what the solubility might be at other temperatures.	• state that a saturated solution has been formed when crystals appear • state the solubility at a particular temperature, *eg at 70°C, 3g of the solid dissolved in 10g of water* • describe the way in which the solubility of the solute varies with temperature • use the pattern of solubility data to predict solubility at higher and lower temperatures	• Pupils are likely to have used a variety of thermometers in key stage 2 and this is extended in unit 7I 'Energy resources'. • As in the previous activity, it is important to draw the distinction between 'how much' and 'how fast'. • This activity works well using potassium chloride, potassium bromide or potassium iodide as the solute. • Extension: pupils could look at previously prepared data about the variation of solubility with temperature of a wider range of solutes, and identify simple patterns and make predictions from these. ⚠ **Safety** – remind pupils how to heat test tubes of chemicals
Reviewing work			
• to identify key points about changes involving making and separating solutions • to explain changes and techniques	• Provide pupils in groups with two sets of cards: each card in one set has the name of a change or technique, each card in the other set has the explanation of a change or technique. Ask them to match the correct explanation to the change or technique. For some pupils increase the range of changes, including some incorrect explanations to encourage discussion and deeper thinking about the phenomena. • Ask pupils to work in groups and list the key ideas about the changes, including two examples of each. Ask them for their ideas and discuss the changes, emphasising that those encountered in this unit can be relatively easily reversed. Together with pupils agree a summary of the unit.	• match the correct explanation to each change • identify, with reasons, incorrect explanations • summarise key points about changes and techniques in the unit	• Unit 8E 'Atoms and elements' introduces the idea of chemical change as changes in which atoms are joined in new ways, making new materials.