4 MATTER IN NATURE

In this unit, students will study the different states of matter, both from a macroscopic point of view, analysing the general properties of solids, liquids and gases, and from a microscopic point of view, by studying the Kinetic Particle Theory.

Students will also look at the diversity of matter at a macroscopic level:

they will classify matter according to whether it is homogeneous or heterogeneous; study several mixtures used in daily life; and explore the principal methods that allow us to separate the different components in mixtures.

Therefore, this unit will allow students to come into contact with and investigate their environment, analysing everyday phenomena related to matter, its states and its diversity. It will also allow students to learn about and practise several standard techniques used in laboratories, such as those followed when making solutions or separating the different components that make up mixtures.

Objectives

- Recognise the relationship between the different states of matter and their properties.
- Identify the properties of the different states of aggregation using the Kinetic Particle Theory.
- Explain changes in state applying the Kinetic Particle Theory.
- Interpret everyday phenomena related to changes of state of matter.
- Draw a heating curve graph during experiments.
- Differentiate homogeneous mixtures from heterogeneous mixtures.
- Identify the solute and the solvent in a solution.
- Recognise the importance of aqueous solutions, alloys and colloids.
- Calculate the percent composition (by mass) of concentrations.
- Prepare solutions with known concentrations in the laboratory.
- Propose methods for separating the different components in a mixture.
- Carry out a research task about the process of obtaining salt from salt mines.

Mixed-ability needs

In order to meet the needs of students of different abilities, a wide variety of resources are provided as complements or alternatives to the work in the unit: slideshow presentations with core content, Oxford investigation and worksheets. Also, since science combines many skills, it is important to pair up students of mixed abilities, so that they can support each other.

The mixed-ability resources are to be used at the teacher's discretion, although each lesson contains suggestions.

Suggested Timing

This unit can be worked on during approximately 10 sessions. The number of sessions should be determined by the interest that the students show for the content and by the general unit planning.

Sections	N° of sessions
Warmer	½
1. The states and properties of matter	½
2. The Kinetic Particle Theory	½
3. Changes of state	1 ½
4. Classifying matter	½
5. Homogeneous mixtures or solutions	2
6. A very special mixture: colloids	½
7. Methods for separating mixtures	1
Consolidation	1
Work and experimentation techniques	1
Final task and Self-assessment	1 ½

UNIT LESSON PLAN

Contents	Assessment criteria	Learning outcomes
The states and properties of matter ▮ Matter ▮ The three states of matter and their properties	1. Know the three states of matter and their properties.	1.1 Recognise examples of the three states of matter in everyday life. (CCL, CMCT) 1.2. Match each state of matter with its main properties. (CCL, CMCT)
The Kinetic Particle Theory	2. Explain the properties of the different states of matter using the Kinetic Particle Theory.	2.1. Justify the properties of solids, liquids and gases using the Kinetic Particle Theory. (CCL, CMCT, CAA) 2.2. Explain the behaviour of gases in everyday situations using the Kinetic Particle Theory. (CCL, CMCT, CAA)
Changes of state ▮ The temperature at which changes of state occur ▮ A heating curve	3. Justify how substances can appear in different states of aggregation, depending on their temperature.	3.1. Recognise the state of aggregation of a substance according to its temperature. (LC, MCST) 3.2. Identify the temperature at which a substance changes state of aggregation. (LC, MCST) 3.3. Draw heating curve graphs from the melting and boiling points of substances shown on data tables, and vice versa with cooling curve graphs. (LC, MCST)
Classifying matter	4. Identify systems to classify matter, such as pure substances and mixtures.	4.1. Categorise substances into pure substances and mixtures. (LC, MCST)
Homogeneous mixtures or solutions ▮ Calculating concentrations ▮ Preparing solutions	5. Recognise homogeneous mixtures and examine them to identify the solute and solvent.	5.1. Recognise the homogenous nature of a solution and identify the solute and solvent from their concentrations. (LC, MCST) 5.2. Prepare solutions and describe the methods and materials used. (LC, MCST)
	6. Calculate the concentration of solutions both in percent concentration (by mass) and mass concentration (g/L).	6.1. Resolve practical exercises calculating the concentration of solutions both in percent composition (by mass) and mass concentration (g/L). (LC, MCST)
	7. Evaluate the importance and the applications of some homogeneous mixtures of special interest, such as aqueous solutions and alloys.	7.1. Recognise and value both the importance and the applications of aqueous solutions and alloys. (LC, MCST, SIE)
A very special mixture: colloids	8. Distinguish between homogeneous mixtures, heterogeneous mixtures and colloids.	8.1. Identify homogeneous mixtures, heterogeneous mixtures and colloids. (LC, MCST)
	9. Evaluate the importance and applications of colloids.	9.1. Recognise the main colloids in everyday use. (LC, MCST)
Methods for separating mixtures ▮ Magnetic separation ▮ Decantation ▮ Filtration ▮ Distillation ▮ Evaporation and crystallisation ▮ Chromatography	10. Design and implement methods for separating the different components in homogeneous and heterogeneous mixtures.	10.1. Choose the most suitable methods for separating the different components in mixtures according to their properties. (LC, MCST, LL, SIE, SCC) 10.2. Describe the laboratory equipment needed to perform each method of separation. (LC, MCST, LL, SIE, SCC)

LC: Linguistic communication; **MCST:** Mathematical competence and basic competences in science and technology; **DC:** Digital competence; **LL:** Learning to learn; **SIE:** Sense of initiative and entrepreneurship; **SCC:** Social and civic competence.

UNIT CONCEPT MAP

STUDENT RESOURCES

Oxford investigation > > > > > >

Interactive activities > > > > > >

Talking book > > > > > >

Video 1: Changing water – states of matter
Weblink 1: Quizlet

Video 2: Solid, liquid, gas and…plasma?

Video 3: Kinetic Theory of Matter experiment
Video 4: Particle arrangements in a solid, a liquid and a gas

Video 5: Dry ice sublimation
Video 6: Sublimation of iodine
Weblink 2: Changing matter
Video 7: Boiling points

Unit 4: Matter in nature

1. The states and properties of matter
- 1.1. Matter
- 1.2. The three states of matter and their properties

2. The Kinetic Particle Theory

3. Changes of state
- 3.1. The temperature at which changes of state occur
- 3.2. A heating curve

4. Classifying matter

TEACHER RESOURCES

Concept map
Presentation

Animation: Changes of state

Reinforcement worksheets > > > > > >

Curricular adaptation worksheets > > > > > >

> > > > > > **Oxford investigation**

> > > > > > **Interactive activities**

> > > > > > **Talking book**

Weblink 3: Solute *vs* solvent
Weblink 4: Kinetic Particle Theory

Video 8: Solution, suspension and colloid

Video 9: Chlorophyll chromatography

5. Homogeneous mixtures and solutions
- 5.1. Calculating concentrations
- 5.2. Preparing solutions

6. A very special mixture: colloids

7. Methods for separating mixtures
- 7.1. Magnetic separation
- 7.2. Decantation
- 7.3. Filtration
- 7.4. Distillation
- 7.5. Evaporation and crystallisation
- 7.6. Chromatography

Consolidation

Work and experimentation techniques
Obtaining a heating curve

Final task
Extracting salt: salt mining

Concept map
Competence test
Extension worksheet
Presentation
Reinforcement worksheet
Unit tests

> > > > > > **Reinforcement worksheets**

> > > > > > **Curricular adaptation worksheets**

TEACHING SUGGESTIONS

4 MATTER IN NATURE

YOU WILL LEARN TO...

- Recognise the relationship between the states of matter and their properties.
- Explain changes in state applying the Kinetic Particle Theory.
- Draw a heating curve.
- Distinguish between homogeneous and heterogeneous mixtures.
- Identify the solute and the solvent in a solution.
- Recognise the importance of aqueous solutions, alloys and colloids.
- Prepare solutions with known concentrations in the lab.
- Propose methods for separating substances in a mixture.

- *Can you think of a substance that you have seen in all three states?*
- *What is the property of gases that allows them to expand and contract so easily?*
- *When you put a drop of red food colouring in a glass of water, why does all the water change colour after a certain amount of time?*
- *Do you know of any substance that can change from solid to gas directly, without passing through a liquid state first?*
- *If you leave a chocolate milkshake to settle for a while, what do you think will happen?*

Final task

Extracting salt: salt mines

In this unit, we propose that you carry out research into the main method of extracting one of the most widely used seasoning by humans; salt. It is possible to make your own salt at home. Are you up to it?

- How do you think we extract salt from sea water?
- Can you think of a way to extract salt from salty water?

4. Matter in nature 77

Verify that all students are familiar with what matter is. First, elicit definitions from different students and write them up on the board, whether they are correct or not (to get ideas flowing). Then ask specific questions to make sure that all students understand that everything is made of matter.

First, point to a chair and ask: *Is this made of matter?* (Yes.) Point to another object, such as a table, and ask again. If anyone says no, point to successive objects until everyone has understood. Then, point at yourself and ask: *Am I made of matter?* (Yes.) Reinforce by pointing to a student and asking again. At this point, all the students should be answering yes. Finally point out the window at the sky and ask: *Is air made of matter?* (Yes.)

Say: *Everything is made of matter; even things we cannot see.* Correct any wrong or incomplete definitions given by the students earlier.

Now turn to states of matter. Ask: *In what three states can matter be found?* (Solid, liquid and gas.)

To help students answer the questions on page 76 of the Student's book, watch Video 1. Before playing, ask students: *Why can we find matter in three different states? What is different in each state?* (Depending on how the particles are arranged, matter will be solid, liquid or gas.) As before, do not correct any answers at this time. The idea is for students to start thinking about the questions and find the answers in the video.

Video 1: CHANGING WATER – STATES OF MATTER

This short video uses the example of water to explain the nature of matter, its three states and how the particles are arranged in each state.

After watching the video, elicit the answer to the questions. You can also ask students how the particles are arranged in solids (they are really close together, so they can't move), in liquids (they can move around but they will stay together) and in gases (the particles move around and do not stay together).

Put students into pairs and direct them to the questions on page 76 of the Student's book. Give them a maximum of 5 minutes to read and confer. Elicit some examples and discuss as a class.

- *Can you think of a substance that you have seen in all three states?*

  Water can be found in the three states. Make sure students give some examples for each: solid (ice cubes, glaciers, snow…); liquid (the water that we drink, rivers, seas…); gaseous (clouds, the water vapour created when boiling water to cook pasta, water vapour created when we have a shower…).

- *What is the property of gases that allows them to expand and contract so easily?*

  Their particles can move and don't stay together, so they can expand and contract easily.

- *When you put a drop of red food colouring in a glass of water, why does all the water change colour after a certain amount of time?*

  The particles in both substances move around. When we add a drop of food colouring to the water, the particles in the food colouring move and mix with the particles of water. However, this process takes some time: the particles in the food colouring need time to move from the place they were dropped, to the edges of the glass. Thus the water doesn't all become red immediately, only after a certain a mount of time.

- *Do you know of any substance that can change from solid to gas directly, without passing through a liquid state first?*

  Examples include iodine, naphthalene and dry ice (solid CO_2).

- *If you leave a chocolate milkshake to settle for a while, what do you think will happen?*

  At the beginning, the mixture will seem homogenous. However, after a while, all the particles of chocolate will slowly sink to the bottom, leaving only milk at the top. This happens because although it may appear to be a homogeneous mixture, the chocolate milkshake is actually a colloid.

Turn to the **Final task (Extracting salt: salt mines).** Read the task in open class and mention that the instructions are on page 95. Say: *You will be researching how salt is extracted from salt mines and carry out an experiment to emulate this. It will form part of your final assessment.* Explain that the results will be presented as a mural or poster and include a report about the experiment and a slideshow presentation.

PRESENTATION

Use the slideshow presentation to show the different sections in the unit and to evaluate students' prior knowledge. The slides can stimulate student participation, as students can be asked about certain topics before they study them. This tool can also be used as revision at the end of the unit.

CONCEPT MAP

To introduce the contents of the unit, you could show an incomplete concept map and ask the students to complete the gaps, either in their notebooks or orally with the whole group. This will help students visualise the links between the different contents of the unit.

Finally, you could introduce the key vocabulary in the **Study Skills** section on page 93 of the Student's book. Vocabulary building tasks familiarise students with the vocabulary of the unit, making the concepts easier for them to follow.

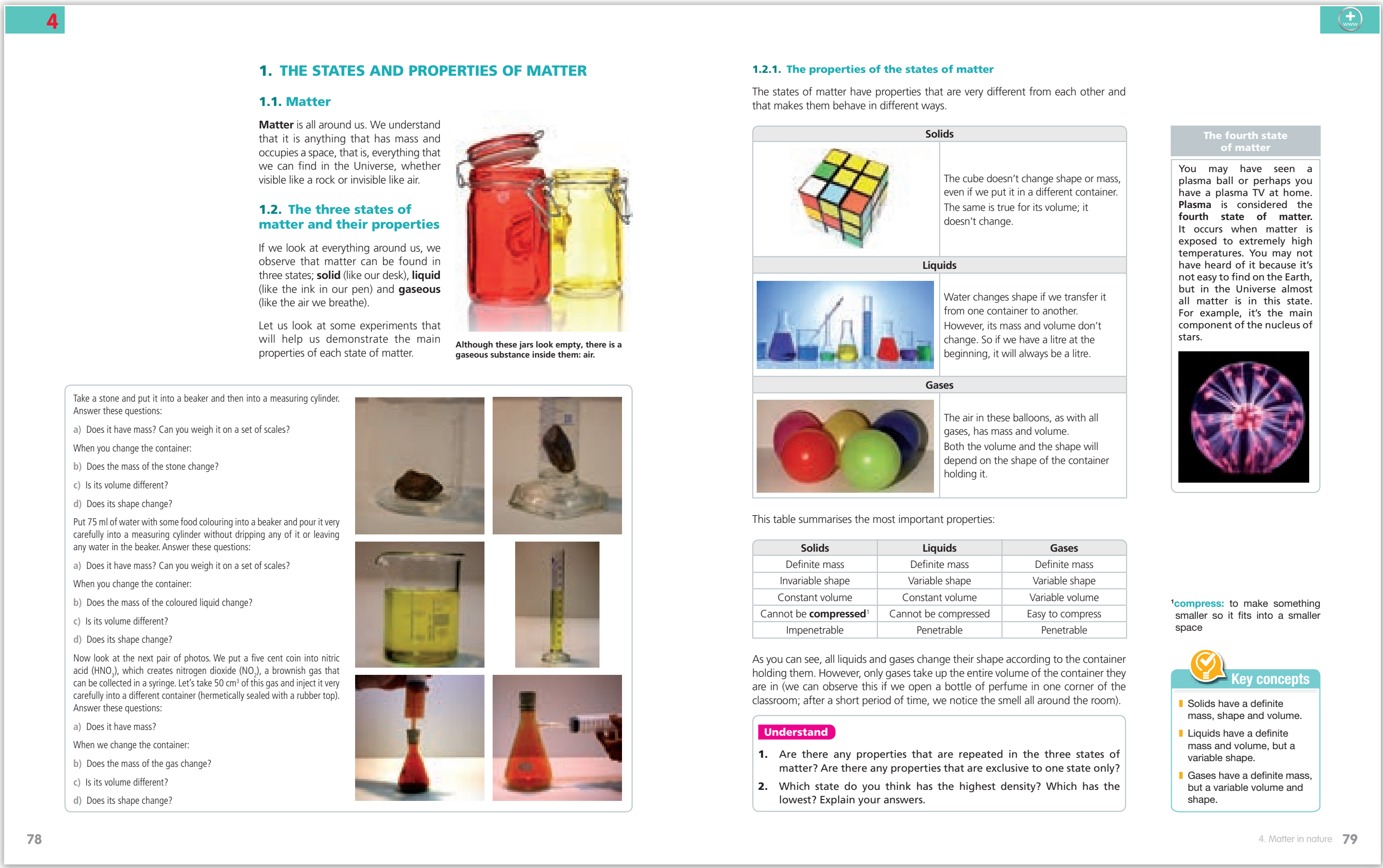
Weblink 1: **QUIZLET**

This program allows the making and sharing of sets of flashcards. The program then makes tests and study games. It also keeps a record of each user's progress, stimulating competition and motivation.

Ask students to create digital flashcards of any new vocabulary they have learnt in this unit, using the online program Quizlet in Weblink 1. Show them how to create a free account and make flashcards with the vocabulary word on one side and the definition on the other. Demonstrate how the cards can be used. Encourage students to share their sets with others. Explain that they will be creating flashcards at the end of each unit.

OXFORD INVESTIGATION

This includes an **introduction** to the unit with preliminary questions and a description of the **Final task.** The Final task is usually a practical problem, involving a variety of learning skills and research. Explain that in particular activities students will learn the concepts and/or the procedures necessary to solve the problem.


4

1. THE STATES AND PROPERTIES OF MATTER

1.1. Matter

Matter is all around us. We understand that it is anything that has mass and occupies a space, that is, everything that we can find in the Universe, whether visible like a rock or invisible like air.

1.2. The three states of matter and their properties

If we look at everything around us, we observe that matter can be found in three states; **solid** (like our desk), **liquid** (like the ink in our pen) and **gaseous** (like the air we breathe).

Let us look at some experiments that will help us demonstrate the main properties of each state of matter.

Although these jars look empty, there is a gaseous substance inside them: air.

Take a stone and put it into a beaker and then into a measuring cylinder. Answer these questions:

a) Does it have mass? Can you weigh it on a set of scales?

When you change the container:

b) Does the mass of the stone change?

c) Is its volume different?

d) Does its shape change?

Put 75 ml of water with some food colouring into a beaker and pour it very carefully into a measuring cylinder without dripping any of it or leaving any water in the beaker. Answer these questions:

a) Does it have mass? Can you weigh it on a set of scales?

When you change the container:

b) Does the mass of the coloured liquid change?

c) Is its volume different?

d) Does its shape change?

Now look at the next pair of photos. We put a five cent coin into nitric acid (HNO_3), which creates nitrogen dioxide (NO_2), a brownish gas that can be collected in a syringe. Let's take 50 cm^3 of this gas and inject it very carefully into a different container (hermetically sealed with a rubber top). Answer these questions:

a) Does it have mass?

When we change the container:

b) Does the mass of the gas change?

c) Is its volume different?

d) Does its shape change?

78

1.2.1. The properties of the states of matter

The states of matter have properties that are very different from each other and that makes them behave in different ways.

Solids

The cube doesn't change shape or mass, even if we put it in a different container. The same is true for its volume; it doesn't change.

Liquids

Water changes shape if we transfer it from one container to another. However, its mass and volume don't change. So if we have a litre at the beginning, it will always be a litre.

Gases

The air in these balloons, as with all gases, has mass and volume. Both the volume and the shape will depend on the shape of the container holding it.

This table summarises the most important properties:

Solids	Liquids	Gases
Definite mass	Definite mass	Definite mass
Invariable shape	Variable shape	Variable shape
Constant volume	Constant volume	Variable volume
Cannot be **compressed**[1]	Cannot be compressed	Easy to compress
Impenetrable	Penetrable	Penetrable

As you can see, all liquids and gases change their shape according to the container holding them. However, only gases take up the entire volume of the container they are in (we can observe this if we open a bottle of perfume in one corner of the classroom; after a short period of time, we notice the smell all around the room).

Understand

1. Are there any properties that are repeated in the three states of matter? Are there any properties that are exclusive to one state only?
2. Which state do you think has the highest density? Which has the lowest? Explain your answers.

The fourth state of matter

You may have seen a plasma ball or perhaps you have a plasma TV at home. **Plasma** is considered the **fourth state of matter.** It occurs when matter is exposed to extremely high temperatures. You may not have heard of it because it's not easy to find on the Earth, but in the Universe almost all matter is in this state. For example, it's the main component of the nucleus of stars.

[1] **compress:** to make something smaller so it fits into a smaller space

Key concepts

- Solids have a definite mass, shape and volume.
- Liquids have a definite mass and volume, but a variable shape.
- Gases have a definite mass, but a variable volume and shape.

4. Matter in nature 79

1. The states and properties of matter

With their books closed, ask the students: *What is matter?* (Everything is made of matter, even the things we can't see. We say that matter is everything that has mass and takes up space.) *What are the three states of matter?* (Solids, liquids and gases.) *Give me some examples of each.*

Read and listen to the sections as a class to find out if they were correct. If you can't reproduce the experiments to demonstrate the main properties of the different states of matter, you can examine the photographs to find out the answers.

Students will learn that the physical properties of matter can be observed on the macro and micro levels. On the macro level solids keep their shape, liquids take the shape of their container and gases expand to fill the container. On the micro level the spacing and movement of particles defines whether a substance is a solid, liquid or gas. Students will also make quantitative observations of the physical properties of matter, such as shape, mass and volume.

1.2.1. The properties of the states of matter

Before reading and listening to this section and with books closed, ask the students to tell you the three properties that were observed in the previous experiment (mass, volume and shape). Write the following table on the blackboard and ask students to copy it in their notebooks, filling in the missing gaps in pairs.

Solids	Liquids	Gases
definite mass	__________ mass	__________ mass
__________ shape	__________ shape	__________ shape
__________ volume	__________ volume	__________ volume

To help students complete the table, write the missing words on the blackboard, making sure that they are not in the right order (for example: variable, definite, variable, constant, variable, constant, invariable and definite).

Give students approximately 5 minutes to complete the table. When they have all finished, call up several volunteer students to complete the table on the board. If there are any mistakes, don't correct them at this point. As students will read the text and find out the answers, students should correct their mistakes once finished.

Tell the students that you are going to read and listen to this section as a class and that they must find out what two new properties of matter it mentions (compressibility and impenetrability). Read the entire section, except for **The four states of matter** box. Once you have finished reading, elicit the answers from the students.

As a class, check if the information written in the table is correct. Correct any mistakes. Then ask the students to do the same with their own tables and to add the information for the two missing properties.

Ask students to complete Activity 1 individually and Activity 2 in pairs. Once they have finished, elicit some of their answers and discuss as a class.

Finally, ask students to read about **The four states of matter** individually. Students will have probably heard of plasma before, as plasma TVs are now quite common. However there are many more examples of plasma. Show students the following video for them to see other examples and learn how plasma is made.

Video 2: **SOLID, LIQUID, GAS AND… PLASMA?**

This short video explains what plasma is and how it is made, giving several examples.

Finally, ask students to add any new vocabulary to their Quizlet flashcard set.

EXTRA RESOURCES

AUDIO
TALKING BOOK
INTERACTIVE ACTIVITIES

Answer key

Understand

1. Are there any properties that are repeated in the three states of matter? Are there any properties that are exclusive to one state only?

Mass remains the same in the three states of matter.

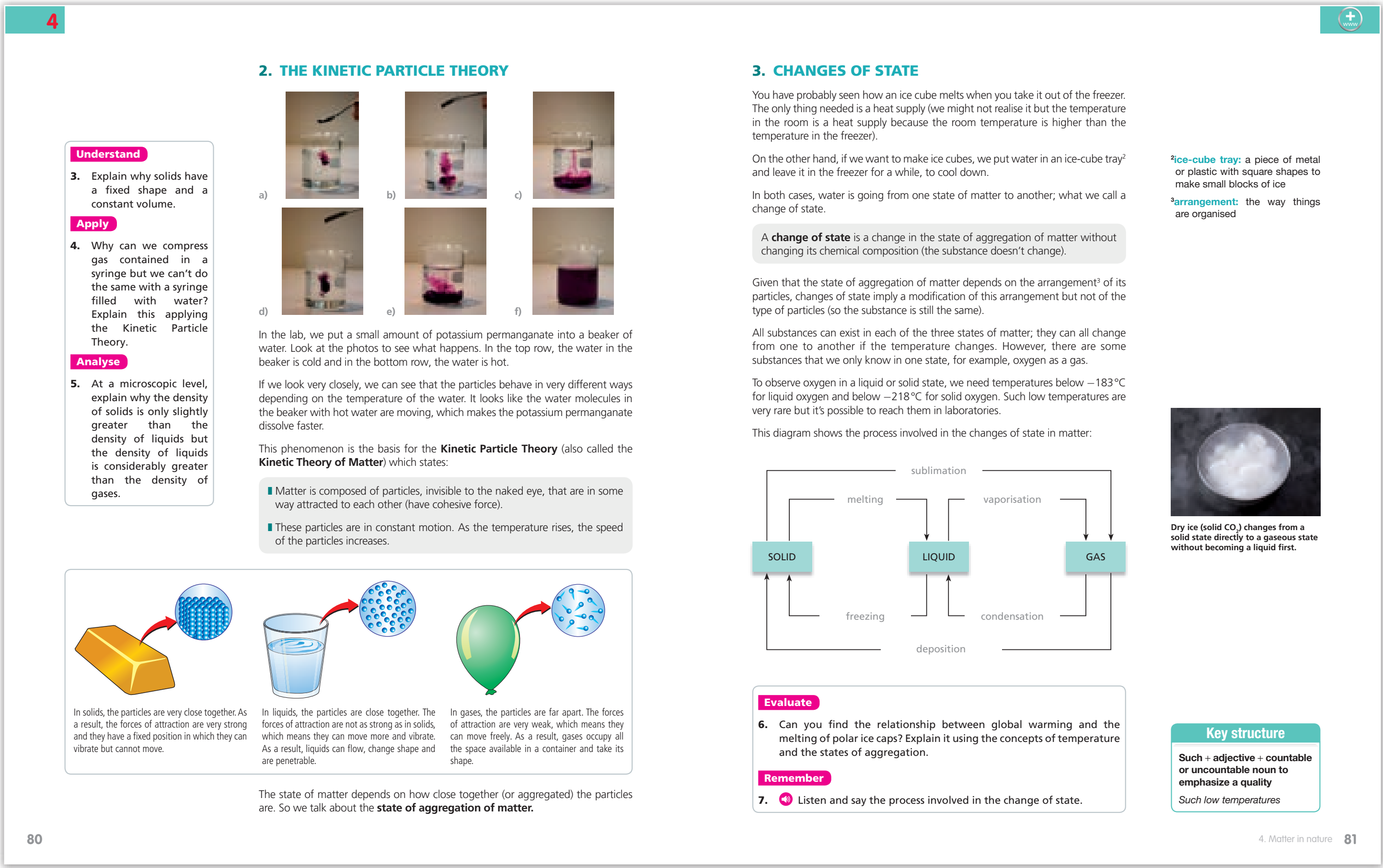
Exclusive properties of solids: invariable shape; impenetrable.

Exclusive properties of gases: variable volume; easy to compress.

2. Which state do you think has the highest density? Which has the lowest? Explain your answers.

Solids have the highest density, as their particles are the closest together and have very little space between them. This means that, in a given volume, there are more particles in solids than in liquids or gases.

Gases have the lowest density, as their particles are furthest apart and have a lot space between them. So, in a given volume, there are fewer particles in gases than in liquids or solids.



4

2. THE KINETIC PARTICLE THEORY

Understand

3. Explain why solids have a fixed shape and a constant volume.

Apply

4. Why can we compress gas contained in a syringe but we can't do the same with a syringe filled with water? Explain this applying the Kinetic Particle Theory.

Analyse

5. At a microscopic level, explain why the density of solids is only slightly greater than the density of liquids but the density of liquids is considerably greater than the density of gases.

a) b) c) d) e) f)

In the lab, we put a small amount of potassium permanganate into a beaker of water. Look at the photos to see what happens. In the top row, the water in the beaker is cold and in the bottom row, the water is hot.

If we look very closely, we can see that the particles behave in very different ways depending on the temperature of the water. It looks like the water molecules in the beaker with hot water are moving, which makes the potassium permanganate dissolve faster.

This phenomenon is the basis for the **Kinetic Particle Theory** (also called the **Kinetic Theory of Matter**) which states:

- Matter is composed of particles, invisible to the naked eye, that are in some way attracted to each other (have cohesive force).
- These particles are in constant motion. As the temperature rises, the speed of the particles increases.

In solids, the particles are very close together. As a result, the forces of attraction are very strong and they have a fixed position in which they can vibrate but cannot move.

In liquids, the particles are close together. The forces of attraction are not as strong as in solids, which means they can move more and vibrate. As a result, liquids can flow, change shape and are penetrable.

In gases, the particles are far apart. The forces of attraction are very weak, which means they can move freely. As a result, gases occupy all the space available in a container and take its shape.

The state of matter depends on how close together (or aggregated) the particles are. So we talk about the **state of aggregation of matter.**

80

3. CHANGES OF STATE

You have probably seen how an ice cube melts when you take it out of the freezer. The only thing needed is a heat supply (we might not realise it but the temperature in the room is a heat supply because the room temperature is higher than the temperature in the freezer).

On the other hand, if we want to make ice cubes, we put water in an ice-cube tray[2] and leave it in the freezer for a while, to cool down.

In both cases, water is going from one state of matter to another; what we call a change of state.

A **change of state** is a change in the state of aggregation of matter without changing its chemical composition (the substance doesn't change).

Given that the state of aggregation of matter depends on the arrangement[3] of its particles, changes of state imply a modification of this arrangement but not of the type of particles (so the substance is still the same).

All substances can exist in each of the three states of matter; they can all change from one to another if the temperature changes. However, there are some substances that we only know in one state, for example, oxygen as a gas.

To observe oxygen in a liquid or solid state, we need temperatures below −183 °C for liquid oxygen and below −218 °C for solid oxygen. Such low temperatures are very rare but it's possible to reach them in laboratories.

This diagram shows the process involved in the changes of state in matter:

sublimation
melting
vaporisation
SOLID
LIQUID
GAS
freezing
condensation
deposition

[2]**ice-cube tray:** a piece of metal or plastic with square shapes to make small blocks of ice

[3]**arrangement:** the way things are organised

Dry ice (solid CO_2) changes from a solid state directly to a gaseous state without becoming a liquid first.

Evaluate

6. Can you find the relationship between global warming and the melting of polar ice caps? Explain it using the concepts of temperature and the states of aggregation.

Remember

7. Listen and say the process involved in the change of state.

Key structure

Such + adjective + countable or uncountable noun to emphasize a quality

Such low temperatures

4. Matter in nature 81

2. The Kinetic Particle Theory

Remind students that they learnt in Unit 2 that matter is formed of atoms. They should also understand that changes happening at a microscopic level can't be seen with the naked eye.

Ideally, to help students understand the Kinetic Particle Theory, carry out the experiment in class. If this is not possible, watch it being performed in Video 3. Alternatively ask the students to analyse the two rows of photographs.

Video 3: KINETIC THEORY OF MATTER EXPERIMENT

This is a short video of the Kinetic Particle Theory experiment in this section.

Whichever method you are using, before reading, refer students to the two rows of images. Ask: *What is the difference between the images in the two rows?* (The potassium permanganate is dissolving at different speeds in each of the beakers.) Then ask: *Why are they dissolving at different speeds?* Unless you are carrying out the experiment, students won't know that the water in one of the beakers is warmer than the other. Allow time to think and discuss. Now ask: *Why is heat making the potassium permanganate dissolve faster?* (The heat makes the particles of both substances move faster, which means they mix faster, making the potassium permanganate dissolve faster.) Allow some time for possible explanations. This is a warmer so students may not know the answer.

Carry out a reading race. Students should read the text in this section, individually, to find out why heat is making the potassium permanganate dissolve faster. They should then raise their hand when they have found the answer. Wait until most of the class has their hand raised. Ask the first student to give the answer (the molecules in the beaker with hot water are moving, which makes the potassium permanganate dissolve faster). Finish reading the section in open class. Now listen to the section or watch Video 4 for visual reinforcement of the knowledge.

Video 4: PARTICLE ARRANGEMENTS IN A SOLID, A LIQUID AND A GAS

This BBC website includes a short video about the particle arrangement in the three states of matter.

Ask students to complete Activities 3, 4 and 5 in pairs. Discuss in open class, helping when necessary.

3. Changes of state

With books closed, say: *So we know there are three states of matter: solids, liquids and gases. Bearing this in mind, what could a change of state mean?* (A change in the state of aggregation of matter without changing its chemical composition.) Ask: *I can think of lots of examples. Can you give an example?* (Ice cubes melting into water.) Elicit examples from several students. Then ask: *How many processes do you think are involved in the changes of state in matter?* If students are confused by this question, give them two examples (melting and freezing are good examples as students will know what they mean). Ask students to estimate how many processes there might be and to name them. Write three or four of their predicted numbers on the board.

Read this section as a class as you listen to the recording. When finished, ask students to tell you how many processes are involved in the changes of state in matter (6). Ask the students to give you an example of each change of state in matter. They should be able to give examples of melting, vaporisation, freezing and condensation, as these terms are widely used and there are many examples in out daily life. For sublimation and deposition you can show them the following videos.

Video 5: DRY ICE SUBLIMATION

This short video shows how dry ice sublimates into gas at room temperature.

Video 6: SUBLIMATION OF IODINE

This video shows how iodine, black-bluish when solid, turns into a purple gas (sublimation) and then how it turns back into a solid (deposition)

Ask students to complete the following interactive demonstration of how matter can change state, in order for them to clearly see how heat affects the particles in matter.

Weblink 2: CHANGING MATTER

This interactive demonstration pays particular attention to how heat affects the movement of particles in matter, from melting to vaporisation.

Students should complete Activity 6 in pairs and Activity 7 individually, then add any new vocabulary to their Quizlet flashcard set.

Animation: CHANGES OF STATE

This short animation explains the different changes of state and how the particles behave in each change.

EXTRA RESOURCES

AUDIO
TALKING BOOK
INTERACTIVE ACTIVITIES

Answer key

Understand

3. Explain why solids have a fixed shape and a constant volume.

In order for solids to change shape and volume, their particles need to be able to move. The particles in solids have a fixed position. They can vibrate but not move, so they always have the same shape and volume.

Apply

4. Why can we compress gas contained in a syringe but we can't do the same with a syringe filled with water? Explain this applying the Kinetic Particle Theory.

The particles in liquids are still quite close together, so we can't reduce the space between them. The particles in gases are very far apart, so when we apply a little force to the syringe we can compress the gas and reduce the space between the partciles.

Analyse

5. At a microscopic level, explain why the density of solids is only slightly greater than the density of liquids but the density of liquids is considerably greater than the density of gases.

The particles in solids are very close together. Thus in a given volume, there are a lot of particles and therefore solids have a high density.

The forces of attraction are not as strong in liquids when compared to solids. Therefore, even though their particles are close together, they are not as close as in solids. Thus liquids have a high density, but not as high as in solids.

The particles in gases are very far apart from each other when compared to liquids. This means that, in the same volume, the density of gases is considerably smaller than in liquids and solids.

Evaluate

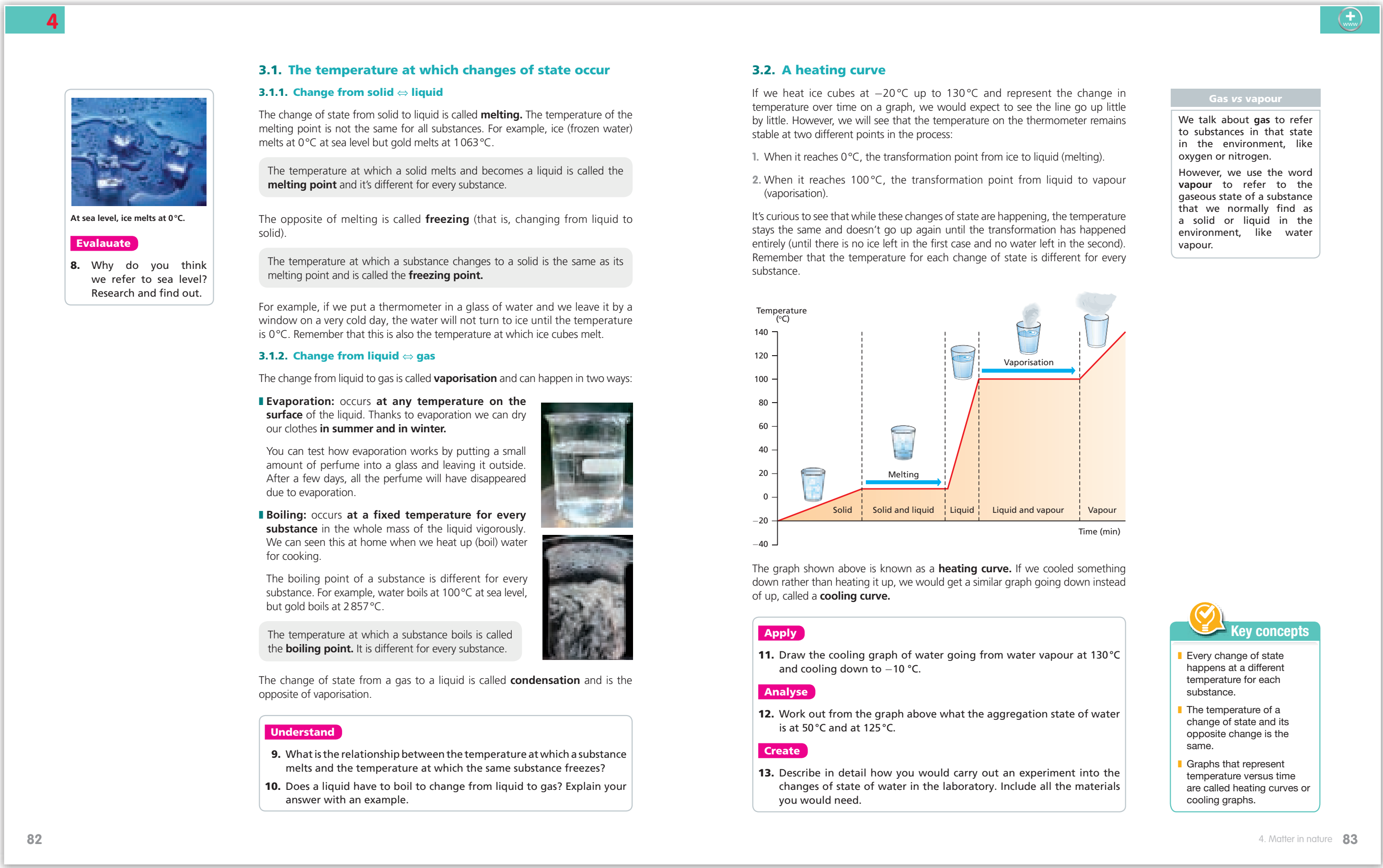
6. Can you find the relationship between global warming and the melting of polar ice caps? Explain it using the concepts of temperature and the states of aggregation.

The greenhouse gases involved in global warming (CO_2, CH_4…) are increasing the Earth's global temperature. This increase in temperature makes the water molecules in the polar ice caps vibrate more, leading to the melting of the ice into water.

Remember

7. Listen and say the process involved in the change of state.

a) **A gas turns into a solid.** Deposition
b) **A liquid turns into a gas.** Vaporisation
c) **A solid turns into a liquid.** Melting
d) **A liquid turns into a solid.** Freezing
e) **A gas turns into a liquid.** Condensation



4

3.1. The temperature at which changes of state occur

3.1.1. Change from solid ⇔ liquid

The change of state from solid to liquid is called **melting.** The temperature of the melting point is not the same for all substances. For example, ice (frozen water) melts at 0 °C at sea level but gold melts at 1 063 °C.

The temperature at which a solid melts and becomes a liquid is called the **melting point** and it's different for every substance.

The opposite of melting is called **freezing** (that is, changing from liquid to solid).

The temperature at which a substance changes to a solid is the same as its melting point and is called the **freezing point.**

For example, if we put a thermometer in a glass of water and we leave it by a window on a very cold day, the water will not turn to ice until the temperature is 0 °C. Remember that this is also the temperature at which ice cubes melt.

At sea level, ice melts at 0 °C.

Evalauate

8. Why do you think we refer to sea level? Research and find out.

3.1.2. Change from liquid ⇔ gas

The change from liquid to gas is called **vaporisation** and can happen in two ways:

- **Evaporation:** occurs **at any temperature on the surface** of the liquid. Thanks to evaporation we can dry our clothes **in summer and in winter.**

  You can test how evaporation works by putting a small amount of perfume into a glass and leaving it outside. After a few days, all the perfume will have disappeared due to evaporation.

- **Boiling:** occurs **at a fixed temperature for every substance** in the whole mass of the liquid vigorously. We can seen this at home when we heat up (boil) water for cooking.

  The boiling point of a substance is different for every substance. For example, water boils at 100 °C at sea level, but gold boils at 2 857 °C.

The temperature at which a substance boils is called the **boiling point.** It is different for every substance.

The change of state from a gas to a liquid is called **condensation** and is the opposite of vaporisation.

Understand

9. What is the relationship between the temperature at which a substance melts and the temperature at which the same substance freezes?

10. Does a liquid have to boil to change from liquid to gas? Explain your answer with an example.

82

3.2. A heating curve

If we heat ice cubes at −20 °C up to 130 °C and represent the change in temperature over time on a graph, we would expect to see the line go up little by little. However, we will see that the temperature on the thermometer remains stable at two different points in the process:

1. When it reaches 0 °C, the transformation point from ice to liquid (melting).
2. When it reaches 100 °C, the transformation point from liquid to vapour (vaporisation).

It's curious to see that while these changes of state are happening, the temperature stays the same and doesn't go up again until the transformation has happened entirely (until there is no ice left in the first case and no water left in the second). Remember that the temperature for each change of state is different for every substance.

The graph shown above is known as a **heating curve.** If we cooled something down rather than heating it up, we would get a similar graph going down instead of up, called a **cooling curve.**

Gas *vs* vapour

We talk about **gas** to refer to substances in that state in the environment, like oxygen or nitrogen.

However, we use the word **vapour** to refer to the gaseous state of a substance that we normally find as a solid or liquid in the environment, like water vapour.

Apply

11. Draw the cooling graph of water going from water vapour at 130 °C and cooling down to −10 °C.

Analyse

12. Work out from the graph above what the aggregation state of water is at 50 °C and at 125 °C.

Create

13. Describe in detail how you would carry out an experiment into the changes of state of water in the laboratory. Include all the materials you would need.

Key concepts

- Every change of state happens at a different temperature for each substance.
- The temperature of a change of state and its opposite change is the same.
- Graphs that represent temperature versus time are called heating curves or cooling graphs.

4. Matter in nature 83

3.1. The temperature at which changes of state occur

Explain that by observing the processes that change solids to liquids and vice versa, and liquids to gases, and vice versa, students will analyse the temperature at which changes of state occur.

Revise the name of the processes involved in each of the changes (solid → liquid: melting; liquid → solid: freezing; liquid → gas: vaporisation; gas → liquid: condensation).

3.1.1. Change from solid ⇔ liquid

Ask students: *What do we mean by melting point and freezing point?* (The temperature at which a solid melts or a liquid freezes.) Write up their answers on the board. Read and listen to the text in open class to check and correct answers. Then ask: *Melting and freezing are two different processes, but do they have anything in common?* (Yes, the temperature at which a solid melts, melting point, and at which a liquid freezes, freezing point, are the same.) Finally ask: *Is the melting point the same for all substances? What about the freezing point?* (No, each substance has its own melting and freezing point.)

Students should complete Activity 8 in pairs and Activity 9 individually. Discuss and correct in open class.

3.1.2. Change from liquid ⇔ gas

Before reading explain that there are two types of vaporisation and that in one of them, liquids become gases faster than in the other. Give the examples of (1) not needing to use a hairdryer in the summer (evaporation) and (2) the water vapour that appears when you put pasta in boiling water (boiling). Ask students: *Which is faster?* (The latter.)

See if students can work out what boiling point means. They should be able to deduce this, as it's similar to melting and freezing points. (The temperature at which a liquid boils.)

Read and listen to the text with the students, stopping the recording and explaining where necessary. Then students should reread it alone and answer: *Why do liquids turn into gases faster during boiling than during evaporation?* (With boiling, the change occurs at a fixed temperature in the whole substance at the same time, whereas evaporation occurs at any temperature and only on the surface of the liquid.)

To reinforce knowledge, experiment boiling different substances to find out their different boiling points and see if their temperature changes while boiling. Alternatively watch Video 7.

Video 7: BOILING POINTS

This video shows the different boiling points of water, margarine and liquid nitrogen. It also demonstrates how the air in a balloon condenses into liquid when dipped into liquid nitrogen.

Ask students to complete Activity 10 individually before discussing first in pairs and then in open class.

3.2. A heating curve

Discuss what a heating curve graph and a cooling curve graph could represent. If necessary, give them a clue: they show temperature during a period of time; or use gestures.

Students should read the text individually. Tell them to raise their hand once they have found the answer to the questions. Read the box of **Gas *vs* vapour.** Ensure that students understand the difference between them. Now listen to the recording of the text to ensure comprehension.

Students should now complete Activities 11 and 12 individually and Activity 13 in pairs. Check their answers for Activities 11 and 12 and discuss Activity 13.

Finally, ask students to add any new vocabulary to their Quizlet flashcard set.

EXTRA RESOURCES

AUDIO
TALKING BOOK
INTERACTIVE ACTIVITIES

Answer key

Evaluate

8. Why do you think we refer to sea level? Research and find out.

The freezing point of a substance changes at different pressure. If you decrease the pressure the freezing point of water will increase slightly. That is why we talk about sea level where the atmospheric pressure is higher.

Understand

9. What is the relationship between the temperature at which a substance melts and the temperature at which the same substance freezes?

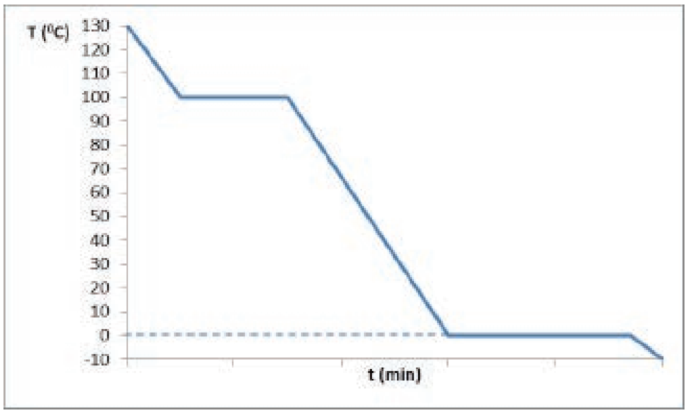
It is the same temperature.

10. Does a liquid have to boil to change from liquid to gas? Explain your answer with an example.

No, a liquid can also change from liquid to gas by evaporating, which occurs at any temperature (unlike boiling). The only difference is the speed at which the change occurs. Examples: drying our clothes during summer or winter; the water cycle.

Apply

11. Draw the cooling graph of water going from water vapour at 130 °C and cooling down to −10 °C.



Analyse

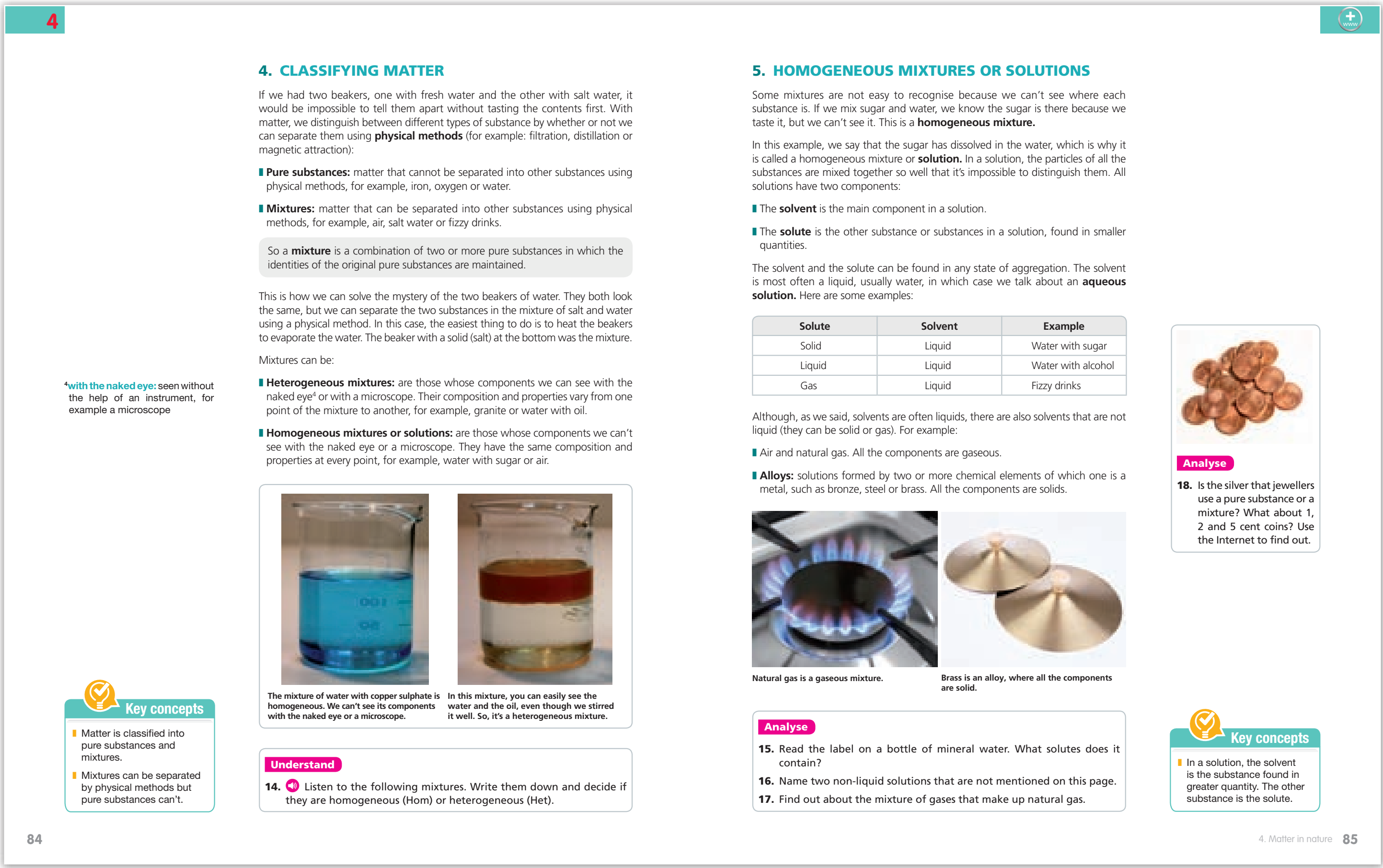
12. Work out from the graph above what the aggregation state of water is at 50°C and at 125°C.

At 50 °C, water is in a liquid state. At 125 °C, water is in a gaseous state (water vapour).

Create

13. Describe in detail how you would carry out an experiment into the changes of state of water in the laboratory. Include all the materials you would need.

Answer is in section **Work and Experimentation Techniques** on page 94 of the Student's book.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4. CLASSIFYING MATTER

If we had two beakers, one with fresh water and the other with salt water, it would be impossible to tell them apart without tasting the contents first. With matter, we distinguish between different types of substance by whether or not we can separate them using **physical methods** (for example: filtration, distillation or magnetic attraction):

- **Pure substances:** matter that cannot be separated into other substances using physical methods, for example, iron, oxygen or water.
- **Mixtures:** matter that can be separated into other substances using physical methods, for example, air, salt water or fizzy drinks.

So a **mixture** is a combination of two or more pure substances in which the identities of the original pure substances are maintained.

This is how we can solve the mystery of the two beakers of water. They both look the same, but we can separate the two substances in the mixture of salt and water using a physical method. In this case, the easiest thing to do is to heat the beakers to evaporate the water. The beaker with a solid (salt) at the bottom was the mixture.

Mixtures can be:

- **Heterogeneous mixtures:** are those whose components we can see with the naked eye[4] or with a microscope. Their composition and properties vary from one point of the mixture to another, for example, granite or water with oil.
- **Homogeneous mixtures or solutions:** are those whose components we can't see with the naked eye or a microscope. They have the same composition and properties at every point, for example, water with sugar or air.

[4]**with the naked eye:** seen without the help of an instrument, for example a microscope

The mixture of water with copper sulphate is homogeneous. We can't see its components with the naked eye or a microscope.

In this mixture, you can easily see the water and the oil, even though we stirred it well. So, it's a heterogeneous mixture.

Key concepts

- Matter is classified into pure substances and mixtures.
- Mixtures can be separated by physical methods but pure substances can't.

Understand

14. Listen to the following mixtures. Write them down and decide if they are homogeneous (Hom) or heterogeneous (Het).

84

5. HOMOGENEOUS MIXTURES OR SOLUTIONS

Some mixtures are not easy to recognise because we can't see where each substance is. If we mix sugar and water, we know the sugar is there because we taste it, but we can't see it. This is a **homogeneous mixture.**

In this example, we say that the sugar has dissolved in the water, which is why it is called a homogeneous mixture or **solution.** In a solution, the particles of all the substances are mixed together so well that it's impossible to distinguish them. All solutions have two components:

- The **solvent** is the main component in a solution.
- The **solute** is the other substance or substances in a solution, found in smaller quantities.

The solvent and the solute can be found in any state of aggregation. The solvent is most often a liquid, usually water, in which case we talk about an **aqueous solution.** Here are some examples:

Solute	Solvent	Example
Solid	Liquid	Water with sugar
Liquid	Liquid	Water with alcohol
Gas	Liquid	Fizzy drinks

Although, as we said, solvents are often liquids, there are also solvents that are not liquid (they can be solid or gas). For example:

- Air and natural gas. All the components are gaseous.
- **Alloys:** solutions formed by two or more chemical elements of which one is a metal, such as bronze, steel or brass. All the components are solids.

Natural gas is a gaseous mixture.

Brass is an alloy, where all the components are solid.

Analyse

15. Read the label on a bottle of mineral water. What solutes does it contain?

16. Name two non-liquid solutions that are not mentioned on this page.

17. Find out about the mixture of gases that make up natural gas.

Analyse

18. Is the silver that jewellers use a pure substance or a mixture? What about 1, 2 and 5 cent coins? Use the Internet to find out.

Key concepts

- In a solution, the solvent is the substance found in greater quantity. The other substance is the solute.

4. Matter in nature 85

4. Classifying matter

You will need three images, in digital or print format, of: (1) a pure substance; (2) a heterogeneous mixture; (3) a homogeneous mixture. These images will be used throughout the entire lesson. Note: At the end of this lesson there is also an optional activity, which requires you to bring in 10 images of different substances for students to categorise in class.

With books still closed, tell the students that matter can also be classified according to the substances it is made of. Ask them how they would classify matter following this criterion. To help them, show them the three images as explained above and ask them to describe the differences.

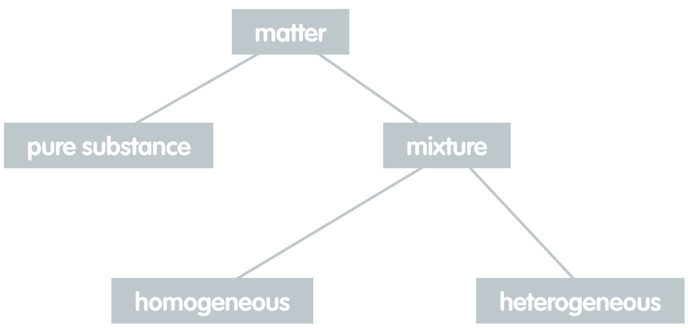
From Unit 3, Students should already know what pure substances and mixtures are. Scaffold their answers if necessary, as follows: Point at the pure substance and ask: *How many substances can you see?* (One.) *Therefore we call this a ______ substance.* Next point at image of the heterogeneous mixture, since it is more obvious that it's a mixture than a homogeneous mixture and ask: *How many substances can you see?* (The answer depends on the mixtures you have selected. Usually there are two substances.) *Therefore we call this a ______.*

In open class, read and listen to the text until the end of the grey box. Ask students to identify which is the pure substance and which is the mixture in the two examples provided at the beginning of the section (water is a pure substance and salt water is a mixture).

Show the three images of substances to the students again. Point out how two of the substances are in fact mixtures, even though they look somewhat different. Ask the students to describe the mixtures and try to reach a conclusion, as a class, on how to classify them. Scientific terms are not necessary. The aim is for them to be able to distinguish the differences in appearance between homogeneous and heterogeneous mixtures.

Read the rest of the section as a class, so that students can find out how we name and distinguish these two types of mixtures. When you have finished, you can discuss the differences between the conclusions discussed before and what they have read.

If you have time, play a game to summarise and practise the contents learnt. In groups of 4 show the groups the images you have brought in (10 in total). Students should classify each substance. You could draw a diagram to help them. Half-way through the game you could delete it. The group with more correct answers wins.



Students should complete listening Activity 14 individually.

5. Homogeneous mixtures or solutions

Tell students that in this section they are going to identify and classify the different components in a homogeneous mixture (also known as solution).

Before you read the section, ask students if they know what the criterion is for classifying the different components (the amount found of each component).

Read and listen to the text to find out the answer to the previous question. Then ask the following questions: *In what state are solvents often found?* (Liquid.) *What are the two examples mentioned of solvents that are not in a liquid state? In what state are they?* (Air in natural gas - all the components are gaseous; and alloys - all the components are solid.)

Ask students to complete the following online test to revise the concepts studies in this section. Help them when needed and stress this does not count for any marks.

Weblink 3: SOLUTE *VS* SOLVENT

This interactive test tests knowledge of solvents and solutions. To answer certain questions students will need to use logic.

Ask students to complete Activities 15, 16, 17 and 18 individually. If you have access to Internet, they can answer these in class, if not, set them as homework.

Finally, ask students to add any new vocabulary to their Quizlet flashcard set.

EXTRA RESOURCES

AUDIO
TALKING BOOK
INTERACTIVE ACTIVITIES

Answer key

Understand

14. Listen to the following mixtures. Write them down and decide if they are homogeneous (Hom) or heterogeneous (Het).

a) **Sand and iron.** Heterogeneous mixture
b) **Water with salt.** Homogeneous mixture
c) **Air.** Homogeneous mixture
d) **Normal sugar with icing sugar.** Heterogeneous mixture
e) **Water with vinegar.** Homogeneous mixture
f) **Oil and vinegar.** Heterogeneous mixture

Analyse

15. Read the label on a bottle of mineral water. What solutes does it contain?

Students' own answers. Examples: bicarbonates, sulfates, chlorides, calcium, magnesium and sodium.

16. Name two non-liquid solutions that are not mentioned on this page.

Students' own answers. Examples: amalgams, hydrogen in platinum, clay, other alloys not mentioned in the text (such as constantan and alnico).

17. Find out about the mixture of gases that make up natural gas.

Natural gas is a homogeneous mixture of methane and other gases in much smaller proportions, such as ethane, propane and butane, nitrogen and carbon dioxide.

18. Is the silver that jewellers use a pure substance or a mixture? What about 1, 2 and 5 cent coins? Use the Internet to find out.

All the cases mentioned are alloys, therefore mixtures.

4

5.1. Calculating concentrations

To work with solutions, we need to know the proportion of the solute and solvent, that is, the concentration.

The **concentration of a solution** indicates the quantity of the solute in a given quantity of a solvent or of a solution.

5.1.1. Percent composition (by mass)

There are many ways to express a concentration but the easiest and most commonly-used one is the percent composition (by mass).

The **percent composition** of a solute in a solution is the mass of solute found in 100 units of the mass of the solution. If we use grams as the units of mass:

$$\% \text{ by mass (solute)} = \frac{\text{mass of the solute (g)}}{\text{mass of the solution (g)}} \times 100$$

It's not necessary to work in grams. You just have to make sure to use the same units of mass in the numerator and denominator.

The result will not have units because it is a percentage.

A sterling silver ring

EXAMPLE EXERCISE

1. **To make a 925 sterling silver ring, a jeweller uses 15.73 g of pure silver and 1.27 g of copper. Calculate the percent composition of the solute in the alloy.**

First, we have to work out what the solute is and what the solvent is in the solution (alloy):

- Solute → copper (in a lower proportion)
- Solvent → silver (in a higher proportion)

Next, we calculate the mass of the solution from the data:

$$m \text{ (solute)} = 1.27\text{ g}$$
$$m \text{ (solvent)} = 15.73\text{ g}$$
$$m \text{ (solution)} = m \text{ (solute)} + m \text{ (solvent)} = 1.27\text{ g} + 15.73\text{ g} = 17\text{ g}$$

Finally, we substitute our values in the equation for the percent composition of the solute:

$$\% \textit{ by mass} \text{ (solute)} = \frac{\text{mass of the solute (g)}}{\text{mass of the solution (g)}} \times 100 = \frac{1.27\text{ g}}{17\text{ g}} \times 100 \approx 7.5\ \%$$

Therefore, 925 Sterling Silver always contains 92.5 % of pure silver and 7.5 % of another metal, usually copper, as in this case.

Apply

19. Calculate the mass of acetic acid in 10 g of a commercial vinegar with a label indicating a percent composition of 6%.

5.1.2. Mass concentration

Another common way to express a concentration relates the amount of solute to the volume of the solution.

The **mass concentration (g/L)** of a solute in a solution indicates the mass of the solute (in grams) that is dissolved in every litre of the solution:

$$\text{g/L} = \frac{\text{mass of the solute (g)}}{\text{volume of the solution (L)}}$$

Remember the relationship that exists between units of capacity and volume: if we make a cube of 1 dm and we fill it up to the top with liquid, the volume of the liquid in the cube is 1 L. So:

1 dm^3 is equivalent to 1 L

EXAMPLE EXERCISE

2. **A student has to prepare an iodine alcoholic solution by dissolving 15 g of iodine in alcohol to obtain a solution with a volume of 250 mL. Calculate the mass concentration of the final solution.**

As in the previous example exercise, we first have to identify the solute and the solvent:

- Solute → iodine (in a smaller quantity)
- Solvent → alcohol (in a greater quantity)

Next, given the grams of the solute (15 g), we have to calculate the volume of the solution in litres:

$$m \text{ (solute)} = 15\text{ g}$$
$$V \text{ (solution)} = 250\text{ mL} = 0.25\text{ L}$$

Finally, we substitute these values into the mass concentration equation:

$$\text{g/L} = \frac{\text{mass of the solute (g)}}{\text{volume of the solution (L)}} = \frac{15\text{ g}}{0.25\text{ L}} = 60\text{ g/L}$$

Therefore, the solution will have a concentration of 60 g/L.

Apply

20. Calculate the mass concentration in g/L of a solution that has 7 g of a pure substance in half a litre of water.

21. In how many litres of water would we have to dissolve 100 g of salt to obtain a solution with a mass concentration of 5 g/L?

22. What is the mass concentration of a solution with 12 g of potassium chloride and 300 cm of water?

23. What is the percent composition of sugar in water if it contains 30 g of solute in 600 g of water?

24. We know that the mass concentration of sodium chloride in a solution is 8 %. How many grams of sodium chloride is dissolved in 75 g of the solution?

Key concepts

- The mass concentration of a solution gives the quantity of solute in a certain quantity of a solution.
- There are different ways to express the concentration: in percent composition (by mass) or in g/L.

5.1. Calculating concentrations

Tell the students that now that they know that there are different components in a solution (the solute and solvent) they will now learn how to calculate their concentrations. Make sure they understand what we mean by concentrations (concentrations tell us how much there is of a particular substance within another substance).

Read and listen to this section in open class, stressing and explaining if necessary the meaning of concentration. Explain that there are two common ways of finding the concentrations of solutes and solvents in solutions: percent composition (by mass) and mass concentration.

5.1.1. Percent composition (by mass)

Before reading and listening to this section, ask students if they know how the percent composition (by mass) will be expressed (as a percentage). Also elicit what information they think they will need in order to calculate the percentage of a solute in a solution (they will need the mass of the solute and of the solution). Not everyone will know and this is not a problem as they will be taught as they study the unit.

Take time to go through the whole section carefully with the class. Elicit the answers to the previous questions if the students didn't know before. To make sure the students have understood the equation properly, ask them: *Could we complete the equation using the mass of the solute in kilograms and the mass of the solution in grams?* (No, we must always use the same unit of mass for both the solute and solution, if not the answer will be wrong.)

Ask students to complete activity 19 individually. Once they have finished, check their answers as a class. Explain carefully any wrong answers to ensure everyone understands.

5.1.2. Mass concentration

Before reading and listening to this section, tell the students that another common way to find out the concentration of the different components in a solution is by mass concentration, which calculates how many grams of solute there are per litre of solution. Ask them if they can work out what the equation will be. To help them, emphasise the words **grams per litre**, or write up on the board g/L so that they see what **per** means. You can also ask them what information will be necessary in order to complete the equation. They should now know, from the previous equation, that they need to know the mass of the solute. Some of the students might be able to deduce from the g/L written on the board that they will also need to know how much solution there is in relation to a litre.

Read the text slowly in open class, ensuring everyone understands and elicit the answers to the previous questions if they weren't answered before.

Students should now complete Activities 20, 21, 22, 23 and 24 individually. Once they have finished, go over their results as a class.

Finally, ask students to add any new vocabulary to their Quizlet flashcard set.

EXTRA RESOURCES

AUDIO

TALKING BOOK

INTERACTIVE ACTIVITIES

Answer key

Apply

19. **Calculate the mass of acetic acid in 10 g of a commercial vinegar with a label indicating a percent composition of 6%.**

Solute → acetic acid (in a larger proportion)

Solvent → water (in a smaller proportion)

m (solution) = 10 g

% m/m (acetic acid) = 6%

Finally, we substitute our values in the equation for the percent composition of the solute:

$$\% \ m/m \ (\text{acetic acid}) = \frac{\text{mass of acetic acid (g)}}{\text{mass of solution (g)}} \times 100$$

$$\text{mass of acetic acid} = \frac{\% \ m/m \ (\text{acetic acid}) \times \text{mass of solution (g)}}{100} = \frac{6 \times 10\text{g}}{100} = 0.6\text{g}$$

20. **Calculate the mass concentration in g/L of a solution that has 7 g of a pure substance in half a litre of water.**

m (solute) = 7 g

V (solution) = 0.5 L

$$\text{mass concentration} = \frac{\text{mass of solute (g)}}{\text{volume of solution (L)}} = \frac{7 \text{ g}}{0.5 \text{ L}} = 14 \text{ g/L}$$

21. **In how many litres of water would we have to dissolve 100 g of salt to obtain a solution with a mass concentration of 5 g/L?**

$$\text{volume of solution (L)} = \frac{\text{mass of salt (g)}}{\text{mass concentration}} = \frac{100 \text{ g}}{5 \text{ g/L}} = 20 \text{ L of water}$$

22. **What is the mass concentration of a solution with 12 g of potassium chloride and 300 cm³ of water?**

300 cm^3 = 0.3 L

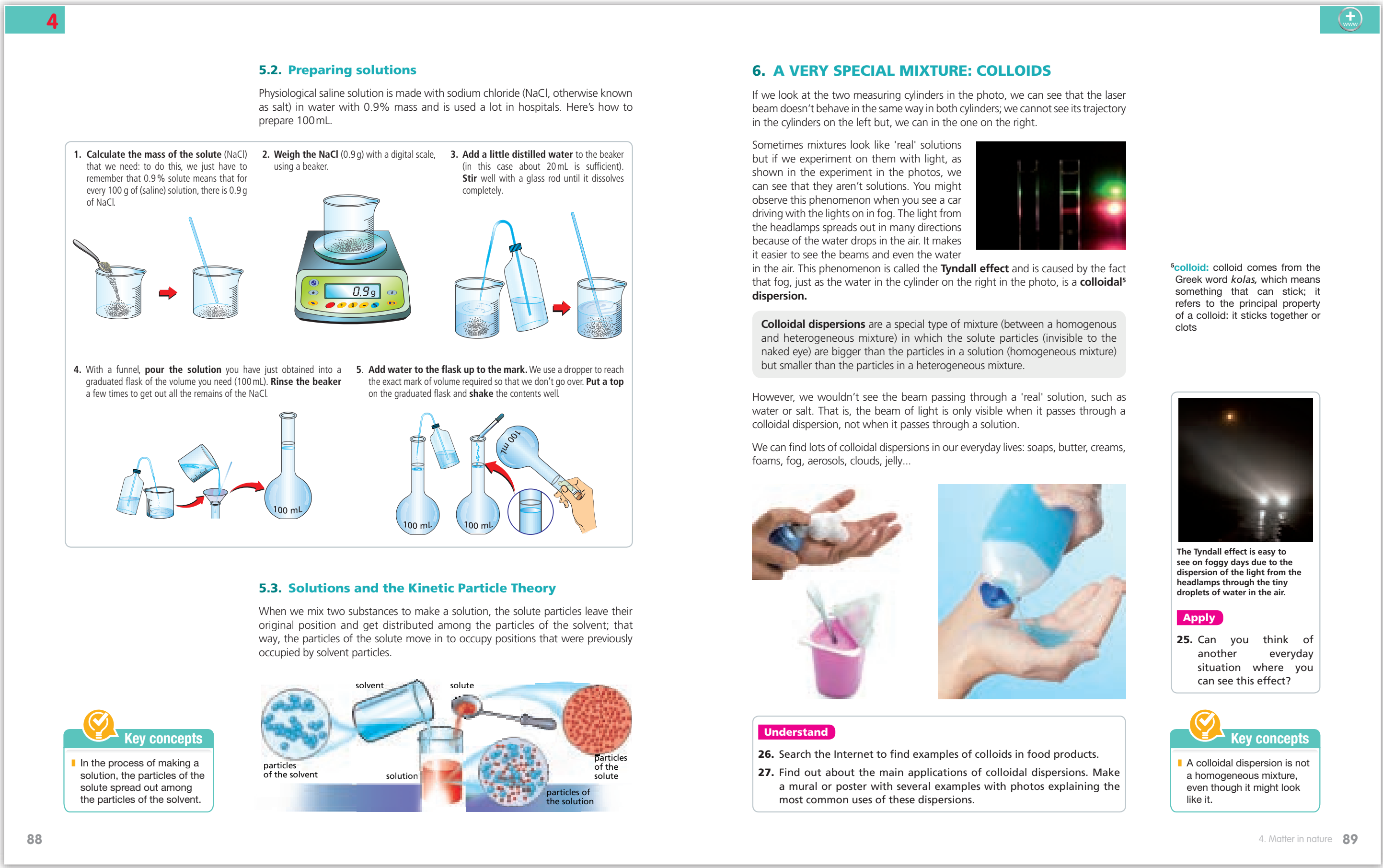
$$\text{mass concentration} = \frac{\text{mass of solute (g)}}{\text{volume of solution (L)}} = \frac{12 \text{ g}}{0.3 \text{ L}} = 40 \text{ g/L}$$

$$\% \ m/m \ (\text{solute}) = \frac{\text{mass of sugar (g)}}{\text{mass of solution (g)}} \times 100 = \frac{30 \text{ g}}{(30 + 600)\text{g}} \times 100 = 4.8\% \text{ of sugar}$$

23. **What is the percent composition of sugar in water if it contains 30 g of solute in 600 g of water?**

24. **We know that the mass concentration of sodium chloride in a solution is 8 %. How many grams of sodium chloride is dissolved in 75 g of the solution?**

$$\text{mass of NaI} = \frac{\% \ m/m \ (\text{NaI}) \times \text{mass of solution (g)}}{100} = \frac{8 \times 75\text{g}}{100} = 6\text{g}$$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5.2. Preparing solutions

Physiological saline solution is made with sodium chloride (NaCl, otherwise known as salt) in water with 0.9% mass and is used a lot in hospitals. Here's how to prepare 100 mL.

1. **Calculate the mass of the solute** (NaCl) that we need: to do this, we just have to remember that 0.9 % solute means that for every 100 g of (saline) solution, there is 0.9 g of NaCl.
2. **Weigh the NaCl** (0.9 g) with a digital scale, using a beaker.
3. **Add a little distilled water** to the beaker (in this case about 20 mL is sufficient). **Stir** well with a glass rod until it dissolves completely.
4. With a funnel, **pour the solution** you have just obtained into a graduated flask of the volume you need (100 mL). **Rinse the beaker** a few times to get out all the remains of the NaCl.
5. **Add water to the flask up to the mark.** We use a dropper to reach the exact mark of volume required so that we don't go over. **Put a top** on the graduated flask and **shake** the contents well.

0.9 g
100 mL
100 mL
100 mL
100 mL

5.3. Solutions and the Kinetic Particle Theory

When we mix two substances to make a solution, the solute particles leave their original position and get distributed among the particles of the solvent; that way, the particles of the solute move in to occupy positions that were previously occupied by solvent particles.

solvent
solute
particles of the solvent
solution
particles of the solute
particles of the solution

Key concepts

- In the process of making a solution, the particles of the solute spread out among the particles of the solvent.

88

6. A VERY SPECIAL MIXTURE: COLLOIDS

If we look at the two measuring cylinders in the photo, we can see that the laser beam doesn't behave in the same way in both cylinders; we cannot see its trajectory in the cylinders on the left but, we can in the one on the right.

Sometimes mixtures look like 'real' solutions but if we experiment on them with light, as shown in the experiment in the photos, we can see that they aren't solutions. You might observe this phenomenon when you see a car driving with the lights on in fog. The light from the headlamps spreads out in many directions because of the water drops in the air. It makes it easier to see the beams and even the water in the air. This phenomenon is called the **Tyndall effect** and is caused by the fact that fog, just as the water in the cylinder on the right in the photo, is a **colloidal[5] dispersion.**

Colloidal dispersions are a special type of mixture (between a homogenous and heterogeneous mixture) in which the solute particles (invisible to the naked eye) are bigger than the particles in a solution (homogeneous mixture) but smaller than the particles in a heterogeneous mixture.

However, we wouldn't see the beam passing through a 'real' solution, such as water or salt. That is, the beam of light is only visible when it passes through a colloidal dispersion, not when it passes through a solution.

We can find lots of colloidal dispersions in our everyday lives: soaps, butter, creams, foams, fog, aerosols, clouds, jelly...

[5] **colloid:** colloid comes from the Greek word *kolas,* which means something that can stick; it refers to the principal property of a colloid: it sticks together or clots

The Tyndall effect is easy to see on foggy days due to the dispersion of the light from the headlamps through the tiny droplets of water in the air.

Apply

25. Can you think of another everyday situation where you can see this effect?

Understand

26. Search the Internet to find examples of colloids in food products.
27. Find out about the main applications of colloidal dispersions. Make a mural or poster with several examples with photos explaining the most common uses of these dispersions.

Key concepts

- A colloidal dispersion is not a homogeneous mixture, even though it might look like it.

4. Matter in nature 89

5.2. Preparing solutions

Remind the students that in the last lesson they learnt how to calculate the concentration of solutes in solutions. Tell them that in this lesson they are going to learn how to prepare solutions.

Before students read and listen to the section, check that they remember the necessary vocabulary needed to understand this section. Check by asking these questions: *Can you remember what two components are found in solutions?* (Solute and solvents.) *Which ones are found in a bigger proportion and which are found in a smaller proportion?* (The solvent is found in a bigger proportion and the solute in a smaller proportion.)

Next ask students to discuss the following question in pairs: *Before we start making a solution, we need to know two very important pieces of information. What do you think they are? If we get this information wrong, we will make the wrong solution.* (The amount of solvent and solute need to be known. We can know this by the percent composition of the solute or by its mass concentration.) Discuss as a class and find out if anyone knew or worked out the correct answer.

Now make the saline solution or read and listen to this section in open class, stopping where necessary to make sure everyone has understood. When you have finished, ask the students, in pairs, to consider the following question: *What will happen to the solution if we add 110 mL of water instead of 100 mL?* (The solution will no longer be the correct physiological saline solution that hospitals need. When we prepare solutions, they have to have the exact concentrations that we need.) Discuss the answer as a class and the importance that these calculations have in the real world.

5.3. Solutions and the Kinetic Particle Theory

Read and listen to this section in open class referring to the diagram. Next ask the following question: *What happens to the solute particles when we make a solution?* (They leave their original position and get distributed among the particles of the solvent. This way they move in to occupy positions that were previously occupied by solvent particles.)

If you would like to test students on the contents so far, ask them to complete the online test in Weblink 4.

Weblink 4: KINETIC PARTICLE THEORY

This weblink has a test I which will test students' knowledge.

6. A very special mixture: colloids

Explain to the students that there is a third special type of solution that is neither a homogeneous nor a heterogeneous mixture. It is called a colloidal dispersion (colloid).

Tell the students that they are going to read the text as a class and that that they have to find the answer to the following question. *How can we distinguish a colloid from a 'real' solution?* (By shining a light through it. If we see the light pass through the substance, it is a colloid.

Read and listen to the section as a class. When you have finished, elicit the answer to the question.

To help students understand the differences between homogeneous solutions, heterogeneous solutions and colloids, watch the following video.

Video 8: SOLUTIONS, SUSPENSIONS AND COLLOIDS

This animated video explains the differences between homogeneous mixtures, heterogeneous mixtures and colloids by carrying out an experiment.

Ask students to complete Activity 25 in pairs. Elicit some example answers and discuss as a class. Students should complete Activity 26 individually. Activity 27 should be completed in pairs or small multi-activity groups, as they have to do quite a lot of research. Activities 26 and 27 can be done in class if you have access to Internet or at home as homework.

Finally, ask students to add any new vocabulary to their Quizlet flashcard set.

EXTRA RESOURCES

AUDIO
TALKING BOOK
INTERACTIVE ACTIVITIES

Answer key

Apply

25. **Can you think of another everyday situation where you can see this effect?**

Students' own answers. An example is when a beam of light shines through a window and into a room; we can see dust particles floating in the air.

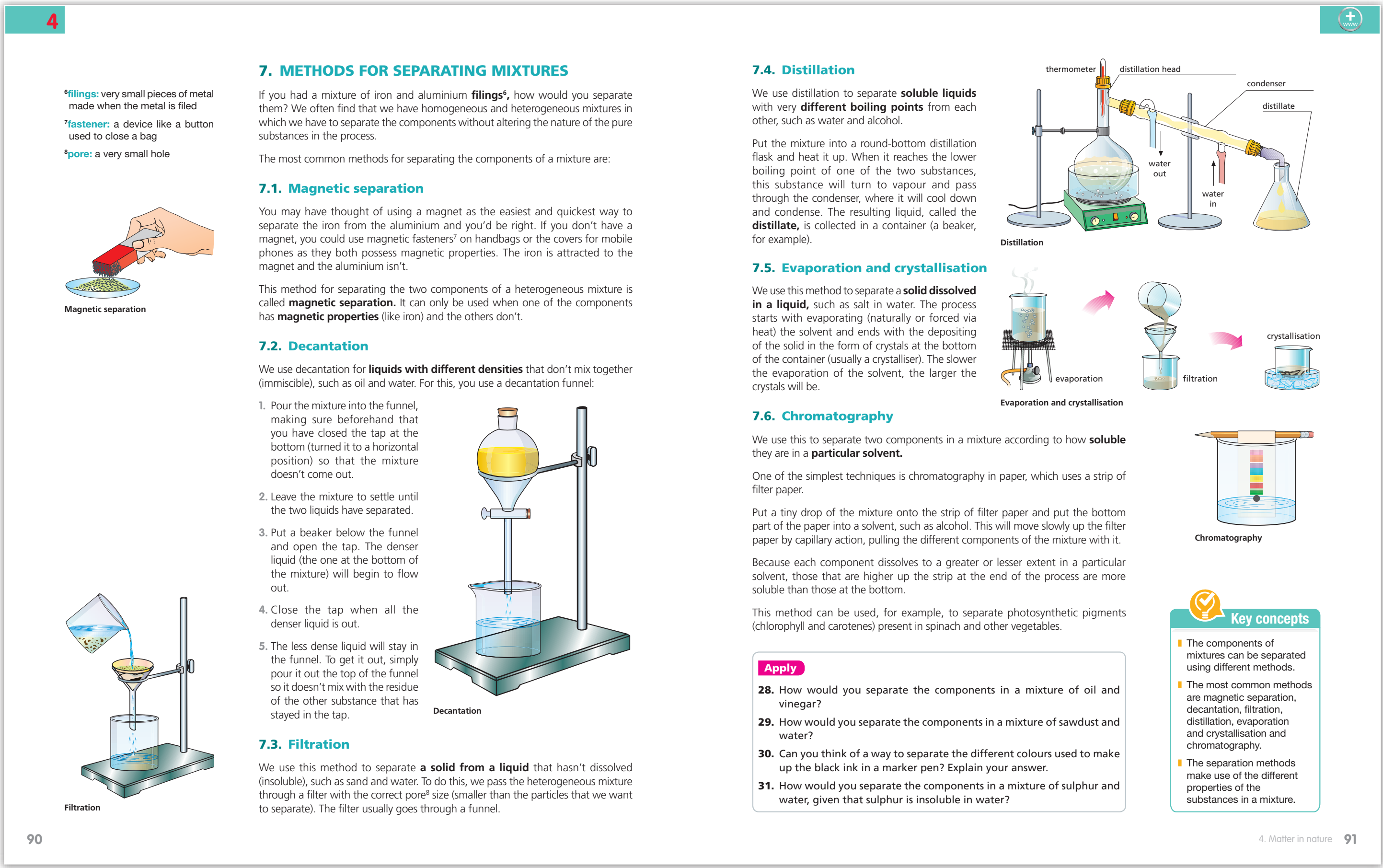
Understand

26. **Search the Internet to find examples of colloids in food products.**

Students' own answers. Examples: jelly, milk, mayonnaise, butter and merengue.

27. **Find out about the main applications of colloidal dispersions. Make a mural or poster with several examples with photos explaining the most common uses of these dispersions.**

Students' own answers.



4

[6]**filings:** very small pieces of metal made when the metal is filed

[7]**fastener:** a device like a button used to close a bag

[8]**pore:** a very small hole

Magnetic separation

Filtration

7. METHODS FOR SEPARATING MIXTURES

If you had a mixture of iron and aluminium **filings[6],** how would you separate them? We often find that we have homogeneous and heterogeneous mixtures in which we have to separate the components without altering the nature of the pure substances in the process.

The most common methods for separating the components of a mixture are:

7.1. Magnetic separation

You may have thought of using a magnet as the easiest and quickest way to separate the iron from the aluminium and you'd be right. If you don't have a magnet, you could use magnetic fasteners[7] on handbags or the covers for mobile phones as they both possess magnetic properties. The iron is attracted to the magnet and the aluminium isn't.

This method for separating the two components of a heterogeneous mixture is called **magnetic separation.** It can only be used when one of the components has **magnetic properties** (like iron) and the others don't.

7.2. Decantation

We use decantation for **liquids with different densities** that don't mix together (immiscible), such as oil and water. For this, you use a decantation funnel:

1. Pour the mixture into the funnel, making sure beforehand that you have closed the tap at the bottom (turned it to a horizontal position) so that the mixture doesn't come out.
2. Leave the mixture to settle until the two liquids have separated.
3. Put a beaker below the funnel and open the tap. The denser liquid (the one at the bottom of the mixture) will begin to flow out.
4. Close the tap when all the denser liquid is out.
5. The less dense liquid will stay in the funnel. To get it out, simply pour it out the top of the funnel so it doesn't mix with the residue of the other substance that has stayed in the tap.

Decantation

7.3. Filtration

We use this method to separate **a solid from a liquid** that hasn't dissolved (insoluble), such as sand and water. To do this, we pass the heterogeneous mixture through a filter with the correct pore[8] size (smaller than the particles that we want to separate). The filter usually goes through a funnel.

90

7.4. Distillation

We use distillation to separate **soluble liquids** with very **different boiling points** from each other, such as water and alcohol.

Put the mixture into a round-bottom distillation flask and heat it up. When it reaches the lower boiling point of one of the two substances, this substance will turn to vapour and pass through the condenser, where it will cool down and condense. The resulting liquid, called the **distillate,** is collected in a container (a beaker, for example).

thermometer
distillation head
condenser
distillate
water out
water in

Distillation

7.5. Evaporation and crystallisation

We use this method to separate a **solid dissolved in a liquid,** such as salt in water. The process starts with evaporating (naturally or forced via heat) the solvent and ends with the depositing of the solid in the form of crystals at the bottom of the container (usually a crystalliser). The slower the evaporation of the solvent, the larger the crystals will be.

evaporation
filtration
crystallisation

Evaporation and crystallisation

7.6. Chromatography

We use this to separate two components in a mixture according to how **soluble** they are in a **particular solvent.**

One of the simplest techniques is chromatography in paper, which uses a strip of filter paper.

Put a tiny drop of the mixture onto the strip of filter paper and put the bottom part of the paper into a solvent, such as alcohol. This will move slowly up the filter paper by capillary action, pulling the different components of the mixture with it.

Because each component dissolves to a greater or lesser extent in a particular solvent, those that are higher up the strip at the end of the process are more soluble than those at the bottom.

This method can be used, for example, to separate photosynthetic pigments (chlorophyll and carotenes) present in spinach and other vegetables.

Chromatography

Apply

28. How would you separate the components in a mixture of oil and vinegar?

29. How would you separate the components in a mixture of sawdust and water?

30. Can you think of a way to separate the different colours used to make up the black ink in a marker pen? Explain your answer.

31. How would you separate the components in a mixture of sulphur and water, given that sulphur is insoluble in water?

Key concepts

- The components of mixtures can be separated using different methods.
- The most common methods are magnetic separation, decantation, filtration, distillation, evaporation and crystallisation and chromatography.
- The separation methods make use of the different properties of the substances in a mixture.

4. Matter in nature 91

7. Methods for separating mixtures

Before the lesson starts, write the following mixtures on the board:

- iron and aluminium filings
- oil and water
- sand and water
- water and alcohol
- salt in water
- photosynthetic pigments in a spinach leaf.

Tell the students that in this lesson they will learn about the different methods used to separate mixtures and that at the end of the lesson they will carry out a science experiment in which they will separate the photosynthetic pigments in a spinach leaf.

Divide the students into multi-ability groups of 4 or 5 and ask them to discuss how they would separate the mixtures. If necessary, take 5 minutes to provide some scaffolding questions or carry out some practical examples with them.

Write up key terminology on the board. These mixtures are mentioned in this section, each under the separating method used to separate them, so students will read the text to find out what method and laboratory equipment they could use to separate each mixture. At the end of the lesson they can compare their initial ideas with the separating methods used.

Read and listen to the text in open class and elicit from students which separating method is used to separate each mixture. To make sure they understand which separating methods work with which properties, elicit the answers to the following questions: (1) *What properties make it possible to separate iron and aluminium filings using magnetic separation?* (Since iron is magnetic and aluminium isn't, the iron will stick to the magnet but the aluminium won't.) (2) *What properties make it possible to separate oil and water using decantation?* (Oil and water have different densities so they don't mix together; they are immiscible. As they don't mix, one substance stays on top of the other, so, using the right equipment, you can easily remove the bottom substance through a tap at the bottom.) (3) *What properties make it possible to separate sand and water using filtration?* (Sand is solid and water is liquid, but the sand is insoluble so it doesn't dissolve in the water. Therefore, the liquid passes through the filter paper leaving the sand behind.) (4) *What properties make it possible to separate water and alcohol using distillation?* (Alcohol and water have different boiling points, so when heated, the substance that has the lowest boiling point will evaporate first, which is then condensed.) (5) *What properties make it possible to separate salt in water using evaporation and crystallisation?* Salt is a solid and water is a liquid, but, unlike sand, salt does dissolve in a liquid. So all the water is evaporated leaving only the salt, which is then crystallised. (6) *What properties make it possible to separate the photosynthetic pigments in a spinach leaf using chromatography?* (The different photosynthetic pigments have a different solubility in alcohol, so when a filter paper is placed inside, those at the top will be more soluble.)

To help students remember the terminology and the key properties that determine which separating method to use, you can play a concentration game. For this you will need to previously prepare several sets of 12 cards: 6 with the names of the separating methods (a name per card) and 6 with images of the separating methods (one per card). Divide the students into groups of 3 or 4 and give each group a set of cards. A student lifts up two cards, if the cards are the name and image of the same separating method, they has to say what properties a mixture must have in order to be separated using that method. If the student answers correctly then they can keep the cards, if not, they must put the cards in the same place.

Write the different properties mixtures must have in order to be separated by the different methods on the board, as there are quite a lot to remember. This way, the student that needs to say them doesn't look at the board, but the others can check their answer.

Ask students to complete Activities 28-31 individually before discussing their answers as a class.

Complete the science experiment below with the students. You can do this in class or set it as homework. Make sure students see a demonstration of how to do this experiment before they do it. You can demonstrate the experiment yourself or use the video below.

Science experiment: SEPARATING PHOTOSYNTHETIC PIGMENTS IN A SPINACH LEAF

By carrying out this experiment, students will be putting into practice what they have learnt.

Video 9: CHLOROPHYLL CHROMATOGRAPHY

This short video explains how to separate photosynthetic pigments in a spinach leaf using chromatography in paper.

Finally, ask students to add any new vocabulary to their Quizlet flashcard set. This can be done in class or at home as homework. As you have finished the unit, you can tell students that they can share their flashcards sets if they want to.

EXTRA RESOURCES

AUDIO

TALKING BOOK

INTERACTIVE ACTIVITIES

Answer key

Apply

28. How would you separate the components in a mixture of oil and vinegar?

Using decantation.

29. How would you separate the components in a mixture of sawdust and water?

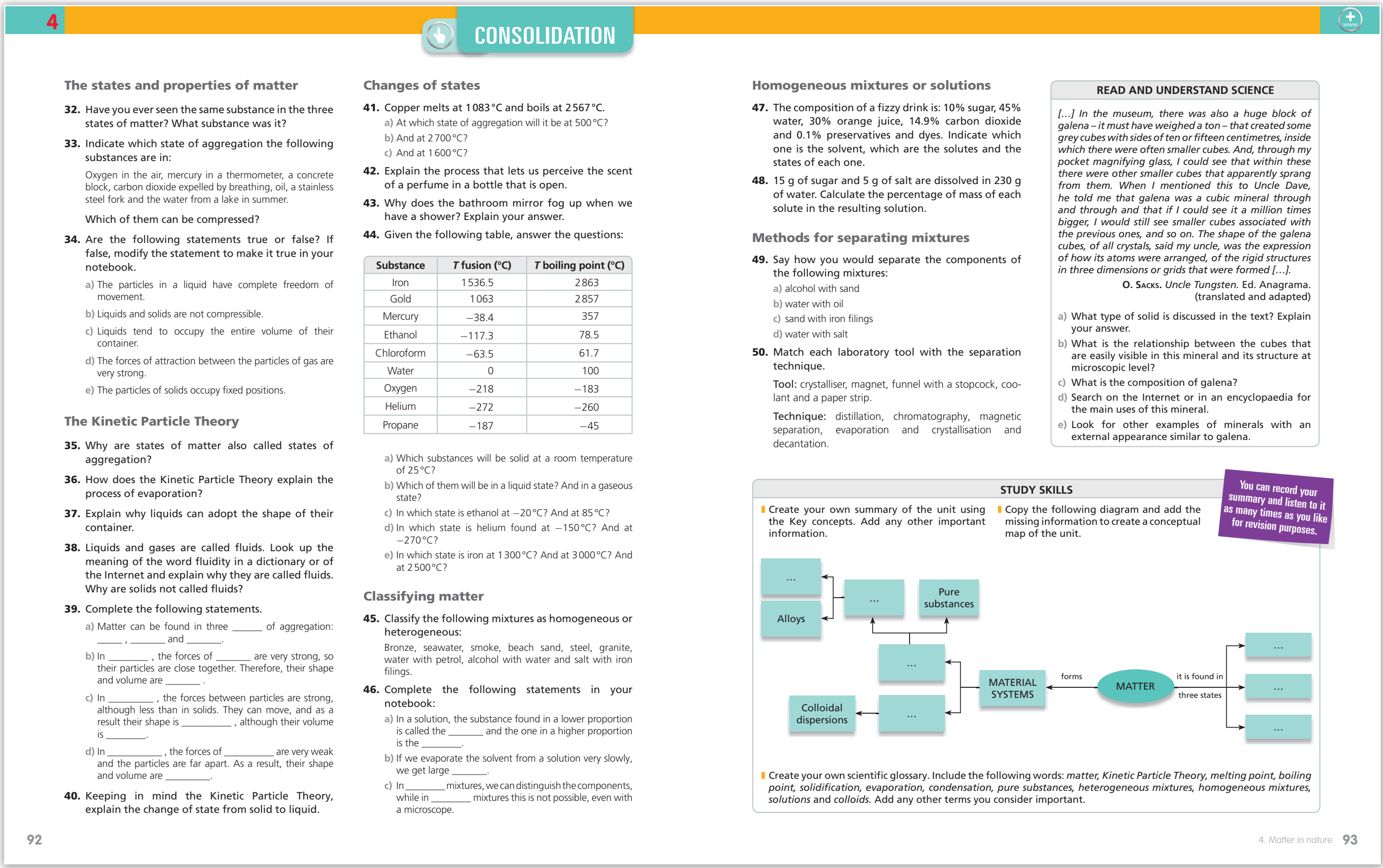
Since sawdust floats on water, we can use filtration or decantation and get rid of the sawdust carefully using a spatula or spoon.

30. Can you think of a way to separate the different colours used to make up the black ink in a marker pen? Explain your answer.

This can be done using chromatography in paper. We draw a horizontal line at the bottom of the filter paper and place only the bottom part in a beaker with a solvent (such as alcohol). The different colours will show at different heights in the filter paper according to how soluble they are in alcohol.

31. How would you separate the components in a mixture of sulphur and water, given that sulphur is insoluble in water?

Using filtration. We pass the mixture through a filter with the correct pore size (smaller than the particles of sulphur) and into a beaker. The water will pass through and the sulphur will stay in the filter.



4 CONSOLIDATION

The states and properties of matter

32. Have you ever seen the same substance in the three states of matter? What substance was it?

33. Indicate which state of aggregation the following substances are in:

Oxygen in the air, mercury in a thermometer, a concrete block, carbon dioxide expelled by breathing, oil, a stainless steel fork and the water from a lake in summer.

Which of them can be compressed?

34. Are the following statements true or false? If false, modify the statement to make it true in your notebook.

a) The particles in a liquid have complete freedom of movement.

b) Liquids and solids are not compressible.

c) Liquids tend to occupy the entire volume of their container.

d) The forces of attraction between the particles of gas are very strong.

e) The particles of solids occupy fixed positions.

The Kinetic Particle Theory

35. Why are states of matter also called states of aggregation?

36. How does the Kinetic Particle Theory explain the process of evaporation?

37. Explain why liquids can adopt the shape of their container.

38. Liquids and gases are called fluids. Look up the meaning of the word fluidity in a dictionary or of the Internet and explain why they are called fluids. Why are solids not called fluids?

39. Complete the following statements.

a) Matter can be found in three _____ of aggregation: _____ , _______ and _______.

b) In _______ , the forces of _______ are very strong, so their particles are close together. Therefore, their shape and volume are _______ .

c) In _________ , the forces between particles are strong, although less than in solids. They can move, and as a result their shape is __________ , although their volume is ________.

d) In __________ , the forces of __________ are very weak and the particles are far apart. As a result, their shape and volume are _________.

40. Keeping in mind the Kinetic Particle Theory, explain the change of state from solid to liquid.

Changes of states

41. Copper melts at 1 083 °C and boils at 2 567 °C.

a) At which state of aggregation will it be at 500 °C?

b) And at 2 700 °C?

c) And at 1 600 °C?

42. Explain the process that lets us perceive the scent of a perfume in a bottle that is open.

43. Why does the bathroom mirror fog up when we have a shower? Explain your answer.

44. Given the following table, answer the questions:

Substance	*T* fusion (°C)	*T* boiling point (°C)
Iron	1 536.5	2 863
Gold	1 063	2 857
Mercury	−38.4	357
Ethanol	−117.3	78.5
Chloroform	−63.5	61.7
Water	0	100
Oxygen	−218	−183
Helium	−272	−260
Propane	−187	−45

a) Which substances will be solid at a room temperature of 25 °C?

b) Which of them will be in a liquid state? And in a gaseous state?

c) In which state is ethanol at −20 °C? And at 85 °C?

d) In which state is helium found at −150 °C? And at −270 °C?

e) In which state is iron at 1 300 °C? And at 3 000 °C? And at 2 500 °C?

Classifying matter

45. Classify the following mixtures as homogeneous or heterogeneous:

Bronze, seawater, smoke, beach sand, steel, granite, water with petrol, alcohol with water and salt with iron filings.

46. Complete the following statements in your notebook:

a) In a solution, the substance found in a lower proportion is called the ________ and the one in a higher proportion is the _________.

b) If we evaporate the solvent from a solution very slowly, we get large ________.

c) In ________ mixtures, we can distinguish the components, while in ________ mixtures this is not possible, even with a microscope.

Homogeneous mixtures or solutions

47. The composition of a fizzy drink is: 10% sugar, 45% water, 30% orange juice, 14.9% carbon dioxide and 0.1% preservatives and dyes. Indicate which one is the solvent, which are the solutes and the states of each one.

48. 15 g of sugar and 5 g of salt are dissolved in 230 g of water. Calculate the percentage of mass of each solute in the resulting solution.

Methods for separating mixtures

49. Say how you would separate the components of the following mixtures:

a) alcohol with sand

b) water with oil

c) sand with iron filings

d) water with salt

50. Match each laboratory tool with the separation technique.

Tool: crystalliser, magnet, funnel with a stopcock, coolant and a paper strip.

Technique: distillation, chromatography, magnetic separation, evaporation and crystallisation and decantation.

READ AND UNDERSTAND SCIENCE

[…] In the museum, there was also a huge block of galena – it must have weighed a ton – that created some grey cubes with sides of ten or fifteen centimetres, inside which there were often smaller cubes. And, through my pocket magnifying glass, I could see that within these there were other smaller cubes that apparently sprang from them. When I mentioned this to Uncle Dave, he told me that galena was a cubic mineral through and through and that if I could see it a million times bigger, I would still see smaller cubes associated with the previous ones, and so on. The shape of the galena cubes, of all crystals, said my uncle, was the expression of how its atoms were arranged, of the rigid structures in three dimensions or grids that were formed […].

O. Sacks. *Uncle Tungsten.* Ed. Anagrama. (translated and adapted)

a) What type of solid is discussed in the text? Explain your answer.

b) What is the relationship between the cubes that are easily visible in this mineral and its structure at microscopic level?

c) What is the composition of galena?

d) Search on the Internet or in an encyclopaedia for the main uses of this mineral.

e) Look for other examples of minerals with an external appearance similar to galena.

STUDY SKILLS

You can record your summary and listen to it as many times as you like for revision purposes.

- Create your own summary of the unit using the Key concepts. Add any other important information.
- Copy the following diagram and add the missing information to create a conceptual map of the unit.

- Create your own scientific glossary. Include the following words: *matter, Kinetic Particle Theory, melting point, boiling point, solidification, evaporation, condensation, pure substances, heterogeneous mixtures, homogeneous mixtures, solutions* and *colloids.* Add any other terms you consider important.

92

4. Matter in nature 93

The states and properties of matter

32. Have you ever seen the same substance in the three states of matter? What substance was it?

Water can be found in a solid state (ice cubes, glaciers, snow…), in a liquid state (drinking water, rivers, lakes…) and in a gaseous state (water vapour when cooking, when we shower, geysers...).

33. Indicate which state of aggregation the following substances are in: oxygen in the air, mercury in a thermometer, a concrete block, carbon dioxide expelled by breathing, oil, a stainless steel fork and the water from a lake in summer. Which of them can be compressed?

- oxygen in the air

  gas (can be compressed)

- mercury in a thermometer

  liquid (can't be compressed)

- a concrete block

  solid (can't be compressed)

- carbon dioxide expelled by breathing

  gas (can be compressed)

- oil

  liquid (can't be compressed)

- a stainless steel fork

  solid (can't be compressed)

- the water from a lake in summer

  liquid (can't be compressed)

34. Are the following statements true or false? If false, modify the statement to make it true in your notebook.

a) The particles in a liquid have complete freedom of movement.

False. The particles in a gas have complete freedom of movement.

b) Liquids and solids are not compressible.

True

c) Liquids tend to occupy the entire volume of their container.

False. Gases tend to occupy the entire volume of their container.

d) The forces of attraction between the particles of gases are very strong.

False. The forces of attraction between the particles of solids are very strong.

e) The particles of solids occupy fixed positions.

True

The Kinetic Particle Theory

35. Why are states of matter also called states of aggregation?

Because the state of matter depends on how close together (or aggregated) the particles are.

36. How does the Kinetic Molecular Theory explain the process of evaporation?

The particles in the surface of the liquid increase their energy from the energy of their surroundings. Therefore, they vibrate more and gain velocity until they have enough energy to escape the surface of the liquid and become a gas (they mix with the gas particles of the air). This process continues to happen layer by layer in the liquid.

37. Explain why liquids can adopt the shape of their container.

Particles in liquids can vibrate, rotate and even move to different positions and therefore adopt the shape of the container.

38. Liquids and gases are called fluids. Look up the meaning of the word fluidity in a dictionary or on the Internet and explain why they are called fluids. Why are solids not called fluids?

Fluid (oxforddictionaries.com): a substance that has no fixed shape and yields easily to external pressure.

Liquids and gases are called fluids because their particles can move around, as the forces of attraction between them are not very strong. Solids can't be called fluid because their particles are in a fixed position, they can't move around.

39. Complete the following statements.

a) Matter can be found in three states of aggregation: solids, liquids and gases.

b) In solids, the forces of attraction are very strong, so their particles are close together. Therefore, their shape and volume are constant.

c) In liquids, the forces between particles are strong, although less than in solids. They can move, and as a result their shape is variable, although their volume is constant.

d) In gases, the forces of attraction are very weak and the particles are far apart. As a result, their shape and volume are variable.

40. Keeping in mind the Kinetic Particle Theory, explain the change of state from solid to liquid.

At the beginning, the particles in the solid are in a fixed position, in which they can only vibrate. As the temperature increases, the vibrations of the particles increase until they are able to move from their positions. While the change of state is happening, all the energy used to heat up the solid is used to increase the vibrations of the particles and break them free from the solid's structure. That is why the temperature remains constant while the change is taking place. If we continue applying heat once the entire solid has turned into liquid, the temperature will stop being constant and start to rise again, as the particles move faster and faster.

Changes of states

41. Copper melts at 1 083°C and boils at 2 567°C.

a) At which state of aggregation will it be at 500 °C?

Solid, as the melting point (1 083°C) hasn't been reached.

b) And at 2 700°C?

Gas, as the temperature is above the boiling point (2 567°C).

c) And at 1 600°C?

Liquid, as the temperature is between the melting and boiling points.

42. Explain the process that lets us perceive the scent of a perfume in a bottle that is open.

We can smell the perfume in an open bottle due to evaporation, where liquid turns into gas.

43. Why does the bathroom mirror fog up when we have a shower? Explain your answer.

Because the water vapour created by showering touches the mirror, which is at a lower temperature. Thus the vapour condenses.

44. Given the following table, answer the questions:

Substance	*T* fusion (°C)	*T* boiling point (°C)
Iron	1 536.5	2 863
Gold	1 063	2 857
Mercury	–38.4	357
Ethanol	–117.3	78.5
Chloroform	–63.5	61.7
Water	0	100
Oxygen	–218	–183
Helium	–272	–260
Propane	–187	–45

a) Which substances will be solid at a room temperature of 25°C?

Iron and gold

b) Which of them will be in a liquid state? And in a gaseous state?

Mercury, ethanol, chloroform and water will be in a liquid state.

Oxygen, ice and propane will be in a gaseous state.

c) In which state is ethanol at -20 °C? And at 85 °C?

At -20 °C, ethanol will be in a liquid state.

At 85 °C, ethanol will be in a gaseous state.

d) In which state is helium found at -150 °C? And at -270 °C?

At -150 °C, helium will be in a gaseous state.

At -270 °C, helium will be in a liquid state.

e) In which state is iron at 1 300 °C? And at 3 000 °C? And at 2 500 °C?

At 1 300 °C, iron will be in a solid state.

At 3 000 °C, iron will be in a gaseous state.

At 2 500 °C, iron will be in a liquid state.

Classifying matter

45. **Classify the following mixtures as homogeneous or heterogeneous: Bronze, seawater, smoke, beach sand, steel, granite, water with petrol, alcohol with water and salt with iron filings.**

Homogeneous mixtures: bronze, seawater, steel and alcohol with water.

Heterogeneous mixtures: smoke, beach sand, granite, water with petrol, and salt with iron filings.

46. **Complete the following statements in your notebook:**

a) In a solution, the substance found in a lower proportion is called the solute and the one in a higher proportion is the solvent.

b) If we evaporate the solvent from a solution very slowly, we get large crystals.

c) In heterogeneous mixtures, we can distinguish the components, while in homogeneous mixtures this is not possible, even with a microscope.

Homogeneous mixtures or solutions

47. **The composition of a fizzy drink is: 10% sugar, 45% water, 30% orange juice, 14.9% carbon dioxide and 0.1% preservatives and dyes. Indicate which one is the solvent, which are the solutes and the states of each one.**

Solvent: water (in a bigger proportion) in a liquid state.

Solutes: sugar in a solid state, orange juice in a liquid state, carbon dioxide in a gaseous state and preservatives and dyes that can be in a solid or liquid state.

48. **15 g of sugar and 5 g of salt are dissolved in 230 g of water. Calculate the percentage of mass of each solute in the resulting solution.**

Solutes → salt and water (in a smaller proportion)

Solvent → water (in a bigger proportion)

m (sugar) = 15 g

m (salt) = 5 g

m (solution) = 230 g

m (solution) = m (sugar) + m (salt) + m (solution) = 15 g + 5 g + 230 = 250 g

Finally, we substitute our values in the equations for the percent composition of the solute:

$$\% \; m/m \text{ (sugar)} = \frac{\text{mass of sugar (g)}}{\text{mass of solution (g)}} \times 100 = \frac{15 \text{ g}}{250 \text{ g}} \times 100 = 6\%$$

$$\% \; m/m \text{ (salt)} = \frac{\text{mass of salt (g)}}{\text{mass of solution (g)}} \times 100 = \frac{5 \text{ g}}{250 \text{ g}} \times 100 = 2\%$$

Methods for separating mixtures

49. **Say how you would separate the components of the following mixtures:**

a) alcohol with sand

filtration

b) water with oil

decantation

c) sand with iron filings

magnetic separation

d) water with salt

evaporation and crystallisation

50. **Match each laboratory tool with the separation technique.**

Tool: crystalliser, magnet, funnel with a stopcock, coolant and a paper strip.

Technique: distillation, chromatography, magnetic separation, evaporation and crystallisation and decantation.

Tool	Technique
crystalliser	evaporation and crystallisation
magnet	magnetic separation
funnel with a stopcock	decantation
coolant	distillation
paper strip	chromatography

READ AND UNDERSTAND SCIENCE

[...] En el museo había también un bloque enorme de galena –debía pesar más de una tonelada- que había dado lugar a unos cubos grises de diez o quince centímetros de lado en cuyo interior a menudo había otros cubos más pequeños. Y, a través de mi lupa de bolsillo, podía ver que dentro de éstos había otros más pequeños que al parecer brotaban de ellos. Cuando se lo mencioné al tío Dave, me dijo que la galena era un mineral cúbico de pies a cabeza, y que si pudiera verlo con un millón de aumentos, seguiría viendo cubos más pequeños asociados a los anteriores, y así sucesivamente. La forma de los cubos de galena, de todos los cristales, dijo mi tío, era la expresión de cómo se disponían sus átomos, de las rígidas estructuras en tres dimensiones o retículas que formaban […]

Oliver Sacks
El tío Tungsteno. Editorial Anagrama.

a) **What type of solid is discussed in the text? Explain your answer.**

A crystal, because it describes how its atoms are arranged.

b) **What is the relationship between the cubes that are easily visible in this mineral and its structure at microscopic level?**

The structure of this mineral at a microscopic level is the same as the structure of the cubes that are easily visible.

c) **What is the composition of galena?**

Lead sulphide (II)

d) **Search on the Internet or in an encyclopaedia for the main uses of this mineral.**

Students' own answers.

e) **Look for other examples of minerals with an external appearance similar to galena.**

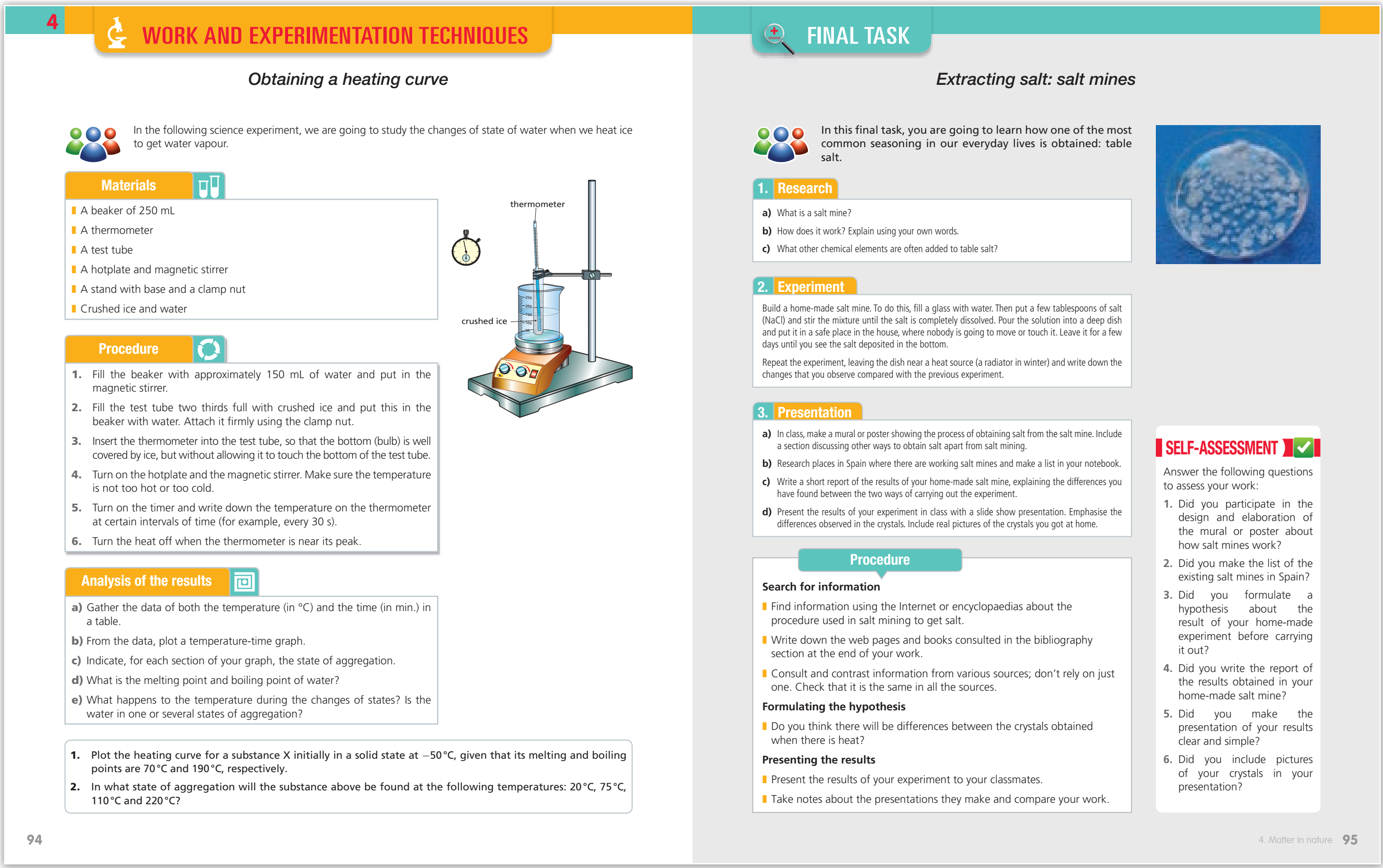
Students' own answers. Examples: pyrite, fluorite and halite (rock salt).

Study Skills

Open answer

EXTRA RESOURCES

PDF
COMPETENCE TEST
CONCEPT MAP
EXTENSION WORKSHEET
REINFORCEMENT WORKSHEET
UNIT TESTS
INTERACTIVE ACTIVITIES
PRESENTATION



4 WORK AND EXPERIMENTATION TECHNIQUES

Obtaining a heating curve

In the following science experiment, we are going to study the changes of state of water when we heat ice to get water vapour.

Materials

- A beaker of 250 mL
- A thermometer
- A test tube
- A hotplate and magnetic stirrer
- A stand with base and a clamp nut
- Crushed ice and water

Procedure

1. Fill the beaker with approximately 150 mL of water and put in the magnetic stirrer.
2. Fill the test tube two thirds full with crushed ice and put this in the beaker with water. Attach it firmly using the clamp nut.
3. Insert the thermometer into the test tube, so that the bottom (bulb) is well covered by ice, but without allowing it to touch the bottom of the test tube.
4. Turn on the hotplate and the magnetic stirrer. Make sure the temperature is not too hot or too cold.
5. Turn on the timer and write down the temperature on the thermometer at certain intervals of time (for example, every 30 s).
6. Turn the heat off when the thermometer is near its peak.

Analysis of the results

a) Gather the data of both the temperature (in °C) and the time (in min.) in a table.
b) From the data, plot a temperature-time graph.
c) Indicate, for each section of your graph, the state of aggregation.
d) What is the melting point and boiling point of water?
e) What happens to the temperature during the changes of states? Is the water in one or several states of aggregation?

1. Plot the heating curve for a substance X initially in a solid state at −50 °C, given that its melting and boiling points are 70 °C and 190 °C, respectively.
2. In what state of aggregation will the substance above be found at the following temperatures: 20 °C, 75 °C, 110 °C and 220 °C?

94

FINAL TASK

Extracting salt: salt mines

In this final task, you are going to learn how one of the most common seasoning in our everyday lives is obtained: table salt.

1. Research

a) What is a salt mine?
b) How does it work? Explain using your own words.
c) What other chemical elements are often added to table salt?

2. Experiment

Build a home-made salt mine. To do this, fill a glass with water. Then put a few tablespoons of salt (NaCl) and stir the mixture until the salt is completely dissolved. Pour the solution into a deep dish and put it in a safe place in the house, where nobody is going to move or touch it. Leave it for a few days until you see the salt deposited in the bottom.

Repeat the experiment, leaving the dish near a heat source (a radiator in winter) and write down the changes that you observe compared with the previous experiment.

3. Presentation

a) In class, make a mural or poster showing the process of obtaining salt from the salt mine. Include a section discussing other ways to obtain salt apart from salt mining.
b) Research places in Spain where there are working salt mines and make a list in your notebook.
c) Write a short report of the results of your home-made salt mine, explaining the differences you have found between the two ways of carrying out the experiment.
d) Present the results of your experiment in class with a slide show presentation. Emphasise the differences observed in the crystals. Include real pictures of the crystals you got at home.

Procedure

Search for information

- Find information using the Internet or encyclopaedias about the procedure used in salt mining to get salt.
- Write down the web pages and books consulted in the bibliography section at the end of your work.
- Consult and contrast information from various sources; don't rely on just one. Check that it is the same in all the sources.

Formulating the hypothesis

- Do you think there will be differences between the crystals obtained when there is heat?

Presenting the results

- Present the results of your experiment to your classmates.
- Take notes about the presentations they make and compare your work.

SELF-ASSESSMENT

Answer the following questions to assess your work:

1. Did you participate in the design and elaboration of the mural or poster about how salt mines work?
2. Did you make the list of the existing salt mines in Spain?
3. Did you formulate a hypothesis about the result of your home-made experiment before carrying it out?
4. Did you write the report of the results obtained in your home-made salt mine?
5. Did you make the presentation of your results clear and simple?
6. Did you include pictures of your crystals in your presentation?

4. Matter in nature 95

Obtaining a heating curve

During this unit, we have studied the different changes in state of matter, analysing, from a theoretical perspective, how temperature varies during the processes of heating and cooling a substance.

By carrying out this science experiment, students will be able to put into practice what they have studied. They will be able to check for themselves how temperature increases steadily when there is no change of state occurring and how temperature remains constant while there is a change of state happening.

Read through the **Procedure** section with the class and ensure that everyone understand the task before giving them the materials. Organise the students into multi-ability groups of three or four. During the experiment, check that the groups are following the procedure correctly.

By doing this science experiment, students will achieve the following key competences:

- **Mathematical competence and basic competences in science and technology (MCST)**
- **Sense of initiative and entrepreneurship (SIE)**

Analysis of the results

a) **Gather the data of both the temperature (in °C) and the time (in min.) in a table.**

Students' own answers.

b) **From the data, plot a temperature-time graph.**

Students' own answers.

c) **Indicate, for each section of your graph, the state of aggregation.**

Students' own answers. Bear in mind that t (temperature) < 0 °C → soild; t = 0 °C → solid + liquid; °C < t < 100 °C → liquid; t = 100 °C → liquid + gas; t > 100 °C → gas.

d) **What is the melting point and boiling point of water?**

Melting point: 0 °C

Boiling point: 100 °C

e) **What happens to the temperature during the changes of states? Is the water in one or several states of aggregation?**

The temperature remains the same while a change in state is taking place. During this time, water can be found in two different states. For example, during melting, water can be found in a liquid and solid state. However, the closer we are to the melting point, the more liquid than solid there is.

Answer key

1. **Plot the heating curve for a substance X initially in a solid state at –50°C, given that its melting and boiling points are 70°C and 190°C, respectively.**

   Students' own answers.

2. **In what state of aggregation will the substance above be found at the following temperatures: 20°C, 75°C, 110 °C and 220 °C?**

   At 20 °C, it will be in a solid state.

   At 75 °C, it will be in a liquid state.

   At 110 °C, it will be in a liquid state.

   At 220 °C, it will be in a gaseous state.

Extracting salt: salt mines

By understanding separating methods, students can understand and familiarise themselves with some of the basic techniques used in laboratories. In this case, the aim is for students to understand the importance of one of these methods in our everyday life. Students will investigate evaporation and crystallisation in salt mines. Some students may have already seen a salt mine before, for example next to a beach.

By completing this research task, students will put the process into practice in their own homes and will analyse its efficiency, taking into consideration its different components. They will also be aware of its use on a bigger scale than a simple laboratory, as they will research its use in an industrial scale.

Point out to students that at the end of their research they will need to make a **mural** or a **poster** with all the information they have gathered, write a short **report** showing the results of their home-made salt mine and present the results to the class using a **slideshow presentation**.

Read through the task with the students, directing them to the four boxes and explaining their purpose.

- The **Research** section outlines the questions that the students should try to answer.
- The **Experiment** section shows students step-by-step how to create their home-made salt mines and how to carry out the experiment.
- The **Presentation** section outlines the steps to be followed as the students carry out the project. It gives them tips on how to search for information, formulate their hypothesis and present their results.
- The **Procedure** section sets out the steps students should follow in order to complete the research.
- The **Self-assessment** section helps students evaluate their work and think about the development of the final task.

The learning outcomes that will be reinforced during this task are:

- 5.1. Recognise the homogenous nature of a solution and identify the solute and solvent from their concentrations. (LC, MCST)
- 5.2. Prepare solutions and describe the methods and materials used. (LC, MCST)
- 10.2. Describe the laboratory equipment needed to perform each method of separation. (LC, MCST, LL, SIE, SCC)
- 10.1. Choose the most suitable methods for separating the different components in mixtures according to their properties. (LC, MCST, LL, SIE, SCC)

An example of how to assess the final task is shown below:

	0	1	2	3
MURAL/POSTER AND PRESENTATION				
The student has participated in the making and design of the mural or poster.				
It includes a list of the existing salt mines in Spain.				
It includes a hypothesis formulated prior to the experiment.				
The results are presented in a clear and concise manner that is easy to understand.				
It includes photographs of the crystals formed during the experiment.				
REPORT				
It includes all the sections that were asked for.				
The student has selected the relevant information.				
The language and structure used are correct.				
It includes a bibliography and/or webography.				

0 = not handed in 1 = very basic 2 = well done 3 = excellent

LEARNING OUTCOMES RUBRIC

Evaluable learning outcomes	Assessment tools	Excellent 3	Satisfactory 2	In process 1	Not achieved 0	Score
1.1 Recognise examples of the three states of matter in everyday life.	1, 2, 32, 33	Able to name many examples for each state.	Able to name several examples for each state.	Able to name a few examples for each state.	Answers in an incorrect way or does not answer.	
1.2. Match each state of matter with its main properties.	1, 33, 34	Identifies all the properties and matches them to their corresponding state.	Identifies many properties and matches them to their corresponding state.	Identifies a few properties and matches some of them to their corresponding state.	Answers in an incorrect way or does not answer.	
2.1. Justify the properties of solids, liquids and gases using the Kinetic Particle Theory.	3, 5, 35, 37, 38, 39, 40	Able to define all the concepts, identifying all the important elements and their relationships.	Able to define many concepts, identifying many important elements and their relationships.	Able to define a few concepts, identifying some important elements and their relationships.	Answers in an incorrect way or does not answer.	
2.2. Explain the behaviour of gases in situations of everyday life using the Kinetic Particle Theory.	4, 5, 36	Explains the processes in a clear manner, identifying all the main elements.	Explains the processes in a valid but incomplete manner, identifying many of the main elements.	Explains the processes making mistakes, identifying few of the main elements.	Answers in an incorrect way or does not answer.	
3.1. Recognise the state of aggregation of a substance according to its temperature.	6, 7, 8, 41, 42, 43, 44, Work and experimentation techniques	Identifies the relationship between the different states of a substance and temperature in a clear manner.	Identifies the relationship between the different states of a substance and temperature in an incomplete manner.	Identifies the relationship between the different states of a substance and temperature making many mistakes.	Answers in an incorrect way or does not answer.	
3.2. Identify the temperature at which a substance changes state of aggregation.	6, 7, 8, 41, 42, 43, 44, Work and experimentation techniques	Performs all the calculations correctly, finding the necessary data.	Performs all the calculations correctly, when the necessary data is provided.	Performs calculations making mistakes, when the necessary data is provided.	Answers in an incorrect way or does not answer.	
3.3. Draw heating curve graphs from the melting and boiling points of substances shown on data tables, and vice versa with cooling curve graphs.	11, 12, Work and experimentation techniques	Draws heating and cooling curve graphs correctly, identifying all the necessary information from the data tables.	Draws heating and cooling curve graphs with some mistakes, identifying most of the necessary information from the data tables.	Draw heating and cooling curve graphs with many mistakes, identifying only some of the necessary information from the data tables.	Answers in an incorrect way or does not answer.	
4.1. Categorise substances into pure substances and mixtures.	18	Distinguishes the concepts correctly, identifying all the important elements and their relationships.	Distinguishes the concepts in a valid but incomplete manner, identifying many of the important elements and their relationships.	Distinguishes the concepts making mistakes, identifying few of the important elements and their relationships.	Answers in an incorrect way or does not answer.	
5.1. Recognise the homogenous nature of a solution and identify the solute and solvent from their concentrations.	14, 15, 16, 17, 47, Final Task	Explains the processes correctly, identifying all the important elements and their relationships.	Explains the processes in a valid but incomplete manner, identifying many of the important elements and their relationships.	Explains the processes making mistakes, identifying few of the important elements and their relationships.	Answers in an incorrect way or does not answer.	

5.2. Prepare solutions and describe the methods and materials used.	Work and experimentation techniques, Final Task	Explains the processes correctly, identifying all the important elements and the relationships.	Explains the processes in a valid but incomplete manner, identifying many of the important elements and the relationships.	Explains the processes making mistakes, identifying some of the important elements and the relationships.	Answers in an incorrect way or does not answer.	
6. 1. Resolve practical exercises calculating the concentration of solutions both in percent composition (by mass) and mass concentration (g/L).	19, 20, 21, 22, 23, 24, 48	Performs all the calculations correctly, finding the necessary data.	Performs all the calculations correctly, when the necessary data is provided.	Performs all the calculations with some mistakes, when the necessary data is provided.	Answers in an incorrect way or does not answer.	
7.1. Recognise and value the importance and applications of aqueous solutions and alloys.	15, 18	Explains the concepts in a clear manner, identifying all the main elements and their relationships.	Explains the concepts in a valid but incomplete manner, identifying many of the main elements and their relationships.	Explains the concepts making mistakes, identifying few of the main elements and their relationships.	Answers in an incorrect way or does not answer.	
8.1. Identify homogeneous mixtures, heterogeneous mixtures and colloids.	14, 25, 26, 45	Distinguishes the concepts correctly, identifying all the important elements and their relationships.	Distinguishes the concepts in a valid but incomplete manner, identifying quite a few of the important elements and their relationships.	Distinguishes the concepts making mistakes, identifying few of the important elements and their relationships.	Answers in an incorrect way or does not answer.	
9. 1. Recognise the main colloids in everyday use.	26, 27	Explains the concepts in a clear manner, identifying all the main elements and their relationships.	Explains the concepts in a valid but incomplete manner, identifying quite a few of the main elements and their relationships.	Explains the concepts making mistakes, identifying few of the main elements and their relationships.	Answers in an incorrect way or does not answer.	
10.1. Choose the most suitable methods for separating the different components in mixtures according to their properties.	13, 28, 29, 30, 31, 49, Work and experimentation techniques, Final Task	Chooses the most suitable method, explaining all the processes and elements.	Chooses the most suitable method, explaining many of the processes and elements.	Chooses a suitable method, explaining few of the processes and elements.	Answers in an incorrect way or does not answer.	
10.2. Describe the laboratory equipment needed to perform each method of separation.	13, 28, 29, 30, 31, 49, 50, Work and experimentation techniques, Final Task	Relates laboratory equipment with separation methods correctly, identifying all the main elements and their relationships.	Relates laboratory equipment with separation methods in a valid but incomplete manner, identifying many of the main elements and their relationships	Relates laboratory equipment with separation methods making mistakes, identifying few of the main elements and their relationships	Answers in an incorrect way or does not answer.	

Objectives, contents and methodology

TYPES OF RESOURCES AND METHODOLOGY USED TO MEET OBJECTIVES	
●	Interactive activities. Elaboration and verification of a hypothesis.
○	Search for information on the Internet.
▶	Visualisation of videos.
□	Analyse images.

SECTIONS	OBJECTIVES AND CONTENTS	METHODOLOGY	
States of matter and their properties	Analyse the properties that characterise each state of matter.	●	
	Find out about the behaviour of the particles that make up matter according to the state they are in.	●	
	Understand the Kinetic Particle Theory.	●	○
	Concepts: States of matter, Kinetic Particle Theory.		
Changes of state	Analyse how changes in state occur.	●	
	Find out the names of the various processes that bring about changes of state.	●	○
	Identify the melting and boiling point of a given substance.	●	
	Concepts: melting point, boiling point, vaporisation, condensation, melting, deposition, sublimation.		
Classifying matter	Analyse the difference between pure substances and mixtures.	●	□
	Analyse the difference between homogeneous and heterogeneous mixtures.	●	□
	Concepts: Pure substance, mixture, homogenous mixture, heterogeneous mixture.		
Solutions	Find out what type of material system solutions are and what their components are.	●	○
	Analyse how to measure the concentration of a solution.	●	○
	Calculate the concentration of different solutions.	●	○
	Concepts: Solution, solute, solvent, concentration, units of measurement.		
Final task	Understand the different methods for separating mixtures.	□	○
	Analyse the different procedures that are used to separate mixtures.	●	▶
	Concepts: Methods for separating mixtures, decantation, filtration, distillation, evaporation, crystallisation.		

NOTAS

1. **Define, using the Kinetic Particle Theory the three states of matter.**

   In solids, the particles are very close together. As a result, the forces of attraction are very strong and they have a fixed position in which they can vibrate but cannot move.

   In liquids, the particles are close together. The forces of attraction are not as strong as in solids, which means they can move more and vibrate. As a result, liquids can flow, change shape and are penetrable.

   In gases, the particles are far apart. The forces of attraction are very weak, which means they can move freely. As a result, gases occupy all the space available in a container and take its shape.

2. **Complete the following sentences:**

   a) **When a substance's temperature is below its** melting **point, it is in a solid state.**

   b) **When a substance's temperature is above its** boiling **point, it is in a gaseous state.**

   c) **If the temperature is between the melting point and boiling point, it is in a liquid state.**

3. **Classify the following mixtures into homogeneous or heterogeneous: sand with gravel, water with honey, hot chocolate with marshmallows, water with ice, coffee powder with coffee grains, steel, salt water, sterling silver, water with petrol, sand with iron, water with oil, and fizzy drinks.**

   Homogeneous mixtures: water with honey, steel, salt water, sterling silver, and fizzy drinks.

   Heterogeneous mixtures: sand with gravel, hot chocolate with marshmallows, water with ice, coffee powder with coffee grains, water with petrol, sand with iron, and water with oil.

4. **What are colloidal dispersions? How can we distinguish them from 'real' solutions? Give at least three examples of colloidal dispersions.**

   Colloidal dispersions are a special type of mixture (between a homogenous and heterogeneous mixture) in which the solute particles (invisible to the naked eye) are bigger than the particles in a solution (homogeneous mixture) but smaller than the particles in a heterogeneous mixture.

   In order to distinguish them from 'real' solutions, we can shine a beam of light through them. When it is a 'real' solution, such as water with sugar, we will not see the beam of light. On the other hand, when it is a colloidal dispersion, we will see the beam of light.

   Some examples are: soaps, butter, creams, foams, fog, aerosols, clouds, and jelly.

5. **Wine is made up of water (in a bigger proportion) and water (in a smaller proportion).**

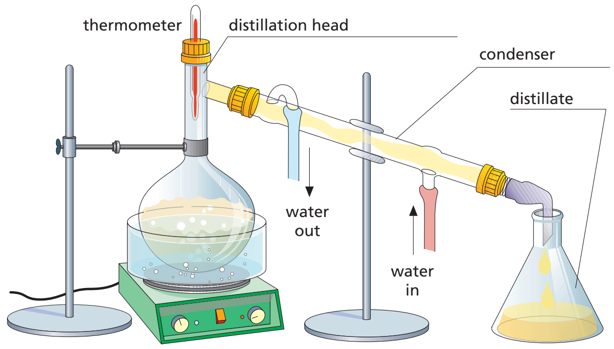
   a) **Identify which is the solute and which is the solvent.**

   The alcohol is the solute and the water is the solvent.

   b) **Explain how you would separate these liquids, knowing that alcohol boils at 78 °C and water at 100 °C.**

   Through distillation, as both components have different boiling points.

   c) **Draw a diagram of how you would carry out b).**



6. **We prepare a solution by dissolving 25 g of copper sulphate (II), $CuSo_4$, in 150 g of water.**

   a) **Which is the solute and which is the solvent?**

   Copper sulphate is the solute since it is the component found in a smaller proportion, and water is the solvent as it is the component found in bigger proportion.

   b) **Calculate the mass of the solution.**

   m (solution) = m (solute) + m (solvent) = 25 g + 150 g = 175 g

   c) **Calculate the percentage by mass of the solution.**

$$\%\ CuSO_4 = \frac{25\text{ g of }CuSO_4}{175\text{ g of solution}} \times 100 = 14.3\%\text{ of }CuSO_4$$

7. **What is the mass concentration of a solution of potassium bromide with water that has been made by dissolving 3.1 g of the salt in water until there was a final volume of 250 mL?**

   250 mL = 0.25 L

   g/L = 3.1 g / 0.25 L = 12.4 g/L

8. **How would you separate the components in the following mixtures?**

   a) **Water and sand**

   Water is added to the mixture and stirred until the sugar is completely dissolved. Then the sand is filtered, because it is insoluble in water. Lastly, the sugar is recovered through evaporation and crystallisation.

   b) **Aluminum filings and iron shavings**

   Through magnetic separation, as they have different magnetic properties. The iron will stick to the magnet and the aluminum won't.

1. Say if the following sentences are true or false. Correct the false sentences.

   a) The word 'gas' and 'vapour' mean the exact same thing, so we can use the one that we like the most.

   False. We use the word 'gas' when referring to substances that are found in a gaseous state in the environment, such as oxygen or nitrogen. We use the word 'vapour' when referring to substances that we usually find as solid or liquid in the environment, such as water vapour.

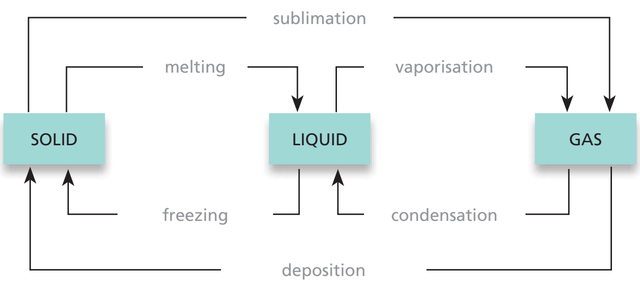
   b) Solid and liquids are also called fluids.

   False. Liquids are fluid, same as gases, but solids are not fluid because they don't flow.

   c) Gases can compress and expand easily.

   True. This is due to the great gap between the particles and that the forces of attraction are very weak, which means they can move freely, coming closer together or moving further apart.

2. Draw a diagram showing all the different processes that change the state of aggregation.



3. Aluminium melts at 660 °C and boils at 2 520 °C. Propane melts at -188 °C and boils at -42 °C.

   a) In what state of aggregation will each substance be found at 100 °C?

   Aluminium will be in a solid state and propane in a gaseous state.

   b) And at -200 °C?

   Both will be in a solid state.

   c) And at 1 000 °C?

   Aluminium will be in a liquid state and propane in a gaseous state.

4. Classify the following materials in solutions, heterogeneous mixtures or colloids: bronze, sand with mud, chocolate milkshake, salt and pepper, water with sugar, clouds, yoghurt with fruit, alcohol and water, mayonnaise, ash with iron shavings, and mist.

   Solutions: bronze, water with sugar, and alcohol and water.

   Heterogeneous mixtures: sand with mud, salt and pepper, yoghurt with fruit, and ash with iron shavings.

   Colloids: chocolate milkshake, clouds, mayonnaise,and mist.

5. Which of these two solutions has a bigger mass percentage of solute: a solution made by adding 15 g of sodium chloride to 485 g of water, or a solution made by adding 5 g of sodium chloride to 145 g of water? Explain your answer by showing the necessary calculations.

   Dissolving 15 g of sodium chloride in 485 g of water:

   % *m*/*m* (NaCl) = (15/500)· 100 = 3 %

   Dissolving 5 g of sodium chloride in 145 g of water:

   % *m*/*m* (NaCl) = (5/150) · 100 = 3.3 %

   Therefore, the second solution has a slightly bigger mass percentage of solute.

6. Calculate the mass concentration of a solution of salt water made by dissolving 0.9 g of salt in water until there iss a final volume of 125 mL.

   125 mL = 0.125 L

   g/L = 0.9 g /0.125 L = 7.2 g/L

7. How would you separate the different components in a mixture made of sawdust and sugar and another one made of water and oil? Explain both processes step-by-step.

   Sawdust and sugar: water is added to the mixture and stirred until the sugar is completely dissolved; the sawdust is separated by decantation using a spatula or spoon; and the sugar is recovered by evaporation and crystallisation.

   Water and oil: decantation is used, as they are both immiscible liquids; the mixture is poured into the funnel (with the tap at the bottom closed); the mixture is left to settle until the two liquids have separated; a beaker is placed under the funnel and the tap is opened; the denser liquid at the bottom (water) begins to flow out; the tap is closed when all the denser liquid is out; and the less dense liquid (oil) is poured out the top of the funnel.