Chapter 4: Chemical elements

4.1 The properties of matter can be described

Student book answers (pages 62–63)

Check your learning 4.1

Remember and understand

1 Group the following substances according to their state of matter as a solid, a liquid or a gas, or even a combination of states: ice cream, chocolate bar, clouds, thick smoke, glass, honey, cake or bread, mashed potato, paper, peanut butter (smooth), cling wrap, play dough, sand, steam, slime.

Student answers will vary. Generally the substances can be grouped as listed below, although some are open for discussion:

Solids: chocolate bar, thick smoke,glass,paper,cling wrap,sand

Liquids: clouds, honey

Gas: steam

Combinations:ice cream (solid and liquid), smoke (can contain solid, liquid and gas), cake or bread (solid and gas), mashed potato (solid and liquid), smooth peanut butter (solid and liquid), play dough (solid and liquid), slime (solid and liquid)

2 What is meant by a property of a substance?

The term ‘property’ refers to the characteristics of the substance that can be measured.

3 Why are the properties of matter so important to us?

Properties are important to identify a substance, to understand a substance and for using the substance.

4 What are the similarities and differences between physical and chemical properties?

Similarities: both can be observed; they help identify a substance; physical properties may influence the chemical properties

Differences: physical properties can be observed and measured without changing the substance into something else, whereas ‘chemical properties’ refer to what a substance does in a chemical reaction

Apply and analyse

5 Decide whether the following properties are physical or chemical: malleability (the ability to be hammered into flat sheets), the ability to explode, the amount of vapour released at different temperatures.

Physical: malleability

Chemical: the ability to explode, the amount of vapour released at different temperatures and pressures

6 Select a common substance, such as cling wrap or vinegar. Name some of the physical properties of this substance.

Student answers will vary depending on the substance chosen.

4.2 Science as a human endeavour: Scientists’ understanding of matter has developed over thousands of years

Student book answers (pages 64–65)

Extend your understanding 4.2

1 What was the major difference between the ideas proposed by Democritus and Dalton?

The major difference between the ideas proposed by Democritus and Dalton is that Democritus’ theory was opinion and philosophy, whereas Dalton’s was based on evidence.

2 How is an ‘idea’ different from a ‘theory’?

When all the current evidence supports an idea, it becomes a theory.

3 Consider a school assembly. Everyone is sitting quietly in their seats in rows. When the assembly finishes, there is a crowd at the doors pushing to go through them to leave. When outside, the students run off in all directions as fast as they can. Explain which parts of this analogy represent a solid, a liquid and a gas.

Everyone sitting in their seats, in rows, in a school assembly would represent a solid. Students leaving the assembly would represent a liquid, and students moving in any direction once outside represents a gas.

4 Some people use analogies or models to compare states of matter. What states do the following situations most closely represent?

a A swarm of bees crawling over each other.

Liquid

b A thousand tennis balls tidily arranged in a large cardboard box.

Solid

c Eggs in trays in a large egg container.

Solid

d A school of fish darting in all directions as they avoid a predator.

Gas

4.3 The particle model explains matter

Student book answers (pages 66–67)

Check your learning 4.3

Remember and understand

1 Is there any difference between the particle model of matter and the kinetic theory of matter? Explain your answer.

The kinetic theory of matter refers to the movement of matter. The particle model of matter refers to how matter is constructed.

2 What is the meaning of ‘kinetic’ in the kinetic theory of matter?

The term ‘kinetic’ refers to anything that is moving.

3 Rank the states solid, liquid and gas in order of energy content, from highest to lowest.

Gas, liquid, solid

4 What is meant by ‘mass’?

The term ‘mass’ refers to the amount of matter a substance has.

5 How does the kinetic molecular theory (or particle model) of matter explain the different masses of different substances?

The mass of a substance is determined by the mass of all its particles. Different particles have different mass.

6 Why does a lump of lead have a greater mass than a lump of wood?

A lump of lead has a greater mass than a lump of wood because lead particles have a greater mass than wood particles.

7 How does the kinetic molecular theory of matter explain diffusion in:

a liquids?

In liquids, the particles jostle against each other. They do not move far before colliding with another particle. As a result, particles in a liquid do not move very far or very fast. Diffusion in liquids is slow.

b gases?

In gases, the particles are moving freely and quickly and there is plenty of space between them. The particles in a gas will spread out quickly and take up all the space they can. Diffusion occurs fastest in gases.

4.4 The particle model can explain the properties of matter

Student book answers (pages 68–69)

Check your learning 4.4

Remember and understand

1 Prepare a table and list the physical properties mentioned in this chapter and their meanings.

|  |  |
| --- | --- |
| Property | Meaning |
| Colour | Appearance of a substance |
| Texture | How the surface of a substance feels |
| Boiling point | Temperature at which a substance changes state from a liquid to a gas |
| Density | Mass of a certain volume of a substance |
| Electrical conductivity | Measure of how well a substance conducts electricity |
| Heat capacity | How much energy is needed to increase 1 gram of the substance by 1°C |
| Solubility | How much of the substance dissolves in a certain volume of water |
| Refractive index | Ability to bend light rays |
| Melting point | Temperature at which a substance changes state from a solid to a liquid |
| Tensile strength | Measure of how well a substance can withstand stretching forces |
| Compressive strength | Measure of how well a substance can withstand compressing forces |
| Hardness | Ability of a substance to scratch another substance |
| Viscosity | Measure of the thickness of a liquid or of its ability to resist flowing |
| Compressibility | Ability of a substance to be compressed |

Apply and analyse

2 Rank the following in order of compressibility: solid, liquid, gas.

Gas, liquid, solid

3 If you placed a highly viscous liquid, such as oil, into a water pistol, what would be the effect? Explain your reasoning.

A water pistol filled with oil wouldn’t shoot as far as it would with water, because oil cannot flow as quickly as water.

4 What would happen to a polished wooden table if you rubbed it with sand? Explain by using the idea of hardness.

If a polished wooden table was rubbed with sand it would be scratched because sand is a much harder substance than wood.

5 Why do gases have a much lower density than solids and liquids?

Gases always have a much lower density than solids and liquids because there is a lot of empty space between the particles in a gas. The particles in solids and liquids are much closer together than in a gas.

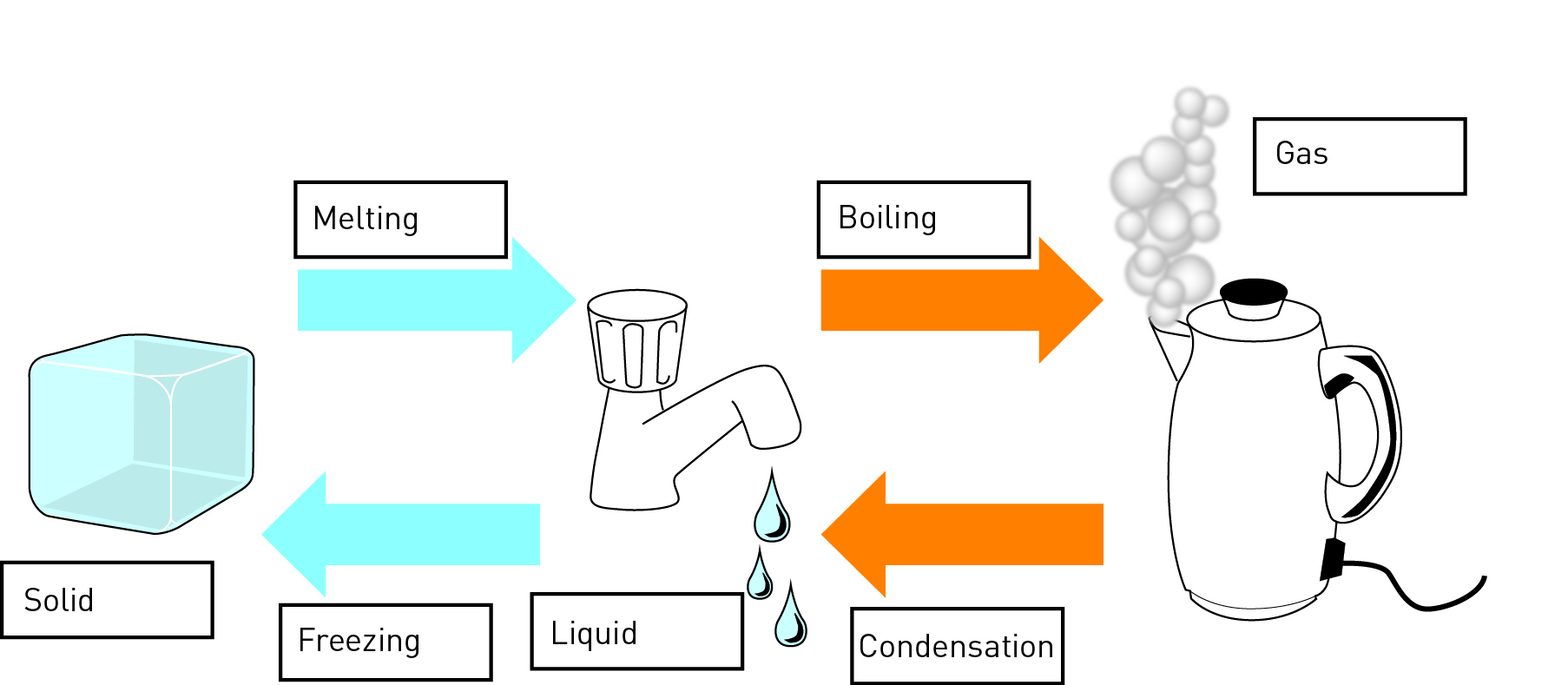
4.5 Increasing kinetic energy in matter causes it to expand

Student book answers (pages 70–71)

Check your learning 4.5

Remember and understand

1 Draw a diagram similar to that shown in Figure 4.27. Add labels to show the energy changes between states.



2 How does the movement of particles change as they get hotter?

As particles get hotter they move faster.

3 What is the difference between the terms ‘expand’ and ‘contract’?

The term ‘expand’ means to increase in size or volume, whereas the term ‘contract’ means to decrease in size or volume.

4 When hot objects cool, do they return to their original lengths?

Yes

Apply and analyse

5 What precautions are taken with railway tracks and bridges to ensure that they do not buckle and bend on a hot day?

Structures such as railway tracks and bridges contain expansion gaps or joints to ensure they don’t buckle and bend on a hot day.

6 How can you be sure that when a solid is heated and expands in size, the increase in size is not caused by more particles (atoms) being added?

Student answers will vary. The particle model states that atoms can neither be created nor destroyed, which indicates that extra atoms are not the cause of the increase in size when a solid is heated.

4.6 Atoms and elements make up matter

Student book answers (pages 72–73)

Check your learning 4.6

Remember and understand

1 What is the connection between atoms and elements?

Each element is made up of a different type of atom.

2 What are the two main types of elements?

The two main types of elements are metals and non-metals.

3 What are the rows of a periodic table called?

Periods

4 What are the names of the first five elements on the periodic table? What are their symbols?

Hydrogen (H), helium (He), lithium (Li), beryllium (Be), boron (B)

5 Which element is in period 3, group 2?

Magnesium (Mg)

6 What two letters are not represented in the elemental symbols of the periodic table?

J and Q

7 How many words can you make up using the elemental symbols of the periodic table?

Student answers will vary.

4.7 Atoms bond together to make molecules and compounds

Student book answers (pages 74–75)

Check your learning 4.7

Remember and understand

1 Look at the diagrams below, which show (i) a mixture of an element and a compound, (ii) a mixture of two elements, and (iii) a pure element.

State which description matches which diagram, explaining your reasoning for each type of substance.

In the left-hand diagram two atoms are bonded together to make a diatomic molecule. All the atoms are the same, so it must be a pure element.

In the middle diagram, the same diatomic element molecules are mixed with another molecule that is made up of two different atoms and is therefore a compound, so this diagram is a mixture of an element and a compound.

In the right-hand diagram, the same diatomic element molecules are mixed with another larger single atom element, so this diagram is a mixture of two elements.

2 What are some elements that exist as molecules rather than single atoms?

Elements that exist as molecules rather than single atoms are called molecular elements and include oxygen, hydrogen and nitrogen.

3 How are molecules and compounds related? Explain your answer.

Molecules of a compound contain atoms of two or more different elements, although molecules can also be formed from atoms of a single element and are therefore not always compounds.

4 What is the difference in meaning between the following groups of words?

a atoms and molecules

Atoms are the basic unit of matter and elements are made of only one type of atom. Molecules are groups of two or more atoms that are bonded together.

b elements and compounds

Elements are a pure substance made of only one type of atom. Compounds are formed when two or more elements or molecules are chemically bonded together.

c diatomic and monatomic

Monatomic means each gas particle is only a single atom. Diatomic means the atoms of these gas elements join in pairs.

d molecule, polymer and lattice.

Molecules are groups of two or more atoms that are bonded together. Polymers are chains of molecules that repeat in a predictable pattern. Lattices are large three-dimensional networks of particles held securely in rows, columns and layers.

5 Ammonia is a gas that contains molecules with the formula NH3. What elements are present in ammonia and how many of each atom is there in each ammonia molecule?

Ammonia contains the elements nitrogen and hydrogen. One nitrogen atom and three hydrogen atoms form an ammonia molecule.

Review 4

Student book answers (pages 76–77)

Remember and understand

1 What are the three common states of matter?

Solid, liquid and gas

2 Select one word to replace each phrase.

a The spreading out of a substance, such as a dye or smell.

Diffusion

b The ability of one substance to scratch another substance.

Hardness

c The ratio of the mass divided by the volume.

Density

3 In which of the three major states of matter do the particles have the most energy? Explain your reasoning.

Particles have the most energy when they are in a gaseous state because the particles move the fastest.

4 What is the difference between the physical and chemical properties of a substance?

Physical properties can be observed and measured without changing the substance into something else, whereas ‘chemical properties’ refers to what a substance does in a chemical reaction.

5 What is the difference between mass and matter?

Matter is the name given to all substances. Mass is the amount of matter in a substance.

6 What is the correct word or words for the following descriptions?

a A group of atoms chemically bonded together.

Molecule

b A three-dimensional arrangement of particles in rows, columns and layers.

Lattice

c Where energy breaks apart a compound into simpler substances or elements.

Chemical reaction OR decomposition

d A feature of a substance that you can observe and measure without destroying or changing the substance.

Physical property

Apply and analyse

7 When you are boiling water, the volume the water is reduced as it evaporates. Does this mean that the density of water changes?

The density of water won’t change because, even though the volume is reduced, the mass is also reduced because some of the particles evaporate.

8 Use the kinetic theory of matter to explain why the pressure inside car tyres will increase on a hot day.

The pressure inside car tyres will increase on a hot day as the particles move faster and exert more force on the tyre walls.

9 If you heated a newly discovered substance and it decomposed into two new substances, was the original substance an element or a compound? Give reasons for your answer.

If a newly discovered substance was heated and decomposed into two new substances it would be a compound, because compounds are formed when two or more elements or molecules are chemically bonded together. The newly discovered substance could not be an element because elements cannot be broken down into new substances.

10 When you breathe out on a cold morning, your breath appears white and foggy. This only occurs when it is very cold. What is the white fog that you see?

The white fog seen when someone breathes out on a cold morning is the water vapour in the breath condensing into water droplets.

Evaluate and create

11 Many people have ideas they think will explain observations and events in science. For an idea to become a theory, it must be able to explain a range of observations. The idea must also be supported by evidence and/or observations.

a Can you suggest what evidence would have been required to support the idea that all substances are made of atoms?

Student answers will vary. Typically, atoms can join together to make other substances. Substances have a mass, even when they are very, very small. Substances such as water can be found in multiple states. Atoms combine in whole numbers to make other substances.

b It is found that a substance cannot be broken down into a more simple substance. How could you use the kinetic theory of matter to explain this observation?

Student answers will vary. However, the substance must consist of all the same individual particles.

12 Elements only contain one type of atom, whereas compounds contain a combination of different atoms. This difference in structure can explain some of the behaviours of elements and compounds. By referring to the arrangement of atoms, explain the following statements.

a When an electric current is passed through water, it is possible to produce hydrogen gas and oxygen gas.

Water consists of two hydrogen atoms bonded to an oxygen atom to form a water molecule. When an electric current is passed through water, the water molecules are broken apart into hydrogen and oxygen by the electricity. The hydrogen atoms pair up to form hydrogen gas and the oxygen atoms pair up to form oxygen gas.

b Early chemists, called alchemists, tried to turn lead and other metals into gold, but none of them succeeded.

Lead consists entirely of lead atoms. There is no way to convert a lead atom into a gold atom by ordinary chemical means.

c When limestone, which is made of the compound calcium carbonate (CaCO3), is heated strongly, carbon dioxide gas is produced. However, when iron is heated, no new substance is created.

Iron consists of iron atoms only, so there is no way to break it down into another substance. However, the limestone molecules can be broken apart because they consist of calcium, carbon and oxygen atoms.

13 You should now realise that the structure and properties of a substance can be explained by the particles that make up the substance. Explain the following observations by referring to the arrangement and/or the movement of the particles within the substance. You can use labelled diagrams to improve your answers.

a Water left in an open bottle will gradually evaporate and, if the temperature of the water increases, the water will evaporate more quickly.

Water left in an open bottle will gradually evaporate; however, if the temperature increases it will evaporate more quickly because the particles have more kinetic energy when they are heated. This faster movement enables the water particles to break their bonds and change into a gaseous form more quickly.

b Mercury is a unique substance because it is the only metal that is liquid at room temperature, and it even gives off a vapour (which makes it very dangerous because this vapour can be breathed into our lungs).

At room temperature some of the mercury atoms have enough kinetic energy to break free from the forces that hold them together as a liquid. As such, the particles are able to move on their own as a gas.

c Polythene can be produced in two different forms, high-density polythene (HDPE) or low-density polythene (LDPE). If the particles in both HDPE and LDPE are the same, suggest how the structure of the two substances would be different.

The structure of HDPE and LDPE can be different despite containing the same particles because of differences in the arrangement and bonding of the particles. HDPE has a much tighter or closer arrangement of particles, making it a stronger material. In LDPE, the particles are still bonded together but are more spread out, making LDPE less dense than HDPE.

d When you heat a piece of polythene it will melt. While it is liquid, it can be formed into a different shape and when it cools the polythene will stay in this new shape.

The polythene molecules start to move more when heated, allowing the piece of polythene to become a liquid and to be manipulated. As it cools, the particles slow down and take up their positions as a solid. Hence, the piece of polythene takes on its new shape. Once solid, it stays in this shape because of the forces holding the particles together.

e We can see steam, but we cannot see water vapour.

Steam contains very small droplets of water suspended in midair. The droplets are large enough for us to see. Water vapour is gaseous water, and the molecules are more spread out and moving faster than in liquid water. We cannot see the individual molecules and hence water vapour has no colour.