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978-1-108-94833-3 — Cambridge IGCSE™ Chemistry Workbook with Digital Access (2 Years)
Richard Harwood , Ian Lodge , Mike Wooster
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Chapter 1

States of matter

Changing physical state

KEY WORDS

boiling: the process of change from liquid to gas at the boiling point of the substance; a condition under which gas bubbles are able to form within a liquid – gas molecules escape from the body of the liquid, not just from its surface

freezing point: the temperature at which a liquid turns into solid – it has the same value as the melting point; a pure substance has a sharp freezing point

melting point: the temperature at which a solid turns into a liquid – it has the same value as the freezing point; a pure substance has a sharp melting point

Exercise 1.1

IN THIS EXERCISE YOU WILL:

- develop your understanding of the distinguishing properties of solids, liquids and gases
- show how the properties of each state of matter are linked to the organisation of the particles present
- use data on melting and boiling points to determine the physical state of a substance at a given temperature.

Focus

1 There are three states of matter, which have different basic physical properties. For all physical states, complete the sentences by adding two properties they show.

A solid has a fixed ..... and .....

A liquid has a fixed ..... but its ..... changes to that of the container in which it is placed.

A gas has no fixed ..... or ..... A gas completely fills the container that it is in.

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2 Complete Figure 1.1 to show how the particles of a substance are arranged in the three states of matter.

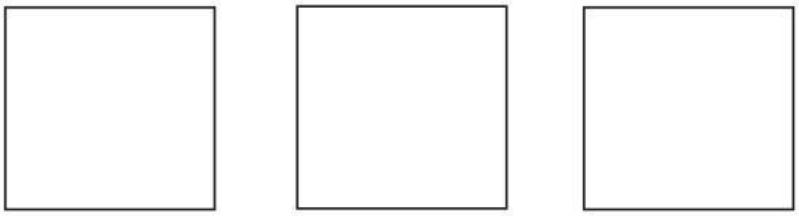

Figure 1.1: The three states of matter.

Practice

Question 2 illustrates the differences in structure and organisation of the particles in the three states. The differences can also be expressed in words. Table 1.1 describes the arrangement of the particles in four different substances A, B, C and D.

Substance	Distance between particles	Arrangement of particles	Movement of particles
A	Very far apart	Randomly arranged	Moving about with high speed
B	Very close together	Regularly ordered	Vibrating about fixed positions
C	Very far apart	Regularly ordered	Vibrating about fixed positions
D	Close together	Irregularly arranged	Moving about

Table 1.1: The arrangement and movement of particles in substances A, B, C and D.

3 Which of substances A, B, C and D is:

a a solid .....

b unlikely to be a real substance .....

c a gas .....

d a liquid .....

TIP

In a liquid, the particles are still close together. However, the particles are not regularly arranged and can move around and move past each other.

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4 Changing the temperature can result in a substance changing its physical state. What are the changes of state A, B, C and D in Figure 1.2? (Note that sublimation is not required knowledge.)

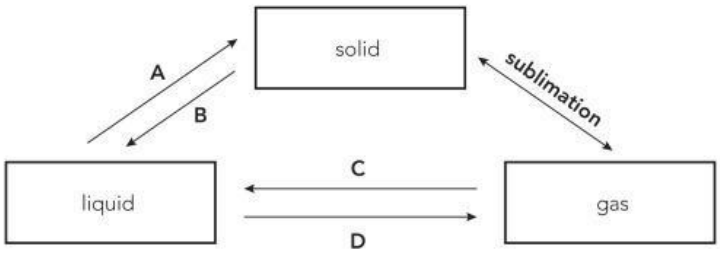

Figure 1.2: Changes of physical state.

A .....

B .....

C .....

D .....

Challenge

5 Use the data provided in Table 1.2 to answer the questions about the physical state of the substances listed when at a room temperature of 25 °C and at atmospheric pressure.

Substance	Melting point / °C	Boiling point / °C
Sodium	98	883
Radon	−71	−62
Ethanol	−117	78
Cobalt	1492	2900
Nitrogen	−210	−196
Propane	−188	−42
Ethanoic acid	16	118

Table 1.2: Melting points and boiling points of various substances.

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a Which substance is a liquid over the smallest range of temperatures?

.....

b Which two substances are gaseous at −50 °C?

..... and .....

c Which substance has the lowest freezing point?

.....

d Which substance is liquid at 2500 °C?

.....

e A sample of ethanoic acid was found to boil at 121 °C at atmospheric pressure. Use the information provided in Table 1.2 to comment on this result.

.....

.....

TIP

Be careful when dealing with temperatures below 0 °C, and remember that −100 °C is a higher temperature than −150 °C.

› Plotting a cooling curve

KEY WORDS

evaporation: a process occurring at the surface of a liquid, involving the change of state from a liquid into a vapour at a temperature below the boiling point

kinetic (particle) theory: a theory which accounts for the bulk properties of the different states of matter in terms of the movement of particles (atoms or molecules) – the theory explains what happens during changes in physical state

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