



11–14 years

# What happens when a substance changes state?





# Introduction



What is happening in the images?

# Think, pair, share

What do you understand about the key terms below?

**Melting**

**Freezing**

**Boiling**

**Condensing**

## Sentence starters to support discussion:

'I think that...'

'I would like to start by saying...'

'I would like to build on that by adding...'

'I agree/disagree because...'

**Challenge:** Can you link all three of these terms to water?

# Learning objectives

1. Recall the definitions of freezing, boiling, condensing and melting as changes of state.
2. Describe the difference between particle diagrams at different states.
3. Explain that molecules do not break up and reform when a substance boils and cools.





# Key terms

Key term	Definition
Boil	when a liquid is heated, gains energy and turns in a gas, at its boiling point
Boiling point	the temperature at which a pure substance changes from a liquid to a gas or from a gas back to a liquid
Condense	when a gas is cooled, energy is transferred from the gas to the gas' surroundings and the gas turns into a liquid
Evaporate	when the surface of a liquid gains energy and turns into a gas; this can happen below the boiling point
Freeze	when a liquid is cooled, energy is transferred from the liquid to the liquid's surroundings and the liquid turns into a solid
Melt	when a solid is heated, gains energy and turns into a liquid, at its melting point
Melting point	the temperature at which a pure substance melts and changes from a solid to a liquid, or from a liquid back to a solid
Sublime	when a solid is heated, gains energy and turns into a gas, without turning into a liquid first

Find more support for vocabulary in our Key terms support bundle for **11–14 Particle model**.



Available to download from: [rsc.li/4cmvSbS](https://www.rsc.li/4cmvSbS)

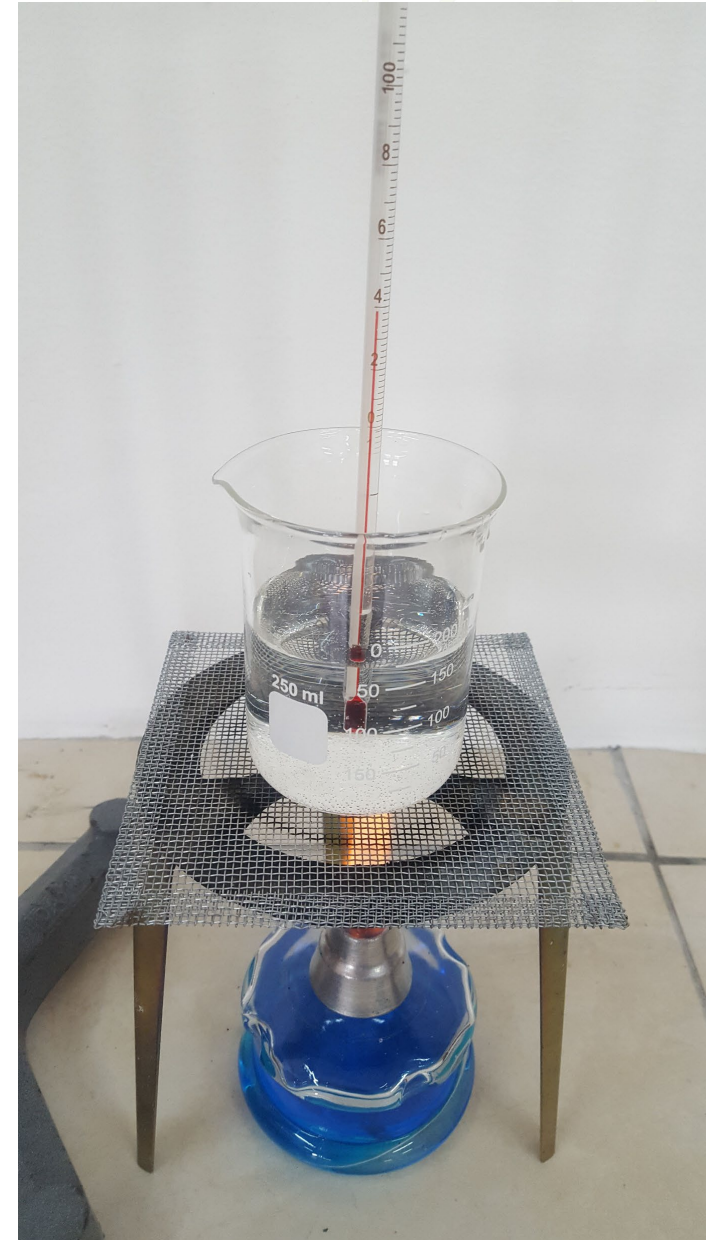


# Boiling water

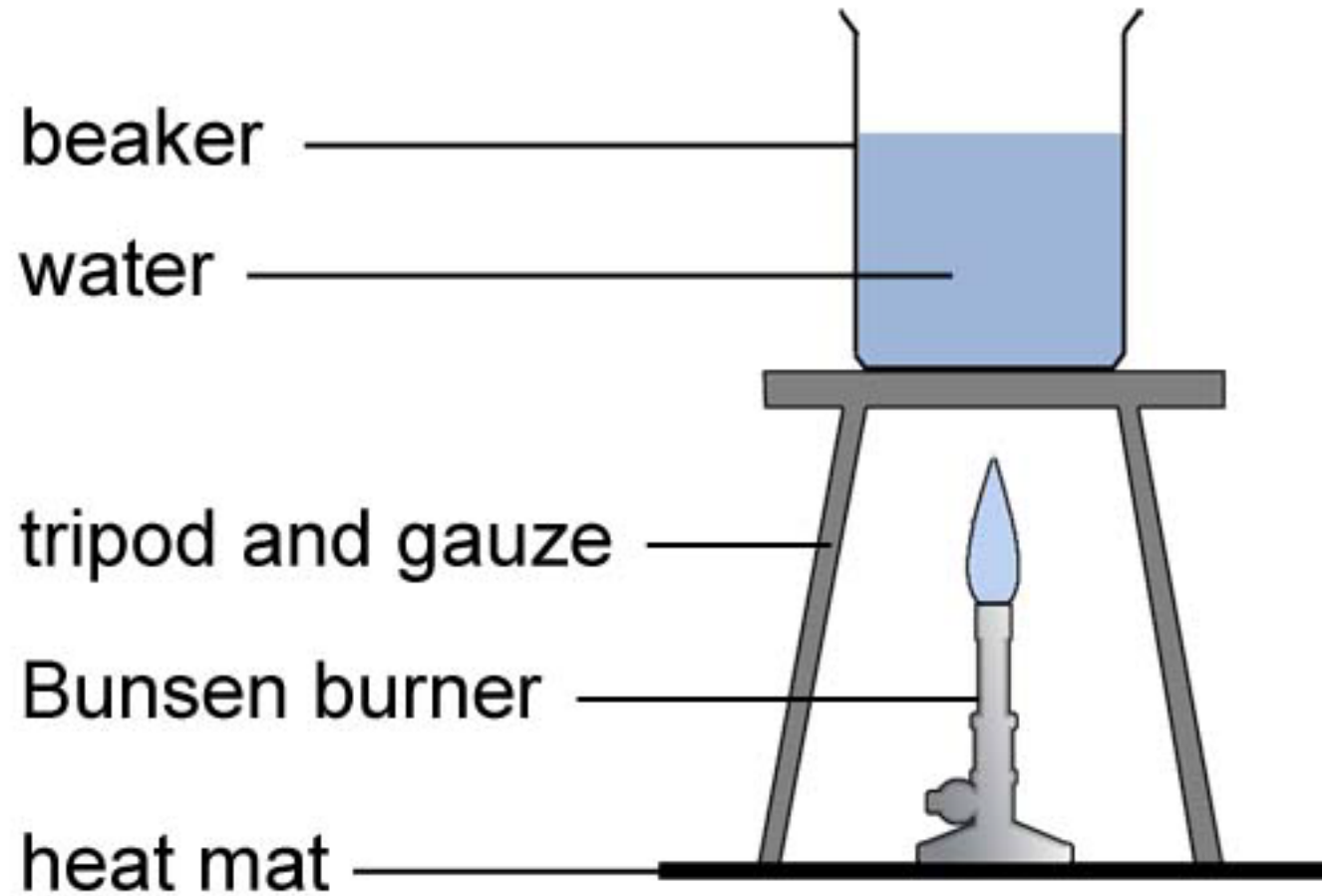
Watch the demonstration of water boiling closely.

What do you observe?

Make a note of this as you will need it later.



# Boiling water: diagram



# Observation and inference

When drawing a conclusion, you need to take care that it is consistent with the evidence.

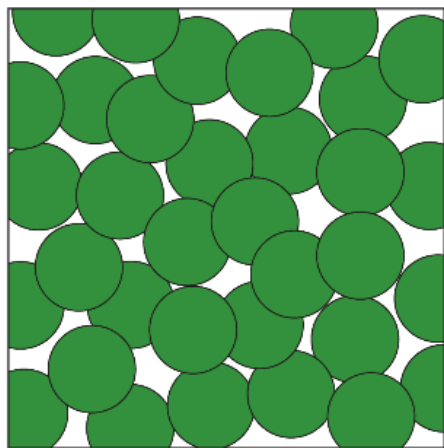
As part of this you need to know the difference between an observation and an inference.

- An **observation** is what is seen – in this practical, bubbles and steam
- An **inference** is interpreting what is seen – what impact does this have on the molecules of water?



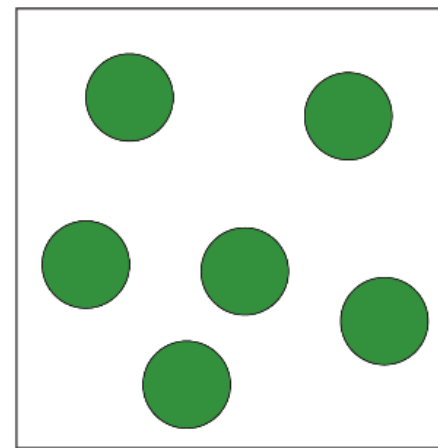
# What do our observations mean?

● = water particle



liquid water

boiling



water vapour  
(steam)

Using the particle diagrams, describe how the particle arrangement changes as a liquid turns into a gas. Describe the difference in:

- relative distances between particles
- relative energy/movement of particles
- relative strength of forces of attraction between particles

# What happens when water boils?

Using your observations from the demonstration, *independently* decide whether each of the statements is **true** or **false** by adding a tick to that column. If you don't know, place a tick in that column instead.

Statement	True	False	Don't know
The bubbles contain a mixture of hydrogen and oxygen			
The bubbles contain carbon dioxide			
The bubbles contain steam (water vapour)			
The bubbles are empty (vacuum)			
The bubbles contain air			
The bubbles contain oxygen only			

# What happens when water boils?

Working in groups of four:

- come to an agreement on whether each statement is true or false
- explain why you agreed on this
- elect a spokesperson to feed back to the class
- complete the following sentences:

**My group agreed that...**

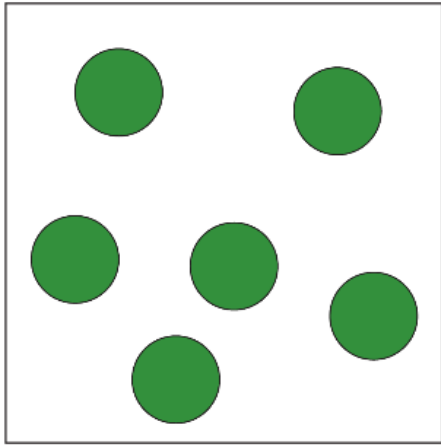
**I changed my ideas because...**

Statement	True	False
The bubbles contain a mixture of hydrogen and oxygen		
The bubbles contain carbon dioxide		
The bubbles contain steam (water vapour)		
The bubbles are empty (vacuum)		
The bubbles contain air		
The bubbles contain oxygen only		



# What do our observations mean?

What is a particle of water?

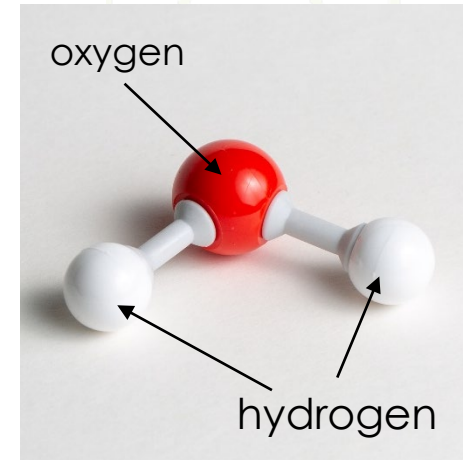


water vapour  
(gas)



water particle

=



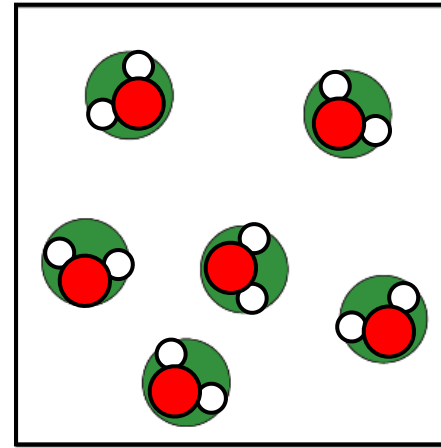
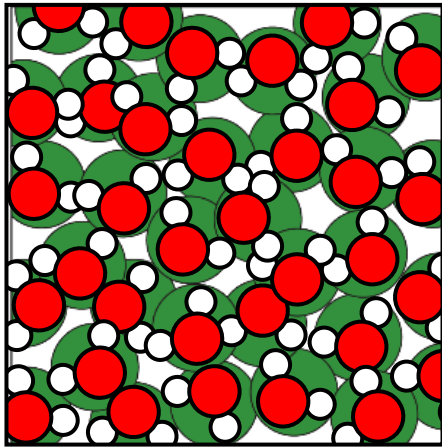
water molecule  
 $\text{H}_2\text{O}$

There are **bonds** between the hydrogen and oxygen atoms in a water molecule. Do you think these bonds break when ice melts or water boils?

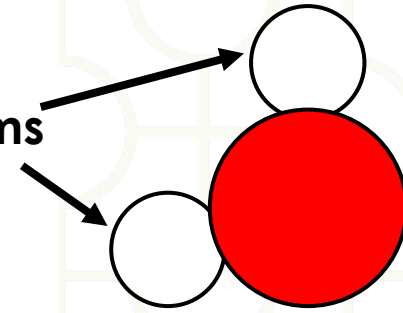


# What do our observations mean?

What is happening to the water molecules?



Hydrogen atoms



Oxygen atom

Why do you think the particle model simplifies 'particles' as circles?



# What happens when water boils?

Self-assess your answers using the table below

Statement	True	False
The bubbles contain a mixture of hydrogen and oxygen		✓
The bubbles contain carbon dioxide		✓
The bubbles contain steam (water vapour)	✓	
The bubbles are empty (vacuum)		✓
The bubbles contain air		✓
The bubbles contain oxygen only		✓

Although there are oxygen and hydrogen atoms, they have a bond between them so are not a mixture.

# Melting ice

Watch the demonstration of ice melting closely.

What molecule is ice made from?

What do you observe?

Which state has more energy?



# What happens when ice melts?

Using your observations from the ice in front of you, *independently* decide whether each of the statements is **true** or **false** by adding a tick to that column.

If you don't know, place a tick in that column instead.

Statement	True	False	Don't know
The molecules in ice get smaller because water takes up less space than ice			
The molecules in ice get warmer because the water is hotter than ice			
The molecules move around more as water than they did in the ice			
Ice molecules and water molecules have different chemical structures			
Ice changes to water at 0°C			
Ice only melts above its melting point			

# What happens when ice melts?

Working in groups of four:

- come to an agreement on whether each statement is true or false
- explain why you agreed on this
- elect a spokesperson to feedback to the class
- complete the following sentences:

**My group agreed that...**

**I changed my ideas because...**

Statement	True	False
The molecules in ice get smaller because water takes up less space than ice		
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# What happens when ice melts?



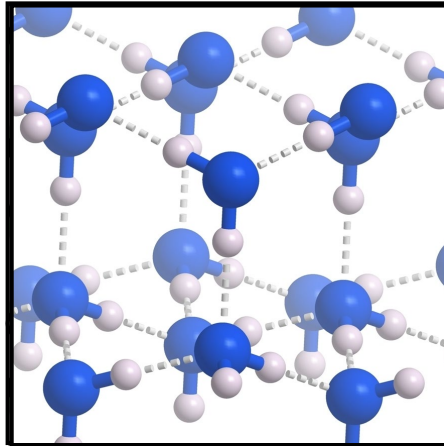
Using the particle diagrams, describe how the particle arrangement changes as a liquid turns into a gas. Describe the difference in:

- relative distances between particles
- relative energy/movement of particles
- relative strength of forces of attraction between particles

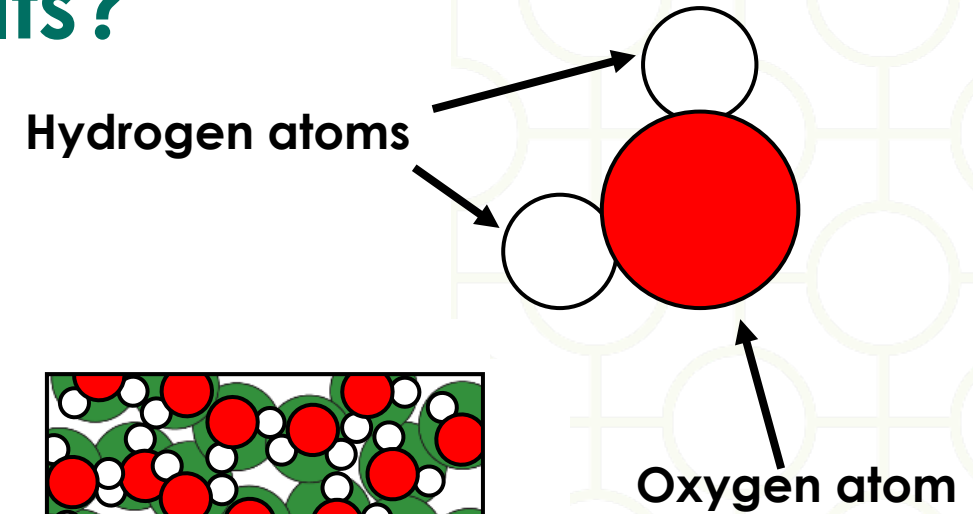
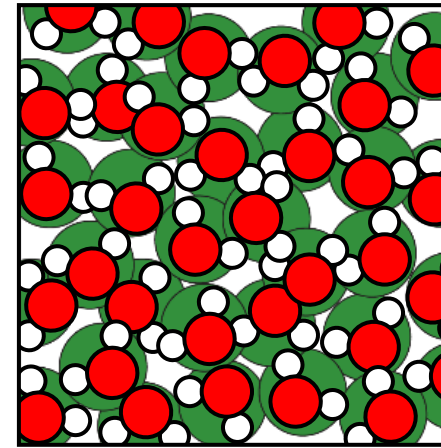




# What happens when ice melts?



melting

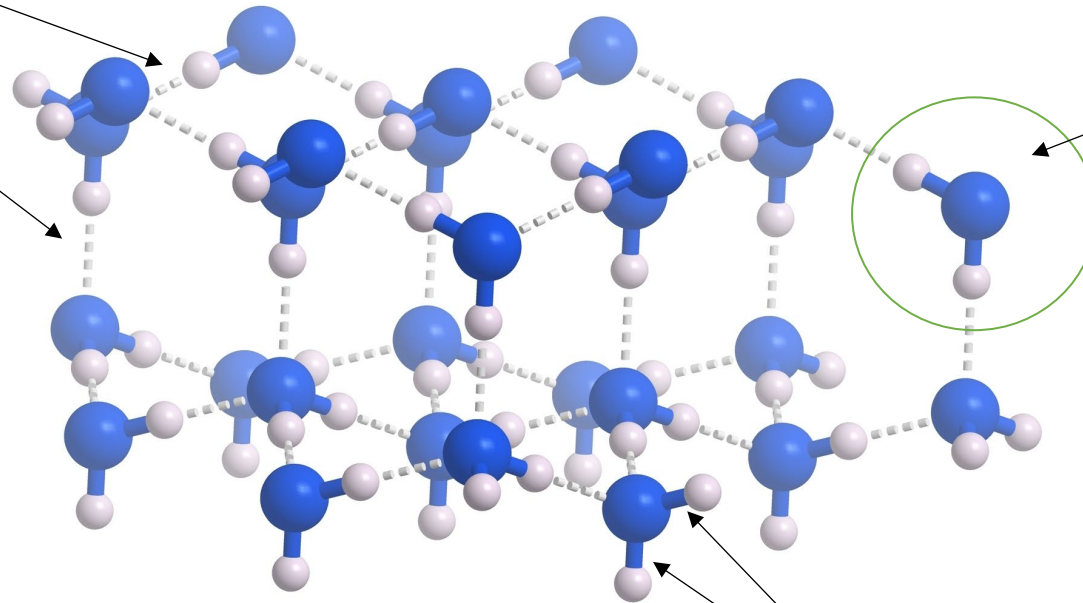


Water in a solid is arranged in hexagons rather than rows.  
Why do you think the particle model diagram of a solid does not match the real structure of ice?

# Bonds vs forces

forces between  
water molecules

a molecule of water



Changes of state affect the forces  
between molecules **not** the bonds  
between the atoms in a molecule.

bonds between  
atoms

# What happens when ice melts?

Self-assess your answers using the table below

Statement	True	False
The molecules in ice get smaller because water takes up less space than ice		✓
The molecules in ice get warmer because the water is hotter than ice		✓
The molecules move around more as water than they did in the ice	✓	
Ice molecules and water molecules have different chemical structures		✓
Ice changes to water at 0°C	✓	
Ice only melts above its melting temperature		✓

Thermal energy is transferred from the surroundings.

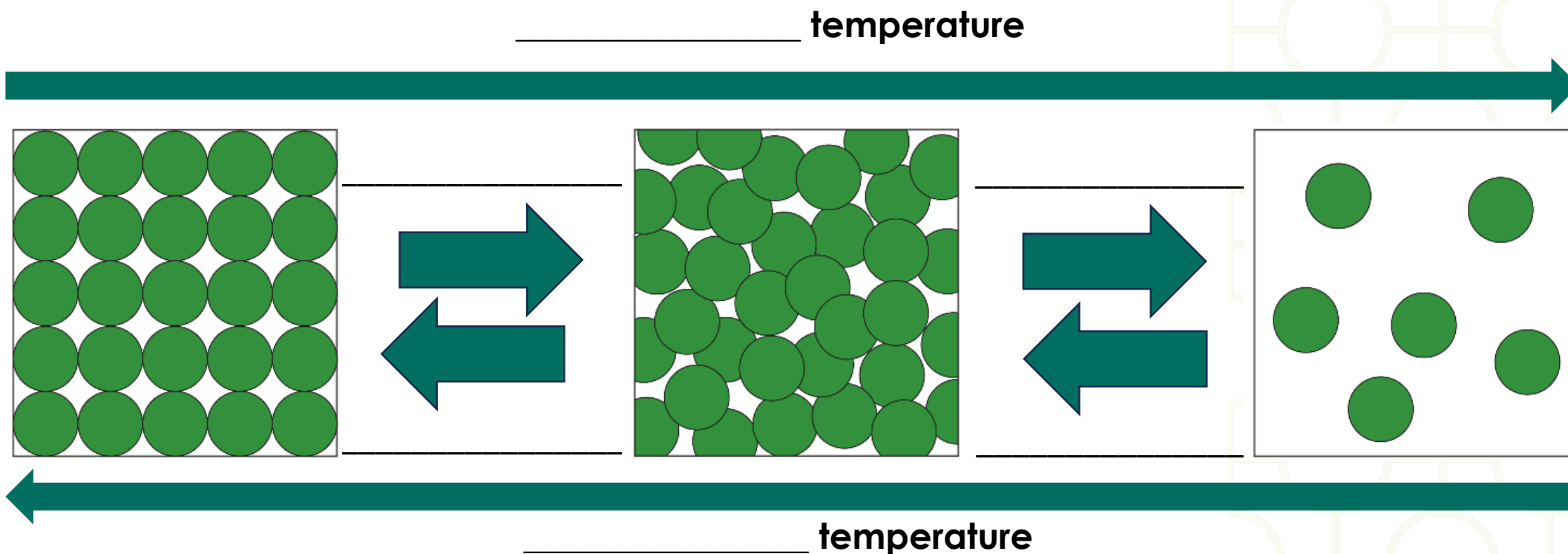
Molecules in a liquid state have more energy than the same molecules in a solid state.

It melts *at* its melting point or above.

# Changes of state in water

Use the terms **boiling**, **condensing**, **freezing** and **melting** to label the changes of state shown as particle diagrams below.

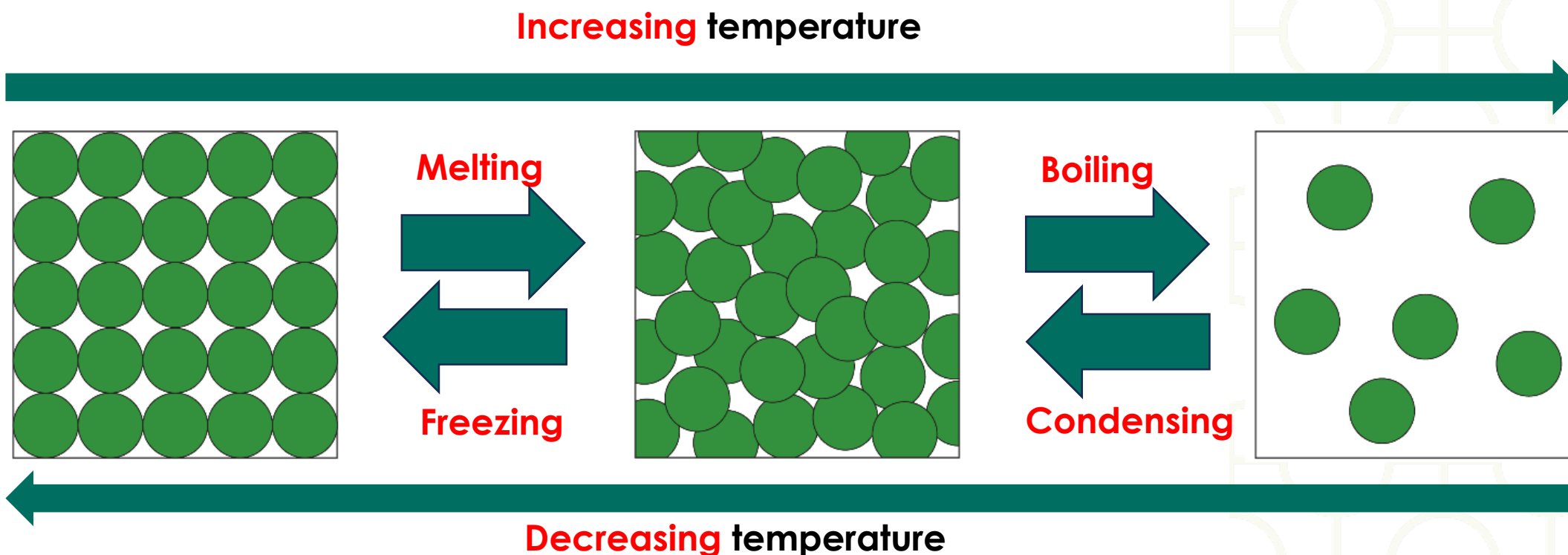
Label the arrows to show whether these state changes occur with **increasing** or **decreasing** temperature.



# Changes of state in water

Use the terms **boiling**, **condensing**, **freezing** and **melting** to label the changes of state shown as particle diagrams below.

Label the arrows to show whether these state changes occur with **increasing** temperature or **decreasing** temperature.







# Revisiting



What is happening in the images?

A – melting

B – boiling

C – condensing

D – freezing

# Reviewing our ideas

Have our ideas changed/developed? Use the sentence starters below.

**Melting**

**Freezing**

**Boiling**

**Condensing**

## Sentence starters:

'Initially I thought that... but now I know...'

'I changed my ideas because...'

'Before this lesson, I didn't know about...'

**Challenge:** Can you link all three of these terms to water?