

## Melting and boiling points











This resource is from the **Johnstone's triangle** series which can be viewed at: [rsc.li/4mFH6ND](https://rsc.li/4mFH6ND). In this series you will also find our **Melting and boiling: Johnstone's triangle** worksheet which introduces the triangle in the context of melting and boiling water: [rsc.li/4laqj4k](https://rsc.li/4laqj4k).

### Learning objectives

LO	Objective	Where assessed
1	Recognise that a pure sample of a substance has a single sharp melting point.	Q1
2	Use melting and boiling point data to deduce the state of materials at given temperatures.	Q2 and Q3
3	Describe the change in arrangement and movement of particles when a substance melts.	Q4
4	Explain why the idea of forces of attraction between particles is necessary to explain differences in melting point.	Q4

### How to use this resource

This resource aims to develop learners' understanding of melting and boiling points and changes of state. The questions encourage learners to think about what the particle model can and cannot explain. As a result, learners should develop more secure mental models to support their thinking about this topic.

When to use?	 Introduce	 Develop	 Revise	 Assess
	Use after initial teaching or discussion of this topic to develop ideas further. You can also use as a revision activity.			
Group size?	 Independent	 Small group	 Whole class	 Homework
	Suitable for independent work either in class or at home. Or use the questions for group or class discussions.			
How long?	 → 		15–30 mins	

## Johnstone's triangle

Johnstone's triangle is a model of the three different conceptual levels in chemistry: macroscopic, sub-microscopic and symbolic. You can use Johnstone's triangle to build a secure understanding of chemical ideas for your learners.

Find further reading about Johnstone's triangle and how to use it in your teaching at [rsc.li/4klRGkR](https://rsc.li/4klRGkR).

### Johnstone's triangle and this resource

The icons in the margin indicate which level of understanding each question is developing to help prompt learners in their thinking.



**Macroscopic:** what we can see. Think about the properties that we can observe, measure and record.



**Sub-microscopic:** smaller than we can see. Think about the particle or atomic level.



**Symbolic:** representations. Think about how we represent chemical ideas including symbols and diagrams.

The levels are interrelated, for example, learners need visual representation of the sub-microscopic to develop mental models of the particle or atomic level. Our approach has been to apply icons to questions based on what the learners should be thinking about.

Questions may be marked with two or all three icons, indicating that learners will be thinking at more than one level. However, individual parts of the question may require learners to think about only one or two specific levels at a time.

## Support

This worksheet is ramped so that the earlier questions are more accessible. The activity becomes more challenging in the later questions. You can give extra explanations for the more challenging questions. If completing as an in-class activity it is best to pause and check understanding at intervals, as often one question builds on the previous one.

It is useful for learners to observe macroscopic properties first-hand. You could circulate examples of substances in the classroom, run a class practical of a chemical reaction or show a teacher demonstration of properties.

Give learners physical models to use and manipulate, such models of the particle model made of marbles or similar.

Additional support may be needed for any learners still lacking in confidence in the required symbolic representation, for example by sharing and explaining a diagram or a simulation that can show movement of the particles.

## Answers



1. *Guidance note:* The question develops learners' understanding of the sharp melting point of a pure metal compared with an impure sample melting over a range of temperatures (macroscopic understanding).

B and C



2. *Guidance note:* This question develops learners' understanding of the link between melting point and the state of a substance at a given temperature above or below that melting point (macroscopic understanding).

(a) Above the melting point gold is in the **liquid** state.

(b) Below the melting point gold is in the **solid** state.

(c)

Metal	Melting point (°C)	State at 1000°C
copper	1084	<b>Solid</b>
aluminium	660	<b>Liquid</b>
silver	961	<b>Liquid</b>
titanium	1670	<b>Solid</b>



3. *Guidance note:* This question develops learners' understanding of how to determine the state of water at a given temperature based on known melting and boiling points (macroscopic understanding).

(a) gas

(b) liquid

(c) solid



4. *Guidance note:* This question develops learners' understanding of the particle model for the solid and liquid states (sub-microscopic understanding). It then supports learners to consider the limitations of the basic particle model which cannot explain the difference in melting point (macroscopic understanding) between two metals. To explain differences in melting point the model needs improving to show there are invisible forces of attraction between particles that can be different for different substances.

(a) The particles are the same shape/size and arranged close together in both states.

(b) The particles are in a regular arrangement vibrating around fixed points in the solid state. In the liquid state the particles have an irregular arrangement and can move past each other.

(c) When a substance melts it involves breaking forces of attraction between particles. The basic particle model does not include forces of attraction and so it cannot explain the difference in melting point between copper and silver.

(d) The forces of attraction between copper particles are stronger than between silver particles. This means that a higher temperature (more energy) is needed to melt copper by overcoming the forces of attraction than the temperature (energy) needed to melt silver.