

Interpreting chemical equations: ionic compounds

This resource is from the **Johnstone's triangle** series, which can be viewed at: rsc.li/3YoYMC8. In this series you will also find our Johnstone's triangle worksheet on ionic equations which introduces the triangle in the context of the reaction between magnesium and oxygen: rsc.li/4pEs1fs.

Learning objectives

LO	Objective	Where assessed
1	Link the formula and state symbol of reactants and products to observations of a chemical reaction.	Q1
2	Interpret the meaning of the formula of different ionic compounds.	Q2, Q3
3	Interpret a chemical equation to identify the structure of each reactant and product and whether each is made up of atoms, molecules or ions.	Q4
4	Recognise that a chemical equation can be used to work out the mass of product that could be produced from the given mass of a reactant.	Q5

How to use this resource

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	

This resource aims to develop learners' understanding of how balanced chemical equations show the ratio in which atoms, molecules and ions of different substances react or are produced. The questions encourage learners to think about how the chemical formula and state symbol of elements and compounds connect to their structure and what is observed during a chemical reaction. The final question

encourages learners to think about how a balanced chemical equation can be used to determine the mass of substances that react or are produced. As a result, learners should develop more secure mental models to support their thinking about this topic.

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/3LePXb6.

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 in order 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 run a class practical of relevant chemical reactions or carry out a teacher demonstration. It is important that learners can observe the detail of the reactions so a camera may be useful.

It may be helpful to learners to show them a physical model or a digital image of a simple ionic lattice such as sodium chloride which can be rotated.

Additional support may be needed for any learners still lacking in confidence in the required symbolic representation. Increasing fluency in recognising symbols and common formulae through quizzing may be beneficial, along with matching to the physical appearance of elements and compounds to improve recognition.

Answers



1. *Guidance note:* This question develops learners' understanding of how observations of the formation of a product (macroscopic understanding) connect to a chemical formula and state symbol (symbolic understanding).

- (a) MgO(s)
- (b) MgO(s)
- (c) CuSO₄(aq)
- (d) CuSO₄(s)



2. *Guidance note:* This question develops learners' understanding of the connection between the chemical formula of an ionic compound (symbolic understanding) and the ratio of the large number of ions that make up its ionic lattice structure (sub-microscopic understanding).

- (a) Diagram A because it shows lots of ions arranged in a lattice.
- (b) One
- (c) The overall charge of an ionic compound must be zero. If there were more negative chloride ions than positive sodium ions, then the overall charge would be negative.



3. *Guidance note:* This question develops learners' understanding by supporting them to apply the idea of a ratio of ions (sub-microscopic understanding) to ionic compounds with different chemical formulas (symbolic understanding).

(a)

Ionic compound	Formula	Metal ions	Non-metal ions
sodium chloride	NaCl	Na ⁺	Cl ⁻
magnesium chloride	MgCl ₂	Mg ²⁺	Cl ⁻
magnesium oxide	MgO	Mg ²⁺	O ²⁻
sodium oxide	Na ₂ O	Na ⁺	O ²⁻

- (b) One
- (c) Two
- (d) One
- (e) One



4. *Guidance note:* This question develops learners' understanding of how to connect a chemical formula and state symbol (symbolic understanding) to the structure of the element or compound (sub-microscopic understanding). This can then be used to determine whether the element or compound is made up of atoms, molecules of ions and the relative number of each.

- (a)
- Na(s): Element
 - Cl₂(g): Element
 - NaCl(s): Metal/non-metal compound
- (b)
- Na(s): Metallic
 - Cl₂(g): Separate covalent molecules
 - NaCl(s): ionic lattice
- (c)
- Na(s): Atoms
 - Cl₂(g): Molecules
 - NaCl(s): Ions

(d)

Number of Mg atoms	Number of chlorine molecules	Number of Mg ²⁺ ions	Number of Cl ⁻ ions
1	1	1	2
2	2	2	4
10	10	10	20
1 billion	1 billion	1 billion	2 billion



5. *Guidance note:* This question develops learners' understanding of how a balanced chemical equation (symbolic understanding) shows the ratio of the number of atoms and ions (in moles) that react or are produced (sub-microscopic understanding). Students are then supported to connect this to the mass of substances that react or are produced (macroscopic understanding). If students do not need to learn about moles, this question could be omitted.

- (a) One mole of magnesium atoms: one mole
Two moles of magnesium atoms: two moles
- (b) 48 g
- (c) 190 g (2 x 95 g)
- (d)
- 24 g of magnesium is one mole of magnesium. One mole of magnesium produces one mole of magnesium chloride, so 95 g of magnesium chloride would be formed.
 - 48 g magnesium:190 g (two moles of magnesium chloride)