Symbols and formulas

This resource is from the **Johnstone's triangle** series which can be viewed at: rsc.li/43jMfSn. In this series you will also find our **C, O and Co Johnstone's triangle worksheet** which introduces the triangle in the context of carbon, carbon monoxide and cobalt: rsc.li/4rnSS0z.

Learning objectives

LO	Objective	Where assessed
1	Recognise that chemical symbols are based on the element name in English or in Latin.	Q1
2	Determine the number of each type of atom in a molecule from a chemical formula.	Q2
3	Interpret the meaning of a chemical formula representing a substance made up of separate molecules.	Q3
4	Interpret the meaning of a chemical formula representing a substance made up of one giant molecule.	Q4

How to use this resource

<table>
<tr><td rowspan="2">When to use?</td><td>Introduce</td><td>Develop</td><td>Revise</td><td>Assess</td></tr>
<tr><td colspan="4">Use after initial teaching or discussion of this topic to develop ideas further. You can also use as a revision activity.</td></tr>
<tr><td rowspan="2">Group size?</td><td>Independent</td><td>Small group</td><td>Whole class</td><td>Homework</td></tr>
<tr><td colspan="4">Suitable for independent work either in class or at home. Or use the questions for group or class discussions.</td></tr>
<tr><td>How long?</td><td colspan="2">→</td><td colspan="2">15–30 mins</td></tr>
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This resource aims to develop learners' understanding of symbols and chemical formulas. The questions encourage learners to think about what is represented by the chemical formula of a substance made of individual molecules. This leads to the idea of a chemical formula as showing the ratio of different types of atom in the bulk substance. 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/44UUtSG.

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 pause and check understanding at intervals, as often one question builds on the previous one.

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:* This question develops learners' understanding of the use of letters to create symbols for a range of elements whose names start with the letter C (symbolic understanding).

(a)

C – carbon
Ca – calcium
Cd – cadmium
Cf – californium
Co – cobalt

(b) Cu

2. *Guidance note:* This question develops learners' understanding of how a chemical formula (symbolic understanding) can show the number of atoms in each molecule of substance (sub-microscopic understanding). It also develops understanding of what information a chemical formula does not provide (the order in which atoms are connected in a molecule).

Please note that whilst all the examples in this question are made up of separate molecules it may help reduce later misconceptions to ensure that learners are aware that a chemical formula does not always represent a substance made up of individual molecules. A formula can represent a single connected giant structure (see Q4). At this point in the curriculum learners will not have encountered the idea of ions and therefore ionic compounds have been avoided in this resource.

(a)

Formula	Number of atoms		
	O	C	H
O_2	**2**	**0**	**0**
CO_2	**2**	**1**	**0**
H_2O	**1**	**0**	**2**
H_2O_2	**2**	**0**	**2**
$C_6H_{12}O_6$	**6**	**6**	**12**

(b) Order in which the atoms are connected/shape of the molecule.

3. *Guidance note:* This question develops learners' understanding of how a chemical formula (symbolic understanding) represents the ratio of atoms in the bulk substance which consists of many molecules. Please note that knowledge of the word ratio is not required. Learners are provided with a sentence structure to express the idea (see Q3c).

(a)

Diagram	Number of atoms	
	C	H
1	**1**	**4**
2	**2**	**8**
3	**3**	**12**
4	**4**	**16**

(b) number of carbon atoms x 4 = number of hydrogen atoms.
(c) For every carbon atom there are always four hydrogen atoms.

4. *Guidance note:* This question develops learners' understanding of how a chemical formula (symbolic understanding) represents the ratio of atoms in silicon dioxide which has giant structure rather than being made up of individual molecules (sub-microscopic understanding). This is why it is important to extend understanding of chemical formulas from giving the number of different types of atoms in a single molecule to giving the ratio of types of atom in the bulk substance. It may help learners to show them a 3D physical model of silicon dioxide or a digital image of the structure.

For every silicon atom … there are always two oxygen atoms.