State symbols

4.2.2.2 · Bonding, structure and the properties of matter · revision notes

The four state symbols, (s), (l), (g) and (aq), and how to add them to equations. They are usually worth 1 or 2 marks in equation questions anywhere on either paper, and you should include them whenever a question asks for them.

Key facts

- (s) solid (l) liquid (g) gas (aq) aqueous = dissolved in water
- Dilute acids and alkalis: (aq)
- Molten substance: (l)
- Water made in a reaction: $H_2O(l)$
- Metals and insoluble compounds: (s); a precipitate is (s)
- Neutralisation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Notes

The four state symbols

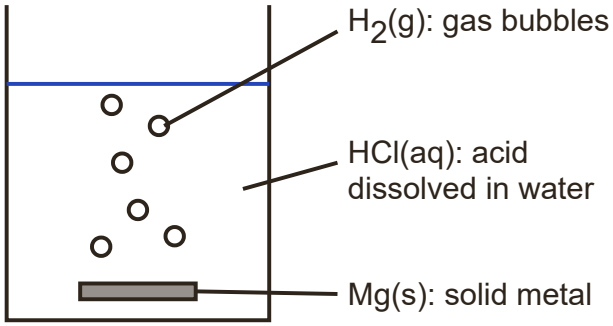
- **(s)** solid
- **(l)** liquid: a pure liquid or a molten (melted) substance
- **(g)** gas
- **(aq)** aqueous: dissolved in water (a solution in water)
- Write the symbol in brackets straight after the formula, e.g. $CO_2(g)$, and give one to every reactant and product.

Choosing the right symbol

- Metals, and oxides and carbonates added as powders or lumps, are solids: Mg(s), CuO(s), $CaCO_3(s)$.
- Acids and alkalis used in the lab are solutions: HCl(aq), $H_2SO_4(aq)$, NaOH(aq).
- Water made in a reaction is **(l)**, never (aq): water cannot be dissolved in itself. Water formed above 100 °C, e.g. when a fuel burns, is steam: $H_2O(g)$.
- Gases given off, e.g. $H_2(g)$, $O_2(g)$, $CO_2(g)$, $Cl_2(g)$.
- A **precipitate** (an insoluble solid that forms when solutions are mixed) is (s). A soluble salt that stays dissolved is (aq).
- A molten ionic compound is (l), e.g. molten lead bromide is $PbBr_2(l)$.
- If you are given melting and boiling points, use them to decide the state at the temperature of the reaction.

Examples

- $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$



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- $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
- $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$
- $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
- Ionic equations use them too: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

How to answer each type of question

Give the meaning of a state symbol

1 mark | **Grade 3**

1. (s) solid, (l) liquid, (g) gas.
2. For (aq), explain it: 'dissolved in water'.

Example. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

What does the state symbol (aq) mean?

Model answer. Dissolved in water / in aqueous solution (1)

Add state symbols to an equation

1 to 2 marks | Grade 5

1. Go through the formulae one at a time.
2. Ask: is it a solid, a pure liquid, a gas, or dissolved in water?
3. Use clues in the question: 'solution', 'bubbles', 'precipitate', 'molten'.
4. Check that water on its own is (l).

Example. Zinc reacts with dilute sulfuric acid. The zinc sulfate formed stays dissolved and bubbles of hydrogen are given off.
Complete the equation by adding state symbols.
$Zn(....) + H_2SO_4(....) \rightarrow ZnSO_4(....) + H_2(....)$

Model answer.

$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

All four correct (2); two or three correct (1)

Write a balanced equation with state symbols

2 marks | Grade 6

1. Write the correct formulae and balance the equation.
2. Add a state symbol to every substance, using the description in the question.

Example. When solutions of barium chloride, $BaCl_2$, and sodium sulfate, Na_2SO_4, are mixed, a white precipitate of barium sulfate, $BaSO_4$, forms. Sodium chloride stays in solution.
Write a balanced equation for this reaction, including state symbols.

Model answer.

$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$ (1)

$BaCl_2(aq)$, $Na_2SO_4(aq)$, $BaSO_4(s)$, $NaCl(aq)$ (1)

Use data to decide a state symbol

2 marks | Grade 7

1. Find the temperature of the reaction.
2. Compare it with each substance's melting and boiling points.
3. Give the symbol and the reason for each.

Example. Sulfur melts at 115 °C and boils at 445 °C. Sulfur dioxide boils at −10 °C.
Sulfur reacts with oxygen at 250 °C: $S + O_2 \rightarrow SO_2$
Give the state symbols for sulfur and for sulfur dioxide at 250 °C.

Model answer.

S(l), because 250 °C is between its melting and boiling points (1)

$SO_2(g)$, because 250 °C is above its boiling point (1)

Don’t lose marks

- Writing H_2O(aq). Water is (l).
- Using (l) for a solution, e.g. HCl(l) for hydrochloric acid. Hydrochloric acid is a solution, so it is (aq); (l) is only for pure liquids and molten substances.
- Giving a precipitate (aq). A solid that forms in a solution is (s).
- Leaving out state symbols when the question asks for them: you can lose the mark even if the equation is balanced.

More tips

Memory tricks

- Aq sounds like aqua (water): aqueous means dissolved in water.
- Bubbles or fizzing → a (g) product. Precipitate → (s). Solution → (aq).
- Water is (l) in these equations, not (aq).

Exam technique

- Add state symbols whenever a question asks for them, and check each one against the information given.
- Read the question for clues about states: 'molten', 'solution', 'gas given off', 'white precipitate'.
- Write the symbols in lower case, in round brackets, straight after each formula.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Recall the four state symbols**
(s) solid, (l) liquid, (g) gas, (aq) aqueous: dissolved in water.

Grade 4 — **Know that aqueous means dissolved in water**
Any solution in water, such as sodium chloride solution or dilute hydrochloric acid, is (aq).

Grade 4 — **Tell (l) apart from (aq)**
Water itself and molten substances are (l); substances dissolved in water are (aq).

Grade 5 — **Add state symbols to a simple equation**
For example, $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$.

Grade 7 — **Use data and observations to choose state symbols**
Use melting and boiling points, or words such as 'bubbles', 'precipitate' and 'solution', to decide each state.

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