SCIENCE FOUNDATIONS

# Polyatomic ions

## Difficulty level: Intermediate

## Science Foundations

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## *Overview of the concept*

This is how you read fertiliser and cleaning labels that list groups like nitrate or hydroxide, which act as one charged unit instead of separate atoms. A gardener buying fertiliser knows the nitrate group is what feeds the plants nitrogen. A homeowner reading a drain cleaner label sees hydroxide listed as a single unit that does the cleaning. Knowing polyatomic ions tells you how to recognise a group of atoms that travels together, so you can read formulas and labels correctly.



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## *Rule*

**Polyatomic ions: in a compound, total positive charge = total negative charge, so the charges balance.**

A polyatomic ion keeps its identity and its charge, and brackets show when more than one of it is needed, as in Ca(OH)2.

Common polyatomic ions: hydroxide $OH^-$, nitrate $NO_3^-$, sulfate $SO_4^{2-}$, carbonate $CO_3^{2-}$, ammonium $NH_4^+$, phosphate $PO_4^{3-}$.

## Worked examples

EXAMPLE 1

**Q** **Write the formula for calcium hydroxide.**

SOLUTION

Write the ions: calcium is Ca 2+, hydroxide is OH -1.

Balance: one Ca 2+ needs two OH -1.

Use brackets for the group: Ca(OH)2

The result is Ca(OH)2.

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EXAMPLE 2

## Q Write the formula for sodium sulfate.

### SOLUTION

Write the ions: sodium is Na +1, sulfate is $SO_4$ 2-.

Balance: two Na +1 balance one $SO_4$ 2-.

Write it: $Na_2SO_4$, no brackets needed for one group.

The result is $Na_2SO_4$.

## Practice questions

**1** **Write the formula for barium hydroxide. State the ions and charges you balanced.**

- **A** Ba(OH)2; Ba2+ with two OH- ions
- **B** BaOH2; Ba+ with two OH- ions
- **C** Ba(OH)2; Ba+ with one OH- ion
- **D** Ba2OH; Ba2+ with one OH- ion

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## 2 Which polyatomic ion is in calcium carbonate, $CaCO_3$?

- A Carbonate, $CO_3^{2-}$
- B Nitrate, $NO_3^-$
- C Sulfate, $SO_4^{2-}$
- D Hydroxide, $OH^-$

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## 3 Potassium sulfate. Give its formula and state the ions and charges you balanced.

- A $K_2SO_4$; two $K^+$ ions with one $SO_4^{2-}$ ion
- B $KSO_4$; $K^+$ with one $SO_4^{2-}$ ion
- C $K_2SO_4$; one $K^+$ ion with two $SO_4^{2-}$ ions
- D $K_2(SO_4)_2$; two $K^+$ ions with two $SO_4^{2-}$ ions

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**4** **Potassium nitrate. Give its formula and state the ions and charges you balanced.**

- **A** KNO3; K+ with NO3-
- **B** KNO3; K2+ with NO3 2-
- **C** K(NO3)2; K+ with two NO3- ions
- **D** KNO3; K+ with NO3 2-

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**5** **What charge does the hydroxide ion carry?**

- **A** -2
- **B** +1
- **C** -1
- **D** 0

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## What charge does the carbonate ion carry?

A -2

B -1

C +1

D 0

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## What charge does the ammonium ion carry?

A -1

B +1

C -2

D 0

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## 8 Why does $Ca(OH)_2$ need brackets?

- **A** To show there are two hydroxide groups
- **B** To show there are two calcium atoms
- **C** To show the charge is 2+
- **D** To show the compound is a liquid

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## 9 Ammonium chloride. What is its formula?

- **A** NH3Cl
- **B** NH4Cl2
- **C** (NH4)2Cl
- **D** NH4Cl

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## Calcium carbonate. What is its formula?

A CaCO2

B CaCO3

C Ca2CO3

D Ca(CO3)2

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## ANSWER KEY

**1.** Ba(OH)2; Ba2+ with two OH- ions

**2.** Carbonate, CO3 2-

**3.** K2SO4; two K+ ions with one SO4 2- ion

**4.** KNO3; K+ with NO3-

**5.** -1

**6.** -2

**7.** +1

**8.** To show there are two hydroxide groups

**9.** $NH_4Cl$

**10.** $CaCO_3$

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