

Precipitation Reactions and Net Ionic Equations

How do you predict a precipitate and write the net ionic equation?

●●○ Intermediate

Reactions & Stoichiometry

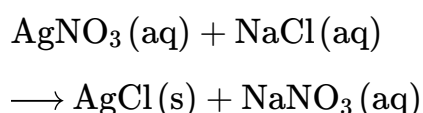
Last reviewed 5 October 2026

Before you start: it helps to understand [Types of Chemical Reactions](#) and [Chemical Names and Formulas](#).

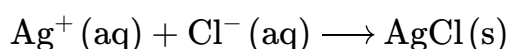
What is it?

When two solutions of ionic compounds are mixed, the ions move around freely. If a positive ion and a negative ion can form an **insoluble** compound, they come together as a solid that settles out: a **precipitate**. This is a **precipitation reaction**.

Mixing silver nitrate and sodium chloride solutions gives a white precipitate of silver chloride:



Only the Ag^+ and Cl^- ions actually react. The Na^+ and NO_3^- ions stay dissolved, unchanged: they are **spectator ions**. The **net ionic equation** shows only the change that happens:



KEY IDEA

Soluble ionic compounds exist in water as **separate ions**. A net ionic equation removes the spectator ions to show the real reaction. The same net ionic equation applies to **any** soluble silver compound mixed with **any** soluble chloride.

Why does it matter?

- **Testing for ions.** Silver nitrate tests for halides; barium chloride tests for sulfate. The colour of the precipitate identifies the ion.
- **Water treatment and analysis.** Precipitation removes phosphates and heavy metals from water, and **gravimetric analysis** finds how much of an ion is present by weighing the precipitate.
- **Health and nature.** Kidney stones (calcium oxalate), limescale (calcium carbonate) and stalactites are precipitates.

How does it work?

1. Solubility rules

Usually soluble	Exceptions (insoluble)
All compounds of Group 1 ions (Na^+ , K^+ , ...) and NH_4^+	none
All nitrates (NO_3^-) and ethanoates (CH_3COO^-)	none
Chlorides, bromides, iodides	with Ag^+ and Pb^{2+}
Sulfates (SO_4^{2-})	with Ba^{2+} , Pb^{2+} ; Ca^{2+} only slightly soluble

Usually insoluble	Exceptions (soluble)
Carbonates, phosphates	with Group 1 ions and NH_4^+
Hydroxides	with Group 1 ions; $\text{Ba}(\text{OH})_2$ soluble, $\text{Ca}(\text{OH})_2$ slightly
Most oxides and sulfides	with Group 1 ions and NH_4^+

2. Predicting a precipitate

1. Write the ions present in each solution.
2. Swap partners to find the two possible new compounds.
3. Check each with the solubility rules. If one is insoluble, it precipitates. If both are soluble, **no reaction**.

3. Writing the three equations

1. **Molecular equation:** balanced, with all compounds written as formulas and state symbols.
2. **Complete ionic equation:** split every **soluble (aq) ionic** compound into its ions. Keep solids, liquids, gases and weak electrolytes (such as H_2O) as formulas.
3. **Net ionic equation:** cross out ions that appear **unchanged on both sides** (spectators). Check that atoms and **charge** balance.

∞ THINK OF IT LIKE THIS

Think of a dance floor. When two groups of dancers mix, most keep dancing alone (spectator ions), but some pairs lock together and leave the floor (the precipitate). The net ionic equation only reports the pairs that left.

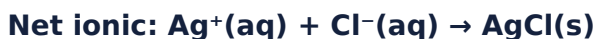
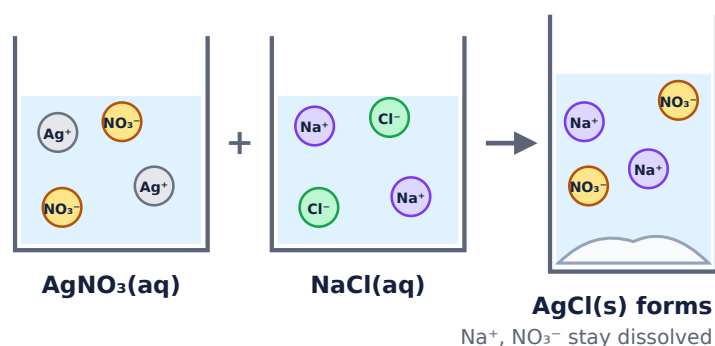
🔍 MORE PRECISELY

“Insoluble” really means **very slightly soluble**: a tiny amount always dissolves, described quantitatively by the **solubility product**, K_{sp} . Solubility also depends on temperature. Strong acids, strong bases and soluble salts are written as ions because they are fully dissociated; weak acids, such as ethanoic acid, are written as molecules because they are mostly undissociated. The neutralization of any strong acid by any strong base has the same net ionic equation: $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})$.

Visualise it

A precipitation reaction

Mixing two solutions of ionic compounds



Spectator ions (Na⁺, NO₃⁻) are left out.

Only Ag⁺ and Cl⁻ react; Na⁺ and NO₃⁻ are spectators.

Worked example

🔗 WORKED EXAMPLE: Does a precipitate form?

Question: Predict whether a precipitate forms when solutions of (a) barium chloride and sodium sulfate, (b) potassium nitrate and ammonium chloride are mixed.

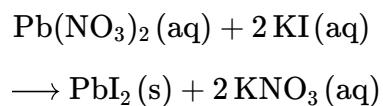
Step 1 (a) Possible new compounds: BaSO₄ and NaCl. Barium sulfate is **insoluble**: a white precipitate forms.

Step 2 (b) Possible new compounds: KCl and NH₄NO₃. Both are soluble: **no reaction**.

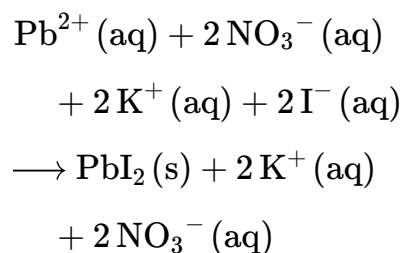
 WORKED EXAMPLE: Molecular, complete ionic and net ionic equations

Question: Write the three equations for the reaction of lead(II) nitrate with potassium iodide.

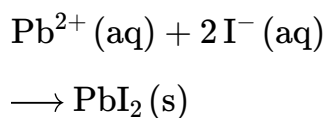
Step 1 Molecular:



Step 2 Complete ionic:



Step 3 Cancel the spectators (K^{+} and NO_3^{-}). Net ionic:



Step 4 Check: 1 Pb and 2 I on each side; charge $(+2) + 2(-1) = 0$ on the left and 0 on the right. Lead(II) iodide is a bright yellow precipitate.

 WORKED EXAMPLE: A gravimetric calculation

Question: Excess silver nitrate is added to 25.0 mL of 0.100 mol/L sodium chloride. What mass of silver chloride precipitates? (AgCl: 143.32 g/mol)

Step 1 Moles of chloride:

$$\begin{aligned} n &= 0.100 \frac{\text{mol}}{\cancel{\text{L}}} \\ &\quad \times 0.0250 \cancel{\text{L}} \\ &= 2.50 \times 10^{-3} \text{ mol Cl}^- \end{aligned}$$

Step 2 $\text{Ag}^+ + \text{Cl}^- \longrightarrow \text{AgCl}$: 1 mol Cl^- gives 1 mol AgCl.

$$\begin{aligned} &2.50 \times 10^{-3} \cancel{\text{mol}} \\ &\quad \times 143.32 \frac{\text{g}}{\cancel{\text{mol}}} \\ &= 0.358 \text{ g AgCl} \end{aligned}$$

Common mistake

 COMMON MISTAKE: Splitting a precipitate into ions

A solid (s) stays as a formula in the ionic equations. Only **dissolved (aq)** ionic compounds are split into ions.

 COMMON MISTAKE: Forgetting coefficients when splitting

$2 \text{KI}(\text{aq})$ gives $2 \text{K}^+(\text{aq}) + 2 \text{I}^-(\text{aq})$, and $\text{Pb}(\text{NO}_3)_2(\text{aq})$ gives **two** nitrate ions. Polyatomic ions stay together: nitrate is NO_3^- , not N and O.

 COMMON MISTAKE: An unbalanced net equation

A net ionic equation must balance in **charge** as well as atoms.

$\text{Ba}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{BaSO}_4$ is balanced: $(+2) + (-2) = 0$.

 NOTATION NOTE

- (aq) means dissolved in water; (s) marks the precipitate.
- Spectator ions can be shown struck through in the complete ionic equation before they are removed.

Remember this

REMEMBER THIS

- Group 1, NH_4^+ and nitrate compounds are always soluble.
- Chlorides are soluble except with Ag^+ , Pb^{2+} ; sulfates except with Ba^{2+} , Pb^{2+} (and Ca^{2+} , slightly).
- Carbonates, phosphates and hydroxides are mostly insoluble.
- Molecular → complete ionic (split aq ionic compounds) → net ionic (remove spectators).
- Check atoms and charge balance in the net equation.

References

1. Brown, T. L.; LeMay, H. E., Jr.; Bursten, B. E.; Murphy, C. J.; Woodward, P. M.; Stoltzfus, M. W. Chemistry: The Central Science, 15th ed.; Pearson, 2022.

Practise this topic with flashcards and a quiz at chemistryclarity.com/chemistry/precipitation-and-net-ionic-equations/