ANSWER KEY. Observations match the simulation for each mixture. Equations include states.

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Net Ionic Reactions Virtual Lab

Chemistry | ANSWER KEY

Open **activities.zornscience.org/net-ionic-lab/** and follow each step. Write states, (s), (l), (g) or (aq), in every equation. Keep polyatomic ions together as one unit.

Objective

Mix ten pairs of reagents, use **evidence** to decide whether each pair reacts, and write **molecular, total ionic and net ionic equations** for the reactions that happen.

NGSS alignment: HS-PS1-2. Explain the outcome of a simple chemical reaction based on the outermost electron states of atoms and patterns of chemical properties. HS-PS1-7. Use mathematical representations to show that atoms, and therefore mass, are conserved in a reaction.
Practices and concepts: Carrying out investigations; Constructing explanations; Patterns.

Meet the simulation

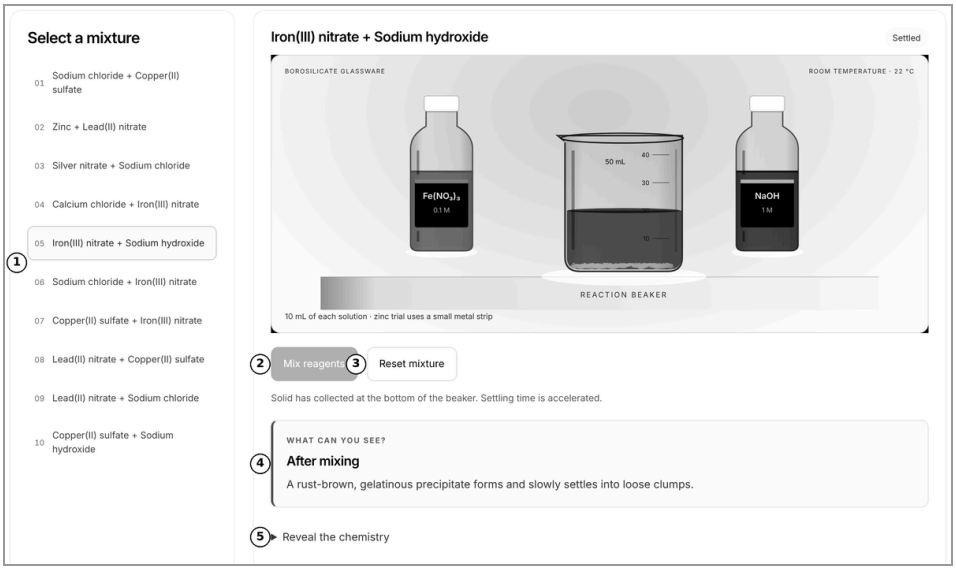


Figure 1. Iron(III) nitrate + sodium hydroxide after mixing.

① **Select a mixture:** the ten reagent pairs, numbered 01 to 10.

② **Mix reagents:** pours 10 mL of each solution into the beaker.

③ **Reset mixture:** empties the beaker to watch again.

④ **What can you see?** A written description of the result.

⑤ **Reveal the chemistry:** open only after you record your own observations.

Pre-lab

1. Define **precipitate** and **spectator ion**. List two observations that are evidence of a chemical reaction.

Precipitate: an insoluble solid that forms when two solutions are mixed. Spectator ion: an ion that is present but unchanged, the same on both sides of the equation. Evidence (any two): a precipitate forms, a gas forms, a new color appears, a metal dissolves or a new metal deposits, temperature changes.

2. Lead(II) nitrate reacts with potassium chromate to form solid lead(II) chromate. Write the balanced molecular, total ionic and net ionic equations. List the spectator ions.

Molecular: $Pb(NO_3)_2(aq) + K_2CrO_4(aq) \rightarrow PbCrO_4(s) + 2KNO_3(aq)$
Total ionic: $Pb^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + CrO_4^{2-}(aq) \rightarrow PbCrO_4(s) + 2K^+(aq) + 2NO_3^-(aq)$
Net ionic: $Pb^{2+}(aq) + CrO_4^{2-}(aq) \rightarrow PbCrO_4(s)$
Spectators: K^+ and NO_3^-

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Part A. Observe the ten mixtures

1. Select mixture **01**. Look at the starting solutions, then select **Mix reagents**.
2. For a precipitate, wait about 10 seconds until the label at the top right says **Settled**. For the zinc trial, look at the metal strip (Figure 2).
3. Record color, clarity, any solid, and any change to the metal. Decide whether a reaction happened. Repeat for mixtures 02 to 10. Do not open **Reveal the chemistry** until your table is done.

#	Mixture	Observations after mixing	Reaction? (yes/no)
01	Sodium chloride + copper(II) sulfate	**Clear, paler blue. No solid.**	**No**
02	Zinc + lead(II) nitrate	**Dark gray crystals coat the zinc. Solution stays colorless.**	**Yes**
03	Silver nitrate + sodium chloride	**White, curdy precipitate forms at once and settles.**	**Yes**
04	Calcium chloride + iron(III) nitrate	**Clear, pale yellow. No solid or gas.**	**No**
05	Iron(III) nitrate + sodium hydroxide	**Rust-brown, gelatinous precipitate settles in clumps.**	**Yes**
06	Sodium chloride + iron(III) nitrate	**Clear, pale yellow. No solid.**	**No**
07	Copper(II) sulfate + iron(III) nitrate	**Clear blue-green mixture. No solid.**	**No**
08	Lead(II) nitrate + copper(II) sulfate	**Fine white precipitate settles; pale blue liquid above.**	**Yes**
09	Lead(II) nitrate + sodium chloride	**White crystalline precipitate settles; colorless liquid.**	**Yes**
10	Copper(II) sulfate + sodium hydroxide	**Light blue, gelatinous precipitate collects at the bottom.**	**Yes**

Solution concentrations: sodium chloride and sodium hydroxide 1 M, all others 0.1 M. Zinc is a small solid strip.

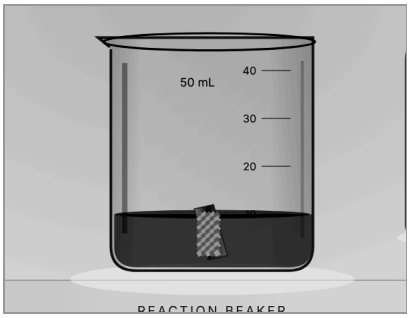


Figure 2. Mixture 02 after mixing (shown inverted for printing).

3. Mixture 07 changed color to blue-green. Why is this color change, by itself, *not* evidence of a reaction?

Blue copper(II) sulfate and yellow iron(III) nitrate simply blend into blue-green. No precipitate, gas or new substance forms; all the ions stay dissolved as spectators.

4. Mixtures 01, 03, 04, 06 and 09 all contain chloride ions, but only 03 and 09 formed a precipitate. Which cations do 03 and 09 have that the others do not? Use this pattern to explain when chloride forms a precipitate.

03 and 09 contain Ag^+ or Pb^{2+}. Chloride forms a precipitate only with ions such as Ag^+ and Pb^{2+} (AgCl and $PbCl_2$ are insoluble). With Na^+, Cu^{2+}, Ca^{2+} or Fe^{3+}, chlorides are soluble, so no solid forms.

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Part B. Write the equations

For each mixture that reacted, write the balanced **molecular** (M), **total ionic** (TI) and **net ionic** (NI) equations with states, and list the **spectator ions** (S). Check your work with **Reveal the chemistry** only after you finish.

5. Mixture 02: zinc + lead(II) nitrate

M: $Zn(s) + Pb(NO_3)_2(aq) \rightarrow Zn(NO_3)_2(aq) + Pb(s)$
TI: $Zn(s) + Pb^{2+}(aq) + 2NO_3^-(aq) \rightarrow Zn^{2+}(aq) + 2NO_3^-(aq) + Pb(s)$
NI: $Zn(s) + Pb^{2+}(aq) \rightarrow Zn^{2+}(aq) + Pb(s)$ S: NO_3^-

6. Mixture 03: silver nitrate + sodium chloride

M: $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$
TI: $Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + Cl^-(aq) \rightarrow AgCl(s) + Na^+(aq) + NO_3^-(aq)$
NI: $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ S: Na^+, NO_3^-

7. Mixture 05: iron(III) nitrate + sodium hydroxide

M: $Fe(NO_3)_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaNO_3(aq)$
TI: $Fe^{3+}(aq) + 3NO_3^-(aq) + 3Na^+(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s) + 3Na^+(aq) + 3NO_3^-(aq)$
NI: $Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$ S: Na^+, NO_3^-

8. Mixture 08: lead(II) nitrate + copper(II) sulfate

M: $Pb(NO_3)_2(aq) + CuSO_4(aq) \rightarrow PbSO_4(s) + Cu(NO_3)_2(aq)$
TI: $Pb^{2+}(aq) + 2NO_3^-(aq) + Cu^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + Cu^{2+}(aq) + 2NO_3^-(aq)$
NI: $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$ S: Cu^{2+}, NO_3^-

9. Mixture 09: lead(II) nitrate + sodium chloride

M: $Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$
TI: $Pb^{2+}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s) + 2Na^+(aq) + 2NO_3^-(aq)$
NI: $Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$ S: Na^+, NO_3^-

10. Mixture 10: copper(II) sulfate + sodium hydroxide

M: $CuSO_4(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + Na_2SO_4(aq)$
TI: $Cu^{2+}(aq) + SO_4^{2-}(aq) + 2Na^+(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s) + 2Na^+(aq) + SO_4^{2-}(aq)$
NI: $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ S: Na^+, SO_4^{2-}

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Analysis

11. Mixture 02 is a single-replacement reaction. Which species lost electrons (was oxidized) and which gained electrons (was reduced)? What observation supports your answer?

Zinc atoms lost 2 electrons each and became Zn^{2+} ions (oxidized). Pb^{2+} ions gained 2 electrons each and became lead metal (reduced). Evidence: a dark gray lead coating grew on the zinc strip.

12. Write the total ionic equation for mixture 04 (calcium chloride + iron(III) nitrate). Explain why it has no net ionic equation.

$Ca^{2+}(aq) + 2Cl^{-}(aq) + Fe^{3+}(aq) + 3NO_3^{-}(aq) \rightarrow Ca^{2+}(aq) + 2Cl^{-}(aq) + Fe^{3+}(aq) + 3NO_3^{-}(aq)$
Every ion is unchanged on both sides (all possible products, $Ca(NO_3)_2$ and $FeCl_3$, are soluble), so all ions cancel as spectators: no reaction.

13. Predict: sodium chloride is mixed with potassium bromide. Write the total ionic equation. Is there a net ionic equation? Explain.

$Na^{+}(aq) + Cl^{-}(aq) + K^{+}(aq) + Br^{-}(aq) \rightarrow Na^{+}(aq) + Br^{-}(aq) + K^{+}(aq) + Cl^{-}(aq)$
No. Both possible products (NaBr and KCl) are soluble, so every ion is a spectator: no reaction.

14. Predict the net ionic equation when strontium nitrate is mixed with sulfuric acid ($SrSO_4$ is insoluble). Name the spectator ions.

$Sr^{2+}(aq) + SO_4^{2-}(aq) \rightarrow SrSO_4(s)$. Spectators: H^{+} and NO_3^{-}.

15. The simulation shows ideal results. Give one way a real lab could give a misleading result, and how you would avoid it.

Sample answers: a faint or slow precipitate could be missed, so watch longer against a dark background; dirty glassware could leave a solid that looks like a precipitate, so rinse glassware first; a color change from mixing colored solutions could be mistaken for a reaction, so look for a solid, gas or metal change.

Conclusion

16. Write a claim that answers the objective: how can you tell whether two solutions react, and what does a net ionic equation show? Support it with evidence from two mixtures (one that reacted and one that did not), then explain your reasoning.

Claim: Two solutions react when ions combine to form an insoluble solid (or a metal replaces another ion); the net ionic equation shows only the particles that change.
Evidence: Mixture 03 formed a white AgCl precipitate, so $Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$. Mixture 06 stayed a clear pale yellow with no solid, so no reaction.
Reasoning: In mixture 03, Ag^{+} and Cl^{-} leave solution as a solid, while Na^{+} and NO_3^{-} stay dissolved and cancel as spectators. In mixture 06 every possible product is soluble, so every ion is a spectator and nothing new forms.

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