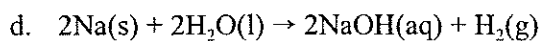


4. [REDACTED] (rule 5)
[REDACTED] (rule 1)
[REDACTED] (rule 6)
[REDACTED] (rule 3)
5. a. $\text{Na}_2\text{SO}_4(\text{aq}) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2 \text{NaNO}_3(\text{aq})$
 The product is lead(II) sulfate.
- b. $\text{NiCl}_2(\text{aq}) + 2 \text{KOH}(\text{aq}) \rightarrow \text{Ni}(\text{OH})_2(\text{s}) + 2 \text{KCl}(\text{aq})$
 The product is nickel(II) hydroxide.
- c. $\text{K}_2\text{S}(\text{aq}) + \text{Zn}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{ZnS}(\text{s}) + 2 \text{KNO}_3(\text{aq})$
 The product is zinc sulfide.
- d. $3 \text{AgNO}_3(\text{aq}) + (\text{NH}_4)_3\text{PO}_4(\text{aq}) \rightarrow \text{Ag}_3\text{PO}_4(\text{s}) + 3 \text{NH}_4\text{NO}_3(\text{aq})$
 The product is silver phosphate.
6. a. $3 \text{Ca}^{2+} + 6 \text{Cl}^- + 6 \text{Na}^+ + 2 \text{PO}_4^{3-} \rightarrow \text{Ca}_3(\text{PO}_4)_2(\text{s}) + 6 \text{Na}^+ + 6 \text{Cl}^-$
 b. $\text{Cu}^{2+} + 2 \text{NO}_3^- + 2 \text{K}^+ + \text{S}^{2-} \rightarrow \text{CuS}(\text{s}) + 2 \text{K}^+ + 2 \text{NO}_3^-$
 c. $2 \text{Ag}^+ + 2 \text{NO}_3^- + 2 \text{K}^+ + \text{SO}_4^{2-} \rightarrow \text{Ag}_2\text{SO}_4(\text{s}) + 2 \text{K}^+ + 2 \text{NO}_3^-$
7. a. $\text{Ca}(\text{NO}_3)_2(\text{aq}) + \text{K}_2\text{SO}_4(\text{aq}) \rightarrow \text{CaSO}_4(\text{s}) + 2 \text{KNO}_3(\text{aq})$
 K^+ and NO_3^- are the spectator ions.
- b. $(\text{NH}_4)_2\text{CO}_3(\text{aq}) + \text{CuCl}_2(\text{aq}) \rightarrow \text{CuCO}_3(\text{s}) + 2 \text{NH}_4\text{Cl}(\text{aq})$
 NH_4^+ and Cl^- are the spectator ions.
- c. $2 \text{NaOH}(\text{aq}) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{Pb}(\text{OH})_2(\text{s}) + 2 \text{NaNO}_3(\text{aq})$
 Na^+ and NO_3^- are the spectator ions.
- d. $\text{Na}_2\text{S}(\text{aq}) + \text{Zn}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{ZnS}(\text{s}) + 2 \text{NaNO}_3(\text{aq})$
 Na^+ and NO_3^- are the spectator ions.
- e. $\text{CoCl}_2(\text{aq}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightarrow \text{Co}(\text{OH})_2(\text{s}) + \text{CaCl}_2(\text{aq})$
 Ca^{2+} and Cl^- are the spectator ions.
8. a. $\text{Ca}^{2+} + \text{CO}_3^{2-} \rightarrow \text{CaCO}_3(\text{s})$
 b. $\text{Pb}^{2+} + \text{S}^{2-} \rightarrow \text{PbS}(\text{s})$
 c. $\text{Hg}_2^{2+} + 2 \text{Cl}^- \rightarrow \text{Hg}_2\text{Cl}_2(\text{s})$
 d. $\text{Mg}^{2+} + 2 \text{OH}^- \rightarrow \text{Mg}(\text{OH})_2(\text{s})$
9. It is possible to produce the solids below from several different soluble salts, so your answer could be correct and not the same as the answer below. If your answer does not match the one below, use the solubility rules to help you determine whether the aqueous salt solutions you chose would be soluble in water, and whether an exchange of anions would produce the desired insoluble salt.
- a. $\text{Zn}(\text{NO}_3)_2$ and NaOH d. CaCl_2 and $(\text{NH}_4)_2\text{SO}_4$
 b. $\text{Ba}(\text{NO}_3)_2$ and K_3PO_4 e. $\text{Co}(\text{NO}_3)_2$ and Na_2CO_3
 c. $\text{Pb}(\text{NO}_3)_2$ and NaCl f. AgNO_3 and K_2SO_4

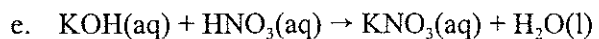
4. (rule 5)
 (rule 1)
 (rule 6)
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5. a. $\text{Na}_2\text{SO}_4(\text{aq}) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2 \text{NaNO}_3(\text{aq})$
 The product is lead(II) sulfate.
- b. $\text{NiCl}_2(\text{aq}) + 2 \text{KOH}(\text{aq}) \rightarrow \text{Ni}(\text{OH})_2(\text{s}) + 2 \text{KCl}(\text{aq})$
 The product is nickel(II) hydroxide.
- c. $\text{K}_2\text{S}(\text{aq}) + \text{Zn}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{ZnS}(\text{s}) + 2 \text{KNO}_3(\text{aq})$
 The product is zinc sulfide.
- d. $3 \text{AgNO}_3(\text{aq}) + (\text{NH}_4)_3\text{PO}_4(\text{aq}) \rightarrow \text{Ag}_3\text{PO}_4(\text{s}) + 3 \text{NH}_4\text{NO}_3(\text{aq})$
 The product is silver phosphate.
6. a. $3 \text{Ca}^{2+} + 6 \text{Cl}^- + 6 \text{Na}^+ + 2 \text{PO}_4^{3-} \rightarrow \text{Ca}_3(\text{PO}_4)_2(\text{s}) + 6 \text{Na}^+ + 6 \text{Cl}^-$
 b. $\text{Cu}^{2+} + 2 \text{NO}_3^- + 2 \text{K}^+ + \text{S}^{2-} \rightarrow \text{CuS}(\text{s}) + 2 \text{K}^+ + 2 \text{NO}_3^-$
 c. $2 \text{Ag}^+ + 2 \text{NO}_3^- + 2 \text{K}^+ + \text{SO}_4^{2-} \rightarrow \text{Ag}_2\text{SO}_4(\text{s}) + 2 \text{K}^+ + 2 \text{NO}_3^-$
7. a. $\text{Ca}(\text{NO}_3)_2(\text{aq}) + \text{K}_2\text{SO}_4(\text{aq}) \rightarrow \text{CaSO}_4(\text{s}) + 2 \text{KNO}_3(\text{aq})$
 K^+ and NO_3^- are the spectator ions.
- b. $(\text{NH}_4)_2\text{CO}_3(\text{aq}) + \text{CuCl}_2(\text{aq}) \rightarrow \text{CuCO}_3(\text{s}) + 2 \text{NH}_4\text{Cl}(\text{aq})$
 NH_4^+ and Cl^- are the spectator ions.
- c. $2 \text{NaOH}(\text{aq}) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{Pb}(\text{OH})_2(\text{s}) + 2 \text{NaNO}_3(\text{aq})$
 Na^+ and NO_3^- are the spectator ions.
- d. $\text{Na}_2\text{S}(\text{aq}) + \text{Zn}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{ZnS}(\text{s}) + 2 \text{NaNO}_3(\text{aq})$
 Na^+ and NO_3^- are the spectator ions.
- e. $\text{CoCl}_2(\text{aq}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightarrow \text{Co}(\text{OH})_2(\text{s}) + \text{CaCl}_2(\text{aq})$
 Ca^{2+} and Cl^- are the spectator ions.
8. a. $\text{Ca}^{2+} + \text{CO}_3^{2-} \rightarrow \text{CaCO}_3(\text{s})$
 b. $\text{Pb}^{2+} + \text{S}^{2-} \rightarrow \text{PbS}(\text{s})$
 c. $\text{Hg}_2^{2+} + 2 \text{Cl}^- \rightarrow \text{Hg}_2\text{Cl}_2(\text{s})$
 d. $\text{Mg}^{2+} + 2 \text{OH}^- \rightarrow \text{Mg}(\text{OH})_2(\text{s})$
9. It is possible to produce the solids below from several different soluble salts, so your answer could be correct and not the same as the answer below. If your answer does not match the one below, use the solubility rules to help you determine whether the aqueous salt solutions you chose would be soluble in water, and whether an exchange of anions would produce the desired insoluble salt.
- a. $\text{Zn}(\text{NO}_3)_2$ and NaOH
 b. $\text{Ba}(\text{NO}_3)_2$ and K_3PO_4
 c. $\text{Pb}(\text{NO}_3)_2$ and NaCl
 d. CaCl_2 and $(\text{NH}_4)_2\text{SO}_4$
 e. $\text{Co}(\text{NO}_3)_2$ and Na_2CO_3
 f. AgNO_3 and K_2SO_4

10. a. HNO_3 is a strong acid.
 b. $\text{C}_2\text{H}_4\text{O}_2$ is a weak acid, so the correct answer is neither of these.
 c. H_2SO_4 is a strong acid.
 d. HCl is a strong acid.
 e. NaCl is a salt produced when HCl and NaOH react, so it is neither a strong acid nor a strong base.
 f. K_2SO_4 is a salt produced when H_2SO_4 and KOH react.
11. a. $2 \text{Na}^+ + 2 \text{OH}^- + 2 \text{H}^+ + \text{SO}_4^{2-} \rightarrow 2 \text{Na}^+ + \text{SO}_4^{2-} + 2 \text{H}_2\text{O}(\text{l})$
 b. $\text{K}^+ + \text{OH}^- + \text{H}^+ + \text{Cl}^- \rightarrow \text{K}^+ + \text{Cl}^- + \text{H}_2\text{O}(\text{l})$
 c. $\text{Na}^+ + \text{OH}^- + \text{H}^+ + \text{NO}_3^- \rightarrow \text{Na}^+ + \text{NO}_3^- + \text{H}_2\text{O}(\text{l})$
12. a. $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}(\text{l})$
 b. $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}(\text{l})$
 c. $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}(\text{l})$
13. a. This is a precipitation reaction.
 b. This is an acid-base reaction. The products are water and the salt KNO_3 .
 c. This is an acid-base reaction. The products are water and the salt Na_2SO_4 .
 d. This is a precipitation reaction.
14. When atoms or molecules lose electrons, a positively charged cation is produced. When electrons are gained, then a negatively charged anion is produced. You can show how electrons are gained or lost by adding electrons to either the right side or the left side of an equation.
- a. $\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^-$
 b. $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$
 c. $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
 d. $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$
 e. $\text{O}_2 + 4\text{e}^- \rightarrow 2\text{O}^{2-}$
 f. $\text{S} + 2\text{e}^- \rightarrow \text{S}^{2-}$
15. Ions can either gain or lose electrons to become neutral atoms or molecules. You can show whether the ions must lose or gain electrons by adding electrons to either the right side or the left side of an equation.
- a. $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
 b. $\text{K}^+ + \text{e}^- \rightarrow \text{K}$
 c. $4\text{P}^{3-} \rightarrow \text{P}_4 + 12\text{e}^-$
 d. $\text{Ca}^{2+} + 2\text{e}^- \rightarrow \text{Ca}$
 e. $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$
 f. $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$
16. When presented with a reaction where electrons are transferred, it is possible to extract the parts of the reaction where electrons are lost and where electrons are gained and to write each part separately. Notice that the number of electrons lost is equal to the number gained.
- a. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ 2 electrons are lost
 $2\text{Ag}^+ + 2\text{e}^- \rightarrow 2\text{Ag}$ 2 electrons are gained
- b. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$ 2 electrons are lost
 $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ 2 electrons are gained

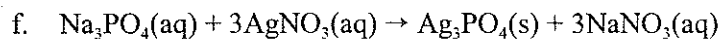
- c. $2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$ 2 electrons are lost
 $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ 2 electrons are gained
- d. $2\text{Hg} \rightarrow 2\text{Hg}^{2+} + 4\text{e}^-$ 4 electrons are lost
 $\text{O}_2 + 4\text{e}^- \rightarrow 2\text{O}^{2-}$ 4 electrons are gained
17. a. In this reaction, two chloride ions lose electrons to become a chlorine molecule, and a bromine molecule gains two electrons to become two bromide ions. This is an oxidation-reduction reaction. Because the chloride ion paired with sodium is exchanged for a bromide ion, this kind of reaction is often called a replacement reaction.
- b. Two aqueous solutions containing ionic compounds react and one of the products is the ionic solid PbSO_4 . This is a precipitation reaction.
- c. The base NaOH reacts with the acid H_2SO_4 to produce water. This is an acid-base reaction.
- d. In this reaction, two Ag^+ ions gain two electrons to become two atoms of silver, and an atom of iron loses two electrons to become an Fe^{2+} ion. This is an oxidation-reduction reaction. Because the silver ion paired with the nitrate ion is exchanged for an iron ion, this kind of reaction is called a replacement reaction.
- e. Two aqueous solutions containing ionic compounds react and one of the products is the ionic solid $\text{Zn}(\text{OH})_2$. This is an example of a precipitation reaction.
18. a. Molecular nitrogen and molecular hydrogen react to produce a larger molecule, ammonia. This is a synthesis reaction.
- b. A molecule which is composed of carbon and hydrogen reacts with oxygen gas. The products are carbon dioxide and water. Reactions which have oxygen as a reactant are members of a sub-class of oxidation-reduction reactions called combustion reactions.
- c. Elemental copper reacts with elemental sulfur. A compound containing both elements is the product. This is a synthesis reaction.
- d. Solid sodium nitrate is converted to two simpler molecules, sodium nitrite and molecular oxygen. This is an example of a decomposition reaction.
- e. In this reaction, two small molecules combine to produce one larger molecule. This is an example of a synthesis reaction.
19. a. $\text{C}_2\text{H}_5\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{g})$
 A molecule reacts with oxygen gas. Because this reaction has oxygen as a reactant, it is an oxidation-reduction reaction.
- b. $(\text{NH}_4)_2\text{S}(\text{aq}) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{PbS}(\text{s}) + 2\text{NH}_4\text{NO}_3(\text{aq})$
 Two aqueous solutions are mixed to produce a solid product. This is a precipitation reaction.
- c. $4\text{Al}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Al}_2\text{O}_3(\text{s})$
 Elemental aluminum loses 3 electrons to become Al^{3+} and molecular oxygen gains 2 electrons to become O^{2-} . This is an oxidation-reduction reaction.



Sodium metal loses an electron to become Na^+ and two hydrogen ions gain an electron to become hydrogen gas. This is an oxidation-reduction reaction.



Aqueous solutions of the base KOH and the acid HNO_3 are mixed to produce liquid water. So this is an acid-base reaction.



Two aqueous solutions are mixed. The product is a solid, Ag_3PO_4 . So this is a precipitation reaction.

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 $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ 2 electrons are gained