Net ionic equation:
$3Ba^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Ba_3(PO_4)_2(s)$

Check Your Solution
The net ionic equation is balanced, including the charges on the ions.

2. Practice Problem (page 410)
Write the net ionic equation for this reaction:

$$Na_2SO_4(aq) + Sr(OH)_2(aq) \rightarrow SrSO_4(s) + NaOH(aq)$$

What Is Required?
You need to write the net ionic equation for the reaction.

What Is Given?
You know that the reaction between sodium sulfate and strontium hydroxide is a double displacement reaction.
You know that strontium sulfate, $SrSO_4(s)$, is the precipitate.
You know the skeleton equation:
$Na_2SO_4(aq) + Sr(OH)_2(aq) \rightarrow SrSO_4(s) + NaOH(aq)$

Plan Your Strategy
Write the complete chemical equation for the reaction.
Write $Na_2SO_4(aq)$, $Sr(OH)_2(aq)$, and $NaOH(aq)$ as ions. Leave $SrSO_4(s)$ as a formula unit since this ionic compound has low solubility.
Write the complete ionic equation for the reaction.
Identify the spectator ions, and cancel them on both sides of the equation.
Write the net ionic equation.

Act on Your Strategy
The precipitate is strontium sulfate, $SrSO_4(s)$.
Skeleton equation:
$Na_2SO_4(aq) + Sr(OH)_2(aq) \rightarrow SrSO_4(s) + NaOH(aq)$
Complete chemical equation:
$Na_2SO_4(aq) + Sr(OH)_2(aq) \rightarrow SrSO_4(s) + 2NaOH(aq)$
Complete ionic equation:
$\cancel{2Na^+(aq)} + SO_4^{2-}(aq) + Sr^{2+} + \cancel{2OH^-(aq)} \rightarrow SrSO_4(s) + \cancel{2Na^+(aq)} + \cancel{2OH^-(aq)}$
Net ionic equation:
$Sr^{2+}(aq) + SO_4^{2-}(aq) \rightarrow SrSO_4(s)$

Check Your Solution
The net ionic equation is balanced, including the charges on the ions.

4. Practice Problem (page 410)

Barium sulfate, $BaSO_4(s)$, is used in some types of paint as a white pigment and as a filler. Barium sulfate precipitates when an aqueous solution of barium chloride, $BaCl_2(aq)$, is mixed with an aqueous solution of sodium sulfate, $Na_2SO_4(aq)$. Write the complete chemical equation and the net ionic equation for this reaction.

What Is Required?

You need to write the complete chemical equation and the net ionic equation for the reaction.

What Is Given?

You know that the reaction between barium chloride and sodium sulfate is a double displacement reaction.
You know that barium sulfate, $BaSO_4(s)$, is the precipitate.
You know the skeleton equation:
$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + NaCl(aq)$

Plan Your Strategy

Write the skeleton equation and the complete chemical equation for the reaction.
Write $BaCl_2(aq)$, $Na_2SO(aq)$, and $NaCl(aq)$ as ions. Leave $BaSO_4(s)$ as a formula unit since this ionic compound is of low solubility.
Write the complete ionic equation for the reaction.
Identify the spectator ions, and cancel them on both sides of the equation.
Write the net ionic equation.

Act on Your Strategy

The precipitate is barium sulfate, $BaSO_4(s)$.
Skeleton equation:
$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + NaCl(aq)$
Complete chemical equation:
$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$
Complete ionic equation:

$$Ba^{2+}(aq) + \cancel{2Cl^-(aq)} + \cancel{2Na^+(aq)} + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + \cancel{2Na^+} + \cancel{2Cl^-(aq)}$$

Net ionic equation:
$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

Check Your Solution

The net ionic equation is balanced, including the charges on the ions.

Check Your Solution
The net ionic equation is balanced, including the charges on the ions. The spectator ions have been correctly identified.

6. Practice Problem (page 410)
Identify the spectator ions in the reaction between each pair of aqueous solutions. Then write the net ionic equation for each reaction.
a. ammonium phosphate and zinc sulfate
b. lithium carbonate and nitric acid
c. sulfuric acid and barium hydroxide

What Is Required?
For each reaction, you need to identify the spectator ions and write the net ionic equation.

What Is Given?
You know that the reactions are double displacement reactions.

Plan Your Strategy
For each reaction, the strategy is as follows:
Predict the name of the products in these double displacement reactions.
Write the chemical formulas for the reactants and the products.
Use the solubility guidelines on page 363 to identify the precipitate.
Write the skeleton equation and the complete chemical equation.
Write the complete ionic equation.
Identify the spectator ions, and cancel them on both sides of the equation.
Write the net ionic equation.

Act on Your Strategy
a. ammonium phosphate and zinc sulfate
The products are predicted to be zinc phosphate and ammonium sulfate.
Chemical formulas for the reactants: ammonium phosphate, $(NH_4)_3PO_4(aq)$; zinc sulfate, $ZnSO_4(aq)$
Chemical formulas for the products: zinc phosphate, $Zn_3(PO_4)_3(s)$; ammonium sulfate, $(NH_4)_2SO_4(aq)$
The precipitate is zinc phosphate, $Zn_3(PO_4)_3(s)$.
Skeleton equation:
$(NH_4)_3PO_4(aq) + ZnSO_4(aq) \rightarrow Zn_3(PO_4)_2(s) + (NH_4)_2SO_4(aq)$
Complete chemical equation:
$2(NH_4)_3PO_4(aq) + 3ZnSO_4(aq) \rightarrow Zn_3(PO_4)_2(s) + 3(NH_4)_2SO_4(aq)$
Complete ionic equation:

$$\cancel{6NH_4^+(aq)} + 2PO_4^{3-}(aq) + 3Zn^{2+}(aq) + \cancel{3SO_4^{2-}(aq)} \rightarrow Zn_3(PO_4)_2(s) + \cancel{6NH_4^+(aq)} + \cancel{3SO_4^{2-}(aq)}$$

The spectator ions are $NH_4^+(aq)$ and $SO_4^{2-}(aq)$.
Net ionic equation:
$3Zn^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Zn_3(PO_4)_2(s)$

b. lithium carbonate and nitric acid
The products are predicted to be lithium nitrate and carbonic acid.
Chemical formulas for the reactants: lithium carbonate, $Li_2CO_3(aq)$; nitric acid, $HNO_3(aq)$
Chemical formulas for the products: lithium nitrate, $LiNO_3(aq)$; carbonic acid, $H_2CO_3(aq)$
Both products are very soluble, so there is no precipitate.
Skeleton equation:
$Li_2CO_3(aq) + HNO_3(aq) \rightarrow LiNO_3(aq) + H_2CO_3(aq)$
Complete chemical equation:
$Li_2CO_3(aq) + 2HNO_3(aq) \rightarrow 2LiNO_3(aq) + H_2CO_3(aq)$
Complete ionic equation:
In aqueous solution, carbonic acid exists as $H_2O(\ell) + CO_2(g)$.
In aqueous solution, lithium nitrate exists as $Li^+(aq) + NO_3^-(aq)$.

$$\cancel{2Li^+(aq)} + CO_3^{2-}(aq) + 2H^+(aq) + \cancel{2NO_3^-(aq)} \rightarrow \cancel{2Li^+(aq)} + \cancel{2NO_3^-(aq)} + H_2O(l) + CO_2(g)$$

The spectator ions are $Li^+(aq)$ and $NO_3^-(aq)$.
Net ionic equation:
$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(\ell) + CO_2(g)$

c. sulfuric acid and barium hydroxide
The products are predicted to be water and barium sulfate.
Chemical formulas for the reactants: sulfuric acid, $H_2SO_4(aq)$; barium hydroxide, $Ba(OH)_2(aq)$
Chemical formulas for the products: water, $H_2O(\ell)$; barium sulfate, $BaSO_4(s)$
The precipitate is barium sulfate, $BaSO_4(s)$.
Skeleton equation:
$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow H_2O(\ell) + BaSO_4(s)$
Complete chemical equation:
$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow 2H_2O(\ell) + BaSO_4(s)$
Complete ionic equation: 2
$H^+(aq) + SO_4^{2-}(aq) + Ba^{2+}(aq) + 2OH^-(aq) \rightarrow 2H_2O(\ell) + BaSO_4(s)$
There are no spectator ions.

Check Your Solution
For each reaction, the net ionic equation is balanced, including the charges on the ions.
The spectator ions are correctly identified.

8. Practice Problem (page 410)

A chemical reaction can be represented by the following net ionic equation: $2Al^{3+}(aq) + 3Cr_2O_7^{2-}(aq) \rightarrow Al_2(Cr_2O_7)_3(s)$. Suggest two aqueous solutions that could be mixed to cause this reaction.

What Is Required?

You need to suggest two aqueous solutions that, when mixed, will result in the given net ionic equation.

What Is Given?

You know the net ionic equation: $2Al^{3+}(aq) + 3Cr_2O_7^{2-}(aq) \rightarrow Al_2(Cr_2O_7)_3(s)$

Plan Your Strategy

You need to start with reactants that have the cation $Al^{3+}(aq)$ and the anion $Cr_2O_7^{2-}(aq)$.

Refer to the solubility guidelines and Table 8.3 on page 363, and select a soluble compound of $Al^{3+}(aq)$ and $Cr_2O_7^{2-}(aq)$.

Write the skeleton equation and the complete chemical equation for the reaction.

Write the complete ionic equation for the reaction.

Identify the spectator ions, and cancel them on both sides of the equation.

Write the net ionic equation and confirm that it is the same as the given net ionic equation.

Act on Your Strategy

Use the reactants aluminum nitrate, $Al(NO_3)_3(aq)$, and potassium dichromate, $K_2Cr_2O_7(aq)$.

Skeleton equation:

$Al(NO_3)_3(aq) + K_2Cr_2O_7(aq) \rightarrow Al_2(Cr_2O_7)_3(s) + KNO_3(aq)$

Complete chemical equation:

$2Al(NO_3)_3(aq) + 3K_2Cr_2O_7(aq) \rightarrow Al_2(Cr_2O_7)_3(s) + 6KNO_3(aq)$

Complete ionic equation:

$$2Al^{3+}(aq) + \cancel{6NO_3^-(aq)} + \cancel{6\,K^+(aq)} + 3Cr_2O_7^{2-}(aq) \rightarrow Al_2(Cr_2O_7)_3(s) + \cancel{6NO_3^-(aq)} + \cancel{6\,K^+(aq)}$$

The spectator ions are $K^+(aq)$ and $NO_3^-(aq)$.

Net ionic equation:

$2Al^{3+}(aq) + 3Cr_2O_7^{2-}(aq) \rightarrow Al_2(Cr_2O_7)_3(s)$

Check Your Solution

The net ionic equation is balanced, including the charges on the ions, and there is agreement with the given net ionic equation.

10. Practice Problem (page 410)

Complete and balance each equation. Then write the corresponding net ionic equation.

a. $Pb(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow$

b. $Co(CH_3COO)_2(aq) + (NH_4)_2S(aq) \rightarrow$

What Is Required?

You need to complete and balance each equation and write the net ionic equation for each reaction.

What Is Given?

You know the reactants in each reaction.

You know that each reaction is a double displacement reaction.

Plan Your Strategy

For each reaction, the strategy is as follows::

Predict the name of the products that form and write the chemical formulas for the products of these double displacement reactions.

Use the solubility guidelines on page 363 to identify the precipitate.

Write the skeleton equation and the complete chemical equation for each reaction.

Write the complete ionic equation for the reactions.

Identify the spectator ions, and cancel them on both sides of both equations.

Write the net ionic equation for each reaction.

Act on Your Strategy

a. $Pb(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow$

The products are predicted to be lead(II) carbonate and sodium nitrate.

The precipitate is lead(II) carbonate, $PbCO_3(s)$.

Skeleton equation:

$Pb(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow PbCO_3(s) + NaNO_3(aq)$

Complete chemical equation:

$Pb(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow PbCO_3(s) + 2NaNO_3(aq)$

Complete ionic equation:

$$Pb^{2+}(aq) + \cancel{2NO_3^-(aq)} + \cancel{2Na^+(aq)} + CO_3^{2-}(aq) \rightarrow PbCO_3(s) + \cancel{2Na^+(aq)} + \cancel{2NO_3^-(aq)}$$

The spectator ions are $Na^+(aq)$ and $NO_3^-(aq)$.

Net ionic equation:

$Pb^{2+}(aq) + CO_3^{2-}(aq) \rightarrow PbCO_3(s)$

b. $Co(CH_3COO)_2(aq) + (NH_4)_2S(aq) \rightarrow$

The products are predicted to be cobalt sulfide and ammonium acetate.

The precipitate is cobalt(II) sulfide, $CoS(s)$.

Skeleton equation:
$Co(CH_3COO)_2(aq) + (NH_4)_2S(aq) \rightarrow CoS(s) + NH_4CH_3COO(aq)$
Complete chemical equation:
$Co(CH_3COO)_2(aq) + (NH_4)_2S(aq) \rightarrow CoS(s) + 2NH_4CH_3COO(aq)$
Complete ionic equation:

$$Co^{2+}(aq) + \cancel{2CH_3COO^-(aq)} + \cancel{2NH_4^+(aq)} + S^{2-}(aq) \rightarrow CoS(s) + \cancel{2NH_4^+(aq)} + \cancel{2CH_3COO^-(aq)}$$

The spectator ions are $NH_4^+(aq)$ and $CH_3COO^-(aq)$.
Net ionic equation:
$Co^{2+}(aq) + S^{2-}(aq) \rightarrow CoS(s)$

Check Your Solution
The net ionic equation is balanced, including the charges on the ions.

Section 9.1 Net Ionic Equations and Qualitative Analysis

Solutions for Selected Review Questions

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2. Review Question (page 414)
Identify the spectator ions in each reaction.
a. $3CuCl_2(aq) + 2(NH_4)_3PO_4(aq) \rightarrow Cu_3(PO_4)_2(s) + 6NH_4Cl(aq)$
b. $2Al(NO_3)_3(aq) + 3Ba(OH)_2(aq) \rightarrow 2Al(OH)_3(s) + 3Ba(NO_3)_2(aq)$
c. $2NaOH(aq) + MgCl_2(aq) \rightarrow 2NaCl(aq) + Mg(OH)_2(s)$

What Is Required?
For each reaction, you need to identify the spectator ions.

What Is Given?
You know the balanced equation and the product that is the precipitate.

Plan Your Strategy
Write the complete ionic equation for the reaction.
Identify the spectator ions, and cancel them on both sides of the equation.

Act on Your Strategy
a. $3CuCl_2(aq) + 2(NH_4)_3PO_4(aq) \rightarrow Cu_3(PO_4)_2(s) + 6NH_4Cl(aq)$:
Balanced chemical equation:
$3CuCl_2(aq) + 2(NH_4)_3PO_4(aq) \rightarrow Cu_3(PO_4)_2(s) + 6NH_4Cl(aq)$
Complete ionic equation:

$$3Cu^{2+}(aq) + \cancel{6Cl^-(aq)} + \cancel{6NH_4^+(aq)} + 2PO_4^{3-}(aq) \rightarrow Cu_3(PO_4)_2(s) + \cancel{6NH_4^+(aq)} + \cancel{6Cl^-(aq)}$$

The spectator ions are $NH_4^+(aq)$ and $Cl^-(aq)$.