

Chapter 3

Synthesis, Decomposition, and Combustion Reactions

Section 3.1 Writing Chemical Equations Solutions for Practice Problems Student Edition page 115

Write a skeleton equation for each chemical reaction. Indicate the state of each reactant and product in the skeleton equation. Remember that the following seven elements are diatomic: hydrogen, $\text{H}_2(\text{g})$; nitrogen, $\text{N}_2(\text{g})$; oxygen, $\text{O}_2(\text{g})$; fluorine, $\text{F}_2(\text{g})$; chlorine, $\text{Cl}_2(\text{g})$; bromine, $\text{Br}_2(\ell)$; and iodine, $\text{I}_2(\text{s})$.

1. Practice Problem (page 115)

Gaseous hydrogen and oxygen react to form gaseous water.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: gaseous hydrogen and gaseous oxygen.

You are given the product: gaseous water.

Plan Your Strategy

Determine the chemical formula for each substance. Include the state.

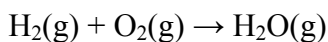
Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

Act on Your Strategy

Gaseous hydrogen: $\text{H}_2(\text{g})$

Gaseous oxygen: $\text{O}_2(\text{g})$

Gaseous water: $\text{H}_2\text{O}(\text{g})$



Check Your Solution

The reactants are written on the left side of the arrow, and the product is written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

2. Practice Problem (page 115)

Solid sodium metal reacts with liquid water to form an aqueous solution of sodium hydroxide and hydrogen gas.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: solid sodium metal and liquid water.

You are given the products: sodium hydroxide solution and hydrogen gas.

Plan Your Strategy

Determine the chemical formula for each substance. Include the state.

Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

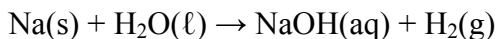
Act on Your Strategy

Solid sodium metal: Na(s)

Liquid water: H₂O(ℓ)

Aqueous solution of sodium hydroxide: NaOH(aq)

Hydrogen gas: H₂(g)

**Check Your Solution**

The reactants are written on the left side of the arrow, and the products are written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

3. Practice Problem (page 115)

Solid potassium chlorate breaks down to form solid potassium chloride and oxygen gas.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactant: solid potassium chlorate.

You are given the products: solid potassium chloride and oxygen gas.

Plan Your Strategy

Determine the chemical formula for each substance. Include the state. Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

Act on Your Strategy

Solid potassium chlorate: $\text{KClO}_3(\text{s})$

Solid potassium chloride: $\text{KCl}(\text{s})$

Oxygen gas: $\text{O}_2(\text{g})$

**Check Your Solution**

The reactant is written on the left side of the arrow, and the products are written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

4. Practice Problem (page 115)

Solid copper reacts with oxygen gas to form solid copper(II) oxide.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: solid copper and oxygen gas.

You are given the product: solid copper(II) oxide.

Plan Your Strategy

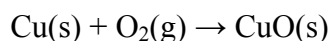
Determine the chemical formula for each substance. Include the state. Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

Act on Your Strategy

Solid copper: $\text{Cu}(\text{s})$

Oxygen gas: $\text{O}_2(\text{g})$

Solid copper(II) oxide: $\text{CuO}(\text{s})$

**Check Your Solution**

The reactants are written on the left side of the arrow, and the product is written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

5. Practice Problem (page 115)

When aqueous solutions of silver nitrate and sodium chloride are combined, the reaction produces an aqueous solution of sodium nitrate and a precipitate of silver chloride.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: a solution of silver nitrate and a solution of sodium chloride.

You are given the products: a solution of sodium nitrate and a precipitate of silver chloride.

Plan Your Strategy

Determine the chemical formula for each substance. Include the state.

Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

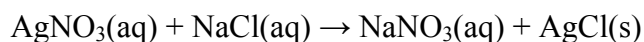
Act on Your Strategy

Aqueous solution of silver nitrate: $\text{AgNO}_3(\text{aq})$

Aqueous solution of sodium chloride: $\text{NaCl}(\text{aq})$

Aqueous solution of sodium nitrate: $\text{NaNO}_3(\text{aq})$

Precipitate of silver chloride: $\text{AgCl}(\text{s})$

**Check Your Solution**

The reactants are written on the left side of the arrow, and the products are written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

6. Practice Problem (page 115)

The complete combustion of propane gas, $\text{C}_3\text{H}_8(\text{g})$, in the presence of oxygen gas forms gaseous water and carbon dioxide.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: propane gas, $\text{C}_3\text{H}_8(\text{g})$, and oxygen gas.

You are given the products: gaseous water and carbon dioxide.

Plan Your Strategy

Determine the chemical formula for each substance. Include the state. Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

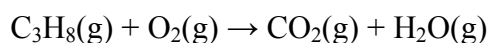
Act on Your Strategy

Propane gas: $\text{C}_3\text{H}_8(\text{g})$

Oxygen gas: $\text{O}_2(\text{g})$

Gaseous water: $\text{H}_2\text{O}(\text{g})$

Carbon dioxide gas: $\text{CO}_2(\text{g})$

**Check Your Solution**

The reactants are written on the left side of the arrow, and the products are written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

7. Practice Problem (page 115)

Sulfur trioxide gas reacts with liquid water to form an aqueous solution of sulfuric acid.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: sulfur trioxide gas and liquid water.

You are given the product: solution of sulfuric acid.

Plan Your Strategy

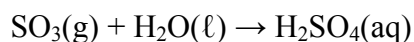
Determine the chemical formula for each substance. Include the state. Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

Act on Your Strategy

Sulfur trioxide gas: $\text{SO}_3(\text{g})$

Liquid water: $\text{H}_2\text{O}(\ell)$

Aqueous solution of sulfuric acid: $\text{H}_2\text{SO}_4(\text{aq})$



Check Your Solution

The reactants are written on the left side of the arrow, and the product is written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

8. Practice Problem (page 115)

Solid ammonium chloride is formed when hydrogen chloride gas reacts with gaseous ammonia.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: hydrogen chloride gas and gaseous ammonia.
You are given the product: solid ammonium chloride.

Plan Your Strategy

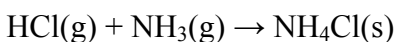
Determine the chemical formula for each substance. Include the state.
Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

Act on Your Strategy

Hydrogen chloride gas: HCl(g)

Gaseous ammonia: $\text{NH}_3\text{(g)}$

Solid ammonium chloride: $\text{NH}_4\text{Cl(s)}$

**Check Your Solution**

The reactants are written on the left side of the arrow, and the product is written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

9. Practice Problem (page 115)

Solid aluminum and gaseous fluorine form when solid aluminum fluoride breaks down.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactant: solid aluminum fluoride.

You are given the products: solid aluminum and gaseous fluorine.

Plan Your Strategy

Determine the chemical formula for each substance. Include the state. Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

Act on Your Strategy

Solid aluminum fluoride: $\text{AlF}_3(\text{s})$

Solid aluminum: $\text{Al}(\text{s})$

Gaseous fluorine: $\text{F}_2(\text{g})$

**Check Your Solution**

The reactant is written on the left side of the arrow, and the products are written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

10. Practice Problem (page 115)

Liquid mercury reacts with oxygen gas to form solid mercury(II) oxide.

What Is Required?

A skeleton equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: liquid mercury and oxygen gas.

You are given the product: solid mercury(II) oxide.

Plan Your Strategy

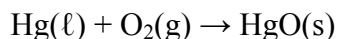
Determine the chemical formula for each substance. Include the state. Write the skeleton equation. Use an arrow to show the direction of the chemical change that is taking place. Use a plus sign to separate two or more reactants or products.

Act on Your Strategy

Liquid mercury: $\text{Hg}(\ell)$

Oxygen gas: $\text{O}_2(\text{g})$

Solid mercury(II) oxide: $\text{HgO}(\text{s})$

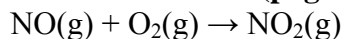
**Check Your Solution**

The reactants are written on the left side of the arrow, and the product is written on the right side. The chemical formula for each substance is written correctly. The physical state of each reactant and product is shown.

Section 3.1 Writing Chemical Equations
Solutions for Practice Problems
Student Edition page 120

Write a balanced chemical equation for each reaction in Practice Problems 11–20.

11. Practice Problem (page 120)



What Is Required?

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given a skeleton equation with the reactants NO(g) and O₂(g) and the product NO₂(g).

Plan Your Strategy

Count the atoms of each element in the reactants and products.

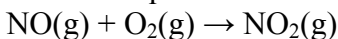
Insert coefficients in front of the reactant and product species until the number of each kind of atom is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Skeleton equation:

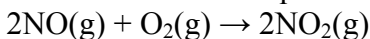


Reactants: 1 N, 3 O

Products: 1 N, 2 O

Insert the coefficient 2 in front of NO(g) and NO₂(g).

Balanced chemical equation:



The ratio of the coefficients is 2:1:2. This is the lowest possible ratio.

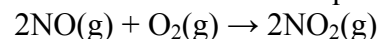
Reactants: 2 N, 4 O

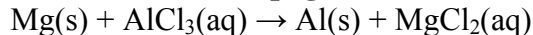
Products: 2 N, 4 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



12. Practice Problem (page 120)**What Is Required?**

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

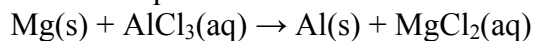
You are given a skeleton equation with the reactants Mg(s) and AlCl₃(aq) and the products Al(s) and MgCl₂(aq).

Plan Your Strategy

Count the atoms and ions of each element in the reactants and products. Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products. Check to make sure that the ratio of the coefficients is the lowest possible ratio. Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

Skeleton equation:



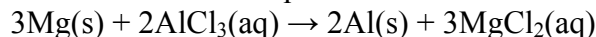
Reactants: 1 Mg, 1 Al³⁺, 3 Cl⁻

Products: 1 Al, 1 Mg²⁺, 2 Cl⁻

Insert the coefficient 2 in front of AlCl₃(aq) and the coefficient 3 in front of MgCl₂(aq) to balance the Cl⁻.

Insert the coefficient 3 in front of Mg(s) and the coefficient 2 in front of Al(s) to balance the Mg and Al.

Balanced chemical equation:



The ratio of the coefficients is 3:2:2:3. This is the lowest possible ratio.

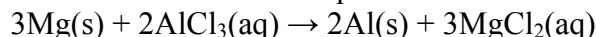
Reactants: 3 Mg, 2 Al³⁺, 6 Cl⁻

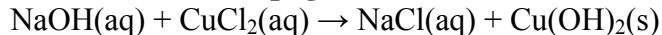
Products: 3 Mg, 2 Al³⁺, 6 Cl⁻

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of each element are equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



13. Practice Problem (page 120)**What Is Required?**

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given a skeleton equation with the reactants NaOH(aq) and CuCl₂(aq) and the products NaCl(aq) and Cu(OH)₂(s).

Plan Your Strategy

Count the atoms and ions of each element in the reactants and products.

Consider the polyatomic OH⁻ ion as a single unit.

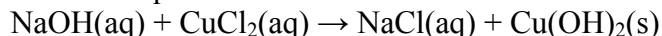
Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each atom and ion is the same in the reactants and products.

Act on Your Strategy

Skeleton equation:

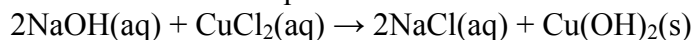


Reactants: 1 Na⁺, 1 OH⁻, 1 Cu²⁺, 2 Cl⁻

Products: 1 Na⁺, 2 OH⁻, 1 Cu²⁺, 1 Cl⁻

Insert the coefficient 2 in front of NaOH(aq) and the coefficient 2 in front of NaCl(aq) to balance the Cl⁻. This also balances the OH⁻.

Balanced chemical equation:



The ratio of the coefficients is 2:1:2:1. This is the lowest possible ratio.

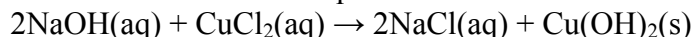
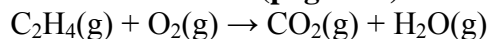
Reactants: 2 Na⁺, 2 OH⁻, 1 Cu²⁺, 2 Cl⁻

Products: 2 Na⁺, 2 OH⁻, 1 Cu²⁺, 2 Cl⁻

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of each element and the number of polyatomic ions are equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**14. Practice Problem (page 120)****What Is Required?**

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given a skeleton equation with the reactants $\text{C}_2\text{H}_4(\text{g})$ and $\text{O}_2(\text{g})$ and the products $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{g})$.

Plan Your Strategy

Count the atoms of each element in the reactants and products.

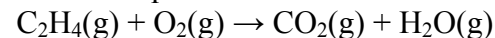
Insert coefficients in front of the reactant and product species until the number of each kind of atom is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

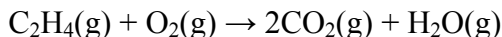
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

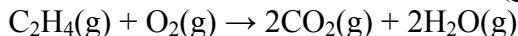
Skeleton equation:



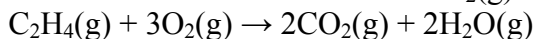
Insert the coefficient 2 in front of $\text{CO}_2(\text{g})$ to balance the C:



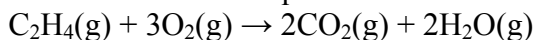
Insert the coefficient 2 in front of $\text{H}_2\text{O}(\text{g})$ to balance the H:



Insert the coefficient 3 in front of $\text{O}_2(\text{g})$ to balance the O:



Balanced chemical equation:



The ratio of the coefficients is 1:3:2:2. This is the lowest possible ratio.

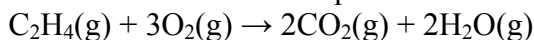
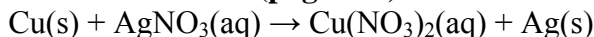
Reactants: 2 C, 4 H, 6 O

Products: 2 C, 4 H, 6 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**15. Practice Problem (page 120)****What Is Required?**

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given a skeleton equation with the reactants $\text{Cu}(\text{s})$ and $\text{AgNO}_3(\text{aq})$ and the products $\text{Cu}(\text{NO}_3)_2(\text{aq})$ and $\text{Ag}(\text{s})$.

Plan Your Strategy

Count the atoms and ions of each element in the reactants and products.

Consider the polyatomic NO_3^- ion as a single unit.

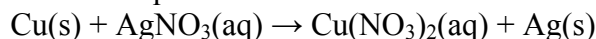
Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

Skeleton equation:



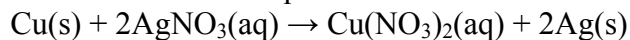
Reactants: 1 Cu, 1 Ag^+ , 1 NO_3^-

Products: 1 Cu^{2+} , 1 Ag, 2 NO_3^-

Insert the coefficient 2 in front of $\text{AgNO}_3(\text{aq})$ to balance the NO_3^- .

Insert the coefficient 2 in front of Ag(s) to balance the Ag.

Balanced chemical equation:



The ratio of coefficients is 1:2:1:2. This is the lowest possible ratio.

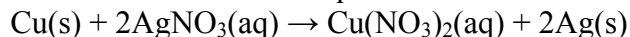
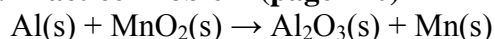
Reactants: 1 Cu, 2 Ag^+ , 2 NO_3^-

Products: 1 Cu, 2 Ag^+ , 2 NO_3^-

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of each element and the number of polyatomic ions are equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**16. Practice Problem (page 120)****What Is Required?**

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given a skeleton equation with the reactants Al(s) and $\text{MnO}_2(\text{s})$ and the products $\text{Al}_2\text{O}_3(\text{s})$ and Mn(s) .

Plan Your Strategy

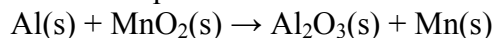
Count the atoms and ions of each element in the reactants and products.

Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products

Act on Your Strategy

Skeleton equation:



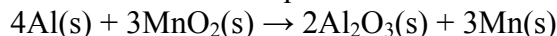
Reactants: 1 Al, 1 Mn⁴⁺, 2 O²⁻

Products: 2 Al, 1 Mn, 3 O²⁻

Insert the coefficient 3 in front of MnO₂(s) and the coefficient 2 in front of Al₂O₃(s) to balance the O.

Insert the coefficient 4 in front of Al(s) and the coefficient 3 in front of Mn(s) to balance these two elements.

Balanced chemical equation:



The ratio of the coefficients is 4:3:2:3. This is the lowest possible ratio.

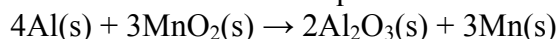
Reactants: 4 Al, 3 Mn⁴⁺, 6 O²⁻

Products: 4 Al, 3 Mn⁴⁺, 6 O²⁻

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of each element are equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



17. Practice Problem (page 120)

Propane, C₃H₈(g), burns in the presence of oxygen gas to form carbon dioxide gas and water vapour.

What Is Required?

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: propane and oxygen gas.

You are given the products: carbon dioxide gas and water vapour.

Plan Your Strategy

Write the chemical formulas for oxygen gas, carbon dioxide gas, and water vapour.

Write a skeleton equation for the reaction.

Count the atoms of each element in the reactants and products.

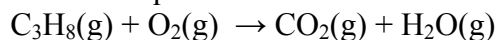
Insert coefficients in front of the reactant and product species until the number of each kind of atom is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: oxygen gas, $O_2(g)$; carbon dioxide gas, $CO_2(g)$; water vapour, $H_2O(g)$

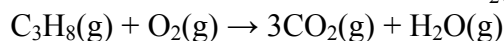
Skeleton equation:



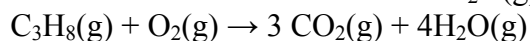
Reactants: 3 C, 8 H, 2 O

Products: 1 C, 2 H, 3 O

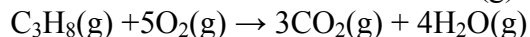
Insert the coefficient 3 in front of $CO_2(g)$ to balance the C:



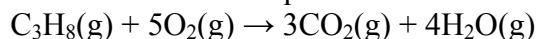
Insert the coefficient 4 in front of $H_2O(g)$ to balance the H:



Insert the coefficient 5 in front of $O_2(g)$ to balance the O:



Balanced chemical equation:



The ratio of the coefficients is 1:5:3:4. This is the lowest possible ratio.

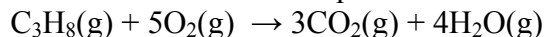
Reactants: 3 C, 8 H, 10 O

Products: 3 C, 8 H, 10 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



18. Practice Problem (page 120)

Gaseous ammonia and oxygen react to form nitrogen dioxide gas and liquid water.

What Is Required?

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: ammonia gas and oxygen gas.

You are given the products: nitrogen dioxide gas and liquid water.

Plan Your Strategy

Write the chemical formulas for ammonia gas, oxygen gas, nitrogen dioxide gas, and liquid water.

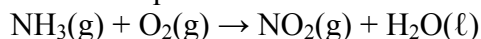
Write the skeleton equation for the reaction.

Count the atoms of each element in the reactants and products.
 Insert coefficients in front of the reactant and product species until the number of each kind of atom is the same in the reactants and in the products.
 Check to make sure that the ratio of the coefficients is the lowest possible ratio.
 Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: ammonia, $\text{NH}_3(\text{g})$; oxygen gas, $\text{O}_2(\text{g})$; nitrogen dioxide gas, $\text{NO}_2(\text{g})$; liquid water, $\text{H}_2\text{O}(\ell)$

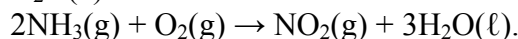
Skeleton equation:



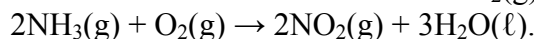
Reactants: 1 N, 3 H, 2 O

Products: 1 N, 2 H, 3 O

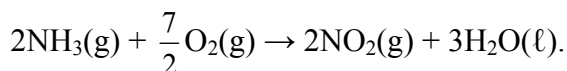
Insert the coefficient 2 in front of $\text{NH}_3(\text{g})$ and the coefficient 3 in front of $\text{H}_2\text{O}(\ell)$ to balance the H:



Insert the coefficient 2 in front of $\text{NO}_2(\text{g})$ to balance the N:

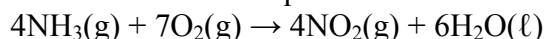


Insert the coefficient $\frac{7}{2}$ in front of $\text{O}_2(\text{g})$ to balance the O:



Since there is a fraction for one of the coefficients, multiply each coefficient by 2 to clear the fraction.

Balanced chemical equation:



The ratio of the coefficients is 4:7:4:6. This is the lowest possible ratio.

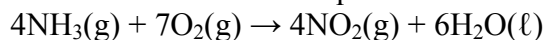
Reactants: 4 N, 12 H, 14 O

Products: 4 N, 12 H, 14 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



19. Practice Problem (page 120)

Aqueous solutions of potassium sulfide and cobalt(II) chloride react to form a solution of potassium chloride and a precipitate of cobalt(II) sulfide.

What Is Required?

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: potassium sulfide solution and cobalt(II) chloride solution.

You are given the products: potassium chloride solution and cobalt(II) sulfide precipitate.

Plan Your Strategy

Write the chemical formulas for potassium sulfide solution, cobalt(II) chloride solution, potassium chloride solution, and solid cobalt(II) sulfide.

Write the skeleton equation for the reaction.

Count the ions of each element in the reactants and products.

Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

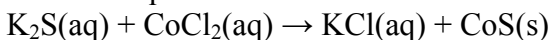
Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of ion is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: potassium sulfide solution, $\text{K}_2\text{S}(\text{aq})$; cobalt(II) chloride solution, $\text{CoCl}_2(\text{aq})$; potassium chloride solution, $\text{KCl}(\text{aq})$; solid cobalt(II) sulfide, $\text{CoS}(\text{s})$

Skeleton equation:

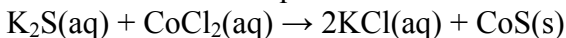


Reactants: 2 K, 1 S^{2-} , 1 Co^{2+} , 2 Cl^-

Products: 1 K, 1 S^{2-} , 1 Co^{2+} , 1 Cl^-

Insert the coefficient 2 in front of $\text{KCl}(\text{aq})$ to balance the K^+ and Cl^- .

Balanced chemical equation:



The ratio of the coefficients is 1:1:2:1. This is the lowest possible ratio.

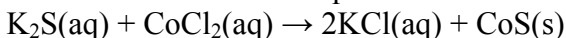
Reactants: 2 K, 1 S^{2-} , 1 Co^{2+} , 2 Cl^-

Products: 2 K, 1 S^{2-} , 1 Co^{2+} , 2 Cl^-

Check Your Solution

The chemical formula for each substance is written correctly. The number of ions of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



20. Practice Problem (page 120)

Carbon dioxide gas, liquid water, and an aqueous solution of sodium chloride form when hydrogen chloride gas is bubbled through a solution of sodium carbonate.

What Is Required?

A balanced chemical equation that represents the chemical reaction is required.

What Is Given?

You are given the reactants: hydrogen chloride gas and a solution of sodium carbonate.

You are given the products: carbon dioxide gas, liquid water, and an aqueous solution of sodium chloride.

Plan Your Strategy

Count the atoms and ions of each element in the reactants and products.

Consider the polyatomic CO_3^{2-} ion as a single unit.

Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

Skeleton equation:



Reactants: 1 H, 1 Cl, 2 Na^{2+} , 1 CO_3^{2-}

Products: 2 H, 1 Na^{2+} , 1 Cl^- , 1 C, 3 O

Insert the coefficient 2 in front of $\text{NaCl}(\text{aq})$ to balance the Na^+ .

Insert the coefficient 2 in front of the $\text{HCl}(\text{g})$ to balance the Cl.

Balanced chemical equation:



The ratio of the coefficients is 2:1:1:1:2. This is the lowest possible ratio.

Reactants: 2 H, 2 Cl, 2 Na^{2+} , 1 CO_3^{2-}

Products: 2 H, 2 Cl^- , 2 Na^{2+} , 1 C, 3 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of each element are equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



Section 3.1 Writing Chemical Equations
Solutions for Selected Review Questions
 Student Edition page 121

11. Review Question (page 121)

Write a balanced chemical equation for each chemical reaction.

- Solid potassium reacts with gaseous chlorine to form solid potassium chloride.
- Aluminum foil is placed in an aqueous solution of copper(II) sulfate, producing solid copper metal and a solution of aluminum sulfate.
- Nitrogen gas and hydrogen gas react to form gaseous ammonia.
- An aqueous solution of calcium chloride reacts with fluorine gas to form an aqueous solution of calcium fluoride and chlorine gas.

- Solid potassium reacts with gaseous chlorine to form solid potassium chloride.

What Is Required?

You need to write a balanced chemical equation that represents the chemical reaction.

What Is Given?

You are given the reactants: solid potassium and chlorine gas.

You are given the product: solid potassium chloride.

Plan Your Strategy

Write the chemical formulas for each reactant and product.

Write the skeleton equation for the reaction.

Count the atoms of each element in the reactants and products.

Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: solid potassium, K(s); chlorine gas, Cl₂(g); solid potassium chloride, KCl(s)

Skeleton equation: K(s) + Cl₂(g) → KCl(s)

Balance Cl: K(s) + Cl₂(g) → 2KCl(s)

Balance K: 2K(s) + Cl₂(g) → 2KCl(s)

Balanced chemical equation: 2K(s) + Cl₂(g) → 2KCl(s)

The ratio of the coefficients is 2:1:2. This is the lowest possible ratio.

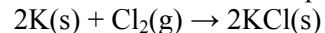
Reactants: 2 K, 2 Cl

Products: 2 K⁺, 2 Cl⁻

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



b. Aluminum foil is placed in an aqueous solution of copper(II) sulfate, producing solid copper metal and a solution of aluminum sulfate.

What Is Required?

You need to write a balanced chemical equation that represents the chemical reaction.

What Is Given?

You are given the reactants: solid aluminum and a solution of copper(II) sulfate.

You are given the products: solid copper metal and a solution of aluminum sulfate.

Plan Your Strategy

Write the chemical formulas for the reactants and products.

Write the skeleton equation for the reaction.

Count the atoms of each element in the reactants and products.

Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: solid aluminum, Al(s); solution of copper(II) sulfate, CuSO₄(aq); solid copper, Cu(s); solution of aluminum sulfate, Al₂(SO₄)₃(aq)

Skeleton equation: Al(s) + CuSO₄(aq) → Cu(s) + Al₂(SO₄)₃(aq)

Balance the SO₄²⁻: Al(s) + 3CuSO₄(aq) → Cu(s) + Al₂(SO₄)₃(aq)

Balance Al: 2Al(s) + 3CuSO₄(aq) → Cu(s) + Al₂(SO₄)₃(aq)

Balance Cu: 2Al(s) + 3CuSO₄(aq) → 3Cu(s) + Al₂(SO₄)₃(aq)

Balanced chemical equation: 2Al(s) + 3CuSO₄(aq) → 3Cu(s) + Al₂(SO₄)₃(aq)

The ratio of the coefficients is 2:3:3:1. This is the lowest possible ratio.

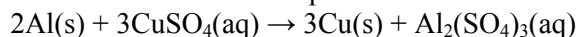
Reactants: 2 Al, 3 Cu²⁺, 3 SO₄²⁻

Products: 2 Al³⁺, 3 Cu, 3 SO₄²⁻

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



c. Nitrogen gas and hydrogen gas react to form gaseous ammonia.

What Is Required?

You need to write a balanced chemical equation that represents the chemical reaction.

What Is Given?

You are given the reactants: nitrogen gas and hydrogen gas.

You are given the product: gaseous ammonia.

Plan Your Strategy

Write the chemical formulas for each reactant and product.

Write the skeleton equation for the reaction.

Count the atoms of each element in the reactants and products.

Insert coefficients in front of the reactant and product species until the number of each kind of atom is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: nitrogen gas, $\text{N}_2(\text{g})$; hydrogen gas, $\text{H}_2(\text{g})$; ammonia gas, $\text{NH}_3(\text{g})$

Skeleton equation: $\text{N}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{NH}_3(\text{g})$

Balance N: $\text{N}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$

Balance H: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$

Balanced chemical equation: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$

The ratio of the coefficients is 1:3:2. This is the lowest possible ratio.

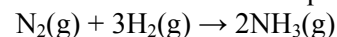
Reactants: 2 N, 6 H

Products: 2 N, 6 H

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



d. An aqueous solution of calcium chloride reacts with fluorine gas to form an aqueous solution of calcium fluoride and chlorine gas.

What Is Required?

You need to write a balanced chemical equation that represents the chemical reaction.

What Is Given?

You are given the reactants: a solution of calcium chloride and fluorine gas.

You are given the products: a solution of calcium fluoride and chlorine gas.

Plan Your Strategy

Write the chemical formulas for the reactants and products.

Write the skeleton equation for the reaction.

Count the atoms of each element in the reactants and products.

Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: calcium chloride solution, $\text{CaCl}_2(\text{aq})$; fluorine gas, $\text{F}_2(\text{g})$; calcium fluoride solution, $\text{CaF}_2(\text{aq})$; chlorine gas, $\text{Cl}_2(\text{g})$

Skeleton equation: $\text{CaCl}_2(\text{aq}) + \text{F}_2(\text{g}) \rightarrow \text{CaF}_2(\text{aq}) + \text{Cl}_2(\text{g})$

Balanced chemical equation: $\text{CaCl}_2(\text{aq}) + \text{F}_2(\text{g}) \rightarrow \text{CaF}_2(\text{aq}) + \text{Cl}_2(\text{g})$

The ratio of the coefficients is 1:1:1:1. This is the lowest possible ratio.

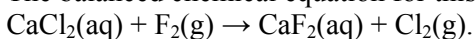
Reactants: 1 Ca^{2+} , 2 Cl^- , 2 F

Products: 1 Ca^{2+} , 2 Cl, 2 F^-

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**12. Review Question (page 121)**

Barium hydroxide can react with phosphoric acid to form barium hydrogen phosphate and water: $\text{Ba}(\text{OH})_2(\text{s}) + \text{H}_3\text{PO}_4(\text{aq}) \rightarrow \text{BaHPO}_4(\text{s}) + \text{H}_2\text{O}(\ell)$.

- Identify the polyatomic ions in the reactants.
- Can each polyatomic ion be treated as a unit when balancing the equation? Explain why or why not.
- Write the balanced chemical equation.

- The polyatomic ions are the hydroxide ion, OH^- , and the phosphate ion, PO_4^{3-} .
- A polyatomic ion can be balanced as a unit when it appears on both sides of the equation.
- Balanced chemical equation:

What Is Required?

You need to write a balanced chemical equation that represents the chemical reaction.

What Is Given?

You are given the reactants: solid barium hydroxide and a solution of phosphoric acid. You are given the products: solid barium hydrogen phosphate and liquid water.

Plan Your Strategy

Write the chemical formulas for the reactants and products.

Write the skeleton equation for the reaction.

Count the atoms of each element in the reactants and products.

Insert coefficients in front of the reactant and product species until the number of each kind of atom or ion is the same in the reactants and in the products.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

Chemical formulas: solid barium hydroxide, $\text{Ba}(\text{OH})_2(\text{s})$; solution of phosphoric acid, $\text{H}_3\text{PO}_4(\text{aq})$; solid barium hydrogen phosphate, $\text{BaHPO}_4(\text{s})$; liquid water, $\text{H}_2\text{O}(\ell)$

Skeleton equation: $\text{Ba}(\text{OH})_2(\text{s}) + \text{H}_3\text{PO}_4(\text{aq}) \rightarrow \text{BaHPO}_4(\text{s}) + \text{H}_2\text{O}(\ell)$

Reactants: 1 Ba^{2+} , 2 OH^- , 3 H, 1 PO_4^{3-}

Products: 1 Ba^{2+} , 1 HPO_4^{2-} , 2 H, 1 O

Insert a 2 in front of the $\text{H}_2\text{O}(\ell)$ to balance the H.

Balanced chemical equation: $\text{Ba}(\text{OH})_2(\text{s}) + \text{H}_3\text{PO}_4(\text{aq}) \rightarrow \text{BaHPO}_4(\text{s}) + 2\text{H}_2\text{O}(\ell)$

The ratio of the coefficients is 1:1:1:2. This is the lowest possible ratio.

Reactants: 1 Ba^{2+} , 2 OH^- , 3 H, 1 PO_4^{3-}

Products: 1 Ba^{2+} , 1 HPO_4^{2-} , 4 H, 2 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of the elements is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

$\text{Ba}(\text{OH})_2(\text{s}) + \text{H}_3\text{PO}_4(\text{aq}) \rightarrow \text{BaHPO}_4(\text{s}) + 2\text{H}_2\text{O}(\ell)$.

14. Review Question (page 121)

Your friend has written the following balanced equation for the reaction in which aluminum and chlorine form aluminum(III) chloride:

$\text{Al}(\text{s}) + \text{Cl}(\text{g}) \rightarrow \text{AlCl}(\text{s})$

Is this correct? If not, how would you suggest that your friend correct it?

The equation is not correct. The chemical formulas for chlorine gas and aluminum chloride are incorrect and the equation is not balanced.

The correct balanced chemical equation for this reaction is:

$2\text{Al}(\text{s}) + 3\text{Cl}_2(\text{g}) \rightarrow 2\text{AlCl}_3(\text{s})$

Section 3.2 Synthesis Reactions and Decomposition Reactions
Solutions for Practice Problems
 Student Edition page 127

21. Practice Problem (page 127)

Predict the product that is likely to form in a reaction between lithium and oxygen, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between lithium and oxygen.

What Is Given?

You are given the reactants: lithium and oxygen.

Plan Your Strategy

Identify the types of elements involved and predict the product that will form. Write the chemical formula for the product and write a balanced equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio. Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.

The product is predicted to be lithium oxide, $\text{Li}_2\text{O}(\text{s})$.

Skeleton equation: $\text{Li}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{Li}_2\text{O}(\text{s})$

Reactants: 1 Li, 2 O

Products: 2 Li^+ , 1 O^{2-}

Balanced chemical equation: $4\text{Li}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{Li}_2\text{O}(\text{s})$

The ratio of the coefficients is 4:1:2. This is the lowest possible ratio.

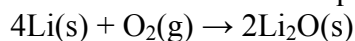
Reactants: 4 Li, 2 O

Products: 4 Li^+ , 2 O^{2-}

Check Your Solution

The overall charge on the compound lithium oxide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.

The balanced chemical equation for this reaction is:

**22. Practice Problem (page 127)**

Predict the product that is likely to form in a reaction between strontium and fluorine, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between strontium and fluorine.

What Is Given?

You are given the reactants: strontium and fluorine.

Plan Your Strategy

Identify the types of elements involved and predict the product that will form. Write the chemical formula for the product and write a balanced chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio. Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.

The product is predicted to be strontium fluoride, $\text{SrF}_2(\text{s})$.

Skeleton equation: $\text{Sr}(\text{s}) + \text{F}_2(\text{g}) \rightarrow \text{SrF}_2(\text{s})$

Reactants: 1 Sr, 2 F

Products: 1 Sr^{2+} , 2 F^-

Balanced chemical equation: $\text{Sr}(\text{s}) + \text{F}_2(\text{g}) \rightarrow \text{SrF}_2(\text{s})$

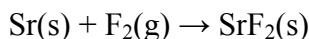
The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.

The skeleton and balanced equations are the same.

Check Your Solution

The overall charge on the compound strontium fluoride is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.

The balanced chemical equation for this reaction is:

**23. Practice Problem (page 127)**

Predict the product that is likely to form in a reaction between iron and bromine, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between iron and bromine.

What Is Given?

You are given the reactants: iron and bromine.

Plan Your Strategy

Identify the types of elements involved and predict the most likely product that will form.

Determine whether the metal involved, iron, is multivalent and, if so, determine its possible charges.

Write the chemical formula for the products and write balanced chemical equations for the reactions.

Check to make sure that the ratio of the coefficients in each equation is the lowest possible ratio.

Check each equation to make sure that the number of each kind of atom and ion is the same in the reactants and products.

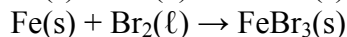
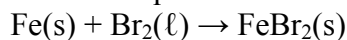
Act on Your Strategy

You know this will be a synthesis reaction between a multivalent metal and a non-metal to form a binary ionic compound.

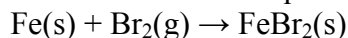
The possible charges on multivalent iron are Fe^{2+} and Fe^{3+} .

The predicted products are solid iron(II) bromide, $\text{FeBr}_2(\text{s})$, and solid iron(III) bromide, $\text{FeBr}_3(\text{s})$.

Skeleton equations:



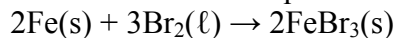
Balanced chemical equation for solid iron(II) bromide:



Reactants: 1 Fe, 2 Br

Products: 1 Fe^{2+} , 2 Br^-

Balanced chemical equation for solid iron(III) bromide:



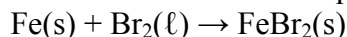
Reactants: 2 Fe, 6 Br

Products: 2 Fe^{3+} , 6 Br^-

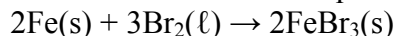
Check Your Solution

The overall charges on the compounds iron(II) bromide and iron(III) bromide are zero and each equation is balanced. The products are what would be expected in synthesis reactions.

The balanced chemical equation for solid iron(II) bromide is:



The balanced chemical equation for solid iron(III) bromide is:



24. Practice Problem (page 127)

Predict the product that is likely to form in a reaction between phosphorus and hydrogen, forming gaseous phosphorus trihydride, and write a balanced chemical equation for the reaction.

What Is Required?

You need to write the balanced chemical equation for the reaction between phosphorus and hydrogen, forming gaseous phosphorus trihydride.

What Is Given?

You are given the reactants: phosphorus and hydrogen.

You are given the product: phosphorus trihydride.

Plan Your Strategy

Identify the types of elements involved in the reaction.

Write the chemical formula for the products and write a balanced chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

You know this will be a synthesis reaction between two non-metals to form a binary molecular compound.

The product is phosphorus trihydride, $\text{PH}_3(\text{g})$.

Skeleton equation: $\text{P}(\text{s}) + \text{H}_2(\text{g}) \rightarrow \text{PH}_3(\text{g})$

Reactants: 1 P, 2 H

Products: 1 P, 3 H

Balanced chemical equation: $2\text{P}(\text{s}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{PH}_3(\text{g})$

The ratio of the coefficients is 2:3:2. This is the lowest possible ratio.

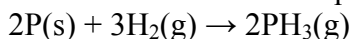
Reactants: 2 P, 6 H

Products: 2 P, 6 H

Check Your Solution

The equation is balanced. The product is what would be expected in a synthesis reaction.

The balanced chemical equation for this reaction is:

**25. Practice Problem (page 127)**

Predict the product that is likely to form in a reaction between calcium and iodine, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between calcium and iodine.

What Is Given?

You are given the reactants: calcium and iodine.

Plan Your Strategy

Identify the types of elements involved and predict the product that will form.

Write the chemical formula for the product and write a balanced chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.

The product is predicted to be solid calcium iodide, $\text{CaI}_2(\text{s})$.

Skeleton equation: $\text{Ca}(\text{s}) + \text{I}_2(\text{g}) \rightarrow \text{CaI}_2(\text{s})$

Reactants: 1 Ca, 2 I

Products: 1 Ca²⁺, 2 I⁻

Balanced chemical equation: $\text{Ca(s)} + \text{I}_2\text{(g)} \rightarrow \text{CaI}_2\text{(s)}$

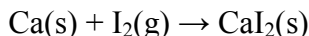
The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.

The skeleton and balanced equations are the same.

Check Your Solution

The overall charge on the compound calcium iodide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.

The balanced chemical equation for this reaction is:



26. Practice Problem (page 127)

Predict the product that is likely to form in a reaction between tin and oxygen, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the most likely product and write a balanced chemical equation for the reaction between tin and oxygen.

What Is Given?

You are given the reactants: tin and oxygen.

Plan Your Strategy

Identify the types of elements involved and predict the most likely product that will form.

Determine whether the metal involved, tin, is multivalent and, if so, determine its possible charges.

Write the chemical formula for the products and write Balanced chemical equations for the reactions.

Check to make sure that the ratio of the coefficients in each equation is the lowest possible ratio.

Check each equation to make sure that the number of each kind of atom and ion is the same in the reactants and products.

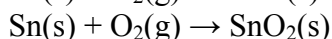
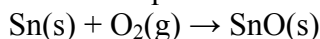
Act on Your Strategy

You know this will be a synthesis reaction between a multivalent metal and a non-metal to form a binary ionic compound.

The possible charges on multivalent tin are Sn²⁺ and Sn⁴⁺.

The predicted products are solid tin(II) oxide, SnO(s), and solid tin(IV) oxide, SnO₂(s).

Skeleton equations:



Balanced chemical equation for solid tin(II) oxide: $2\text{Sn(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{SnO(s)}$

Reactants: 2 Sn, 2 O

Products: 2 Sn²⁺, 2 O²⁻

Balanced chemical equation for solid tin(IV) oxide: $\text{Sn(s)} + \text{O}_2\text{(g)} \rightarrow \text{SnO}_2\text{(s)}$

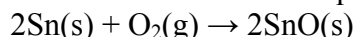
Reactants: 1 Sn, 2 O

Products: 1 Sn⁴⁺, 2 O²⁻

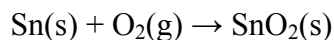
Check Your Solution

The overall charges on the compounds tin(II) oxide and tin(IV) oxide are zero and each equation is balanced. The products are what would be expected in synthesis reactions.

The balanced chemical equation for solid tin(II) oxide is:



The balanced chemical equation for solid tin(IV) oxide is:



27. Practice Problem (page 127)

Predict the product that is likely to form in a reaction between bismuth and sulfur, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between bismuth and sulfur.

What Is Given?

You are given the reactants: bismuth and sulfur.

Plan Your Strategy

Identify the types of elements involved and predict the most likely product that will form.

Determine whether the metal involved, bismuth, is multivalent and, if so, determine its possible charges.

Write the chemical formula for the products and write Balanced chemical equations for the reactions.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

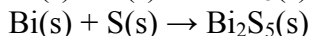
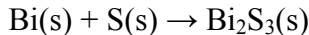
Act on Your Strategy

You know this will be a synthesis reaction between a multivalent metal and a non-metal to form a binary ionic compound.

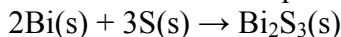
The possible charges on multivalent bismuth are Bi³⁺ and Bi⁵⁺.

The predicted products are solid bismuth(III) sulfide, Bi₂S₃(s), and solid bismuth(V) sulfide, Bi₂S₅(s).

Skeleton equations:



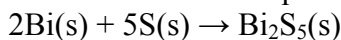
Balanced chemical equation for solid bismuth(III) sulfide:



Reactants: 2 Bi, 3 S

Products: 2 Bi^{3+} , 3 S^{2-}

Balanced chemical equation for solid bismuth(V) sulfide:



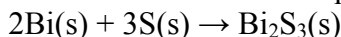
Reactants: 2 Bi, 5 S

Products: 2 Bi^{5+} , 5 S^{2-}

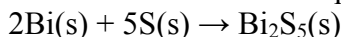
Check Your Solution

The overall charges on the compounds bismuth(III) sulfide and bismuth(V) sulfide are zero and each equation is balanced. The products are what would be expected in synthesis reactions.

The balanced chemical equation for bismuth(III) sulfide is:



The balanced chemical equation for bismuth(V) sulfide is:



28. Practice Problem (page 127)

Predict the product that is likely to form in a reaction between aluminum and iodine, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between aluminum and iodine.

What Is Given?

You are given the reactants: aluminum and iodine.

Plan Your Strategy

Identify the types of elements involved and predict the product that will form.

Write the chemical formula for the product and write a balanced chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.

The product is predicted to be solid aluminum iodide, $\text{AlI}_3\text{(s)}$.

Skeleton equation: $\text{Al(s)} + \text{I}_2\text{(s)} \rightarrow \text{AlI}_3\text{(s)}$

Reactants: 1 Al, 2 I

Products: 1 Al³⁺, 3 I⁻

Balanced chemical equation: $2\text{Al}(\text{s}) + 3\text{I}_2(\text{s}) \rightarrow 2\text{AlI}_3(\text{s})$

The ratio of the coefficients is 2:3:2. This is the lowest possible ratio.

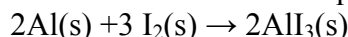
Reactants: 2 Al, 6 I

Products: 2 Al³⁺, 6 I⁻

Check Your Solution

The overall charge on the compound aluminum iodide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.

The balanced chemical equation for this reaction is:



29. Practice Problem (page 127)

Predict the product that is likely to form in a reaction between silver and oxygen, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between silver and oxygen.

What Is Given?

You are given the reactants: silver and oxygen.

Plan Your Strategy

Identify the types of elements involved and predict the product that will form. Write the chemical formula for the product and write a balanced chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio. Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.

The product is predicted to be solid silver oxide, Ag₂O(s).

Skeleton equation: $\text{Ag}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{Ag}_2\text{O}(\text{s})$

Reactants: 1 Ag, 2 O

Products: 2 Ag⁺, O²⁻

Balanced chemical equation: $4\text{Ag}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{Ag}_2\text{O}(\text{s})$

The ratio of the coefficients is 4:1:3. This is the lowest possible ratio.

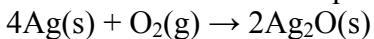
Reactants: 4 Ag, 2 O

Products: 4 Ag⁺, 2 O²⁻

Check Your Solution

The overall charge on the compound silver oxide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.

The balanced chemical equation for this reaction is:

**30. Practice Problem (page 127)**

Predict the product that is likely to form in a reaction between nitrogen and oxygen, forming nitrogen dioxide, and write a balanced chemical equation for the reaction.

What Is Required?

You need to write a balanced chemical equation for the reaction between nitrogen and oxygen forming nitrogen dioxide.

What Is Given?

You are given the reactants: nitrogen and oxygen.

You are given the product: nitrogen dioxide.

Plan Your Strategy

Write the chemical formula for the product and write a balanced chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

You know this will be a synthesis reaction between two non-metals to form a binary molecular compound.

The product is nitrogen dioxide, $\text{NO}_2\text{(g)}$.

Skeleton equation: $\text{N}_2\text{(g)} + \text{O}_2\text{(g)} \rightarrow \text{NO}_2\text{(g)}$

Reactants: 2 N, 2 O

Products: 1 N, 2 O

Balanced chemical equation: $\text{N}_2\text{(g)} + 2\text{O}_2\text{(g)} \rightarrow 2\text{NO}_2\text{(g)}$

The ratio of the coefficients is 1:2:2. This is the lowest possible ratio.

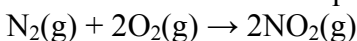
Reactants: 2 N, 4 O

Products: 2 N, 4 O

Check Your Solution

The equation is balanced. The product is what would be expected in a synthesis reaction.

The balanced chemical equation for this reaction is:



Section 3.2 Synthesis Reactions and Decomposition Reactions
Solutions for Practice Problems
Student Edition page 134

31. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of potassium bromide, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when potassium bromide decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: potassium bromide.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A binary compound is decomposing.

The products of the decomposition of a binary compound are two elements.

Word equation: potassium bromide \rightarrow potassium + bromine

Skeleton equation: $\text{KBr}(\ell) \rightarrow \text{K}(\ell) + \text{Br}_2(\ell)$

Reactants: 1 K^+ , 1 Br^-

Products: 1 K, 2 Br

Balanced chemical equation: $2\text{KBr}(\ell) \rightarrow 2\text{K}(\ell) + \text{Br}_2(\ell)$

The ratio of the coefficients is 2:2:1. This is the lowest possible ratio.

Reactants: 2 K^+ , 2 Br^-

Products: 2 K, 2 Br

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal halide.

The balanced chemical equation for this reaction is:



32. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of aluminum oxide, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when aluminum oxide decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: aluminum oxide.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A binary compound is decomposing.

The products of the decomposition of a binary compound are the two elements.

Word equation: aluminum oxide \rightarrow aluminum + oxygen

Skeleton equation: $\text{Al}_2\text{O}_3(\ell) \rightarrow \text{Al}(\ell) + \text{O}_2(\text{g})$

Reactants: 2Al^{3+} , 3O^{2-}

Products: 1 Al, 2 O

Balanced chemical equation: $2\text{Al}_2\text{O}_3(\ell) \rightarrow 4\text{Al}(\ell) + 3\text{O}_2(\text{g})$

The ratio of the coefficients is 2:4:3. This is the lowest possible ratio.

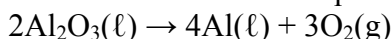
Reactants: 4Al^{3+} , 6O^{2-}

Products: 4 Al, 6 O

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal halide.

The balanced chemical equation for this reaction is:



33. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of magnesium hydroxide, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when magnesium hydroxide decomposes write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: magnesium hydroxide.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A metal hydroxide is decomposing.

A metal oxide and water are the usual products that form when a metal hydroxide decomposes.

Word equation: magnesium hydroxide \rightarrow magnesium oxide + water

Skeleton equation: $\text{Mg(OH)}_2(\text{s}) \rightarrow \text{MgO}(\text{s}) + \text{H}_2\text{O}(\text{g})$

Reactants: 1 Mg^{2+} , 2 OH^-

Products: 1 Mg^{2+} , 1 O^{2-} , 2 H, 1 O

Balanced chemical equation: $\text{Mg(OH)}_2(\text{s}) \rightarrow \text{MgO}(\text{s}) + \text{H}_2\text{O}(\text{g})$

The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.

The skeleton and balanced equations are the same.

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal hydroxide.

The balanced chemical equation for this reaction is:



34. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of calcium nitrate, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when calcium nitrate decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: calcium nitrate.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A metal nitrate is decomposing.

A metal nitrite and oxygen are the usual products that form when a metal nitrate decomposes.

Word equation: calcium nitrate \rightarrow calcium nitrite + oxygen

Skeleton equation: $\text{Ca}(\text{NO}_3)_2(\text{s}) \rightarrow \text{Ca}(\text{NO}_2)_2(\text{s}) + \text{O}_2(\text{g})$

Reactants: 1 Ca^{2+} , 2 NO_3^-

Products: 1 Ca^{2+} , 2 NO_2^- , 2 O

Balanced chemical equation: $\text{Ca}(\text{NO}_3)_2(\text{s}) \rightarrow \text{Ca}(\text{NO}_2)_2(\text{s}) + \text{O}_2(\text{g})$

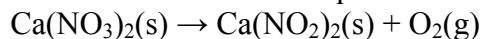
The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.

The skeleton and balanced equations are the same.

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal nitrate.

The balanced chemical equation for this reaction is:



35. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of copper(II) carbonate, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when copper(II) carbonate decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: copper(II) carbonate.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A metal carbonate is decomposing.

A metal oxide and carbon dioxide are the usual products that form when a metal carbonate decomposes.

Word equation: copper(II) carbonate \rightarrow copper(II) oxide + carbon dioxide

Skeleton equation: $\text{CuCO}_3(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{CO}_2(\text{g})$

Reactants: 1 Cu^{2+} , 1 CO_3^{2-}

Products: 1 Cu^{2+} , 1 O^{2-} , 1 C, 2 O

Balanced chemical equation: $\text{CuCO}_3(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{CO}_2(\text{g})$

The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.

The skeleton and balanced equations are the same.

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal carbonate.

The balanced chemical equation for this reaction is:



36. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of chromium(III) chloride, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when chromium(III) chloride decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.
You are given the reactant: chromium(III) chloride.

Plan Your Strategy

Identify the type of compound that is decomposing.
Determine the types of products that usually form in this type of reaction.
Write a word equation for the reaction.
Write and balance a chemical equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A binary compound is decomposing.
The products of the decomposition of a binary compound are the two elements.
Word equation: chromium(III) chloride \rightarrow chromium + chlorine
Skeleton equation: $\text{CrCl}_3(\ell) \rightarrow \text{Cr}(\ell) + \text{Cl}_2(\text{g})$
Reactants: 1 Cr^{3+} , 3 Cl^-
Products: 1 Cr, 2 Cl
Balanced chemical equation: $2\text{CrCl}_3(\ell) \rightarrow 2\text{Cr}(\ell) + 3\text{Cl}_2(\text{g})$
The ratio of the coefficients is 2:2:3. This is the lowest possible ratio.
Reactants: 2 Cr^{3+} , 6 Cl^-
Products: 2 Cr, 6 Cl

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal halide.

The balanced chemical equation for this reaction is:
 $2\text{CrCl}_3(\ell) \rightarrow 2\text{Cr}(\ell) + 3\text{Cl}_2(\text{g})$

37. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of barium carbonate, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when barium carbonate decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: barium carbonate.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A metal carbonate is decomposing.

A metal oxide and carbon dioxide are the usual products that form when a metal carbonate decomposes.

Word equation: barium carbonate \rightarrow barium oxide + carbon dioxide

Skeleton equation: $\text{BaCO}_3(\text{s}) \rightarrow \text{BaO}(\text{s}) + \text{CO}_2(\text{g})$

Reactants: 1 Ba^{2+} , 1 CO_3^{2-}

Products: 1 Ba^{2+} , 1 O^{2-} , 1 C, 2 O

Balanced chemical equation: $\text{BaCO}_3(\text{s}) \rightarrow \text{BaO}(\text{s}) + \text{CO}_2(\text{g})$

The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.

Reactants: 1 Ba^{2+} , 1 CO_3^{2-}

Products: 1 Ba^{2+} , 1 O^{2-} , 1 C, 2 O

The skeleton and balanced equations are the same.

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal carbonate.

The balanced chemical equation for this reaction is:



38. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of rubidium nitrate, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when rubidium nitrate decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: rubidium nitrate.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A metal nitrate is decomposing.

A metal nitrite and oxygen are the usual products that form when a metal nitrate decomposes.

Word equation: rubidium nitrate \rightarrow rubidium nitrite + oxygen

Skeleton equation: $\text{RbNO}_3(\text{s}) \rightarrow \text{RbNO}_2(\text{s}) + \text{O}_2(\text{g})$

Reactants: 1 Rb^+ , 1 NO_3^-

Products: 1 Rb^+ , 1 NO_2^- , 2 O

Balanced chemical equation: $2\text{RbNO}_3(\text{s}) \rightarrow 2\text{RbNO}_2(\text{s}) + \text{O}_2(\text{g})$

The ratio of the coefficients is 2:2:1. This is the lowest possible ratio.

Reactants: 2 Rb^+ , 2 NO_3^-

Products: 2 Rb^+ , 2 NO_2^- , 2 O

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal nitrate.

The balanced chemical equation for this reaction is:



39. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of lithium hydroxide, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when lithium hydroxide decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: lithium hydroxide.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A metal hydroxide is decomposing.

A metal oxide and water are the usual products that form when a metal hydroxide decomposes.

Word equation: lithium hydroxide \rightarrow lithium oxide + water

Skeleton equation: $\text{LiOH(s)} \rightarrow \text{Li}_2\text{O(s)} + \text{H}_2\text{O(g)}$

Reactants: 1 Li^+ , 1 OH^-

Products: 2 Li^+ , 1 O^{2-} , 2 H, 1 O

Balanced chemical equation: $2\text{LiOH(s)} \rightarrow \text{Li}_2\text{O(s)} + \text{H}_2\text{O(g)}$

The ratio of the coefficients is 2:1:1. This is the lowest possible ratio.

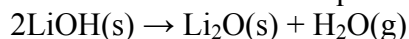
Reactants: 2 Li^+ , 2 OH^-

Products: 2 Li^+ , 1 O^{2-} , 2 H, 1 O

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal hydroxide.

The balanced chemical equation for this reaction is:



40. Practice Problem (page 134)

Determine the products that are likely to form in the decomposition of magnesium chloride, and write a balanced chemical equation for the reaction.

What Is Required?

You need to determine the products that are likely to form when magnesium chloride decomposes and write a balanced chemical equation for the reaction.

What Is Given?

You are given the type of reaction: decomposition.

You are given the reactant: magnesium chloride.

Plan Your Strategy

Identify the type of compound that is decomposing.

Determine the types of products that usually form in this type of reaction.

Write a word equation for the reaction.

Write and balance a chemical equation for the reaction.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy

A binary compound is decomposing.

The products of the decomposition of a binary compound are the two elements.

Word equation: magnesium chloride \rightarrow magnesium + chlorine

Skeleton equation: $\text{MgCl}_2(\ell) \rightarrow \text{Mg}(\ell) + \text{Cl}_2(\text{g})$

Reactants: 1 Mg^{2+} , 2 Cl^-

Products: 1 Mg, 2 Cl

Balanced chemical equation: $\text{MgCl}_2(\ell) \rightarrow \text{Mg}(\ell) + \text{Cl}_2(\text{g})$

The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.

The skeleton and balanced equations are the same.

Check Your Solution

Each chemical formula is correct, and the chemical equation is balanced. The products are what you would expect to be produced from the decomposition of a metal halide.

The balanced chemical equation for this reaction is:



Section 3.2 Synthesis Reactions and Decomposition Reactions
Solutions for Selected Review Questions
 Student Edition page 136

7. Review Question (page 136)

Predict whether each compound would form an acid or a base in a reaction with water.

- a. dinitrogen trioxide c. sulfur trioxide
 b. lithium oxide d. calcium oxide

- a. acid c. acid
 b. base d. base

15. Review Question (page 136)

If you wanted to generate lithium oxide, what are two decomposition reactions you could try?

Heat solid lithium carbonate: $\text{Li}_2\text{CO}_3(\text{s}) \rightarrow \text{Li}_2\text{O}(\text{s}) + \text{CO}_2(\text{g})$

Heat solid lithium hydroxide: $2\text{LiOH}(\text{s}) \rightarrow \text{Li}_2\text{O}(\text{s}) + \text{H}_2\text{O}(\text{g})$

Section 3.3 Combustion Reactions
Solutions for Practice Problems
 Student Edition page 141

41. Practice Problem (page 141)

Write the chemical equation for the complete combustion of heptane, $\text{C}_7\text{H}_{16}(\ell)$.

What Is Required?

You need to write a balanced chemical equation for the complete combustion of heptane.

What Is Given?

You are given the reactant: heptane

You are given the type of reaction: complete combustion

Plan Your Strategy

Identify the reactants.

Identify the product.

Write the balanced equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

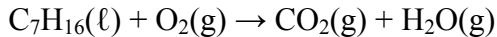
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Reactants: heptane, $\text{C}_7\text{H}_{16}(\ell)$, and oxygen, $\text{O}_2(\text{g})$

Products: carbon dioxide, $\text{CO}_2(\text{g})$, and water vapour, $\text{H}_2\text{O}(\text{g})$

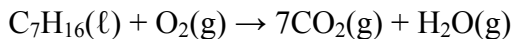
Skeleton equation:



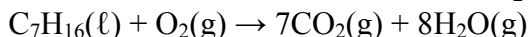
Reactants: 7 C, 16 H, 2 O

Products: 1 C, 2 H, 3 O

Insert the coefficient 7 in front of the $\text{CO}_2(\text{g})$ to balance the C:

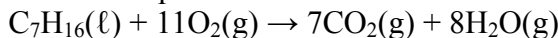


Insert the coefficient 8 in front of the $\text{H}_2\text{O}(\text{g})$ to balance the H:



Insert the coefficient 11 in front of the $\text{O}_2(\text{g})$ to balance the O.

Balanced equation:



The ratio of the coefficients is 1:11:7:8. This is the lowest possible ratio.

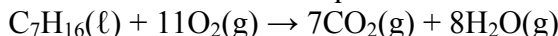
Reactants: 7 C, 16 H, 22 O

Products: 7 C, 16 H, 22 O

Check Your Solution

The products are correct for the complete combustion of a hydrocarbon. The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



42. Practice Problem (page 141)

Write the balanced equation for the complete combustion of nonane, $\text{C}_9\text{H}_{20}(\ell)$.

What Is Required?

You need to write a balanced chemical equation for the complete combustion of nonane.

What Is Given?

You are given the reactant: nonane

You are given the type of reaction: complete combustion

Plan Your Strategy

Identify the reactants.

Identify the products.

Write the balanced equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

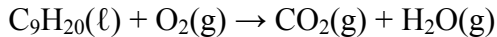
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Reactants: nonane, $\text{C}_9\text{H}_{20}(\ell)$, and oxygen, $\text{O}_2(\text{g})$

Products: carbon dioxide, $\text{CO}_2(\text{g})$, and water vapour, $\text{H}_2\text{O}(\text{g})$

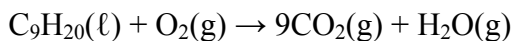
Skeleton equation:



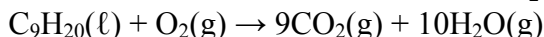
Reactants: 9 C, 20 H, 2 O

Products: 1 C, 2 H, 3 O

Insert the coefficient 9 in front of the $\text{CO}_2(\text{g})$ to balance the C:

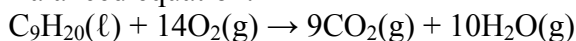


Insert the coefficient 10 in front of the $\text{H}_2\text{O}(\text{g})$ to balance the H:



Insert the coefficient 14 in front of the $\text{O}_2(\text{g})$ to balance the O.

Balanced equation:



The ratio of the coefficients is 1:14:9:10. This is the lowest possible ratio.

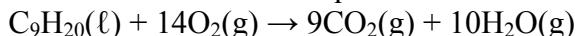
Reactants: 9 C, 20 H, 28 O

Products: 9 C, 20 H, 28 O

Check Your Solution

The products are correct for the complete combustion of a hydrocarbon. The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



43. Practice Problem (page 141)

Write the balanced equation for the complete combustion of ethyne, $\text{C}_2\text{H}_2(\text{g})$.

What Is Required?

You need to write a balanced chemical equation for the complete combustion of ethyne.

What Is Given?

You are given the reactant: ethyne

You are given the type of reaction: complete combustion

Plan Your Strategy

Identify the reactants.

Identify the products.

Write the balanced equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

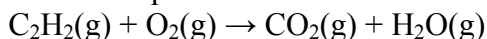
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Reactants: ethyne, $\text{C}_2\text{H}_2(\text{g})$, and oxygen, $\text{O}_2(\text{g})$

Products: carbon dioxide, $\text{CO}_2(\text{g})$, and water vapour, $\text{H}_2\text{O}(\text{g})$

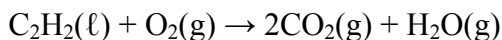
Skeleton equation:



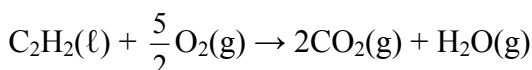
Reactants: 2 C, 2 H, 2 O

Products: 1 C, 2 H, 3 O

Insert the coefficient 2 in front of the $\text{CO}_2(\text{g})$ to balance the C:

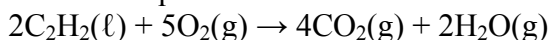


Insert the coefficient $\frac{5}{2}$ in front of the $\text{O}_2(\text{g})$ to balance the O:



Multiply each coefficient by 2 to clear the fraction.

Balanced equation:



The ratio of the coefficients is 2:5:4:2. This is the lowest possible ratio.

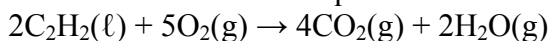
Reactants: 4 C, 4 H, 10 O

Products: 4 C, 4 H, 10 O

Check Your Solution

The products are correct for the complete combustion of a hydrocarbon. The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**44. Practice Problem (page 141)**

Write the balanced equation for the complete combustion of benzene, $\text{C}_6\text{H}_6(\ell)$.

What Is Required?

You need to write a balanced chemical equation for the complete combustion of benzene.

What Is Given?

You are given the reactant: benzene

You are given the type of reaction: complete combustion

Plan Your Strategy

Identify the reactants.

Identify the products.

Write the balanced equation.

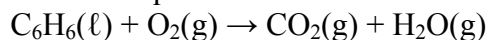
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Reactants: benzene, $C_6H_6(\ell)$, and oxygen, $O_2(g)$

Products: carbon dioxide, $CO_2(g)$, and water vapour, $H_2O(g)$

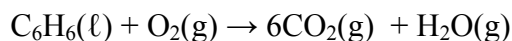
Skeleton equation:



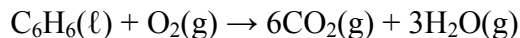
Reactants: 6 C, 6 H, 2 O

Products: 1 C, 2 H, 3 O

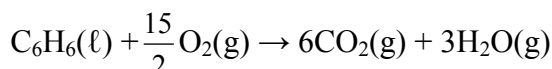
Insert the coefficient 6 in front of the $CO_2(g)$ to balance the C:



Insert the coefficient 3 in front of the $H_2O(g)$ to balance the H:

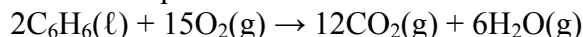


Insert the coefficient $\frac{15}{2}$ in front of the $O_2(g)$ to balance the O:



Multiply each coefficient by 2 to clear the fraction.

Balanced equation:



The ratio of the coefficients is 2:15:12:6. This is the lowest possible ratio.

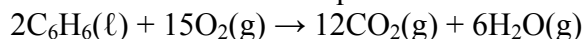
Reactants: 12 C, 12 H, 30 O

Products: 12 C, 12 H, 30 O

Check Your Solution

The products are correct for the complete combustion of a hydrocarbon. The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



45. Practice Problem (page 141)

Write the balanced equation for the complete combustion of octane, $C_8H_{18}(\ell)$.

What Is Required?

You need to write a balanced chemical equation for the complete combustion of octane.

What Is Given?

You are given the reactant: octane

You are given the type of reaction: complete combustion

Plan Your Strategy

Identify the reactants.

Identify the products.

Write the balanced equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

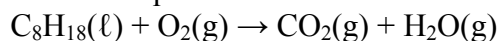
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

Reactants: octane, $C_8H_{18}(l)$, and oxygen, $O_2(g)$

Products: carbon dioxide, $CO_2(g)$, and water vapour, $H_2O(g)$

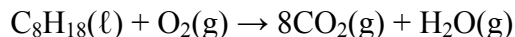
Skeleton equation:



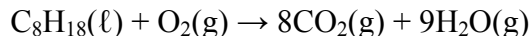
Reactants: 8 C, 18 H, 2 O

Products: 1 C, 2 H, 3 O

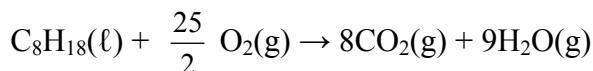
Insert the coefficient 8 in front of the $CO_2(g)$ to balance the C:



Insert the coefficient 9 in front of the $H_2O(g)$ to balance the H:

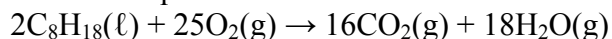


Insert the coefficient $\frac{25}{2}$ in front of the $O_2(g)$ to balance the O:



Multiply each coefficient by 2 to clear the fraction.

Balanced equation:



The ratio of the coefficients is 2:25:16:18. This is the lowest possible ratio.

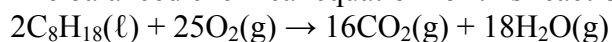
Reactants: 16 C, 36 H, 50 O

Products: 16 C, 36 H, 50 O

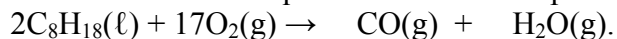
Check Your Solution

The products are correct for complete combustion of a hydrocarbon. The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**46. Practice Problem (page 141)**

Write the balanced equation for the incomplete combustion of octane:

**What Is Required?**

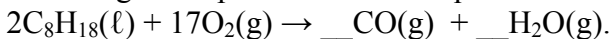
You need to write a balanced chemical equation for the incomplete combustion of octane based upon the given partial equation.

What Is Given?

You are given the reactant: octane

You are given the type of reaction: incomplete combustion

You are given a partial chemical equation:



You know the products: $\text{CO}(\text{g})$ and $\text{H}_2\text{O}(\text{g})$

Plan Your Strategy

Identify the information that is missing in the given partial chemical equation.

Begin balancing the equation from the known information in the partial equation.

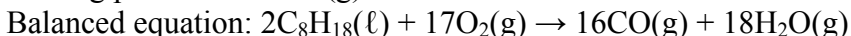
Complete the balancing of the equation knowing what products could form.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

For the equation to balance, the coefficient in front of $\text{H}_2\text{O}(\text{g})$ must be 18. This leads to the conclusion that the second product must contain the remaining oxygen. The other product must contain $34 - 18 = 16$ oxygen atoms. The missing product is $16\text{CO}(\text{g})$. This balances the carbon atoms.



The ratio of the coefficients is 2:17:16:18. This is the lowest possible ratio.

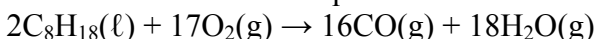
Reactants: 16 C, 36 H, 34 O

Products: 16 C, 36 H, 34 O

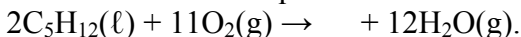
Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**47. Practice Problem (page 141)**

Write the balanced equation for the incomplete combustion of pentane:

**What Is Required?**

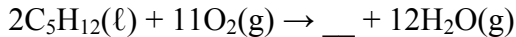
You need to write a balanced chemical equation for the incomplete combustion of pentane based upon the given partial equation.

What Is Given?

You are given the reactant: pentane

You are given the type of reaction: incomplete combustion

You are given a partial chemical equation:



You know the possible products are C(s) and CO(g).

Plan Your Strategy

Identify the information that is missing in the given partial chemical equation. Begin balancing the equation from the known information in the partial equation.

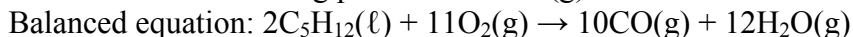
Complete the balancing of the equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

For the equation to balance, the unknown product must contain 10 C atoms and 10 O atoms. The missing product is 10CO(g).



The ratio of the coefficients is 2:11:10:12. This is the lowest possible ratio.

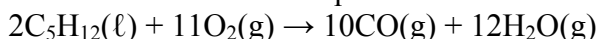
Reactants: 10 C, 24 H, 22 O

Products: 10 C, 24 H, 22 O

Check Your Solution

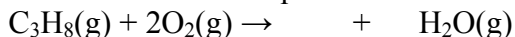
The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:



48. Practice Problem (page 141)

Write the balanced equation for the incomplete combustion of propane:



What Is Required?

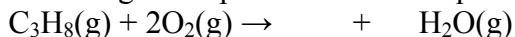
You need to write a balanced chemical equation for the incomplete combustion of propane based upon the given partial equation.

What Is Given?

You are given the reactant: propane

You are given the type of reaction: incomplete combustion

You are given a partial chemical equation:



You know the possible products: C(s) and CO(g)

Plan Your Strategy

Identify the information that is missing in the given partial chemical equation. Begin balancing the equation from the known information in the partial equation.

Identify the coefficient required in front of $\text{H}_2\text{O}(\text{g})$.

Complete the balancing of the equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

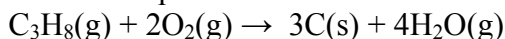
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

The possible products that could balance the equation are $\text{C}(\text{s})$ and $\text{CO}(\text{g})$.

For the equation to balance, the number coefficient in front of $\text{H}_2\text{O}(\text{g})$ must be 4 to balance the H atoms. This number supplies enough O atoms to balance the equation. The other product must be $\text{C}(\text{s})$.

Balanced equation:



The ratio of the coefficients is 1:2:3:4. This is the lowest possible ratio.

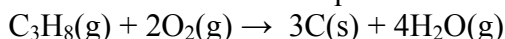
Reactants: 3 C, 8 H, 4 O

Products: 3 C, 8 H, 4 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**49. Practice Problem (page 141)**

Write the balanced equation for the incomplete combustion of heptane:

**What Is Required?**

You need to write a balanced chemical equation for the incomplete combustion of heptane based upon the given partial equation.

What Is Given?

You are given the reactant: heptane

You are given the type of reaction: incomplete combustion.

You are given a partial chemical equation:



You know the identity of the products.

Plan Your Strategy

Identify the information that is missing in the given partial chemical equation. Begin balancing the equation from the known information in the partial equation.

Identify the coefficient required in front of $\text{H}_2\text{O}(\text{g})$.

Complete the balancing of the equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

For the equation to balance, the product must contain 64 H atoms. The coefficient in front of H_2O is 32. This accounts for 32 O atoms in the products. There are 2×37 O atoms in the reactants. The remainder of the O atoms, $74 - 32 = 42$ O must be shared between CO_2 and CO .

Balanced equation: $4\text{C}_7\text{H}_{16}(\ell) + 37\text{O}_2(\text{g}) \rightarrow 14\text{CO}_2(\text{g}) + 14\text{CO}(\text{g}) + 32\text{H}_2\text{O}(\text{g})$

The ratio of the coefficients is 4:37:14:14:32. This is the lowest possible ratio.

Reactants: 28 C, 64 H, 74 O

Products: 28 C, 64 H, 74 O

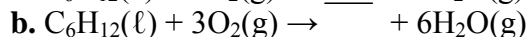
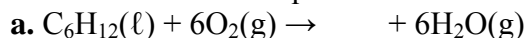
Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.

The balanced chemical equation for this reaction is:

**50. Practice Problem (page 141)**

Write two balanced equations for the incomplete combustion of cyclohexane:

**What Is Required?**

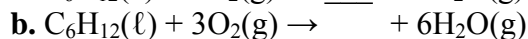
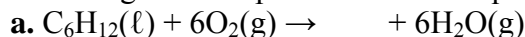
You need to write a balanced chemical equation for the incomplete combustion of cyclohexane based upon the given partial equations.

What Is Given?

You are given the reactant: cyclohexane

You are given the type of reaction: incomplete combustion

You are given two partial chemical equations:



You know the possible products: $\text{C}(\text{s})$ and $\text{CO}(\text{g})$

Plan Your Strategy

Identify the information that is missing in the given partial chemical equation. Begin balancing the equation from the known information in the partial equation.

Complete the balancing of the equation.

Check to make sure that the ratio of the coefficients is the lowest possible ratio.

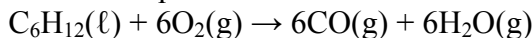
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy

The possible products that could balance the equations are C(s) and CO(g).

a. For the equation to balance, the product must contain 6 C atoms and 6 O atoms. The product is 6CO(g).

Balanced equation:



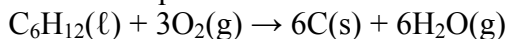
The ratio of the coefficients is 1:6:6:6. This is the lowest possible ratio.

Reactants: 6 C, 12 H, 12 O

Products: 6 C, 12 H, 12 O

b. For the equation to balance, 6 C are needed. The product is 6C(s).

Balanced equation:



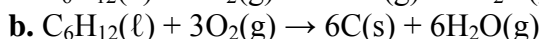
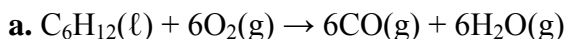
The ratio of the coefficients is 1:3:6:6. This is the lowest possible ratio.

Reactants: 6 C, 12 H, 6 O

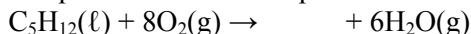
Products: 6 C, 12 H, 6 O

Check Your Solution

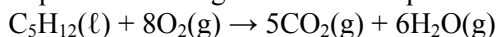
The chemical formula for each substance is written correctly. The number of atoms of each element is equal on both sides of the equation. The coefficients are written in the lowest possible ratio. The balanced chemical equations for the two reactions:

**Section 3.3 Combustion Reactions****Solutions for Selected Review Questions****Student Edition page 145****5. Review Question (page 145)**

Identify the missing product in the following balanced chemical equation for the complete combustion of pentane:



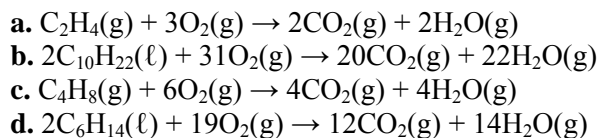
Since the combustion is complete, the missing product is CO₂(g). 5 C atoms are required on the right side of the equation to balance the reaction.



6. Review Question (page 145)

Write a balanced chemical equation for the complete combustion of each hydrocarbon.

- a. ethene, $C_2H_4(g)$ c. butene, $C_4H_8(g)$
b. decane, $C_{10}H_{22}(l)$ d. hexane, $C_6H_{14}(l)$

**12. Review Question (page 145)**

Why is it not possible to balance a chemical equation representing incomplete combustion without having additional information about the reaction?

The products vary depending upon the temperature and amount of oxygen available. Either or both $CO(g)$ and $C(s)$ may form. $CO_2(g)$ may be produced. $H_2O(g)$ will be produced.

14. Review Question (page 145)

What causes a candle flame to appear yellow?

Glowing particles of carbon give the flame a yellow colour.

15. Review Question (page 145)

Classify each reaction as a synthesis or combustion reaction, or both. Give reasons for your classifications.

- a. $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$
b. $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$
c. $6K(s) + N_2(g) \rightarrow 2K_3N(s)$

a. The reaction is a synthesis reaction (also combustion of a metal), since two elements combine to form a compound. It is also a combustion reaction, since oxygen combines with the metal (could also be called oxidation). This combustion is different from hydrocarbon combustion.

b. The reaction is complete combustion of a hydrocarbon, since the products are $CO_2(g)$ and $H_2O(g)$.

c. The reaction is a synthesis reaction, since two elements combine to form a compound.