Chapter 7

Consider the following unbalanced chemical equation:

Al(*s*)+Cl2(*g*)→AlCl3(*s*)

A student tries to balance the equation by changing the subscript 2 on Cl to a 3.

**Part A**

What is the correct balanced equation?

**Express your answer as a chemical equation.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.38

Write a balanced chemical equation for each of the following.

**Part A**

Gaseous acetylene (C2H2) reacts with oxygen gas to form gaseous carbon dioxide and gaseous water.

**Express your answer as a chemical equation. Identify all of the phases in your answer.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part B**

Chlorine gas reacts with aqueous potassium iodide to form solid iodine and aqueous potassium chloride.

**Express your answer as a chemical equation. Identify all of the phases in your answer.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part C**

Solid lithium oxide reacts with liquid water to form aqueous lithium hydroxide.

**Express your answer as a chemical equation. Identify all of the phases in your answer.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part D**

Gaseous carbon monoxide reacts with oxygen gas to form carbon dioxide gas.

**Express your answer as a chemical equation. Identify all of the phases in your answer.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.42

When iron rusts, solid iron reacts with gaseous oxygen to form solid iron(III) oxide.

**Part A**

Write a balanced chemical equation for this reaction.

**Express your answer as a chemical equation. Identify all of the phases in your answer.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.46

**Part A**

Write a balanced chemical equation for the reaction of gaseous nitrogen dioxide with hydrogen gas to form gaseous ammonia and liquid water.

**Express your answer as a chemical equation. Identify all of the phases in your answer.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.48

**Part A**

Write a balanced chemical equation for the photosynthesis reaction in which gaseous carbon dioxide and liquid water react in the presence of chlorophyll to produce aqueous glucose (C6H12O6) and oxygen gas.

**Express your answer as a chemical equation. Identify all of the phases in your answer.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.59 with eText link

Determine whether each of the following compounds is soluble or insoluble. For the soluble compounds, write the ions present in solution.

**Part A**

NaC2H3O2

|  |  |
| --- | --- |
|  | soluble |
|  | insoluble |

**Part B**

**Express your answers as ions separated by a comma. If the compound is not soluble, enter noreaction.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part C**

Sn(NO3)2

|  |  |
| --- | --- |
|  | soluble |
|  | insoluble |

**Part D**

**Express your answers as ions separated by a comma. If the compound is not soluble, enter noreaction.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part E**

AgI

|  |  |
| --- | --- |
|  | soluble |
|  | insoluble |

**Part F**

**Express your answers as ions separated by a comma. If the compound is not soluble, enter noreaction.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part G**

Na3PO4

|  |  |
| --- | --- |
|  | soluble |
|  | insoluble |

**Part H**

**Express your answers as ions separated by a comma. If the compound is not soluble, enter noreaction.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.62 with eText link

Pair each cation on the left with an anion on the right that will form a *soluble*compound and write a formula for the soluble compound. Use each anion only once.   
Na+NO3−   
Sr2+SO42−   
Co2+S2−   
Pb2+CO32−

**Part A**

Pair each cation on the left with an anion on the right that will form a *soluble* compound. Use each anion only once.

**Drag the cations on the left to the appropriate blanks on the right to form soluble compounds.**

* Sr2+
* Pb2+
* Na+
* Co2+
* 1. **\_\_\_\_**NO3−
* 2. **\_\_\_\_**SO42−
* 3. **\_\_\_\_**CO32−
* 4. **\_\_\_\_**S2−

**Part B**

Write a formula for the soluble compound.

**Express your answers as chemical formulas in alphabetical order separated by commas.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.66

Complete and balance each of the following equations. If no reaction occurs, write noreaction .

**Part A**

NaOH(aq)+FeBr3(aq)→

**Express your answer as a chemical equation. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part B**

BaCl2(aq)+AgNO3(aq)→

**Express your answer as a chemical equation. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part C**

Na2CO3(aq)+CoCl2(aq)→

**Express your answer as a chemical equation. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part D**

K2S(aq)+BaCl2(aq)→

**Express your answer as a chemical equation. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.70 with eText link

Determine whether each of the following equations for precipitation reactions is correct. If not, write the correct equation. If no reaction occurs, choose NO REACTION.

**Part A**

AgNO3(*aq*)+NaCl(*aq*)→NaCl(*s*)+AgNO3(*aq*)

|  |  |
| --- | --- |
|  | correct |
|  | incorrect |
|  | no reaction |

**Part B**

K2SO4(*aq*)+Co(NO3)2(*aq*)→CoSO4(*aq*)+2KNO3(*aq*)

|  |  |
| --- | --- |
|  | correct |
|  | incorrect |
|  | no reaction |

**Part C**

Cu(NO3)2(*aq*)+(NH4)2S(*aq*)→CuS(*s*)+2NH4NO3(*aq*)

|  |  |
| --- | --- |
|  | correct |
|  | incorrect |
|  | no reaction |

**Part D**

Hg2(NO3)2(*aq*)+2LiCl(*aq*)→Hg2Cl2(*s*)+2LiNO3(*aq*)

|  |  |
| --- | --- |
|  | correct |
|  | incorrect |
|  | no reaction |

Exercise 7.5

What does each abbreviation, often used in chemical equations, represent?

**Part A**

(g)



**Part B**

(l)



**Part C**

(s)



**Part D**

(aq)



Exercise 7.6

To balance a chemical equation, adjust the \* as necessary to make the numbers of each type of atom on both sides of the equation equal. Never adjust the \*\* to balance a chemical equation.

**Part A**

\*

|  |  |
| --- | --- |
|  | coefficients |
|  | superscripts |
|  | subscripts |
|  | signs of charge |

**Part B**

\*\*

|  |  |
| --- | --- |
|  | superscripts |
|  | coefficients |
|  | subscripts |
|  | signs of charge |

Exercise 7.11

**Part A**

Do polyatomic ions dissociate when they dissolve in water, or do they remain intact?

Do polyatomic ions dissociate when they dissolve in water, or do they remain intact?

|  |  |
| --- | --- |
|  | remain intact |
|  | dissociate into the ions |

Exercise 7.10

**Part A**

Explain what happens to an ionic substance when it dissolves in water.

**Drag the terms on the left to the appropriate blanks on the right to complete the sentences.**

* **ions**
* **atoms**
* Na−
* Cl+
* Na+
* Cl
* **molecules**
* Na
* Cl−

Ionic compounds dissolve in water and dissociate into the **\_\_\_\_\_** that make up the compound. For example, NaCl in water will form **\_\_\_\_\_**(*aq*)(element of the I group) and **\_\_\_\_\_**(*aq*)(element of the VII group).

Exercise 7.24

**Part A**

Explain the difference between a single-displacement reaction and a double-displacement reaction.

**Drag the terms on the left to the appropriate blanks on the right to complete the sentences.**

* **single**
* **double**
* **two**
* **three**
* **double**
* **two**
* **three**
* 1. In a **\_\_\_\_\_** replacement reaction one element displaces another in a compound.
* 2. In a **\_\_\_\_\_** displacement reaction **\_\_\_\_\_** elements or groups of elements in **\_\_\_\_\_** different compounds exchange places.

Exercise 7.96

Predict the products of each of these reactions and write balanced complete ionic and net ionic equations for each. If no reaction occurs, write NOREACTION .

**Part A**

LiCl(*aq*)+AgNO3(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part B**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part C**

H2SO4(*aq*)+Li2SO3(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part D**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part E**

HC2H3O2(*aq*)+Ca(OH)2(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part F**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part G**

HCl(*aq*)+KBr(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part H**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no reaction occurs.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.98

Predict the products of each of these reactions and write balanced complete ionic and net ionic equations for each. If no reaction occurs, write NOREACTION .

**Part A**

H2SO4(*aq*)+HNO3(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part B**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part C**

NaOH(*aq*)+LiOH(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part D**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part E**

Cr(NO3)3(*aq*)+LiOH(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part F**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part G**

HCl(*aq*)+Hg2(NO3)2(*aq*)→

**Express your answer as a complete ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part H**

**Express your answer as a net ionic equation. Identify all of the phases in your answer. Enter noreaction if no precipitate is formed.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Exercise 7.28 with eText link

When a chemical drain opener is added to a clogged sink, bubbles form and the water in the sink gets warmer.

**Part A**

Has a chemical reaction occurred?

|  |  |
| --- | --- |
|  | yes |
|  | no |

Chapter 7 Reading Quiz Question 1

**Part A**

Reactions that immobilize ions in hard water are called \_\_\_\_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
|  | oxidation-reduction reactions |
|  | precipitation reactions |
|  | combustion reactions |
|  | gas evolution reactions |

Chapter 7 Reading Quiz Question 2

**Part A**

Which of the following is a chemical reaction?

|  |  |
| --- | --- |
|  | water molecules mixing with sugar molecules |
|  | liquid water changes to gaseous oxygen and hydrogen molecules. |
|  | liquid molecules changing to gas water molecules |
|  | solid ice water changing to liquid water |

Chapter 7 Reading Quiz Question 3

**Part A**

Which of the following symbols represents a solution in a chemical reaction?

|  |  |
| --- | --- |
|  | (*l*) |
|  | (*g*) |
|  | (*s*) |
|  | (*aq*) |

Self Assessment 7.1

**Part A**

Which process is a chemical reaction?

|  |  |
| --- | --- |
|  | Iron rusting when left outdoors |
|  | Water boiling on a stove top |
|  | Dew condensing on grass during the night |
|  | Gasoline evaporating from a gasoline tank |

Self Assessment 7.2

**Part A**

How many oxygen atoms are on the reactant side of this chemical equation?   
K2CO3(*aq*)+Pb(NO3)2(*aq*)→2KNO3(*aq*)+PbCO3(*s*)

|  |  |
| --- | --- |
|  | 3 |
|  | 6 |
|  | 9 |
|  | 12 |

Self Assessment 7.3

**Part A**

What is the coefficient for hydrogen in the balanced equation for the reaction of solid iron(III) oxide with gaseous hydrogen to form solid iron and liquid water?

|  |  |
| --- | --- |
|  | 3 |
|  | 6 |
|  | 2 |
|  | 4 |

Self Assessment 7.4

**Part A**

Determine the correct set of coefficients to balance the chemical equation.   
\_\_C6H6(*l*) + \_\_O2(*g*)→ \_\_CO2(*g*) + \_\_H2O(*g*)

|  |  |
| --- | --- |
|  | 2, 15, 12, 12 |
|  | 2, 15, 12, 6 |
|  | 1, 15, 6, 3 |
|  | 1, 7, 6, 3 |

Chapter 7 Reading Quiz Question 6

**Part A**

What are the products of the precipitation reaction between aqueous potassium iodide, KI, and aqueous lead(II) nitrate, Pb(NO3)2?

|  |  |
| --- | --- |
|  | PbI and KNO3 |
|  | PbK and INO3 |
|  | PbI and K(NO3)2 |
|  | PbI2 and KNO3 |

Chapter 7 Reading Quiz Question 5

**Part A**

Given the rule that all compounds containing Li+, Na+, K+, NH4 +, NO3 −, and C2H3O2 − ions are soluble, which of the following is insoluble?

|  |  |
| --- | --- |
|  | Ca(C2H3O2)2 |
|  | NaNO3 |
|  | LiBr |
|  | CaCO3 |

Chapter 7 Reading Quiz Question 7

**Part A**

Which of the following are spectator ions in the reaction: AgNO3(*aq*) + NaCl(*aq*) → AgCl(*s*) + NaNO3(*aq*)

|  |  |
| --- | --- |
|  | Ag+ and Cl− |
|  | Na+ and NO3 − |
|  | Na+ and Cl− |
|  | Ag+ and NO3 − |

Chapter 7 Reading Quiz Question 8

**Part A**

Which of the following would be written as two separate ions in a complete ionic equation?

|  |  |
| --- | --- |
|  | NH3(*g*) |
|  | KNO3(*aq*) |
|  | H2O(*l*) |
|  | PbI2(*s*) |

Chapter 7 Reading Quiz Question 9

**Part A**

Which of the following compounds decompose to form water and a gas?

|  |  |
| --- | --- |
|  | NH4Cl |
|  | H2SO4 |
|  | H2CO3 |
|  | Na2CO3 |

Self Assessment 7.8

**Part A**

What is the net ionic equation for the reaction between Pb(C2H3O2)2(*aq*) and KBr(*aq*)?

|  |  |
| --- | --- |
|  | Pb(C2H3O2)2(*aq*)+KBr(*aq*)→PbBr2(*s*)+2KC2H3O2(*aq*) |
|  | Pb(C2H3O2)2(*aq*)+2KBr(*aq*)→2KC2H3O2(*s*)+PbBr2(*aq*) |
|  | Pb2+(*aq*)+2Br−(*aq*)→PbBr2(*s*) |
|  | K+(*aq*)+C2H3O2−(*aq*)→KC2H3O2(*s*) |

Chapter 7 Reading Quiz Question 10

**Part A**

Which of the following compounds will NOT help relieve heartburn?

|  |  |
| --- | --- |
|  | Mg(OH)2 |
|  | Al(OH)3 |
|  | CaCO3 |
|  | HCl |

Self Assessment 7.9

**Part A**

Complete the equation:   
HBr(*aq*)+NaOH(*aq*)→\_\_\_\_\_\_\_

Complete the equation:   
\_\_\_\_\_\_\_

|  |  |
| --- | --- |
|  | NaBr(*s*)+NaOH(*aq*) |
|  | H2O(*l*)+NaBr(*aq*) |
|  | No Reaction occurs |
|  | NaH(*s*)+BrOH(*aq*) |

Signs of a Chemical Reaction

A chemical reaction is a process by which one or more substances transform into different substances via a chemical change. Sometimes, chemical reactions exhibit evidence that can be easily observed when they occur.

**Part A**

Which changes are evidence of a chemical reaction? Is it Evidence or Not evidence?

A beaker of water becomes hot to the touch upon adding detergent powder to it. (Evidence or Non evidence)

Bubbles forming in a pot of boiling water. (Evidence or Not evidence)

Ethanol evaporating (Evidence or Not evidence)

A cloudy solution becomes clear upon adding another solution to it. (Evidence or Not evidence)

Bubble formation on chalk added to acid (Evidence or Not evidence)

**Part B**

In a lab, silver nitrate,AgNO3, is dissolved in water until no solid is observed in the container. Then, a solution of sodium chloride, NaCl, is added to the container. When you combine these aqueous solutions, there is no noticeable change in temperature; however, a solid precipitates and there is a slight change of color.

Which statements about the lab experiment involving silver nitrate and a sodium chloride solution are true?

Formation of solid indicates a chemical reaction occurred. (True or False)

A chemical reaction did occur when the solutions were combined. (True or False)

A chemical reaction occurred when silver nitrate was added to water. (True or False)

The initial disappearance of silver nitrate in water indicates of a chemical reaction occurred. (True or False)

The lack of temperature change indicates a chemical reaction didn’t occur. (True or False)

The color change of the solution indicates a chemical reaction occurred. (True or False)

Balancing Different Types of Chemical Equations

A chemical equation is used to describe a chemical reaction. The reactants are written on the left, and the products are written on the right. A reaction arrow; which often is a symbol such as →, is used to indicate the chemical change. The reactants and products are written using element symbols and chemical formulas with coefficients to indicate the quantity of each, either as moles or atoms. Terms such as heat may be written over the reaction arrow to indicate the condition applied on the reactants.

Some features of chemical equations are described in the table

|  |  |
| --- | --- |
| **Symbols** | **Meaning** |
| (s), (l), (g), (aq) | Physical state of the species (called *phases*) |
| + | Separation of two or more species |
| → | Separation of reactants and products |
| Δ or heat | Reaction is heated |

A chemical equation should always be balanced, that is, the reactants must have the same number and type of atoms of each element as the products. To balance the chemical equation, the law of conservation of mass must be upheld, which means matter is neither created nor destroyed during a chemical reaction.

How to balance a chemical equation

The process of balancing chemical reactions can often feel like a trial and error process. When balancing a chemical equation, follow these general steps:

1. Start with the unbalanced equation, and write each reactant and product using the correct element symbols and chemical formulas. Keep in mind that each subscript indicates the number of atoms in the chemical formula in the unbalanced chemical reaction, and also in the final balanced chemical equation.
2. Add coefficients before each species to balance the number of atoms of each element on each side of the reaction arrow. This involves multiplying the added coefficient by the subscript in the chemical formula. Usually one element is adjusted with its coefficient to balance that element, and then the next element is often balanced with its coefficient, and the process continues until the chemical equation is balanced.
3. Check the final chemical equation to ensure that it is balanced, keeping in mind that you might need to go back and forth between the elements to adjust the coefficients to produce a final, balanced chemical equation.
4. After checking the final chemical equation and verifying that all atoms are balanced, reduce the coefficients to the smallest whole-number ratio. Fractional coefficients are not the best form for a balanced chemical equation.

Balancing example

When balancing a chemical equation, keep in mind that the number of atoms of each element increases as the coefficient increases, such that the coefficients for several species may be affected by the adjustment of a single number. Take the example of the formation of water:

2H2+O2→2H2O

There are four hydrogen atoms on the reactant side, 2H2, and four hydrogen atoms on the product side, 2H2O. Now, change the coefficient before water to 4: 4H2O:

2H2+O2→4H2O (not balanced)

Notice that now there are eight hydrogen atoms and four oxygen atoms on the product side, but there are still only four hydrogen atoms and two oxygen atoms on the reactant side. The coefficients before both hydrogen gas, H2, and oxygen gas, O2, must now be adjusted to balance the equation:

4H2+2O2→4H2O

A properly balanced equation has all the coefficients in the smallest whole-number ratio; however, this equation does show the relationship between four moles of hydrogen gas and two moles of oxygen gas to form four moles of the product, water.

**Part A**

Balance the chemical equation by indicating the number of each species in the appropriate blanks. For this exercise, indicate coefficients of 1 explicitly.

* **1**
* **2**
* **3**
* **4**
* **5**

**\_\_\_\_\_**Fe (s) +**\_\_\_\_\_**H2O (l) →**\_\_\_\_\_**Fe3O4 (s) +**\_\_\_\_\_**H2 (g)

Types of chemical reactions

Using some general pattern, we can classify chemical reactions as:

* Combination (synthesis) reaction: A+B→AB
* Decomposition reaction: AB→A+B
* Single replacement reaction: A+BC→AC+B
* Double replacement reaction: AB+CD→AD+CB
* Combustion reaction in which carbon-containing compounds such as methane, ethane, and so on, burn in oxygen to produce carbon dioxide, water, and heat energy.

Uniquely, the combustion reaction is one of the simplest reactions to balance. The carbon atoms are always balanced first, followed by the hydrogen atoms, and finally the oxygen atoms. Sometimes, fractional coefficients, such as 1/2, 3/2, 5/2, and so on, result, but all coefficients can be multiplied by two to obtain whole-number coefficients.

**Part B**

Listed are examples of several types of chemical equations. Note that a combination reaction and a synthesis reaction are the same type of reaction. Each reaction is only partially balanced. Complete the task of balancing each chemical equation.

**Part C**

When aluminum, Al, metal is dipped in an aqueous solution of hydrochloric acid, HCl, hydrogen gas, H2, is produced with the formation of an aluminum chloride, AlCl3, solution. Write the balanced chemical equation showing the phases of reactants and products.

**Express your answer as a chemical equation including phases.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

Introduction to Balancing Chemical Equations

**Learning Goal:**

To learn how to balance chemical equations.

Chemical equations are written representations of chemical reactions. For example, a chemical equation can be written for the reaction of hydrogen gas (H2) with oxygen gas (O2), producing liquid water (H2O):

H2(g)+O2(g)→H2O(l)

This chemical equation is *unbalanced* because the number of each type of atom is not equal for both sides of the chemical equation:

H2(g)+O2(g)2 H atoms2 O atoms→H2O(l)2 H atoms1 O atom

To balance the equation, place coefficients in front of the reactants and/or products so that the number of each type of atom on each side of the arrow is equal. The coefficient indicates the number of moles of each substance present in the reaction.

To balance this chemical equation, start by placing a coefficient of 2 in front of the H2O to give a total of 4 Hatoms (note the subscript of 2 on the H atom) and 2 Oatoms on the product side of the equation. Now the oxygen atoms are balanced. Next, place a coefficient of 2 in front of the H2 to give a total of 4 H atoms on the reactant side of the equation. The chemical equation is now balanced for all elements:

2H2(g)+O2(g)4 H atoms2 O atoms→2H2O(l)4 H atoms2 O atoms

In a combustion reaction, ethanoic acid (CH3COOH) is burned in the presence of oxygen (O2), producing carbon dioxide (CO2) and water (H2O).

**Part A**

Classify each substance as either a reactant or product in the chemical reaction.

Ethanoic acid (Reactants or Products)

Water (Reactants or Products)

Oxygen (Reactants or Products)

Carbon dioxide (Reactants or Products)

Writing Balanced Equations for the Combustion of Alkanes

An alkane undergoes combustion when it reacts with oxygen to produce carbon dioxide, water, and energy:

alkane+O2→CO2+H2O+energy

**Part A**

Balance the reaction for the combustion of pentane:

?C5H12+?O2→?CO2+?H2O

**Enter the four coefficients in order, separated by commas (e.g., 1,2,3,4), where 1 indicates the absence of a coefficient.**



|  |  |
| --- | --- |
| **Solubility Rules for Ionic Compounds in Water** | |
| An ionic compound is soluble in water if it contains one of the following: | |
| Positive ions: | Li+, Na+, K+, Rb+, Cs+, NH4+ |
| Negative ions: | NO3−, C2H3O2− |
| Cl−, Br−, I− except when combinded with Ag+, Pb2+, or Hg22+ |
| SO42− except when combinded with Ba2+, Pb2+, Ca2+, Sr2+, or Hg22+ |
| Ionic compounds that do not contain at least one of these ions are usually insoluble. | |

**Part A**

Consider the following ionic compounds: CdCO3, Na2S, PbSO4, (NH4)3PO4, and Hg2Cl2. Which compounds will be soluble when added to water?

Consider the following ionic compounds: , , , , and . Which compounds will be soluble when added to water?

|  |  |
| --- | --- |
|  | Hg2Cl2 |
|  | Na2S and (NH4)3PO4 |
|  | Hg2Cl2, Na2S, and (NH4)3PO4 |
|  | CdCO3, PbSO4, and Hg2Cl2 |

**Part B**

What precipitate will form when aqueous solutions of sodium carbonate (Na2CO3) and calcium chloride (CaCl2) are mixed?

What precipitate will form when aqueous solutions of sodium carbonate () and calcium chloride () are mixed?

|  |  |
| --- | --- |
|  | NaCl(s) |
|  | CaCO3(s) |
|  | CaCl2(s) |
|  | Na2CO3(s) |

**Part C**

Predict the products for the following precipitation reaction:

NiCl2(aq)+(NH4)2S(aq)→

Predict the products for the following precipitation reaction:

|  |  |
| --- | --- |
|  | NiS(s)+2NH4Cl(aq) |
|  | NiS(s)+2NH4Cl(s) |
|  | NiS(aq)+2NH4Cl(aq) |
|  | NiS(s)+NH4Cl(aq) |

**Part D**

What is the overall balanced equation for the precipitation reaction occurring between silver nitrate and calcium bromide?

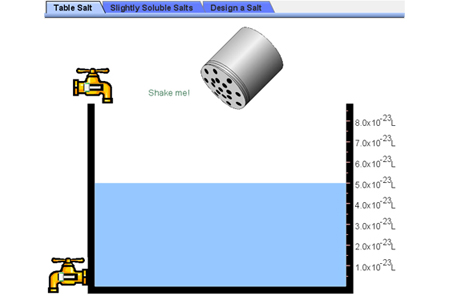
What is the overall balanced equation for the precipitation reaction occurring between silver nitrate and calcium bromide?

|  |  |
| --- | --- |
|  | AgNO3(aq)+CaBr2(aq)→AgBr(s)+Ca(NO3)2(aq) |
|  | 2AgNO3(aq)+CaBr2(aq)→2AgBr(aq)+Ca(NO3)2(aq) |
|  | 2AgNO3+CaBr2→2AgBr+Ca(NO3)2 |
|  | 2AgNO3(aq)+CaBr2(aq)→2AgBr(s)+Ca(NO3)2(aq) |

PhET Simulation - Introduction to Salts and Solubility

Using only water and a set volume, you can predict the solubility of a salt and learn whether the reaction between two salts would result in a precipitation reaction.

Click on the image below to explore this [simulation](http://media.pearsoncmg.com/aw/aw_0media_physics/phet/sims/soluble-salts/soluble-salts.jnlp), which demonstrates the solubility of different salts. When you click the simulation link, you may be asked whether to run, open, or save the file. Choose to run or open it.

[](http://media.pearsoncmg.com/aw/aw_0media_physics/phet/sims/soluble-salts/soluble-salts.jnlp)

In the simulation, you will find three tabs. The first tab demonstrates the solubility of table salt. The second tab explores other salts that are slightly soluble. The third tab enables you to design your own salt. You can add anions and cations to the beaker that contains water, as well as adjust the water level by adding or removing the water from the available taps.

**Part A**

Go to the **Slightly Soluble Salts** tab. Choose a salt from the dropdown menu to the right. Mouse over the salt shaker and move your mouse up and down while clicking the left mouse button to add the salt to the container of water. You can also add and remove water from the container by moving the sliders on the faucets to the left of the container back and forth.

Notice that there is a table indicating the number of dissolved and bound (solid) ions to the right under the dropdown menu. Using the data in this table, enter the chemical formula of mercury(II) bromide.

**Express your answer as a chemical formula.**

|  |  |  |
| --- | --- | --- |
| |  |  | | --- | --- | |  |  | |
|  |

**Part B**

Making sure the default volume of water is 1.00×10−16 L when using the **Slightly Soluble Salts**tab, add each of the possible salts to the water. Observe how much salt dissolves before the solution becomes saturated. Arrange the following salts according to their solubility in water.

Put in order from most soluble to least soluble.

Thallium(I) sulfide mercury(II) bromide copper(I) iodide silver bromide

Solubility and Precipitation Reactions

Some reactions produce chemical compounds that do not dissolve in water to form aqueous solutions.  These compounds are classified as insoluble and will coagulate and form solids that settle out of solution to the bottom of the container.  This process is called precipitation, and the solid that forms is called a precipitate.  Whether or not a compound is soluble or insoluble can be predicted based on some general guidelines called *solubility rules*.

Solubility rules

The following are general guidelines to predict whether or not a substance is soluble:

* All nitrate, acetate, and ammonium compounds are soluble.
* All compounds of alkali metal cations are soluble.
* All chloride, bromide, and iodide compounds are soluble except for those of silver, mercury(I), and lead(II).
* All sulfates are soluble except for those of strontium, barium, mercury(I), and lead(II).
* All phosphates are insoluble except for those of ammonium and alkali metal cations.
* All hydroxides and sulfides are insoluble except for those of ammonium; alkali metal cations; and cations of calcium, strontium, and barium.

Often it is helpful to locate elements on the [periodic table](https://session.masteringchemistry.com/assets/help/tools.html) .

**Part A**

Determine if each compound shown is soluble or insoluble.

AgNO3 (Soluble or Insoluble)

LiBr (Soluble or Insoluble)

BaSO4 (Soluble or Insoluble)

Cu(OH)2 (Soluble or Insoluble)

FeCl3 (Soluble or Insoluble)

MgCl2 (Soluble or Insoluble)

NaNO3 (Soluble or Insoluble)

AgCl (Soluble or Insoluble)

RbCl (Soluble or Insoluble)