Chapter 4

Classifying Reactions: Chemicals in Balance

Solutions for Practice Problems

Section 4.1

Student Textbook page 112

1. Problem

Describe each reaction using a word equation. Label the reactant(s) and product(s).

(a) Calcium and fluorine react to form calcium fluoride.

(b) Barium chloride and hydrogen sulfate react to form hydrogen chloride and barium sulfate.

(c) Calcium carbonate, carbon dioxide, and water react to form calcium hydrogen carbonate.

(d) Hydrogen peroxide reacts to form water and oxygen.

(e) Sulfur dioxide and oxygen react to form sulfur trioxide.

What Is Required?

You must write a word equation that summarizes the chemical change.

What Is Given?

The names of the reactants and products are given.

Plan Your Strategy

In writing an equation the reactants are the starting materials and they are on the left side. The products are the new substances that form and they are on the right side. A plus sign, "+", separate more than one reactant or product from another and an →, read as "to form", separates the reactant(s) from the product(s).

Act on Your Strategy

	Reactants		Products
(a)	calcium + fluorine	→	calcium fluoride
(b)	barium chloride + hydrogen sulfate	→	hydrogen chloride + barium sulfate
(c)	calcium carbonate + carbon dioxide + water	→	calcium hydrogen carbonate
(d)	hydrogen peroxide	→	water + oxygen
(e)	sulfur dioxide + oxygen	→	sulfur trioxide

Check Your Solution

Each equation has substances on the left and right side of the → and where more than one reactant or product is present, they are separated by a "+". These answers are correct.

2. Problem

Yeast can facilitate a reaction in which the sugar in grapes reacts to form ethanol and carbon dioxide. Write a word equation to describe this reaction.

What Is Required?

You must write a word equation that summarizes the chemical change.

What Is Given?
The names of the reactants and products are given.

Plan Your Strategy
In writing an equation the reactants are the starting materials and they are on the left side. The products are the new substances that form and they are on the right side. A plus sign, "+", separate more than one reactant or product from another and an →, read as "to form", separates the reactant(s) from the product(s). When a facilitator is present in a reaction, it is often written above the →.

Act on Your Strategy
sugar $\xrightarrow{\text{yeast}}$ ethanol + carbon dioxide

Check Your Solution
There are substances on both sides of the → and the products are separated by a + sign.
This equation is correct.

Solutions for Practice Problems

Student Textbook page 113

3. Problem
Write a skeleton equation for each reaction.
(a) Solid zinc reacts with chlorine gas to form solid zinc chloride.
(b) Solid calcium and liquid water react to form solid calcium hydroxide and hydrogen gas.
(c) Solid barium reacts with solid sulfur to produce solid barium sulfide.
(d) Aqueous lead(II) nitrate and solid magnesium react to form aqueous magnesium nitrate and solid lead.

What Is Required?
You must write the skeleton equation for each of the reactions.

What Is Given?
The name and state of each reactant and product are given.

Plan Your Strategy
A skeleton equation lists the chemical formula of each reactant on the left, separated by a + sign if more than one reactant is present, followed by →. The chemical formula of each product is listed on the right, separated by a + sign if more than one product is produced. The state of each reactant and product is shown in brackets after the formula.

Act on Your Strategy
(a) $Zn_{(s)} + Cl_{2(g)} \rightarrow ZnCl_{2(s)}$
(b) $Ca_{(s)} + H_2O_{(\ell)} \rightarrow Ca(OH)_{2(s)} + H_{2(g)}$
(c) $Ba_{(s)} + S_{(s)} \rightarrow BaS_{(s)}$
(d) $Pb(NO_3)_{2(aq)} + Mg_{(s)} \rightarrow Mg(NO_3)_{2(aq)} + Pb_{(s)}$

Check Your Solution
For each reaction, the formulae of the reactants and the products have their state indicated in brackets and where more than one reactant or product is present, they are separated by a + sign. The reactants and products are separated by an →. The formulas of the compounds were checked and are correct.

4. Problem

In each reaction below, a solid reacts with a gas to form a solid. Write a skeleton equation for each reaction.

(a) carbon dioxide + calcium oxide → calcium carbonate
(b) aluminum + oxygen → aluminum oxide
(c) magnesium + oxygen → magnesium oxide

What Is Required?

You must write the skeleton equation for each of the reactions.

What Is Given?

The name and state of each reactant and product are given.

Plan Your Strategy

A skeleton equation lists the chemical formula of each reactant on the left, separated by a + sign if more than one reactant is present, followed by →. The chemical formula of each product is listed on the right, separated by a + sign if more than one product is produced. The state of each reactant and product is shown in brackets after the formula.

Act on Your Strategy

(a) $CO_{2(g)} + CaO_{(s)} \rightarrow CaCO_{3(s)}$
(b) $Al_{(s)} + O_{2(g)} \rightarrow Al_2O_{3(s)}$
(c) $Mg_{(s)} + O_{2(g)} \rightarrow MgO_{(s)}$

Check Your Solution

For each reaction, the formulae of the reactants and the products have their state indicated in brackets and where more than one reactant or product is present, they are separated by a + sign. The reactants and products are separated by an →. The formulas of the compounds were checked and are correct.

Solutions for Practice Problems

Student Textbook page 116

5. Problem

Copy the skeleton equation into your notebook, and balance it.

(a) $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$
(b) $P_{4(s)} + O_{2(g)}P_4O_{10(s)}$
(c) $H_{2(g)} + Cl_{2(g)}HCl_{(g)}$
(d) $SO_{2(g)} + H_2O_{(\ell)}H_2SO_{3(aq)}$

What Is Required?

Ensure that there is the same number of atoms of each element on each side of the equation.

What Is Given?

The skeleton equation is given.

Plan Your Strategy

Count the number of atoms on each side of the equation. The formula cannot be changed. Place numerical coefficients in front of each compound or element, using a back and forth process, until there is the same number of atoms of each element on both sides of the equation.

Act on Your Strategy

(a) $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$
(b) $P_{4(s)} + 5\ O_{2(g)} \rightarrow P_4O_{10(s)}$

(c) $H_{2(g)} + Cl_{2(g)} \rightarrow 2\ HCl_{(g)}$
(d) $SO_{2(g)} + H_2O_{(\ell)} \rightarrow H_2SO_{3(aq)}$

Check Your Solution
In each case, ensure that there is the same number of atoms of each element on both sides of the equation. This is the case. The equations are balanced.

6. Problem
Indicate whether these equations are balanced. If they are not, balance them.
(a) $4\ Fe_{(s)} + 3\ O_{2(g)} \rightarrow 2\ Fe_2O_{3(s)}$
(b) $HgO_{(s)} \rightarrow Hg_{(\ell)} + O_{2(g)}$
(c) $H_2O_{2(aq)} \rightarrow 2\ H_2O_{(\ell)} + O_{2(g)}$
(d) $2\ HCl_{(aq)} + Na_2SO_{3(aq)} \rightarrow 2\ NaCl_{(aq)} + H_2O_{(\ell)} + SO_{2(g)}$

What Is Required?
You must check to see if there is the same number of atoms of each element on each side of the equation. If this is not the case, balance the equation.

What Is Given?
An equation is given that may or may not be balanced.

Plan Your Strategy
To determine if the equation is balanced, count the number of atoms on each side of the equation. The formula cannot be changed. For equations that are not balanced, place numerical coefficients in front of each compound or element, using a back and forth process, until there is the same number of atoms of each element on both sides of the equation.

Act on Your Strategy
(a) $4\ Fe_{(s)} + 3\ O_{2(g)} \rightarrow 2\ Fe_2O_{3(s)}$ balanced
(d) $2\ HCl_{(aq)} + Na_2SO_{3(aq)} \rightarrow 2\ NaCl_{(aq)} + H_2O_{(\ell)} + SO_{2(g)}$ balanced
(b) $\mathbf{2}\ HgO_{(s)} \rightarrow \mathbf{2}\ Hg_{(\ell)} + O_{2(g)}$
(c) $\mathbf{2}\ H_2O_{2(aq)} \rightarrow 2\ H_2O_{(\ell)} + O_{2(g)}$

Check Your Solution
In each case, ensure that there is the same number of atoms of each element on both sides of the equation. This is the case. The equations are balanced.

Solutions for Practice Problems

Student Textbook page 117

7. Problem
Copy each chemical equation into your notebook and balance it.
(a) $SO_{2(g)} + O_{2(g)} \rightarrow SO_{3(g)}$
(b) $BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow NaCl_{(aq)} + BaSO_{4(s)}$

What Is Required?
You must balance the equations.

What Is Given?
You are given a skeleton equation.

Plan Your Strategy
Step 1. Check to see that the skeleton equation has been copied correctly.
Step 2. Balance the atoms that occur in the largest number on either side of the equation. Generally leave the hydrogen and oxygen until the end.

Step 3. Balance the polyatomic ions that occur on both sides of the equation as an ion unit.
Step 4. Balance the hydrogen and oxygen and any other element that occurs in its uncombined state.
Step 5. Count the number and type of atoms on both sides.

Act on Your Strategy

(a) $SO_{2(g)} + O_{2(g)} \rightarrow SO_{3(g)}$

The S is balanced but there is an odd number O on the right side. Whatever numerical coefficients are inserted on the left side, there will always be an even number of O on the left. Address this odd/even difference by putting a 2 in front of SO_3 on the right side.

$SO_{2(g)} + O_{2(g)} \rightarrow \mathbf{2}\ SO_{3(g)}$

Now go back and balance the S by putting a 2 in front of the SO_2.

$\mathbf{2}\ SO_{2(g)} + O_{2(g)} \rightarrow \mathbf{2}\ SO_{3(g)}$

Check Your Solution

Left side: 2 S, 6 O Right side: 2 S, 6 O
The equation is balanced.

(b) $BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow NaCl_{(aq)} + BaSO_{4(s)}$

The SO_4^{2-} ion unit is balanced. Put a 2 in front of the NaCl to balance the Na and the Cl.

$BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow \mathbf{2}\ NaCl_{(aq)} + BaSO_{4(s)}$

Check Your Solution

Left side: 1 Ba, 2 Cl, 2 Na, 1 S, 4 O Right side: 1 Ba, 2 Cl, 2 Na, 1 S, 4 O
The equation is balanced.

8. Problem

When solid white phosphorus, P_4, is burned in air, it reacts with oxygen to produce solid tetraphosphorus decoxide, P_4O_{10}. When water is added to the P_4O_{10}, it reacts to form aqueous phosphoric acid, H_3PO_4. Write and balance the chemical equations that represent these reactions.

What Is Required?

Write the skeleton and balanced equations for the reactions that are described.

What Is Given?

The names of the reactant and product molecules are given.

Plan Your Strategy

Write the skeleton equation for each reaction. Follow the general plan for the balancing of equations.
Step 1. Check to see that the skeleton equation has been copied correctly.
Step 2. Balance the atoms that occur in the largest number on either side of the equation. Generally leave the hydrogen and oxygen until the end.
Step 3. Balance the polyatomic ions that occur on both sides of the equation as an ion unit.
Step 4. Balance the hydrogen and oxygen and any other element that occurs in its uncombined state.
Step 5. Count the number and type of atoms on both sides.

Act on Your Strategy

(a) $P_{4(s)} + O_{2(g)} \rightarrow P_4O_{10(s)}$

The P is balanced. Balance the O by putting a 5 in front of the O_2.

$P_{4(s)} + \mathbf{5}\ O_{2(g)} \rightarrow P_4O_{10(s)}$

(b) $P_4O_{10(s)} + H_2O_{(\ell)} \rightarrow H_3PO_{4(aq)}$

Balance the P by putting a 4 in front of the H_3PO_4.
$P_4O_{10(s)} + H_2O_{(\ell)} \rightarrow \mathbf{4}\ H_3PO_{4(aq)}$
Balance the H by putting a 6 in front of the H_2O. This also balances the O.
$P_4O_{10(s)} + \mathbf{6}\ H_2O_{(\ell)} \rightarrow \mathbf{4}\ H_3PO_{4(aq)}$

Check Your Strategy
(a) Left side: 4 P 10 O Right side: 4 P 10 O
(b) Left side: 4 P, 16 O, 12 H Right side: 4 P, 16 O, 12 H
These equations are balanced.

Solutions for Practice Problems

Student Textbook page118

9. Problem
Copy each element each chemical equation into your notebook and balance it.
(a) $As_4S_{6(s)} + O_{2(g)} \rightarrow As_4O_{6(s)} + SO_{2(g)}$
(b) $Sc_2O_{3(s)} + H_2O_{(\ell)} \rightarrow Sc(OH)_{3(s)}$
(c) $C_2H_5OH_{(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(\ell)}$
(d) $C_4H_{10(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(\ell)}$

What Is Required?
You must balance each equation.

What Is Given?
A skeleton equation is given for each reaction.

Plan Your Strategy
Step 1. Check to see that the skeleton equation has been copied correctly.
Step 2. Balance the atoms that occur in the largest number on either side of the equation. Generally leave the hydrogen and oxygen until the end.
Step 3. Balance the polyatomic ions that occur on both sides of the equation as an ion unit.
Step 4. Balance the hydrogen and oxygen and any other element that occurs in its uncombined state.
Step 5. Count the number and type of atoms on both sides.

Act on Your Strategy
(a) $As_4S_{6(s)} + O_{2(g)} \rightarrow As_4O_{6(s)} + SO_{2(g)}$
The As is balanced; balance the S by putting a 6 in front of the SO_2
$As_4S_{6(s)} + O_{2(g)} \rightarrow As_4O_{6(s)} + \mathbf{6}\ SO_{2(g)}$
Check the O on each side of the equation. Balance the O by putting a 9 in front of O_2.
$As_4S_{6(s)} + \mathbf{9}\ O_{2(g)} \rightarrow As_4O_{6(s)} + 6\ SO_{2(g)}$
(b) $Sc_2O_{3(s)} + H_2O_{(\ell)} \rightarrow Sc(OH)_{3(s)}$
Balance the Sc by putting a 2 in front of $Sc(OH)_3$
$Sc_2O_{3(s)} + H_2O_{(\ell)} \rightarrow \mathbf{2}\ Sc(OH)_{3(s)}$
Balance the H by putting a 3 in front of H_2O
This also balances the O.
$Sc_2O_{3(s)} + \mathbf{3}\ H_2O_{(\ell)} \rightarrow \mathbf{2}\ Sc(OH)_{3(s)}$
(c) $C_2H_5OH_{(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(\ell)}$
Balance the C by putting a 2 in front of CO_2
$C_2H_5OH_{(\ell)} + O_{2(g)} \rightarrow \mathbf{2}\ CO_{2(g)} + H_2O_{(\ell)}$
Balance the H by putting a 3 in front of H2O
$C_2H_5OH_{(\ell)} + O_{2(g)} \rightarrow \mathbf{2}\ CO_{2(g)} + \mathbf{3}\ H_2O_{(\ell)}$
Balance the O, by putting a 3 in front of the O2.

$C_2H_5OH_{(\ell)} + \mathbf{3}\ O_{2(g)} \rightarrow \mathbf{2}\ CO_{2(g)} + \mathbf{3}\ H_2O_{(\ell)}$

(d) $C_4H_{10(g)} + O_{2(g)} \rightarrow CO_{(g)} + H_2O_{(\ell)}$

Balance the C by putting a 4 in front of CO and balance the H by putting a 5 in front of the H_2O.

$C_4H_{10(g)} + O_{2(g)} \rightarrow \mathbf{4}\ CO_{(g)} + \mathbf{5}\ H_2O_{(\ell)}$

This leaves an odd/even situation with the O. There is no whole number numerical coefficient that can be used in front of O_2 to balance the odd number of O on the right. To remedy this, put a 2 in front of C_4H_{10} and make the necessary changes to the numerical coefficients on the right side. Balance the O by putting a 9 in front of O_2.

$\mathbf{2}\ C_4H_{10(g)} + \mathbf{9}\ O_{2(g)} \rightarrow \mathbf{8}\ CO_{(g)} + \mathbf{10}\ H_2O_{(\ell)}$

Check Your Solution

In each case the total number of atoms of each element are the same on the left and right sides of the equation.

Solutions for Practice Problems

Section 4.2

Student Textbook page 122

10. Problem

Copy the following synthesis reaction into your notebook. Predict the product of each reaction.

(a) $K + Br_2 \rightarrow$

(b) $H_2 + Cl_2 \rightarrow$

(c) $Ca + Cl_2 \rightarrow$

(d) $Li + O_2 \rightarrow$

What Is Required?

The products of each reaction must be predicted, the skeleton equation must be completed and this equation must be balanced.

What Is Given?

The reactant half of the skeleton equation is given.

Plan Your Strategy

Synthesis reactions follow the general pattern, $A + B \rightarrow C$. Add each pair of reactants and write the chemical formula of the expected product. Balance these simple synthesis reactions by a back-and-forth process of reasoning, as was used in practice problems 5 and 6.

Act on Your Strategy

(a) $2\ K + Br_2 \rightarrow 2\ KBr$

(b) $H_2 + Cl_2 \rightarrow 2\ HCl$

(c) $Ca + Cl_2 \rightarrow CaCl_2$

(d) $2\ Li + O_2 \rightarrow Li_2O$

Check Your Solution

In each case, there are two reactants and one product which fits the pattern of a synthesis reaction. A check of the number of atoms of each element shows that the equations are balanced.

11. Problem

Copy the following synthesis reactions into your notebook. For each set of reactants, write the equations that represent the possible products.

(a) $Fe + O_2 \rightarrow$ (suggest two different synthesis reactions)

(b) $V + O_2 \rightarrow$ (suggest two different synthesis reactions)

(c) $Co + Cl_2 \rightarrow$ (suggest two different synthesis reactions)

(d) $Ti + O_2 \rightarrow$ (suggest two different synthesis reactions)

What Is Required?
Complete and balance the synthesis reactions for each set of reactants.

What Is Given?
The reactants are given.

Plan Your Strategy
Synthesis reactions follow the general pattern, A + B → C. Add each pair of reactants and write the chemical formula of the expected product. Balance these synthesis reactions by a back-and-forth process of reasoning, as was used in Practice Problems 5 and 6.

Act on Your Strategy
(a) $Fe + O_2 \rightarrow$
$2\ Fe + O_2 \rightarrow 2\ FeO$
$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$
(b) $V + O_2 \rightarrow$
$2\ V + O_2 \rightarrow 2\ VO$
$V + O_2 \rightarrow VO_2$
$4\ V + 3\ O_2 \rightarrow 2\ V_2O_3$
$4\ V + 5\ O_2 \rightarrow 2\ V_2O_5$
(c) $Co + Cl_2 \rightarrow$
$Co + Cl_2 \rightarrow CoCl_2$
$2\ Co + 3\ Cl_2 \rightarrow 2\ CoCl_3$
(d) $Ti + O_2 \rightarrow$
$Ti + O_2 \rightarrow TiO_2$
$2\ Ti + O_2 \rightarrow 2\ TiO$
$4\ Ti + 3\ O_2 \rightarrow 2\ Ti_2O_3$

Check Your Solution
In each case, there are two reactants and one product, which fits the pattern of a synthesis reaction. A check of the number of atoms of each element shows that the equations are balanced.

12. Problem
Copy the following equations into your notebook. Write the product of each reaction. Then balance each chemical equation.
(a) $K_2O + H_2O \rightarrow$
(b) $MgO + H_2O \rightarrow$
(c) $NO + H_2O \rightarrow$
(d) $SO_2 + H_2O \rightarrow$

What Is Required?
Complete and balance the synthesis reactions for each set of reactants.

What Is Given?
The reactants are given.

Plan Your Strategy
Synthesis reactions follow the general pattern, A + B → C. Add each pair of reactants and write the chemical formula of the expected product. Balance these synthesis reactions by a back-and-forth process of reasoning, as was used in Practice Problems 5 and 6.

Act on Your Strategy
(a) $K_2O + H_2O \rightarrow 2\ KOH$
(b) $2\ MgO + H_2O \rightarrow Mg(OH)_2$
(c) $2\ NO + H_2O \rightarrow 2\ HNO_3$
(d) $SO_2 + H_2O \rightarrow H_2SO_3$

Check Your Solution
In each case, there are two reactants and one product, which fits the pattern of a synthesis reaction. A check of the number of atoms of each element shows that the equations are balanced.

13. Problem
Ammonia gas and hydrogen chloride gas react to form a solid compound. Name the predicted solid compound and write a balanced chemical equation for the reaction.

What Is Required?
You must predict the name of the product of the synthesis reaction and write the balanced equation to represent this reaction.

What Is Given?
You know the name of the two reactants and you know that a synthesis reaction will occur.

Plan Your Strategy
Add the two reactants together and name the product. Write the formula for the reactants, the product, write the skeleton equation and balance this synthesis reaction by a back-and-forth process of reasoning, as was used in Practice Problems 5 and 6.

Act on Your Strategy
ammonia + hydrogen chloride $\rightarrow$ ammonium chloride
skeleton equation: $NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$
balanced equation: $NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$

Check Your Solution
In each case, there are two reactants and one product, which fits the pattern of a synthesis reaction. A check of the number of atoms of each element shows that the equation is balanced.

Solutions for Practice Problems

Student Textbook page 123

14. Problem
Mercury(II) oxide or mercuric oxide, is a bright red powder. It decomposes on heating. What are the products of the decomposition of HgO?

What Is Required?
You must predict the products that form when HgO decomposes.

What Is Given?
The name and formula of the compound are given.

Plan Your Strategy
A decomposition reaction has the general form represented as C $\rightarrow$ A + B. One compound breaks up into two simpler products. From the name and formula of this compound, there are two elements in mercury(II) oxide.

Act on Your Strategy
From the name mercury(II) oxide, the products of decomposition must be mercury and oxygen.

Check Your Solution
The name of the compound is simple enough to make this prediction. Two products form from one compound which fits the general pattern for decomposition.

15. Problem

What are the products of the following decomposition reactions? Predict the products and write a balanced equation for each reaction.

(a) HI
(b) Ag_2O
(c) $AlCl_3$
(d) MgO

What Is Required?

Predict the name of the product, complete and balance the decomposition reaction for each compound listed.

What Is Given?

The formula of the starting compound is given.

Plan Your Strategy

Each compound should break up into its elements. The names of the elements can be determined from the chemical formula of the compound. Use a periodic table to predict the correct formula of the element. Balance these decomposition reactions by a back-and-forth process of reasoning, as was used in Practice Problems 5 and 6.

Act on Your Strategy

(a) $2\ HI \rightarrow H_2 + I_2$
(b) $2\ Ag_2O \rightarrow 4\ Ag + O_2$
(c) $2\ AlCl_3 \rightarrow 2\ Al + 3\ Cl_2$
(d) $2\ MgO \rightarrow 2\ Mg + O_2$

Check Your Solution

In each case the general pattern of a decomposition reaction is followed. Two products are formed from one compound. A check of the final equations shows that the same number of atoms of each element are on the left and right side. The equations are balanced.

16. Problem

Calcium carbonate decomposes into calcium oxide and carbon dioxide when it is heated. Based upon this information, predict the products of the following decomposition reactions.

(a) $MgCO_3$
(b) $CuCO_3$

What Is Required?

Predict the products of decomposition based upon the given information.

What Is Given?

The products of the decomposition of calcium carbonate are given. The formulae of two additional carbonates are given.

Plan Your Strategy

The two carbonates, $MgCO_3$ and $CuCO_3$, would be predicted to decompose in a manner similar to calcium carbonate, namely, to a metallic oxide and carbon dioxide.

Act on Your Strategy

$MgCO_3$ should decompose into MgO and CO_2 and $CuCO_3$ should decompose into CuO and CO_2.

The balanced equations would be as follows:

$MgCO_3 \rightarrow MgO + CO_2$

$CuCO_3 \rightarrow CuO + CO_2$

Check Your Solution
In each case, the general pattern for decomposition is followed, one compound breaks up into two products. The products have names and formulae that are similar to the decomposition products of $CaCO_3$.

Solutions for Practice Problems

Student Textbook page 124

17. Problem
The alcohol lamps that are used in some science labs are often fuelled with methanol, CH_3OH. Write the balanced chemical equation for the complete combustion of methanol.

What Is Required?
You must write a balanced chemical equation that represents the complete combustion of this fuel.

What Is Given?
The name and formula of the fuel is given.

Plan Your Strategy
You know that complete combustion of a hydrocarbon or any compound containing carbon, hydrogen and oxygen will produce carbon dioxide gas and water vapour. Write the skeleton equation for the combustion of the fuel and balance this equation. First balance the carbon atoms, then the hydrogen atoms. If an odd/even situation arises in the balancing of the oxygen atoms, go back and double the numerical coefficient used to balance the carbons in the fuel. After making the appropriate changes to the CO_2 and H_2O, the oxygen atoms can be easily balanced.

Act on Your Strategy
$CH_3OH_{(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$
The carbon atoms are balanced. Balance the hydrogen with a 2 in front of the H_2O.
There is now an odd number of oxygen on the left side. Double the numerical coefficients in front of the CH_3OH, CO_2, and H_2O.
$CH_3OH_{(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + \mathbf{2}\ H_2O_{(g)}$
$\mathbf{2}\ CH_3OH_{(\ell)} + O_{2(g)} \rightarrow \mathbf{2}\ CO_{2(g)} + \mathbf{4}\ H_2O_{(g)}$
Now balance the oxygen with a 3 in front of the O_2.
$\mathbf{2}\ CH_3OH_{(\ell)} + \mathbf{3}\ O_{2(g)} \rightarrow \mathbf{2}\ CO_{2(g)} + \mathbf{4}\ H_2O_{(g)}$

Check Your Solution
The products of the combustion are carbon dioxide and water. The number of atoms of C, H, and O are the same on each side of the equation. This answer is correct.

18. Problem
Gasoline is a mixture of compounds containing hydrogen and carbon, such as octane, C_8H_{18}. Write the balanced chemical equation for the complete combustion of C_8H_{18}.

What Is Required?
You must write a balanced chemical equation that represents the complete combustion of this fuel.

What Is Given?
The name and formula of the fuel is given.

Plan Your Strategy

You know that complete combustion of a hydrocarbon or any compound containing carbon, hydrogen and oxygen will produce carbon dioxide gas and water vapour. Write the skeleton equation for the combustion of the fuel and balance this equation. First balance the carbon atoms, then the hydrogen atoms. If an odd/even situation arises in the balancing of the oxygen atoms, go back and double the numerical coefficient used to balance the carbons in the fuel. After making the appropriate changes to the CO_2 and H_2O, the oxygen atoms can be easily balanced.

Act on Your Strategy

$C_8H_{18(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$

Balance the carbon and hydrogen atoms by putting an 8 in front of the CO_2 and a 9 in front of the H_2O. This leads to an odd number of O on the right. Go back and double the numerical coefficients in front of the C_8H_{18}, CO_2 , and H_2O.

$C_8H_{18(\ell)} + O_{2(g)} \rightarrow \mathbf{8}\ CO_{2(g)} + \mathbf{9}\ H_2O_{(g)}$

$\mathbf{2}\ C_8H_{18(\ell)} + O_{2(g)} \rightarrow \mathbf{16}\ CO_{2(g)} + \mathbf{18}\ H_2O_{(g)}$

Now balance the O with a 25 in front of the O_2.

$\mathbf{2}\ C_8H_{18(\ell)} + \mathbf{25}\ O_{2(g)} \rightarrow \mathbf{16}\ CO_{2(g)} + \mathbf{18}\ H_2O_{(g)}$

Check Your Solution

The products of the combustion are carbon dioxide and water. The number of atoms of C, H, and O are the same on each side of the equation. This answer is correct.

19. Problem

Acetone, C_3H_6O, is often contained in nail polish remover. Write the balanced chemical equation for the complete combustion of acetone.

What Is Required?

You must write a balanced chemical equation that represents the complete combustion of this fuel.

What Is Given?

The name and formula of the fuel is given.

Plan Your Strategy

You know that complete combustion of a hydrocarbon or any compound containing carbon, hydrogen and oxygen will produce carbon dioxide gas and water vapour. Write the skeleton equation for the combustion of the fuel and balance this equation. First balance the carbon atoms, then the hydrogen atoms. If an odd/even situation arises in the balancing of the oxygen atoms, go back and double the numerical coefficient used to balance the carbons in the fuel. After making the appropriate changes to the CO_2 and H_2O, the oxygen atoms can be easily balanced.

Act on Your Strategy

$C_3H_6O_{(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$

Balance the C with a 3 in front of CO_2 and the H with a 3 in front of the H_2O.

$C_3H_6O_{(\ell)} + O_{2(g)} \rightarrow \mathbf{3}\ CO_{2(g)} + \mathbf{3}\ H_2O_{(g)}$

Now balance the oxygen with a 4 in front of the O_2.

$C_3H_6O_{(\ell)} + \mathbf{4}\ O_{2(g)} \rightarrow \mathbf{3}\ CO_{2(g)} + \mathbf{3}\ H_2O_{(g)}$

Check Your Solution

The products of the combustion are carbon dioxide and water. The number of atoms of C, H, and O are the same on each side of the equation. This answer is correct.

20. Problem

Kerosene consists of a mixture of hydrocarbons. It has many uses including jet fuel and rocket fuel. It also is used as a fuel for hurricane lamps. If we represent kerosene

as $C_{16}H_{34}$, write the balanced chemical equation for the complete combustion of kerosene.

What Is Required?
You must write a balanced chemical equation that represents the complete combustion of this fuel.

What Is Given?
The name and formula of the fuel are given.

Plan Your Strategy
You know that complete combustion of a hydrocarbon or any compound containing carbon, hydrogen and oxygen will produce carbon dioxide gas and water vapour. Write the skeleton equation for the combustion of the fuel and balance this equation. First balance the carbon atoms, then the hydrogen atoms. If an odd/even situation arises in the balancing of the oxygen atoms, go back and double the numerical coefficient used to balance the carbons in the fuel. After making the appropriate changes to the CO_2 and H_2O, the oxygen atoms can be easily balanced.

Act on Your Strategy
$C_{16}H_{34(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$
Balance the C and H atoms by putting an 16 in front of the CO_2 and a 17 in front of the H_2O. This leads to an odd number of O on the right. Go back and double the numerical coefficients in front of the $C_{16}H_{34}$, CO_2 , and H_2O.
$C_{16}H_{34(\ell)} + O_{2(g)} \rightarrow \mathbf{16}\ CO_{2(g)} + \mathbf{17}\ H_2O_{(g)}$
$\mathbf{2}\ C_{16}H_{34(\ell)} + O_{2(g)} \rightarrow \mathbf{32}\ CO_{2(g)} + \mathbf{34}\ H_2O_{(g)}$
Now balance the O with a 49 in front of the O_2.
$\mathbf{2}\ C_{16}H_{34(\ell)} + \mathbf{49}\ O_{2(g)} \rightarrow \mathbf{32}\ CO_{2(g)} + \mathbf{34}\ H_2O_{(g)}$

Check Your Solution
The products of the combustion are carbon dioxide and water. The number of atoms of C, H, and O are the same on each side of the equation. This answer is correct.

Solutions for Practice Problems

Section 4.3

Student Textbook page 127

21. Problem
Each of the following incomplete equations represents a single displacement reaction. Copy each equation into your notebook and write the products. Balance each chemical equation. When in doubt, use the most common valence.

(a) $Ca + H_2O \rightarrow$
(b) $Zn + Pb(NO_3)_2 \rightarrow$
(c) $Al + HCl \rightarrow$
(d) $Cu + AgNO_3 \rightarrow$
(e) $Pb + H_2SO_4 \rightarrow$
(f) $Mg + Pt(OH)_4 \rightarrow$
(g) $Ba + FeCl_2 \rightarrow$
(h) $Fe + Co(ClO_3)_2 \rightarrow$

What Is Required?
For each example, predict the products of the single displacement reaction and balance the equation.

What Is Given?
The reactant side of the skeleton equation has been given.

Plan Your Strategy
The general pattern of these single displacement reactions can be represented as $A + BC \rightarrow AC + B$. Follow this pattern.

Act on Your Strategy

(a) $Ca + H_2O \rightarrow$
treat water as H^+OH^-
$Ca + H^+OH^- \rightarrow Ca(OH)_2 + H_2$
balanced equation: $Ca + \mathbf{2}\ H_2O \rightarrow Ca(OH)_2 + H_2$

(b) balanced equation: $Zn + Pb(NO_3)_2 \rightarrow Pb + Zn(NO_3)_2$

(c) $Al + HCl \rightarrow AlCl_3 + H_2$
balanced equation: $\mathbf{2}\ Al + \mathbf{6}\ HCl \rightarrow \mathbf{2}\ AlCl_3 + \mathbf{3}\ H_2$

(d) $Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$
balanced equation: $Cu + \mathbf{2}\ AgNO_3 \rightarrow Cu(NO_3)_2 + \mathbf{2}\ Ag$

(e) $Pb + H_2SO_4 \rightarrow$
treat H_2SO_4 as $H^+H^+SO_4^{2-}$
balanced equation: $Pb + H_2SO_4 \rightarrow PbSO_4 + H_2$

(f) $Mg + Pt(OH)_4 \rightarrow Mg(OH)_2 + Pt$
balanced equation: $\mathbf{2}\ Mg + Pt(OH)_4 \rightarrow \mathbf{2}\ Mg(OH)_2 + Pt$

(g) balanced equation: $Ba + FeCl_2 \rightarrow BaCl_2 + Fe$

(h) balanced equation: $Fe + Co(ClO_3)_2 \rightarrow Fe(ClO_3)_2 + Co$

Check Your Solution

Each equation follows the pattern for a single displacement reaction and each equation is balanced.

Solutions for Practice Problems

Student Textbook page 131

22. Problem

Using the activity series, write a balanced chemical equation for each single displacement reaction. If you predict that there will be no reaction, write "NR".

(a) $Cu + MgSO_4 \rightarrow$
(b) $Zn + FeCl_2$
(c) $K + H_2O \rightarrow$
(d) $Al + H_2SO_4 \rightarrow$
(e) $Fe + Al_2(SO_4)_3 \rightarrow$
(f) $Ni + NiCl_2 \rightarrow$
(g) $Zn + H_2SO_4 \rightarrow$
(h) $Mg + SnCl_2 \rightarrow$

What Is Required?

Predict whether or not a single displacement reaction will occur and write a balanced chemical equation for those reactions that do occur. Write "NR" if no reaction occurs.

What Is Given?

The reactant half of the skeleton equation is given.

Plan Your Strategy

For each equation, compare the position of the two metals in the activity series for metals. A reactive metal will displace any metallic ion that is below it in the activity series. The reaction will be a single displacement reaction that follows the pattern $A + BC \rightarrow AB + B$. Balance these equations.

Act on Your Strategy

(a) $Cu + MgSO_4 \rightarrow NR$ — Cu is below Mg^{2+} in the activity series.
(b) $Zn + FeCl_2 \rightarrow ZnCl_2 + Fe$ — Zn is above Fe^{2+} in the activity series.
(c) $\mathbf{2}\ K + \mathbf{2}\ H_2O \rightarrow \mathbf{2}\ KOH + H_2$ — K is above Hydrogen in the activity series.
(d) $\mathbf{2}\ Al + \mathbf{3}\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + \mathbf{3}\ H_2$ — Al is above hydrogen in the activity series.
(e) $Fe + Al_2(SO_4)_3 \rightarrow NR$ — Fe is below Al^{3+} in the activity series.
(f) $Ni + NiCl_2 \rightarrow NR$ — Ni will displace itself.
(g) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ — Zn is above hydrogen in the activity series.

(h) $Mg + SnCl_2 \rightarrow MgCl_2 + Sn$ Mg is above Sn^{2+} in the activity series.

Check Your Solution
Each equation follows the pattern for a single displacement reaction and each equation is balanced.

23. Problem
Using the activity series for the halogens, write a balanced chemical equation for each single displacement reaction. If you predict that there will be no reaction, write "NR".
(a) $Br_2 + KCl \rightarrow$ **(b)** $Cl_2 + NaI \rightarrow$

What Is Required?
Predict whether or not a single displacement reaction will occur and write a balanced chemical equation for those reactions that do occur. Write "NR" if no reaction occurs.

What Is Given?
The reactant half of the skeleton equation is given.

Plan Your Strategy
For each equation, compare the position of the two halogens in the activity series for halogens. A halogen will displace any halide that is below it in this activity series. The reaction will be a single displacement reaction that follows the pattern $DE + F \rightarrow DF + E$. Balance these equations.

Act on Your Strategy
(a) $Br_2 + KCl \rightarrow NR$ Br_2 is below Cl^- in the activity series.
(b) $Cl_2 + \mathbf{2}\ NaI \rightarrow \mathbf{2}\ NaCl + I_2$ Cl_2 is above F^- in the activity series.

Check Your Solutions
Each equation follows the pattern for a single displacement reaction and each equation is balanced.

24. Problem
Using the appropriate activity series for the halogens, write a balanced chemical equation for each single displacement reaction. If you predict that there will be no reaction, write "NR".
(a) $Pb + HCl \rightarrow$ **(d)** $Ca + H_2O \rightarrow$
(b) $KI + Br_2 \rightarrow$ **(e)** $MgSO_4 + Zn \rightarrow$
(c) $KF + Cl_2 \rightarrow$ **(f)** $Ni + H_2SO_4 \rightarrow$

What Is Required?
Predict whether or not a single displacement reaction will occur and write a balanced chemical equation for those reactions that do occur. Write "NR" if no reaction occurs.

What Is Given?
The reactant half of the skeleton equation is given.

Plan Your Strategy
For reactions involving metals, refer to the activity series for metals. A metal higher in this series will displace a metallic ion that is below it. For reactions involving the halogens, refer to the activity series for the halogens. A halogen higher in the series will displace a halide that is below it. Complete a balanced equation for any reaction that occurs following the appropriate pattern for the single displacement reaction.

Act on Your Strategy
(a) $Pb + 2\ HCl \rightarrow PbCl_2 + H_2$ Pb is above hydrogen in the activity series.

(b) $2\ KI + Br_2 \rightarrow 2\ KBr + I_2$ — Br_2 is above I^- in the activity series.
(c) $KF + Cl_2 \rightarrow NR$ — Cl_2 is below F^- in the activity series.
(d) $Ca + 2\ H_2O\ Ca(OH)_2 + H_2$ — Ca is above hydrogen in the activity series.
(e) $MgSO_4 + Zn \rightarrow NR$ — Zn is below Mg^{2+} in the activity series.
(f) $Ni + H_2SO_4 \rightarrow NiSO_4 + H_2$ — Ni is above hydrogen in the activity series.

Check Your Solution
Each equation follows the pattern for a single displacement reaction and each equation is balanced.

Solutions for Practice Problems

Student Textbook page 134

25. Problem
Write a balanced chemical equation for each double displacement reaction, Write "NR" if you predict that no reaction will occur. Note that K^+, Na^+, and Li^+ ions form soluble compounds with all anions. All nitrate compounds are soluble. Sulfate compounds with Ca^{2+}, Sr^{2+}, Ba^{2+}, Ra^{2+}, and Pb^{2+} are insoluble, but most other sulfate compounds are soluble. Lead(II) iodide is insoluble.
(a) $Pb(NO_3)_{2(aq)} + KI_{(aq)} \rightarrow$
(b) $FeCl_{3(aq)} + Na_2SO_{4(aq)} \rightarrow$
(c) $NaNO_{3(aq)} + MgSO_{4(aq)} \rightarrow$
(d) $Ba(NO_3)_{2(aq)} + MgSO_{4(aq)} \rightarrow$

What Is Required?
Predict whether or not a double displacement reaction will occur and write a balanced chemical equation for those reactions that do occur. Write "NR" if no reaction occurs.

What Is Given?
The reactant half of the skeleton equation is given. Solubility information is given about certain compounds.

Plan Your Strategy
"Deconstruct" the reactants, switch the cations, and "reconstruct" the products with the proper chemical formulas. The general pattern for a double displacement reaction is AB + CD → CB + AD. Use the solubility information given in the question to determine if a precipitate forms. If a precipitate does form, balance the equation indicating which compounds are soluble (aq) and which are insoluble (s). If both products are soluble, write "NR".

Act on Your Strategy
(a) $Pb(NO_3)_{2(aq)} + KI_{(aq)} \rightarrow 2\ KNO_{3(aq)} + PbI_{(s)}$
(b) $FeCl_{3(aq)} + Na_2SO_{4(aq)} \rightarrow NR$ (both products are soluble)
(c) $NaNO_{3(aq)} + MgSO_{4(aq)} \rightarrow NR$ (both products are soluble)
(d) $Ba(NO_3)_{2(aq)} + MgSO_{4(aq)} \rightarrow Mg(NO_3)_{2(aq)} + BaSO_{4(s)}$

Check Your Solution
In the two cases where a reaction has occurred, the general pattern of a double displacement reaction is followed. The precipitates match the solubility information given in the question and the equations are balanced. These answers are correct.

Solutions for Practice Problems

Student Textbook page 135

26. Problem

(a) When sodium sulfite, $Na_2SO_{3(aq)}$, is mixed with hydrogen chloride, $HCl_{(aq)}$ (hydrochloric acid), the odour of sulfur dioxide gas, $SO_{2(g)}$, is detected. Write the balanced chemical equation for this reaction.

(b) Hydrogen sulfide, $H_2S_{(aq)}$, is a poisonous gas that has the odour of rotten eggs. When aqueous calcium sulfide, $CaS_{(aq)}$, is reacted with sulfuric acid, a rotten egg smell is detected. Write the balanced chemical equation for this reaction.

What Is Required?

You must determine the products of the double displacement reaction that occurs and write the balanced chemical equation.

What Is Given?

The names and formulas of the reactants and the name and formula of the gaseous product are given.

Plan Your Strategy

Complete the double displacement that you predict will occur between the given reactants. One of the products is unstable and decomposes into a gas and water. Rewrite the balanced equation to indicate these products.

Act on Your Strategy

(a) $Na_2SO_{3(aq)} + HCl_{(aq)} \rightarrow H_2SO_{3(aq)} + NaCl_{(aq)}$

$H_2SO_{3(aq)} \rightarrow SO_{2(g)} + H2O_{(\ell)}$

$Na_2SO_{3(aq)} + \mathbf{2}\ HCl_{(aq)} \rightarrow SO_{2(g)} + H_2O_{(\ell)} + \mathbf{2}\ NaCl_{(aq)}$

(b) $CaS_{(aq)} + H_2SO_{4(aq)}H_2S_{(aq)} \rightarrow +CaSO_{4(s)}$ (a precipitate forms)

Check Your Solution

Both equations follow the general pattern for a double displacement reaction and the equations are balanced. These answers are correct.

27. Problem

Write the balanced chemical equation for each neutralization reaction.

(a) $HCl_{(aq)} + LiOH_{(aq)} \rightarrow$

(b) $HClO_{4(aq)} + Ca(OH)_{2(aq)} \rightarrow$

(c) $H_2SO_{4(aq)} + NaOH \rightarrow$

What Is Required?

You must determine the products of the double displacement reaction that occurs and write the balanced chemical equation.

What Is Given?

The names and formulas of the reactants are given.

Plan Your Strategy

Complete the double displacement that you predict will occur between the given reactants. Follow the general pattern for double displacement reactions. One of the products is water. Write the balanced equation to indicate the products that form.

Act on Your Strategy

(a) $HCl_{(aq)} + LiOH_{(aq)} \rightarrow LiCl_{(aq)} + H_2O_{(\ell)}$

(b) $HClO_{4(aq)} + Ca(OH)_{2(aq)} \rightarrow Ca(ClO_4)_{2(aq)} + \mathbf{2}\ H_2O_{(\ell)}$

(c) $H_2SO_{4(aq)} + \mathbf{2}\ NaOH \rightarrow \mathbf{2}\ Na_2SO_{4(aq)} + \mathbf{2}\ H_2O_{(\ell)}$

Check Your Solution

The equations follow the general pattern for a double displacement reaction and the equations are balanced. These answers are correct.

28. Problem

Write the balanced chemical equation for each double displacement reaction. Be sure to indicate the physical state of all products.

(a) $BaCl_{2(aq)} + Na_2CrO_{4(aq)}$ (a precipitate forms)

(b) $H_3PO_{4(aq)} + NaOH_{(aq)}$ (water is produced)

(c) $K_2CO_{3(aq)} + HNO_{3(aq)}$ (a gas is produced)

What Is Required?

You must determine the products of the double displacement reaction that occurs and write the balanced chemical equation.

What Is Given?

The names and formulas of the reactants are given and information about one of the products is known.

Plan Your Strategy

Complete the double displacement that you predict will occur between the given reactants. Follow the general pattern for double displacement reactions. Write the balanced equation to indicate the products that form using the information given about one of the products.

Act on Your Strategy

(a) $BaCl_{2(aq)} + Na_2CrO_{4(aq)} \rightarrow \mathbf{2}\ NaCl_{(aq)} + BaCrO_{4(s)}$

We know that NaCl is soluble and therefore the precipitate must be $BaCrO_4$.

(b) $H_3PO_{4(aq)} + \mathbf{3}\ NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + \mathbf{3}\ H_2O_{(\ell)}$

(c) $K_2CO_{3(aq)} + HNO_{3(aq)} \rightarrow \mathbf{2}\ KNO_{3(aq)} + H_2O_{(\ell)} + CO_{2(g)}$

Check Your Solution

The equations follow the general pattern for a double displacement reaction and the equations are balanced. These answers are correct.

Solutions for Practice Problems

Section 4.4

Student Textbook page 143

29. Problem

Uranium was the first element shown to be radioactive. Complete the following reaction representing the alpha decay of uranium-238.

$$^{238}_{92}U \rightarrow \quad + {}^{4}_{2}He$$

What Is Required?

The nuclear equation must be balanced by finding the second product that forms.

What Is Given?

The reactant nucleus, with its atomic number and mass number, is given. You also know that one of the products of the decay is an alpha particle.

Plan Your Strategy

Apply the rules for balancing a nuclear reaction:

- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other product.

Act on Your Strategy

difference in mass numbers on left and right side of equation = 238 − 4 = 234
difference in atomic numbers on left and right side of the equation = 92 − 2 = 90
The other product is the element of atomic number 90 which is thorium.
The other product is $^{234}_{90}\text{Th}$.
The complete equation will be: $^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$

Check Your Solution

The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

30. Problem

Radon-222, $^{222}_{86}\text{Rn}$, is known to decay by alpha particle emission. Write a balanced nuclear equation and name the element produced in this decay process.

What Is Required?

The nuclear equation must be balanced by determining the second product that forms.

What Is Given?

The reactant nucleus, with its atomic number and mass number, is given. You also know that one of the products of the decay is an alpha particle.

Plan Your Strategy

Apply the rules for balancing a nuclear reaction:

- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other product.

Act on Your Strategy

$^{222}_{86}\text{Rn} \rightarrow {}^{4}_{2}\text{He} + ?$
difference in mass numbers on left and right side of equation = 222 − 4 = 218
difference in atomic numbers on left and right side of the equation = 86 − 2 = 84
The other product will be $^{218}_{84}\text{Po}$.
The equation will be $^{222}_{86}\text{Rn} \rightarrow {}^{4}_{2}\text{He} + {}^{218}_{84}\text{Po}$

Check Your Solution

The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

31. Problem

Plutonium-242 decays by emitting an alpha particle. Write balanced nuclear equation for this reaction.

What Is Required?

The nuclear equation must be balanced by determining the second product that forms.

What Is Given?
The reactant nucleus, with its atomic number and mass number, is given. You also know that one of the products of the decay is an alpha particle.

Plan Your Strategy
Apply the rules for balancing a nuclear reaction:
- the sum of the mass numbers on each side of the equation must be equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other product.

Act on Your Strategy
$^{242}_{94}Pu \rightarrow {}^{4}_{2}He + ?$
difference in mass numbers on left and right side of equation $= 242 - 4 = 238$
difference in atomic numbers on left and right side of the equation $= 94 - 2 = 92$
The other product is $^{238}_{92}U$.
The equation is $^{242}_{94}Pu \rightarrow {}^{4}_{2}He + {}^{238}_{92}U$

Check Your Solution
The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

32. Problem
Neodymium-144, $^{144}_{60}Nd$, decays by alpha particle emission. Write the balanced nuclear equation for this nuclear decay.

What Is Required?
The nuclear equation must be balanced by determining the second product that forms.

What Is Given?
The reactant nucleus, with its atomic number and mass number, is given. You also know that one of the products of the decay is an alpha particle.

Plan Your Strategy
Apply the rules for balancing a nuclear reaction:
- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other product.

Act on Your Strategy
$^{144}_{60}Nd \rightarrow {}^{4}_{2}He + ?$
difference in mass numbers on left and right side of equation $= 144 - 4 = 140$
difference in atomic numbers on left and right side of the equation $= 60 - 2 = 58$
The other product is $^{140}_{58}Ce$.
The equation is $^{144}_{60}Nd \rightarrow {}^{4}_{2}He + {}^{140}_{58}Ce$

Check Your Solution
The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

Solutions for Practice Problems

Student Textbook page 144

33. Problem

Write the balanced nuclear equation for the radioactive decay of potassium-40 by emission of a β particle.

What Is Required?

You must write a balanced nuclear equation for the decay of K-40.

What Is Given?

You know that one of the products is a β particle or an electron. The mass number of potassium is 40 and its atomic number, as found on the periodic table, is 19.

Plan Your Strategy

Apply the rules for balancing a nuclear reaction:

- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other product.

Act on Your Strategy

$^{40}_{19}\text{K} \rightarrow {}^{0}_{-1}\text{e} + ?$

difference in mass numbers on left and right side of equation $= 40 - 0 = 40$

difference in atomic numbers on left and right side of the equation $= 19 - (-1) = 20$

The other product is $^{40}_{20}\text{Ca}$.

The equation is $^{40}_{19}\text{K} \rightarrow {}^{0}_{-1}\text{e} + {}^{40}_{20}\text{Ca}$

Check Your Solution

The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

34. Problem

What radioisotope decays by β particle emission to form $^{47}_{21}\text{Sc}$?

What Is Required?

You must write a balanced nuclear equation to show the nucleus that decays to Sc-47 and a β particle.

What Is Given?

Scandium-47 is one product and the other is a β particle or an electron. The mass number and the atomic number of Sc are given.

Plan Your Strategy

Apply the rules for balancing a nuclear reaction:

- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the sum of the mass numbers and the atomic numbers on the right side. These totals must equal the mass number and atomic number of the nucleus that is unknown. Refer to the periodic table and find an element with this atomic number. This element will be the reactant nucleus.

Act on Your Strategy

$? \rightarrow {}^{0}_{-1}\text{e} + {}^{47}_{21}\text{Sc}$

The sum of the mass numbers on the right = 47

The sum of the atomic numbers on the right 21 + (−1) = 20
The other product is $^{47}_{20}$Ca.
The equation is $^{47}_{20}Ca \rightarrow {}^{0}_{-1}e + {}^{47}_{21}Sc$

Check Your Solution
The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

35. Problem
Complete the following nuclear equation:
$^{73}_{31}Ga \rightarrow {}^{0}_{-1}e +$

What Is Required?
You must write a balanced nuclear equation for the decay of Ga-73.

What Is Given?
You know that one of the products is a β particle or an electron. The mass number and atomic number of Ga are also given.

Plan Your Strategy
Apply the rules for balancing a nuclear reaction:
- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other product.

Act on Your Strategy
$^{73}_{31}Ga \rightarrow {}^{0}_{-1}e + ?$
difference in mass numbers on left and right side of equation = 73 − 0 = 73
difference in atomic numbers on left and right side of the equation = 31 − (−1) = 32
The other product is $^{73}_{32}$Ge.
The equation is $^{73}_{31}Ga \rightarrow {}^{0}_{-1}e + {}^{73}_{32}Ge$

Check Your Solution
The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

Solutions for Practice Problems

Student Textbook page 147

36. Problem
Astatine can be produced by the bombardment of a certain atom with alpha particles, as follows:

$$+{}^{4}_{2}He \rightarrow {}^{211}_{85}At + 2\ {}^{1}_{0}n$$

Identify the atom.

What Is Required?
You must balance this nuclear equation by finding the identity of the missing reactant nucleus.

What Is Given?
You know the identity, mass number and atomic number of all of the other atomic species.

Plan Your Strategy

Apply the rules for balancing a nuclear reaction:

- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other reactant.

Act on Your Strategy

difference in mass numbers on left and right side of equation=(211 + 2) − 4=209
difference in atomic numbers on left and right side of the equation=(85+0)−2=83
The other reactant nucleus is $^{209}_{83}$Bi.
The equation is $^{209}_{83}\text{Bi} + {}^{4}_{2}\text{He} \rightarrow {}^{211}_{85}\text{At} + 2\ {}^{1}_{0}\text{n}$

Check Your Solution

The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

37. Problem

Balance the following equation by adding a coefficient.

$$^{252}_{96}\text{Cf} + {}^{10}_{5}\text{B} \rightarrow {}^{257}_{101}\text{Md} + \quad {}^{1}_{0}\text{n}$$

What Is Required?

You must balance this nuclear equation by finding the missing coefficient in front of the $^{1}_{0}$n.

What Is Given?

You know the identity, mass number and atomic number of all of the other atomic species.

Plan Your Strategy

Apply the rules for balancing a nuclear reaction:

- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) (excluding the neutron) on the left and right sides of the equation. This difference corresponds to the total mass number of the neutrons. Since each neutron has a mass number of 1, this difference in mass numbers is also the number of neutrons.

Act on Your Strategy

difference in mass numbers on left and right side of equation=(252+10)−257=5
There must be 5 $^{1}_{0}$n.

The equation is $^{252}_{96}\text{Cf} + {}^{10}_{5}\text{B} \rightarrow {}^{257}_{101}\text{Md} + \mathbf{5}\ {}^{1}_{0}\text{n}$

Check Your Solution

The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

38. Problem

How many neutrons are produced when U-238 is bombarded with C-12 nuclei in a particle accelerator? Balance the following equation:

$$^{238}_{92}\text{U} + {}^{12}_{6}\text{C} \rightarrow {}^{246}_{98}\text{Cf} + \quad {}^{1}_{0}\text{n}$$

What Is Required?
You must balance this nuclear equation by finding the missing coefficient in front of the ${}^{1}_{0}n$.

What Is Given?
You know the identity, mass number and atomic number of all of the other atomic species.

Plan Your Strategy
Apply the rules for balancing a nuclear reaction:
- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) (excluding the neutron) on the left and right sides of the equation. This difference corresponds to the total mass number of the neutrons. Since each neutron has a mass number of 1, this difference in mass numbers is also the number of neutrons.

Act on Your Strategy
difference in mass numbers on left and right side of equation=(238+12)−246=4
There must be 4 ${}^{1}_{0}n$.

The equation is ${}^{238}_{92}U + {}^{12}_{6}C \rightarrow {}^{246}_{98}Cf + \mathbf{4}\ {}^{1}_{0}n$

Check Your Solution
The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.

39. Problem
Aluminum-27, when it collides with a certain nucleus, transforms into phosphorus-30 along with a neutron. Write a balanced nuclear equation for this reaction.

What Is Required?
You must determine the reactant nucleus and write the balanced nuclear equation.

What Is Given?
One reactant nucleus is Al-27. The products are a neutron and a P-30 nucleus. The atomic numbers of aluminum and of phosphorus can be found on the periodic table.

Plan Your Strategy
Apply the rules for balancing a nuclear reaction:
- the sum of the mass numbers on each side of the equation must be the equal
- the sum of the atomic numbers on each side of the equation must be equal

Find the difference between the mass number(s) on the left and right sides of the equation. This is the mass number of the other product. Similarly, find the difference in the atomic number(s) on the left and right sides. This is the atomic number of the other product. Refer to the periodic table and find an element with this atomic number. This element will be the other reactant.

Act on Your Strategy
${}^{27}_{13}Al + ? \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$
difference in mass numbers on left and right side of equation $(30 + 1) - 27 = 4$
difference in atomic numbers on left and right side of the equation=(15)−(13)=2
The other reactant nucleus is ${}^{4}_{2}He$.

The equation is ${}^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$

Check Your Solution

The sum of the mass numbers is equal on both sides of the equation and the sum of the atomic numbers is equal on both sides of the equation. The equation is balanced.