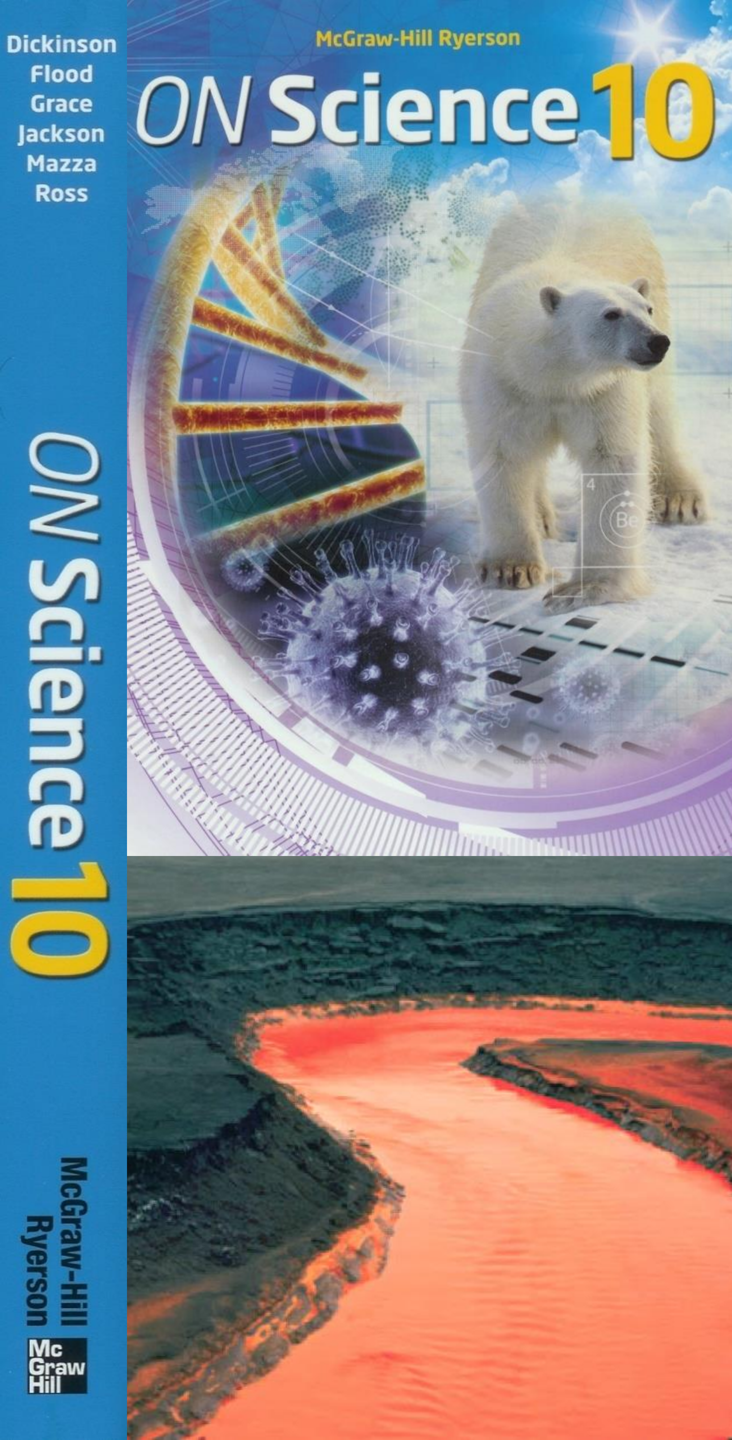


UNIT 2

Chemical Reactions

- **Chapter 4**: Developing Chemical Equations
- **Chapter 5**:Classifying Chemical Reactions
- **Chapter 6**:Acids and Bases

CHAPTER 4 *Developing Chemical Equations*

In this chapter, you will investigate how to:

- ***identify***, ***name***, *and* ***write*** *the formulas of ionic and molecular compounds*
- ***write*** *and* ***balance*** *chemical equations*
- ***describe*** *how balanced chemical equations demonstrate the Law of Conservation of Mass*

Chemistry Review

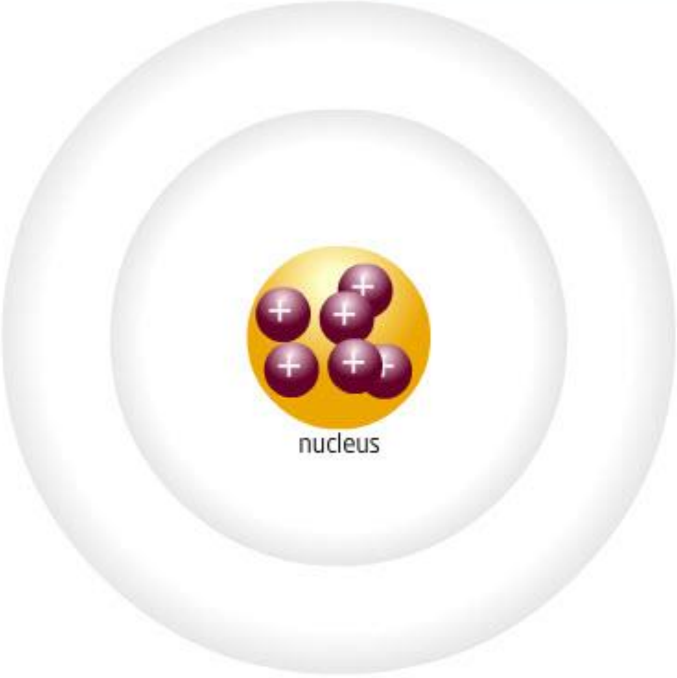
Click the "Start" button to review **subatomic particles**.

Subatomic Particles and Isotopes

subatomic particles | isotopes | hydrogen isotopes

Atoms and isotopes are made up of subatomic particles, including protons, neutrons, and electrons.

Name	Relative Mass	Electric Charge
proton	1836	+
neutron	1837	0
electron	1	-



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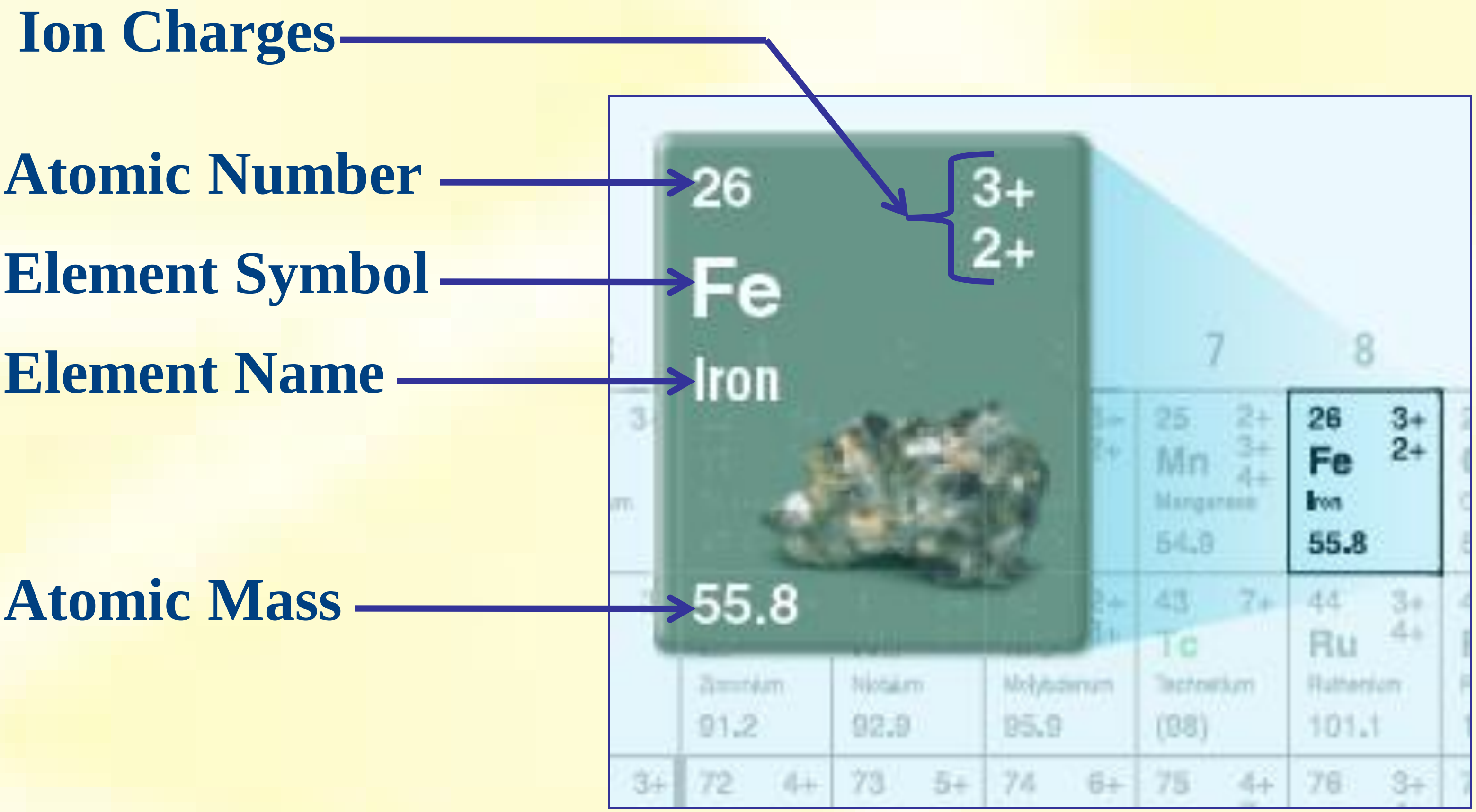
replay

Chemistry Review

Review the use of the **periodic table of the elements** and how to read the information found within it.

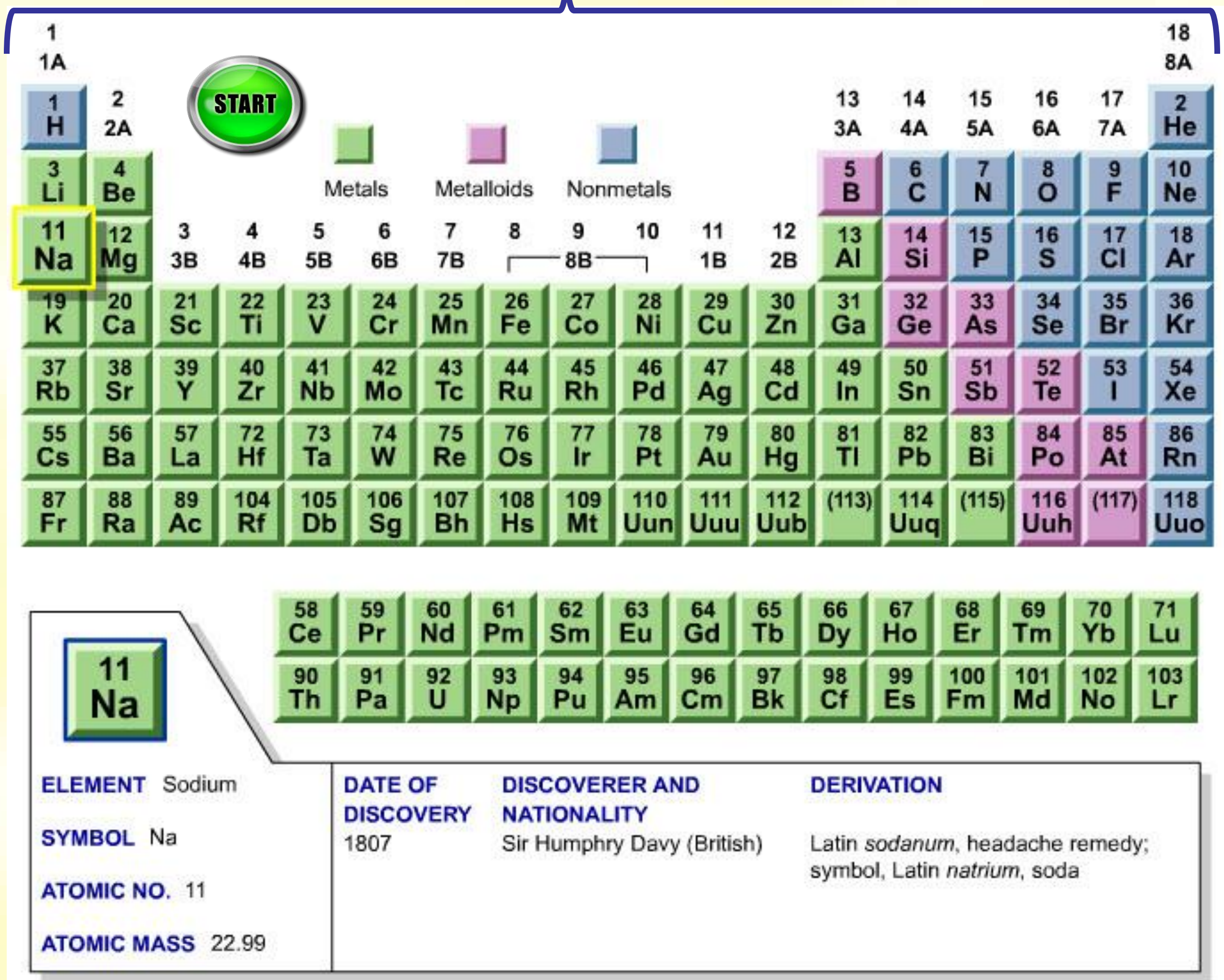


Chemistry Review

(Pages 134-135)

Click the "Start" button to review **element properties**.

Groups or Families (1-18)



Periods

(1-7)

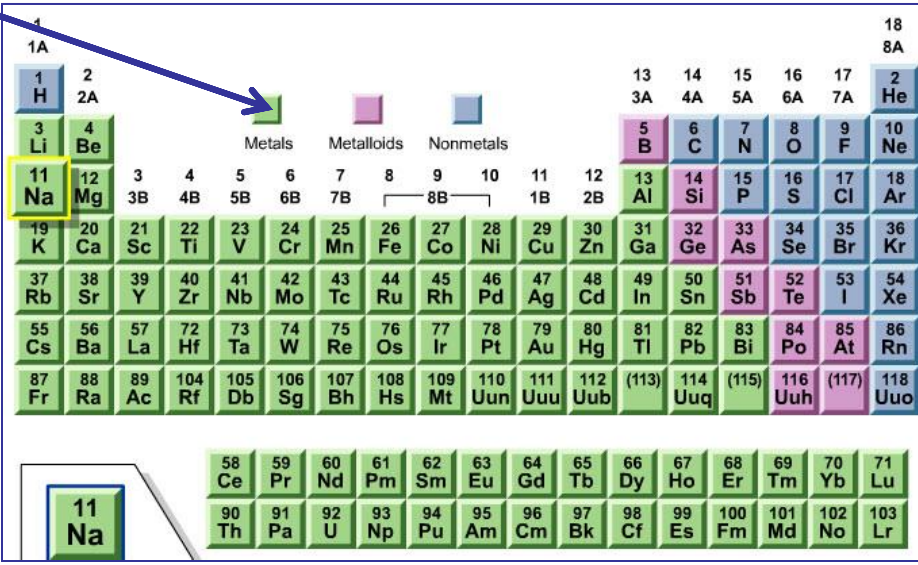
Metals

The metals are:

- Good conductors of heat (used in pots and pans)
- Good conductors of electricity (used in wires)
- Lustrous (used in jewelry and other ornamental objects)
- Almost all are solids (except for mercury)
- Malleable (can be hammered into sheets)
- Ductile (can be drawn into wires)

Examples: Gold, Aluminum, Silver, Copper, and Sodium

Roll over images to learn more.



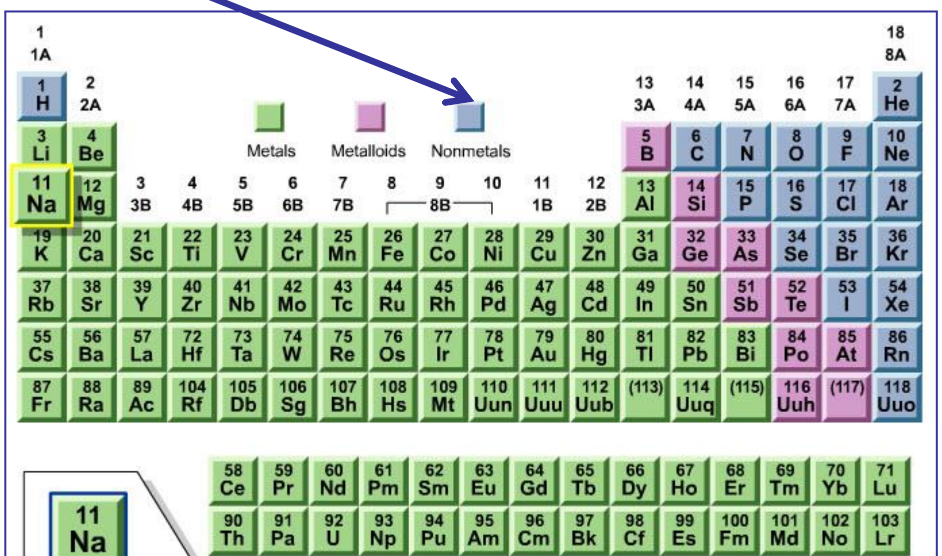
Non-metals

Roll over images to learn more.

The non-metals are:

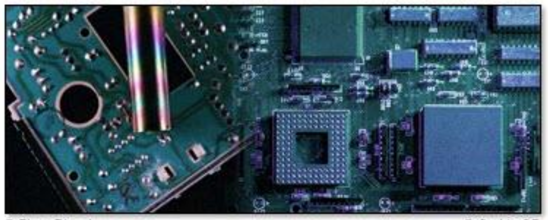
- Poor conductors of heat (used as insulators in construction)
- Poor conductors of electricity (used to insulate wires)
- Non-lustrous (dull in appearance)
- Either solids, liquids, or gases (there are examples of each)
- Brittle in the solid state (break easily when hammered)
- Non-ductile (cannot be drawn into wires)

Examples: Phosphorus, Sulfur, Chlorine, and Neon



Metalloids

Metalloids have properties of both metals and non-metals. The metalloids show the largest variance in properties of any group in the periodic table. They can be metallic or non-metallic, malleable or non-malleable. The most notable members of this group are silicon and germanium, which have brought about revolutionary changes in the semiconductor industry. (Semiconductors normally will not conduct electricity but can be induced to do so at elevated temperatures or when they are mixed with trace amounts of other elements.)



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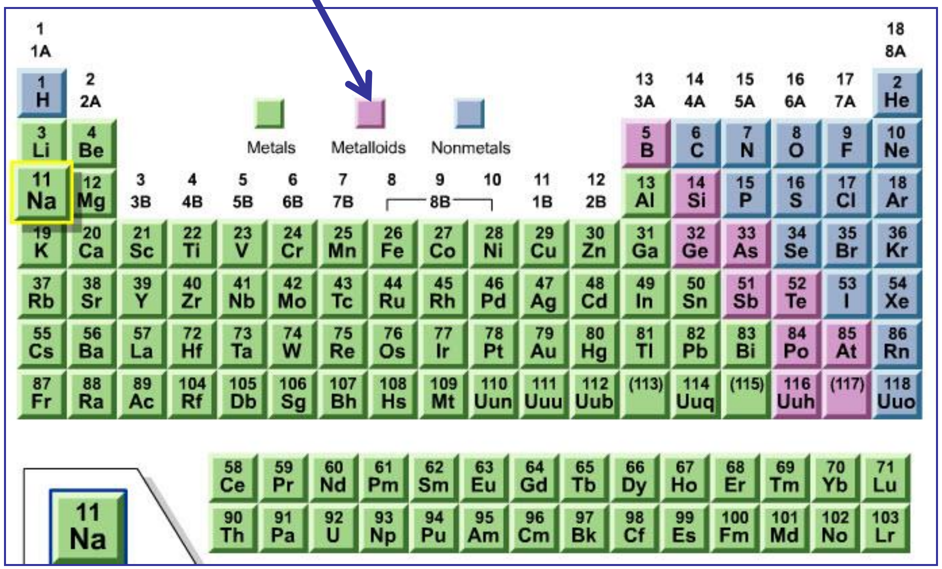
Roll over image to learn more.



Examples: Boron, Silicon, Arsenic, and Antimony

Chemistry Review

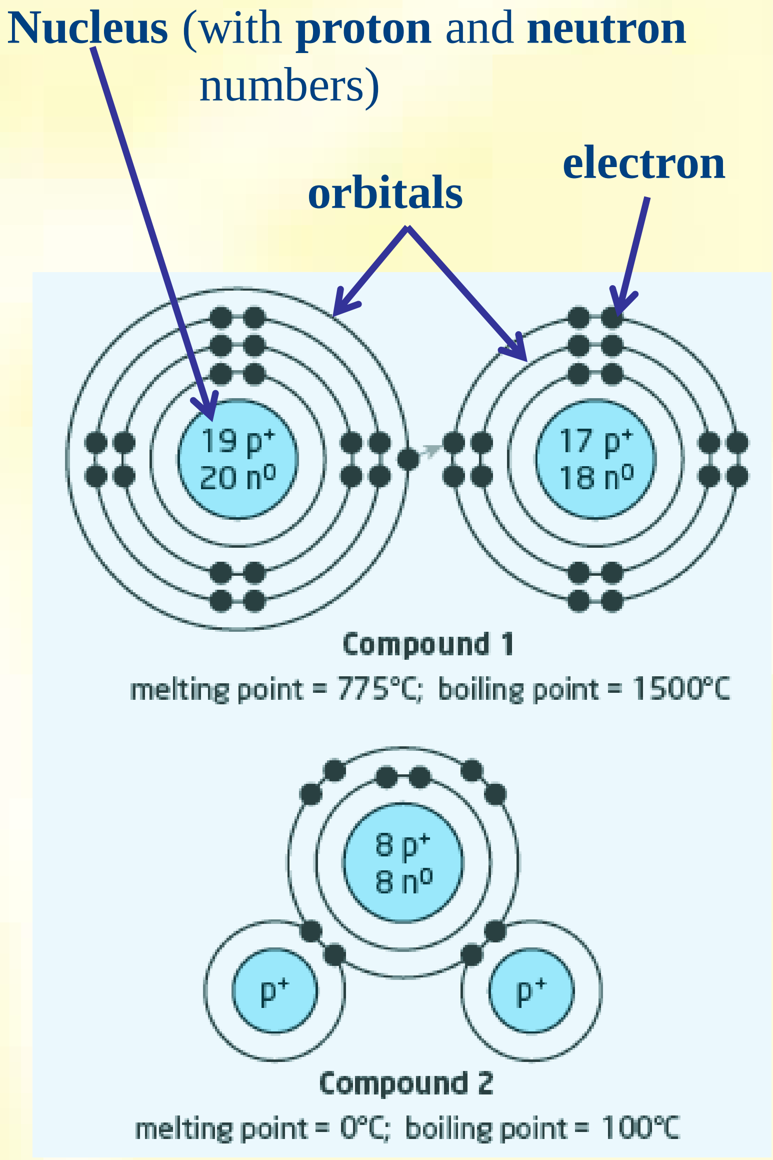
(Pages 134-135)

Bohr-Rutherford diagrams illustrate the structure of atoms, showing the numbers of **protons**, **neutrons**, and **electrons** and their relative positions.

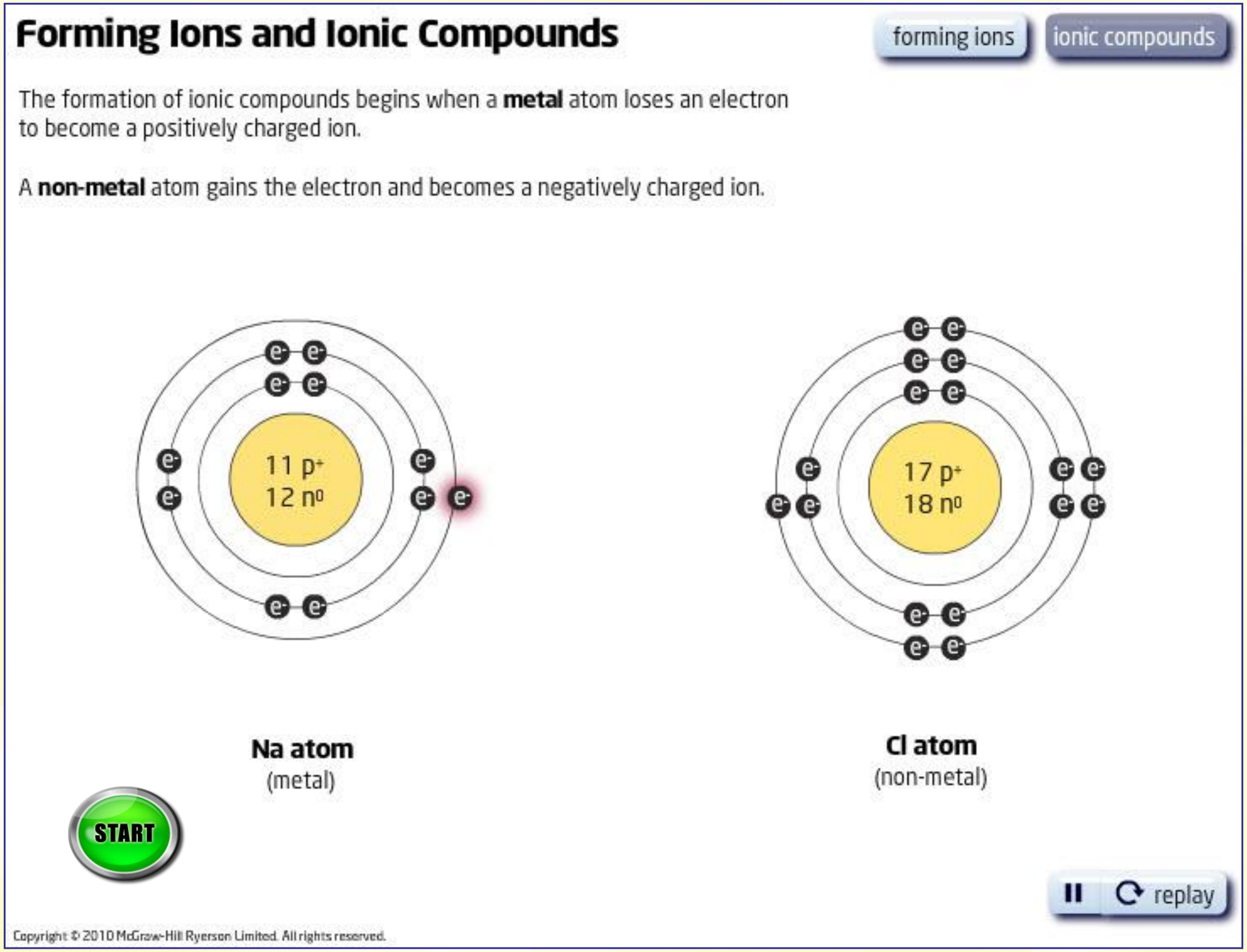
- The **nucleus** is shown as a solid circle at the centre of the atom.

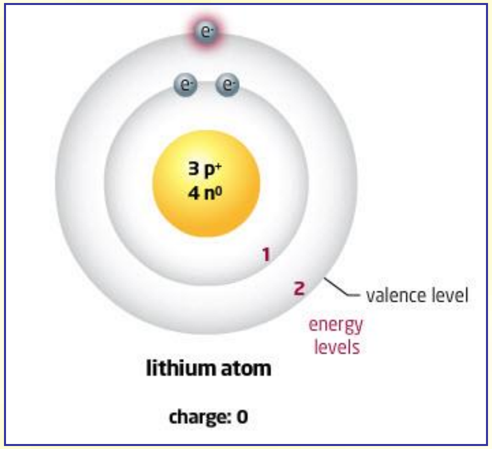
- The numbers of **protons (__ p$^+$)** and **neutrons (__ n^0)** are written inside the nucleus.

- The **electron** (numbers and positions) are illustrated by placing dots (●) in the appropriate **orbital** or **energy level** (indicated by circles) around the nucleus.



Click the “Start” button to review the **formation of ions** and **ionic compounds**.





Ions are charged particles formed after the loss or gain of one or more electrons.

Making a Reaction Happen

What conditions are required for a chemical reaction to occur?

How do you know if a chemical reaction has occurred?

What evidence might indicate that a chemical reaction has occurred?

Will mass change during a chemical reaction?

Reactions require the right conditions in order to occur.

4.1 Representing Ionic Compounds (Page 139)

Ionic compounds are composed of oppositely charged **ions**.

Ionic compounds may be created as the **products** or **wastes** (solid, liquid, or gas) of industrial processes such as the one illustrated on the left.

Forming Ionic Compounds

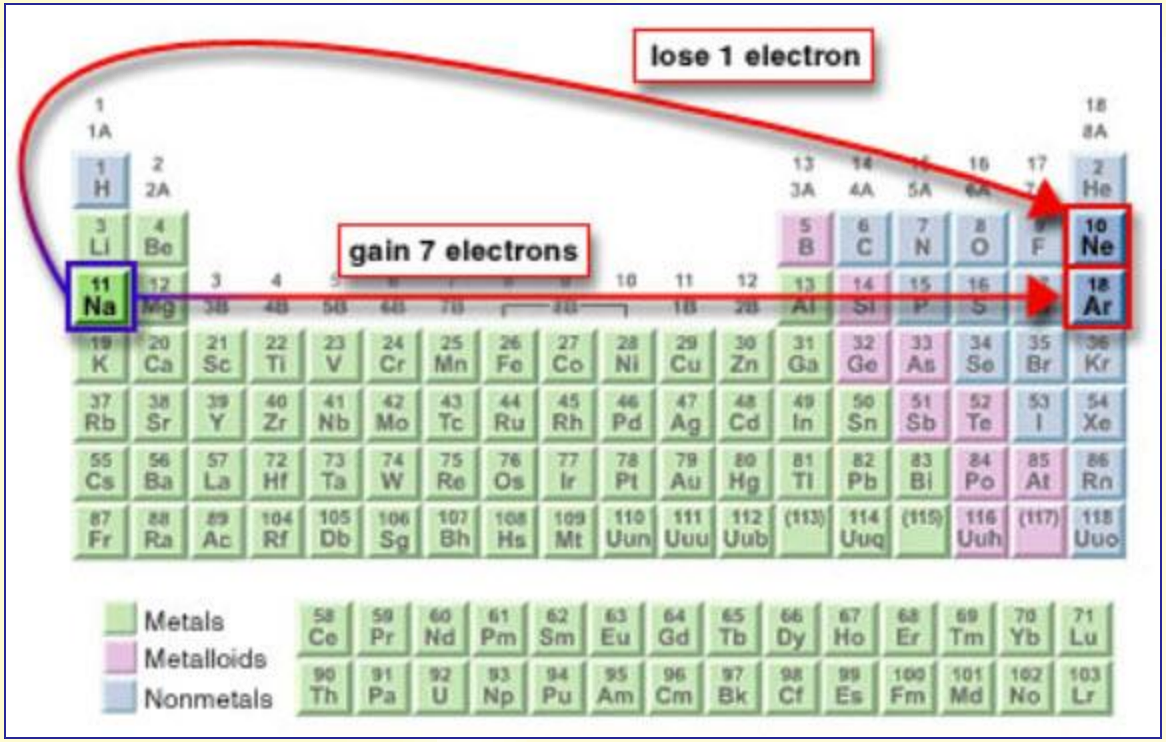
(Pages 140-141)

Elements combine to form **ionic compounds** when their atoms gain or lose **electrons**, becoming charged particles called **ions.**

Ionic compounds are usually composed of a **metal** and a **non-metal**.

Metals lose (or lend) electrons to the **non-metal**, becoming positively charged **cations**.

Non-metals gain (or borrow) electrons from the **metal**, becoming negatively charged **anions**.

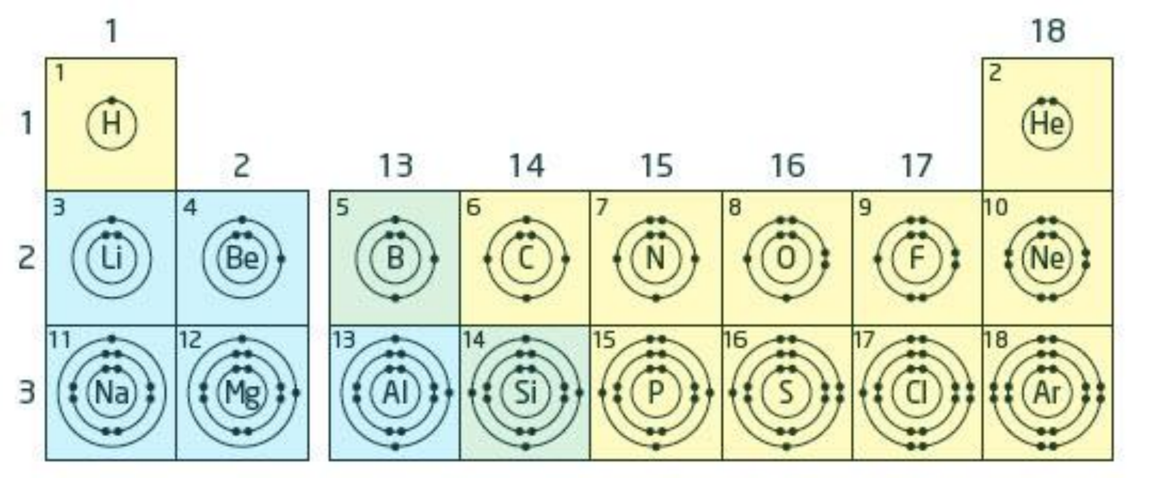


Forming Ionic Compounds

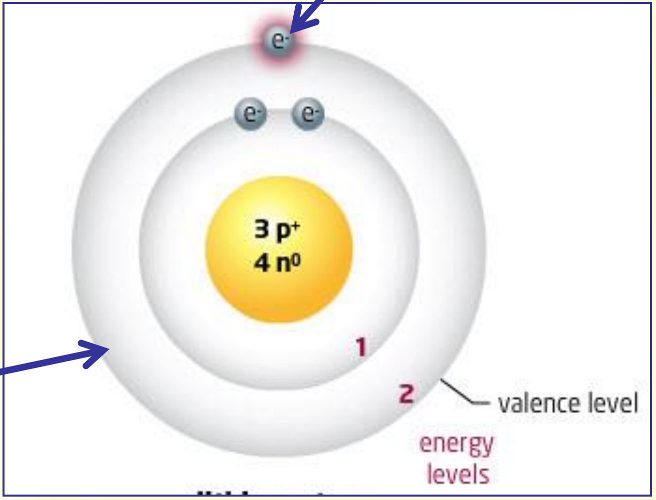
(Pages 140-141)

The **periodic table** is arranged so that elements in the same **group (family)** have the same number of **valence electrons**.

Valence electrons are electrons occupying the outermost occupied energy level (electron shell).



valence electron



outermost (valence) energy level

Naming Binary Ionic Compounds

(Page 142)

Binary ionic compounds are composed of only **two** different elements, a **metal cation** and a **non-metal anion**.

Rules for Naming Binary Ionic Compounds

1. The first part of the name *always* identifies the positive ion, which is the metal cation. Thus, this part of the name is the name of the metal.
2. The second part of the name *always* identifies the negative ion, which is the non-metal anion. The name of the non-metal ion always ends with the suffix *-ide*. Some examples are provided in **Table 4.1**.

Table 4.1 Examples of Names of Non-Metal Ions

Name	Symbol
fluoride	F^-
chloride	Cl^-
oxide	O^{2-}
sulfide	S^{2-}
nitride	N^{3-}
phosphide	P^{3-}

Table 4.2 Examples of Names of Ionic Compounds

Elements in Ionic Compound	Name of Ionic Compound
magnesium and phosphorus	magnesium phosphide
sodium and chlorine	sodium chloride (table salt)
calcium and bromine	calcium bromide
aluminum and oxygen	aluminum oxide

Chemical Formulas for Binary Ionic Compounds (Page 143)

(P

Binary ionic compounds form when electrons are transferred from a metal to a non-metal. The electrons given up by the metal must equal the number of electrons gained by the non-metal.

The metal can only give up its electrons if there are enough non-metal atoms to receive them.

The reaction on the right would result in the formation of:

Aluminum Chloride

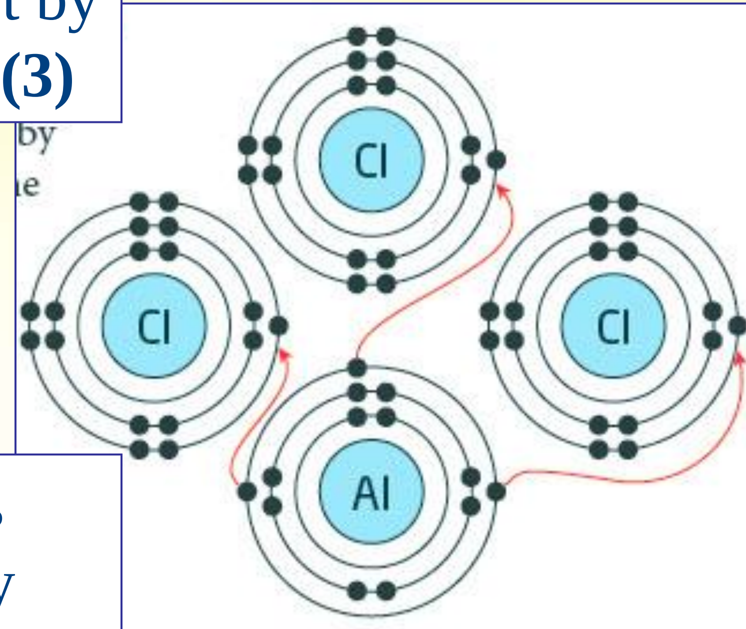
$AlCl_3$

electrons lost by **aluminum (3)**

equals

(=)

electrons gained by **chlorine (3)**



Writing Chemical Formulas for Binary Ionic Compounds

(Page 145)

Table 4.4 How to Write the Chemical Formula for a Binary Ionic Compound

Steps	Examples	
	Aluminum Fluoride	Magnesium Nitride
1. Identify each ion and its charge.	aluminum: Al^{3+} fluoride: F^{-}	magnesium: Mg^{2+} nitride: N^{3-}
2. Determine the total positive charge and the total negative charge needed to equal zero.	Al^{3+}: 3+ = 3+ F^{-}: 3(1–) = 3– (3+) + (3–) = 0	Mg^{2+}: 3(2+) = 6+ N^{3-}: 2(3–) = 6– (6+) + (6–) = 0
3. Note the ratio of cations to anions.	$1Al^{3+}$:$3F^{-}$	$3Mg^{2+}$:$2N^{3-}$
4. Use subscripts to show the ratio of ions.	AlF_3	Mg_3N_2

Writing Chemical Formulas for Binary Ionic Compounds

(Page 145)

Use the cross-over method to write ionic compound formulas.

Writing the Chemical Formula for Magnesium Chloride

Determine the subscripts by "crossing over" the amount of charge from each ion. Remember that you do not write the number 1.

$Mg^{2+}\ Cl^{1-}$

$MgCl_2$

Writing the Chemical Formula for Calcium Oxide

Cross over the amount of charge from each ion.

$Ca^{2+}\ O^{2-}$

Ca_2O_2

Express the ratio in simplest form. In this case, that is 1:1.

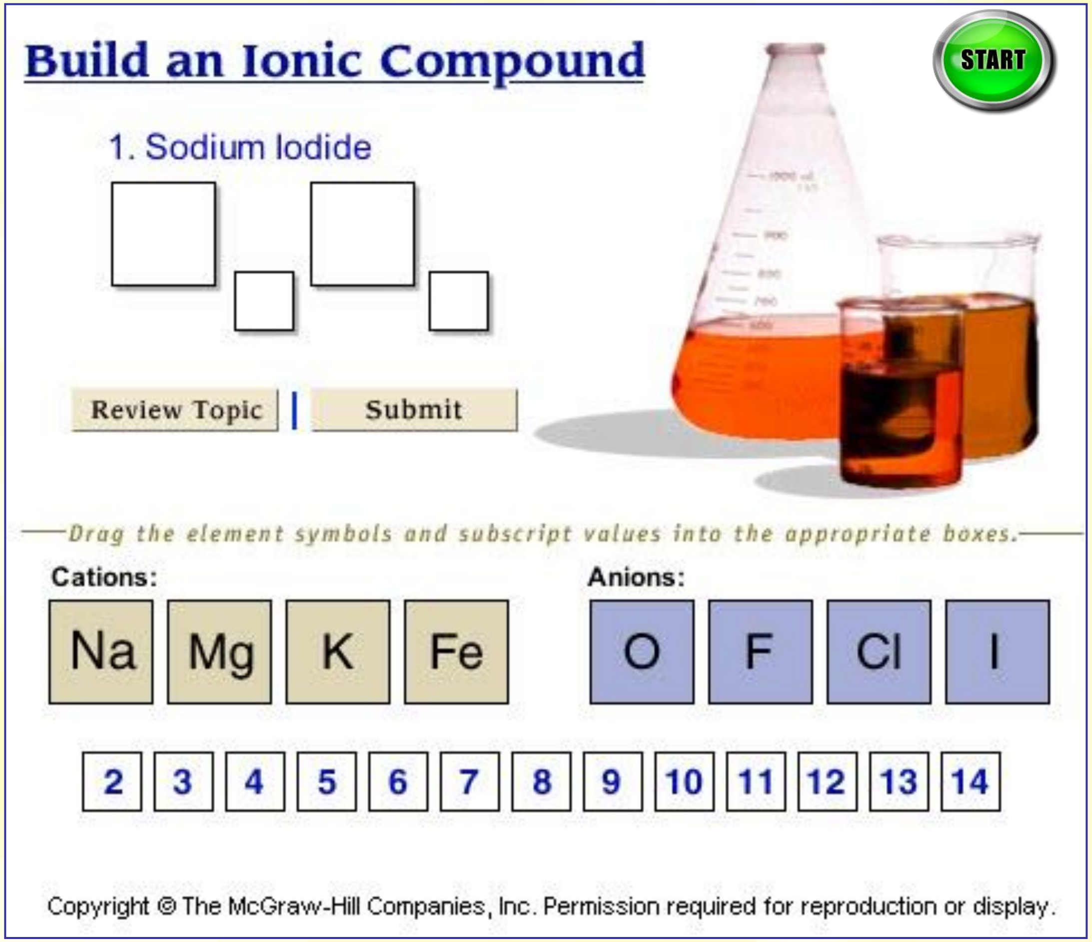
CaO

$Al^{+3}O^{-2}$

Writing Chemical Formulas for Binary Ionic Compounds

(Page 145)

Click the "Start" button and use a periodic table that includes ion charges and the rules for writing ionic compound formulas to complete the activity below.



Multivalent Metals

(Page 146)

Multivalent metals are metals with more than one **ion charge**. These elements can form different ions depending on the chemical reaction they undergo.

Examples of **multivalent metals**

4	5	6	7	8	9	10	11	12	Aluminum 27.0
22 Ti Titanium 47.9 (4+, 3+)	23 V Vanadium 50.9 (5+, 4+)	24 Cr Chromium 52.0 (3+, 2+)	25 Mn Manganese 54.9 (2+, 3+, 4+)	26 Fe Iron 55.8 (3+, 2+)	27 Co Cobalt 58.9 (2+, 3+)	28 Ni Nickel 58.7 (2+, 3+)	29 Cu Copper 63.5 (2+, 1+)	30 Zn Zinc 65.4 (2+)	31 Ga Gallium 69.7 (3+)
40 Zr Zirconium 91.2 (4+)	41 Nb Niobium 92.9 (3+, 5+)	42 Mo Molybdenum 95.9 (2+, 3+)	43 Tc Technetium (98) (7+)	44 Ru Ruthenium 101.1 (3+, 4+)	45 Rh Rhodium 102.9 (3+, 4+)	46 Pd Palladium 106.4 (2+, 4+)	47 Ag Silver 107.9 (1+)	48 Cd Cadmium 112.4 (2+)	49 In Indium 114.8 (3+)
72 Hf Hafnium 178.5 (4+)	73 Ta Tantalum 180.9 (5+)	74 W Tungsten 183.8 (6+)	75 Re Rhenium 186.2 (4+, 7+)	76 Os Osmium 190.2 (3+, 4+)	77 Ir Iridium 192.2 (3+, 4+)	78 Pt Platinum 195.1 (4+, 2+)	79 Au Gold 197.0 (3+, 1+)	80 Hg Mercury 200.6 (2+, 1+)	81 Tl Thallium 204.4 (1+, 3+)

Copper (I) Oxide (contains **Cu^{1+}**)

Copper (II) Oxide (contains **Cu^{2+}**)

Writing Formulas and Names with Multivalents

(Page 147)

Table 4.6 Naming an Ionic Compound That Contains a Multivalent Metal

Steps	Examples	
	Cu_3N	SnS_2
1. Identify the metal.	copper (Cu)	tin (Sn)
2. Verify that the metal can form more than one kind of ion by checking the periodic table.	Cu^{+} and Cu^{2+}	Sn^{2+} and Sn^{4+}
3. Determine the ratio of the ions in the chemical formula.	3 copper:1 nitride	1 tin:2 sulfide
4. Note the charge of the anion.	3–	2–
5. The positive and negative charges must balance out so that the net charge is zero.	Total negative charge: 3– Total positive charge: 3+	Total negative charge: 4– Total positive charge: 4+
6. Determine what charge the metal ion must have to balance the anion.	$3(Cu^{?}) = 3+$ Therefore, the charge on the copper must be 1+.	$1(Sn^{?}) = 4+$ Therefore, the charge on the tin must be 4+.
7. Write the name of the metal ion.	The name of the metal ion is copper(I).	The name of the metal ion is tin(IV).
8. Write the name of the compound.	copper(I) nitride	tin(IV) sulfide

FeO

Fe^{+} O^{-}

Fe^{2+} O^{2-}

Using the **reverse** of the **cross-over** method, the form of **iron** involved must be $\mathbf{Fe^{2+}}$ or **Iron (II)**

Number	Roman Numeral
1	I
2	II
3	III
4	IV
5	V
6	VI
7	VII

Ionic Compounds with Polyatomic Ions

(Page 148)

Polyatomic ions are ions composed of more than one atom.

Ternary compounds are compounds composed of **three** different elements. Whenever a **polyatomic ion** is involved in a reaction, a **ternary compound** is formed.

Table 4.7 Common Polyatomic Ions

1+ Charge	3− Charge	2− Charge	1− Charge
• ammonium, NH_4^+	• phosphate, PO_4^{3-}	• carbonate, CO_3^{2-}	• hydrogen carbonate (bicarbonate), HCO_3^-
	• phosphite, PO_3^{3-}	• sulfate, SO_4^{2-}	• hydroxide, OH^-
		• sulfite, SO_3^{2-}	• nitrate, NO_3^-
		• peroxide, O_2^{2-}	• nitrite, NO_2^-
			• chlorate, ClO_3^-

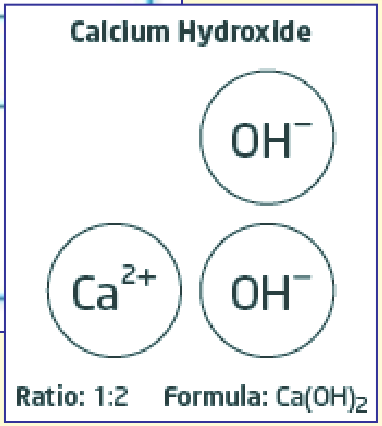
Polyatomic ions have distinct names, as noted in the table above.

Writing Formulas for Ionic Compounds with Polyatomic Ions

Table 4.8 How to Write the Chemical Formula for a Compound with a Polyatomic Ion

(Page 149)

Steps	Examples: Aluminum Carbonate (used as an antacid)	Examples: Ammonium Sulfate (used as a fertilizer)
1. Using the periodic table and a table of common polyatomic ions, identify each ion and its charge.	aluminum: Al^{3+} carbonate: CO_3^{2-}	ammonium: NH_4^+ sulfate: SO_4^{2-}
2. Determine the total positive charge and the total negative charge needed to equal zero.	Al^{3+}: 2(3+) = 6+ CO_3^{2-}: 3(2–) = 6– (6+) + (6–) = 0	NH_4^+: 2(1+) = 2+ SO_4^{2-}: 2– = 2– (2+) + (2–) = 0
3. Note the ratio of cations to anions.	2:3	2:1
4. Use subscripts to show the ratio of ions. Place the polyatomic ion in brackets if it needs a subscript.	$Al_2(CO_3)_3$	$(NH_4)_2SO_4$

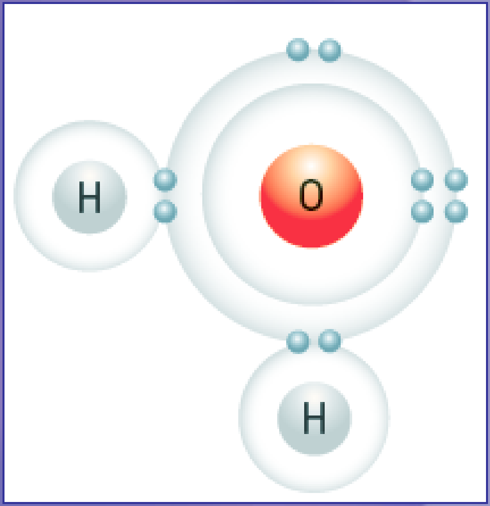


Concepts to be reviewed:

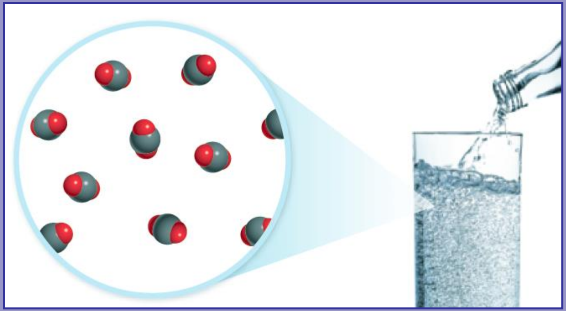
- *ionic compounds are composed of oppositely charged ions called cations and anions*
- *writing chemical formulas of ionic compounds*
- *naming ionic compounds*

4.2 Representing Molecular Compounds (Page 152)

Molecular compounds are usually composed of two or more different **non-metals**. The elements within a molecular compound **share electrons**.



A water molecule with **oxygen** and hydrogen molecules **sharing electrons**



Molecular compounds feature **covalent bonds** between **molecules** and are often referred to as **covalent compounds**.

Molecules are neutral particles composed of two or more atoms joined together.

Naming Binary Molecular Compounds (Pages 154-155)

A **binary molecular compound** is composed of **two non-metals** joined by one or more covalent bonds.

Table 4.10 Naming a Binary Molecular Compound

Steps	Examples: N_2O_4 (used as a rocket fuel)	Examples: BrCl (used to detect mercury in water)
1. Count the number of atoms of the first element in the chemical formula.	Number of nitrogen atoms: 2	Number of bromine atoms: 1
2. Write the appropriate prefix followed by the name of the element. Note that the prefix *mono-* is never used for the first element.	First part of name: dinitrogen	First part of name: bromine
3. Count the number of atoms of the second element in the chemical formula.	Number of oxygen atoms: 4	Number of chlorine atoms: 1
4. Write the appropriate prefix followed by the name of the element using the suffix *-ide*. If the prefix ends with *a* or *o*, this letter is dropped before *oxide*.	Second part of name: tetroxide Full name: dinitrogen tetroxide	Second part of name: monochloride Full name: bromine monochloride

Prefix	Number
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8

Prefixes indicate the number of atoms of each element in a molecule of the compound.

Molecular Compounds and Pollution

(Page 155)

Molecular compounds such as **nitrogen dioxide (NO_2)** contribute to the air pollution (smog) in major Canadian cities.

Molecular Compounds and Consumer Products

(Pages 156-157)

Molecular compounds such as **phosphorus trichloride (PCl_3)**, used in herbicides, and **octane (C_8H_{18})**, used in gasoline, are part of our everyday lives.

Writing Formulas for Binary Molecular Compounds

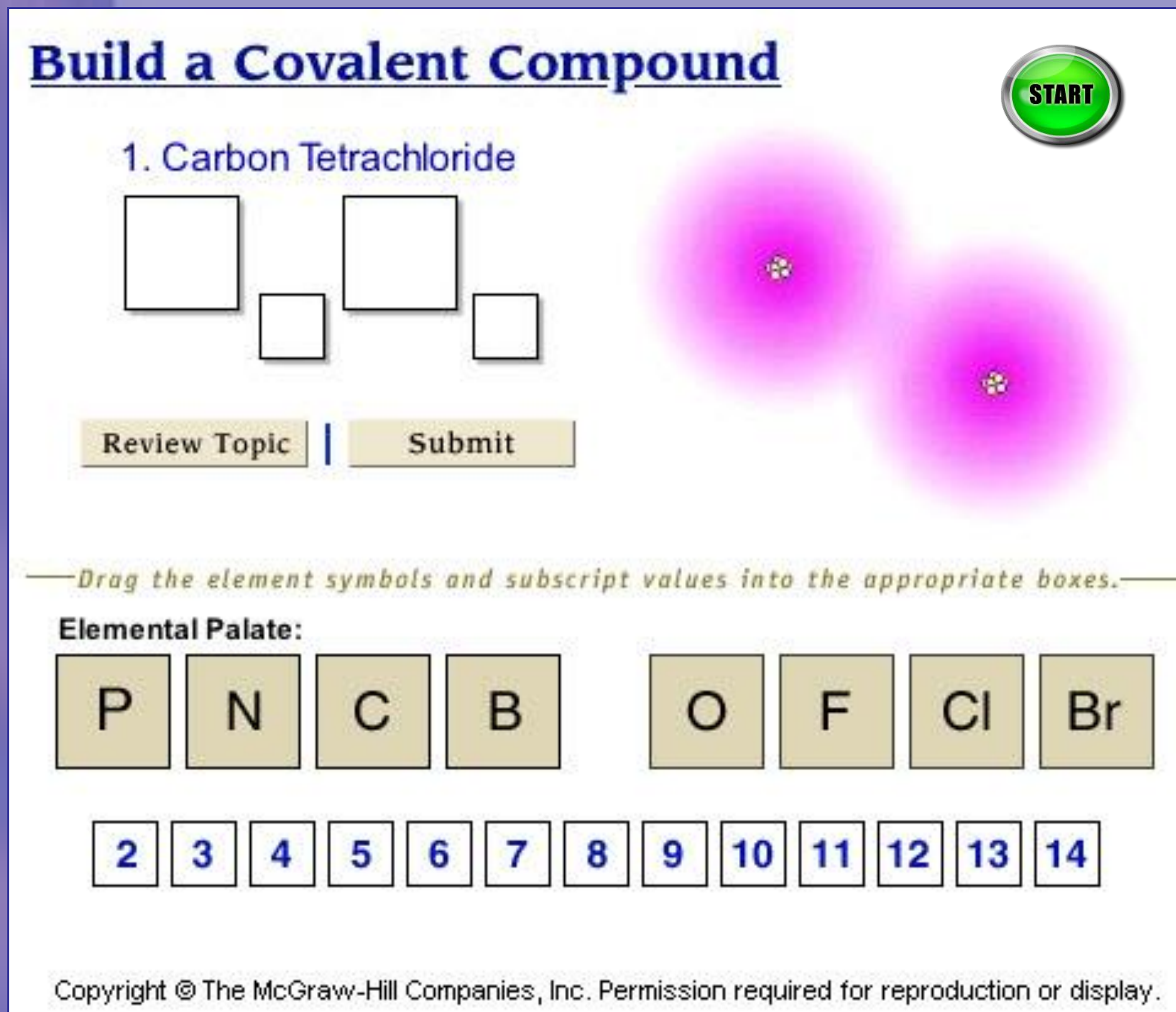
(Pages 156-157)

Table 4.11 Writing the Chemical Formula for a Binary Molecular Compound

Steps	Examples	
	Phosphorus Trichloride (used to make insecticide)	Disulfur Dinitride (used to synthesize other chemicals)
1. Write the chemical symbol of the first element.	First element in formula: P	First element in formula: S
2. Determine the number of atoms of the first element, based on the prefix. This number will appear in the final chemical formula. If there is no prefix for the first element, there is only one atom.	Number of phosphorus atoms: 1	Number of sulfur atoms: 2
3. Write the chemical symbol of the second element. Keep in mind that the ending *-ide* is not part of the element's name.	Second element in formula: Cl	Second element in formula: N
4. Determine the number of atoms of the second element, based on the prefix. This number will appear in the final chemical formula.	Number of chlorine atoms: 3	Number of nitrogen atoms: 2
5. Write the chemical formula for the compound, using the appropriate subscripts.	Formula: PCl_3	Formula: S_2N_2

Writing Formulas for Binary Molecular Compounds (Pages 156-157)

Click the “Start” button and use a periodic table and the rules for writing molecular (covalent) compound formulas to complete the activity below.



Section 4.2 Review

Concepts to be reviewed:

- *what molecular compounds are and how they form*
- *how to use prefixes to write the names of molecular compounds*
- *the procedure to be followed for writing formulas for molecular compounds*

4.3 Conservation of Mass and Chemical Equations

(Page 159)

A **chemical reaction** is a process in which new substances with new properties are formed.

The explosive reaction between **water (H_2O)** and **sodium (Na)** produces **light**, **heat**, and **hydrogen (H_2) gas**.

In a **chemical reaction**, **reactants** (the starting materials) undergo a **chemical change**, changing into the **products** of the reaction.

A **reactant** is a pure substance that undergoes a chemical change.

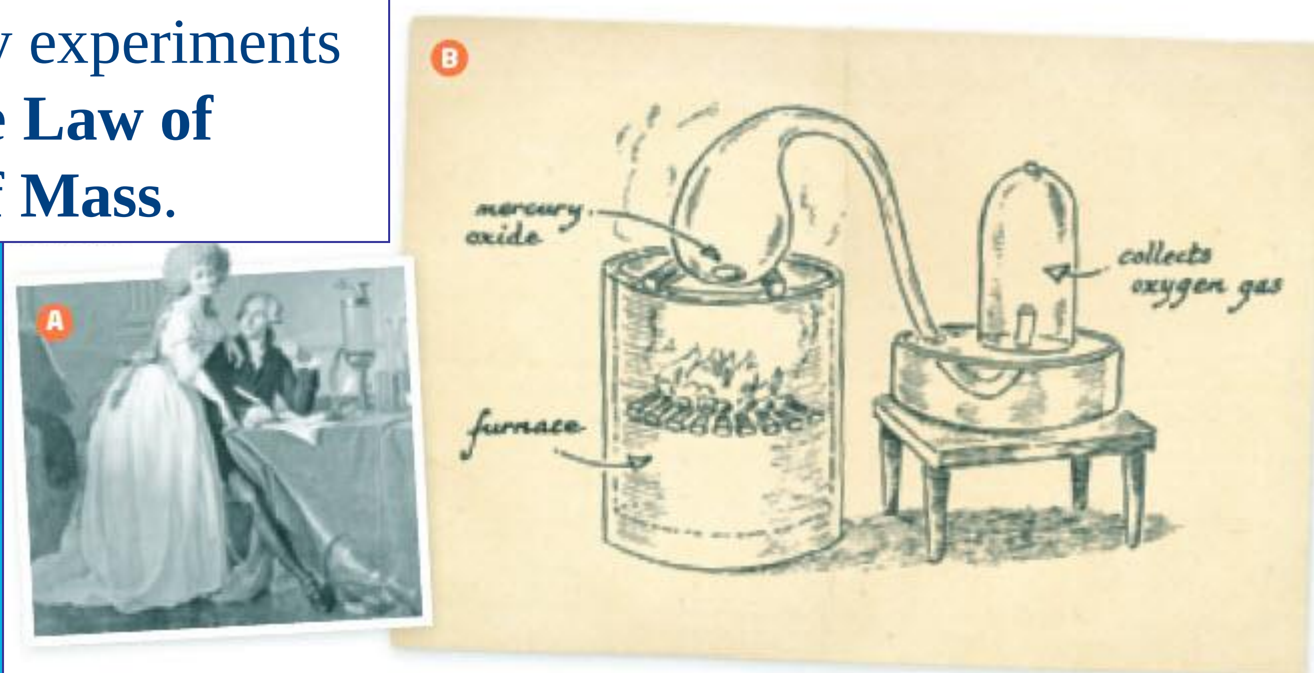
A **product** is a pure substance formed in a chemical change. The properties of the products are different from the properties of the reactants.

Conservation of Mass in Chemical Changes

Law of Conservation of Mass

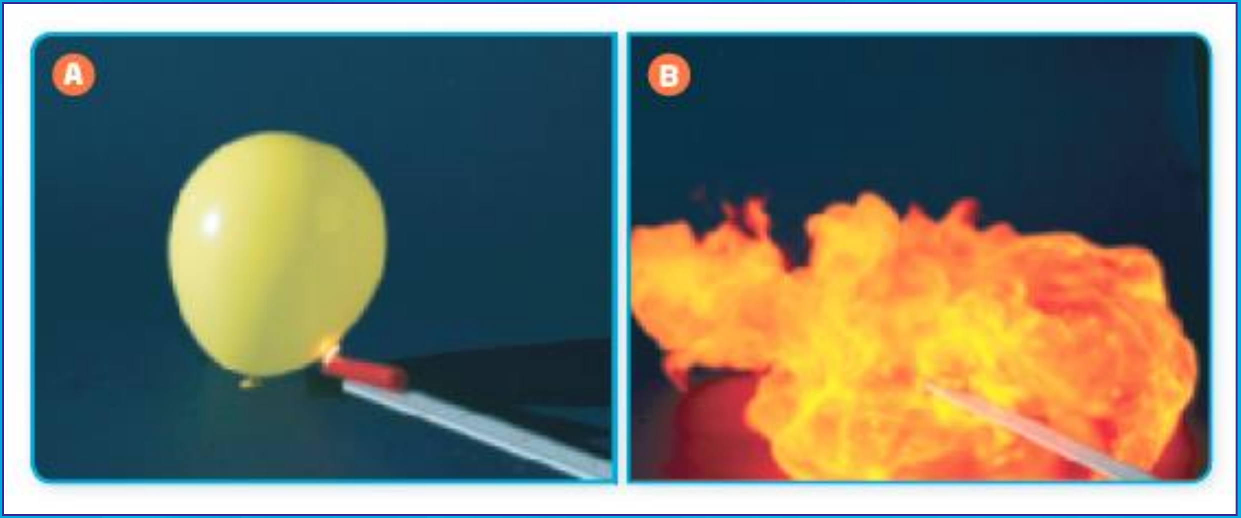
In a chemical reaction, the total mass of the products is always the same as the total mass of the reactants.

Antoine and **Marie-Anne Lavoisier's** early experiments demonstrated the **Law of Conservation of Mass**.



Chemical Reaction Example

(Page 161)



When a flame is used to ignite a balloon filled with hydrogen and oxygen gas, the result is a loud explosion and water vapour.

Reactants = hydrogen gas and **oxygen gas**

Product = water vapour

A **chemical equation** can be used to represent this reaction.

Writing Chemical Equations

(Page 161)

A **chemical equation** is a representation of what happens to the reactants and products during a chemical change. There are **three** forms of chemical equations.

1. **Word Equations** show the **names** of the reactants and products, with an arrow dividing reactants on the left from products on the right.

hydrogen + oxygen → water

2. **Skeleton Equations** replace the names of the reactants and products with their **chemical formulas**.

$$H_2 + O_2 \rightarrow H_2O$$

3. **Balanced Chemical Equations** add **coefficients** in front of the skeleton reactants and products to balance the equations.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Writing Chemical Equations

(Page 162)

In addition to the **chemical formulas** and **balancing coefficients,** the **states** of the reactants and products may be included.

Table 4.12 Abbreviations for the States of Reactants and Products

State	Abbreviation	Example (at room temperature)
Solid	(s)	sodium chloride: NaCl(s)
Liquid	(ℓ)	water: $H_2O(\ell)$
Gas	(g)	hydrogen: $H_2(g)$
Aqueous solution	(aq)	aqueous sodium chloride solution: NaCl(aq)

The abbreviations of the various states are written after the chemical formula that they apply to.

NOTE: Aqueous solution means that the product or reactant is dissolved in water.

How to Balance a Chemical Equation

The following steps summarize how to use coefficients to balance chemical equations.

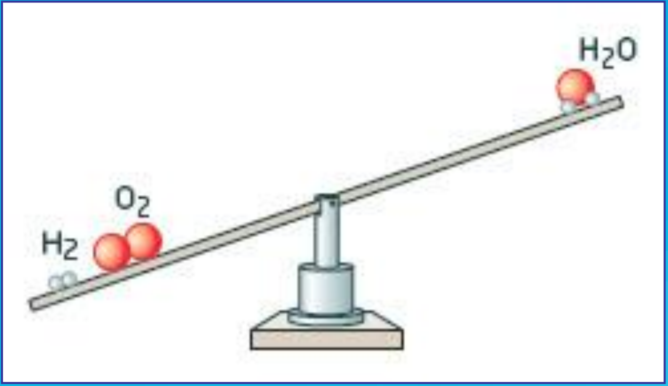
STEP #1

1. $H_2(g) + O_2(g) \rightarrow H_2O(\ell)$

In the skeleton equation, there is the same number of hydrogen atoms on both sides of the equation. There are more oxygen atoms in the reactants, however, than in the product.

Checking the Atom Balance

Element	Reactant	Product	Equal?
H	2	2	yes
O	2	1	no



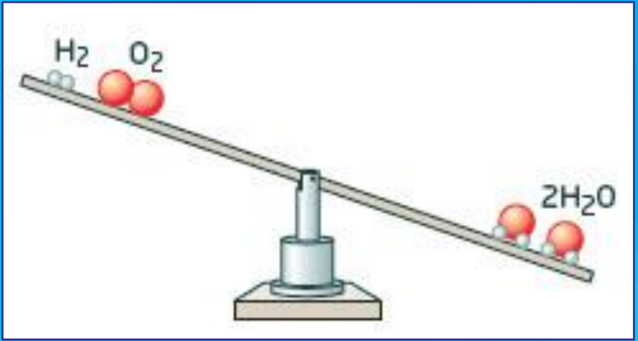
STEP #2

2. $H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$

Placing the coefficient 2 in front of H_2O causes the number of oxygen atoms on both sides of the equation to be the same. Because the coefficient applies to all the elements in the compound, however, it causes the number of hydrogen atoms in the product to increase to four.

Checking the Atom Balance

Element	Reactant	Product	Equal?
H	2	4	no
O	2	2	yes



How to Balance a Chemical Equation

(Page 163)

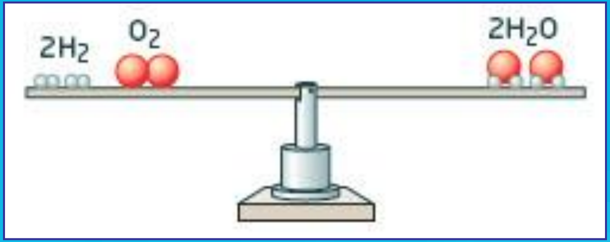
STEP #3

3. $2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$

Placing the coefficient 2 in front of H_2 makes the number of hydrogen atoms on both sides of the equation equal again. The coefficient 2 applies only to H_2 on the left side because H_2 and O_2 are separate substances.

Checking the Atom Balance

Element	Reactant	Product	Equal?
H	4	4	yes
O	2	2	yes



Tips for Balancing Chemical Equations

(Page 164)

The following tips can help you avoid errors when balancing equations.

Tips for Balancing Chemical Equations

- Remember that these elements exist as diatomic molecules: hydrogen (H_2), nitrogen (N_2), fluorine (F_2), chlorine (Cl_2), bromine (Br_2), iodine (I_2), and oxygen (O_2), shown in **Figure 4.22**.

- Balance compounds first and elements last.
- Balance hydrogen and oxygen last. They often appear in more than one reactant or more than one product, so they are easier to balance after the other elements are balanced.
- If a polyatomic ion appears in both a reactant and a product, think of it as a single unit to balance the chemical equation faster.
- Once you think the chemical equation is balanced, do a final check by counting the atoms of each element one more time.
- If you go back and forth between two substances, using higher and higher coefficients, double-check each chemical formula. An incorrect chemical formula might be preventing you from balancing the chemical equation.

Writing Chemical Equations

Click the “Start” button to review the writing of chemical equations.

Writing Chemical Equations

START

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Methane gas burning on a cooking range.

The Fundamental Parts of a Chemical Equation

$$CH_4 + O_2 \longrightarrow CO_2 + H_2O$$

Reactants

The reactants in a chemical equation are written on the left hand side of the arrow and correspond to those substances that exist before the reaction takes place. A plus sign is used to separate reactants.

Roll over the chemical equation to learn more.

Applications of The Law of Conservation of Mass

(Page 167)

The use of chemicals to help clean up toxic chemical spills or to produce industrial chemical products relies on an understanding of the **Law of Conservation of Mass**.

Section 4.3 Review

Concepts to be reviewed:

- *the Law of Conservation of Mass*
- *chemical reactions can be represented by word, skeleton, or balanced chemical equations*
- *balanced chemical equations have coefficients in front of chemical formulas. The number of atoms of each element must be equal in the reactants and products.*
- *how the Law of Conservation of Mass can be applied to the clean-up of hazardous materials and in the manufacture of products*

In this chapter, you will:

- ***describe*** *evidence of chemical reactions*
- ***identify*** *reactants and products of the four reaction types*
- ***discuss*** *chemical reactions associated with environmental concerns*

Introductory Activity 5.1: Foiled Again! (Page 177)

With a reaction such as the one shown on **page 177**, answer the following questions.

Aluminum can undergo a reaction with aqueous copper(II) chloride.

- What changes do you observe?
- Why is this a **chemical change**?
- What were the **reactants** and **products**?
- What happens to the mass of reactants and products during the reaction?

5.1 Synthesis and Decomposition Reactions

(Page 179)

Metal corrosion led to the damage shown in the picture below. The **chemical reaction** that occurred is illustrated by the following balanced **chemical equation**.

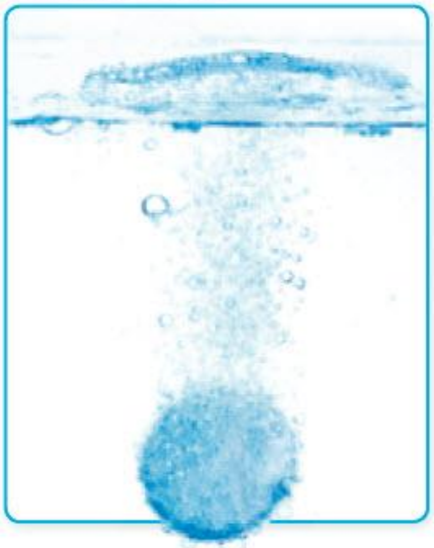
$$4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$$

Evidence of Chemical Change

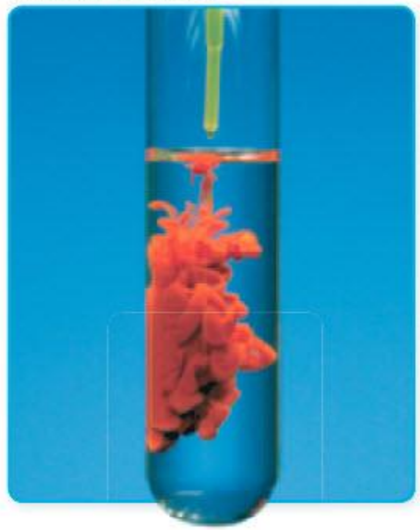
(Page 180)

The following images illustrate some examples of evidence that a **chemical change** has occurred.

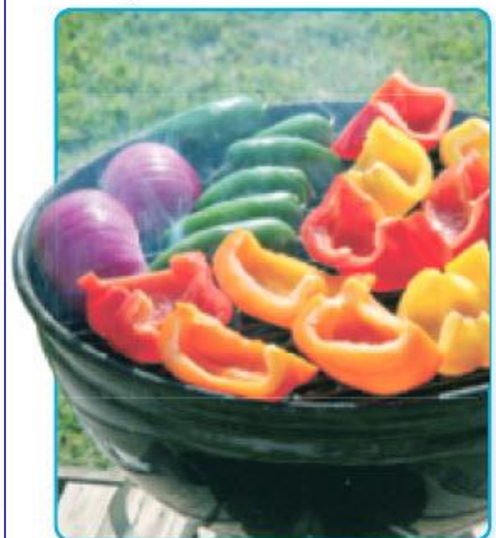
The formation of a gas



The formation of a precipitate and a change in colour



A change in odour



The production of light and heat

Gas formation - usually observed as bubbles

Precipitate formation – an insoluble solid formed during a reaction

Odour change – a new smell being produced

Energy production – the production of light or heat by a reaction

Synthesis Reactions

A **synthesis reaction** is a chemical reaction in which two or more reactants combine to produce a new product.

$$A + B \rightarrow AB$$

Examples of **synthesis reactions**

The "Haber" process to produce ammonia

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

The shuttle "blast off"

$2H_2(l) + O_2(l) \rightarrow 2H_2O(g)$

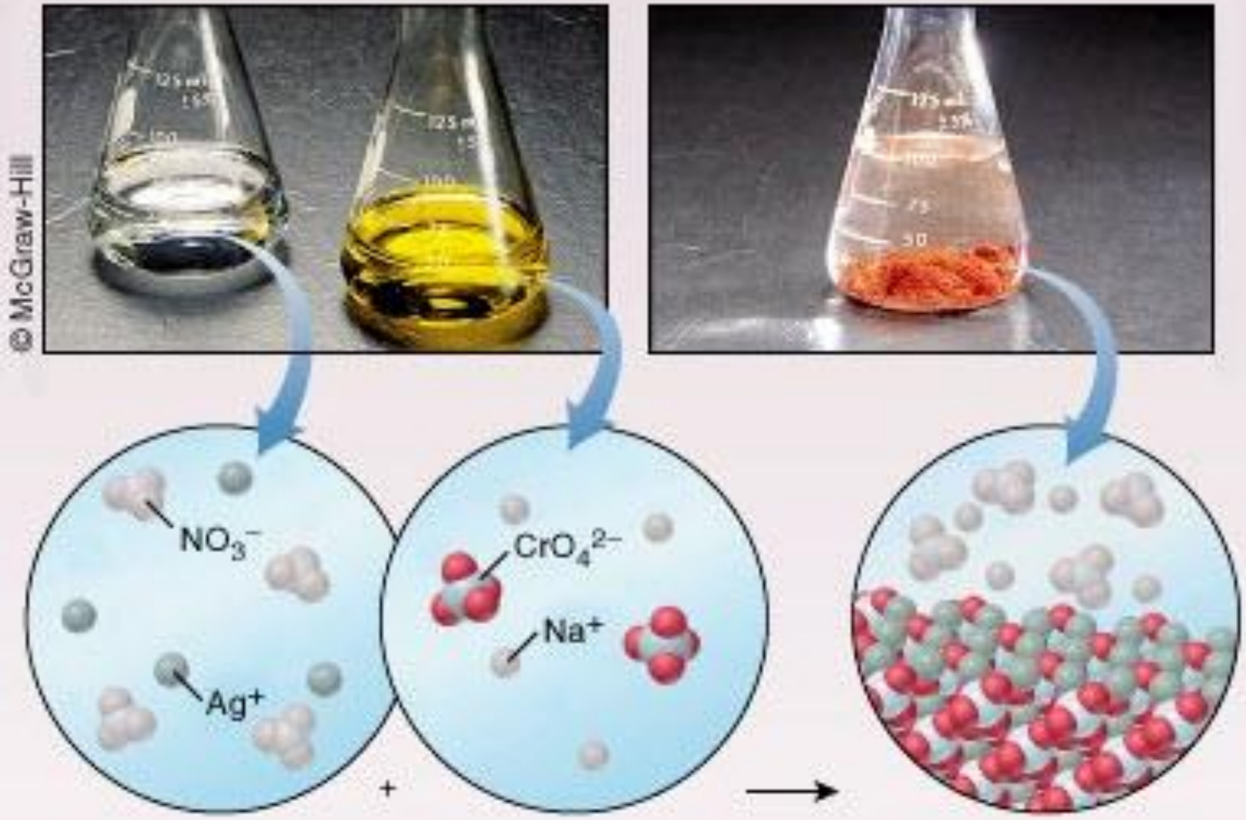
The production of "smog"

$N_2(g) + O_2(g) \rightarrow 2NO_2(g)$

and

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

Precipitation Reactions



Molecular equation

$2AgNO_3(aq) + Na_2CrO_4(aq) \longrightarrow Ag_2CrO_4(s) + 2NaNO_3(aq)$

Silver nitrate — Sodium chromate — Silver chromate — Sodium nitrate

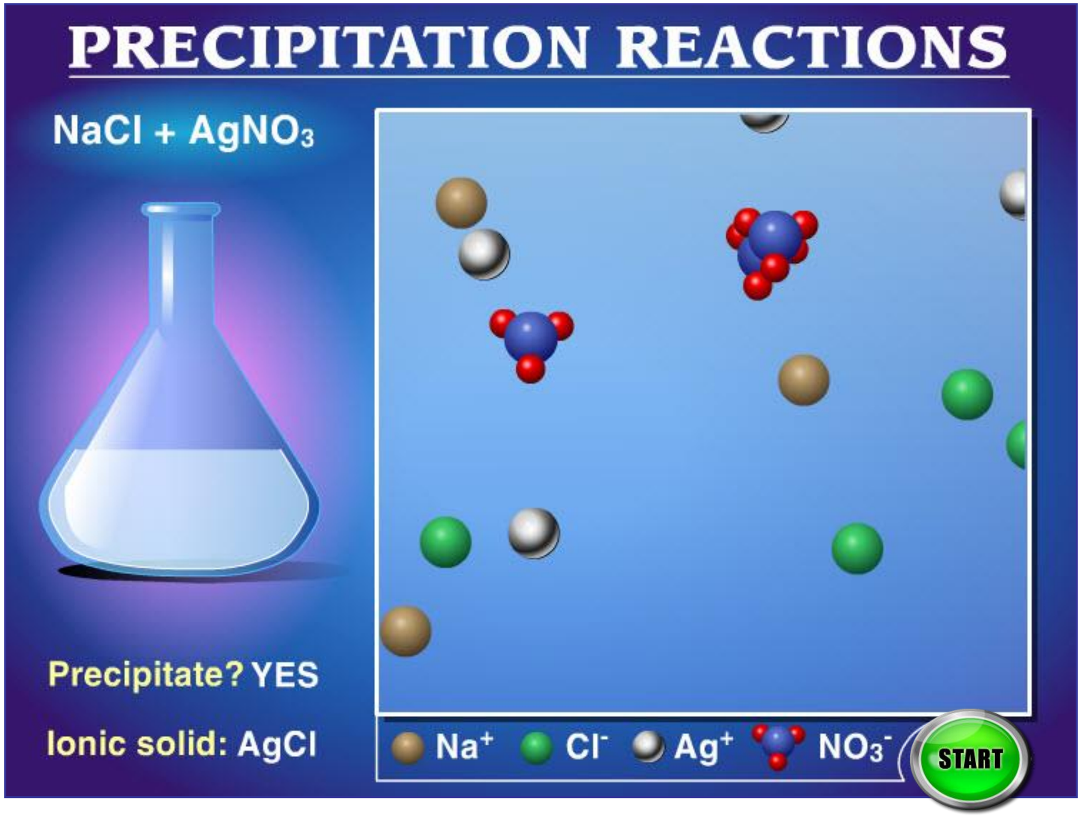
Total ionic equation

$2Ag^+(aq) + 2NO_3^-(aq) + 2Na^+(aq) + CrO_4^{2-}(aq) \longrightarrow Ag_2CrO_4(s) + 2Na^+(aq) + 2NO_3^-(aq)$

Precipitation Reactions

(Page 180)

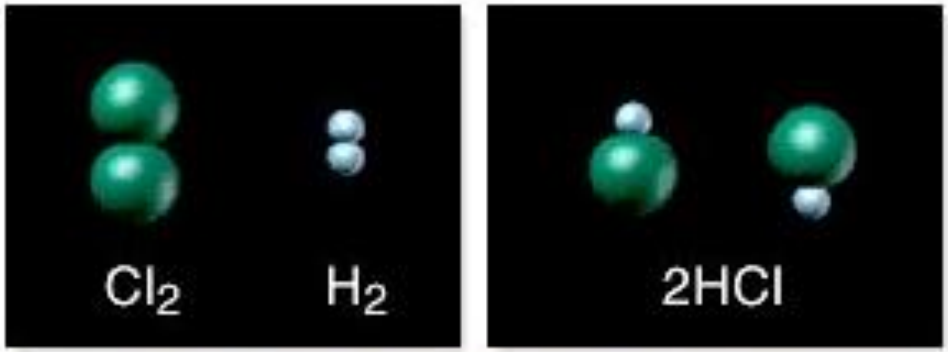
Click the "Start" buttons to review your understanding of **synthesis reactions that produce precipitate**.



Synthesis Reactions

(Page 181)

Review your understanding of **synthesis reactions**.



Combination (Synthesis)		$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$	
Decomposition		$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$	
Single Displacement		$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$	
Double Displacement		$AgNO_{3(aq)} + KCl_{(aq)} \longrightarrow AgCl_{(s)} + KNO_{3(aq)}$	

Decomposition Reactions

(Pages 185-186)

A **decomposition reaction** is a chemical reaction in which a compound breaks down (decomposes) into two or more simpler compounds or elements.

$$AB \rightarrow A + B$$

Examples of

decomposition reactions

The electrolysis of water

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

A TNT Explosion

$$2C_7H_5N_3O_6\,(s) \rightarrow 3N_2(g) + 5H_2O(g) + 7CO(g) + 7C(s)$$

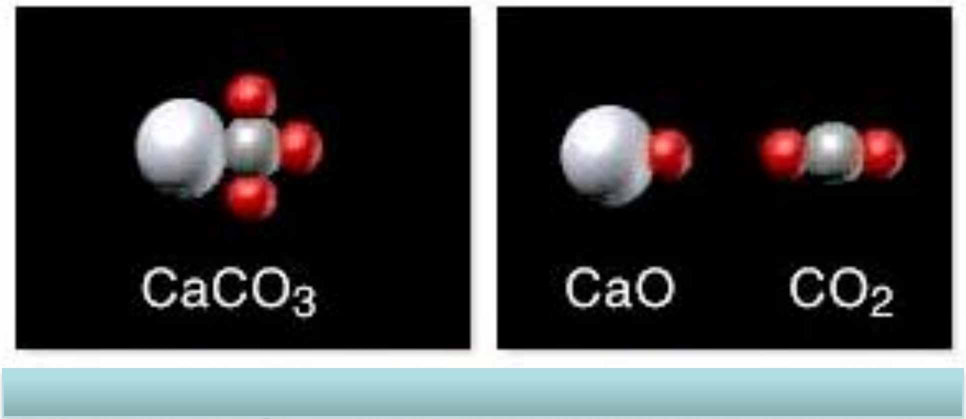
Decomposition of sodium azide

$$2NaN_3(s) \rightarrow 3N_2(g) + 2Na(s)$$

Decomposition Reactions

(Pages 185-186)

Review your understanding of **decomposition reactions**.



Combination (synthesis)	$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$
Decomposition	$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$
Single Displacement	$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$
Double Displacement	$AgNO_{3(aq)} + KCl_{(aq)} \longrightarrow AgCl_{(s)} + KNO_{3(aq)}$

Section 5.1 Review

(Page 189)

Concepts to be reviewed:

- *evidence of a chemical change*
- *synthesis reactions (chemical equation and examples)*
- *decomposition reactions (chemical equation and examples)*

5.2 Displacement Reactions

(Page 190)

Many industrial processes, such as the one used to isolate nickel from the deposits found around Sudbury, rely on a series of chemical reactions that include the **displacement** of one element by another to form a new compound.

Single Displacement Reactions

A **single displacement reaction** is a chemical reaction in which one element (a reactive metal or non-metal) takes the place of an element in a compound to produce another element and another compound.

A + BC → AC + B

Where **A** is a **metal**

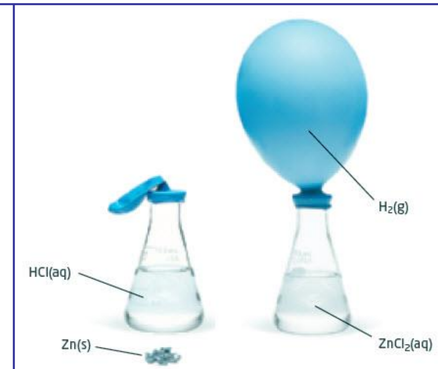
A + BC → BA + C

Where **A** is a **non-metal**

Examples of **single displacement reactions**

Producing zinc chloride (**$ZnCl_2$**) and hydrogen gas (**H_2**)

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$



Producing copper (**Cu**) metal

$$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$$

Displacing silver (**Ag**) from silver nitrate (**$AgNO_3$**)

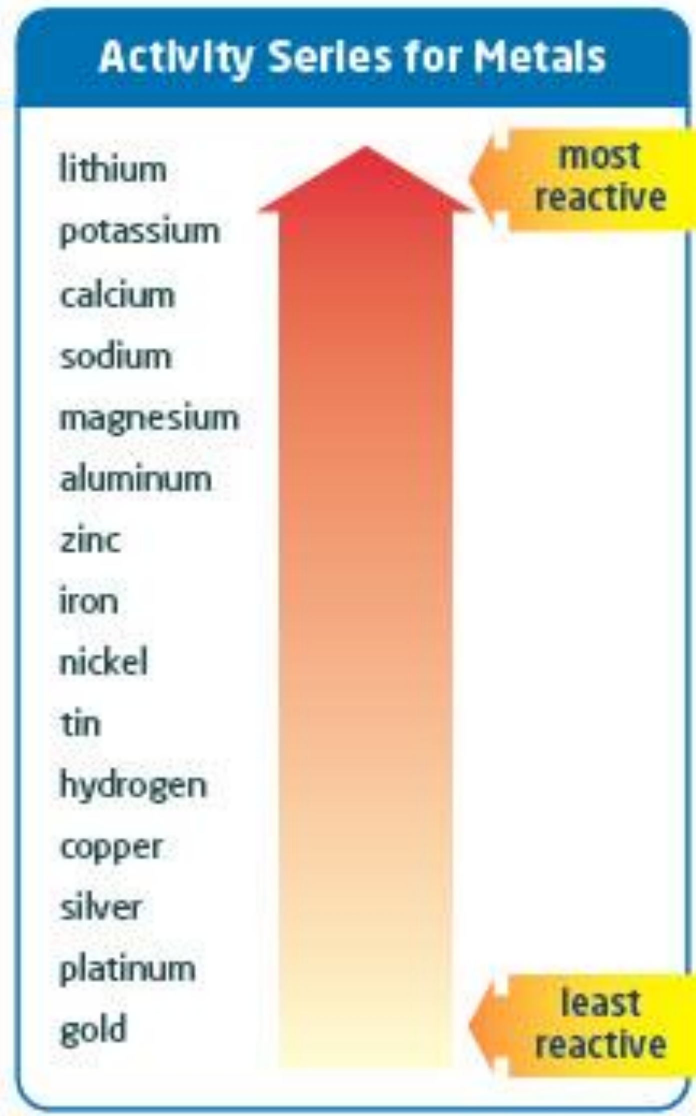
$$Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

Activity Series

The **activity series** is a list of elements organized according to their chemical reactivity. The most reactive element appears on the top, and the least reactive appears at the bottom.

Remember! **Metals** can only replace other **metals** in a reaction, and **non-metals** can only replace other **non-metals.**

Metals higher up on the activity series list will replace metals lower on the list during a **single displacement reaction**.



Single Displacement Reactions (Pages 191-194)

Review your understanding of **single displacement reactions**.

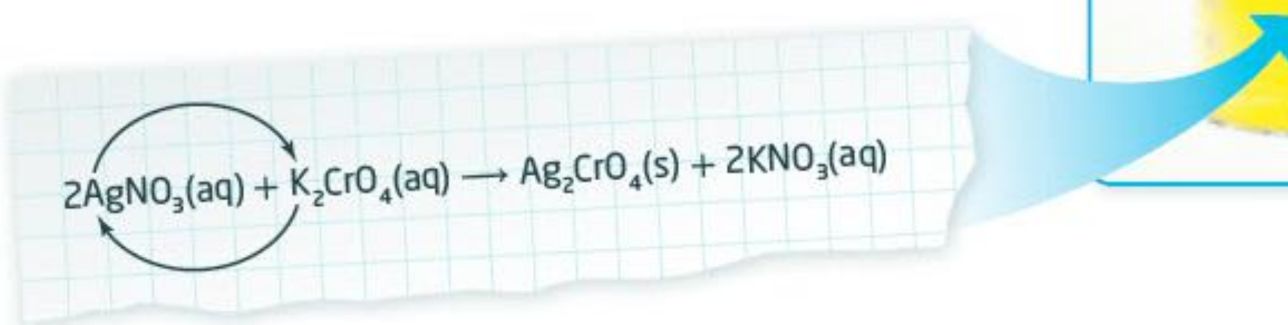
Combination (Synthesis)	$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$
Decomposition	$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$
Single Displacement	$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$
Double Displacement	$AgNO_{3(aq)} + KCl_{(aq)} \longrightarrow AgCl_{(s)} + KNO_{3(aq)}$

Double Displacement Reactions (Pages 195-196)

A **double displacement reaction** is a chemical reaction in which the positive ions of two different compounds exchange places, resulting in the formation of two new compounds – one of which may be a precipitate.

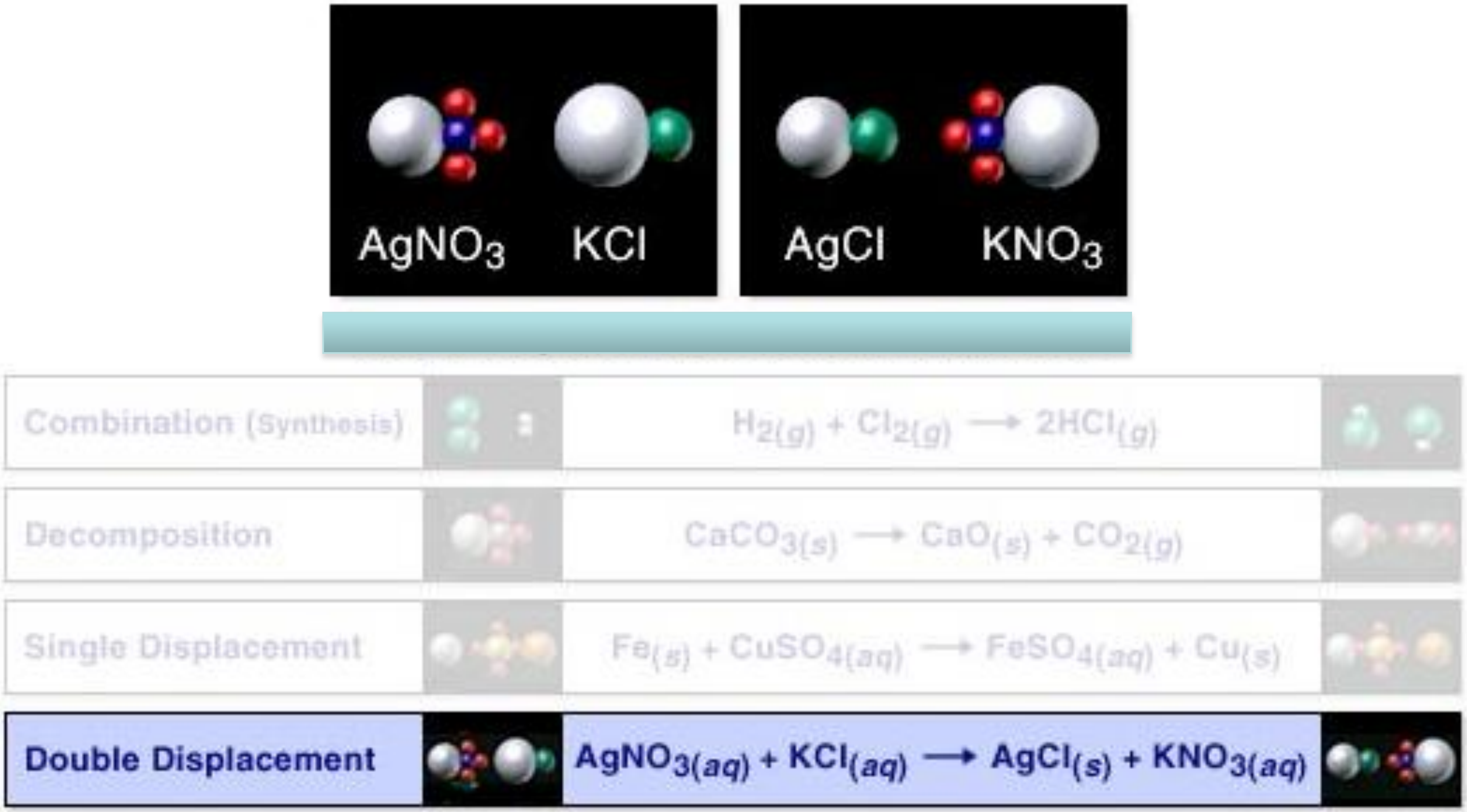
$$AB + CD \rightarrow AD + CB$$

Producing silver chromate (**$AgCrO_4$(s)**) (the red precipitate) and potassium nitrate (2**KNO_3(aq)**)



Double Displacement Reactions (Pages 195-196)

Review your understanding of **double displacement reactions**.



Chemical Reactions and Food Preservation

Sulfur dioxide (**SO_2**) is used to preserve the colour of dried fruit. A **double displacement reaction** followed by a **decomposition reaction** releases the sulfur dioxide gas required for the process.

The **double replacement reaction**

$$Na_2SO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2SO_3(aq)$$

The **decomposition reaction**

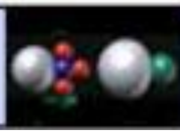
$$H_2SO_3(aq) \rightarrow H_2O(l) + SO_2(g)$$

Summary of Reaction Types

(Page 197)

Reaction Type	General Chemical Equation	Example	Characteristics
Synthesis	A + B → AB 	$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$	Two reactants join to form a single compound.
Decomposition	AB → A + B 	$2C_7H_5N_3O_6(s) \rightarrow 3N_2(g) + 5H_2O(g) + 7CO(g) + 7C(s)$	A single compound breaks apart into two or more products.
Single displacement	A + BC → AC + B A + BC → BA + C 	$2Al(s) + 3CuCl_2(aq) \rightarrow 2AlCl_3(aq) + 3Cu(s)$ (metal displacement) $F_2(g) + 2NaI(s) \rightarrow I_2(s) + 2NaF(s)$ (non-metal displacement)	A reactive element takes the place of a less reactive element in a compound.
Double displacement (precipitate)	AB + CD → AD + BC 	$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$	Two ionic compounds in a solution switch ions and form two new compounds, including a precipitate.

Summary of Reaction Types

Combination (Synthesis)		$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$	
Decomposition		$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$	
Single Displacement		$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$	
Double Displacement		$AgNO_{3(aq)} + KCl_{(aq)} \longrightarrow AgCl_{(s)} + KNO_{3(aq)}$	

One additional type of chemical reaction that you will learn about in future studies is a **combustion reaction**. These reactions always involve a “fuel” reacting with oxygen to release energy. Carbon dioxide and water are also produced by the reaction.

Combustion		$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$	

Section 5.2 Review

Concepts to be reviewed:

- *single displacement reactions*
- *the activity series of elements*
- *double displacement reactions*

5.3 Reactions and Environmental Issues

Although **chemical reactions** can cause environmental issues, they can also be used to help solve environmental challenges.

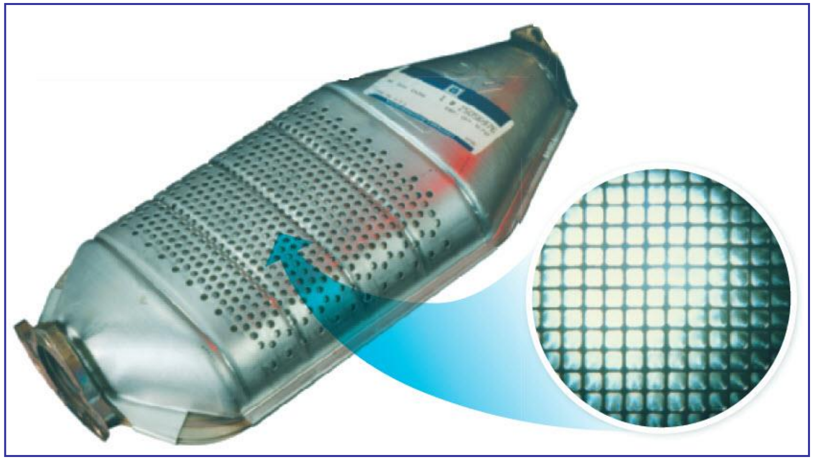
Treating Car Exhaust

(Pages 200-201)

The complete **combustion** of gasoline in a car's engine is represented by the following chemical equation.

$$2C_8H_{18}(l) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(g)$$

Incomplete combustion can result in **carbon (C)** (soot), **carbon monoxide (CO)**, and **nitrogen oxides (NO_2 and NO_3)** entering the air.

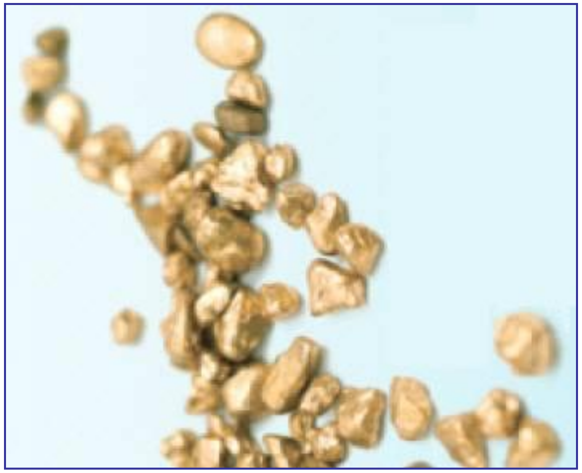


A **catalytic converter** installed in a vehicle's exhaust system can help reduce the amounts of these pollutants in the atmosphere.

Recovering Gold using Cyanide and Zinc

(Pages 202-203)

Cyanide ions (CN^-) are used to extract gold from rock or ore.



$$4Au(s) + 8NaCN(aq) + O_2(g) + 2H_2O(l) \rightarrow 4Na[Au(CN)_2](aq) + 4NaOH(aq)$$

Leaching, a technique that removes gold by dissolving it in an aqueous solution, is used to drain the gold away from the ore.

Zinc (Zn) can then be used in a **single displacement reaction** to displace the gold from the solution.

$$2Na[Au(CN)_2](aq) + Zn(s) \rightarrow 2NaCN(aq) + Zn(CN)_2(aq) + 2Au(s)$$

Cleaning and Disinfecting Pools

A variety of compounds containing **chlorine (**Cl) are used to prevent the growth of bacteria and other organisms in the water in swimming pools and hot tubs.

Care must be taken when using these chemicals to ensure that they are effective in disinfecting the water but remain safe for the users.

Hazards in the Home

(Pages 204-205)

Precautions must be taken when using household chemicals. When mixed, reactions could occur that might be detrimental to the user’s health.

Table 5.2 Hazardous Household Product Symbols (HHPS)

Symbol	Safety Precaution
Explosive 	This **container** can explode if it is heated or punctured. Flying pieces of metal or plastic can cause serious injuries, especially to the eyes.
Corrosive 	This **product** will burn skin or eyes on contact, or throat and stomach if swallowed.
Flammable 	This **product**, or its fumes, will catch fire easily if it is near heat, flames, or sparks.
Poison 	Licking, eating, drinking, or sometimes smelling this **product** will cause illness or death.

Figure 5.24 These common household cleaners contain chemicals that require precautions when using them.

Bleach and Ammonia – A Toxic Combination

The mixing of **bleach (NaClO)** (a compound containing **chlorine)**, and **ammonia** (**NH_3)** can have dire consequences.

$$2NH_3(aq) + 2NaClO(aq) \rightarrow 2NaONH_3(aq) + Cl_2(g)$$

Toxic **chlorine gas** (**Cl_2**) is produced in this reaction.

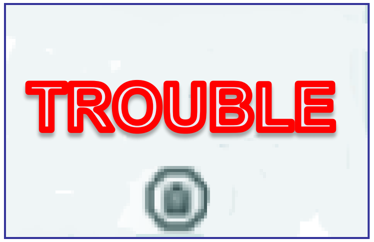
Two other ammonia and bleach reactions produce toxic compounds called **chloramines** (**$NCl_3(g)$** and **$NH_2Cl(g)$**).

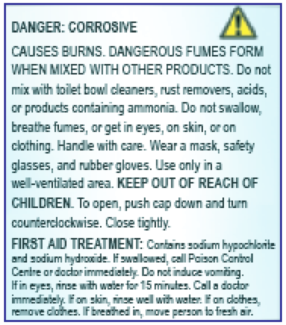
$$NH_3(aq) + 3NaClO(aq) \rightarrow 3NaOH(aq) + NCl_3(g)$$

$$NH_3(aq) + NaClO(aq) \rightarrow NaOH(aq) + NH_2Cl(g)$$

+

=

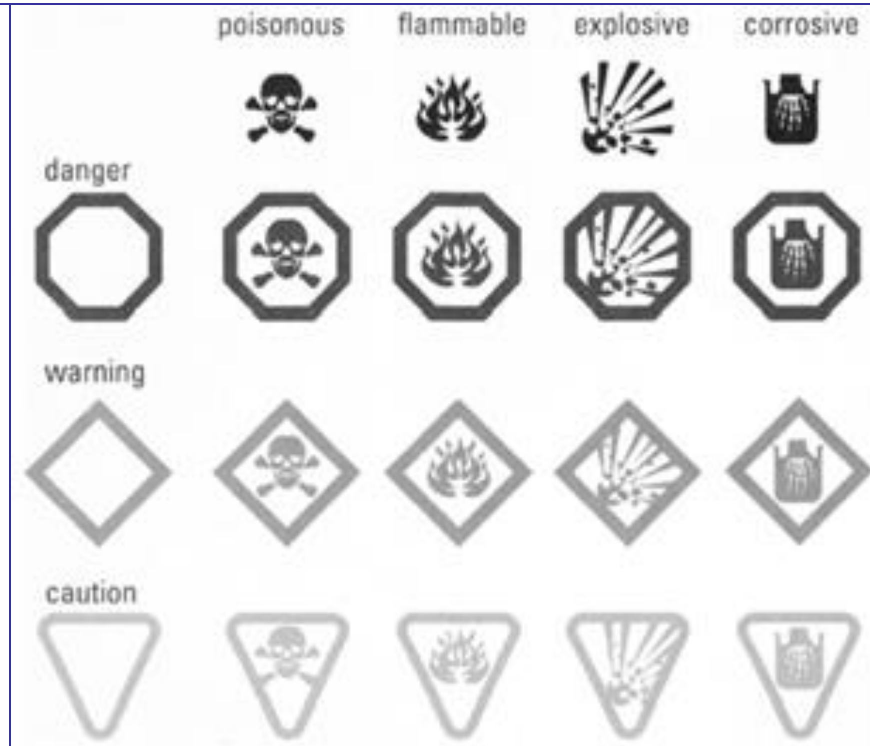




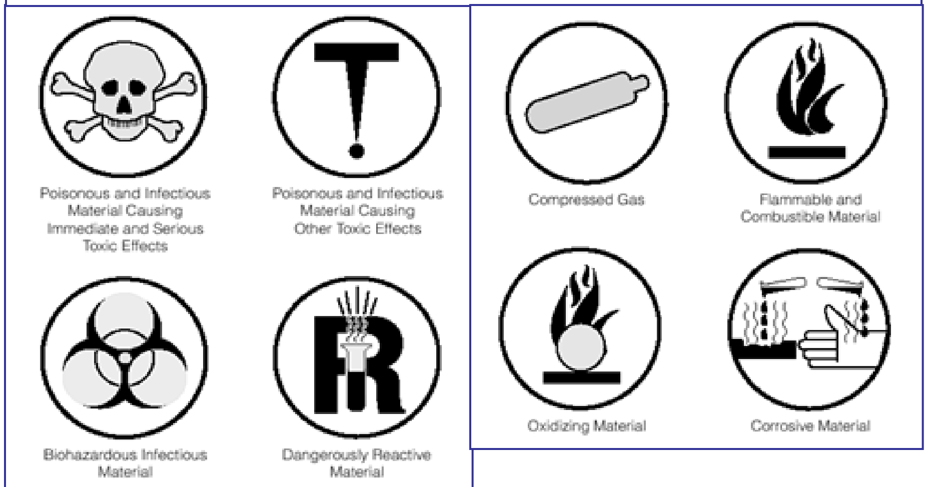
Chemical Safety

Be familiar with the **WHMIS** and **HHPS** symbols that identify the hazards associated with the handling and use of chemicals at home and in the workplace.

Hazardous Household Product Symbols (HHPS)



Workplace Hazardous Materials Information System (WHMIS)



Section 5.3 Review

(Page 206)

Concepts to be reviewed:

- *the use of catalytic converters to help combat exhaust pollutants*
- *the chemical reactions involved in gold extraction*
- *the hazards involved in the use and handling of household chemicals*
- *safe practices for the handling and use of chemicals*
- *familiarity with WHMIS and HPPS symbols and warnings*

In this chapter, you will:

- ***name*** *and* ***write*** *formulas for acids and bases*
- ***explain*** *how the pH scale is used to classify aqueous solutions as acidic, basic, or neutral*
- ***discuss*** *chemical reactions that involve acids and bases*
- ***classify*** *substances as acidic, basic, or neutral*
- ***investigate*** *reactions between acids and bases*

Cabbage Detector

(Page 217)

Many common household substances are acids and bases.

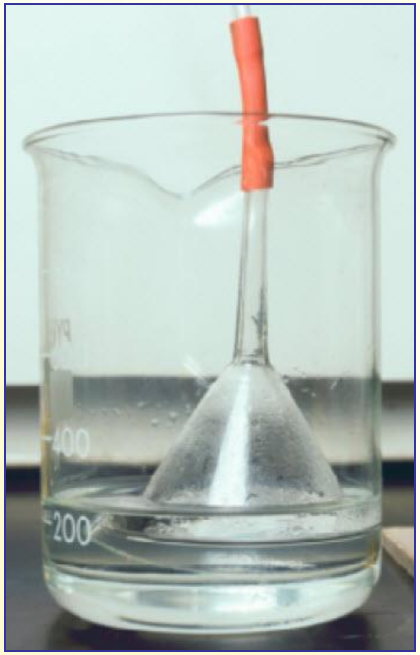
What properties can be used to determine whether a substance is an acid or a base?

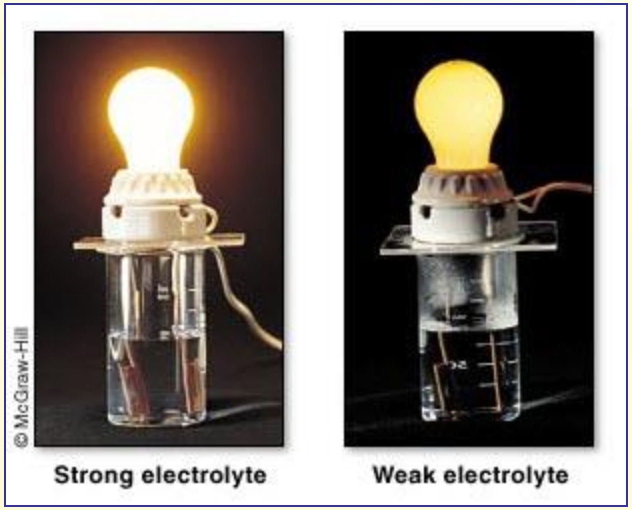
How might an acid/base indicator help with this task?

6.1 Identifying Acids and Bases (Page 219)

An **acid** is a compound that produces hydrogen ions **$H^+(aq)$** when dissolved in water. Acids can also be described in the following ways:

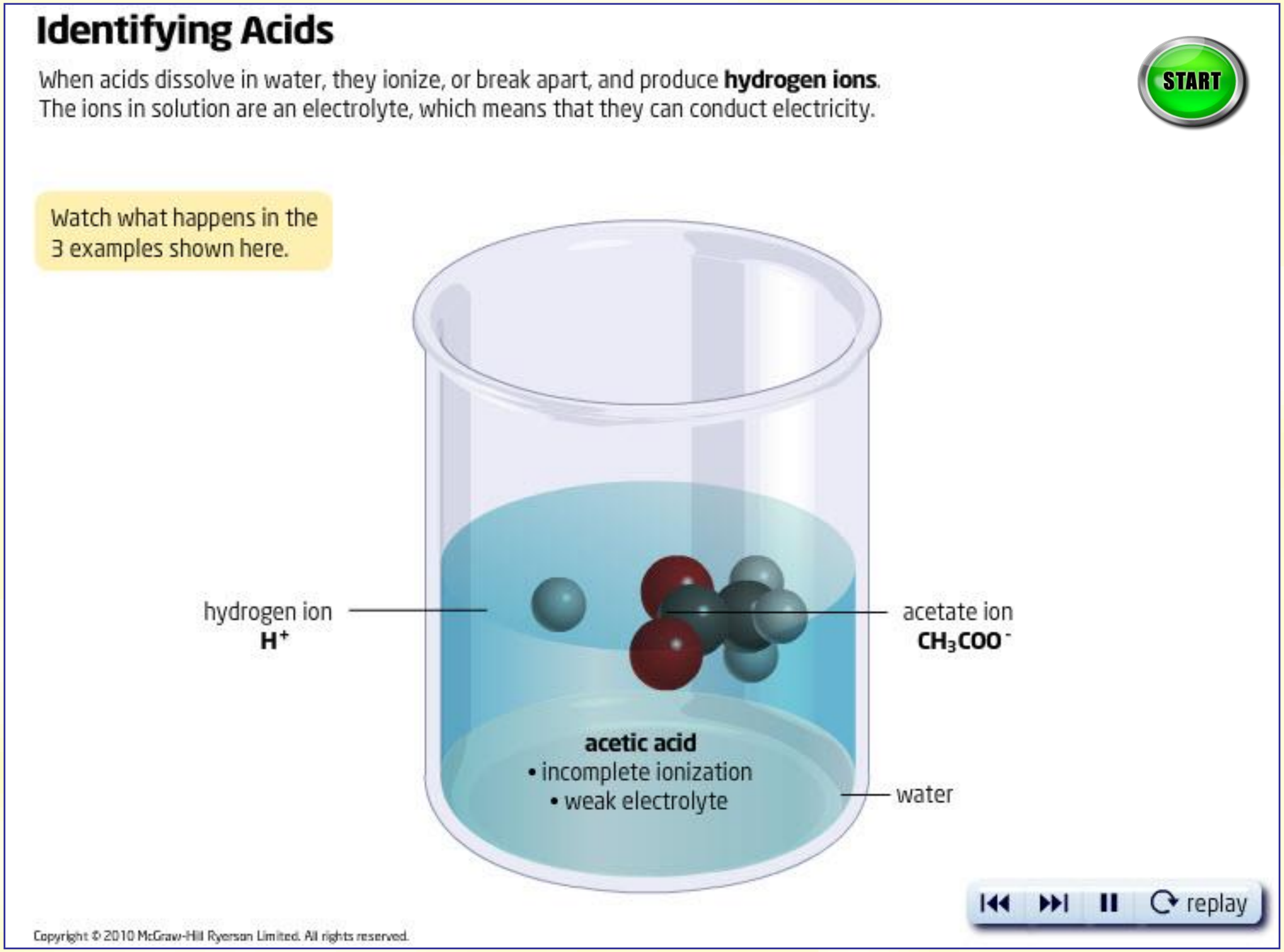
- Acids have a **sour taste**.
- Many acids are **corrosive** and will **react with metals**.
- Aqueous solutions of acid **conduct electricity**.





Identifying Acids

Click the “Start” button to review your understanding of the nature of acids.



Identifying Acids

There are two common definitions for an acid. The Arrhenius definition considers acids to be substances that produce H^+ in aqueous solution. The second definition, a Brønsted acid, considers an acid to be anything that donates a proton. This definition does not require an acid to be in solution.

© Corbis CD

Some Properties of Aqueous Acid Solutions

- Tastes sour
- Turns blue litmus red
- Liberates $H_2(g)$ when reacted with certain metals (for instance, Fe and Zn)

Citrus fruit contains ascorbic acid, also known as vitamin C.

Visualizing Acids in Nature

Examine page **221** in your text to discover the connection between acids and scorpion defence mechanisms, cave formation, the colour of flowers, and stinging insects and plants.

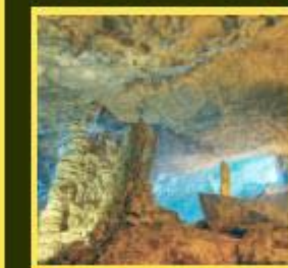
NATIONAL GEOGRAPHIC

VISUALIZING ACIDS IN NATURE

Figure 6.3

From giant limestone structures to delicate flower petals, acids are at work in nature. All of the animals, plants, and rock formations you see here either produce their own acids or are affected by acids in the environment. In addition, many of the foods you eat are acidic, including lemons, peaches, and tomatoes.

◀ **WHIP SCORPION** The whip scorpion is also known as the vinegaroon because it smells like vinegar. In self-defence, the whip scorpion sprays a mist of acetic acid from glands near the rear of its abdomen. Acetic acid is the active ingredient of vinegar. The whip scorpion, which has no venom, is sometimes kept as a pet.



▲ **LIMESTONE CAVES** Carbon dioxide in the air dissolves in rainwater, forming carbonic acid. Therefore, rainwater is naturally acidic. Acidic water reacts with limestone, very slowly dissolving it. Over a long time, this process can carve large caverns in regions that have thick layers of limestone. In the caverns, some of the dissolved limestone can be deposited as solid rock again, forming twisted spires and flowing draperies of stone.

▲ **HYDRANGEA FLOWERS** Acids in soil determine whether some types of hydrangeas produce blue or pink flowers. In acidic soil, the plants produce blue flowers. In soils that are less acidic, the plants produce pink flowers.

▲ **ANT AND NETTLE STINGS** When you are bitten by an ant or brush against the tiny hairs on a stinging nettle plant, you feel a stinging pain that comes in large part from formic acid. The acid dissolves the ends of the nerves in your skin, causing pain.

Naming Acids

(Page 222)

Binary acids are acids composed of two elements: hydrogen and a non-metal.

When naming **acids** you can either follow the **IUPAC** (International Union of Pure and Applied Chemistry) guidelines or use the classical naming method. The rules for naming **binary acids** according to the classical method are:

1. Write the root of the non-metal name.

2. Add the prefix *hydro-* to the root name.

3. Add the ending –*ic* to the root name.

Naming Binary Acids: Formulas, Names, and Uses

(Page 222)

Chemical Formula in Solution	Classical Acid Name	IUPAC Name	Uses
HF(aq)	hydrofluoric acid	aqueous hydrogen fluoride	• manufacturing aluminum and uranium • etching glass
HCl(aq)	hydrochloric acid	aqueous hydrogen chloride	• producing plastic • processing metals
HBr(aq)	hydrobromic acid	aqueous hydrogen bromide	• extracting metal ore
HI(aq)	hydroiodic acid	aqueous hydrogen iodide	• taking part in chemical reactions to make other compounds

Naming Oxoacids

(Page 223)

Oxoacids are composed of hydrogen, oxygen, and another element.

When using the classical method to name an **oxoacid,** the following steps must be followed:

1. Write the name of the anion, without the *-ate* or *-ide* ending.

2. If the anion name ended in *-ate* replace it with *-ic* at the end of the name.

3. If the anion name ended in *-ite*, replace it with *-ous* at the end of the name.

4. Add the word *acid*.

Acid names for compounds containing **sulfur** start with ***sulfur-*** and those containing **phosphorus** start with ***phosphor-***, rather than just starting with ***sulf-*** and ***phosph-***.

Naming Oxoacids: Formulas, Names , and Uses

(Page 223)

Chemical Formula in Solution	Classical Acid Name	IUPAC Name	Uses
$H_2SO_4(aq)$	sulfuric acid	aqueous hydrogen sulfate	• in most car batteries • component of acid precipitation
$H_2SO_3(aq)$	sulfurous acid	aqueous hydrogen sulfite	• disinfecting and bleaching
$HNO_3(aq)$	nitric acid	aqueous hydrogen nitrate	• producing explosives and fertilizers
$H_3PO_4(aq)$	phosphoric acid	aqueous hydrogen phosphate	• making fertilizers, soaps, and detergents
$HClO_3(aq)$	chloric acid	aqueous hydrogen chlorate	• producing explosives and matches
$H_2CO_3(aq)$	carbonic acid	aqueous hydrogen carbonate	• occurs naturally in water • in carbonated drinks

Writing Chemical Formulas for Acids

(Page 224)

The following steps should be followed when writing acid formulas.

1. Determine whether it is a **binary acid** or an **acid containing a polyatomic ion**.
2. If it is a **binary acid,** the name starts with ***hydro-*** and ends with ***-ic***. Find the ion symbols and their charges using a periodic table and then **add subscripts to balance the charges**.

   If it is a **polyatomic acid**, the name doesn't start with ***hydro-***. If it ends with ***-ic***, the polyatomic ion's name must end with ***-ate***. If it ends with ***–ous,*** the polyatomic ion's name must end with ***-ite***.

   Check the periodic table and table of polyatomic ions for the ion symbols and charges. **Add subscripts** to the **H^+ ion** to **balance the charges**.

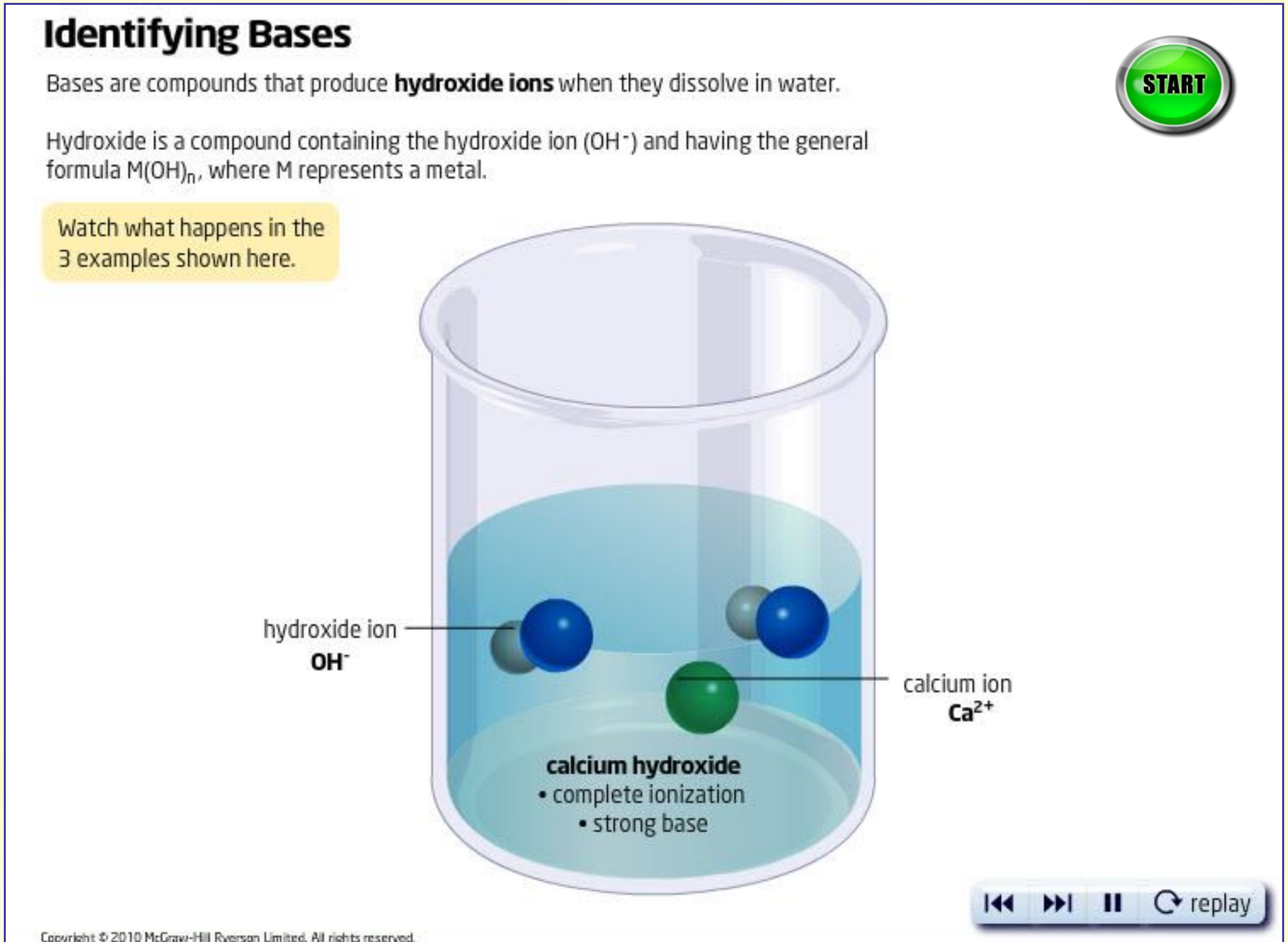
Identifying Bases

Bases are compounds that form hydroxide ions **OH^-(aq)** when dissolved in water. Bases can also be described in the following ways:

- Bases have a **bitter taste**.
- Bases are **slippery** to the touch.
- Bases can give serious chemical burns. They are **corrosive** to skin.

Identifying Bases

Click the "Start" button to review your understanding of the nature of bases.



Identifying Bases

As with acids, there are two definitions for bases. The Arrhenius definition considers a base to be a substance that dissociates in water to produce OH-. The Brønsted base is defined more broadly as a proton acceptor. As with the definition for a Brønsted Acid, the Brønsted base is not required to be in solution.

Some Properties of Aqueous Base Solutions

- Tastes bitter
- Turns red litmus blue
- Feels slippery to the touch

NaOH is found in plumbing products, while $NaHCO_3$ is the key ingredient in baking soda.

Naming Bases

Since many bases are **ionic compounds,** they follow the same naming rules. Some bases have common names often found on consumer products. The rules for naming bases are:

1. The **first part** of the name is that of the **positive ion** (cation), the **name of the metal**.

2. The **second part** of the name always identifies the **negative ion** (anion), the **name of the non-metal**. The name of the non-metal ion always **ends with** the suffix ***-ide***.

Naming Bases: Formulas, Names , and Uses

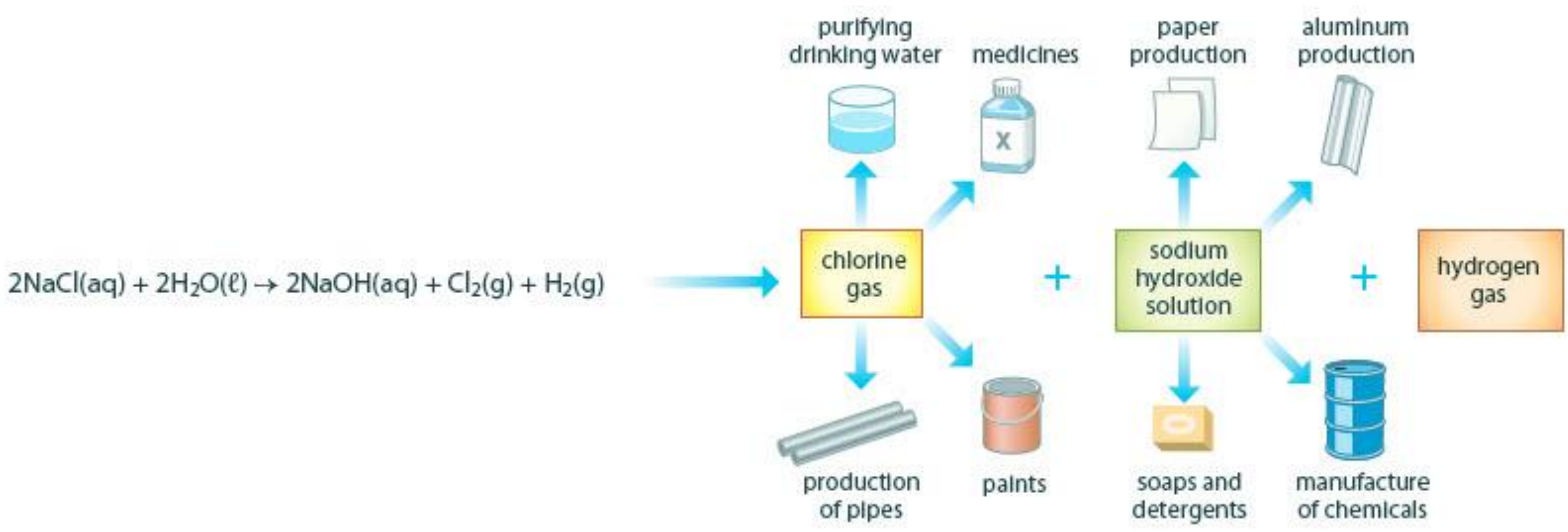
(Page 226)

Chemical Formula	Chemical Name	Common Name	Uses
NaOH	sodium hydroxide	lye, caustic soda	• in drain and oven cleaners • used to make paper, glass, and soap
$Mg(OH)_2$	magnesium hydroxide	Milk of Magnesia®	• in laxatives and antacids
$Ca(OH)_2$ (aq)	calcium hydroxide	lime water	• for soil and water treatment

Sodium Hydroxide in Industry

As illustrated by the diagram below, **sodium hydroxide (NaOH)** is one of the most important chemicals in industry. The majority of sodium hydroxide is produced by the **chlor-alkali process**.

$$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$



Writing Chemical Formulas for Bases

(Page 227)

The following steps should be followed when writing base formulas.

1. Use the periodic table and/or table of polyatomic ions to identify the symbols for the **cation** and **anion** in the base and their charges.
2. **Add subscripts** to balance the charges.

Section 6.1 Review

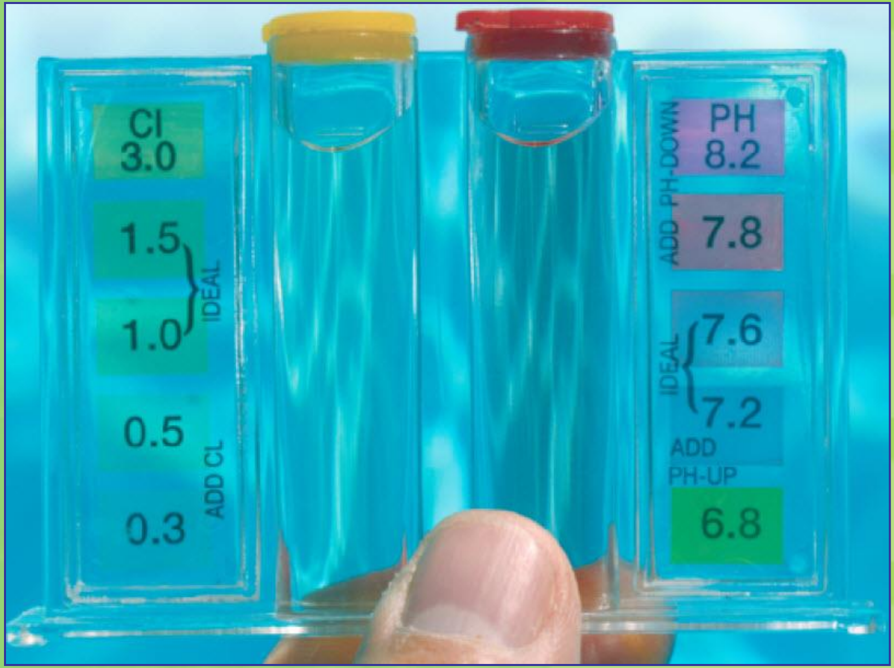
(Page 228)

Concepts to be reviewed:

- *properties of acids*
- *naming and writing formulas for binary acids (acids with a hydrogen and a non-metal)*
- *naming and writing formulas for oxoacids (acids with hydrogen and a polyatomic ion)*
- *properties of bases*
- *naming and writing formulas for bases*

6.2 The pH Scale and Indicators (Page 229)

The **pH scale** is a numerical scale, ranging from 0 to 14, that is used to classify solutions as **acidic**, **basic**, or **neutral**.

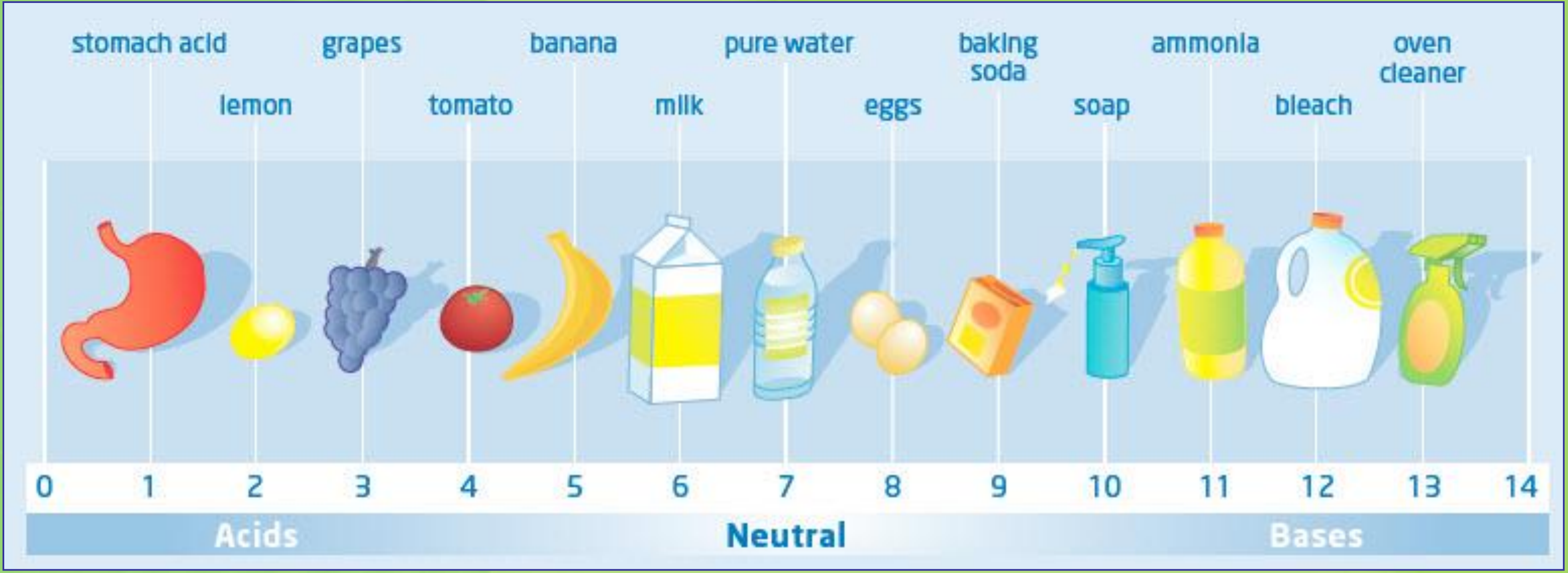


The **pHs** of a variety of solutions (pool water, foods and beverages, and solutions from industrial processes) are regularly monitored.

The pH Scale

(Page 230)

Acidic: pH < 7 **Basic: pH > 7** **Neutral: pH = 7**



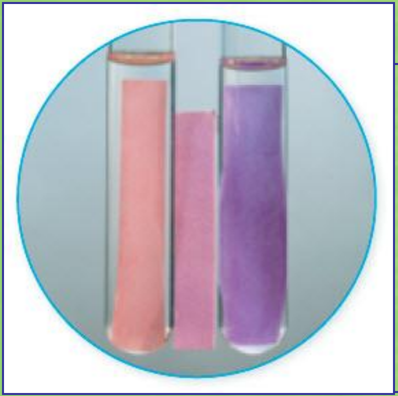
A **pH** (Power of Hydrogen) value relates to the **concentration of hydrogen ions** in a solution. Values increase or decrease exponentially (by a power of 10) as you move up or down the scale.

Determining the pH of a Solution (Pages 231-232)

There are a variety of ways to determine the pH of a solution.

pH Indicators are substances that change colour to show the concentration of hydrogen ions (**H^+**) and hydroxide ions (**OH^-**) in a solution.

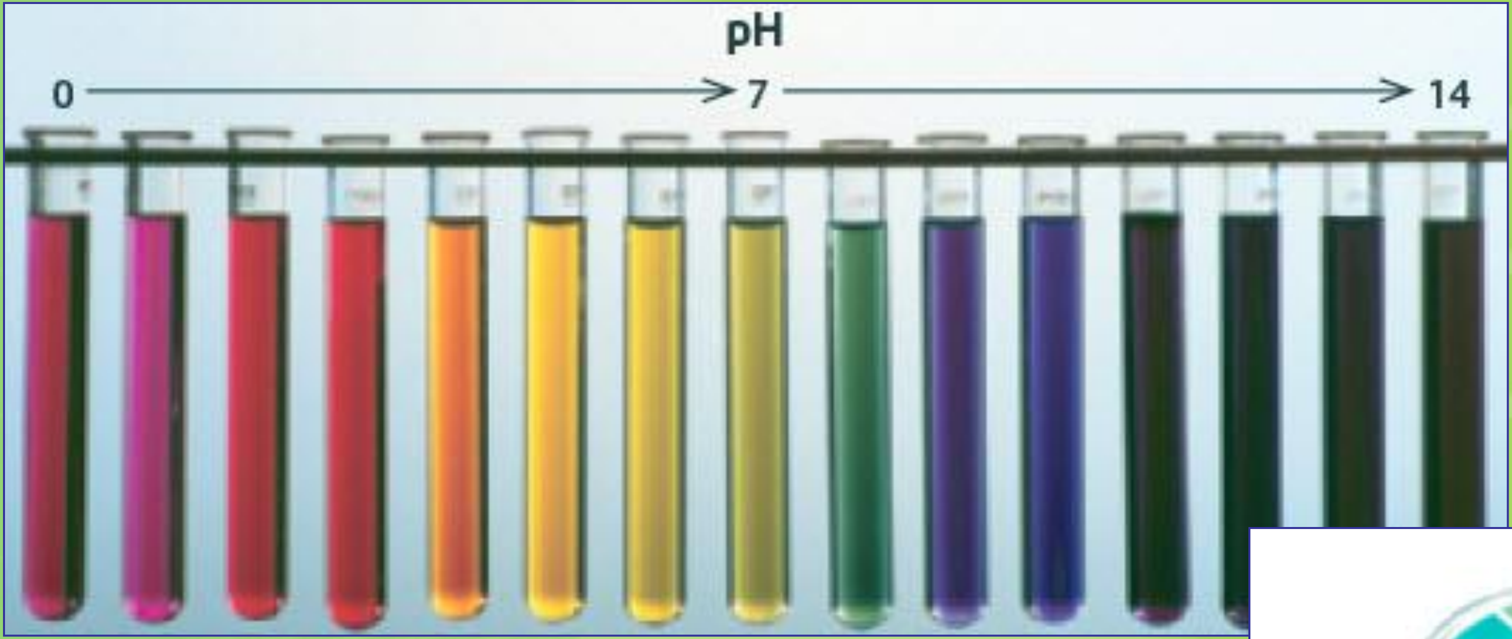
pH Meters have a sensor or probe that electronically produces a precise (real time) reading of the pH of a solution that is displayed digitally on the meter.



Red and Blue Litmus Paper – A chemically treated indicator paper. **Blue litmus turns red in acids**. **Red litmus turns blue in bases**. This simple indicator can determine whether a solution is acidic, basic, or neutral.

Determining the pH of a Solution (Pages 231-232)

Universal Indicator and **pH Paper** are composed of a mixture of indicators that change to different colours under different pH conditions. These indicators cover the entire pH range from 0-14.



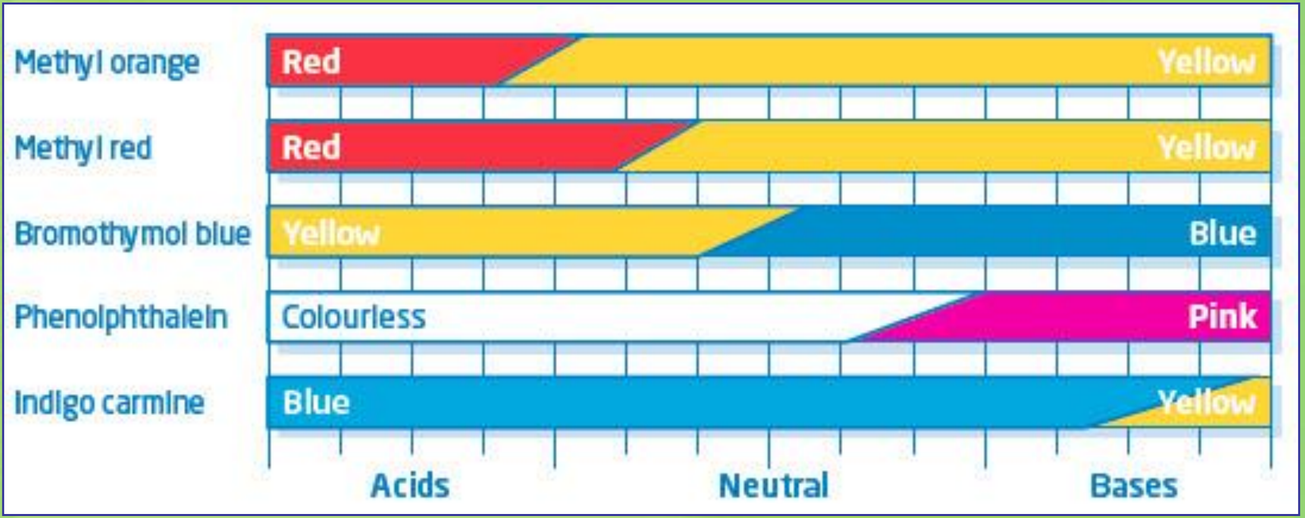
A key or legend of the colours and the pHs they represent is used to analyze the changes in the colour of the indicator.

Other pH Indicators

(Page 233)

Specific indicators that change colour within a very small range of pHs may be used to monitor small changes in pH within that range.

Indicator	pH Range in Which Colour Change Occurs	Colour Change as pH Increases
Methyl orange	3.2-4.4	red to yellow
Methyl red	4.8-6.0	red to yellow
Bromothymol blue	6.0-7.6	yellow to blue
Phenolphthalein	8.2-10.0	colourless to pink
Indigo carmine	11.2-13.0	blue to yellow



pH Indicators in Nature

(Page 234)

A variety of plants contain juices that can act as natural acid-base indicators. A few of these are listed below.

Plant	Colour of Indicator		
	Acid	Neutral	Base
Apple	red	grey-purple	green
Blackberry	red	purple	blue-green
Blueberry	red	purple	blue
Cherry	red	red-purple	blue-green
Mountain cranberry	red	pale purple	pale green
Grape	red	purple	blue-green
Plum	red	pale purple	pale green
Pomegranate	red	purple	blue-green
Raspberry	red	red purple	pale green

Acids and Bases: Similarities and Differences

(Page 234)

Property	Acid	Base
Taste CAUTION: Never taste chemicals in the laboratory.	Acids taste sour.	Bases taste bitter.
Touch CAUTION: Never touch chemicals in the laboratory with your bare skin.	Many acids will burn your skin.	Bases feel slippery and many bases will burn your skin.
Indicator tests	Acids turn blue litmus paper red.	Bases turn red litmus paper blue.
Electrical conductivity	Solutions of acids conduct electricity.	Solutions of bases conduct electricity.
pH	The pH of acidic solutions is less than 7.	The pH of basic solutions is greater than 7.
Production of ions	Acids form hydrogen ions, H^+ (aq), when dissolved in water.	Bases form hydroxide ions, OH^- (aq), when dissolved in water.

Section 6.2 Review

(Page 235)

Concepts to be reviewed:

- *the pH scale and how it relates to acidic, basic, and neutral solutions*
- *the meaning of pH and how changes to the pH of a solution relate to the change in the concentration of the acid or base*
- *the nature and use of a variety of pH indicators*

6.3 Reactions of Acids and Bases (Page 236)

Emissions and acid rain produced by smelters around Sudbury have had a devastating impact on the local environment. Reductions in the levels of these pollutants have given the area a chance to recover.

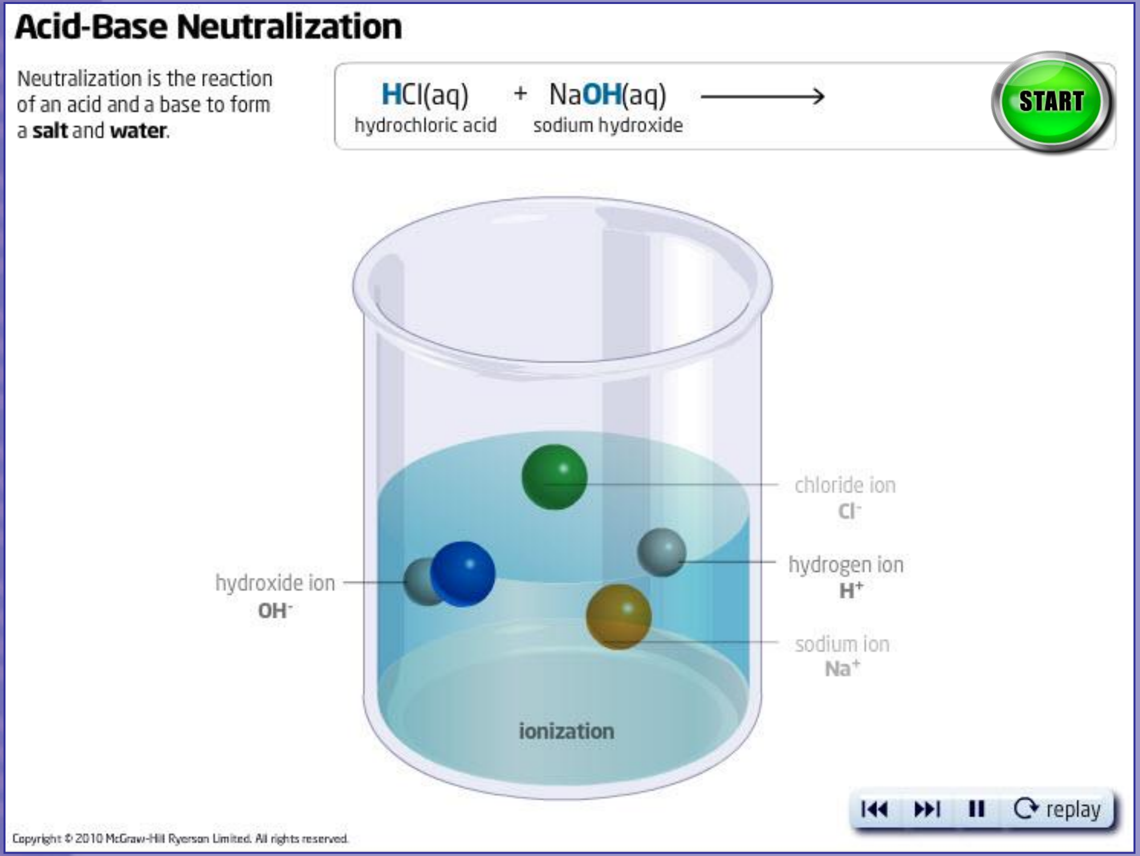
Acid-Base Neutralization

(Page 237)

Neutralization is the reaction of an acid and a base to form a salt and water.

$$HCl(aq) + NaOH(aq) \longrightarrow H_2O\,(l) + NaCl(aq)$$

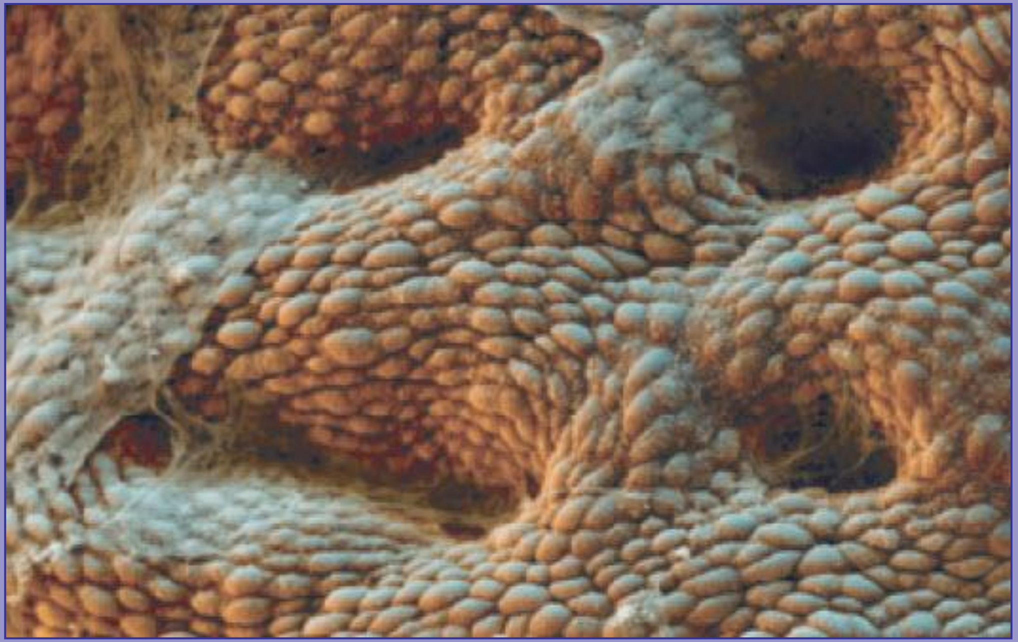
Click the "Start" button to review your understanding of the neutralization of acids.



Neutralizing Stomach Acid

(Page 237)

Antacids such as those shown below are taken to **neutralize** excess acid produced in the dark pits of the stomach lining shown on the right. This excess acid leads to a burning sensation called heartburn.



Neutralizing Acid Spills

(Page 238)

The environmental damage caused by accidental acid spills like the one from the train derailment shown below can be reduced by adding a base to neutralize the acid.

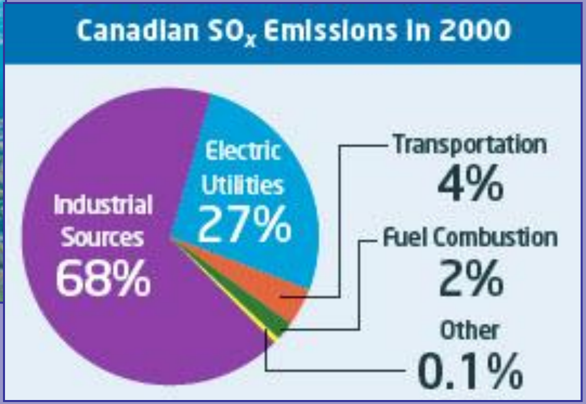
$$H_2SO_4\,(aq) + Ca(OH)_2(aq) \longrightarrow CaSO_4\,(aq) + H_2O\,(l)$$

Acid Precipitation

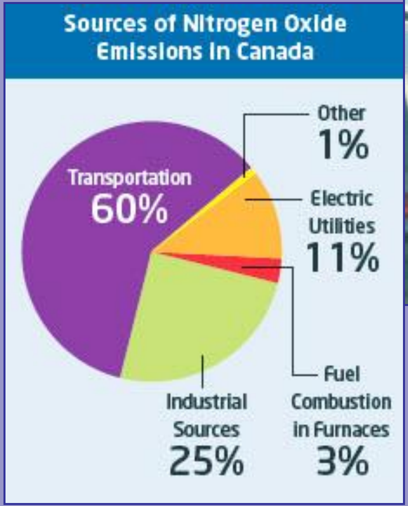
Acid precipitation (acid rain) is rain that has a pH lower than that of normal rain (which is around **5.6**).

Acid precipitation is primarily caused by emissions of **nitrogen oxides** and **sulfur oxides** that combine with water and other gases in the atmosphere to produce **nitric** and **sulfuric acids**.

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$



$NO_2(g) + H_2O(l) \rightarrow HNO_3(aq)$



Effects of Acid Precipitation

(Pages 240-241)

Changes in the pH of water can be abrupt when a rapid snowmelt in the spring releases large amounts of acid trapped in the snow.

Gradual changes in the pH of waterways can reduce fish and waterfowl populations dramatically. Food that these animals rely on disappears, and low pH levels have a negative effect on reproduction.

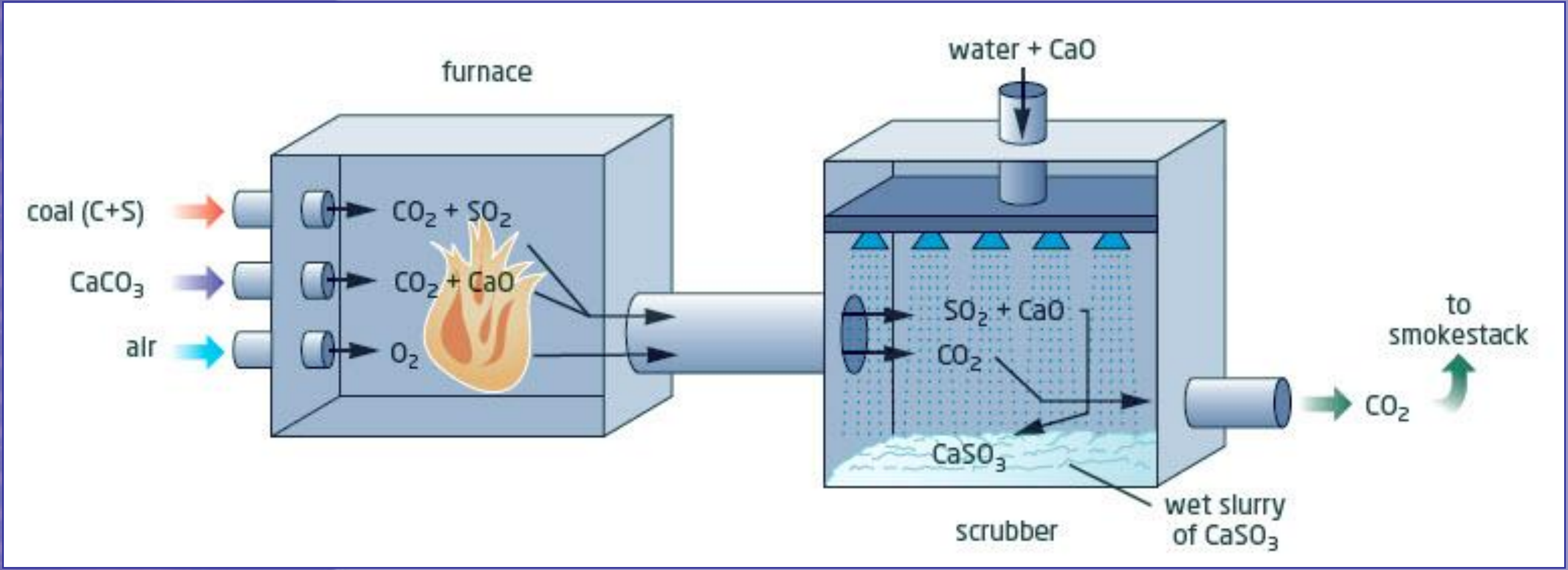
pH	Effects
6.0	• some insects, plankton, and crustaceans die
5.0	• large change in the variety of plankton • invasion by less desirable species of plankton and moss • loss of some fish populations
< 5.0	• few fish remain • land animals are affected by the loss of fish

Reducing Emissions That Cause Acid Precipitation

(Page 242)

Acid-precipitation-causing gases like **SO_2** can be removed from exhaust fumes through the use of **scrubbers** like the one pictured below.

A slurry of **CaO (calcium oxide)** is sprayed on the exhaust gases, effectively removing the **sulfur oxides** (**SO_2**).



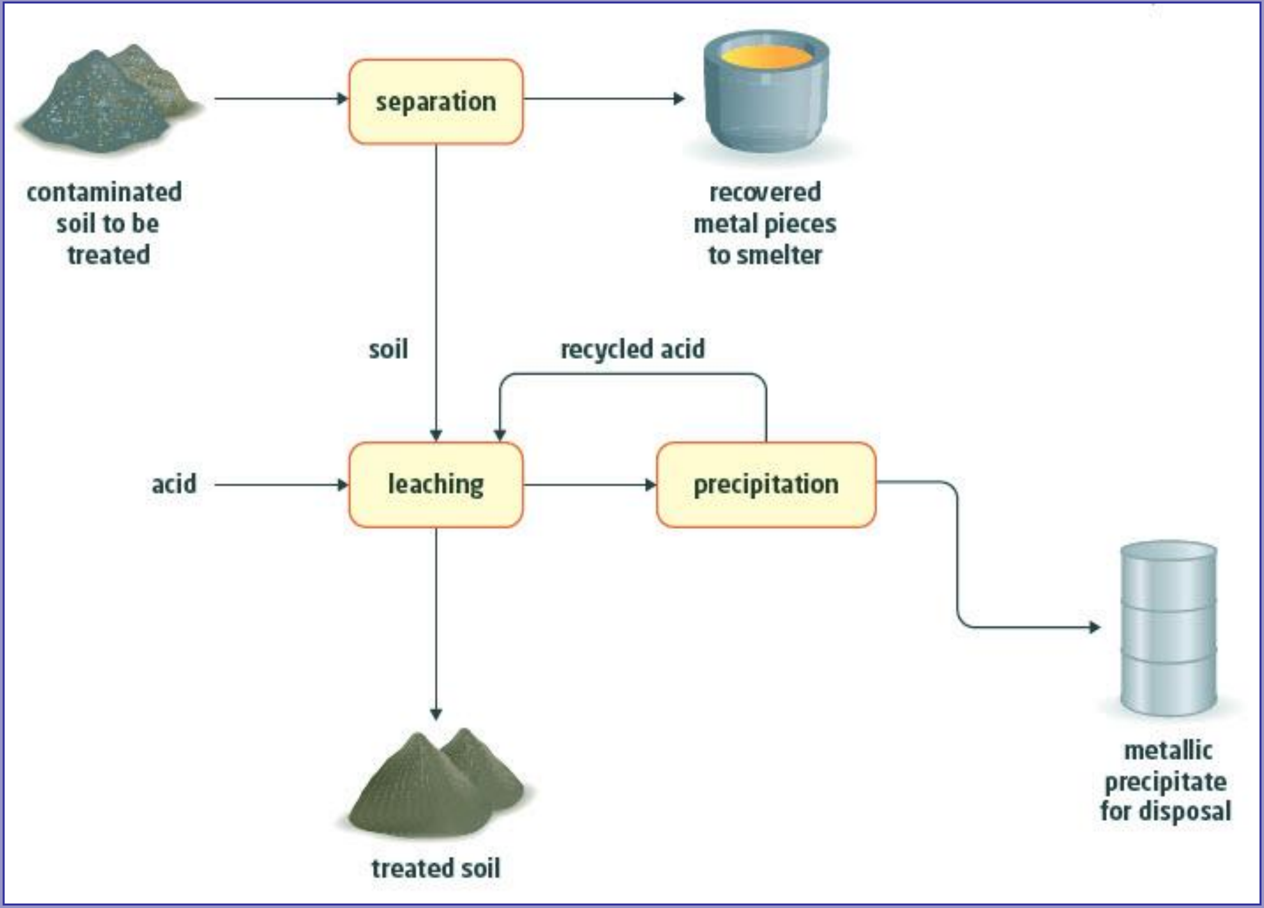
Renewing Acidified Lakes

One strategy for reversing the effects of acid precipitation is to add basic materials to neutralize the acid in lakes. **Liming** involves the application of basic materials, typically lime-based, to renew acidified lakes and regions.

Toxic Metal Contamination Clean-Up

(Page 245)

Acid leaching can be used to clean up soils that have been contaminated by toxic metals that were by-products of mining operations.



Section 6.3 Review

Concepts to be reviewed:

- *the neutralization reaction between acids and bases*
- *the causes of acid precipitation and the measures that can be taken to prevent it or reduce its effects*
- *the detrimental effects of acid precipitation*
- *how liming can be used to renew acidified lakes*
- *how the properties of acids that make them useful for extracting metals from ore can be used to remove toxic metals from soil*