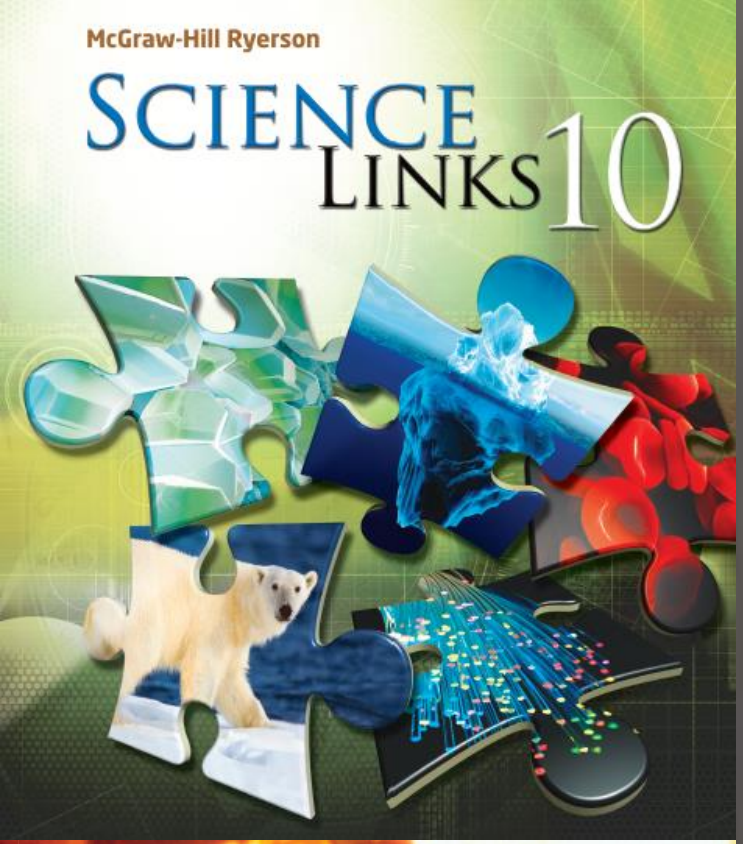


UNIT 2

Chemical Reactions and Their Practical Applications

- ***Topic 2.1***: *How do chemical reactions affect your daily life?*
- ***Topic 2.4***: *What are acids and bases and how do they react?*
- ***Topic 2.2*** : *How can we understand, describe, and name chemical compounds?*
- ***Topic 2.3***: *What happens during a chemical reaction, and how can it be described?*

Topic 2.1 How do chemical reactions affect your life?

(Pages 110-7)

Key Concepts

- Chemical reactions support our lives and assist us at home and at work.
- Chemical compounds require safe handling to minimize their hazards.

How do chemical reactions affect your life?

A car battery

A welder's torch

Fresh-baked bread

Food cooking

A flare used to signal for help

Food preservatives

Ethanol added to gasoline

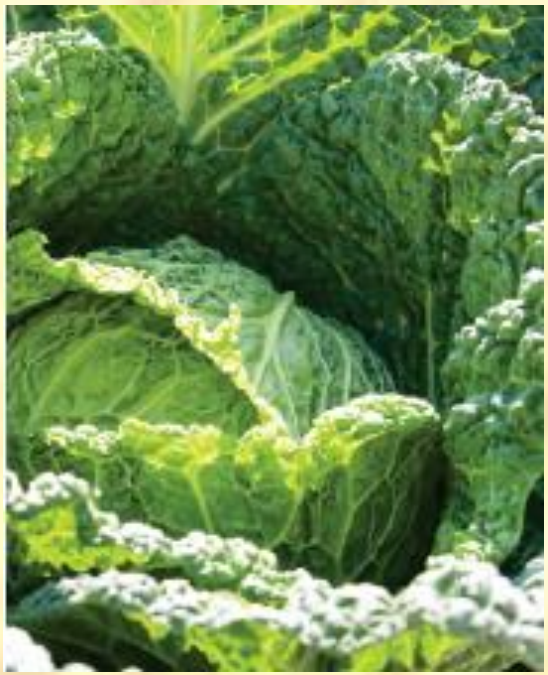
Brightening and disinfecting fabrics

The images above all represent practical applications of chemical reactions.

What chemical reaction is occurring in each example?

Chemical reactions support our lives and assist us at home and at work.

A **chemical reaction** is a change in matter that produces new substances with new properties. Chemical reactions can be written as:



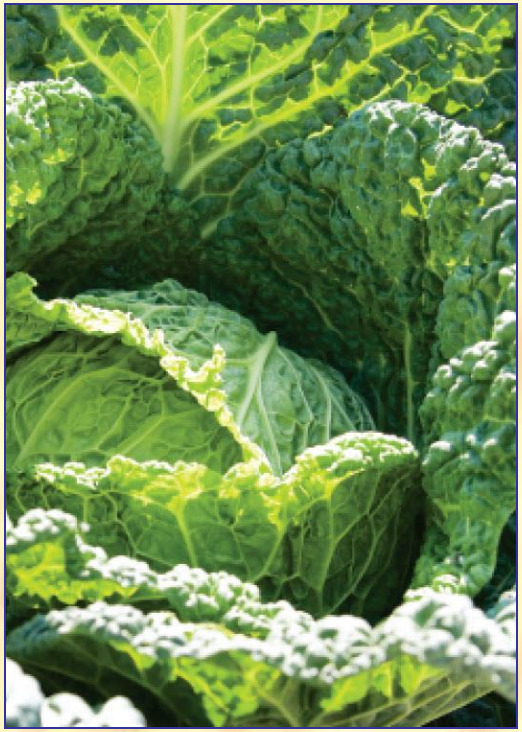
$$\text{reactants} \rightarrow \text{products}$$

What examples of chemical reactions can you think of?

Chemical reactions support our lives and assist us at home and at work.

Reactants are the substances that react together in a chemical reaction. Reactants are "what you start with."

Products are the new substances produced in a chemical reaction. Products are "what you end up with."



Photosynthesis is a chemical reaction that occurs in green plants. It allows energy to be stored in a chemical form.

In photosynthesis, the **reactants** are carbon dioxide and water. The reaction produces sugar and oxygen as **products**.

Chemical reactions support our lives and assist us at home and at work.

Cellular respiration is a chemical reaction that releases energy from the food you eat.

In cellular respiration, the **reactants** are sugar and oxygen. The reaction produces carbon dioxide and water as **products**.

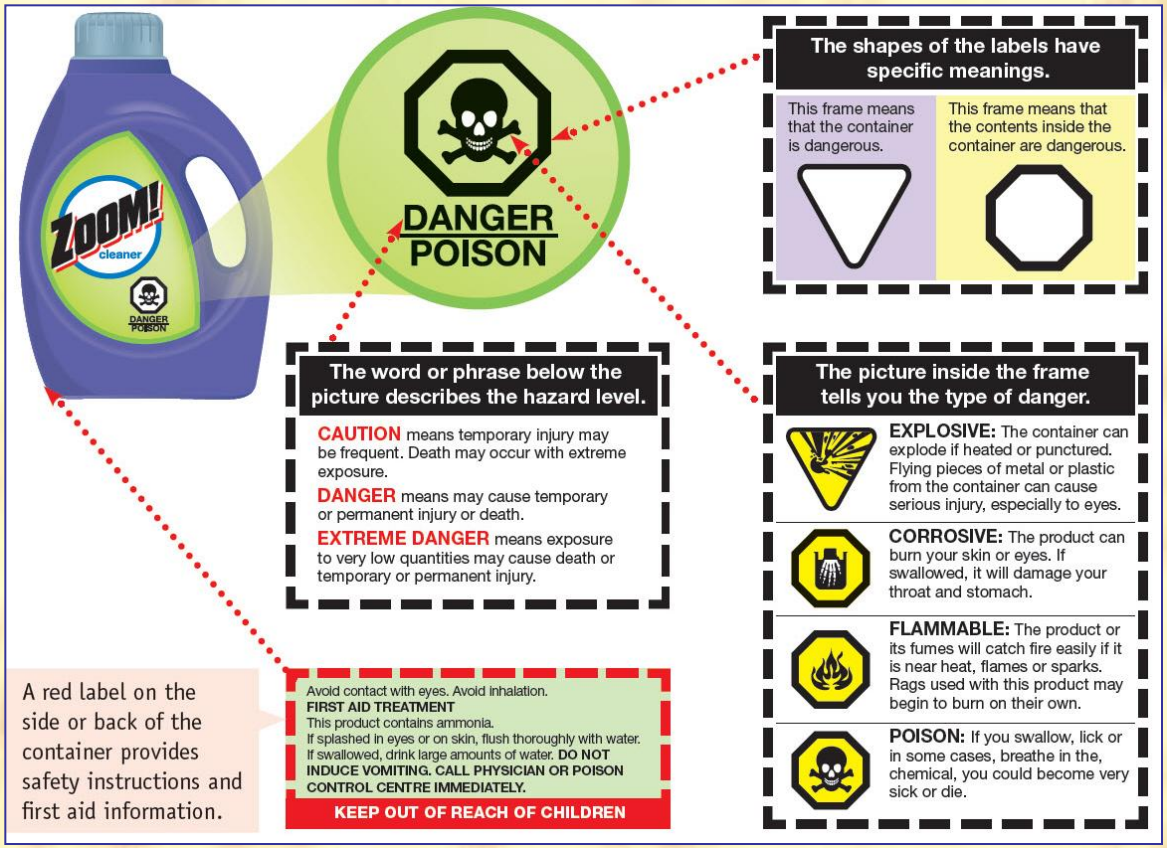
Chemical Reactions at Home and at Work

Many different chemical products are found in your home, including cleaners, foods, and food ingredients. All of these products are produced using chemical reactions or are used to make chemical reactions happen.

Vinegar is a common household chemical that is produced by **diluting** (watering down) acetic acid. As shown on the left, this chemical is used to make a variety of products.

Chemical compounds require safe handling to minimize their hazards.

Hazardous chemicals can be found in laboratories, in industries, and in your home. Labels on the chemicals explain possible hazards.



Hazards in the Home

HHPS (Hazardous Household Product Symbols) use different shapes and easy-to-recognize icons to display basic safety information about a product.

Chemical compounds require safe handling to minimize their hazards.

Workplaces such as restaurants, repair shops, industrial plants, and schools have many hazardous substances.

ACETONE

SEE MATERIAL SAFETY DATA SHEET FOR THIS PRODUCT

DANGER! EXTREMELY FLAMMABLE. IRRITATES EYES.

PRECAUTIONS: Keep away from heat, sparks, and flames. Ground containers when pouring. Avoid breathing vapours of mist. Avoid eye contact. Avoid prolonged or repeated contact with skin. Wear splash-proof safety goggles or faceshield and butyl rubber gloves. If acetone is present in concentrations greater than 250 ppm, wear a NIOSH-approved respirator with an organic vapour cartridge. Use with adequate ventilation, especially in enclosed areas. Store in a cool, well-ventilated area, away from incompatibles.

FIRST AID: In case of contact with eyes, immediately flush eyes with lots of running water for 15 minutes, lifting the upper and lower eyelids occasionally. Get medical attention immediately. In case of contact with skin, immediately wash skin with lots of soap and water. Remove contaminated clothing and shoes. Get medical attention if irritation persists after washing. Wash clothing before reuse. If inhaled, remove subject to fresh air. Give artificial respiration if not breathing. Get medical attention immediately. If swallowed, contact the Poison Control Centre. Get medical attention immediately. Do not give anything by mouth to an unconscious or convulsing person.

ATTENTION! THIS CONTAINER IS HAZARDOUS WHEN EMPTY. ALL LABELLED HAZARD PRECAUTIONS MUST BE OBSERVED.

BIG CHEMICAL COMPANY
123 Nitro Avenue,
Vapour Town,
BC/123-4567

ACÉTONE

VOIR LA FICHE SIGNALÉTIQUE POUR CE PRODUIT

DANGER! EXTRÉMEMENT INFLAMMABLE. IRRITE LES YEUX.

MESURES DE PRÉVENTION: Tenir á récart de la chaleur, des étincelles et des flammes. Relier les récipients á la terre lors du transvasement. Éviter de respirer les vapeurs ou les brumes. Éviter le contact avec les yeux. Éviter le contact prolongé ou répété avec la peau. Porter des lunettes contre les éclaboussures de

ACETONE

FLAMMABLE

Keep away from heat, sparks, and flames

Wear butyl rubber gloves and safety goggles

Use with local exhaust ventilation

See Material Safety Data Sheet (MSDS) for more information.

Hazards in the Workplace

WHMIS (Workplace Hazardous Materials Information System) labels provide detailed information about how to store, handle, and dispose of chemical substances. The labels also provide first aid information.

Chemical compounds require safe handling to minimize their hazards.

Compressed Gas

Flammable and Combustible Material

Oxidizing Material

Corrosive Material

Poisonous and Infectious Material Causing Immediate and Serious Toxic Effects

Poisonous and Infectious Material Causing Other Toxic Effects

Biohazardous Infectious Material

Dangerously Reactive Material

WHMIS (Workplace Hazardous Materials Information System) symbols are used to identify dangerous materials.

Describe the hazard represented by each of the symbols on the left.

What products might carry these labels?

Chemical compounds require safe handling to minimize their hazards.

Hazardous workplace chemicals must come with an **MSDS** (Material Safety Data Sheet) such as the one shown below.

ABC GASES
Division of The ABC Group, Inc.

MATERIAL SAFETY DATA SHEET

CHLORINE

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

ABC Gases Division of The ABC Group, Inc.
313 Oxygen Road North Bay, Ontario

TELEPHONE NUMBER: (705) 555-5555
24-HOUR EMERGENCY
TELEPHONE NUMBER: (408) 444-4444
Emergency Response Plan NO: 20101

PRODUCT NAME: CHLORINE
CHEMICAL NAME: Chlorine
COMMON NAMES/SYNONYMS: Bertholite, Molecular Chlorine
TDG (Canada) CLASSIFICATION: A, DIA, D2A, D2B, E, C
PREPARED BY: ABC GASES 97050 555-5555
PREPARATION DATE: 3/1/00
REVIEW DATES: 3/7/01

2. COMPOSITION, INFORMATION ON INGREDIENTS

INGREDIENT	% VOLUME	PEL-OSHA[1]	TLV-ACGIH[2]	LD_{50} or LC_{50} Route/Species
Chlorine FORMULA: CL_2 CAS: 7782-50-5 RTECS #: FO2100000	100.0	1 ppm Ceiling	0.5 ppm TWA 1 ppm STEL	LC_{50} 293 ppm/1H (rat)

[1]As stated in 24 CFR 1910, Subpart Z (revised July 1, 1993)
[2]As stated in the ACGIH 1994-95 Threshold Limit Values for Chemical Substances and Physical Agents

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
Corrosive and irritating to the eyes, skin and mucous membranes. Inhalation may result in chemical pneumonitis and pulmonary edema. Nonflammable oxidizer, may explode or accelerate combustion if contacting reducing agents.

After examining the sample MSDS on the left, list the information that an MSDS must include.

Topic 2.1 Review

Key concepts to be reviewed:

- Chemical reactions support our lives and assist us at home and at work.
- Chemical compounds require safe handling to minimize their hazards.

Topic 2.2

How can we understand, describe, and name chemical compounds?

(Pages 118-39)

Key Concepts

- Chemical compounds are formed from elements in the periodic table.
- Chemical compounds are represented using chemical names and chemical formulas.
- Reactive elements can become more stable when they form compounds.
- Chemical compounds are described as either ionic or molecular.
- Ionic compounds are named with the metal ion first and then the non-metal ion ending in "ide."
- Molecular compounds are named using numerical prefixes.

How can we understand, describe, and name chemical compounds?

People use **bleach** to make clothes look whiter and brighter and to disinfect them.

We must be familiar with the official name, the common name, and the proper use of everyday chemicals such as bleach.

How can we understand, describe, and name chemical compounds?

Chlorine bleach (containing the compound sodium hypochlorite) and **oxygen bleach** (containing hydrogen peroxide) are both used in laundry.

These are only two of the over 10^{200} types of compounds used by humans.

With so many compounds in existence, how can people recognize the many official names that go with them?

Chemical compounds are formed from elements in the periodic table.

In order to describe compounds, scientists must first know how they were formed. All compounds are formed from two or more elements. The periodic table can be used to determine which elements, and in what proportion to each other, will combine to form compounds.

Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Chemical compounds are formed from elements in the periodic table.

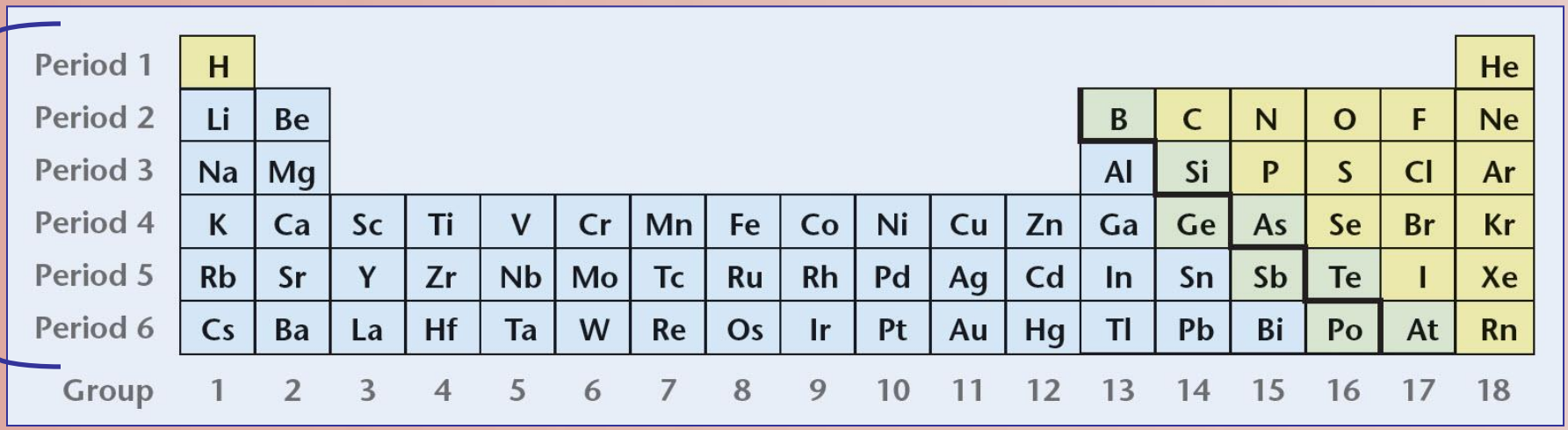
The **periodic table** organizes elements into rows (called **periods**) and columns (called **groups** or **families**). Each element has its own place in the periodic table, based on its properties and atomic structure.

Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Chemical compounds are formed from elements in the periodic table.

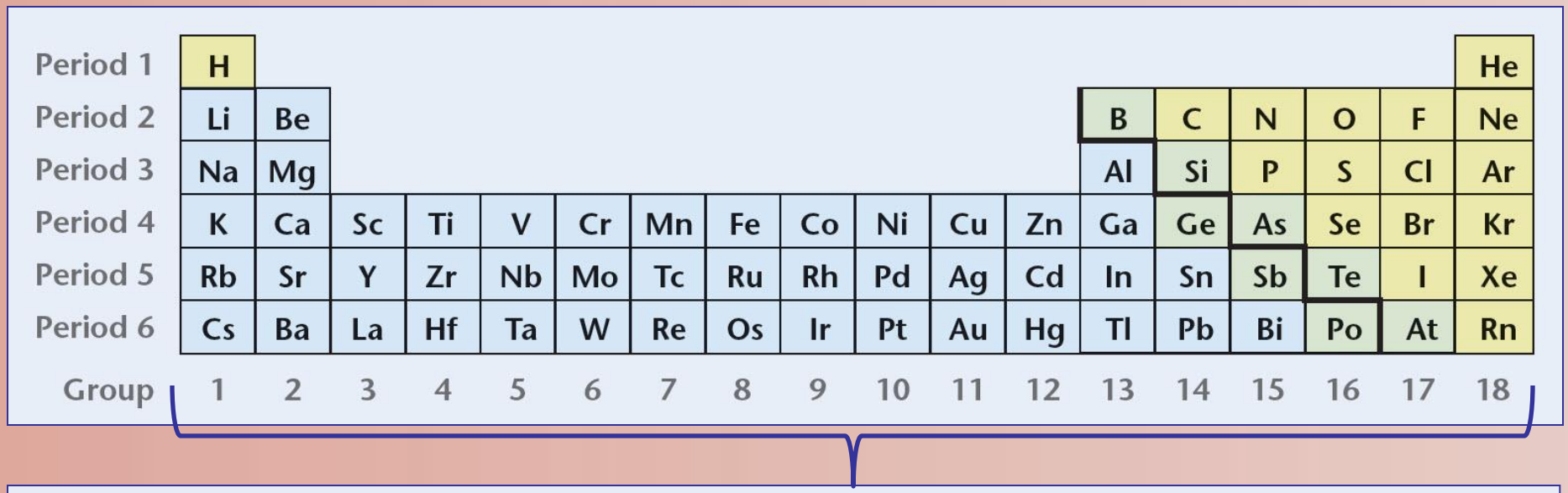
Periods

Each row in the periodic table is called a *period*. The period number represents the number of electron shells in the atoms of an element.



Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Chemical compounds are formed from elements in the periodic table.

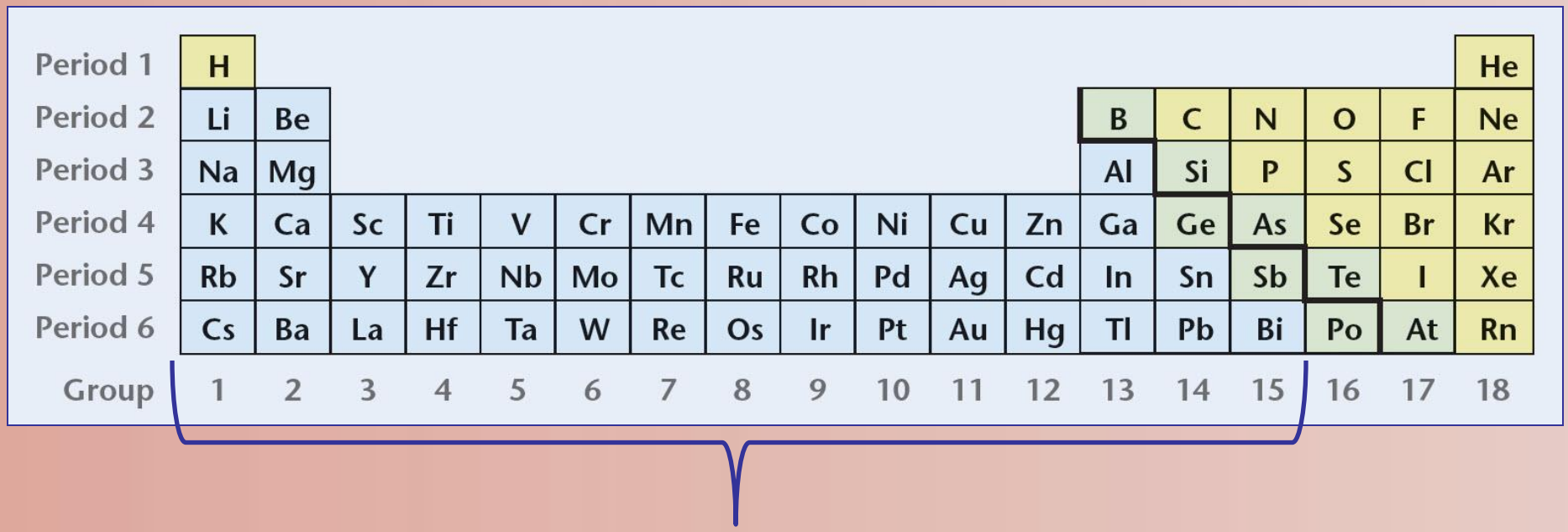


Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Families

Each column in the periodic table is called a group or family. All the elements in a group have the same number of electrons in their outer electron shell. They also have similar chemical and physical properties.

Chemical compounds are formed from elements in the periodic table.



	Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period 1	H																	He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

Metals

The elements left of the staircase (blue) are metals. All metals except mercury are malleable, shiny, conduct heat and electric current, and are solids at room temperature.

Chemical compounds are formed from elements in the periodic table.

Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Group 1 Metals (Alkali Metals)

The Group 1 metals are also called alkali metals. They have only one electron in their outer electron shell. This makes them very reactive. In fact, the alkali metals in Group 1 are the most reactive metals. Their reactivity increases as you go down the group. The most reactive Group 1 metal is cesium (Cs).

Chemical compounds are formed from elements in the periodic table.

Non-metals

The elements on the right (yellow) are non-metals. Non-metals are not malleable, do not conduct heat or electric current, and can be solids, liquids, or gases at room temperature.

Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Chemical compounds are formed from elements in the periodic table.

Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Group 17 Non-metals (Halogens)

The Group 17 non-metals are also called halogens. Their outermost electron shell is one electron short of being full. This makes the halogens very reactive. In fact, the halogens are the most reactive non-metals. Their reactivity decreases as you go down the group. The most reactive Group 17 non-metal is fluorine (F).

Chemical compounds are formed from elements in the periodic table.

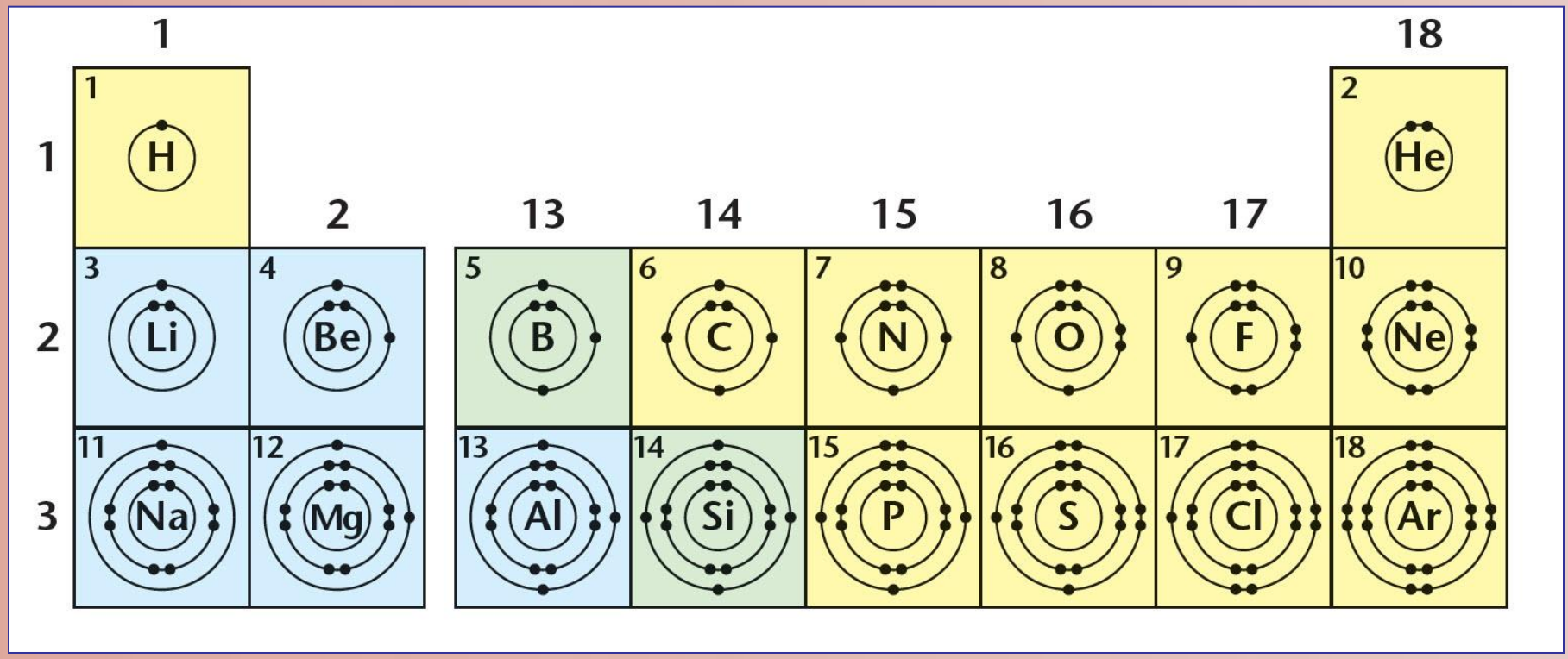
Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Group 18 (Noble Gases)

The Group 18 elements are all gases. They have a full outer electron shell (eight electrons), which makes them unreactive. They are called the "noble gases" or "inert gases" because they do not react with other elements.

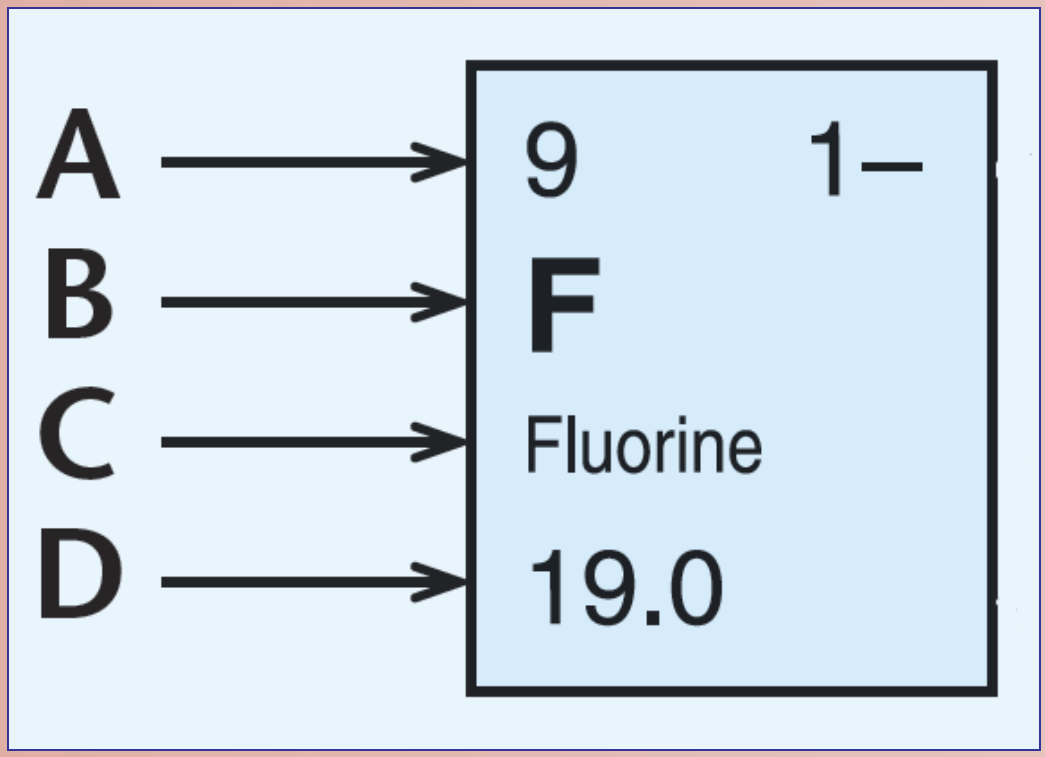
The Periodic Table and Reactivity

The closer an element's outer electron shell is to being full, the more reactive the element will be.



Which elements in the diagram above would be "most reactive"? Which would be "least reactive"? Explain why.

Electrons and Protons of Elements



Examine this cell from the periodic table. What do the parts labelled **A**, **B**, **C**, and **D** represent?

Chemical compounds are represented using chemical names and chemical formulas.

In 1919, **IUPAC** (the International Union of Pure and Applied Chemistry) was formed and the chemists agreed on a set of chemical symbols that are used in the periodic table and in chemical formulas all over the world.

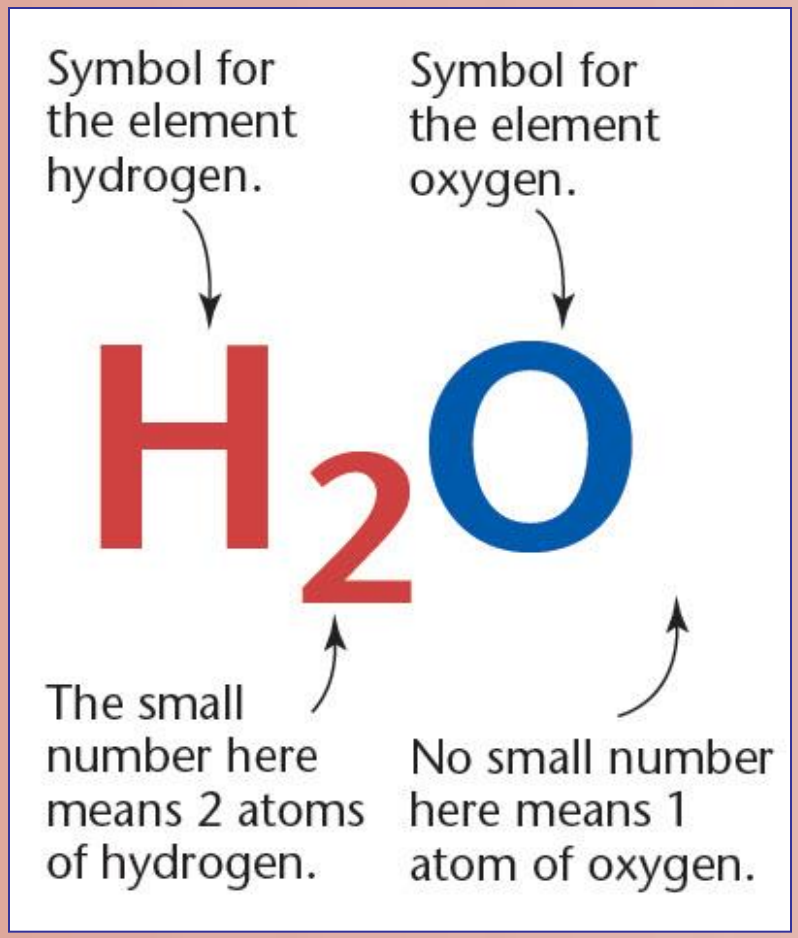
ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ,
ОСНОВАНОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ

			Ti=50		Zr=90	?=180.
			V=51		Nb=94	Ta=182.
			Cr=52		Mo=96	W=186.
H=1	Be=9,4	Mg=24	Mn=55		Rh=104,4	Pt=197,4
	B=11	Al=27,4	Fe=56		Ru=104,4	Ir=198.
	C=12	Si=28	Ni=Co=59		Pl=106,6	Os=199.
	N=14	P=31	Cu=63,4		Ag=108	Hg=200.
	O=16	S=32	Zn=65,2		Cd=112	
	F=19	Cl=35,5	?=68		Ur=116	Au=197?
Li=7	Na=23	K=39	?=70		Sn=118	
		Ca=40	As=75		Sb=122	Bi=210?
		?=45	Se=79,4	Ce=92	Te=128?	
		?Er=56	Br=80	La=94	I=127	
		?Yt=60	Rb=85,4	Di=95	Cs=133	Tl=204.
		?In=75,6	Sr=87,6	Th=118?	Ba=137	Pb=207.

Chemistry students learn the same symbols everywhere in the world, regardless of their own alphabets and languages.

Chemical Formulas

A **chemical formula** is a group of letters and subscript numbers that represents the make-up of a chemical compound. It is the "short form" for a chemical compound.



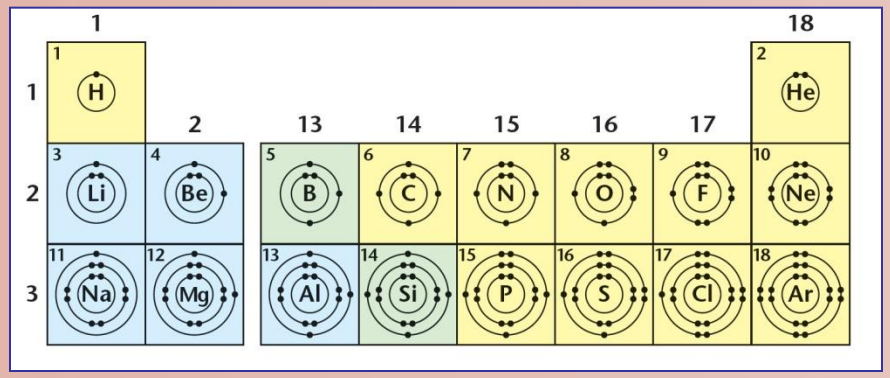
The **letters** are the chemical symbols. They tell you what elements are in the compound.

The **subscript numbers** tell you how many atoms of these elements are in the compound.

Reactive elements can become more stable when they form compounds.

When elements form compounds, they become more stable.

Elements can achieve a full, stable electron-shell structure in one of three ways:

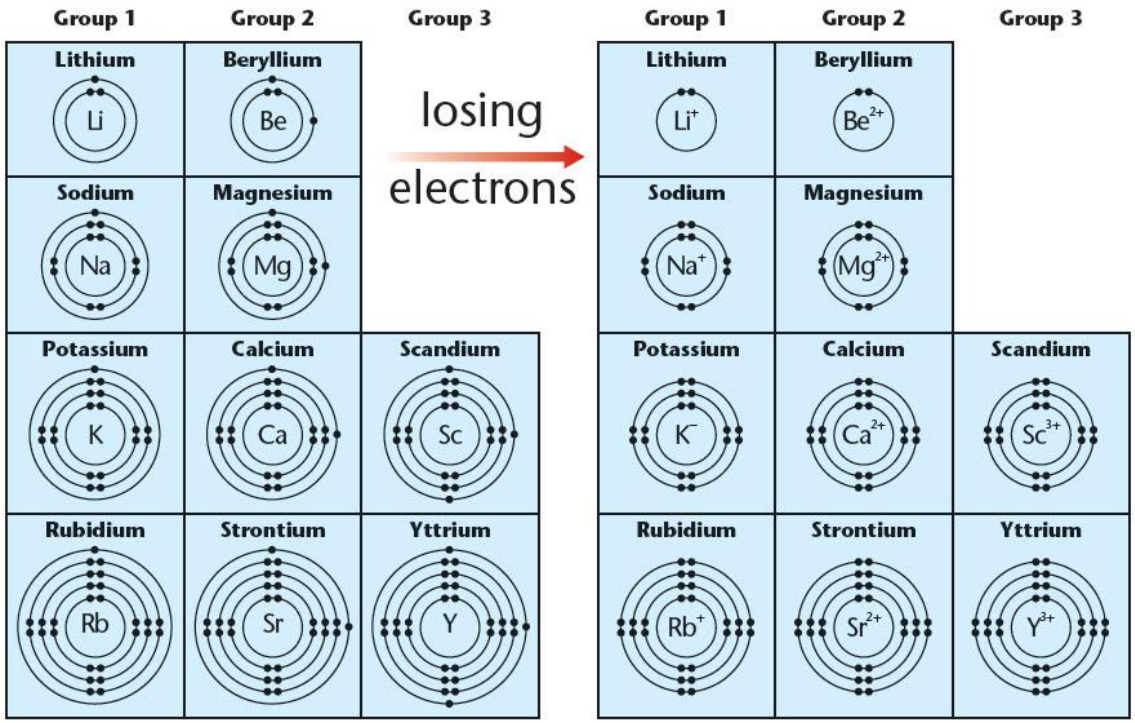


1. Metals lose electrons to form positive ions.
2. Non-metals gain electrons to form negative ions.
3. Non-metals share electrons.

An **ion** is an atom or a group of atoms that has an electrical charge, either positive or negative.

The Ways That Elements Become Stable

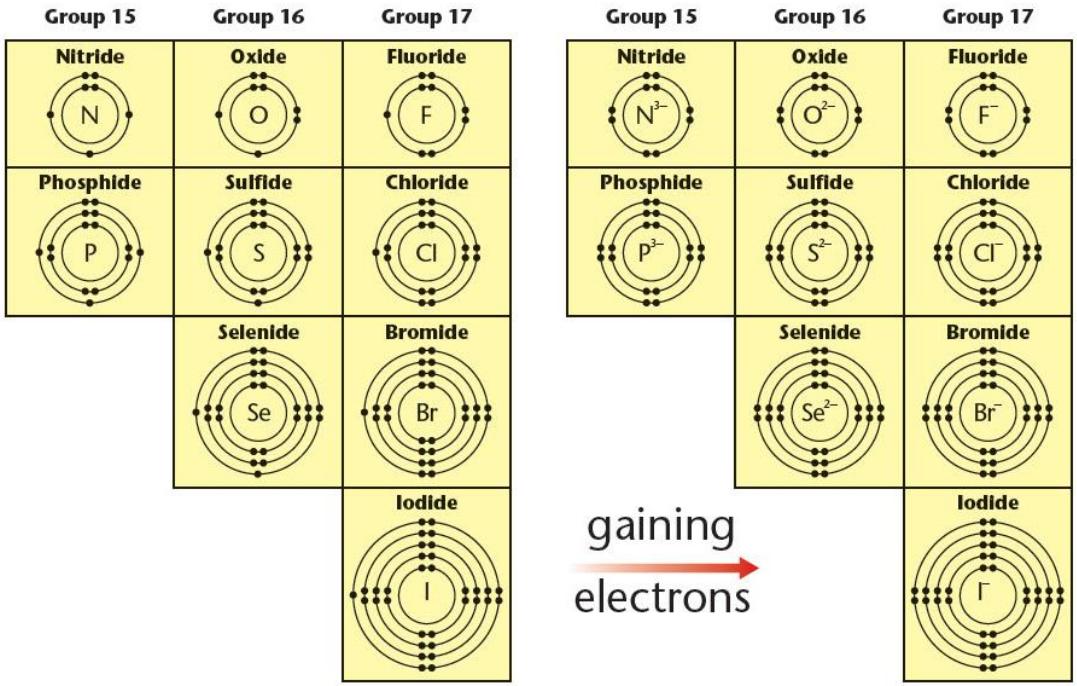
1. Metals lose electrons to form positive ions. The charge on the Group 1 metal ions is +1 because they have lost one electron. The group 2 metal ions have a charge of +2, and Group 3 metal ions have a charge of +3.



Metal atoms can lose electrons to become stable. Because they have lost electrons, which have a negative charge, the charge on metal ions is positive. All metal ions have a stable electron-shell structure.

The Ways That Elements Become Stable

2. Non-metals gain electrons to form negative ions. The charge on the Group 17 non-metal ions is -1 because they have gained one electron. The Group 16 non-metal ions have a charge of -2; Group 15 non-metal ions have a charge of -3.



Non-metal atoms can gain electrons to become stable. Because they have gained electrons, which have a negative charge, the charge on metal ions is negative. Notice that the name of a negative ion ends in "ide." All non-metal ions have a stable electron-shell structure.

The Ways That Elements Become Stable

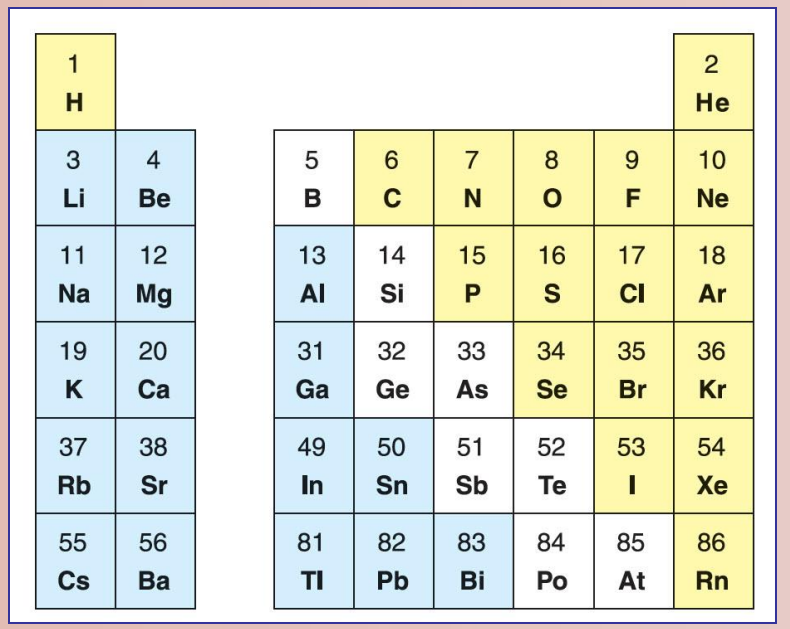
3. Non-metals share electrons.

Non-metal atoms can also share electrons with other non-metal atoms to become stable. Their electron shells overlap. Since electrons have not been lost or gained, there is no charge on the atoms when electrons are shared.

Chemical compounds are described as either ionic or molecular.

Ionic compounds form because positively charged metal ions attract negatively charged non-metal ions.

Chemical Formula	Chemical Name (common name, if there is one)	Common Use
NaCl	sodium chloride (table salt)	seasoning for food
$CaCl_2$	calcium chloride (road salt)	de-icer for roads in the winter
CaO	calcium oxide (lime)	plaster
MgO	magnesium oxide (magnesia)	laxative
$CuBr_2$	copper(II) bromide	lasers and photographic processing

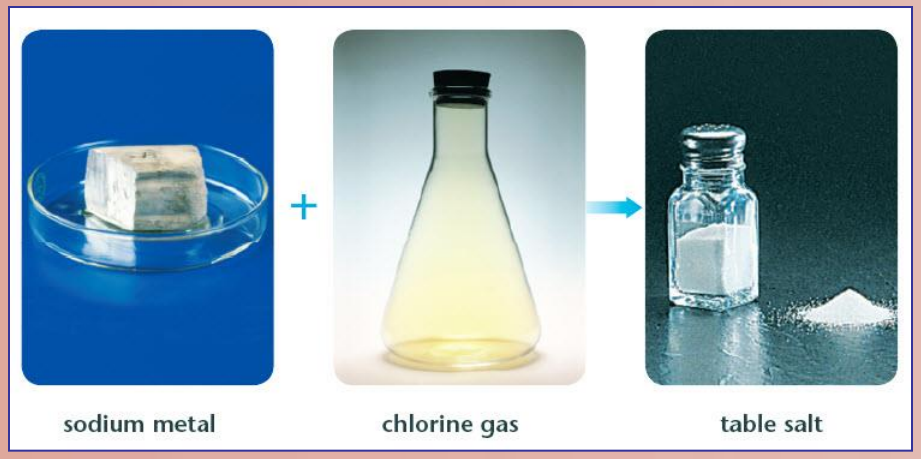


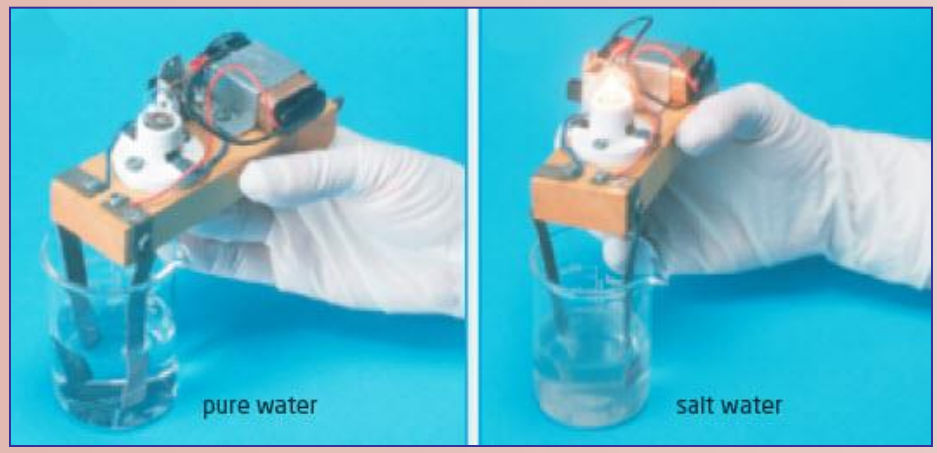
Metals are shown in blue and non-metals are shown in yellow.

Properties of Ionic Compounds

Ionic compounds have the following properties:

- they are **solids** at room temperature
- they have a **very high melting point**
- they **conduct electricity** when they are melted or dissolved in water





Chemical compounds are described as either ionic or molecular.

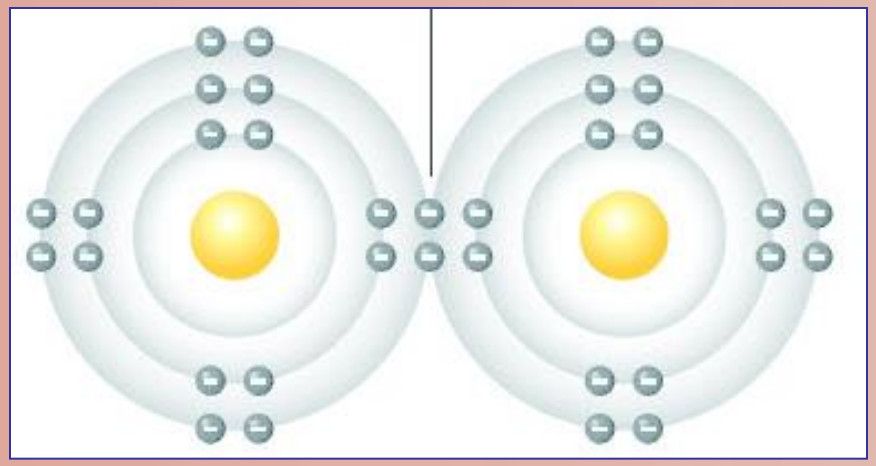
Molecular compounds form when non-metal atoms share electrons with other non-metal atoms.

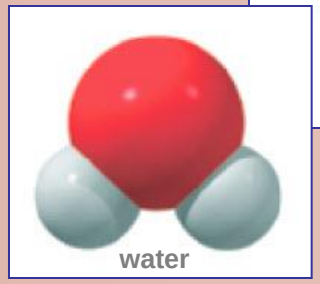
Chemical Formula	Chemical Name (common name, if there is one)	Common Use
CH_4	methane	heating
CO	carbon monoxide	production of acetic acid
$C_{12}H_{22}O_{11}$	sucrose (table sugar)	sugar
CCl_4	carbon tetrachloride	dry cleaning fluid
CH_3OH	methanol	windshield washer fluid

Properties of Molecular Compounds

Molecular compounds have the following properties:

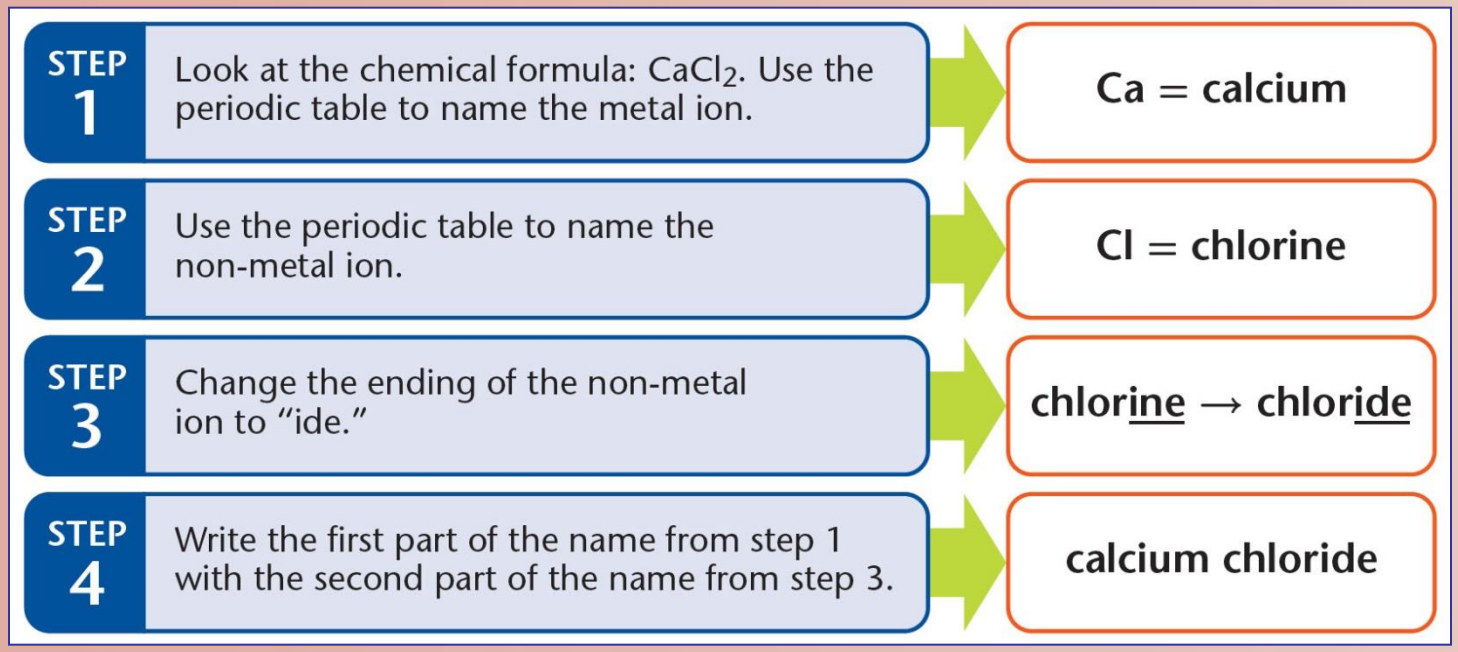
- they may be **solids**, **liquids**, or **gases** at room temperature
- they have **lower melting points** than ionic compounds
- they **do not conduct electric current** when they are melted or dissolved in water, except in the case of certain acids





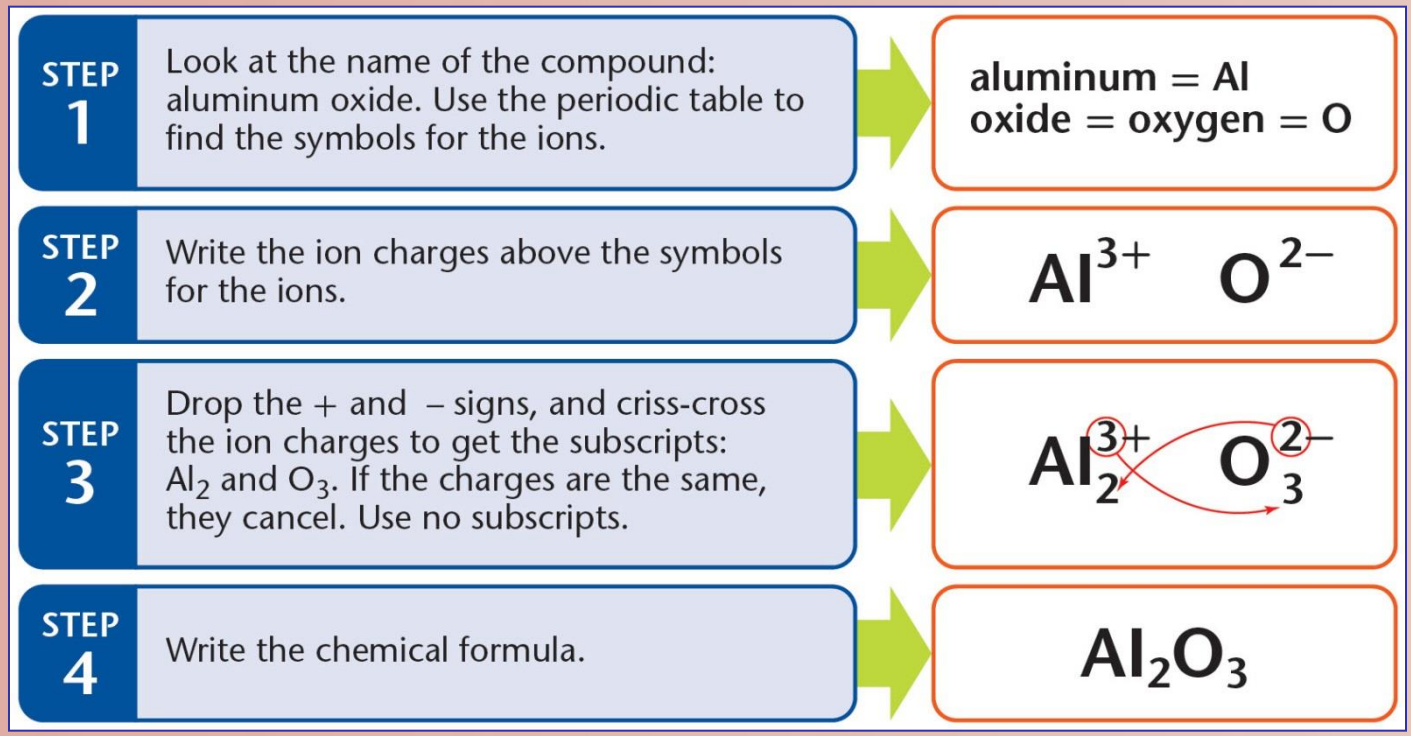
Naming a Simple Ionic Compound from Its Chemical Formula: $CaCl_2$

Ionic compounds have two-part names. The first part of the name is the metal ion, and the second part is the non-metal ion ending in "ide." If you know the formula for an ionic compound, the name can be derived as follows.



Writing the Chemical Formula of a Simple Ionic Compound from Its Name: aluminum oxide

The instructions below describe how to write the chemical formula for an ionic compound if you are given its name. A periodic table with ion charges of the elements is required.



Common Non-metal Ions

The table below shows the names of some of the common non-metal ions.

Element Name	Element Symbol	Ion Symbol	Ion Name
nitrogen	N	N^{3-}	nitride
oxygen	O	O^{2-}	oxide
fluorine	F	F^{-}	fluoride
phosphorus	P	P^{3-}	phosphide
sulfur	S	S^{2-}	sulfide
chlorine	Cl	Cl^{-}	chloride
selenium	Se	Se^{2-}	selenide
bromine	Br	Br^{-}	bromide
iodine	I	I^{-}	iodide

Molecular compounds are named using numerical prefixes.

There are many ways that atoms of two non-metal elements can react to form a molecular compound. The compounds described in the table below contain only nitrogen and oxygen in different proportions.

Chemical Formula	IUPAC Name	What It Is
NO	nitrogen monoxide	pollutant from car exhaust
N_2O	dinitrogen monoxide	used by dentists (laughing gas)
NO_2	nitrogen dioxide	used to make nitric acid
N_2O_3	dinitrogen trioxide	deep blue liquid
N_2O_4	dinitrogen tetroxide	used in rocket fuel
N_2O_5	dinitrogen pentoxide	dissolves in water to form nitric acid

Naming a Molecular Compound from Its Chemical Formula: CO_2

STEP 1	Look at the formula of the molecular compound: CO_2. Use the periodic table to name the first element.	**C = carbon**
STEP 2	Choose the correct prefix for the number of atoms of the element.	**carbon** There is only one atom of carbon, so the correct prefix is "mono." But "mono" is not included for the first element.
STEP 3	Use the periodic table to name the second element.	**O = oxygen**
STEP 4	Change the ending of the second element to "ide."	**oxygen → oxide**
STEP 5	Choose the correct prefix for the number of atoms of the element.	**2 = di → dioxide** There are two atoms of oxygen, so the correct prefix is "di."
STEP 6	Combine the two parts of the name.	**carbon dioxide**

The steps involved in naming a molecular compound are described on the left.

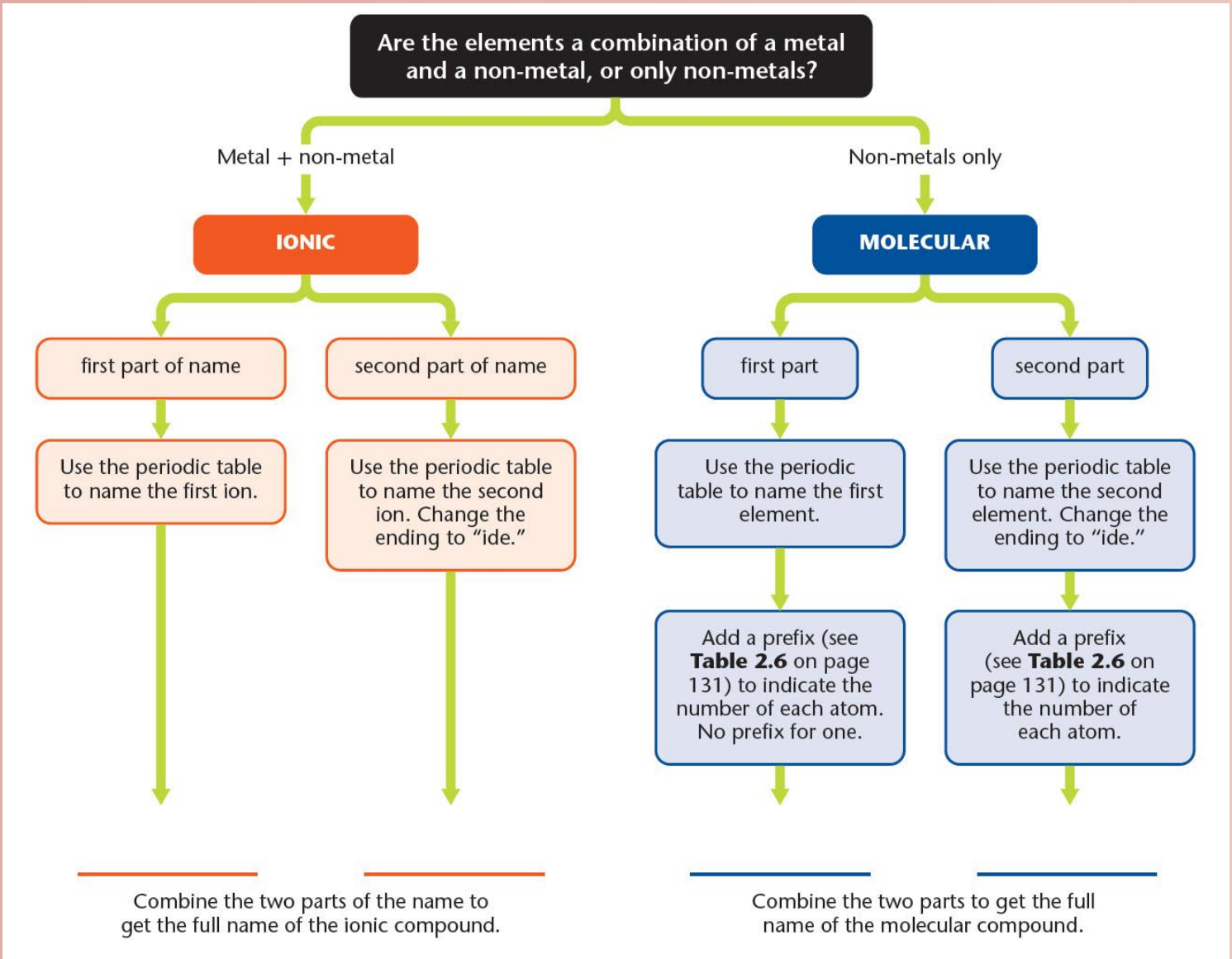
Numerical Prefix	Number It Represents
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8

Writing the Chemical Formula of a Molecular Compound from its Name: dinitrogen tetroxide

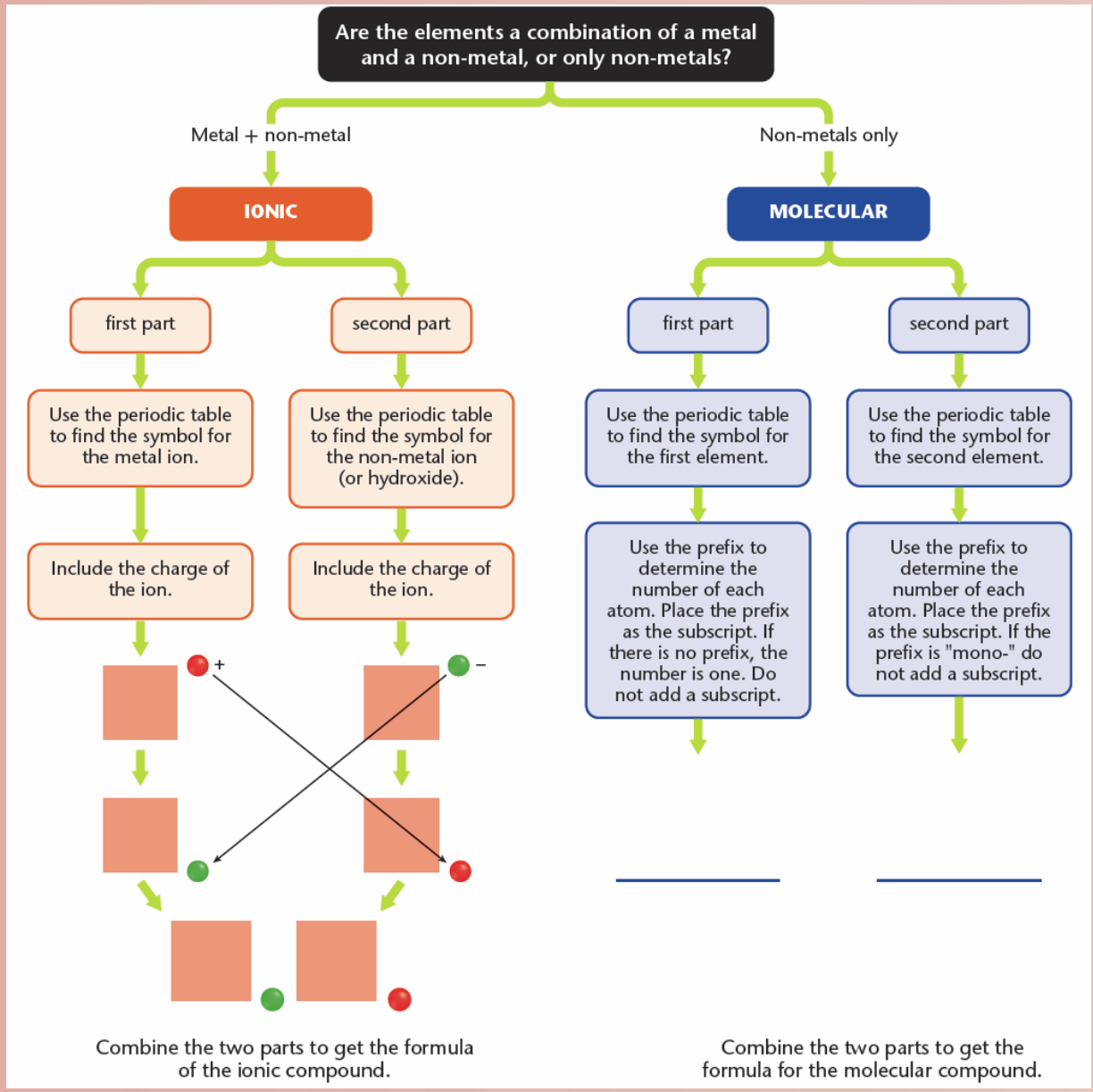
The steps involved in determining the formula of a molecular compound are outlined below.

STEP 1	Look at the name of the molecular compound: dinitrogen tetroxide. Use the periodic table to find the symbols for the elements.	nitrogen = N oxide = oxygen = O
STEP 2	Compare the prefixes in the name to those in **Table 2.6** on page 131 to determine the number of atoms of each element.	di = 2 two nitrogen = 2N tetra = 4 four oxygen = 4O
STEP 3	Write in the subscripts, and write the chemical formula.	N_2O_4

A Flowchart for Naming Chemical Compounds



A Flowchart for Writing Chemical Formulas



Topic 2.2 Review

Key concepts to be reviewed:

- Chemical compounds are formed from elements in the periodic table.
- Chemical compounds are represented using chemical names and chemical formulas.
- Reactive elements can become more stable when they form compounds.
- Chemical compounds are described as either ionic or molecular.
- Ionic compounds are named with the metal ion first, and then the non-metal ion ending in "ide."
- Molecular compounds are named using numerical prefixes.

Topic 2.3 What happens during a chemical reaction, and how can it be described?

(Pages 140-57)

Key Concepts

- During a chemical reaction, chemical compounds are changed into different compounds with different properties.
- The four types of chemical reactions can be described using word equations.
- Chemical reactions can be described using chemical equations.
- Atoms and mass are conserved during a chemical reaction.

What happens during a chemical reaction, and how can it be described?

There are five types of fire extinguishers because there are different types of fires. The next slide shows the labels for the different classes of fire extinguishers.

What happens during a chemical reaction, and how can it be described?

Different types of fire extinguishers are used to extinguish different types of fires. The different classes of fire extinguishers are labelled as shown below.

A	B	C	D	K
Ordinary Combustibles	**Flammable Liquids**	**Electrical Equipment**	**Combustible Metals**	**Cooking Oils**
For ordinary combustibles such as wood or paper	For flammable liquids such as oil, grease, or gasoline	For electrical fires	For flammable metals such as lithium, magnesium, sodium, and potassium	For kitchen fires such as cooking oil or fats catching fire in a frying pan

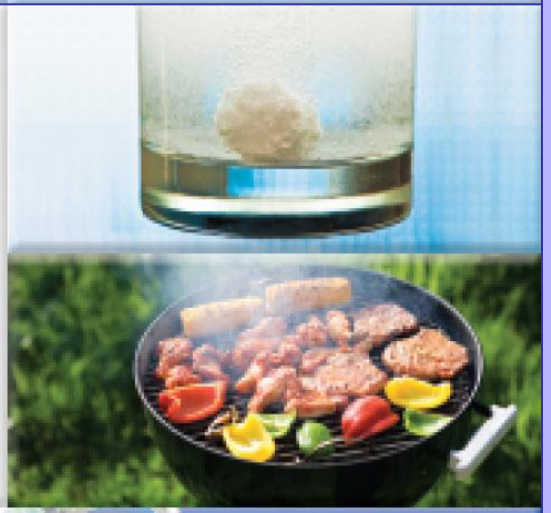
What do you think would be different about the five types of fire extinguishers?

During a chemical reaction, chemical compounds are changed into different compounds with different properties.

The next two slides describe examples of **evidence** that might indicate a chemical reaction has occurred.

Evidence	Description	Example
There is a change in energy.	All chemical reactions involve a change in energy, although it is not always possible to detect it. A change in energy may be • a temperature change (increase or decrease) • light produced • electrical energy produced	
There is a change in colour.	In some chemical reactions, the colour of the products is different from the colour of the reactants.	

During a chemical reaction, chemical compounds are changed into different compounds with different properties.

Evidence	Description	Example
A gas is formed.	Gases are formed in some chemical reactions. You would observe • bubbles in a liquid, or • odour (smell)	
A solid substance (a precipitate) is formed.	In some reactions, when two clear solutions are mixed, the product is a solid that appears in the beaker. The solid that appears is called a precipitate.	

The four types of chemical reactions can be described using word equations.

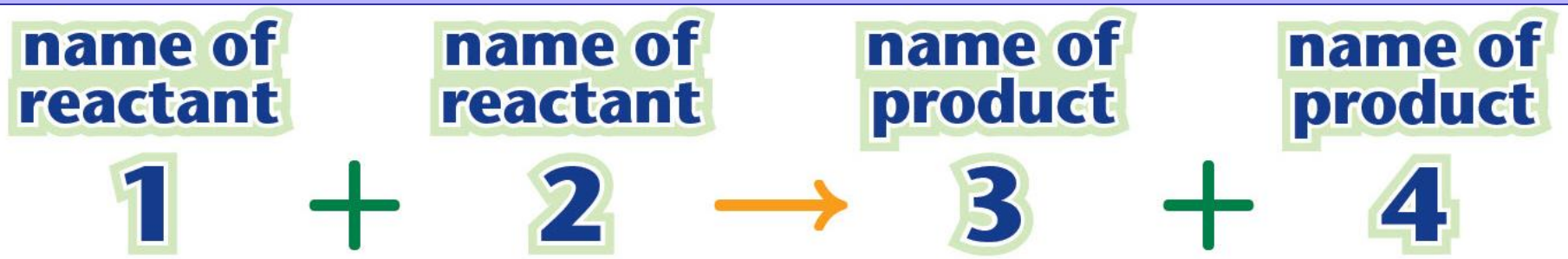
There are four types of chemical reactions:

- synthesis reactions
- decomposition reactions
- single displacement reactions
- double displacement reactions

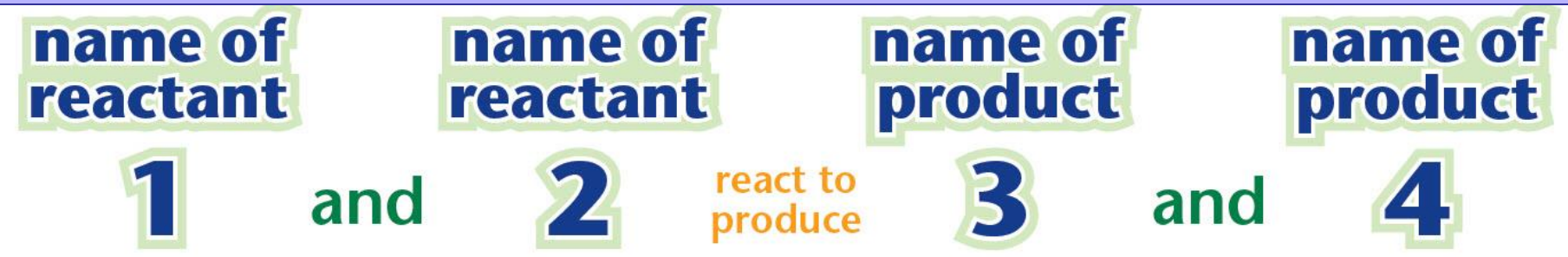
What type of reaction do you think is pictured here?

The four types of chemical reactions can be described using word equations.

Word equations use words instead of chemical formulas to describe what happens to reactants (written on the left) and products (written on the right) during chemical reactions.

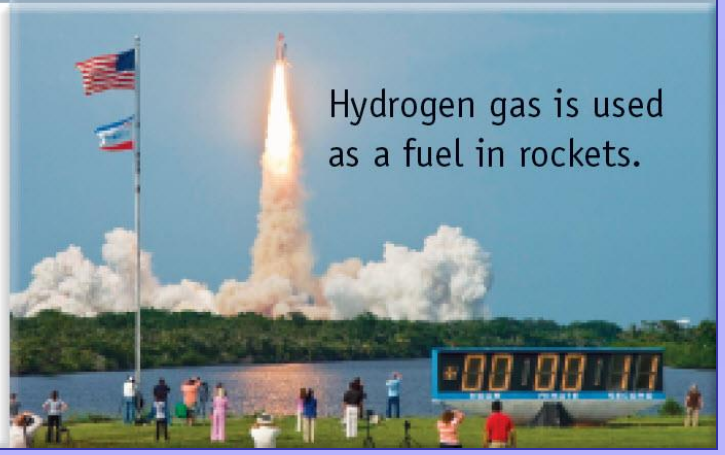


When reading a word equation, "+" signs are replaced with "**and**", and the arrow is read as "**react to produce**".



Synthesis Reactions

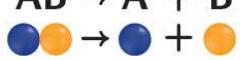
A **synthesis reaction** occurs when two or more reactants combine to produce a new product.

Type of Reaction	Representation of the Reaction	Example
Synthesis reaction • Two or more reactants combine to produce a new product.	A + B → AB  hydrogen + oxygen → water	 Hydrogen gas is used as a fuel in rockets.

What examples of synthesis reactions can you think of?

Decomposition Reactions

A **decomposition reaction** occurs when one compound breaks down ("decomposes") into two or more simpler compounds or elements.

Type of Reaction	Representation of the Reaction	Example
Decomposition reaction • One compound breaks down into two or more simpler compounds or elements.	AB → A + B  water → hydrogen + oxygen	 Oxygen gas is collecting at the top of the left tube and hydrogen gas is collecting at top of the right test tube.

What examples of decomposition reactions can you think of?

Single Displacement Reactions

A **single displacement reaction** occurs when one element takes the place of ("displaces") another element in a compound.

Type of Reaction	Representation of the Reaction	Example
Single displacement reaction • One element takes the place of another element in a compound.	$A + BC \rightarrow AC + B$  $D + BC \rightarrow BD + C$  copper + silver nitrate → copper(II) nitrate + silver	 One of the reactants and one of the products are elements. Silver crystals are forming on the copper coil.

What examples of single displacement reactions can you think of?

Double Displacement Reactions

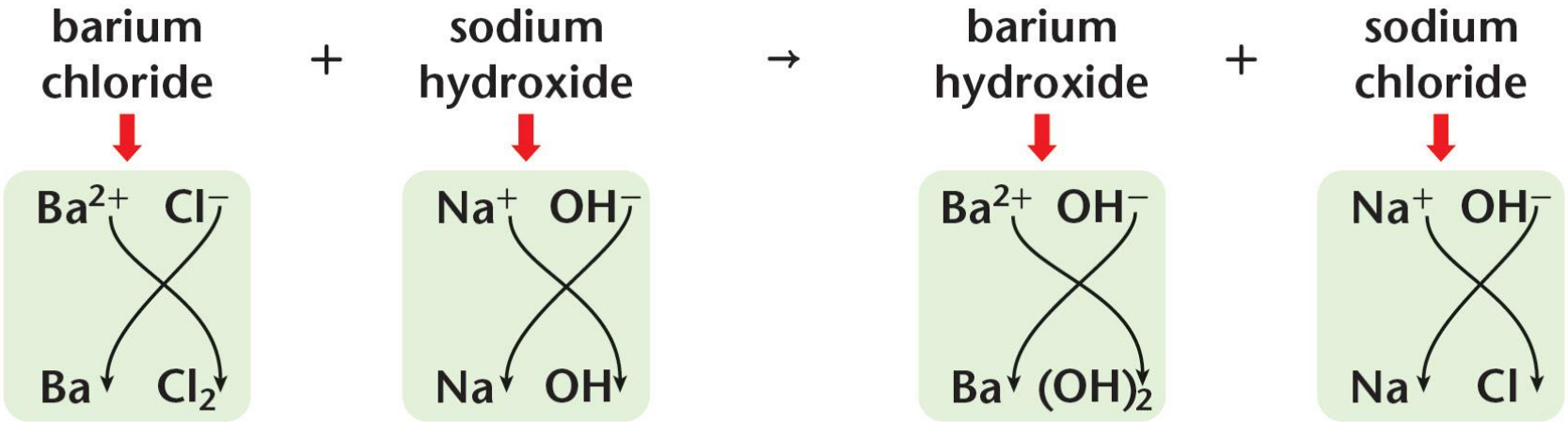
A **double displacement reaction** occurs when the metal ions of two different compounds exchange places ("two displacements occur").

Type of Reaction	Representation of the Reaction	Example
Double displacement reaction • The metal ions of two different compounds exchange places.	$AB + CD \rightarrow AD + CB$  silver nitrate + potassium chromate → silver chromate + potassium nitrate	 A precipitate is often produced in a double-displacement reaction. The silver chromate forms the red precipitate.

What examples of double displacement reactions can you think of?

Chemical reactions can be described using chemical equations.

Chemical equations are equations that use chemical symbols to represent reactants and products in a chemical reaction. Word equations can be converted into chemical equations. An example is shown below.



Note that compounds containing more than one **OH** ion (hydroxide ion) have brackets around the **OH**.

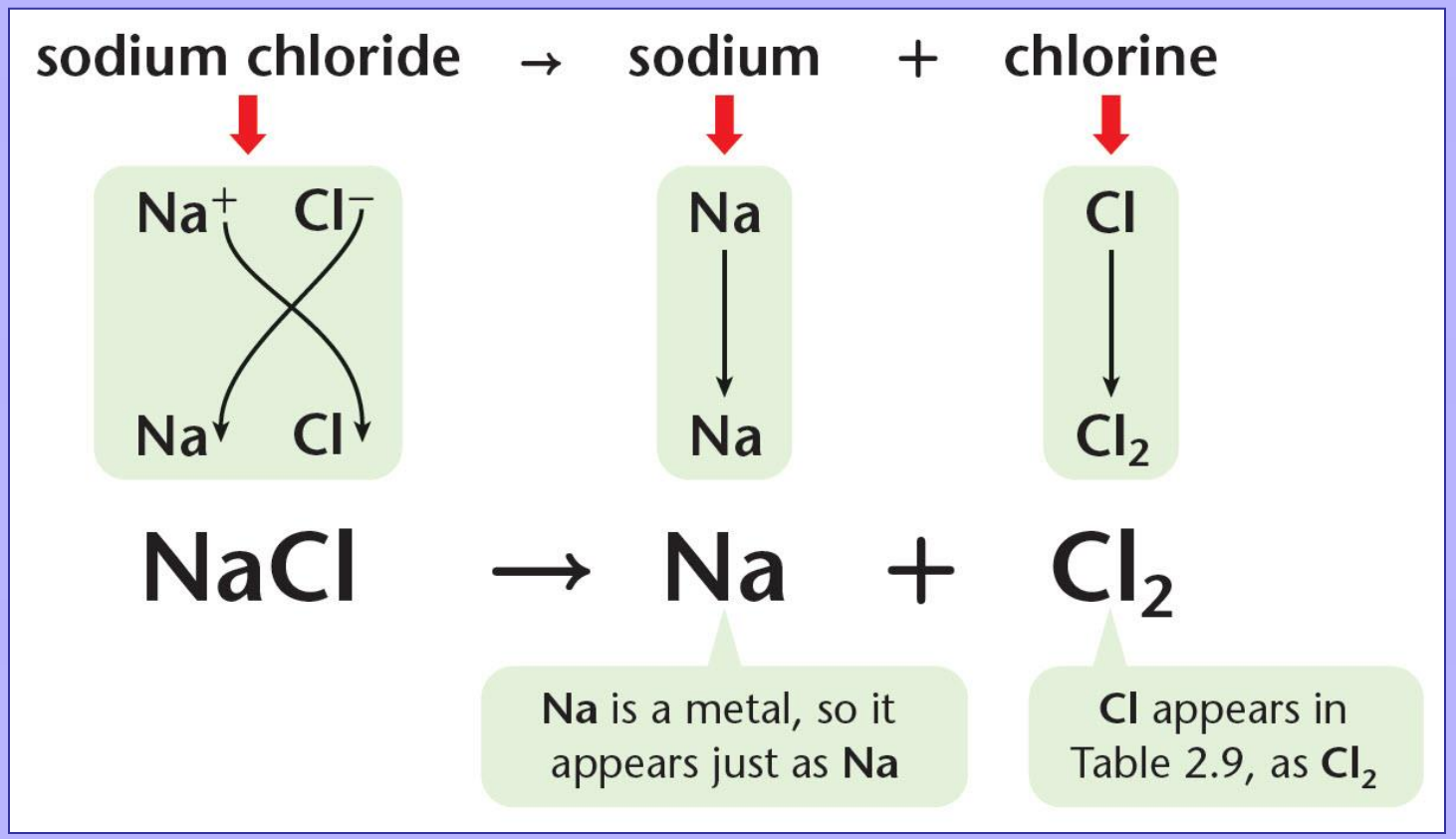
Writing a Chemical Equation for Word Equations That Include Elements

The chemical formulas for most elements are the same as the elements' formulas in the periodic table. However, some non-metal elements are found as molecules that contain more than one atom of the element. These elements are shown in the table below.

Non-metal Element	Found in Nature as	Non-metal Element	Found in Nature as
hydrogen, H	H_2	sulfur, S	S_8
nitrogen, N	N_2	chlorine, Cl	Cl_2
oxygen, O	O_2	selenium, S	Se_8
fluorine, F	F_2	bromine, Br	Br_2
phosphorus, P	P_4	iodine, I	I_2

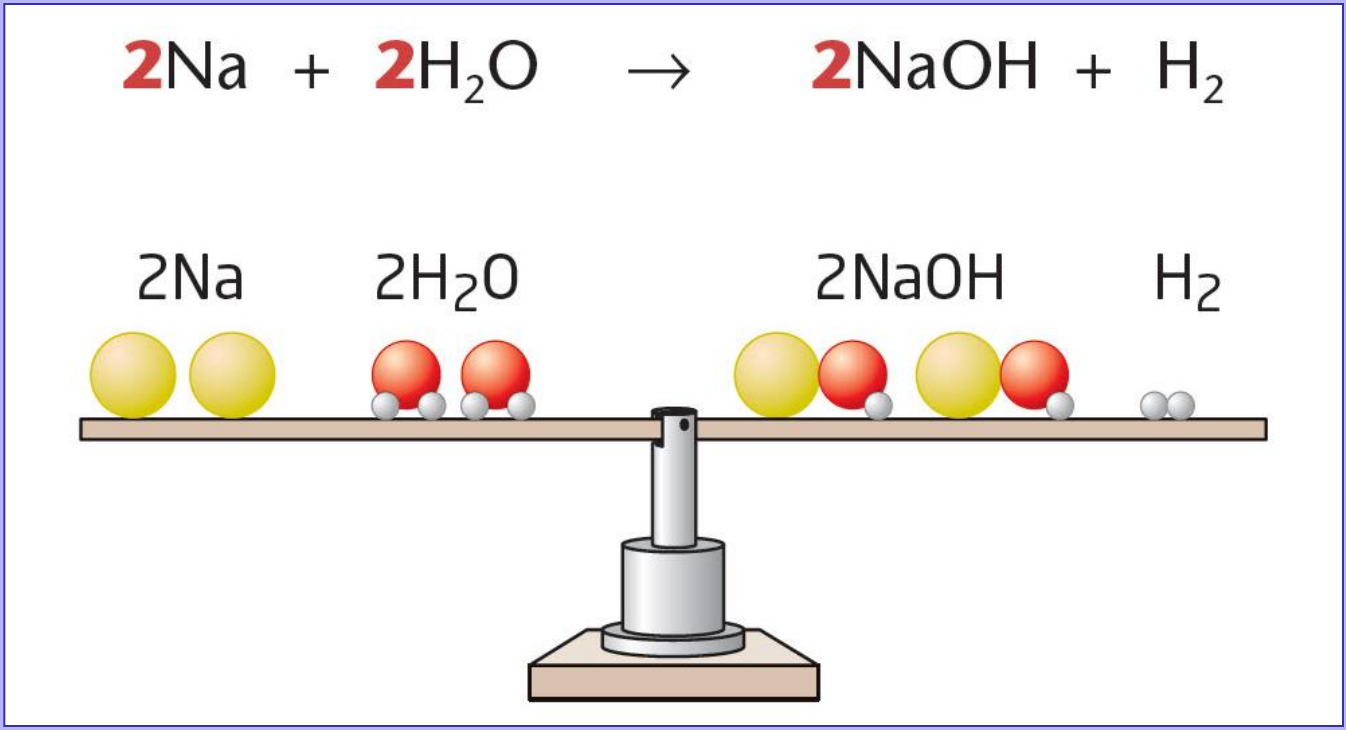
Writing a Chemical Equation for Word Equations That Include Elements

Since chlorine exists in nature as Cl_2 (a molecule with two atoms of chlorine), it must be shown this way when written in a chemical equation.



Atoms and mass are conserved during a chemical reaction.

A **balanced chemical equation** represents a chemical reaction using coefficients (numbers in front of the reactants and products) that tell you how much of the reactants are used and how much of the products are made.



Balancing Chemical Equations

Follow the steps to balance a chemical equation on the next few slides.

Step 1 Make a table with the reactants and products. Count and record how many of each type of atom are on each side of the equation.

$Na + CuCl_2 \rightarrow Cu + NaCl$

Reactants	Products
1 Na	1 Na
1 Cu	1 Cu
2 Cl	1 Cl

Balancing Chemical Equations

Chlorine is unbalanced. Since there are only 2 Cl atoms on the product side, place the coefficient 2 in front of NaCl. (This means that you multiply NaCl by 2.) The coefficient must go in front of the whole compound, because it applies to the Na atoms and the Cl atoms in the whole compound.

Step 2

Identify an unbalanced atom. *Multiply* the compound on the other side of the equation, which contains that atom, by a coefficient to balance this atom in the reaction. Change the numbers in your table to indicate the change.

$$Na + CuCl_2 \rightarrow Cu + \mathbf{2}\ NaCl$$

Reactants	Products
1 Na	**2** Na
1 Cu	1 Cu
2 Cl	**2** Cl

Balancing Chemical Equations

Now sodium is unbalanced. Since there are now 2 Na on the product side and there is only 1 Na on the reactant side, place the coefficient 2 in front of Na on the reactant side. (Multiply Na by 2.)

Step 3 Repeat what you did in step 2 for any other unbalanced atoms, until all the atoms balance.

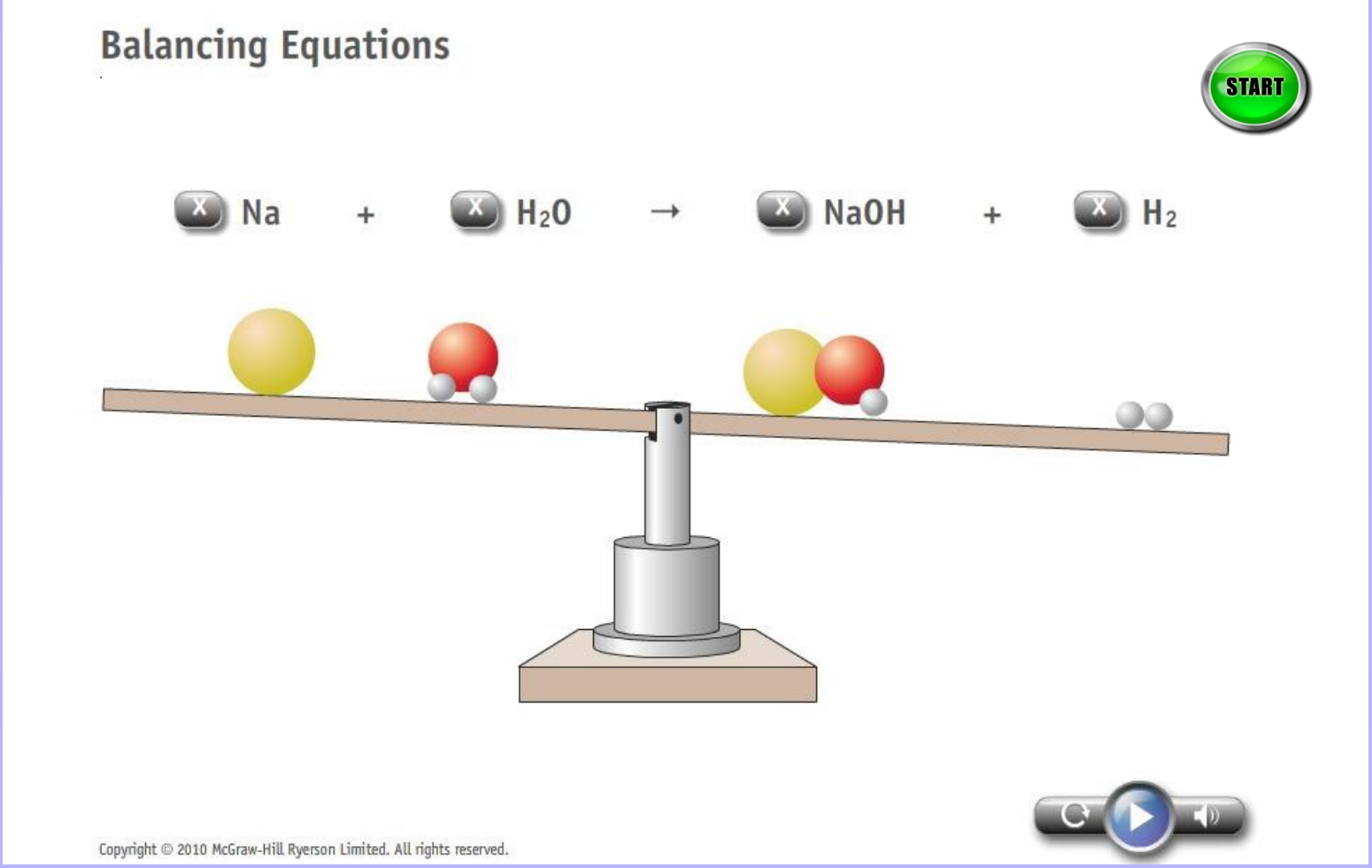
$$2\ Na + CuCl_2 \rightarrow Cu + 2\ NaCl$$

Step 4 Count the atoms on each side of the chemical equation to make sure that they are all balanced.

Reactants	Products
2 Na	**2** Na
1 Cu	1 Cu
2 Cl	**2** Cl

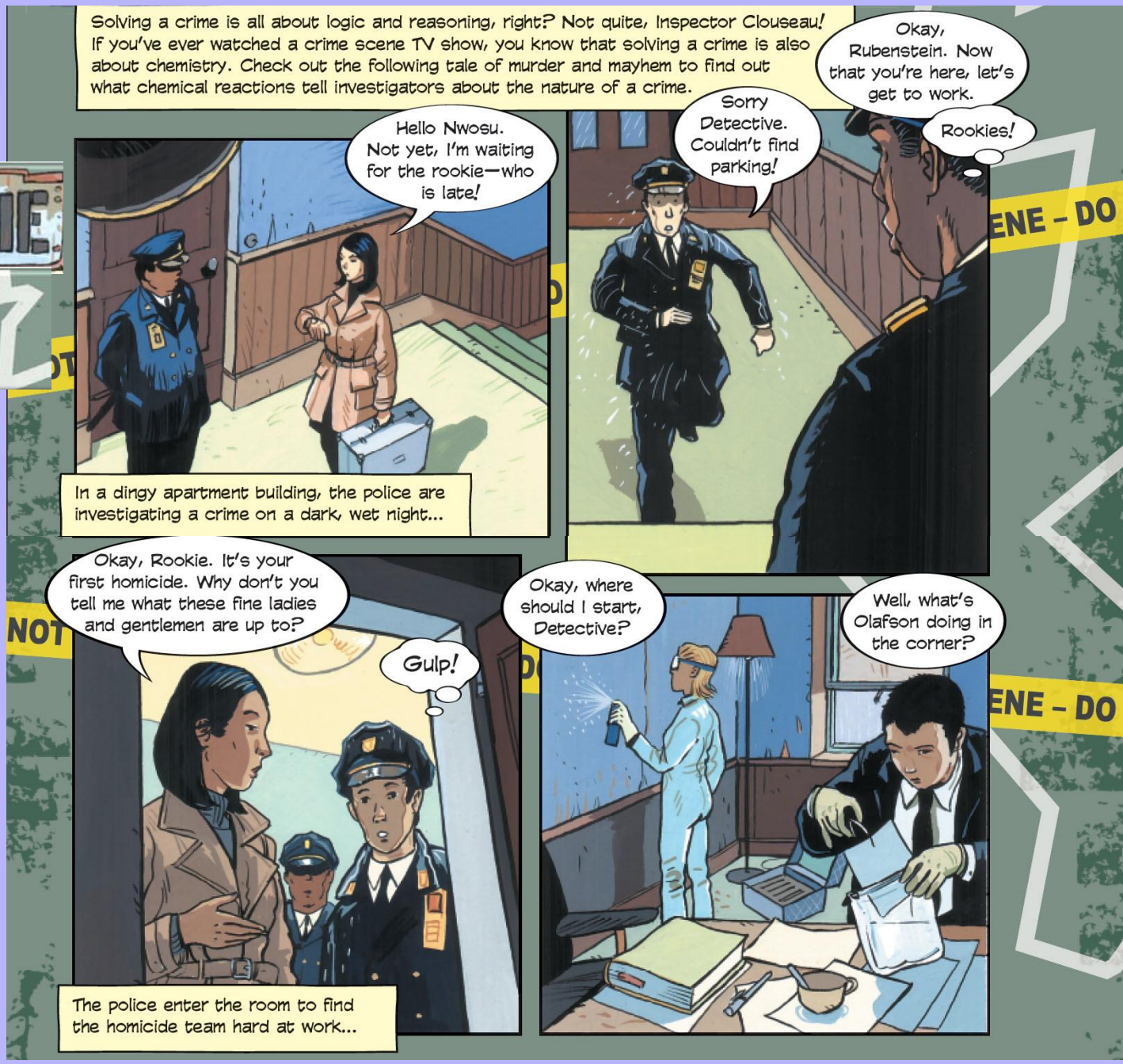
Reviewing Balancing Equations

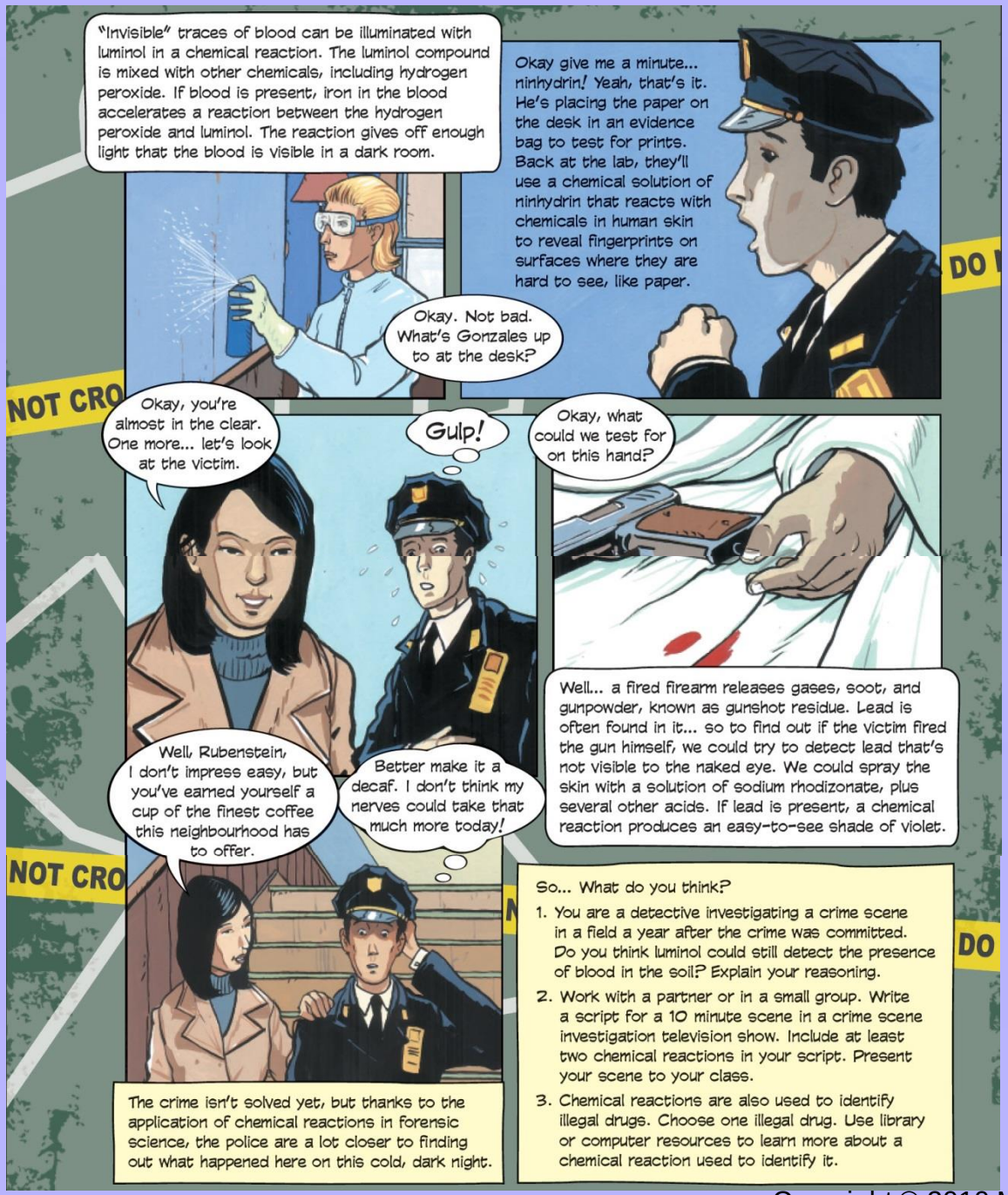
Click the "Start" button to review the process of balancing equations.



Strange Tales of Science

Crime Scene Chemistry





Topic 2.3 Review

Key concepts to be reviewed:

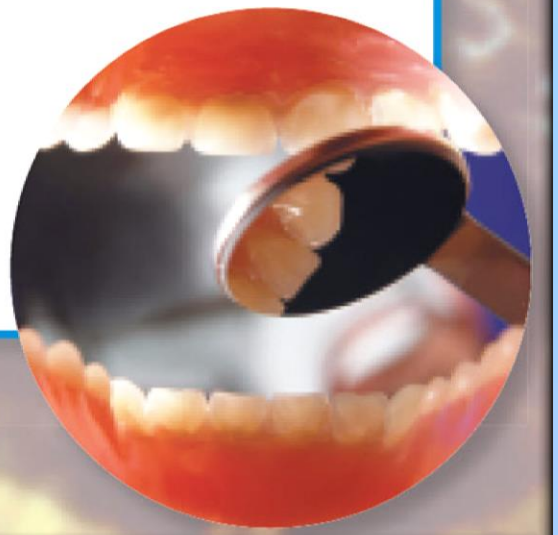
- During a chemical reaction, chemical compounds are changed into different compounds with different properties.
- The four types of chemical reactions can be described using word equations.
- Chemical reactions can be described using chemical equations.
- Atoms and mass are conserved during a chemical reaction.

Topic 2.4 What are acids and bases, and how do they react?

(Pages 158-75)

Key Concepts

- Acids and bases are compounds with specific properties.
- An acid and a base react in a neutralization reaction to produce a salt and water.
- Chemical reactions involving acids, bases, and other compounds require safe handling to minimize hazards.



What are acids and bases, and how do they react?

Many toothpastes, mouthwashes, and water supplies have a compound called sodium fluoride added to them. This compound chemically reacts with the calcium in your teeth to resist the effects of tooth decay.

Acids and bases are compounds with specific properties.

An **acid** is a compound that:

- tastes sour
- corrodes metals and tissue
- turns blue litmus paper red

Name the type of acid represented by each of the images below.

Acids and bases are compounds with specific properties.

An **base** is a compound that:

- tastes bitter
- has a slippery texture
- corrodes tissue
- turns red litmus paper blue

Name the type of base represented by each of the images shown.

Comparing Properties Used to Identify Acids and Bases

Property	Acids	Bases
Taste	taste sour	taste bitter
Texture (feel)	have no characteristic texture	have a slippery texture
Conductivity	conduct electric current when dissolved in water	conduct electric current when dissolved in water
Corrosion	corrode living and once-living tissue, as well as metals	corrode living and once-living tissue
Chemical reaction with metals	are reactive with metals	are not reactive with metals
*Chemical reaction with litmus paper	turn blue litmus paper red	turn red litmus paper blue
*Chemical reaction with each other	lose many of their properties when they react with bases	lose many of their properties when they react with acids

Acid-Base Indicators and the pH Scale

An **acid-base indicator** is a substance that changes colour when added to an acid or a base.

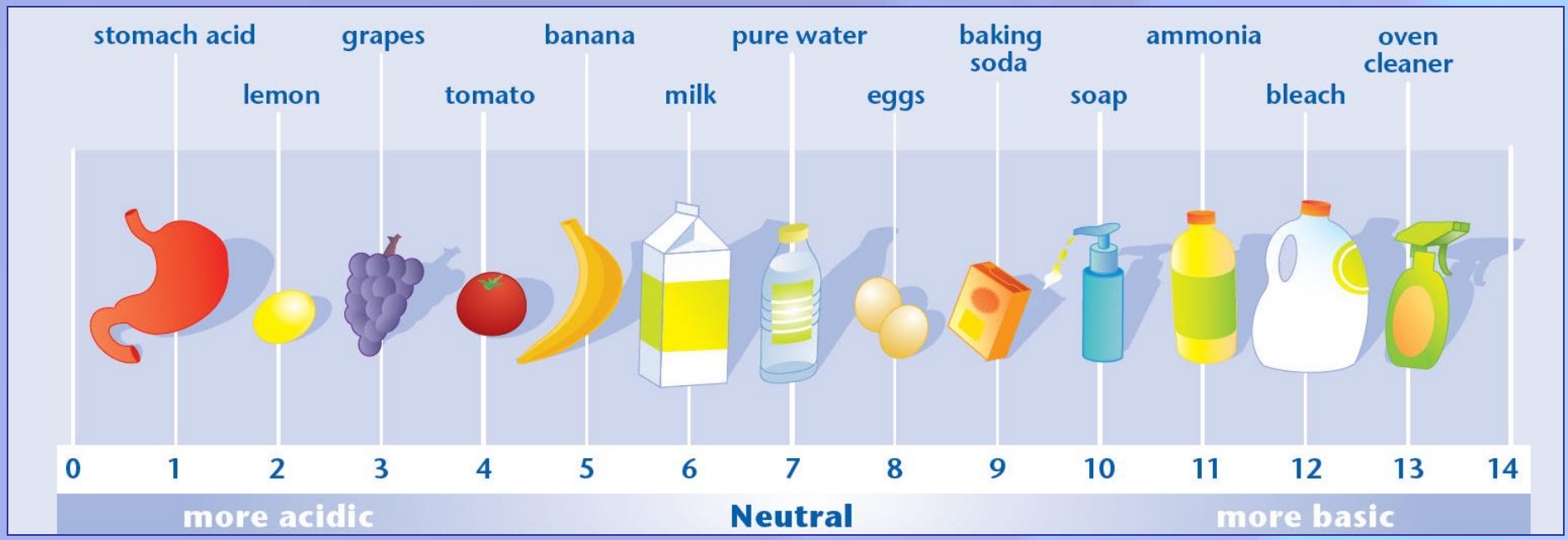
Litmus paper is a type of acid-base indicator that often comes in two colours: red and blue.

- **Acids** turn blue litmus paper red.
- **Bases** turn red litmus paper blue.

The pH Scale

The **pH scale** is a scale from 0 to 14 that describes how acidic or basic a substance is.

- The **lower** the pH number, the **more acidic** a substance is.
- The **higher** the pH number, the **more basic** a substance is.

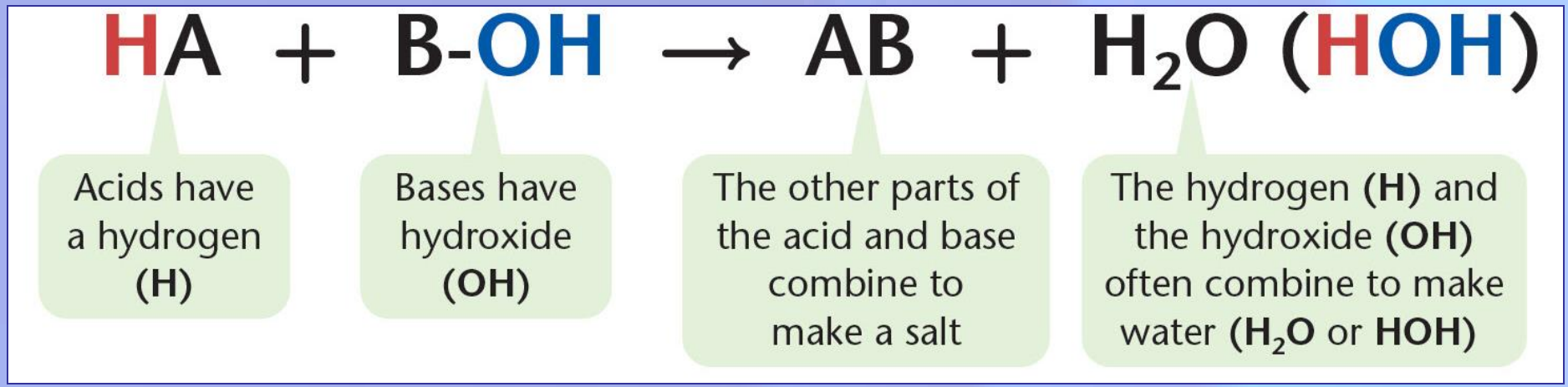


When pH changes by one, the strength of the acid or base changes by ten times.

An acid and a base react in a neutralization reaction to produce a salt and water.

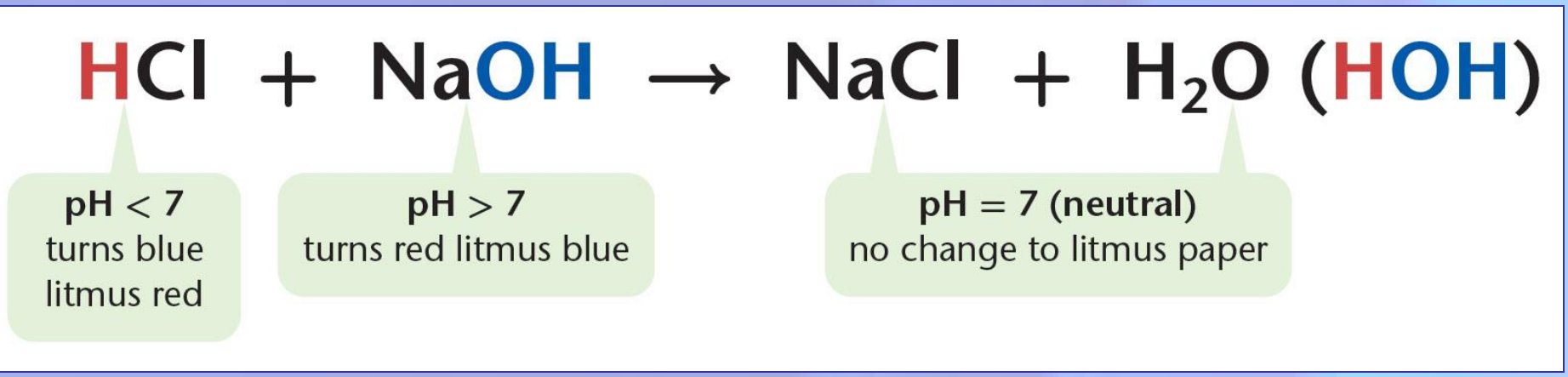
The chemical reaction between an acid and a base is a double displacement reaction. When an acid and base take part in a chemical reaction:

- the hydrogen (**H**) in the acid combines with the hydroxide (**OH**) in the base to form **water** (H_2O).
- the other elements in the acid and base combine to form an ionic compound called a **salt**.



Neutralization Reactions

A **neutralization reaction** is a double displacement reaction between an acid and a base that "neutralizes" (cancels out) their acidic and basic properties.



How would you neutralize an acid that was spilled in the science lab? What if a base was spilled?

Examples of Neutralization Reactions

After eating, people sometimes experience "heartburn" or acid reflux due to an excess of acid being produced in their stomachs. **Antacids** are non-toxic bases that are used to neutralize stomach acid.

People usually take antacids in a "chewable" tablet form or in a liquid form.

Examples of Neutralization Reactions

Large acid spills can be neutralized using an equally large amount of a base such as calcium hydroxide ($Ca(OH)_2$) as shown in the image below.

Examples of Neutralization Reactions

Lakes that have become acidified due to acid rain falling or runoff from acid snowmelt can sometimes be neutralized through the addition of lime.

Chemical reactions involving acids, bases, and other compounds require safe handling to minimize hazards.

Bases and other compounds that are used or produced during chemical reactions can be hazardous to peoples' safety, to the environment, or to both. The images on the following slides show examples of professionals who must know how to handle chemical compounds in their workplaces.

Hair stylist If you read the warnings on hair products from a drugstore, you know how dangerous these products can be if they are not used properly. The products stylists use in a hair salon are more concentrated and must be handled even more carefully. Stylists wear gloves to protect their hands and aprons to protect their clothes.

Reactions involving acids, bases, and other compounds require safe handling to minimize hazards.

Auto body technician The chemicals used in car paint make the paint durable enough to withstand winter road conditions, but they can cause severe damage to skin, eyes, and lungs. Auto body technicians must wear a full-face air-purifying respirator to protect their face and lungs from exposure.

Nail technician Nail technicians are exposed to the chemicals in polish, solvents (nail polish remover), adhesives (for gel and acrylic nails), and the dust formed from polishing. The chemicals that make nails look great can cause both skin irritation and respiratory problems from exposure.

Custodian Some people think the "best" cleaning products are the ones with the most hazard symbols on them! More and more schools and office buildings are switching to "green" cleaning products that not only reduce the environmental impact of cleaning products, but also protect custodians from exposure to dangerous compounds that can harm skin and other body tissues if they are not handled safely.

Reactions involving acids, bases, and other compounds require safe handling to minimize hazards.

Food preparation We use a variety of compounds to sanitize surfaces to protect us from food-borne illnesses caused by bacteria and other microbes. But the same compounds that are toxic to microorganisms are also toxic to us. People who work in food preparation must take care to ensure that their skin doesn't come in contact with the chemicals, that they don't breathe in the fumes, and that all traces are washed away before any food comes into contact with these surfaces after cleaning.

Welder You may have noticed that welders wear eye protection to protect their vision against ultraviolet radiation. Other risks that welders face include exposure to metal fumes and the possibility of an explosion. A balloon filled with acetylene, a common welding fuel, has the explosive power of 20 sticks of dynamite!

Reactions involving acids, bases, and other compounds require safe handling to minimize hazards.

Firefighter Firefighters not only fight fires, but also battle spills from industrial and automobile accidents. The compounds spilled may be any combination of toxic, flammable, or hazardous—including acids and bases. They must be prepared to protect themselves, the people nearby, and the environment, from the hazardous effects. They wear heat and chemical-resistant clothing, and have breathing apparatus if needed. When possible, they will use other chemical products to help neutralize or clean up the spill.

Topic 2.4 Review

Key concepts to be reviewed:

- Acids and bases are compounds with specific properties.
- An acid and a base react in a neutralization reaction to produce a salt and water.
- Chemical reactions involving acids, bases, and other compounds require safe handling to minimize hazards.