Physical Science

Corbin

Week 3 & 4

Chemistry

Section 1

Periodic Table of Elements

atomic mass → 1.00794
element name → hydrogen
symbol → **H**
atomic number → 1

1.00794 hydrogen **H** 1																	4.0026 helium **He** 2
6.941 lithium **Li** 3	9.012 beryllium **Be** 4											10.811 boron **B** 5	12.0107 carbon **C** 6	14.00674 nitrogen **N** 7	15.9994 oxygen **O** 8	18.9984 fluorine **F** 9	20.1797 neon **Ne** 10
22.98977 sodium **Na** 11	24.3050 magnesium **Mg** 12											26.9815 aluminium **Al** 13	28.0855 silicon **Si** 14	30.9737 phosphorus **P** 15	32.065 sulfur **S** 16	35.453 chlorine **Cl** 17	39.984 argon **Ar** 18
39.0983 potassium **K** 19	40.078 calcium **Ca** 20	44.95591 scandium **Sc** 21	47.867 titanium **Ti** 22	50.9415 vanadium **V** 23	51.9961 chromium **Cr** 24	54.938 manganese **Mn** 25	55.845 iron **Fe** 26	58.9332 cobalt **Co** 27	58.6934 nickel **Ni** 28	63.546 copper **Cu** 29	65.409 zinc **Zn** 30	69.723 gallium **Ga** 31	72.64 germanium **Ge** 32	74.9216 arsenic **As** 33	78.96 selenium **Se** 34	79.904 bromine **Br** 35	83.798 krypton **Kr** 36
85.4678 rubidium **Rb** 37	87.62 strontium **Sr** 38	88.90585 yttrium **Y** 39	91.225 zirconium **Zr** 40	92.90638 niobium **Nb** 41	95.94 molybdenum **Mo** 42	[98] technetium **Tc** 43	101.07 ruthenium **Ru** 44	102.9055 rhodium **Rh** 45	106.42 palladium **Pd** 46	107.8682 silver **Ag** 47	112.411 cadmium **Cd** 48	114.818 indium **In** 49	118.710 tin **Sn** 50	121.760 antimony **Sb** 51	127.60 tellurium **Te** 52	126.9045 iodine **I** 53	131.293 xenon **Xe** 54
132.905 cesium **Cs** 55	137.327 barium **Ba** 56	174.967 lutetium **Lu** 71	1.00794 hafnium **Hf** 72	180.9479 tantalum **Ta** 73	183.84 tungsten **W** 74	186.207 rhenium **Re** 75	190.23 osmium **Os** 76	192.217 iridium **Ir** 77	195.078 platinum **Pt** 78	196.9665 gold **Au** 79	200.59 mercury **Hg** 80	204.383 thallium **Tl** 81	207.2 lead **Pb** 82	208.980 bismuth **Bi** 83	[209] polonium **Po** 84	[210] astatine **At** 85	[222] radon **Rn** 86
[223] francium **Fr** 87	[226] radium **Ra** 88	[262] lawrencium **Lr** 103	[261] rutherfordium **Rf** 104	[262] dubnium **Db** 105	[266] seaborgium **Sg** 106	[264] bohrium **Bh** 107	[269] hassium **Hs** 108	[268] meitnerium **Mt** 109	[271] darmstadtium **Ds** 110	[272] roentgenium **Rg** 111	[285] ununbium **Uub** 112		[289] ununquadium **Uuq** 114				

138.9055 lanthanum **La** 57	140.116 cerium **Ce** 58	140.90765 praseodymium **Pr** 59	144.24 neodymium **Nd** 60	[145] promethium **Pm** 61	150.36 samarium **Sm** 62	151.964 europium **Eu** 63	157.25 gadolinium **Gd** 64	158.9253 terbium **Tb** 65	162.50 dysprosium **Dy** 66	164.930 holmium **Ho** 67	167.259 erbium **Er** 68	168.934 thulium **Tm** 69	173.04 ytterbium **Yb** 70
[227] actinium **Ac** 89	232.038 thorium **Th** 90	231.0359 protactinium **Pa** 91	238.0289 uranium **U** 92	[237] neptunium **Np** 93	[244] plutonium **Pu** 94	[243] americium **Am** 95	[247] curium **Cm** 96	[247] berkelium **Bk** 97	[251] californium **Cf** 98	[252] einsteinium **Es** 99	[257] fermium **Fm** 100	[258] mendelevium **Md** 101	[259] nobelium **No** 102

Chemistry

Lexile

Chemistry is the physical science that deals with the composition, structure, and properties of substances and also the transformations that these substances undergo. Because the study of **chemistry** encompasses the entire material universe, it is central to the understanding of other sciences.

A basic chemical theory has been formulated as the result of centuries of observation and measurement of the various elements and compounds (see **chemistry**, history of). According to this theory, matter is composed of minute particles called atoms. The more than 100 different kinds of atoms that are known are called chemical elements. Atoms of the same element or of different elements can combine together to form molecules and chemical compounds. The atoms are held together by forces, primarily electrostatic, called chemical bonds. In a chemical reaction two or more molecules can undergo various changes to form different molecules by means of breaking and making the chemical bonds.

Branches of Chemistry

Five subdivisions traditionally are used to classify various aspects of **chemistry**. The study of organic **chemistry** originally was limited to compounds that were obtained from living organisms, but now the field deals with hydrocarbons (compounds of carbon and hydrogen) and their derivatives. The study of inorganic **chemistry** includes compounds derived from all of the elements except for hydrocarbons. Biochemistry is the subdivision in which the compounds and chemical reactions involved in processes of living systems are studied.

Physical **chemistry** deals with the structure of matter and the energy changes that occur during physical and chemical changes of matter. This field provides a theoretical basis for the chemical observations of the other subdivisions. Analytical **chemistry** is concerned with the identification of chemical substances, the determination of the amounts of substances present in a mixture, and the separation of mixtures into their individual components.

Special subdivisions of **chemistry** are now recognized that account for knowledge at the interface of **chemistry** and other physical sciences. For example, recent research has involved the chemical origin of life—reactions between simple molecules at low pressures to form such complex organic molecules as proteins found in living organisms.

Astrochemistry is the interdisciplinary physical science that studies the origin and interaction of the chemical constituents, especially interstellar matter, in the universe. Geochemistry is concerned with the chemical aspects of geology—for instance, the improvement of ore processing, coal utilization, shale oil recovery—and the use of chemicals to extract oil from wells that are considered dry by ordinary standards.

Nuclear **chemistry** deals with natural and induced transformations of the atomic nucleus. Studies in this field now center on the safe and efficient use of nuclear power and the disposal of nuclear wastes. Radiochemistry deals with radioactive isotopes of chemical elements and the utilization of those isotopes to further the understanding of chemical and biochemical systems. Environmental **chemistry** is a subdivision that has as its subject the impact of various elements and compounds on the ecosphere.

Tools of Chemistry

Chemistry is a precise laboratory science, and the equipment of a chemical laboratory is usually involved with measurement. Balances are used to measure mass, pipettes and burettes to measure volume, colorimeters to measure color intensities, and thermometers to measure temperature changes. Advances in electronics and computer technology have enabled the development of scientific instruments that determine the chemical properties, structure, and content of substances accurately and precisely.

Most modern chemical instrumentation has three primary components: a source of energy, a sample compartment within which a substance is subjected to the energy, and some sort of detector to determine the effect of the energy on the sample. An X-ray diffractometer, for instance, enables the chemist to determine the arrangement of atoms, ions, and molecules that constitute crystals by means of scattering X rays (see X-ray diffraction). Most modern laboratories contain ultraviolet, visible, and infrared spectrophotometers, which use light of various wavelengths on gaseous or liquid samples. By such a means the chemist can determine the electron configuration and the arrangement of atoms in molecules. A nuclear magnetic resonance spectrophotometer subjects a sample in a strong magnetic field to radio frequency radiation. The absorption of this energy by the sample gives the chemist information concerning the bonding within molecules. Other instruments include mass spectrometers, which use electrons as an energy source, and differential thermal analyzers, which use heat.

An entirely different class of instruments are those which use chromatography to separate complex mixtures into their components. Chemists are also using extremely short pulses of laser light to investigate the atomic and molecular processes taking place in chemical reactions at the microsecond level. These and other devices generate so much data that chemists frequently must use computers to help analyze the results.

Impact On Society

Chemistry is closely associated with four basic needs of humans: food, clothing, shelter, and medical services. The applications of **chemistry** usually bring to mind industries engaged in the production of chemicals. A significant portion of the chemical industry is engaged in the production of inorganic and organic chemicals, which are then used by other industries as reactants for their chemical processes. In the United States the great majority of the leading chemicals being produced are inorganic, and their manufacture is a multibillion-dollar industry.

The **chemistry** of polymers—large molecules made up of simple repeating units linked together by chemical bonds (see polymerization)—includes plastics, resins, natural and synthetic rubber, synthetic fibers, and protective coatings. The growth of this segment of **chemistry** has been phenomenal since the late 1930s. The fabrication of natural rubber and coatings (paints, varnishes, lacquers, and enamels) derived from natural agricultural products has been a mainstay of the chemical industry for more than 150 years.

The search for new energy sources and the improvement of existing ones are in many ways chemical problems (see fuel). At the heart of the petroleum industry are the processes of refining crude hydrocarbons into such products as gasoline and petrochemicals. The utilization of nuclear power depends heavily on the chemical preparation and reprocessing of fuel, the treatment and disposal of nuclear waste, and the problems of corrosion and heat transfer. The conversion and storage of solar energy as electrical energy is primarily a chemical process, and the development of fuel cells is based on either chemical or electrochemical technology (see electrochemistry).

Chemical research has been the basis of the pharmaceutical industry's production of drugs. The controlled introduction of specific chemicals into the body assists in the diagnosis, treatment, and often the cure of illness. Chemotherapy is a prime treatment in combating cancer.

Tremendous agricultural gains have been achieved since about 1940 as a result mainly of farmers' use of chemical fertilizers and pesticides. Other chemical industries include soap and detergent production; food processing; and the production of glass, paper, metals, and photographic supplies.

Specialized Uses

Outside the mainstream of what is traditionally considered **chemistry** is research that supports other professions. **Chemistry** is used by museums in art conservation and restoration, the dating of objects (see radiometric age-dating), and the uncovering of frauds. Forensic chemists work in crime laboratories, carrying out tests to assist law-enforcement agencies (see forensic science; forensic genetics). Toxicologists study the potentially adverse effects of chemicals on biological systems (see toxicology), as do those involved in industrial hygiene. The **chemistry** involved in sanitary engineering and sewage treatment has come to be of major importance to society as populations increase and environmental concerns intensify.

Problems

Through the use of **chemistry** and related technology, chemical substances have been produced that either immediately or eventually are harmful to humans, animals, and the environment. Pollution is not a new problem, but the combination of a rapidly growing chemical industry and the use of sophisticated detection devices has brought the extent of pollution to public attention.

The discharge and disposal of industrial waste products into the atmosphere and water supply, for example, at Love Canal, have caused grave concern about environmental deterioration (see pollution, air; pollution, water). The repeated exposure of workers to some toxic chemicals at their jobs has caused long-range health problems (see diseases, occupational). In addition, the use of some pesticides and herbicides can cause long-term toxicity, the effects of which are still only partially understood. The safe storage and disposal of chemical and biological warfare agents and nuclear waste continue to be a serious problem. An advance in chemical technology almost always involves some trade-off with regard to an alteration of the environment.

Challenges and Trends

Much of the future of **chemistry** will lie in providing answers to such technological problems as the creation of new sources of energy and the eradication of disease, famine, and environmental pollution. The improvement of the safety of existing chemical products, for example, pesticides, is another challenge. Research into the chemical complexities of the human body may reveal new insights into a variety of diseases and dysfunctions. The improvement of industrial processes will serve to minimize the use of energy and raw materials, thereby diminishing negative environmental effects.

Norman V. Duffy

Further Reading:

American Chemical Society Staff ***Chemistry*** *in Context3d ed.* (2000).

Brown, Theodore L. ***Chemistry:*** *The Central Science8th ed.* (1999).

Hall, Ninaed. *The New* ***Chemistry*** (2001).

Hunt, Andrew *Dictionary of* ***Chemistry*** (1999).

Kelter, Paul ***Chemistry:*** *A World of Choices* (1999).

Sterner, Olof ***Chemistry,*** *Health, and Environment* (1999).

Williams, Robert Joseph Paton, and Frusto Da Silva, J. J. R. *Bringing* ***Chemistry*** *to Life: From Matter to Man* (1999).

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ELEMENTAL SYMBOLS

Provide the chemical symbols for the elements listed below.

1	bromine	______	11	lead	______
2	calcium	______	12	magnesium	______
3	carbon	______	13	manganese	______
4	chlorine	______	14	neon	______
5	copper	______	15	nitrogen	______
6	fluorine	______	16	phosphorus	______
7	Gold	______	17	potassium	______
8	helium	______	18	silver	______
9	hydrogen	______	19	sodium	______
10	iron	______	20	sulfur	______

Provide the name for the element corresponding to the chemical symbols below.

21	Ag	______	31	I	______
22	Al	______	32	K	______
23	Au	______	33	Na	______
24	C	______	34	Ni	______
25	Ca	______	35	O	______
26	Cu	______	36	P	______
27	F	______	37	Pb	______
28	Fe	______	38	S	______
29	H	______	39	Sn	______
30	Hg	______	40	Zn	______

Water Mixtures, Types of

Lexile

Chemists marvel at water's ability to dissolve other substances. Seawater contains over 70 elements dissolved in mineral form. This has earned water the somewhat-exaggerated title of "universal solvent." Water can also speed reactions between the chemicals dissolved in it. Many of these reactions would never take place in its absence.

Water in Mixtures

Pure water contains only water molecules. Each molecule consists of two hydrogen atoms bonded to one oxygen atom.

More commonly, water contains other substances. In other words, it is part of a mixture. There are several types. In homogeneous **mixtures**, one cannot see different components. Such **mixtures** look uniform. In heterogeneous **mixtures**, one can see distinct particles.

Heterogeneous **mixtures** include suspensions. In suspensions, particles can settle out of the mix. Muddy water is an example. It consists of soil particles that can settle, leaving the water clear.

Homogeneous **mixtures** include colloids and solutions. In a colloid, one substance disperses completely into another. The particles become too small to see. But they are large enough to scatter light. Thus, colloids are cloudy.

Blood is a colloid. It consists of cells and other substances dispersed in plasma. Plasma is mostly water.

In solutions, the different components are mere molecules. The most-abundant ingredient is called the solvent. The less-abundant ingredients are solutes. Sugar water is a solution. Water is the solvent, and sugar is the solute.

The solute molecules are too small to scatter light. Thus, solutions are clear. But they may be colored.

Water as a Solvent

As mentioned, water is a remarkable solvent. This quality traces to the water molecule's structure. Each molecule's oxygen end has a slightly negative charge. At the opposite end, its hydrogen atoms have a slightly positive charge. This turns each water molecule into a tiny magnet. It enables water to pull apart many compounds. Salts are good examples. They consist of positively charged and negatively charged ions. Water attracts these charged ions to its opposite poles. As a result, salts dissolve readily in water.

Rain and runoff remove salts and other minerals from soil and rocks. Rivers carry these dissolved minerals to the ocean. There, they concentrate to make seawater salty. Groundwater also delivers dissolved minerals to the roots of plants.

Water can also dissolve gases. Fish extract dissolved oxygen gas when they breathe underwater. Water carries away their exhaled carbon dioxide.

Concentration

Solutions come in different concentrations. Concentration refers to the amount of solute dissolved in the solvent. A dilute solution has a relatively small amount of solute. A concentrated solution has a relatively large amount. Sugar water is a familiar example. It consists of sugar dissolved in water. Extremely sweet sugar water has a higher sugar concentration than slightly sweet sugar water.

Saturation

Water can dissolve only so much of a substance. A cup of tea, for example, dissolves only so much sugar. Add more, and the extra settles to the bottom. Similarly, only so much salt will dissolve in a given amount of water. A solution that is holding all the solute it can hold is called saturated. Further solute will not dissolve.

Heat increases water's saturation point. One sees this in everyday life. One can dissolve more salt or sugar in hot liquids than in cold ones.

Sometimes, one can create supersaturated solutions. Mix sugar in hot water. When the water cools, it holds more sugar than it normally would at room temperature. But supersaturated solutions are unstable. Disturb it and the extra solute may come out of solution.

Solubility of Substances in Water

Solubility is the extent to which one substance will dissolve in another. For instance, 36 grams of salt will dissolve in 100 grams of water at room temperature. Two substances are called insoluble if they will not form a solution. Oil, for example, is insoluble in water.

Like Dissolves Like

Water is a polar molecule. It readily dissolves other polar substances.

Temperature and Solubility

As mentioned, heat increases water's ability to dissolve solids such as salt and sugar. This is because heat energy helps solids break apart.

By contrast, gases become less soluble with increasing temperature. Gas molecules must slow down, or lose energy, to enter liquid. Heat only encourages them to break free.

What about the solubility of liquids in liquids? Temperature changes have little effect either way.

Pressure and Solubility

Increased pressure encourages gases to dissolve in water. This is why we keep soda bottles capped tightly. The cap prevents gas from escaping. This increases pressure inside the bottle. The increased pressure, in turn, keeps more bubbles dissolved in the water. When we open the bottle, gas escapes and pressure decreases. We see the fizz of gas rushing out of solution.

Chemical Properties of Water

Water reacts differently with different substances. Many metals react with water. At the extreme, metallic sodium can produce explosive reactions in water at room temperature.

Many common compounds react with water to form acids or bases. Water reacts with carbon dioxide to produce carbonic acid. This weak acid is found in blood and other body fluids. Calcium oxide and water combine to form calcium hydroxide. This base is used in plasters and cement.

Water also reacts with many salts. Water and ammonium chloride form an acidic solution. Water and sodium carbonate form a basic solution. Water and sodium chloride (table salt) produce a neutral solution.

Water can also form unique compounds called hydrates. The blue crystals of copper sulfate pentahydrate are a beautiful example. Inside each crystal, every copper sulfate molecule is surrounded by five water molecules.

Substances Found in Water

Because it is such a good solvent, water is seldom found in pure form in nature. As mentioned, seawater contains many kinds of mineral salts. Fresh water contains these same salts in smaller quantities. Both fresh and ocean water contain dissolved oxygen.

Other dissolved substances are not so desirable. Water can become polluted by animal, human, and industrial waste. Fortunately, nature continually filters and purifies water. Soil is especially good at filtering groundwater clean. But natural purification methods are no match for the waste of modern industries and populations. Today, most communities need sewer-treatment and water-purification plants.

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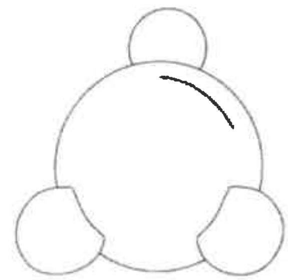
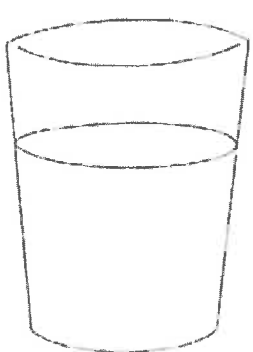
SUBSTANCES AND MIXTURES

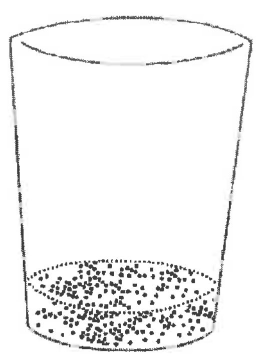


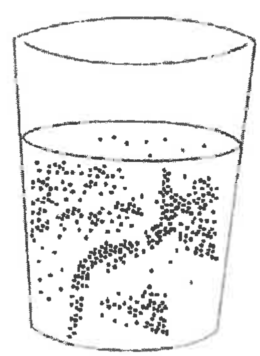
If a specific chemical formula can be written for a material can be provided (e.g., elements or compounds), the material is called a "substance." Other materials in which the components or parts are not chemically boned are termed "mixtures."

In the table below, classify the following materials as substances or mixtures by writing S or M respectively in the empty boxes.

1	air		11	milk	
2	alcohol		12	nail polish	
3	blood		13	nitrogen	
4	cake batter		14	oxygen	
5	carbon dioxide		15	salt water	
6	coffee		16	sodium	
7	cola		17	soil	
8	eggs		18	soup	
9	ice cream		19	table salt	
10	iron		20	water	







chapter 19

Chemical Reactions

section 1 Chemical Changes

What You'll Learn
- how to identify the reactants and products in a chemical reaction
- how a chemical reaction follows the law of conservation of mass
- how chemists describe chemical changes with equations

Study Coach

Create a Quiz As you read this section, write the headings that ask questions. Write questions you have about the main ideas and the vocabulary terms. After you read, make your questions into a quiz.

FOLDABLES™

A Ask Questions Make a Foldable like the one shown. As you read the section, answer the questions about Antoine Lavoisier and his experiments.

Before You Read

Think about what happens when you bake a cake. On the lines below, describe how the ingredients change form throughout the process of baking a cake.

____

____

____

Read to Learn

Describing Chemical Reactions

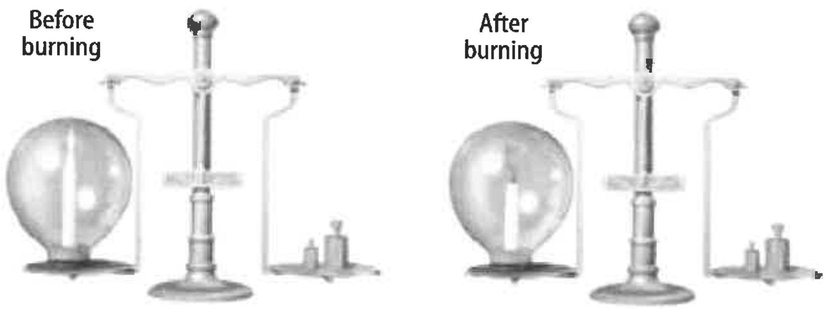
Dark, mysterious mixtures react. Gases bubble up and expand out of liquids. Powerful aromas move through the air. Are you in a chemistry lab? No. You are in your kitchen baking a chocolate cake. Many chemical reactions occur in the kitchen.

Chemical reactions take place everywhere. They even happen inside your body. A **chemical reaction** is a change in which one or more substances are converted into new substances. A **reactant** is one of the substances that react. A **product** is one of the new substances that are produced. You can describe a chemical reaction as follows:

$$\text{reactants} \xrightarrow{\text{produce}} \text{products}$$

Conservation of Mass

By the 1770s, chemistry was changing from an art to a science. Scientists began to study chemical reactions more carefully. The French chemist Antoine Lavoisier discovered an important rule. He found that the total mass of the products of a chemical reaction always equals the mass of the reactants. This is called the conservation of mass.



The figures above show an experiment he performed. The mass of the candle and the air in the jar (the reactants) before burning is the same as the mass of the gases and the candle (the products) after burning.

What were Lavoisier's experiments?

Lavoisier wanted to know exactly what happened when substances changed form. To answer this question, he experimented with mercury. He put solid mercury(II) oxide, a red powder, in a sealed container. He found the mass of the reactant in the container. When he heated the container, the mercury(II) oxide changed to a silvery liquid. It also gave off a gas. The silvery liquid was the metal mercury. He then found the mass of the products in the container again. It was the same as the mass before the experiment. ✔

mercury(II) oxide		oxygen	plus	mercury
10g	=	0.3g	+	9.7g

Lavoisier also figured out that the gas produced in the experiment, oxygen, was a part of air. He did this by heating mercury metal with air. He saw that a portion of the air combined with mercury to make mercury(II) oxide. He studied the effect of oxygen on living animals and humans.

Lavoisier did hundreds of experiments in his laboratory. He confirmed that in a chemical reaction, matter is not created or destroyed, but is conserved. This principle is known as the law of conservation of mass. This means that the total starting mass of the reactants of a chemical reaction always equals the total final mass of the products.

Why is Lavoisier called the father of modern chemistry?

Lavoisier's explanation of the law of conservation of mass started modern science. He also was the first to describe a chemical reaction called combustion. These discoveries are why Lavoisier is called the father of modern chemistry.

Picture This

1. **Compare** How does the height of the right side of the scale in the first figure compare to the height of the right side of the scale in the second figure?

____

____

✔ Reading Check

2. **Identify** What did Lavoisier find about the mass of the container with reactants and the mass of the container with products in his experiment with mercury(II) oxide?

____

____

____

Think it Over

3. **Draw Conclusions** Imagine that chemists did not use the same rules to name compounds. How might this cause problems for a chemist who was trying to repeat an experiment done by the first chemist?

____

____

____

Picture This

4. **Summarize** What does the symbol (*g*) placed next to a compound in a chemical equation mean?

____

____

Applying Math

5. **Explain** What do you notice about the numbers on the left side of the arrow and the numbers on the right side of the arrow in the chemical equation?

____

____

Why are names important?

Scientists needed better ways to describe their ideas. Lavoisier wanted to improve the way elements and compounds were named. He knew that if all chemists used the same names for elements and compounds, they could understand one another better. In 1787, Lavoisier and several other scientists wrote the first instructions for naming compounds. Since then, the guidelines have continued to evolve. In 1919, an organization was formed to coordinate guidelines for naming compounds. It is called the International Union of Pure and Applied Chemistry (IUPAC).

Writing Equations

It is important to include all the information when you describe a chemical reaction. What were the reactants? What did you do with them? What happened when they reacted? What were the products? When you answer all these questions, the description of the reaction can be quite long.

Scientists have a shortcut for describing chemical reactions. A **chemical equation** is a way to describe a chemical reaction using chemical formulas and other symbols. Some of the symbols used in chemical equations are shown in the table.

Symbols Used in Chemical Equations

Symbol	Meaning	Symbol	Meaning
→	produces or forms	(*aq*)	Aqueous; a substance is dissolved in water.
+	plus	heat →	The reactants are heated.
(*s*)	solid	light →	The reactants are exposed to light.
(*l*)	liquid	elec. →	An electric current is applied to the reactants.
(*g*)	gas		

Look at this description of a chemical reaction:

Nickel(II) chloride, dissolved in water, plus sodium hydroxide, dissolved in water, produces solid nickel(II) hydroxide plus sodium chloride, dissolved in water.

If you use a chemical equation, the same description is shorter and easier to understand as:

$$NiCl_2(aq) + 2NaOH(aq) \rightarrow Ni(OH)_2(s) + 2NaCl(aq)$$

Coefficients

Look again at the chemical equation on the previous page. What do the numbers to the left of NaOH and NaCl mean? Do you remember the law of conservation of mass? Matter is not made or lost in a chemical reaction. Atoms are rearranged, but they are never created or destroyed. The numbers in the equation are called coefficients. A **coefficient** shows the number of units of a substance taking part in a reaction.

Suppose you were going to make sandwiches for a picnic. You know that each sandwich needs two slices of bread, one slice of turkey, one slice of cheese, two slices of tomato, and one leaf of lettuce. If you also know how many sandwiches you need to make, you can figure out how much bread, turkey, cheese, tomato, and lettuce you need to buy so you do not have any food left over.

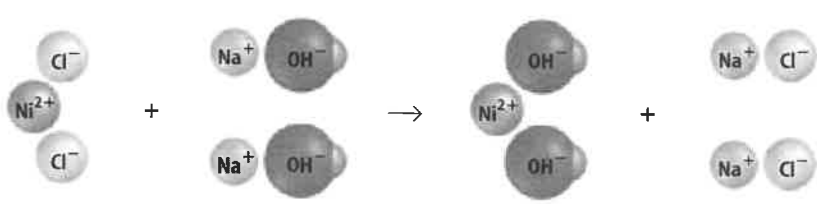
Making sandwiches is like a chemical reaction. The ingredients for the sandwiches are the reactants. The finished sandwiches are the products. The number of units of bread, turkey, cheese, tomato, and lettuce are the coefficients of the reactants. The number of finished sandwiches is the coefficient of the product. However, the quantity of each ingredient is the same in the reactants and product.

How do chemists use coefficients?

When chemists know the number of units of each reactant, they are able to add the correct amounts of reactants needed for a reaction. The units or coefficients will tell how much product will form. For example, here is the chemical equation from the example on the previous page.

$$NiCl_2(aq) + 2NaOH(aq) \rightarrow Ni(OH)_2(s) + 2NaCl(aq)$$

You can see that one unit of $NiCl_2$ and two units of NaOH produce one unit of $Ni(OH)_2$ and two units of NaCl. The figure below shows you how the coefficients affect the number of molecules in the reaction.



$NiCl_2$ + 2NaOH → $Ni(OH)_2$ + 2NaCl

Reading Check

6. **Explain** What does a coefficient show?

Applying Math

7. **Apply** Suppose $NiCl_2$ reacts with NaOH. For each molecule of $NiCl_2$, how many molecules of NaOH are needed?

Picture This

8. **Observe** What does the 2NaOH represent?

Balancing Equations

The equation below is for Lavoisier's mercury(II) oxide reaction.

$$HgO(s) \xrightarrow{\text{heat}} Hg(l) + O_2(g)$$

How many atoms of mercury (Hg) are on each side of the equation? There is one mercury (Hg) atom on the reactant side and one mercury (Hg) atom on the product side. How many atoms of oxygen (O) are on each side? Notice that there is one oxygen (O) atom on the reactant side, but the product side has two oxygen (O) atoms.

Atoms	HgO	→	Hg	+	O_2
Hg	1		1		
O	1				2

Remember that according to the law of conservation of mass, one oxygen atom cannot become two oxygen atoms. You cannot rewrite HgO as HgO_2. That would make the number of oxygen atoms balance, but HgO and HgO_2 are not the same compound. The formula in a chemical equation must accurately represent the compounds that react.

What does a balanced equation show?

A chemical equation must be balanced. Balancing only changes the way a reaction is represented. It does not change what happens in the reaction. To balance a chemical equation, you change the coefficients. A **balanced chemical equation** has the same number of atoms of each element on each side of the equation.

How do you choose coefficients?

You often can find the coefficients to balance an equation just by guessing and checking your guess. In the mercury(II) oxide equation, the number of mercury atoms is balanced. You need to balance the number of oxygen atoms. Try putting a coefficient of 2 in front of HgO on the left side of the equation. This balances the oxygen, but not the mercury.

Atoms	2HgO	→	Hg	+	O_2
Hg	2		1		
O	2				2

Think it Over

9. **Analyze Results** Why does putting a coefficient of 2 in front of HgO on the left side of the equation balance the oxygen but not the mercury?

To balance the mercury, put a 2 in front of the mercury on the right side of the equation.

Atoms	2HgO	→	2Hg	+	O_2
Hg	2		2		
O	2				2

Now the equation is balanced.

$$2HgO \rightarrow 2Hg + O_2$$

What are the steps for balancing an equation?

Magnesium burns with a very bright light. Have you ever seen a flare burning at the scene of a traffic accident? The flare probably was made of magnesium. When magnesium burns, it leaves a white powder, magnesium oxide. To write a balanced chemical equation for the burning of magnesium, follow these steps.

Step 1 Write a chemical equation using formulas and symbols. Remember that oxygen is a diatomic molecule, which means that it consists of two oxygen atoms in a covalent bond.

$$Mg(s) + O_2(g) \rightarrow MgO(s)$$

Step 2 Count the atoms in the reactants and products.

Atoms	Mg	+	O_2	→	MgO
Mg	1				1
O			2		1

The magnesium atoms are balanced, but the oxygen atoms are not. So, the equation is not balanced.

Step 3 Choose coefficients to balance the equation. Remember that you cannot change the subscripts of a formula to balance the equation. Instead, try putting the coefficient 2 in front of MgO.

$$Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

Think it Over

10. Apply Hydrogen (H), like oxygen, is a diatomic molecule. Write the chemical formula for hydrogen.

____

Applying Math

11. Apply When lithium metal is treated with water, hydrogen gas and lithium hydroxide are produced. Balance the following chemical equation that shows this reaction.

$Li(s) + H_2O(g) \rightarrow LiOH(aq) + H_2(g)$

____

____

Applying Math

12. Calculate What number goes in each indicated blank in the table?

Fe __________

Cl_2 __________

Cl_3 __________

Step 4 Check the number of atoms on each side of the equation again. Now, there are two magnesium atoms on the right side of the equation and only one on the left. You need to put the coefficient 2 in front of Mg to balance the equation.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

The above chemical equation for the burning of magnesium is balanced.

Now try one on your own. Balance the equation for the following reaction:

$$Fe(s) + Cl_2(g) \rightarrow FeCl_3(s)$$

Write the correct number of atoms in the column under the each element. Then write the balanced numbers in the bottom row.

Atoms	Fe	Cl_2	→	Fe	Cl_3
Fe			→		
Cl			→		
balanced					

What are moles? To help chemists figure out how much of a substance is needed to get a certain reaction, they use a counting unit called the mole (mol). One **mole** is the amount of a substance that contains 6.022×10^{23} particles of that substance. The mass in grams of one mole of a substance is called its **molar mass**. Just as the mass of a dozen eggs is different from the mass of a dozen watermelons, different substances have different molar masses. The atomic mass of titanium (Ti), for example, is 47.87 amu, and the molar mass is 47.87 g/mol. By comparison, the atomic mass of sodium (Na) is 22.99 amu, and its molar mass is 22.99 g/mol. For a compound such as nitrogen dioxide (NO_2), the molar mass is the sum of the masses of its component atoms. The nitrogen dioxide (NO_2) molecule contains one nitrogen atom (1×14.01 amu) and two oxygen atoms (2×16.00 amu $=$ 32.00 amu). So, NO_2 has a molar mass of 46.01 g/mol.

Given the mass of a substance, you can use the molar mass as a conversion factor to calculate the number of moles.

$$50.00 \text{ g } NO_2 \times \frac{1 \text{ mol } NO_2}{46.01 \text{ g } NO_2} = 1.087 \text{ mol } NO_2$$

Given the number of moles of a substance, you can use the molar mass as a conversion factor to calculate the mass.

$$0.2020 \text{ mol } NO_2 \times \frac{46.01 \text{ g } NO_2}{1 \text{ mol } NO_2} = 9.294 \text{ g } NO_2$$

After You Read

Mini Glossary

balanced chemical equation: having the same number of atoms of each element on both sides of an equation

chemical equation: a way to describe a chemical reaction using chemical formulas and other symbols

chemical reaction: a change in which one or more substances are converted into new substances

coefficient: a number that shows how many units of a substance take part in a reaction

molar mass: the mass of one mole of substance in grams

mole: 6.022×10^{23} number of particles of a substance

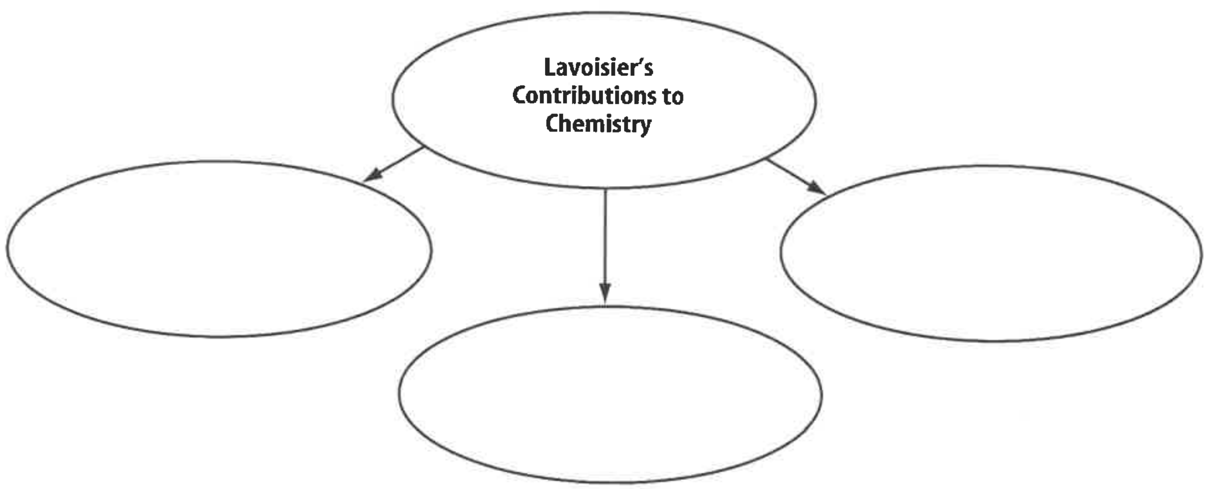
products: the new substances that are produced in a chemical reaction

reactants: the substances that react in a chemical reaction

1. Review the terms and their definitions in the Mini Glossary. Write a sentence describing a chemical equation.

____

2. Complete the concept web by writing three ways that Antoine Lavoisier helped to make chemistry into a modern science.



3. Study Coach You created a quiz with questions about important topics from the section. Which question was the hardest for you to answer? Why do you think this was?

____

____

End of Section

Name ____________________ Date __________

Chemical Reactions

Before You Read

Before you read the chapter, respond to these statements.

1. Write an **A** if you agree with the statement.
2. Write a **D** if you disagree with the statement.

Before You Read	Chemical Reactions
	• There is no gain or loss of matter in a chemical reaction.
	• In synthesis reactions, one element replaces another in a compound.
	• Energy is required to initiate a chemical reaction.
	• A catalyst can be used to slow down a chemical reaction.

FOLDABLES™ Study Organizer

Construct the Foldable as directed at the beginning of this chapter.

Science Journal

Describe several cause-and-effect types of events that might happen in your refrigerator. Decide which events are chemical reactions.

Name ______________________________ **Date** ____________

Chemical Reactions

Section 1 Chemical Changes

Predict *Review the objectives of Section 1. Predict three topics that might be discussed.*

1. ______________________________

2. ______________ 3. ______________

Review Vocabulary

Define chemical formula. *Use your book for help.*

chemical formula ______________________________

New Vocabulary

Use your book to define the following key terms.

chemical reaction ______________________________

reactants ______________________________

products ______________________________

chemical equation ______________________________

coefficient ______________________________

balanced chemical equation ______________________________

mole ______________________________

molar mass ______________________________

Main Idea | **Details**

Lavoisier and the Conservation of Mass

I found this information on page ______.

Summarize *the contributions of Lavoisier by filling out the organizer. Include information on his experiments, observations, and theories.*

Lavoisier

- **Conservation of Mass:**
- **Father of Modern Chemistry:**
- **Naming Compounds:**

Identify *the reactants and the products in the following chemical equations.*

Chemical Equation	Reactants	Products
$Zn + S \rightarrow ZnS$		
$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$		
$C_{12}H_{22}O_{11} \rightarrow 12C + 11H_2O$		
$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$		
$CaCO_3 + 2HCl \rightarrow H_2O + CO_2 + CaCl_2$		

Writing Equations

I found this information on page ______.

Complete *the graphic organizer about symbols used in chemical equations.*

Symbols Used in Chemical Equations

- 4 states of matter
- 3 conditions that may be required for a reaction to occur

$\longrightarrow$ $\longrightarrow$ $\longrightarrow$

Main Idea

Details

Writing Equations

I found this information on page ________.

Complete *the following chemical formula and its translation.*

$2Mg + \_\_ \rightarrow 2MgO + light$

Magnesium _____ oxygen _________ magnesium oxide and ___________.

Coefficients

I found this information on page ________.

Analyze *the role of coefficients in writing chemical equations.*

____

____

____

Evaluate *the student responses. The science teacher gave students the following equation to balance, and three students made responses as shown in the chart. State who is correct and give an explanation of what the meaning of the two wrong responses would be and why those solutions do not work.*

$$Mg(s) + O_2(g) \rightarrow MgO(s)$$

Student Name	Student's Answer	Evaluation: Are they right or wrong? What does the student's answer mean?
Melinda	Put a 2 in front of the Mg.	
Barni	Put a 2 in front of the MgO.	
Ali	Put a 0.5 in front of the O_2.	

Name ______________________________ Date ______________

Main Idea | **Details**

Balancing Equations

I found this information on page ______.

Summarize *information about balancing equations by completing the prompts.*

Balancing an equation means ____.

Coefficients are the numbers that show ____.

Subscripts are numbers that show there is ____.

Identify *each number 3 below as a coefficient (C) or a subscript (S).*

2 $FeSO_3$		6 AlH_3	
3 HCl		4 Al_2O_3	
3 Na		3 H_2	

Complete *The number of atoms for each element on the left side of the equation has been filled in for you. Complete the right side of the equation.*

Atoms	$BaCl_2$	+	H_2SO_4	→	$BaSO_4$	+	HCl
Ba	1						
Cl	2						
H			2				
S			1				
O			4				

I found this information on page ______.

Evaluate *whether the equation above is balanced. Give the total number of atoms on the left side and the total number on the right side.*

____

____

Identify *the coefficient for HCl that would balance the equation in the table above.*

____

Name ______________________________ Date ____________

Main Idea	Details

Balancing Equations

I found this information on page ________.

Sequence *and describe 4 steps involved in balancing a chemical equation. In the right column, write an example for each step.*

1.	
2.	
3.	
4.	

I found this information on page ________.

Identify coefficients *that balance each equation.*

1. $\_P(s) + \_O_2(g) \rightarrow \_P_4O_{10}(s)$
2. $\_KClO_3(s) \rightarrow \_KCl(s) + \_O_2(g)$
3. $\_H_2O(l) \rightarrow \_H_2(s) + \_O_2(g)$
4. $\_CH_4(s) + \_O_2(g) \rightarrow \_CO_2(g) + \_H_2O(g)$
5. $\_Al_2O_3(s) \rightarrow \_Al(s) + \_O_2(g)$
6. $\_MgSO_4(aq) + \_KCl(aq) \rightarrow \_MgCl_2(s) + \_K_2SO_4(aq)$

CONNECT IT Compare chemical equations and mathematical equations.

____

____

____

CHAPTER 19 LESSON 1 QUIZ

NAME: ______________________________ PERIOD: _____ TEACHER: ____________________

- **1.**A change in which one or more substances are converted into new substances is a _______.
  A. ○ physical change
  B. ○ chemical reaction
  C. ○ nuclear reaction
  D. ○ chemical fusion

- **2.**New substances produced by a chemical reaction are _______.
  A. ○ resultants
  B. ○ reactants
  C. ○ coefficients
  D. ○ products

- **3.**The law of conservation of mass states that _______.
  A. ○ matter can be created and destroyed but does not change forms
  B. ○ in a chemical reaction, efforts should be made to preserve rare elements without changing them
  C. ○ in a chemical reaction, matter is not crated or destroyed, but is conserved
  D. ○ in a chemical reaction, the final mass of the products is always greater than the starting mass of the reactants

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- **4.**Ten grams of mercury(II) oxide react to produce 9.3 g of mercury and oxygen. What is the mass of the oxygen produced?
  A. ○ 0.7 g
  B. ○ 19.3 g
  C. ○ 7.0 g
  D. ○ 1.7 g

- **5.**_______ is a way to describe a chemical reaction using chemical formulas and symbols.
  A. ○ A chemical equation
  B. ○ Synthesis
  C. ○ A physical law
  D. ○ The law of conservation of matter