爱上科学
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爱上科学

INTRODUCING • 化学系列
CHEMISTRY

神奇的化学反应

CHEMICAL REACTIONS 双语版

[英] Graham Bateman 编
陈晟 译
黄勇 刘子宁 审

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内容提要

《爱上科学》系列科普丛书为读者全面地讲述了科学知识和原理，以通俗的文字、生动的图表为特色，每本书介绍一个或几个主题。从日常生活中有趣的现象出发，引导和培养读者学习的兴趣，扩宽读者的视野，同时还可以帮助读者学习英语词汇、练习英语阅读。丛书涵盖物理、化学、生物、科技与发明这4个系列。适合对科学知识感兴趣的广大科普爱好者阅读。

本书是化学系列中的一本。化学系列主要阐释现代化学的基本概念，涵盖化学反应、有机化学、生物化学、金属、非金属、分子、原子、物态等多方面内容。

化学反应是什么？是什么使得食物变成能量，煤炭变成火焰，钢铁变成铁锈？这本书详细描述了化学反应的科学知识，包括化学的重要组成部分、能量和热量如何参与化学反应、化学反应的过程中什么因素会影响反应速率等。书中含有“科学词汇”栏目，提取每章重点知识词汇。同时还有“试一试”栏目，包含丰富有趣的家庭小实验，有助于提高大家的动手能力。

丛书编委会

丛书序

这是一个科技新时代，我们曾经认为遥不可及的科学，时刻围绕在我们身边。你是否曾经怀疑过所谓的“2012，世界末日”，或者好奇过在地下高速飞驰的地铁，抑或每天都在关注着PM2.5……这说明科学已然走进了你的生活。学习科学，分享科学，爱上科学，让我们共同聆听来自科学的声音。

《爱上科学》系列科普丛书是一套引进版系列科普丛书，译自英国大型出版商棕熊图书（BROWN BEAR BOOKS）有限公司出版的著名系列科普图书《Facts At Your Fingertips》，其独特的科学解读视角、生动的科普画面、优美的图文设计，得到了欧洲读者的青睐，尤其是得到了欧洲青少年的极大欢迎。本丛书为读者全面地讲述了各个领域的基础科学知识和基本事实，以精彩的主题、通俗的文字、生动的画面为特色，从我们身边的素材和现象出发，激发和培养读者学习的兴趣。

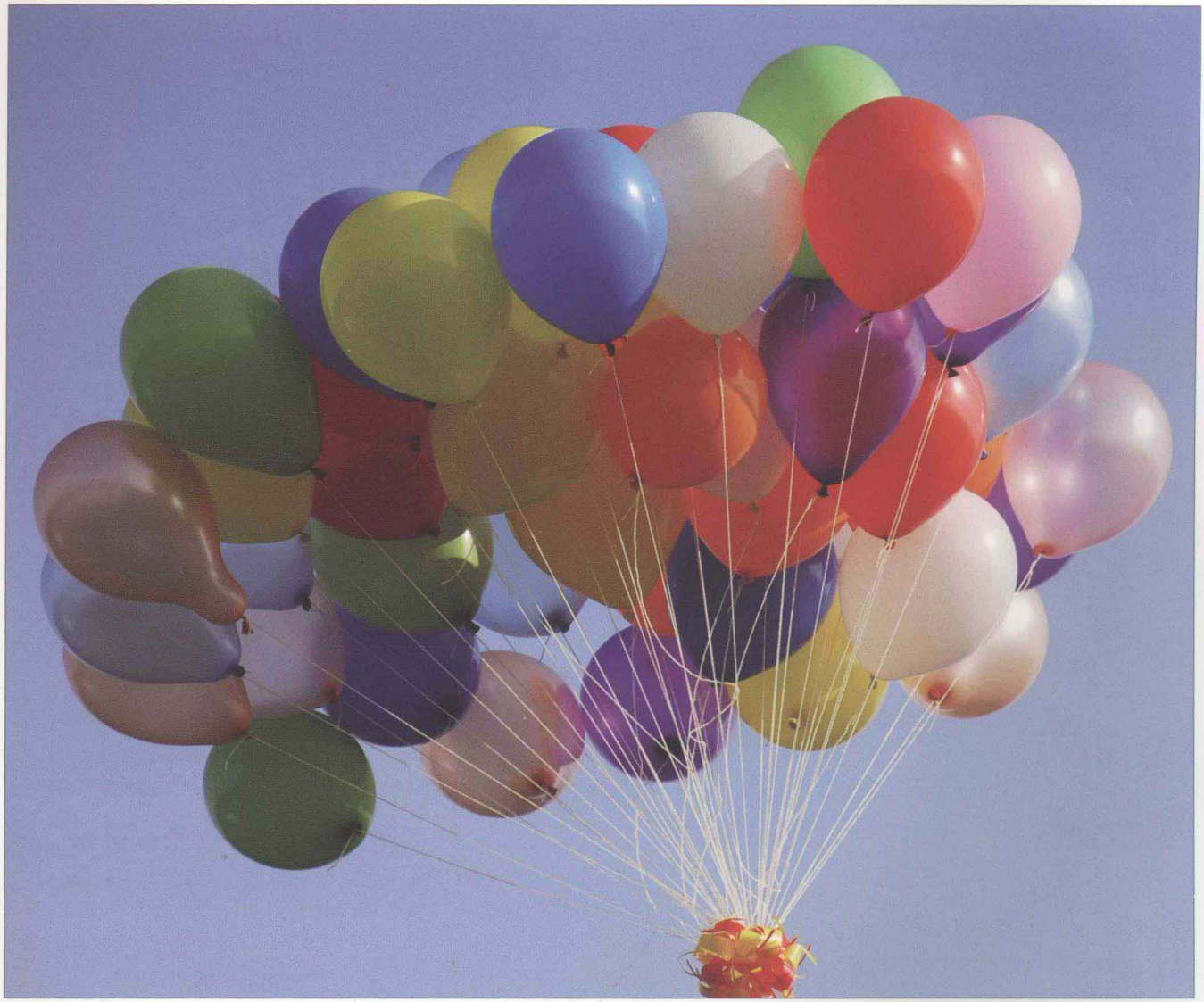
丛书涵盖物理、化学、生物、科技与发明四大系列。物理系列阐释和说明了物理学知识及其发展史，包含对物理学发展史许多重大的物理发现以及著名的物理学家的介绍。化学系列主要阐释现代化学的基本概念，涵盖化学反应、有机化学、生物化学、金属、非金属、分子、原子、物态等多方面内容。生物系列主要阐释生命科学的基本概念，并探讨有关生物学的各个方面，包括植物学、微生物学、动物和人类、遗传学、细胞生物学以及生命形式等。科技与发明系列主要介绍各种科技成果以及相关发明，覆盖多个领域，包括建筑、交通、医学、军事、能源以及航空航天等，指导读者认知和学习各种科学技术，拓宽视野，引发思考，提升创新能力以及发明意识。

本丛书还具有中英双语的独特设计，让读者在阅读中文时，能对照性地阅读英语原文，为他们提高科学领域的英文阅读能力以及扩展科学类英语词汇量提供了很好的帮助。

丛书中还有“试一试”栏目，该栏目包含了丰富有趣的家庭小实验，为大家在生活实践中验证科学知识提供了更多的选择。

学无止境，让我们一起爱上科学！

目录 CONTENT



WHAT IS A CHEMICAL REACTION?

What turns food into energy, coal into fire, and iron into rust? The answer is chemical reactions. Chemical reactions are taking place all around us and even inside our bodies.

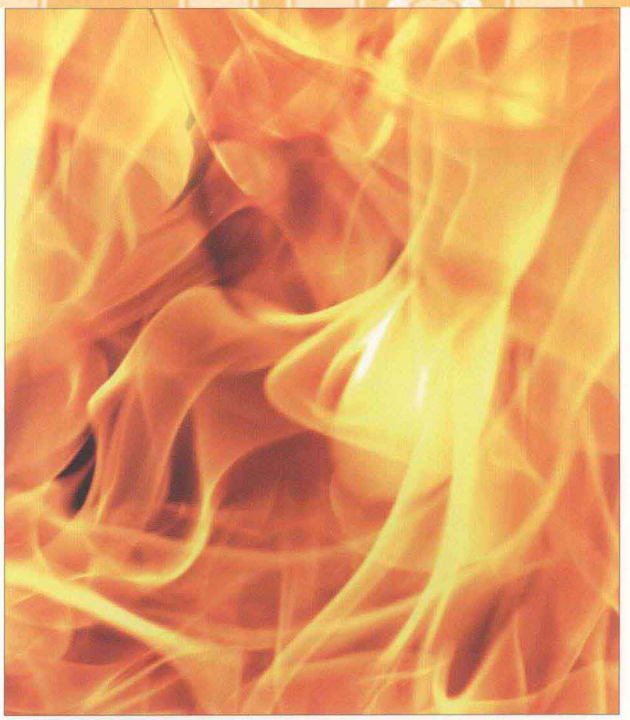
Without chemical reactions, the world would be a very boring place. A chemical reaction is any process that changes one substance into another. Some reactions happen naturally, such as when we digest food or when metal objects become rusty. Other reactions are produced by people to improve their lives. For example, we burn fuel to heat our homes or power an automobile engine.

Reactions involve the interaction between two basic components of the universe—matter and energy. Scientists call any substance that takes up space matter. Rocks, water, and air are all made of matter. Energy is the ability to do work—to move or reshape matter in some way. Heat, light, and electricity are types of energy. During a chemical reaction, energy works to reorganize matter.

CHEMISTRY AND LIFE

Life could not exist without chemical reactions. Like the bodies of all life-forms, the human body is powered by chemical reactions. You inhale oxygen (O_2) when you take a breath of air. And when you eat food, your stomach extracts useful chemicals, such as sugar, from it. Oxygen reacts with the sugars in your body to produce carbon dioxide (CO_2) and water (H_2O). Biologists call this chemical reaction respiration. The reaction releases energy from sugar, which keeps the body alive. You exhale the products of respiration with each breath.

Plants complete the same chemical reaction in reverse—a process called photosynthesis. The plants take in carbon dioxide and water, and use the energy found in sunlight to produce oxygen and sugar.



Inside matter

All matter on Earth is made of elements. An element cannot be reduced to a simpler substance. All elements are made of atoms. An atom is the smallest piece of an element that still has the properties of that element. Atoms do have smaller parts, which have other properties. Chemists represent each element with a symbol of one or two letters.

Atoms are often found in simple combinations called molecules. A pure substance consists of only one type of molecule, which is described by a molecular formula. The formula shows how many atoms of each element are involved. One of the simplest molecules is hydrogen (H_2). This formula shows that the molecule contains two hydrogen (H) atoms. The formula for water is H_2O; two hydrogen atoms are connected to one oxygen (O) atom.

Chemical reaction ingredients

The substances you start with in a chemical reaction are called

All chemical reactions involve change. Burning is one way of converting chemicals such as coal or oil into other compounds, releasing energy that can be used to power engines or provide heat.

the reactants. The new substances that are created are called the products. Chemists write the reactants and products as chemical equations. All chemical equations follow the same format: Reactants→Products. Numbers are used in the equation to indicate how much of each substance is needed. The arrow indicates that a chemical reaction has taken place and a new chemical has been produced.

A simple chemical reaction occurs when carbon dioxide (CO_2) forms. This molecule contains carbon (C) and oxygen atoms. These two elements combine to produce carbon dioxide. The equation of this reaction looks like this:

$C + O_2 \rightarrow CO_2$

A balanced chemical equation shows exactly how much of the reactant and product are involved in the reaction. Chemists balance equations to determine how many reactants are needed to produce new substances. A balanced equation is one where the number of atoms on one side is the same as the number on the other.

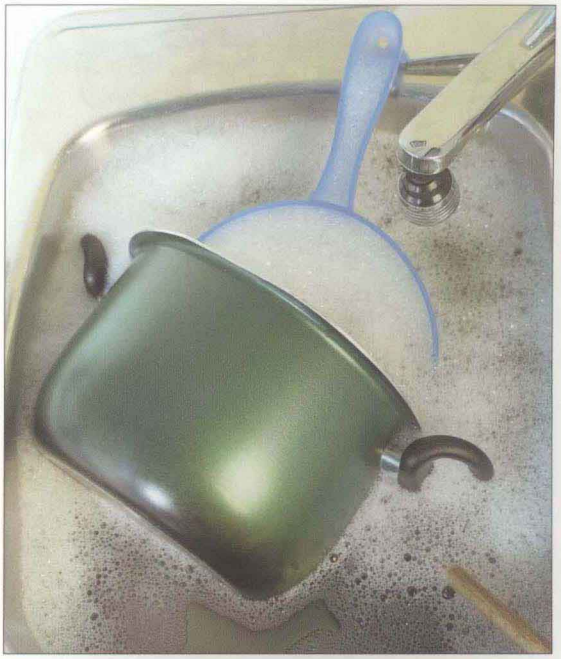
Subatomic particles

The smaller parts of the atom are the pieces involved in a chemical reaction. These parts are called subatomic particles. At the center of the atom is the nucleus. The nucleus is a densely packed ball of positively charged particles called protons. These are mixed with neutral (noncharged) particles called neutrons.

Opposite charges attract, while like charges repel. The positively charged protons in the nucleus attract negatively charged particles called electrons. Electrons are much smaller than protons. They move in clouds around the nucleus. It is the electrons that allow an atom to form bonds with other atoms. How the electrons from two atoms interact determines which type of bond forms. Electrons can be given, taken, or shared to create a bond between two or more atoms. During a chemical reaction, bonds linking some atoms are broken and new bonds are built between others. When atoms of different elements bond they create a substance called a compound. Compounds often look very different from the reactants that produced them. For example, sugar is a compound of carbon, hydrogen, and oxygen. Pure hydrogen and oxygen are both invisible gases and pure carbon forms diamonds, or graphite, the substance

EVERYDAY CHEMISTRY

Using chemical reactions, chemists have created countless products we use everyday. Look around your home and you are bound to see many. Plastics are chains of different types of chemicals strung together. Soaps and toothpastes are made from fatty substances using chemical reactions. And recipes tell us how to use chemical reactions to cook food. Chemical reactions are everywhere.



Dish soap uses to clean dirty pans plates is prodrced by a chemical heaction.

什么是化学反应？

是什么使得食物转化成能量，煤炭燃烧，铁生锈？答案就是化学反应。化学反应在我们周围的外部世界和我们体内随处都在发生着。

如果没有化学反应，世界将变得了无情趣。化学反应，就是任何一个将一种物质变为另一种物质的过程。一些化学反应在自然界就会发生，比如我们消化食物和金属物体变得锈迹斑斑。另一些化学反应则是人为的，用以改善我们的生活。比如，我们点燃燃料来为屋子取暖、启动汽车的发动机等。

化学反应包括宇宙间最基本的两个组成部分——能量和物质之间的相互作用。科学家们把所有占有一定空间的东西都称为物质。岩石、水、空气都是由物质组成的。能量则是可以去做功的东西，比如以某种方式把物质移动或改变。热量、光和电都是能量存在的一种形式。在化学反应的过程中，能量使得物质重新组合起来。

化学与生命

如果没有化学反应，生命将不复存在。和其他所有的生命体一样，人类的身体也从化学反应中获得能量。在呼吸时，你从空气中吸入了氧气（O_2）。当你吃饭时，你的胃从食物中吸收有用的化合物，比如说糖。氧气和糖在你的身体里发生反应，生成了二氧化碳（CO_2）和水(H_2O)。生物学家把这个化学反应叫做“呼吸作用”。这一反应会从糖中释放出能量来，保持身体的活力。而呼吸作用的产物则被你在每次呼吸中排放出去。

植物可以从相反的方向完成这个化学反应，这种过程叫做光合作用。植物吸收二氧化碳和水，利用从阳光中获得的能量，来把它们变为氧气和糖。

物质内部

地球上所有的物质都是由元素构成的。一种元素不能简化为更基础的物质。所有元素都是由原子组成的，原子是某种元素还能够保持其化学特征的最小的片段。原子由更小的部分组成，但那些部分的属性已经不同于原子了。化学家们给每种元素规定了一个符号，该符号由一个或两个字母构成。

原子通常简单地结合起来而形成分子。一种纯的物质只由一种分子构成，可以用分子式来表示。分子式表示了每种元素各有多少个原子参加构成了这个分子。最简单的分子就是氢气（H_2）。这个分子式表示该分子包含两个氢（H）原子。水的分子式是H_2O，表示两个氢原子和一个氧原子（O）结合起来。

化学反应的原料

在化学反应中，所用的起始原料被称为反应物，而新产生的物质则被叫作生成物。化学家们把

所有的化学反应都包含变化。燃烧是将一种物质，比如煤炭、石油，转化为其他物质的化学反应，反应释放出来的能量可以用作能源或提供热量。

反应物和生成物一起写成化学反应方程式的形式。所有的化学反应都遵循如下格式：反应物→生成物。反应方程式中还会用到数字，表示每个反应物需要用到多少份。箭头则表示化学反应的发生和新物质的生成。

当二氧化碳(CO_2)形成时，一个简单的化学反应就发生了。这个分子中含有碳(C)和氧原子。这两种元素结合生成二氧化碳。这一反应的化学反应方程式看起来就是下面这个样子：

$C + O_2 \rightarrow CO_2$

一个已配平的化学反应方程式精确地表示了该反应中涉及了多少反应物和生成物。化学家们配平化学反应方程式，以确定需要多少比例的反应物来产生生成物。一个已配平的反应方程式中，方程式两边的原子总数是相等的。

亚原子粒子

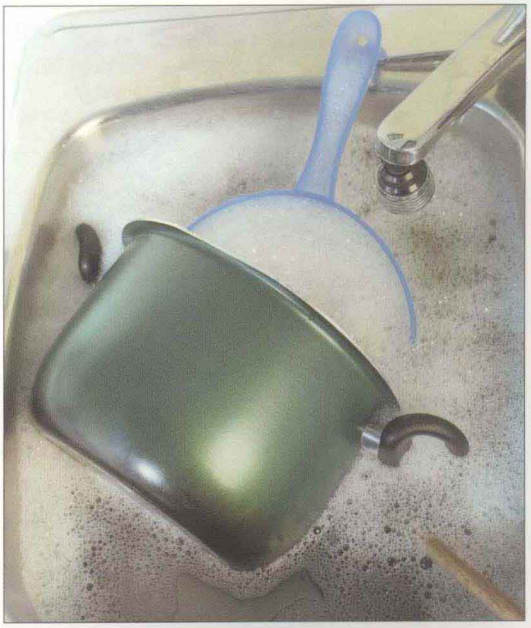
原子中更小的部分是与化学反应相关的，这些部分称为亚原子粒子。在原子中心的是原子核。原子核是一个致密、紧实的球体，其中含有带正电荷的粒子，被称为质子。质子与中性（不带电荷）的粒子混合在一起，这种中性粒子称为中子。

异种电性相吸引，同种电性相排斥。带正电荷的质子吸引带负电荷的粒子，这种带有负电荷的粒子被称为电子。电子的体积要比质子小得多。它们在围绕着原子核的电子云中移动。正是电子，使得原子可以与其他原子形成连接（也称为键）。而两个原子的电子如何相互作用，决定了它们能够形成什么类型的连接。电子可以在两个或更多的原子之间，彼此给予、夺去或分享，以创造出一个连接来。在化学反应时，一些原子之间的连接被打破，而在另一些原子之间新的连接被建立。当不同元素的原子之间的连接被建立起来时，就形成了一种物质，称为化合物。化合物往往和制造它们的原料看起来相差很大。

比如，糖是由碳、氢和氧组成的化合物。纯氢和纯氧都是无色气体，而纯的碳则可以形成钻石和石墨，后者则被用作铅笔芯。把这几种元素结合起

化学每一天

运用化学反应，化学家们创造了难以计数的产品，我们在每天的生活中都使用这些产品。在家里四处看看，你一定能看到很多。塑料由许多类型的化合物串在一起。肥皂和牙膏则是用通过化学反应从脂类化合物中制造出来的。菜谱告诉我们如何在做菜时利用化学反应。化学反应无处不在。



洗洁精用于清洗脏盘子和平底锅，它也是通过化学反应制造而来的。

used as pencil lead. Together these elements form many compounds called carbohydrates. These include the sweet-tasting crystals known as sugar.

Inside energy

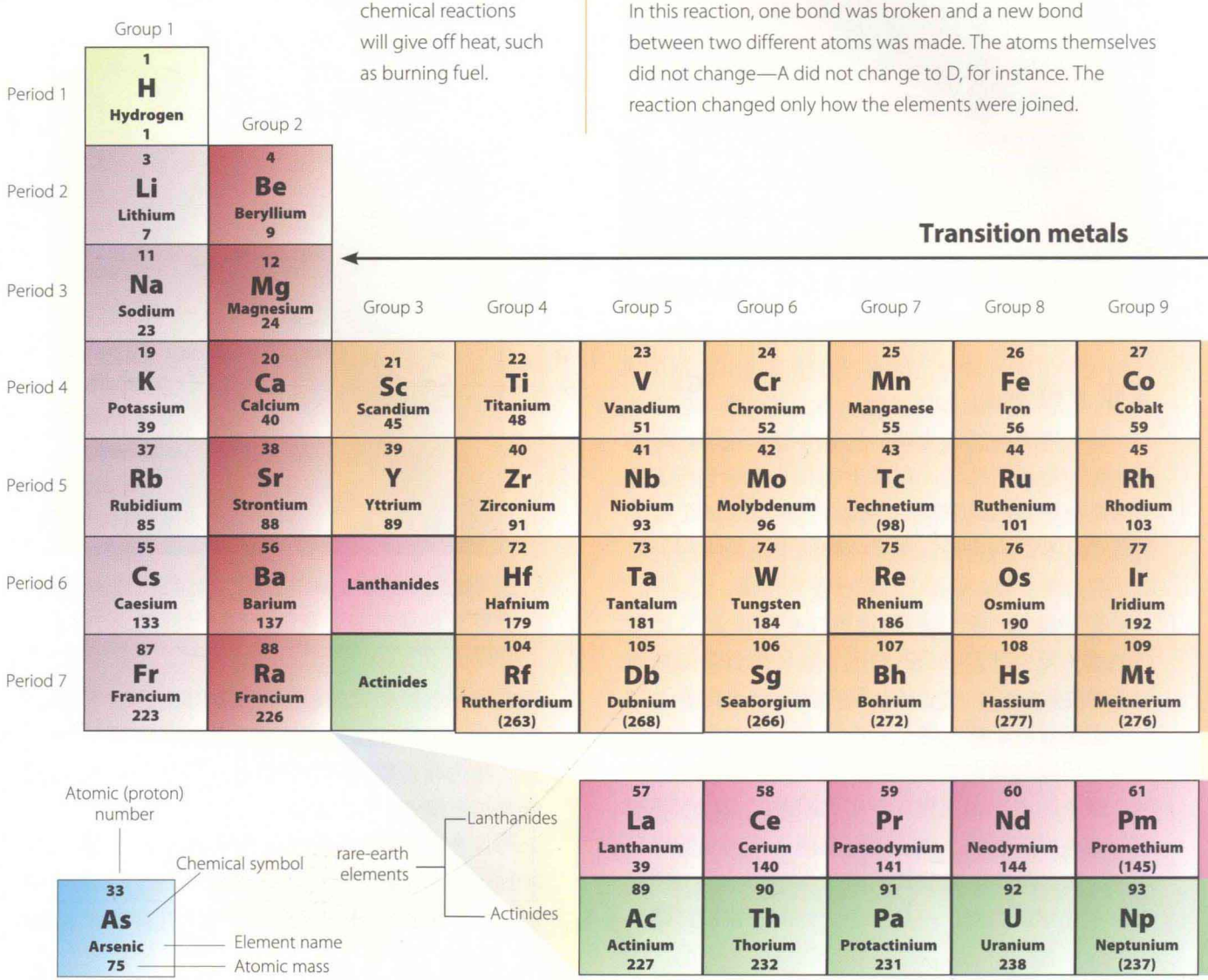
Energy is an essential part of chemical reactions. It is required to break a chemical bond, and energy is released when another bond forms. Heat is one type of energy often involved in chemical reactions. Some reactions will take in heat. Other chemical reactions will give off heat, such as burning fuel.

Putting it all together

When compounds undergo a chemical reaction, energy works to rearrange the bonds between the atoms. For example, consider the equation: AB + C→A + BC.

Elements A and B are bonded to form the AB compound. The AB compound and C are the reactants. During the reaction, the bond between A and B breaks and a bond between B and C is built. A and the BC compound are the products.

In this reaction, one bond was broken and a new bond between two different atoms was made. The atoms themselves did not change—A did not change to D, for instance. The reaction changed only how the elements were joined.



SCIENCE WORDS

- **Atom:** The smallest piece of an element that still retains the properties of that element.
- **Chemical reaction:** A process in which atoms of different elements join together or break apart.
- **Element:** A substance made up of just one type of atom.
- **Matter:** Anything that can be weighed.

The periodic table

The periodic table—shown below—is an organized list providing information about individual and groups of elements. The vertical columns are called groups, or families, of elements. Members of each group usually react in the same way.

Each group has a set of known properties. For example, the column on the left of the periodic table is known as the alkali metals. These are very reactive elements, such as sodium and potassium. Instead of memorizing the properties for every element, chemists simply consult the periodic table.

ACTINIDES
NOBLE GASES
NONMETALS
METALLOIDS
HYDROGEN
ALKALI METALS
ALKALINE-EARTH METALS
METALS
LANTHANIDES

Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
			5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	2 He Helium 4
			13 Al Aluminium 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulfur 32	17 Cl Chlorine 35	10 Ne Neon 20
28 Ni Nickel 59	29 Cu Copper 64	30 Zn Zinc 65	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	18 Ar Argon 40
46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	36 Kr Krypton 84
78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium (209)	85 At Astatine (210)	54 Xe Xenon 131
110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (291)	116 Uuh Ununhexium (293)	117 Uus Ununseptium (295)	86 Rn Radon (222)
								118 Uuo Ununoctium (294)

62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 163	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175
94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (260)

来，可以形成很多很多种化合物，统称为碳水化合物。这其中也包括带有甜味的晶体——也就是糖。

内能

能量是化学反应中必不可少的一部分。打破一个化学键时需要有它，而当另一个化学键形成时则把能量释放出来。热量，则是化学反应中能量的一种常见表现形式。许多化学反应需要吸热，另一些反应则放出热量来，比如燃烧。

把它们拉到一起来

当化合物经历一个化学反应时，能量使得原子之间的化学键重新洗牌。比如，假设有一个反应：

$AB + C \rightarrow A + BC$

元素A和B连接起来，形成化合物AB。化合物AB和化合物C是反应物。在反应过程中，A和B之间的化学键被打破了，而B和C之间的新的化学键则建立起来。A和BC都是生成物。

在这个反应中，一个化学键被打破，而在两个不同原子之间的新的化学键被建立起来。但原子本身并未改变，比如，A并没有变成D。化学反应改变的只是元素之间结合的方式而已。

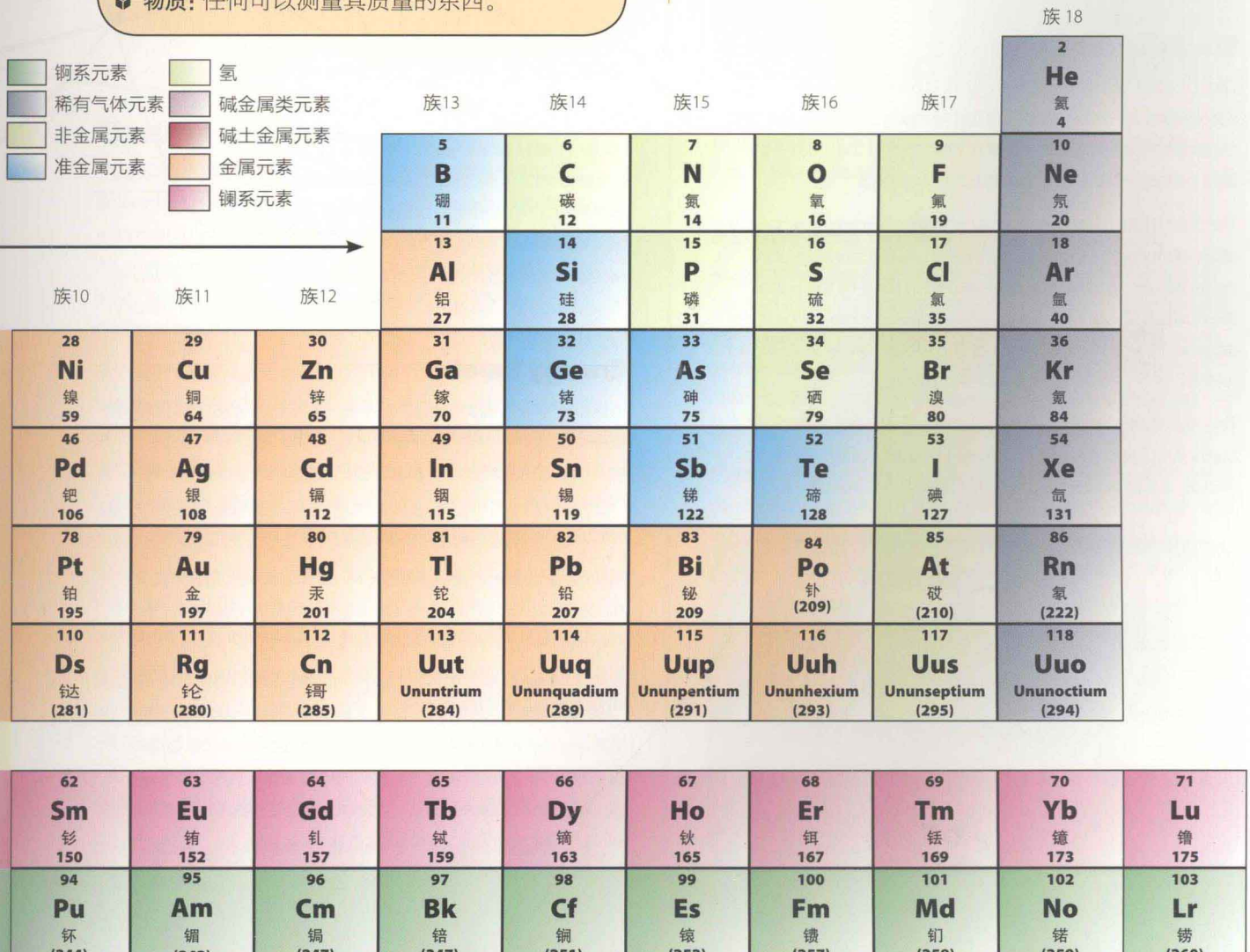
科学词汇

- **原子：**元素中最小的片段，能够保持该元素的化学特性的最小单位。
- **化学反应：**不同元素的原子间结合或解离的过程。
- **元素：**仅由一种原子组成的物质（这种物质应为“单质”。在英文中“元素”与“单质”并不做区分——译者注）。
- **物质：**任何可以测量其质量的东西。

元素周期表

元素周期表（见下图）是一种有组织结构的表格，可以提供单个元素和某一族元素的信息。表格上竖着的一列称为“一族”元素，每一族中的元素们通常会以类似的方式发生反应。

每一族元素具有一类性质。比如，元素周期表最左侧的一列是碱金属。它们是非常活跃的元素，如钠、钾等。化学家们只要简单地查阅一下元素周期表，就可以知道每一个元素的性质了。



CHEMICAL BONDS

Chemical bonds allow atoms to stick together in different combinations. How a bond between atoms forms depends on the number and location of the atom's electrons.

Chemical bonds are created when atoms give, take, or share electrons. There are three types of chemical bonds: ionic, covalent, and metallic. The type of bond formed between atoms depends on how many electrons they have in the atom and how they are arranged.

Electron locations

The location of electrons in an atom is one factor that determines how that atom will form bonds. Scientists use two models to explain the location of electrons in the atom—the Bohr model and the quantum mechanics model.

The Bohr model describes electrons orbiting (circling) the nucleus of an atom like the planets orbit the Sun. As electrons travel in circles around the nucleus, they are held in place by the pull of the nucleus. The nucleus has a positive charge, which attracts the negative charges of the electrons. This model for the atom works well for very simple atoms, such as hydrogen.

The quantum mechanics model is more modern and mathematical. It describes volumes of space called electron clouds, inside which electrons reside. It is not possible to know exactly where each electron is or how fast it is moving inside a cloud. However, their average positions can be calculated. The quantum mechanics model is a much more complicated and more accurate way of describing how an atom is put together than the Bohr model.

SCIENCE WORDS

- **Metal:** A hard but flexible element. Metals are good conductors. Their atoms have only a few outer electrons.
- **Metalloid:** An element that has both metallic and nonmetallic properties.
- **Nonmetal:** An element that is not a metal. Nonmetals are poor conductors. Their atoms tend to have several outer electrons.

Energy levels

In both models, electrons sit at different energy levels. An energy level determines how likely an electron is to be involved in a chemical reaction and form a bond. Electrons in energy levels farthest from the nucleus are most likely to become involved in a reaction because they are held only weakly by the nucleus.

Atoms can have several energy levels. The level closest to the nucleus can only hold two electrons. Chemists call this the lowest energy level. The levels farther from the nucleus can hold more than two electrons. Electrons need more energy to sit in the outer energy levels.

The energy levels are sometimes called orbitals—the areas in which electrons orbit around the nucleus. Chemists also describe them as electron shells because they can be thought of as layers, or shells, surrounding the nucleus.