爱上科学

Science

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爱上科学

INTRODUCING • 化学系列

CHEMISTRY

有机化学与生物化学

ORGANIC CHEMISTRY AND BIOCHEMISTRY 双语版

[英] Graham Bateman 编

赵玥 任雨橦 译

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POSTS & TELECOM PRESS

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北京

图书在版编目（C I P）数据

爱上科学. 有机化学与生物化学 : 双语版 / (英)
贝特曼 (Bateman,G.) 编 ; 赵玥, 任雨橦译. -- 北京 :
人民邮电出版社, 2013.10
ISBN 978-7-115-32915-8

Ⅰ. ①爱… Ⅱ. ①贝… ②赵… ③任… Ⅲ. ①科学知
识－普及读物－汉、英②有机化学－普及读物－汉、英③
生物化学－普及读物－汉、英 Ⅳ. ①
Z228②062-49③Q5-49

中国版本图书馆CIP数据核字(2013)第192471号

版 权 声 明

◆ 编 ［英］Graham Bateman
译 赵 玥 任雨橦
审 戚江凡
责任编辑 宁 茜
执行编辑 周 璇
责任印制 彭志环 焦志炜

◆ 人民邮电出版社出版发行 北京市崇文区夕照寺街 14 号
邮编 100061 电子邮件 315@ptpress.com.cn
网址 http://www.ptpress.com.cn
北京顺诚彩色印刷有限公司印刷

◆ 开本：889×1194 1/20
印张：6.4
字数：187 千字 2013 年 10 月第 1 版
印数：1- 4 000 册 2013 年 10 月北京第 1 次印刷

著作权合同登记号 图字：01-2012-9119 号

定价：39.80 元

读者服务热线：(010)67132837 印装质量热线：(010)67129223
反盗版热线：(010)67171154
广告经营许可证：京崇工商广字第 **0021** 号

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。

碳元素是地球上所有生命的基础。大多数含有碳元素的化学物质被称为有机化合物。研究这些有机化合物的学科为有机化学，研究在生命体中化学反应的学科则为生物化学。本书讲解了什么是有机化学、生物化学，包括有机化合物、碳水化合物、脂类、蛋白质和氨基酸、代谢途径等。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 ORGANIC CHEMISTRY?

Chemists divide chemicals into two groups: organic and inorganic. Organic chemicals contain large amounts of carbon. They occur in everything from plastics to gasoline to drugs and even make up life-forms, including you!

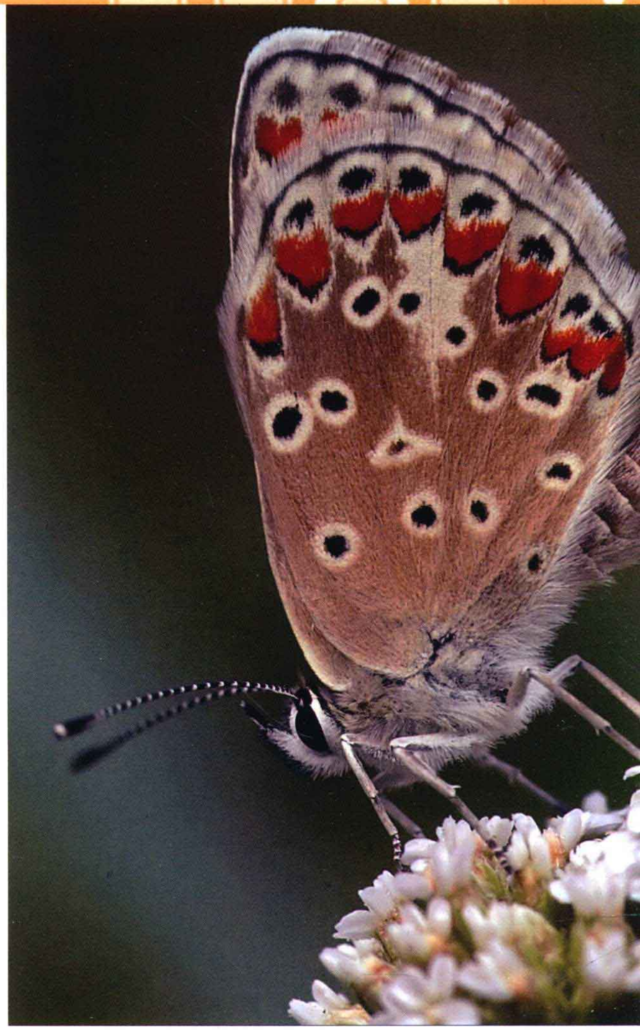
When you are learning about chemistry, you are shown many examples of how atoms and molecules (atoms joined together) react with each other, and how their structures affect the way they behave. Most of these examples are very simple, so you can understand them easily. You learn about water, salt, and metals—substances that you come across everyday. However, most of the substances around you now are not so simple to make or easy to understand.

Complex chemicals

Living bodies—the most complex things in nature—and many of the most useful materials made by people, such as plastics, fuels, and drugs, are made from very complex compounds. Chemists describe the compounds as being organic. That is because those compounds that occur in nature have all originally been produced by living things.

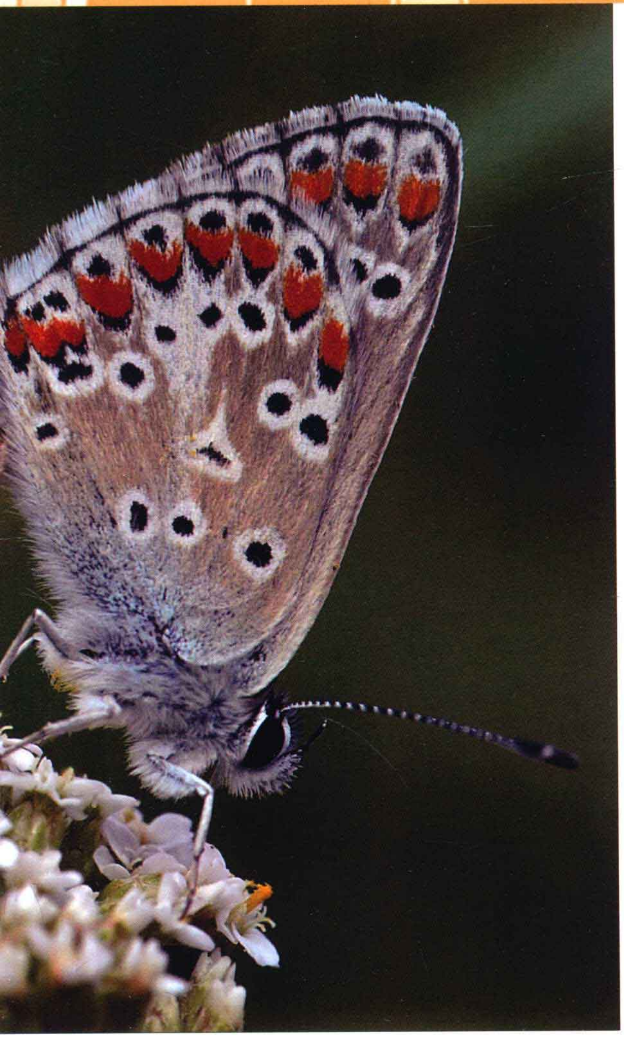
SCIENCE WORDS

- **Atom:** The smallest piece of an element that still retains the properties of that element.
- **Biochemistry:** The study of chemical reactions inside bodies.
- **Compound:** A substance formed when atoms of two or more different elements bond together.
- **Inorganic:** Describes a substance that is not organic.
- **Molecule:** Two or more atoms connected by chemical bonds.
- **Organic:** Describes a compound that is made of carbon and generally also contains hydrogen.



A pair of butterflies in the wild. Their bodies are made up of organic chemicals, such as sugars, proteins, and fats. All life on Earth is based on organic compounds.

A compound is a substance that is made when the atoms of two or more elements bond together. Organic compounds contain many atoms, even thousands, bonded together in a very precise pattern. All organic compounds are based on the element carbon (C). The



compounds also contain atoms of other elements, most often hydrogen (H), but oxygen (O), nitrogen (N), and chlorine (Cl) are also commonly involved.

Connecting sections

The first chemists to investigate organic compounds could not figure out much about them. The methods used for studying inorganic compounds did not work very well with organic ones. Chemists knew that organic compounds contained carbon and hydrogen because when the compounds burned, they produced water vapor (H_2O) and carbon dioxide (CO_2). Burning, or combustion, occurs when a compound reacts with oxygen. Chemists can calculate the proportions of carbon and hydrogen atoms in an organic compound by measuring the amount of each of these gases produced when it burns.

In 1828, Friedrich Wöhler (1800-1882) discovered that organic compounds could be made from inorganic ones. Chemists began to look at organic compounds in a new way. They looked at simple compounds with just a few atoms in them. These included nut oils, formic acid made by stinging ants, and alcohol made by rotting fruit.

The chemists saw that some compounds react in the same ways even though they are very different in other ways. The scientists realized that these compounds all have the same group of atoms somewhere in their molecule. It is these so-called functional groups that give the compounds their properties. Today's organic chemists study how these functional groups work and even make up new ones.

DIVIDING CHEMISTRY

Chemists first studied organic compounds in the early 19th century, when people began investigating the substances inside the bodies of life-forms. Many believed that these compounds were so complex that they could only be made inside a living body, or organism. Because of this, Swedish chemist Jöns Jacob Berzelius (1779–1848) called the compounds organic. All other compounds were therefore inorganic. However, in 1828, the German chemist Friedrich Wöhler (1800–1882) showed that organic compounds could be made in a laboratory as well. He reacted two inorganic compounds together and, completely by accident, produced urea, a substance that occurs in urine. This discovery showed that organic compounds were built the same way as other compounds, but that they were just more complicated.

化学家将化学分为两大部分：有机化学与无机化学。有机化合物含有大量的碳元素。它们普遍存在于一切物品之中，从塑料到汽油到药物，同时也是生命的重要组分，包括你！

当你在学习化学时，你会看到很多原子和分子（分子是聚合到一起的原子）是如何相互反应的例子，它们的结构是如何影响它们的性质的。大多数的例子都很简单，很容易理解。你会了解到每天都会见到的一些物质，如盐、水和金属。然而，大多数这些物质，在你学了化学之后，就没那么简单制作和容易理解了。

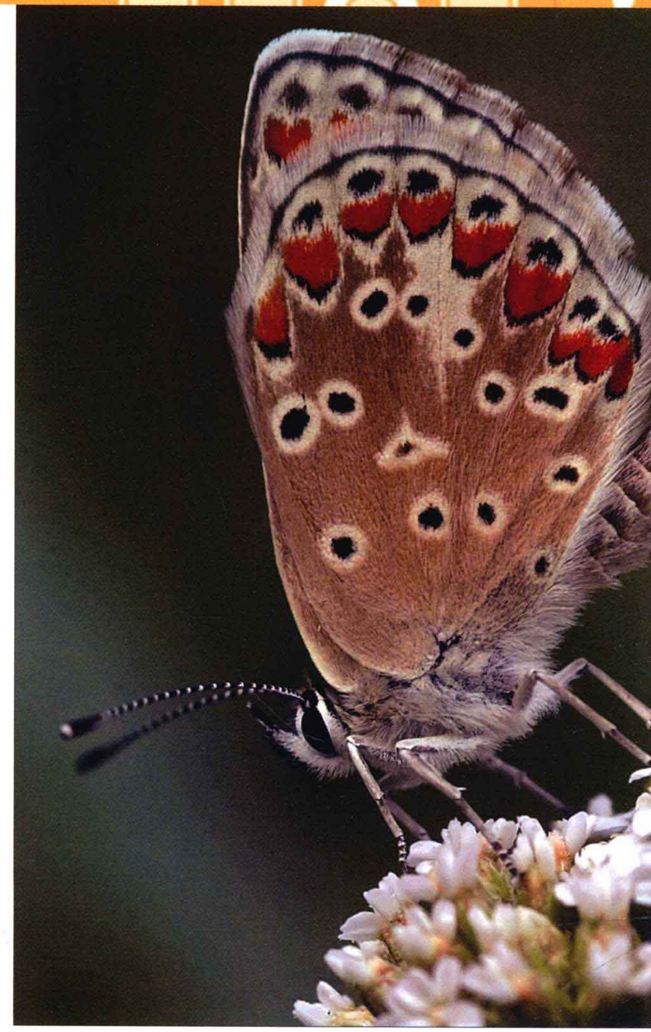
复杂化合物

生命体（自然界中最复杂的物质）和很多人类制造的最有用的物质，如塑料、燃料和药品，都是由非常复杂的化合物组成的。化学家称这些化合物为有机化合物。这是因为这些化合物最开始都是由生命体制造出来的。

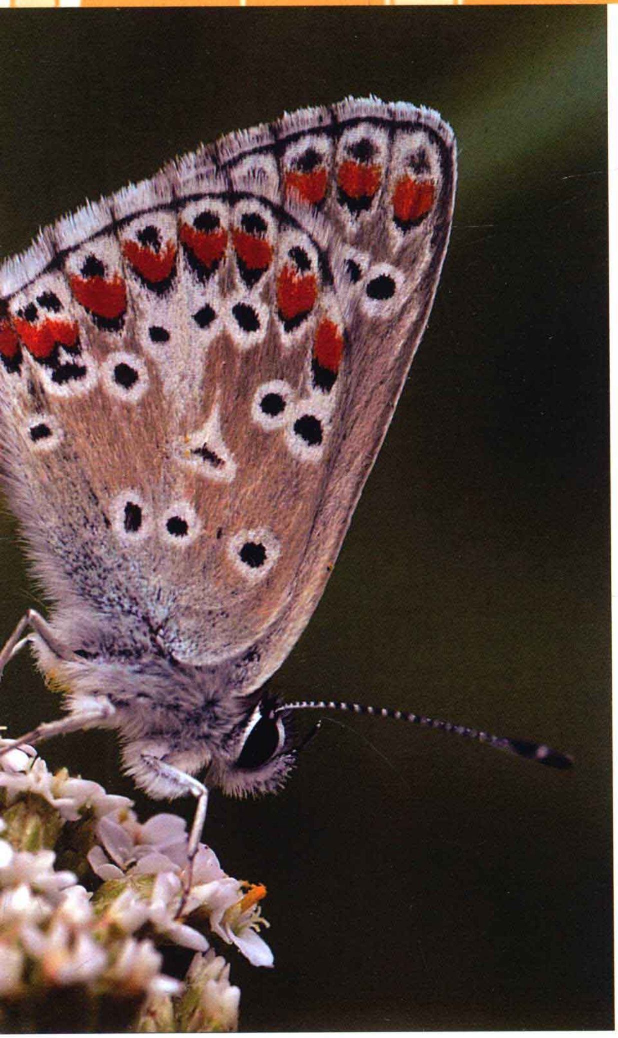
一个化合物指的是由两种或更多元素的原子通过化学键结合而成的物质。有机化合物包含很多原子，甚至上千个原子，这些原子精确地通过一定模

科学词汇

- **原子：**一个元素可分割的最小的单位，它们依然保持着元素的特性。
- **生物化学：**研究生物体内化学反应的学科。
- **化合物：**由两种或两种以上不同的元素通过化学键连接而成的物质。
- **无机：**形容一类非有机的物质。
- **分子：**由两个或更多的原子通过化学键连接而成的物质。
- **有机：**一类由碳元素构成的化合物，通常也会包含氢元素。



野外的一对蝴蝶。它们的身体由有机化学物质组成，像糖、蛋白质和脂肪等。有机化合物是地球上所有生命形成的基础。



式连接在一起。所有的有机化合物都是在碳（C）元素的基础上形成的。这些化合物还包含了其他元素的原子，通常是氢（H）元素，但氧（O）、氮（N）和氯（Cl）元素的原子也常被包含。

连接部分

早期探索有机化合物的化学家们不太成功。研究无机化合物的方法不能很好地应用于有机化合物的研究。化学家们知道有机化合物包括碳和氢元素，因为当燃烧这些化合物时，会产生水蒸气（H_2O）和二氧化碳（CO_2）。当这些化合物与氧气反应时会燃烧或者氧化，化学家们可以通过测量燃烧时产生气体的量来计算出碳原子与氢原子的比例。

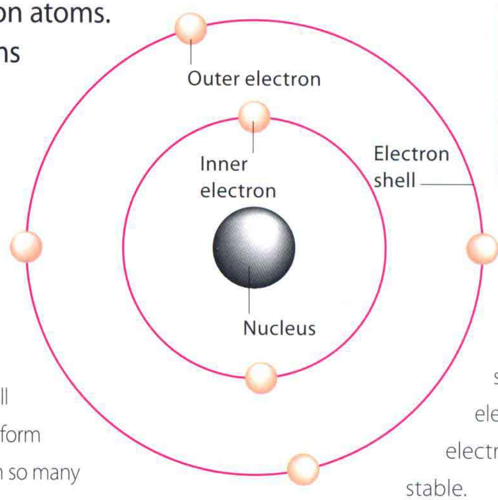
1828 年，Friedrich Wöhler（1800—1882）发现有机化合物可以由无机化合物合成。化学家开始用新的方法来观察有机化合物。它们观察一个简单的只有几个原子组成的化合物，这些包括坚果油、刺蚂蚁产生的甲酸和由腐烂的水果产生的酒精。

化学家们发现，一些化合物的反应方式相同，即使它们在其他方面有很大差异。科学家们认识到，这些化合物分子的一些部分都含有相同的一组原子。这一组原子被称为官能团，正是它们赋予了这些化合物各自的特性。今天的有机化学家在研究这些官能团的作用并合成新的官能团。

分离化学

化学家最初研究有机化合物是在19世纪早期。当时，人们开始探索生物体内的物质。很多人相信这些化合物非常复杂，只能在生物体，或机体内合成。因此，瑞典化学家 Jöns Jacob Berzelius 将这些化合物称为有机物。因此所有其他的化合物称为无机物。然而，1828 年，德国化学家 Friedrich Wöhler（1800—1882）证明了有机化合物也可以在实验室内合成。他将两个无机化合物放在一起进行化学反应，完全偶然地，他合成出了尿素，一种存在于尿液中的物质。这一发现说明，有机化合物和其他物质的构建方式一样，只是更为复杂。

All organic compounds contain carbon atoms. Carbon is the only element with atoms that can form limitless chains as well as branched and ring structures. This ability is a result of the way carbon forms bonds.



Carbon has two electron shells. The inner shell has two electrons and the outer shell has four electrons. These four electrons allow carbon to form single, double, or triple covalent bonds.

Organic compounds exist in a mind-boggling array of shapes and sizes. Their molecules often form chains, rings, and networks of the two, but there are also coiled molecules, spheres, and even tiny tubes. All this variety is a result of the ability of carbon atoms to form strong bonds. To understand how carbon atoms form so many molecules, it is worth looking at pure carbon itself.

Pure forms of carbon

Carbon occurs in nature in four main forms:soot, fullerenes, diamond, and graphite. Both soot and fullerenes are made when carbon-containing compounds are burned. Fullerenes are very fragile structures and were only discovered 20 years ago. Soot, a fine black powder also known as amorphous carbon, does not have an ordered structure; its carbon atoms are arranged randomly.

Graphite and diamond are the two most stable and familiar forms of pure carbon. Despite being made of nothing but carbon atoms, the two substances are very different.

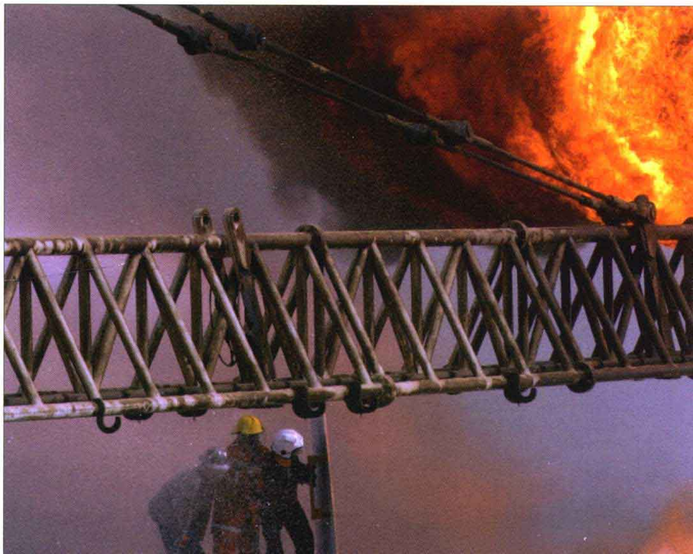
Carbon atom

How can the atoms of one element make two so very different materials? The answer is in the way the atoms are connected inside each substance. To understand how carbon forms bonds, we must look inside an atom of carbon.

Oil is a hydrocarbon. When it burns in air, it creates carbon dioxide, carbon monoxide, water, and pure carbon (soot). The black smoke in this oil well fire is composed of soot particles, which will settle on the ground as ash.

Carbon atoms have four electrons in their outer shell. These electrons are the ones that form bonds with other atoms. Atoms form bonds by sharing, taking, or giving away their outer electrons. They do this to make their outer electron shell full, which makes the atoms stable.

An atom's outer shell can hold eight electrons. To become stable, a carbon atom must share four electrons with other atoms. A bond formed when atoms share electrons is called a covalent bond. Carbon atoms are unusual, however, because their outer shell is half full (or half empty). That makes the atoms more stable than most. As a result carbon atoms can form two or even three strong bonds with just one other atom. Carbon's ability to form so-called double and triple bonds is behind the differences between graphite, diamond, and other forms of pure carbon.

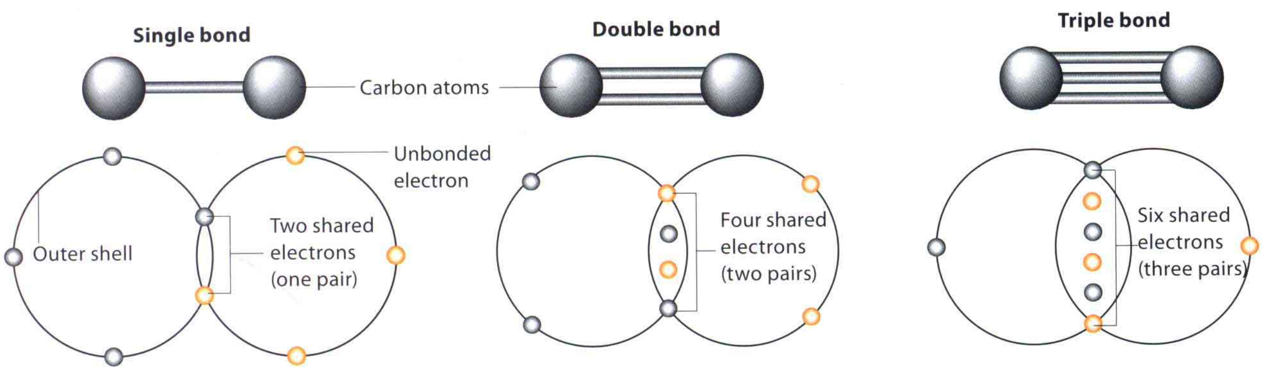


CARBON AND COVALENT BONDS

A carbon atom can form up to four covalent bonds. These bonds involve two atoms sharing electrons. In a simple covalent bond, each atom provides one electron, forming a pair. The pair of electrons sits in the outer shell of both atoms. As a result the atoms are pulled side by side. The shared pair of electrons is being pulled on by the positive charge of the nucleus of both atoms. These pulling forces hold, or bond, the atoms together. This arrangement is called a single bond.

A carbon atom can form two or three bonds with one other atom. These are known as double and triple bonds. Most of the time, double and triple bonds form between two carbon atoms.

In a double bond, each atom shares two of its electrons. A triple bond involves three pairs. Compounds with double and triple bonds are more reactive than those with single bonds. The bonds often break so they can form more stable single bonds.



In a single bond, each atom gives one electron, forming a pair shared between both of the atoms. The atoms' other electrons are free to form bonds with other atoms.

In a double bond, each atom gives two electrons, forming two pairs of shared electrons. The bond pulls the two atoms closer together than in a single bond.

In a triple bond, each atom gives three electrons, forming three pairs shared between them. The bond pulls the two atoms even closer together.

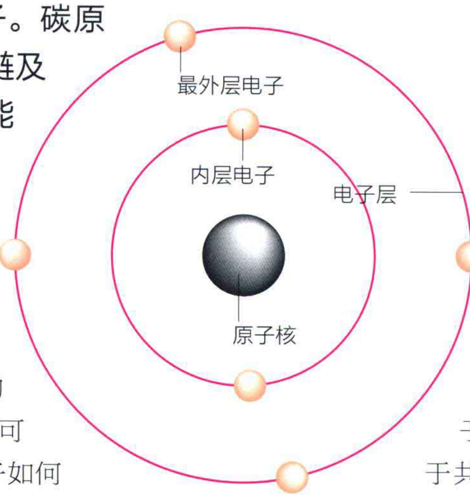
Different bonds

Inside a diamond, carbon atoms are connected by only single bonds. Each carbon atom is bonded to the four atoms surrounding it. With all the atoms bonded to one another, a piece of diamond is one huge molecule.

Diamond's extreme hardness is a result of its atoms being bonded into a rigid interconnecting structure. Graphite is so soft and different from diamond in many other ways because some of the atoms inside are joined by a weaker type of bond.

Inside graphite, each carbon is joined to just three atoms by single bonds. The atom is also connected to a fourth atom, but this time the bond is a weak bond that forms in the same way as a double bond. However, the bond in graphite is not quite the same because only one pair of electrons is shared.

所有的有机化合物都包含碳原子。碳原子是唯一一种可以形成无限长的链及分枝状和环状结构的元素。这一能力是碳原子成键方式的结果。



碳原子有两个电子层。内电子层有2个电子，外电子层有4个电子。这4个电子可以使碳原子形成单键、双键或三键共价键。

有机化合物存在多种形状与大小。这些分子通常形成链状、环状或由链、环组成的网状结构，而且还可以形成卷曲状的、球状的甚至小管状的形态。这么多的变化形式是由于碳原子可以形成很强的化学键。为了理解碳原子如何形成这么多的分子，我们值得去看一看单纯的碳原子本身。

碳的纯净形态

碳元素在自然界中以4种形式存在：煤、富勒烯、钻石和石墨。煤和富勒烯都是含碳化合物燃烧后形成的。富勒烯具有非常易碎的结构， 20年前才被发现。煤——一种黑色粉末，通常也称为非晶碳，无规则结构，碳原子是随机排列的。

石墨和钻石是两种最稳定、最常见的纯碳，尽管除了碳以外没有其他任何原子，这两种物质却很不相同。

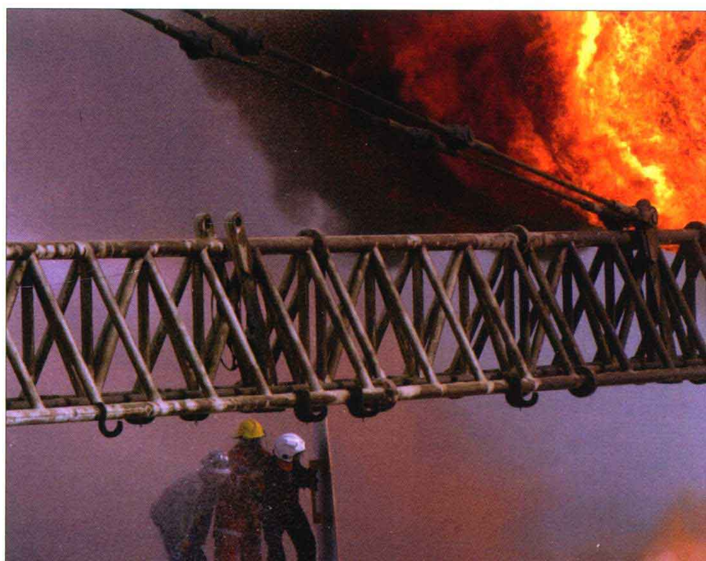
碳原子

同一元素的原子如何能够形成两种非常不同的物质？这一问题的答案在于原子在物质内部连接的方式。为了理解碳原子是如何成键的，我们必须来看看碳原子内部的结构。

碳原子的外层有4个电子。这些电子可以与其他的原子成键。原子之间的键的形成在于共享，获取，或者给出它们最外层的电子，这样可以使其外层电子排满，从而使原子稳定。

一个原子的最外层可以容纳8个电子。为了使原子层稳定，一个碳原子必须与其他原子分享4个电子。通过共享电子形成的键称为共价键。碳原子是非同寻常的，这是因为它的外层电子是半满（或半空）状态。这使得碳原子比大多数原子稳定。从而使碳原子可以与一个其他原子形成2个甚至3个共价键。碳原子的这种形成双键和三键的能力，是石墨、钻石和其他纯碳有各自不同形态的根本原因。

石油是烃类化合物（由多种碳氢化合物组成的混合物——审者注）。当它在空气中燃烧时，可以产生二氧化碳、一氧化碳、水和纯碳（煤烟）。石油完全燃烧产生的黑色烟雾就是煤烟的小粒子，它们会落在地面上形成灰尘。

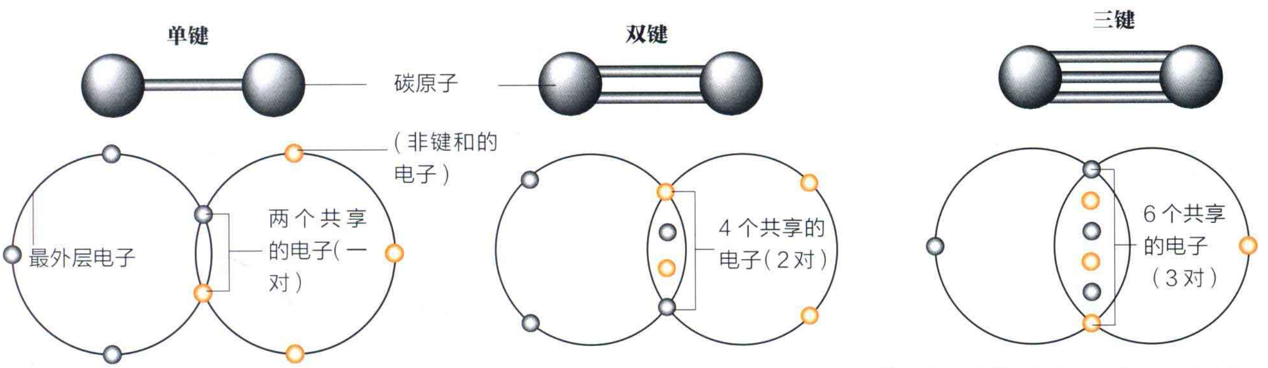


碳和共价键

一个碳原子可以形成 4 个共价键。这些键需要两个共享电子的原子。在一个简单的共价键中，每个原子提供一个电子，形成一对电子。这一对电子存在于两个原子的外层轨道上，从而使原子并排吸引在一起。共享的电子对被带正电的一对原子核所吸引。这一拉力支持两个原子键合在了一起。这种排列称为单键。

一个碳原子能够与其他原子形成两个键或三个键，这称为双键和三键。大多数时候，两个碳原子之间是通过双键和三键形式结合的。

在一个双键中，每个碳原子共享两个它们的电子。一个三键则形成 3 个电子对。含有双键或三键的化合物比单键化合物反应活性更强。这些键经常断裂，因此它们可以形成更稳定的单键。



在一个单键中，每个原子给出一个电子，在它们中间形成了一对共享电子。原子的其他电子可以自由地与其他原子成键。

在一个双键中，每个原子给出 2 个电子形成 2 个电子对，双键比单键将两个原子拉得更紧密。

在一个三键中，每个原子给出 3 个电子，形成了 3 对共享的电子。三键将两个原子拉得更紧密。

不同的键

在钻石的内部，碳原子仅由一个单键相连。每一个碳原子周围有 4 个碳原子与其成键。所有的碳原子都与其他的碳原子成键，因此一块钻石就是一个巨大的分子。

钻石非常坚硬，是原子成键时形成了一个坚硬的内部结构的结果。石墨却非常柔软，而且在很多别的性状方面不同于钻石，因为其原子内部是由更弱的键连接起来的。

在石墨的内部，每一个碳原子仅与其周围的 3 个原子形成单键。碳原子也可以与第 4 个原子成键，但是这次这个键是一个弱键（一种弱的作用——审者注），其成键形式与双键一样。然而，石墨中的键与双键并不完全一样，因为只有一对电子被共享了。

This fourth bond is very weak, and as a result the carbon atoms inside graphite are not as strongly connected to each other. When a force pushes on graphite, it breaks the atoms' weak bonds easily, and the graphite breaks or changes shape. A lump of graphite feels slippery. That is because even the touch of your fingers is enough to rub away a layer of graphite. Graphite is used as a lubricant instead of oil or grease.

Carrying electricity

The structure of graphite also explains how it carries electricity, though diamond cannot. An electric current is a flow of electrons—sometimes other charged particles—through a substance. The moving particles transfer energy from one place to another, and electric currents are used to power many machines in our homes, schools, and places of work.

Substances that can carry electricity are conductors; they have electrons that are free to move around inside. Insulators—materials that do not carry electricity—do not have free electrons. Graphite is a conductor because the electrons involved in the weak bonds break free easily. They then flow through the graphite crystal between the sheets of carbon atoms. All the electrons in diamond are held in strong bonds and cannot be released to form a current. As a result, diamond is an insulator.

SCIENCE WORDS

- **Allotrope:** One form of a pure element.
- **Conductor:** A substance that carries electricity and heat well.
- **Covalent bond:** A bond in which two or more atoms share electrons.
- **Crystal:** A solid made of repeating patterns of atoms.
- **Electron shell:** A layer of electrons that surrounds the nucleus of an atom.
- **Inorganic:** Describes a substance that is not organic.
- **Insulator:** A substance that does not transfer an electric current or heat.
- **Nucleus:** The central core of an atom containing protons and neutrons.

NANOTUBES

Fullerenes do not have to be balls. In 1991, Japanese scientist Iijima Sumio (1939–) made fullerenes that were tube shaped. The tubes were made from a sheet of carbon atoms bonded in the same hexagon pattern as graphite molecules. The structures were named nanotubes. Nanotubes are very thin. One long enough to stretch from Earth to the Moon could be rolled into a ball the size of a poppy seed! So far, scientists can only make short pieces. If we learn how to make them long enough, there will be many uses for nanotubes. For example, the tubes could be woven to make a material many times stronger than steel, but much lighter.

Fullerenes

Fullerenes, the third structural form of carbon, are also conductors. However, the way their electrons are free to move is different again from other carbon allotropes. Looking at the structure of fullerenes will also help us understand the properties of organic compounds.

Fullerenes are made when carbon compounds are burned. These molecules are fragile, and in normal conditions they fall apart and form sootlike substances.

The smallest and simplest fullerene contains 60 carbon atoms. Its formula is C_{60}. This fullerene was the first to be discovered in 1985. It was named buckminsterfullerene for the designer of geodesic domes, which it closely resembles. All similar fraile carbon structures are now referred to as fullerenes, and C_{60} molecule has been nicknamed "the buckyball."