北京高等教育精品教材

应用化学专业英语

第二版

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《应用化学专业英语》第二版是北京高等教育精品教材，是根据大学英语教学大纲（理工科本科用）的专业阅读部分的要求，受“全国部分高校化工类及相关专业大学英语专业阅读教材编审委员会”委托而编写的，旨在为应用化学专业师生提供一本较系统的专业英语教学用书。

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PART ONE

CHEMISTRY AND SOCIETY

Unit 1 The Roots of Chemistry

Chemistry can be broadly defined as the science of molecules and their transformations. In contrast to mathematics，chemistry is older than people. The appearance of life and people on our planet（Earth）is most probably the end result of specific chemical processes. Chemical processes have been present in the lives of people from the dawn of history until the present time. Initially，these processes were not under our control，for instance，the fermentation of fruit juice，the rotting of meat and fish，and the burning of wood. Later on we learned to control chemical processes and to use them to prepare a variety of different products such as food，metals，ceramics and leather. In the development of chemistry，four periods may be distinguished：prehistoric chemistry，Greek chemistry，alchemy，and scientific chemistry.

The early beginnings of chemistry were clearly motivated by the practical needs of people. The discovery of fire offered the first opportunity to prehistoric people to carry our controlled chemical processes. They learned to prepare objects made of copper，bronze and other materials that were readily available. Since the use of chemical processes by these early people predates writing there are no written records about their chemical skills. One can judge their chemical abilities only from the archeological discoveries of various artifacts. What has been found indicates clearly that practical needs influenced the early development of chemistry，as was the case for the early development of mathematics.[1] But chemistry and mathematics at this stage probably did not interact. If they did，there is no record to establish this.

Greek chemistry was based mainly on speculation rather than on experiment. This was a common trait of all Greek science in antiquity. The Greek scientist of antiquity was in fact the Greek philosopher，and so it is not surprising that the Greeks were much more interested in contemplating than in experimenting. Actually they seldom performed experiments outside of the thought experiment. This was a good approach for mathematics but hardly one to recommend itself for the physical，chemical or biological sciences. Nevertheless，because the Greeks thought a lot about the nature and structure of matter，they can be considered as the creators of the first chemical theories.

The Greeks introduced the concept of the element and proposed in all four elements. Thales（625—547 BC）of Miletus thought that all things were formed from one elementary substance，namely water. Anaximenes（ca 585—ca 528 BC），also from Miletus，accepted the idea of element，but he believed that the single element from which all things are made is air. Heraclitus（ca 540—480 BC）of Ephesus，who considered that the fundamental characteristic of the universe is continuous change, regarded fire as the element that embodied perpetual change. Empedocles (ca 490—ca430 BC), from the Greek city of Akragas in Sicily, abandoned the idea of a single element and introduced the principle of four elements: water, air, fire and earth, and the two forces of attraction and repulsion that operate between them. Empedocles is also known for his experimental proof that air is a material body.

The term "element" was first used by Plato (428—347 BC) who assumed that the particles of each element have a specific shape, even though such particle are too small to be seen. Thus, the smallest particle of fire had the shape of a regular tetrahedron; of air a regular octahedron; of water a regular icosahedron, and of earth a cube (or regular hexahedron).[2] The regular tetrahedron, the regular octahedron, the regular icosahedron and the cube are examples of regular polyhedra, and there are in all five of them; the fifth is the regular dodecahedron. In regular polyhedra the surfaces are bounded by congruent regular polygons and the vertices are symmetrically equivalent to one another.

Fire was thought to be the smallest, most pointed and lightest among the elements because it can easily attack and destroy. It seemed a natural choice that the regular tetrahedron (which consists of four regular triangles) be taken as the shape of fire, since it is the smallest and most pointed among the regular polyhedra. Water was the largest, smoothest and heaviest, because it always flows smoothly into the valleys of the Earth. Therefore, it appeared a natural choice that the regular icosahedron, composed of twenty regular triangles, was taken as its shape. Air is between fire and water and so it appeared natural to assign the regular octahedron (which consists of eight regular triangles) to air. The regular octahedron has the same faces, viz. the regular triangles, as the regular tetrahedron and the regular octahedron. Its numbers of faces is between the numbers of faces of those two. From the fact that the tetrahedron, octahedron and icosahedron could be decomposed into regular triangles which could be reassembled to form the other polyhedra, Plato concluded that fire, air and water could also be mutually transformed, that is, water could be transformed by fire into air, whereas when air loses fire in the upper atmosphere it becomes water in the form of rain or snow. The last element was earth which is heavy and stable, and this was assumed to take the shape of a cube, composed of six squares. Since it was not possible to reduce the cube into regular triangles, but only into squares, Plato concluded that earth could not be transformed into fire, air or water. This is discussed in Plato's dialogue *Timaeus*. In the dodecahedron, because, of all the regular polyhedra, its volume most nearly approaches that of the sphere, Plato saw the outer shape of the universe. The *Timaeus* also contains discussion on the composition of organic and inorganic bodies and may be considered as a rudimentary treatise on chemistry. At this point it should be perhaps emphasized that Plato taught that the idea, the form, was the truly fundamental pattern behind phenomena, that is to say, ideas are more fundamental than objects.

Plato's description of the shapes of the four elements was perhaps the first mathematical model used in chemistry, since regular polyhedra are mathematical objects. The regularity that exists between the numbers of vertices V, edges E and faces F, was discovered by Euler (1707—1783) and is thus called the Euler theorem.

This states that:

$$V+F-E=2$$

Which is considered by some to be the second most beautiful mathematical theorem? It is of interest to speculate why the Greeks did not discover Euler's theorem. Perhaps the simplest explanation is that Greek mathematics was two thousand years away from topology.

Topology ("rubber sheet geometry") is the part of mathematics that deals with the way objects are connected, without regard to "straightness" and metric.

A generalization of the above ideas on elements was put forward by Aristotle (384—322 BC). He accepted the idea of four elements, but introduced the concept of transmutation of elements. Aristotle thought that the elements could be obtained by combining the pairs of opposing fundamental properties of matter. These properties were hotness, coldness, moistness and dryness. The combination of hotness and moistness produced air. Moistness and coldness gave water and, similarly, coldness and dryness produced earth. Aristotle added the fifth element or quintessence, ether. The sky and heavenly bodies were supposedly made up of this fifth element. Aristotle defined an element as simple body that other bodies can be decomposed into but one that is not itself capable of being divided into simpler bodies.[3] He classified several chemical processes, first mentioned mercury and was familiar with the technique of distillation.[4] Aristotle's ideas dominated science for almost two thousand years.

There was another theory on the structure of matter put forward by Greek thinkers. This was concerned with the divisibility of matter. The first Greek philosopher to think about this problem appears to have been Leucippus (ca 470—420 BC) from Miletus. He came up with the proposition that matter cannot be divided endlessly, for in the process of dividing matter one will sooner or later come to a piece not divisible into smaller parts. His pupil Democritus (ca 460—ca 370 BC), from Abdera, continued to develop the ideas of Leucippus. He named these ultimately small pieces of matter *ατομοσ* (atomos), meaning indivisible. This is the origin of our term atom. The concept of the atom is the basis of the atomic theory of the structure of matter and the philosophy of materialism. Most Greek philosophers, and particularly Aristotle, did not accept the atomistic teachings of Leucippus and Democritus. Atomism, however, did not die out because Epicurus (ca 342—270 BC) made atomism part of his philosophy, and Epicureanism won many followers over the next few centuries. One of these was the Roman poet and philosopher Lucretius (ca 96—55 BC), who wrote a fine didactic poem entitled *De Rerum Natura* (On the Nature of Things) in which he expounded the atomistic teachings of Democritus and Epicurus. Most of the works by Democritus and Epicurus are lost, but Lucretius's poem has survived intact and has served to convey the atomistic teachings of the Greeks to modern times. The splitting of the atom and the advent of the atomic bomb have surely confirmed what an excellent model of reality atomistic theory was.

The philosophy of idealism and the philosophy of materialism were opposed throughout history. From a chemical point of view the philosophy of materialism affords a basis for an understanding of the structure of compounds. However, the collective properties of compounds such as their smell or color or taste can also be interpreted in terms of Plato's ideas, which are particularly well suited for studying the mathematical properties of chemical structures. If we link the philosophy of materialism with experimental work in chemistry and likewise the philosophy of idealism with theoretical work, it is clear that both philosophies as well as both experiment and theory are needed to advance chemistry. This is of course also true for other sciences.

Alchemy is a type of chemistry that existed from about 300 BC until the second half of the seventeenth century. This constitutes a less interesting period for our purposes, since alchemists were practical people who did not care much for theories and mathematics. The alchemists had two main objectives: (ⅰ) to turn base metals into gold and (ⅱ) to discover the elixir of life. The origins of alchemy can be traced back to the ancient Egyptians.

There was a lot of magic involved in the work of alchemists and their symbols were difficult to decipher. However, the coding systems used by various alchemists are really cryptograms and as such possess a mathematical basis.

It is important to stress that chemistry as a science started only in the second half of the seventeenth century when alchemy gradually transformed itself into the science now known as chemistry following the appearance of the book *The Sceptical Chymist* (London, 1661) by Boyle (1627—1691).[5] The transition period from alchemy to chemistry lasted more than a century. It started with Boyle's book and ended with the book *Traité Élémentaire de Chimie* (Elementary Treatise on Chemistry, Paris, 1789) by Lavoisier (1742—1794). During this period appeared the first unifying chemical theory, namely, the phlogiston theory. The term phlogiston is derived from the Greek word *φλογιστοσ*, which means flammable.

Now, most dictionaries define chemistry as ***the science that deals with the composition, structure, and properties of substances and the reactions by which one substance is converted into another***. Knowing the definition of chemistry, however, is not the same as understanding what it means. In essence, ***chemistry is an experimental science***. Experiment serves two important roles. It forms the basis of observations that define the problems that theories must explain, and it provides a way of checking the validity of new theories. This text emphasizes an experimental approach to chemistry. As often as possible, it presents the experimental basis of chemistry before the theoretical explanations of these observations.

From *Concepts in Chemistry by N. Trinajstić*
and *Chemistry: Structure and Dynamics by James N. Spencer*

New Words and Expressions

fermentation [ˌfəːmenˈteiʃən] *n.* **发酵**
ceramics [siˈræmiks] *n.* **制陶术，陶瓷学，陶瓷制品**
leather [ˈleðə] *n.* **皮革，皮革制品**
alchemy [ˈælkimi] *n.* **炼金术，炼丹术**
bronze [brɔnz] *n.* **青铜（一种铜锡合金），青铜制品**
archeological [ˌɑːkiəˈɔlədʒikəl] *a.* **考古学的**
artifact [ˈɑːtifækt] *n.* **人工制品**
speculation [ˌspekjuˈleiʃən] *n.* **思索，推测**
antiquity [ænˈtikwiti] *n.* **古代，古人，古迹**
Thales [ˈθeiliːz] *n.* **泰利斯（古希腊哲学家，数学家，天文学家）**
tetrahedron [ˈtetrəˈhedrən] *n.* **四面体**
octahedron [ˌɔktəˈhedrən] *n.* **八面体**
icosahedron [ˌaikəusəˈhedrən] *n.* **二十面体**
hexahedron [ˌheksəˈhedrən] *n.* **六面体**
polyhedra [ˌpɔliˈhiːdrə]（polyhedron **的复数形式**） *n.* **多面体**
theorem [ˈθiərəm] *n.* **定理，原则**
topology [təˈpɔlədʒi] *n.* **拓扑学，拓扑**
Aristotle [ˈæristɔtl] *n.* **亚里士多德（古希腊哲学家）**
elixir [iˈliksə] *n.* **长生药，万能药**
decipher [diˈsaifə] *v.* **解开（疑团），破译（密码）**
cryptogram [ˈkriptəugræm] *n.* **密码，暗记，暗号**

flammable ['flæməbl] *n*. 易燃物 *a*. 易燃的，可燃的
phlogiston [flə'dʒistən] *n*. 燃素

Notes

1. as 作关系代词时可代替整个主句或一件事（上文或下文所说的事），并在从句中作主语、宾语或表语。as 引出的定语从句为非限制性定语从句。本句在从句中作主语。参考译文：已有事实清楚地表明：正如早期数学的发展一样，实际需要影响着化学的发展。

2. of air 与 a regular octahedron 之间、of water 与 a regular icosahedron 之间、and of earth 与 a cube 之间均省略 had the shape of。参考译文：所以，火的最小微粒具有正四面体形状，气的最小微粒具有正二十面体的形状，土的最小微粒具有立方体（或正六面体）形状。

3. 参考译文：亚里士多德把元素定义成一个简单的物体，其他的物体能被分解成元素，而元素本身不能被分解成更简单的物体。

4. 句中 classified，mentioned，was familiar with 为并列成分，主语均为 He。参考译文：他对数种化学过程进行了分类，第一个论及汞，并通晓蒸馏技术。

5. 参考译文：化学是在 17 世纪后半叶才开始被称为一门科学的，强调这一点很重要。因为当时炼金术才逐渐将其本身转变为科学，随着 Boyle（1627—1691）所著的书 *The Sceptical Chymist*（1661 年，伦敦）的出现。这种科学被看作是化学。

Exercises

Ⅰ. Comprehension

1. It can be inferred from this article which one of the following items is not mainly based on practical use ____.

A. prehistoric chemistry and alchemy　　B. alchemy and chemistry
C. Greek chemistry　　D. Greek chemistry and chemistry

2. It was ____ who first introduced the idea that all things are not formed from just one element.

A. Aristotle　　B. Empedocles　　C. Theatetos　　D. Theodoros

3. In the development of Greek chemistry，____ was the first one definiting the ultimately constituents of matter?

A. Plato　　B. Aristotle　　C. Leucippus　　D. Democritus

4. According to Plato，there are ____ "elements" whose faces are constituted by regular polygons.

A. 3　　B. 4　　C. 5　　D. 6

5. In the last paragraph，authors think that experiment ____.

A. can examine whether the assumption is right
B. can be used to check the new theories
C. can be carried out by the chemist
D. can deal with the reactions by which one substance is converted into another

Ⅱ. Make a sentence out of each item by rearranging the words in brackets

1. The purification (is usually/a matter of considerable difficulty，/often/of an organic compound/for this purpose/to employ various methods/it is/necessary/and).

2. Science is (is generated/and systematized knowledge/an ever-increasing body of accumulated/and is also an activity/by which knowledge).

3. Life, after all, is (in fact, /a small example of chemistry/observed on a single, / only chemistry, /mundane planet) .

4. People (some of the molecules/are made of molecules; /in people are rather simple/ are/highly complex/whereas others).

5. Chemistry is (from birth to death/ever present in our lives/there is neither life nor death/because without chemistry).

6. Mathematics appears (and also permeates/to be almost as humankind/all aspects of human life, /are not fully/although many of us/aware of this).

Ⅲ. Translation

1. (a) **化学过程**;(b) **自然科学**;(c) **蒸馏技术**。
2. **正是原子构成了铁、水、氧等**。
3. **化学具有悠久的历史，事实上，人类的化学活动可追溯到无记录时代以前**。
4. **根据水的蒸发现象，人们认识到液体在一定条件下可以变成气体**。
5. **在你使用这种材料之前，你必须弄清它的各种性质**。

Ⅳ. Translation

Chemistry is one of three fundamental natural sciences, the other two being physics and biology. Chemical processes have continually unfolded since the Big Bang and are probably responsible for the appearance of life on the planet Earth. One might consider that life is the end result of an evolutionary process in three steps, the first step being very fast and the other two rather slow. These steps are (ⅰ) physical evolution (the formation of chemical elements); (ⅱ) chemical evolution (the formation of molecules and biomolecules); and (ⅲ) biological evolution (the formation and development of organisms).

Ⅴ. Problem

(1) The absolute mass of a ^{1}H atom is 1.6735×10^{-24} grams, whereas the absolute mass of a ^{12}C atom is 1.9926×10^{-23} grams. Calculate the ratio of the mass of a ^{1}H atom to that of a ^{12}C atom when the masses are measured in units of grams. Use this ratio to calculate the mass of a ^{1}H atom in units of amu if the mass of a ^{12}C atom is exactly 12 amu.

(2) A bone taken from a garbage pile found buried deep under a Turkish hillside had a $^{14}C/^{12}C$ ratio 0.477 times the ratio in a living plant or animal. What was the date of the prehistoric village in which the bone was discovered?

Reading Material

What is Modern Molecular Structure About

One of the more fundamental issues chemistry addresses is molecular structure, which means how the molecule's atoms are linked together by bonds and what the interatomic distances and angles are.[1] Another component of structure analysis relates to what the electrons are doing in the molecule; that is, how the molecule's orbitals are occupied and in which electronic state the molecule exists. For example, in the arginine molecule shown in Fig. 1.1, a HOOC— carboxylic acid group is linked to an adjacent carbon atom which itself is bonded to an $—NH_2$ amino group. Also connected to the α-carbon atom are a chain of three methylene $—CH_2—$ groups, an —NH— group, then a carbon atom attached both by a double bond to an imine —NH group and to an amino $—NH_2$ group.

The connectivity among the atoms in arginine is dictated by the well-known valence preferences displayed by H, C, O and N atoms. The internal bond angles are, to a large

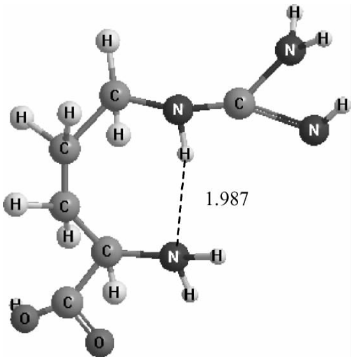

Fig. 1. 1 the arginine molecule in its non-zwitterion form with dotted hydrogen bond

extent, also determined by the valences of the constituent atoms (i. e., the sp^3 or sp^2 nature of the bonding orbitals). However, there are other interactions among the several functional groups in arginine that also contribute to its ultimate structure. In particular, the hydrogen bond linking the α-amino group's nitrogen atom to the —NH— group's hydrogen atom causes this molecule to fold into a less extended structure than it otherwise might.

What does theory have to do with issues of molecular structure and why is knowledge of structure so important? It is important because the structure of a molecule has a very important role in determining the kinds of reactions that molecule will undergo, what kind of radiation it will absorb and emit, and to what "active sites" in neighboring molecules or nearby materials it will bind. A molecule's shape (e. g., rod-like, flat, globular, etc.) is one of the first things a chemist thinks of when trying to predict where, at another molecule or on a surface or a cell, the molecule will "fit" and be able to bind and perhaps react. The presence of lone pairs of electrons (which act as Lewis base sites), of π orbitals (which can act as electron donor and electron accepter sites), and of highly polar or ionic groups guide the chemist further in determining where on the molecule's framework various reactant species (e. g., electrophilic or nucleophilic or radical) will be most strongly attracted. Clearly, molecular structure is a crucial aspect of the chemists' toolbox.

How does theory relate to molecular structure? As we discussed in the Background Material, the Born-Oppenheimer approximation leads us to use quantum mechanics to predict the energy E of a molecule for any positions ($\{R(a)\}$) of its nuclei given the number of electrons N_e in the molecule (or ion). This means, for example, that the energy of the arginine molecule in its lowest electronic state (i. e., with the electrons occupying the lowest energy orbitals) can be determined for any location of the nuclei if the Schrödinger equation governing the movements of the electrons can be solved.

It often turns out that a molecule has more than one stable structure (isomer) for a given electronic state. Moreover, the geometries that pertain to stable structures of excited electronic states are different than those obtained for the ground state (because the orbital occupancy and thus the nature of the bonding is different).[2] Again using arginine as an example, its ground electronic state also has the structure shown in Fig. 1. 2 as a stable isomer. Notice that this isomer and that shown earlier have the atoms linked together in identical manners, but in the second structure the α-amino group is involved in two hydrogen bonds while it is involved in only one in the former. In principle, the relative energies of these two geometrical isomers can be determined by solving the electronic Schrödinger equation while placing the constituent nuclei in the locations described in the two figures.

If the arginine molecule is excited to another electronic state, for example, by promo-

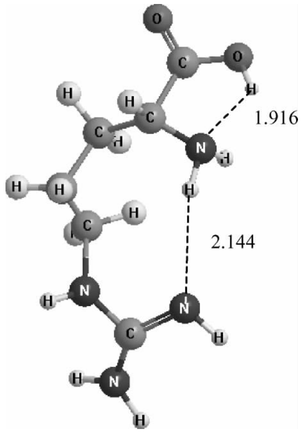

Fig. 1. 2 another stable structure for the arginine molecule

ting a non-bonding electron on its C═O oxygen atom into the neighboring C—O π^* orbital, its stable structures will not be the same as in the ground electronic state. In particular, the corresponding C—O distance will be longer than in the ground state, but other internal geometrical parameters may also be modified (albeit probably less so than the C—O distance). Moreover, the chemical reactivity of this excited state of arginine will be different than that of the ground state because the two states have different orbitals available to react with attacking reagents.

In summary, by solving the electronic Schrödinger equation at a variety of geometries and searching for geometries where the gradient vanishes and the Hessian matrix has all positive eigenvalues, one can find stable structures of molecules (and ions).[3] The Schrödinger equation is a necessary aspect of this process because the movement of the electrons is governed by this equation rather than by Newtonian classical equations. The information gained after carrying out such a geometry optimization process includes (ⅰ) all of the interatomic distances and internal angles needed to specify the equilibrium geometry and (ⅱ) the total electronic energy E at this particular geometry.

From *An Introduction to Theoretical Chemistry by Jack, Simons*

New Words and Expressions

arginine [ˈɑːdʒini(ː)n] *n*. **精氨酸**
carboxylic [ˌkɑːbɔkˈsilik] *a*. **羧基的**
adjacent [əˈdʒeisənt] *a*. **邻近的，接近的**
methylene [ˈmeθiliːn, -lin] *n*. **亚甲基**
imine [ˈimiːn, -in; iˈmiːn] *n*. **亚胺**
amino [ˈæminəu] *a*. **氨基的**
zwitterions [ˈtsvitəraiən] *n*. **两性离子**
electrophilic [iˌlektrəuˈfilik] *a*. **亲电（子）的**
nucleophilic [ˌnjuːkliəuˈfilik] *a*. **亲核的，亲质子的**
isomer [ˈaisəumə] *n*. **异构体**
gradient [ˈgreidiənt] *n*. **梯度，倾斜度**
vanish [ˈvæniʃ] *vi*. **消失，变成零**
matrix [ˈmeitriks] *n*. **矩阵**

eigenvalue [ˈaigənˌvæljuː] *n.* **特征值**
Newtonian [njuːˈtəunjən，-niən] *a.* **牛顿的，牛顿学说的**

Notes

1. **这是一个名词性从句，**which **引导的句子用来说明** molecular structure。**参考译文：很多化学文章讨论的基本论点之一就是分子结构，也就是说，分子中原子是怎样通过化学键、分子间距和键角连接在一起的。**

2. **参考译文：然而，用于描述电子激发态稳定结构的几何学与那些用于描述基态几何学是不相同的（因为占据轨道与成键的性质是不同的）。**

3. solving **和** searching **是并列成分。参考译文：总体上说，通过对不同几何构型的电子薛定谔方程求解，寻找梯度变为零和赫赛函数矩阵均具有正特征值的几何构型，可以找出分子（和离子）的稳定结构。**

Unit 2 Hot Springs and Fool's Gold

To make organic molecules from inorganic gases requires an energy source to drive the reactions—atmospheric lightning, volcanoes or ultraviolet light are all candidates. But these sources have the potential to destroy delicate organic molecules too. Another, very different proposal for the prebiotic synthesis of amino acids invokes an energy source that lies at great depths beneath the sea, where the products would be shielded from the inclement conditions at the planet's surface.

In the 1970s, automated bathymetric vessels lowered to the floor of the Pacific Ocean revealed hot springs that were ejecting water at great temperatures sometimes exceeding 300 degrees Celsius (the water remains liquid only by virtue of the great pressures at these depths, which raise the boiling point). These springs, called hydrothermal vents, are formed when seawater transported down through cracks and pores in the rocks of the Earth's crust is heated by magma inside the Earth and rises back to the seafloor under pressure. Vents are therefore common in regions where undersea volcanic activity is strong, such as at "mid-ocean ridges". Here molten rock wells up from deep within the Earth's mantle to form new oceanic crust. The hot water issuing from a vent is generally rich in minerals, which are deposited to form tall chimney-like structures. The vent fluid is rendered turbid and opaque, like smoke, by its load of small mineral particles.

John Corliss from NASA's[1] Goddard Space Flight Center in Maryland was amongst the team that discovered hydrothermal vents. He and his fellow researchers found that the vent chimneys were swarming with communities of creatures such as clams, marine worms and bacteria. These bacteria derive their energy and nourishment at least in part from sulfur-containing compounds formed in the volcanic environment and emitted from the vents.[2] They are representatives of a very primitive class, called archaebacteria, which bask happily in hot surroundings and have no need of oxygen—characteristics that would have been necessary in the earliest organisms.

Far from being unpleasantly hot, hydrothermal vents therefore apparently provide a comfortable environment for living creatures. Corliss proposed that they might have been ideal locations for life to begin. The volcanic gases that are mixed in with the hot effluent of the vent are comprised largely of the simple chemical compounds, such as H_2, N_2, hydrogen sulfide, carbon monoxide and carbon dioxide, from which more complex organics may be formed. Here too was a source energy (the heat of the vent waters) to drive prebiotic chemistry. And there would be nutrients aplenty, in the form of minerals, to sustain the primitive organisms that might develop. (Inorganic nutrients are still an important part of the diet of today's marine microorganisms.) If creatures took up residence *inside* the vents, Corliss suggested that they would be protected from the worst of the natural catastrophes that the young Earth experienced, such as giant meteorite impacts. Corliss's vent hypothesis renders curiously prophetic the words of the Greek Archelaus in the fifth century BC: "When the Earth was first being warmed, in the lower part where the warm and cold were mingled together, many living creatures appeared, deriving their sustenance from the slime."

Some researchers, Stanley Miller amongst them, have little time for[3] the vent hypothesis. Miller points out those temperatures in most vent fluids are so high that they would be more likely to destroy organic molecules than to create them. As a volume of water equivalent to the entire ocean is cycled through vents and mid-ocean ridges every 8 to 10 million years, Miller argues that subsea volcanism might have acted to frustrate the appearance of life, by burning up organic compounds formed elsewhere in the sea, rather than promoting it. It is certainly hard to imagine that the sort of chemistry that might generate living organisms can carry on amidst temperatures of hundreds of degrees: any amino acids and sugars formed in this environment would survive for scarcely a minute or so before falling apart again in the heat.

Supporters of the vent theory counter this by pointing out that further from the direct outflow; temperatures are milder while the waters are still rich in volcanic gases and nutrients. Geologists from the University of Glasgow in Scotland have reported that "minivents" made of iron pyrites, emitting waters at less than 150 degrees Celsius, can form on the seafloor close to vent systems. They suggest that the chemical environment within these mineral structures would have been ideal for the formation and the joining together of simple organic molecules. The hydrothermal vent scenario seems likely to continue to provoke lively debate, but it cannot be denied that it remains a speculative idea for which the precise details of how it might work are not clear.

One of the protagonists for the vent model is A. G. Cairns-Smith, a chemist from Glasgow who has for many years advanced an alternative theory for the origin of life which borders on the bizarre. He proposes that the first self-replicating "organisms" may not have been made of organic molecules at all, but was instead inorganic crystals. For all the peculiarity of this idea, it is based on principles similar to those that direct the replication of DNA[4] molecules, and has been considered sufficiently intriguing to be afforded serious attention. Cairns-Smith points out that crystals grow via a kind of template-directed process in which the crystal surface acts as a guiding framework for assembly of a new layer, just as a single strand of DNA provides a template on which a new strand can be built.[5] Many crystals can be fractured quite easily along the planes of atoms. The growth and subsequent fracturing of crystals might, Cairns-Smith suggests, be regarded as a kind of replication, like cell growth and division. Moreover, different crystal faces are known generally to grow at different rates, while the speed of growth is also influenced by the presence of irregularities and defects in the perfect crystal structure. This could provide a means by *which* slightly different crystal shapes might mutate and compete with each other in an evolutionary sense.[6]

Cairns-Smith suggests that clay minerals are particularly good candidates for primitive inorganic replicators. These substances are multidecker sandwiches of negatively charged aluminosilicate sheets stuffed with water and metal ions.[7] The metal ions between layers can be exchanged with others quite easily; ion exchange in clays is exploited in some water-purification processes to remove toxic metals from solution. Cairns-Smith proposes that clays might use different sequences of metals between layers as primitive "gene banks" that pass on advantageous traits to new crystals.

There is little doubt that the idea of clay replicators is far-fetched, but Cairns-Smith does not propose that these systems could ever be considered as living organisms (or even "inorganisms"). Rather, he thinks that they might have evolved to a stage at which they were able to facilitate the formation of organic molecules. Initially the organics would have been mere slaves, created because they help the crystals to replicate; but eventually they would have become adept at replication themselves. In support of the idea, we might note that clay minerals are sometimes rather good catalysts for reactions involving organic compounds, and because of their variable layer spacing they can show a degree of catalytic specificity reminiscent of that of zeolites. Furthermore, some organic molecules are known to act as growth inhibitors or promoters which engineer preferential growth of certain crystal faces. This kind of control of mineral growth is crucial to the formation of biominerals such as tooth and bone, which is orchestrated very skillfully by proteins.

Minerals lie also at the heart of the recent addition to origin-of-life scenarios put forward by the German Gunter Wächtershäuser, a one-time organic chemist now turned patent lawyer.[8] His theory focuses largely on the energy source that might have driven prebiotic chemistry, rather than being concerned with the details of the molecules so formed. In most biochemical reactions, energy means electrons: the reactions are often assisted by enzymes that are good at supplying electrons to, or extracting them from, the reactants. This is something that inorganic chemistry can do too, and Wächtershäuser singles out in particular iron pyrites—fool's gold, or FeS_2—as a potential electron source; this compound is the very constituent of the "minivents" identified by the Glasgow geologists. Wächtershäuser suggests that iron pyrites might have acted as a kind of battery to drive the metabolism of primitive precellular organisms consisting of layers of organic molecules attached to the positively charged surface of the mineral. Iron and its other principal sulfide FeS could have been sequestered by these "surface metabolists" and transformed into FeS_2 with the concomitant release of an electron for use in the "organism's" metabolic processes.

Wächtershäuser is the first to admit that his theory is highly speculative. But it gains a certain degree of respectability from the existence of a rare type of bacteria that do in fact seem to use tiny particles of iron pyrites for metabolism. If Wächtershäuser's "surface metabolists" were able to break free of the mineral surface and close up their organic membranous coat to form a sac with a tiny lump of iron pyrites inside,[9] they could be considered to represent a very crude kind of organism—protocells containing their own batteries.

From *Designing the Molecular World by G. M. Rawlins*

New Words and Expressions

ultraviolet [ˈʌltrəˈvaiəlit] *a.* **紫外（线）的** *n.* **紫外线辐射**
delicate [ˈdelikit] *a.* **精巧的，精致的，脆弱的，微妙的**
prebiotic [ˌpriːbaiˈɔtik] *a.* **生命起源以前的**
invoke [inˈvəuk] *v.* **求助，借助**
inclement [inˈklemənt] *a.* **险恶的，严酷的**
bathymetric [ˌbæθiˈmetrik] *a.* **（海洋）深测术的**
crack [kræk] *n.* **裂缝**
pore [pɔː] *n.* **毛孔，小孔，气孔**
magma [ˈmægmə] *n.* **岩浆**
vent [vent] *n.* **通风孔，出烟孔，出口**
mantle [ˈmæntl] *n.* **覆盖物**
Earth's mantle **地幔**
turbid [ˈtəːbid] *a.* **浑浊的，雾重的**
hydrothermal [ˈhaidrəuˈθəːməl] *a.* **热水的，热液的**
marine [məˈriːn] *a.* **海的，海产的，航海的**
archaebacteria [ˌɑːkibækˈtiəriə] *n.* **太古细菌，原始细菌**
nutrient [ˈnjuːtriənt] *a.* **有营养的**
catastrophe [kəˈtæstrəfi] *n.* **大灾难，大祸**
pyrites [paiˈraitiːz] *n.* **硫化铁矿**

scenario [si'nɑːriəu] *n*. 剧情
provoke [prə'vəuk] *vt*. 引起，惹起，驱使
protagonist [prəu'tægənist] *n*. （戏剧，小说中的）主角，领导者
peculiarity [piˌkjuːli'æriti] *n*. 特性，怪癖
intriguing [in'triːgiŋ] *a*. 引起兴趣（或好奇心）的，迷人的
fracture ['fræktʃə] *v*. （使）分裂，（使）破裂
multideck ['mʌltidek] *n*. 多层（板）
aluminosilicate [əˌljuːmənəu'silikeit] *n*. 铝硅酸盐
far-fetched [fɑːfetʃt] *a*. 牵强的，勉强的
facilitate [fə'siliteit] *vt*. 使便利，推动，促进
reminiscent [remi'nis(ə)nt] *a*. 回忆往事的
inhibitor [in'hibitə(r)] *n*. 抑制剂，抑制者
precellular [ˌpri'seljulə] *n*. 前细胞的
concomitant [kən'kɔmitənt] *a*. 伴随的；*n*. 伴随物
metabolic [ˌmetə'bɔlik] *a*. 新陈代谢的
speculative ['spekjulətiv] *a*. 推测的，投机的
metabolist [me'tæbəlist] *n*. 新陈代谢者

Notes

1. NASA：National Aeronautics and Space Administration 美国国家航空航天局
2. 句中 sulfur-containing compounds 是 from 的宾语，formed in the volcanic environment and emitted from the vents 为 sulfur-containing compounds 的定语。参考译文：这些细菌获得的能量和养料至少有一部分是形成于火山环境、并从火山口中喷出的含硫化合物。
3. have little time for sth：对某事不感兴趣
4. DNA：deoxyribonucleic acid 脱氧核糖核酸
5. 句中 in which 引导定语从句，修饰 process。just as 引导的定语从句修饰 guiding framework。on which 引导介词从句修饰 template。参考译文：Cairns-Smith 指出晶体的生长经由一种模板导向的过程，在这个过程中晶体表面充当一个新层面形成的指导框架，就像单股 DNA 为形成新股 DNA 提供的模板一样。
6. 句中 This 是形式主语，指代上文中的 different crystal faces are known generally to grow at different rates。which 指代 means。参考译文：不同的晶体表面一般按照不同的速度生长可以提供一种途径。通过这一途径，具有微小差别的晶体类型就可以发生变异，并与其他的晶体类型按照进化论的观点竞争生长。
7. 参考译文：这种物质有类似三明治的多层结构，在带负电荷的硅酸铝层中充满了水和金属离子。
8. 参考译文：由一位德国有机化学家（现转行做了专利律师）提出的矿石假说，最近成为生命起源论的热点。
9. 如果 Wächtershäuser 的"表面代谢生物"能够不受矿物表面的约束而贴近它们的有机膜外表形成一个内有一小团黄铁矿的液囊，……

Exercises

Ⅰ. Comprehension

1. We can find the " hot springs " at ____.
A. the floor of pacific ocean
B. undersea where volcanic activity is strong
C. the cracks and the pores in the rock under the sea

D. undersea where the seawater was heated by magma inside the earth

2. John Corliss thought that the hydrothermal vents were the places where living creatures appeared because that ____.

A. they had found the creatures such as clams, marine worms and bacteria in the hydrothermal vents

B. the hydrothermal vents provided a comfortable environment for living creatures

C. in hydrothermal vents, there had some chemical compounds to form organics and energy to drive that react

D. the hydrothermal vents had the same natural environment like that of the young earth

3. Which of the following is not true? ____

A. Stanley Miller didn't admit the vent theory.

B. "Minivents" made of iron pyrites could provide the mineral to form organic molecules.

C. Amino acids and sugars would fall apart at high temperature.

D. The debate of the vent theory will last.

4. According to paragraph 7 and 8, we can know that ____.

A. A. G. Cairns-Smith was a supporter of the vent model

B. Smith suggested that the organisms growed up via self-replicating by organic molecules

C. the structure of clay could be described as layers aluminosilicate between water and metal ions

D. crystals could be fractured easily either along or cross the planes of atoms

5. Clay minerals are sometimes good catalysts for reactions forming organic molecules because ____.

A. they can help the crystals to replicate

B. they can self-replicate

C. they have variable layer spacing and special constituent

D. they can control the growth of organisms

6. According to Wächtershäuser's theory, we can know all except ____.

A. it didn't concern the details of how molecules had formed but the energy which had driven the prebiotic chemistry

B. FeS_2 is a potential electron source because it might act as a kind of battery

C. the energy which has driven prebiotic chemistry is electron

D. his theory is speculative and there has no example to support it

Ⅱ. Fill in the blanks with the appropriate forms of the verbs given in the brackets

1. Perhaps the only thing we can be sure of is that there ____ never ____ (be) any lack of ideas ban how organic compounds ____ (appear) on Earth to seed the beginning of life.

2. Many geologists now ____ (believe) that meteorites ____ (supply) substantial amounts of organic matter to the early Earth.

3. Much of what we know about extraterrestrial organic chemistry ____ (derive) from analyses of the rocky objects that find their way to Earth in the form of meteorites.

4. In the spectra of interstellar gas clouds, astronomers ____ (read) the signature of simple organics such as methanol.

5. There is nevertheless no doubt that its raw materials-Organic molecules-____ (form) in space.

6. The Swedish chemist ____ (propose) in 1908 that the seeds of life ____ (sow) by deep-frozen spores from another world, blown to earth by the radiation pressure of the stars.

Ⅲ. Translation

1. **化学革命是周围变革中人们最不理解的变革。**
2. **因此，我们要想了解世界，就得弄清什么是化学。**
3. **机器的这一部分的材质是熟铁。**
4. **从传导性的观点来看，铝是做电线的好材料。**
5. **这种溶液马上就要沸腾起来了。**

Ⅳ. Translation

In the 1950s the American chemist Harold Urey and his student Stanley Miller, working at the University of Chicago, set out to test this hypothesis. Miller proposed that the best way of testing whether organics could really have formed in the primitive atmosphere was to carry out an experiment that simulated the conditions on earth at that time (as far as these were known). Urey and Miller circulated a mixture of methane, ammonia, water and hydrogen (thought to mimic the composition of the early atmosphere) through a reaction vessel, heating the brew in one part of the cycle and allowing it to cool and condense in another, while in the gaseous state, an electrical discharge was passed through the mixture to simulated lightning. After running the experiment for a week, Urey and Miller found a mixture of organic compounds dissolved in the water that condensed in the cool part of the cycle, amongst which were substantial quantities of simple amino acids such as glycine and alanine.

Ⅴ. Problem

(1) A liter of water contains 0.10 mole of solid FeS. Another contains 0.10 mole of solid HgS. What concentration of H_3O^+ is necessary to dissolve completely the precipitate in each case? Assume the total volumes remain at 1 liter. (K_{sp} for FeS is 3.7×10^{-19}; K_{sp} for HgS is 1×10^{-19}.)

(2) Calculate the concentrations of all solute species present in a solution made up of 0.10 mole of mole of H_2S in 1.00 liter of water ($K_{a1}=9.1\times10^{-8}$, $K_{a2}=1.0\times10^{-14}$).

Reading Material

How Chemistry Came to Life

It is a long way from granite to the oyster…

Ralph Waldo Emerson

The American chemist Julius Rebek has said that "once there was physics and there was chemistry but there was no biology". In other words, unless you are inclined to take a more biblical view, there seems to be no avoiding the conclusion that the former two begat the latter. While evolution from primitive to complex life is the concern of the biologist, the initial appearance of life on Earth sets a puzzle that physical science must solve. In earlier ages the fundamental question was: can life arise from chemistry alone? But now that we understand, in considerable measure, the replicating mechanism of DNA, the manufacture of protein, the chemical basis of photosynthesis, cell metabolism, immune responses and the host of other molecular processes on which life depends, few scientists would doubt that this question can be met with a resounding affirmative.[1] The issue has instead become that of *how* these exquisitely tuned (bio)chemical systems could have arisen spontaneously on a planet of rock, water and a mixture of simple gases. We don't yet have all the answers, but this