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# Great Chemists

## From the History of Chemical Science


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Иваново 2008

Федеральное агентство по образованию Российской Федерации
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# *Great Chemists*

## *From the History of Chemical Science*

Учебное пособие

Иваново 2008

“Great Chemists”: учебное пособие для студентов I и II курсов технологических специальностей ИГХТУ/ А.И. Киркин, Р.М. Москвина под ред. Н.К. Ивановой; ГОУВПО Иван. Гос. хим-технол. ун-т. Иваново, 2008,

Учебное пособие “Great Chemists” предназначено для студентов I и II курсов технологических специальностей ИГХТУ, а также можно рекомендовать для самостоятельной работы студентов.

Пособие включает оригинальные тексты из научно-популярной литературы и имеют аудиоприложения с химическими текстами.

Для эффективного усвоения языкового материала разработаны различные упражнения, стимулирующие мыслительную деятельность и развивающие творческое отношение к изучаемому материалу и позволяющие выражать свое мнение по прочитанному, логически обосновывать свою точку зрения.

Пособие имеет большой образовательный и воспитательный потенциал, помогает студентам расширить кругозор.

Печатается по решению редакционно-издательского совета Ивановского государственного химико-технологического университета.

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# От составителя

Настоящее учебное пособие предназначено для студентов I и II курсов технологических специальностей ИГХТУ. Его можно рекомендовать также для использования при самостоятельной работе студентов.

Пособие состоит из 9 основных уроков и аудиоприложений с химическими текстами.

Урок представляет собой совокупность вводного текста, характеризующего развитие химической науки на определенном этапе и основных текстов с биографиями ученых химиков. Тексты взяты из оригинальной научно-популярной литературы и имеют большую познавательную ценность.

В конце каждого урока разработаны специальные упражнения различных видов, развивающие навыки понимания информации на иностранном языке, формирование умений анализировать лексические и грамматические формы.

Упражнения нацелены на глубокое проникновение в смысл текста и подводят студентов к творческой работе с текстовым материалом.

Аудиоприложения озвучены носителями языка. Их цель – развивать слуховое восприятие и способность понимать иностранную речь.

При первом чтении текст произносит диктор. Студенты должны при прослушивании текста выписать как можно больше лексических единиц.

При втором чтении студенты проговаривают текст вслед за диктором в паузах.

Во время третьего чтения студентам дается установка закончить фразу на иностранном языке в паузах.

Весь учебный и иллюстративный материал для пособия взят из Encarta 2006, English Platinum 1999, Encyclopedia Britannica 2006 и БСЭ -2004.

# Unit 1
# History of Chemistry
## The Period of Magic

Alchemy ancient art practiced especially in the Middle Ages was devoted chiefly to discovering a substance that would transmute the more common metals into gold or silver and to finding a means of indefinitely prolonging human life. Although its purposes and techniques were dubious and often illusory, alchemy was in many ways the predecessor of modern science, especially the science of chemistry.

The birthplace of alchemy was ancient Egypt, where, in Alexandria, it began to flourish in the Hellenistic period. Simultaneously, a school of alchemy was developing in China. The writings of some of the early Greek philosophers might be considered to contain the first chemical theories; and the theory advanced in the 5th century BC by Empedocles—that all things are composed of air, earth, fire, and water—was influential in alchemy. The Roman emperor Caligula is said to have instituted experiments for producing gold from orpiment, a sulfide of arsenic, and the emperor Diocletian is said to have ordered all Egyptian works concerning the chemistry of gold and silver to be burned in order to stop such experiments. Zosimus the Theban (about AD250-300) discovered that sulfuric acid is a solvent of metals, and he liberated oxygen from the red oxide of mercury.

### Alchemy Workshop

Photo Researchers, Inc./J. L. Charmet/Science Source

The caricature illustrates an alchemist's workshop of the 17th century, poking fun at the quest for a "philosopher's stone" by which ordinary metals could be turned into gold. Here, the alchemists eagerly watch an experiment while working bellows to work up the fire. Although drawings like this one reveal a certain amount of disdain for the art, alchemy played an important role in the development of science. Transmuting metals became possible in the 20th century by bombarding them with neutrons.

The period of magic extended from prehistoric times to about the beginning of the 1st century AD. Most people believed that natural processes were controlled by spirits, and they relied on magic to persuade the spirits to help while they conducted practical operations. Very little progress was made toward understanding how the universe is made, but much practical knowledge was gathered. Perhaps 9,000 years ago, people devised reliable techniques for making and sustaining fire. Gradually they learned to use fire to harden pottery, extract metals from ores, make alloys, and develop materials such as glass. Certain elements that occur naturally in a pure state, such as gold, copper, and sulfur, were recognized and valued for their properties. This was the period of the Sumerian, Babylonian, Egyptian, and Greek cultures.

In about 400 BC the Greek philosopher Democritus theorized that all matter was made up of tiny, indivisible units he called atoms, but his idea was not based on scientific evidence. Other Greek philosophers, including Thales and Aristotle, also speculated on the nature of matter, though their theories, too, had little in common with modern chemical knowledge. They believed that earth, air, fire, and water (some imagined a fifth substance called “quintessence”) were the basic elements of all matter. They speculated on the possibility of removing such qualities as hardness, heat or cold, and color from common materials and combining them to make rarer or more valuable substances. They knew that iron could be drawn from a dirty, brown earthen rock and that bronze was made by combining copper and tin. Therefore it seemed possible that if yellowness, hardness, and other qualities could be properly combined, the product would be gold. Such speculations gave rise to alchemy.

## *Answer the questions:*

1. What was alchemy devoted chiefly to?

2. What theory was influential in alchemy?

3. The Roman emperor Caligula had instituted experiments for producing gold from orpiment, had not he?

4. Did most people believe in ancient times that natural processes were controlled by spirits?

5. What purpose did ancient people use fire for?

6. Who theorized that all matter was made up of tiny, indivisible units he called atoms.

7. What elements were the basic elements of all matter?

8. What speculations gave rise to alchemy?


## Roger Bacon (1214?-1294)

*Experimental science is the mistress of the speculative sciences, it alone is able to give us important truths within the confines of the other sciences, which those sciences can learn in no other way.*

English Scholastic philosopher, monk and scientist, one of the most influential teachers of the 13th century.

Born in Ilchester, Somersetshire, Bacon was educated at the universities of Oxford and Paris. He remained in Paris after completing his studies and taught for a time at the University of Paris. Soon after his return to England in about 1251, he entered the religious order of the Franciscans and settled at Oxford. He carried on active studies and did experimental research, mainly in alchemy, optics, and astronomy.

Bacon was critical of the methods of learning and in the late 1260s, at the request of Pope Clement IV, he wrote his *Opus Majus* (Major Work). In this work he represented the necessity of a reformation in the sciences through different methods of studying languages and nature. The *Opus Majus* was an encyclopedia of all science, embracing grammar and logic, mathematics, physics, experimental research, and moral philosophy. The response of the pope to Bacon's masterpiece is not known, but the work could not in any circumstances have had much effect in Bacon's time, because it reached Clement during the period of his fatal illness.

Bacon's revolutionary ideas about the study of science caused his condemnation by the Franciscans for his heretical views. In 1278 the general of the Franciscan order, Girolamo Masci, later Pope Nicholas IV, forbade the reading of Bacon's books and had arrested Bacon. After ten years in prison, Bacon returned to Oxford. He wrote *Compendium Studii Theologiae* (A Compendium of the Study of Theology, 1292) shortly before his death.

Despite his advanced knowledge, Bacon accepted some of the popular but later disproved beliefs of his time, such as the existence of a philosopher's stone and the efficacy of astrology. Although many inventions have been credited to him, some of them undoubtedly were derived from the study of Arab scientists. His writings brought new and ingenious views on optics, particularly on refraction, on the apparent magnitude of objects, and on the apparent increase in the size of the sun and moon at the horizon. He found that with sulfur, saltpeter, and charcoal, a substance (now known as gunpowder) could be produced that would imitate lightning and cause explosions. The previous use of gunpowder by the Arabs, however, has since been shown. Bacon considered mathematics, together with experimentation, the only means of arriving at a knowledge of nature. He studied several languages and wrote Latin with great elegance and clarity. Because of his extensive knowledge he was known as Doctor Admirabilis. Six of his works were printed between 1485 and 1614, and in 1733 the *Opus Majus* was edited and published.

## *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……
Well, it seems …..

1. Born in Ilchester, Somersetshire, Bacon was educated at the universities of Cambridge and Cairo.

2. He carried on active studies and did experimental research, mainly in alchemy, optics, and astronomy.

3. In the work *Opus Majus* he represented the necessity of a reformation in the sciences through different methods of studying grammar and mathematics.

4. In 1278 the general of the Franciscan order, Girolamo Masci, later Pope Nicholas IV, allowed the reading of Bacon's books and had released Bacon.

5. Bacon rejected some of the popular but later disproved beliefs of his time, such as the existence of a philosopher's stone and the efficacy of astrology.

6. Bacon considered mathematics, together with experimentation, the only means of arriving at a knowledge of nature.

## *2. Fill in the blanks with the prepositions where necessary:*

1. He remained ….. Paris ….. completing his studies and taught ….. a time ….. the University ….. Paris.

2. Soon ….. his return ….. England …..   ….. 1251, he entered the religious order ….. the Franciscans and settled ….. Oxford.

3. Bacon was critical ….. the methods ….. learning ….. the times, and ….. the late 1260s, ….. the request ….. Pope Clement IV, he wrote his *Opus Majus* (Major Work).

4. Bacon's revolutionary ideas ….. the study ….. science caused his condemnation ….. the Franciscans ….. his heretical views.

5. ….. ten years …..  prison, Bacon returned ….. Oxford

6. Bacon considered mathematics, …..   ….. experimentation, the only means ….. arriving …… a knowledge ….. nature.

## *3. Give the initial forms of the following words:*

completing, experimental, known, illness, returned, refraction, knowledge, extensive, published.

## *4. Put the verbs in brackets in the correct tense:*

1. Bacon (to educate) at the universities of Oxford and Paris.

2. After his return to England in about 1251, he (to enter) the religious order of the Franciscans and (to settle) at Oxford.

3. Although many inventions (to credit) to him, some of them undoubtedly (to derive) from the study of Arab scientists

4. Bacon (to accept) some of the popular but later (to disprove) beliefs of his time.

5. He (to study) several languages and (to write) Latin with great elegance and clarity.

6. Six of his works (to print) between 1485 and 1614, and in 1733 the *Opus Majus* (to edit) and (to publish).

## *5. Translate the following sentences paying attention to the words with (-ing) endings and state their grammar forms:*

1. He remained in Paris after completing his studies and taught for a time at the University of Paris.

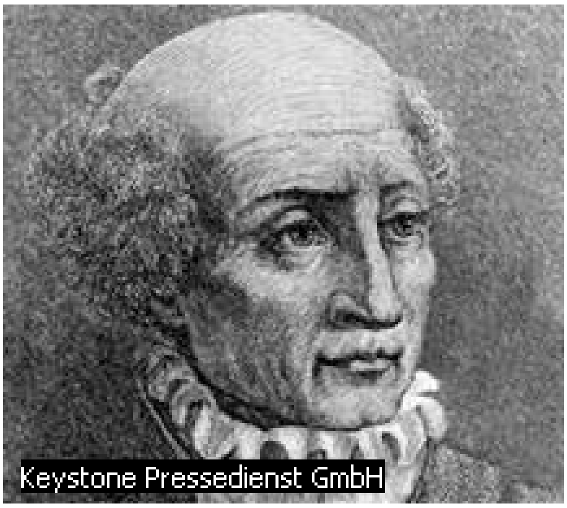
2. Bacon was critical of the methods of learning at that time.

3. The *Opus Majus* was an encyclopedia of all science, embracing grammar and logic

4. His writings brought new and ingenious views on optics,

5. Bacon considered mathematics, together with experimentation, the only means of arriving at a knowledge of nature.

In the 16th century, another important leader in the new trend was Theophrastus Bombastus von Hohenheim, an aggressive, talented Swiss who used the Latin name Paracelsus. He insisted that the object of alchemy should be the cure of the sick. The elements, he said, were salt, sulfur, and mercury (connected with the "elixir of life," another nonexistent alchemical substance), and they would give health if present in the body in the proper proportions. On this basis he practiced medicine and attracted many followers. Thus iatrochemistry, or chemistry applied to the study of medicine and the treatment of diseasebegan to be developed.




*The book of Nature is that which the physician must read; and to do so he must walk over the leaves.*

## Philippus Aureolus Paracelsus (1493 - 1541),

German alchemist and physician

Sixteenth-century Swiss physician and chemist Philippus Aureolus Paracelsus rejected the prevalent medieval belief that medical disorders were caused by an imbalance of bodily "humors" or fluids. Instead, he proposed that diseases were caused by external agents. His methods of treatment were similar in some respects to today's homeopathic remedies.

Philippus Aureolus Paracelsus, pseudonym of Theophrastus Bombastus von Hohenheim (1493?-1541), was a Swiss physician and chemist. Quarrelsome and vitriolic, Paracelsus defied the medical tenets of his time, asserting that diseases were caused by agents that were external to the body.

Born in Einsiedeln (now in Switzerland), Paracelsus received a degree in medicine, possibly from Vienna University, and traveled widely in search of alchemical knowledge, especially of mineralogy. He sharply criticized the cherished belief of the Scholastics, derived from the writings of the Greek physician Galen. He identified the characteristics of numerous diseases, such as goiter and syphilis, and used ingredients such as sulfur and mercury compounds. Many of his remedies were based on the belief that "like cures like," and in this respect he was a precursor of homeopathy.

Most famous of all was the 16th-century Swiss alchemist Philippus Paracelsus. Paracelsus considered that the elements of compound bodies were salt, sulfur, and mercury, representing, respectively, earth, air, and water. He regarded as something nonmaterial. He believed, however, in the existence of one undiscovered element common to all, of which the four elements of the ancients were merely derivative forms. Paracelsus termed *alkahest,* and he maintained that if it were found, it would prove to be the philosopher's stone, a universal medicine, and an irresistible solvent.

After Paracelsus, the alchemists of Europe became divided into two groups. One group was composed of those who earnestly devoted themselves to the scientific discovery of new compounds and reactions. These scientists were the legitimate ancestors of modern chemistry.

### *6. Read and translate the text "Philippus Aureolus Paracelsus". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.*

# Unit 2

## The Sterile Period of Alchemy

The ancient peoples had learned how to extract metals from ores and knew how to make alloys, soap, glass, leather, alum, dyes, and fermented liquors.

Many alchemists were impostors and fakers who pretended to be able to produce gold. Others, however, were honest. They performed practical experiments in their quest for the philosophers' stone. They never found it, but they made contributions to chemistry and developed laboratory techniques. By heating the compound iron sulfate, for example, they produced “oil of vitriol,” which is known today as sulfuric acid. They made hydrochloric and nitric acid and compounds such as potash and sodium carbonate. They also identified the elements arsenic, antimony, and bismuth.

The span of time from about the beginning of the 1st century AD to about the 17th century is considered the period of alchemy. The alchemists discovered new elements, and they invented basic laboratory equipment and techniques that are still used by chemists. However, the alchemists learned very little that was worthwhile concerning the fundamental nature of matter or of chemical behavior. They failed because their basic theories had almost nothing to do with what actually happens in chemical reactions.

### *Answer the questions:*

1. What did the alchemists seek?

2. They made contributions to chemistry and developed laboratory techniques, did not they?

3. What substances and compounds did they produce?

4. Why did the alchemists fail?

One of the first scientific chemists was Robert Boyle. In 1660 he helped to found one of the first scientific organizations in Europe, the Royal Society of London.

In a book called *The Sceptical Chymist* (1661) he rejected previous theories of the composition of matter and compiled the first list of the elements that are recognized today. He also discovered the relationship between the volume and the pressure of a gas.


## Robert Boyle (1627-1691),

Irish –born scientist

Considered a founder of the scientific method, 17th-century English scientist Robert Boyle believed in the importance of objective observation and controlled experimentation. He separated chemistry from alchemy and was the first to isolate and study a gas. He also discovered a law of physics, now called Boyle's law, that describes the relationship between the pressure and volume of a gas.

Boyle was born in Lismore Castle in Lismore, Ireland. His father was Richard Boyle, who was the first earl of Cork. Robert learned to speak French and Latin as a child and went to Eton College in England at the early age of eight.

In 1641 Boyle began a tour of Europe, returning to England in 1644. He settled there, because Ireland was in turmoil over colonization efforts by English protestants. Boyle had inherited parts of several estates upon his father's death in 1643, and income from these allowed him to live independently. He joined a group known as the Invisible College, whose aim was to cultivate ideas called the "new philosophy." The new philosophy included new methods of experimental science, in which scientists tried to prove or disprove hypotheses through careful experiments. Boyle moved to Oxford, which was one of the meeting places of the Invisible College, in 1654. King Charles II granted a charter in 1663 that allowed the Invisible College to become the Royal Society of London for Improving Natural Knowledge, and Boyle was a member of its first council. (He was elected president of the Royal Society in 1680, but declined the office.) He moved to London in 1668 and lived with his sister until his death in 1691.

Boyle carried out his most active research while he lived in Oxford. Much of his research dealt with the behavior of gases, including the earth's atmosphere. By careful experiments, he established Boyle's law. Boyle's law states that the volume of a given amount of gas varies inversely with its pressure, if temperature is constant. This means that at a constant temperature, the pressure of a gas will increase as the volume of the gas is decreased, and vice versa. Boyle determined the density of air in the earth's atmosphere and pointed out that the weight of objects varies with changes in atmospheric pressure. He compared the lower layers of the earth's atmosphere to a number of sponges or small springs that the weight of the layers above compresses. In 1660 Boyle published these findings in a book entitled *The Spring of Air.*

A year later Boyle published *The Sceptical Chymist,* in which he criticized previous researchers for believing that salt, sulfur, and mercury were the “true principles of things.” He advanced the view that the basic elements of matter are “corpuscles,” or particles, of various sorts and sizes. Boyle believed that these corpuscles were capable of arranging themselves into groups, and that each group constituted a chemical substance. He successfully distinguished between mixtures (substances mixed together) and compounds (chemically bonded substances) and showed that a compound can have different qualities.

Boyle studied the chemistry of combustion around 1660 with the assistance of his pupil Robert Hooke. They pumped the air out of a jar and showed that neither charcoal nor sulfur burns in a vacuum, although both substances burn in the presence of air. Boyle then found that a mixture of either substance with saltpeter (potassium nitrate) catches fire even when in a vacuum and concluded that combustion must depend on something common to both air and saltpeter. The component of air and saltpeter that allows combustion was not isolated until British chemist Joseph Priestley did so in 1774. This substance was not given its present name until French chemist Antoine Lavoisier named it oxygen three years later.

Boyle also coined the term *analysis* and used many of the reactions that modern qualitative chemists use today. He introduced certain plant extracts, notably litmus, which indicates whether a substance is an acid or a base. In 1667 he was the first to study the phenomenon of bioluminescence, the emission of light from living organisms. He showed that fungi and bacteria require air (oxygen) for luminescence, becoming dark in a vacuum and glowing again when air is readmitted. Boyle drew a comparison between a glowing coal and phosphorescent wood, although oxygen was still not known and combustion was not properly understood. Boyle also seems to have been the first to construct a small, portable, box-type camera obscura in about 1665. A *camera obscura* is a system used to project an image onto a surface. Boyle’s camera obscura could be extended or shortened like a telescope to focus an image on a piece of paper stretched across the back of the box opposite the lens.

In 1665 Boyle published in England the first account of the use of a hydrometer for measuring the density of liquids. The instrument he described is essentially the same as those in use today. Hydrometers consist of a sealed capsule of lead or mercury inside a glass tube into which the liquid being measured is placed. The height at which the capsule floats represents the density of the liquid. Boyle is also credited with the invention of the match. In 1680 he found that he could produce fire by drawing a sulfur-tipped splint through a fold in a piece of paper that was coated with phosphorus. Boyle experimented in animal physiology, although he disliked performing actual dissections. He also carried out experiments in the hope of changing one metal into another.

Boyle was interested in theology as well as science. He spent large sums on biblical translations and learned Hebrew, Greek, and Syriac in order to further his studies of the Scriptures.

Boyle accomplished much important work in physics. He studied the behavior of gases, the role of air in allowing sound to travel, and the outward force of water in the process of freezing. He was also interested in the ability of crystals to bend light, the density of liquids, electricity, color, and the behavior of liquids at rest, among other physical topics. Boyle's greatest fondness was researching in chemistry. He was the main agent in changing the unscientific field of alchemy, which was mostly concerned with turning common metals into precious metals, into modern scientific chemistry. He was the first person to work toward removing the mystique around chemistry and to change it into a pure science. He questioned the basis of the chemical theory of his day and taught that the purpose of chemistry was to determine the compositions of substances. After his death, his natural history collections passed as a bequest to the Royal Society.

### *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……
Well, it seems …..

1. He separated chemistry from physics and was the first to isolate and study a gas.

2. Much of his research dealt with the behavior of liquids, including the earth's atmosphere.

3. Boyle's law states that the volume of a given amount of gas varies inversely with its pressure, if temperature is constant.

4. Boyle determined the density of air in the earth's atmosphere and pointed out that the weight of objects does not depend from changes in atmospheric pressure.

5. He advanced the view that the basic elements of matter are "corpuscles," or particles, of various sorts and sizes.

6. He also carried out experiments in the hope of changing one metal into another.

## *2. Fill in the blanks with the prepositions where necessary:*

1. Boyle had inherited parts ….. several estates ….. his father's death ….. 1643.

2. Boyle determined the density ….. air ….. the earth's atmosphere and pointed ….. that the weight ….. objects varies ….. changes ….. atmospheric pressure.

3. They pumped the air ….. …… a jar and showed that neither charcoal nor sulfur burns ….. a vacuum,

4. ….. 1665 Boyle published the first account ….. England ….. the use ….. a hydrometer ….. measuring the density ….. liquids.

5. Hydrometers consist ….. a sealed capsule ….. lead or mercury ….. a glass tube ….. which the liquid being measured is placed.

## *3. Put the verbs in brackets in the correct tense:*

1. He (to elect) president of the Royal Society in 1680, but (to decline) the office.

2. Boyle (to carry) out his most active research while he (to live) in Oxford.

3. Boyle then (to find) that a mixture of either substance with saltpeter (potassium nitrate) (to catch) fire even when in a vacuum.

4. Boyle also (to coin) the term *analysis* and (to use) many of the reactions that modern qualitative chemists (to use) today.

5. He (to spend) large sums on biblical translations and (to learn) Hebrew, Greek, and Syriac in order (to further) his studies of the Scriptures.

## *4. Translate the following sentences paying attention to the words with (-ing) endings and state their grammar forms:*

1. In 1641 Boyle began a tour of Europe, returning to England in 1644.

2. A year later Boyle published *The Sceptical Chymist,* in which he criticized previous researchers for believing that salt, sulfur, and mercury were the "true principles of things."

3. Boyle believed that these corpuscles were capable of arranging themselves into groups, and that each group constituted a chemical substance.

4. He showed that fungi and bacteria require air (oxygen) for luminescence, becoming dark in a vacuum and glowing again when air is readmitted.

5. In 1665 Boyle published the first account in England of the use of a hydrometer for measuring the density of liquids.

6. He also carried out experiments in the hope of changing one metal into another.

7.He founded the Boyle Lectures for defending Christianity against other religions.

### *5. Practice in pronouncing the following words using a transcription from the vocabulary:*

mixture substance burn air saltpeter combustion compound isolate oxygen react acid base emission coal wood lead mercury tube liquid density salt sulphur matter arrange bond compound volume pressure increase decrease layer

## Johann Joachim Becher (1635-1682),

German chemist. Becher's research in the area of combustion had a major influence on an important theory in that field. Becher was born in Speyer, Germany. In 1666 he suggested a Rhine-Danube canal to establish trade with other areas of Europe. While living in Vienna, Austria, he conducted experiments in order to transmute the sand of the Danube River into gold. Subsequently falling into disgrace with his patron, Becher fled from Vienna to live in Britain.

Becher's studies of combustion led him to a theory of the existence of a spirit of fire, which, although it escaped into the air, could again become imprisoned in a substance to which it imparted the property of combustibility. This theory was the basis for the phlogiston theory of combustion, postulated by Becher and his pupil, the German physician and chemist Georg Ernst Stahl, and later developed by Stahl. The theory held that a substance called *phlogiston* is the basis for both combustion and oxidation. Though Stahl's theory was later disproved, he was the first chemist to recognize that these processes are analogous. Becher's ideas on the nature of minerals and other substances are found in his most important work, *Physica subterranea*, which appeared in 1669.

Phlogiston (Greek *phlogistos,* “flammable”), hypothetical substance, representing flammability was postulated in the late 17th century by the German chemists Johann Becher and Georg Stahl to explain the phenomenon of combustion. According to the phlogiston theory, every substance capable of undergoing combustion contains phlogiston, and the process of combustion is essentially the process of losing phlogiston. Because it was known that a substance such as mercury becomes heavier during combustion, it was assumed that phlogiston had negative weight; that is, the substance became heavier when it lost phlogiston. Substances such as coal and sulfur were believed to be composed almost entirely of phlogiston. In experiments with the substance now known as oxygen, the English chemist Joseph Priestley discovered its properties of supporting combustion, but he described the gas as dephlogisticated air. The phlogiston theory was disproved by the French chemist Antoine Lavoisier, who demonstrated through his quantitative experiments that combustion is a process in which oxygen combines with another substance. By 1800 virtually all chemists had recognized the validity of Lavoisier's work, and the phlogiston theory was discredited.

***6. Read and translate the text “Johann Joachim Becher”. Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 3

## The Beginnings of Modern Chemistry

For about two centuries after Boyle, scientists continued to make useful discoveries but made little progress in understanding the true nature of matter or chemical behavior.

Perhaps the greatest source of confusion and defeat in these centuries was a theory of burning (combustion) called the phlogiston theory. It was originated by the German chemists Johann Joachim Becher and Georg Ernst Stahl in the late 1600s. According to this theory, phlogiston, an "essence" like yellowness or hardness in the theories of the ancient philosophers, escaped from substances during the burning process. It had been observed that a substance would not burn long in a closed container. Becher and Stahl thought that combustion stopped because the air in the closed container had become so saturated with phlogiston that it could not absorb any more of it. Today, of course, it is known that a substance burning in a closed container will stop burning when it uses up all the oxygen.

When oxygen was discovered, it was found that combustible substances burned much better in it than they did in air. It was then mistakenly assumed that oxygen had to be a gas completely devoid of phlogiston so that it could absorb whatever was released from the burning substance. The newly discovered oxygen was thus called "dephlogisticated air."

### *Answer the questions:*

1. Did scientists make great success in understanding the true nature of matter after Boyle?

2. What caused the greatest source of confusion and defeat in these centuries?

3. A theory of burning was originated by the German chemists Johann Joachim Becher and Georg Ernst Stahl in the late 1600s, was not it?

4. Would a substance burn in a closed container?

5. Did combustible substances burn much better in oxygen or in air?

6. Why was the newly discovered oxygen called "dephlogisticated" air?

7. What was an "essence" in the theories of the ancient philosophers?

# Georg Ernst Stahl (1660-1734),

German chemist and physician, who is best known as the main developer of the phlogiston theory, which offered an explanation for combustion. Although many of Stahl's theories have been replaced by more modern ideas, his work was important in the development of chemistry. Stahl was born in Ansbach, Bavaria, and served as court physician at Weimar. He lectured on medicine at the University of Halle and in 1716 became physician to Prussia's King Frederick William I. Basing his work on that of his teacher, Johann Joachim Becher, another German chemist, Stahl proposed that a substance called *phlogiston* is the basis for both combustion and oxidation. He was the first chemist to recognize that these processes are analogous. The phlogiston theory was later disproved by the French chemist Antoine Lavoisier, who demonstrated the role of oxygen in combustion. In medicine, Stahl supported the vitalist viewpoint that life processes are different from physical or chemical ones.

### *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……
Well, it seems …..

1. German chemist and physician, who is best known as the main developer of the phlogiston theory, which offered an explanation for combustion.

2. He lectured on mathematics at the University of Halle and in 1716.

3. Stahl proposed that a substance called *phlogiston* is the basis for both combustion and oxidation.

4. The phlogiston theory was later praised by the French chemist Antoine Lavoisier.

5. Lavoisier demonstrated the role of hydrogen in combustion.

## *2. Fill in the blanks with the prepositions where necessary:*

1. Stahl was born ….. Ansbach, Bavaria, and served as court physician ….. Weimar.

2. Many …..  Stahl's theories have been replaced ….. more modern ideas.

3. His work was important ….. the development ….. chemistry.

4. Stahl proposed that a substance called *phlogiston* is the basis ….. both combustion and oxidation.

5. The phlogiston theory was later disproved ….. the French chemist Antoine Lavoisier.

6. Lavoisier demonstrated the role ….. oxygen ….. combustion.

## *3. Give the initial forms of the following words:*

physician, oxidation, demonstrated, different, chemical, explanation, teacher, rational, developer.

## *4. Put the verbs in brackets in the correct tense:*

1. His work (to be) important in the development of chemistry.

2. Stahl (to bear) Ansbach, Bavaria, and (to serve) as court physician at Weimar.

3. He (to lecture) on medicine at the University of Halle and in 1716 (to become) physician to Prussia's King Frederick William I.

4. The phlogiston theory (to disprove)  later by the French chemist Antoine Lavoisier.

5. Lavoisier (to demonstrate) the role of oxygen in combustion.

The first clue to a more useful theory came when an English chemist, Joseph Priestley, discovered in 1774 that a gas (now known as oxygen) was essential to the burning process. (Oxygen was also discovered by the Swedish chemist Carl Wilhelm Scheele at about the same time.) A few years earlier another English scientist, Henry Cavendish, had identified hydrogen as an element. The French chemist Antoine Laurent Lavoisier used the discoveries of Priestley and Cavendish in a series of experiments from which he formulated the presently accepted theory of combustion. He also showed that burning, the rusting of metals, and the breathing of animals are all processes in which oxygen combines chemically with other substances. Lavoisier's most significant finding was that the products of a chemical reaction have the same total mass as the reactants, no matter how much the substances are changed. This means that, even when chemical changes take place, something essential stays the same. These contributions are often considered to mark the beginning of modern chemistry.


*More is owing to what we call chance, that is, philosophically speaking, to the observation of events arising from unknown causes, than to any proper design, or pre-conceived theory of the business.*
**Joseph Priestley** (1733 - 1804)
British theologian and scientist.

## Joseph Priestley (1733-1804),

British chemist, who isolated and described several gases, including oxygen, and who is considered one of the founders of modern chemistry because of his contributions to experimentation.

Priestley was born on March 13, 1733, in Fieldhead, Yorkshire, the son of a Calvinist minister. Priestley trained as a minister of the Dissenting church, which Lavoisier used the discoveries of Priestley and Cavendish in a series of experiments from which he formulated the presently accepted theory of combustion.comprised various churches that had separated from the Church of England. He was educated at Daventry Academy, where he became interested in physical science. His first ministry was at Needham Market, Suffolk, in 1755, and he was minister at Nantwich from 1758 to 1761. Later he became a tutor at Warrington Academy in Lancashire, where he was noted for his development of practical courses for students planning to enter industry and commerce. He also wrote a text, *Rudiments of English Grammar* (1761), which differed from older, classical approaches. He was ordained in 1762.

Priestley was encouraged to conduct experiments in the new science of electricity by the American statesman and scientist Benjamin Franklin, whom he met in London in 1766. Priestley wrote *The History of Electricity* the following year. He also discovered that charcoal can conduct electricity. In 1767 Priestley became minister at Leeds, where he grew interested in research on gases. His innovative experimental work resulted in his election to the French Academy of Sciences in 1772, the same year in which he was employed by William Petty Fitzmaurice, 2nd earl of Shelburne, as librarian and literary companion.

During Priestley's experiments in 1774, he discovered oxygen and described its role in combustion and in respiration. An advocate of the phlogiston theory, however, Priestley called the new gas *dephlogisticated air* and did not completely understand the future importance of his discovery. The Swedish chemist Carl Wilhelm Scheele may have discovered oxygen before Priestley, but did not make his work known in time to be credited with its discovery. Priestley also isolated and described the properties of several other gases, including ammonia, nitrous oxide, sulfur dioxide, and carbon monoxide. During his career, Priestley remained opposed to the revolutionary theories of the French chemist Antoine Lavoisier, who gave oxygen its name and correctly described its role in combustion.

In 1780 Priestley left his position because of religious differences. He became a minister in Birmingham. By this time he had turned to Unitarian thinking, and was considered a religious radical. His book, *History of the Corruptions of Christianity* (1782), was officially burned in 1785. Because of his open support of the French Revolution, his house and effects were burned by a mob in 1791. He went to live in London, and in 1794 he emigrated to the United States, where he pursued his writing for the remainder of his life. Priestley died in Northumberland, Pennsylvania, on February 6, 1804. His posthumously collected *Theological and Miscellaneous Works* (25 volumes, 1817-1832) and *Memoirs and Correspondence* (2 volumes, 1831-1832) cover a wide variety of subjects in science, politics, and religion.

***5. Read and translate the text "Joseph Priestley". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 4

## Dalton's Theory of Atoms

Lavoisier's results gave chemists their first sound understanding concerning the nature of chemical reactions. The next milestone was the atomic theory, advanced in 1805 by an English schoolteacher, John Dalton. This theory states that matter is made up of small particles called atoms, that each chemical element has its own kind of atoms (in contrast to earlier ideas that atoms are essentially alike), and that chemical changes take place between atoms or groups of atoms. To support his theory Dalton set about calculating the relative weights of the atoms of several elements. The Swedish chemist Jöns Jacob Berzelius greatly expanded this work in a long series of experiments in which he found accurate atomic weights for about 40 elements. He also found chemical formulas for most of the inorganic compounds known at that time.

Equipped at last with sound views about the nature of matter and of chemical reactions, chemistry made rapid advances. In about 1811 came the hypothesis of Amedeo Avogadro, an Italian chemist, about the number of molecules in a given volume of gas. To Dalton's theory that the atoms of a single element all have the same weight, Avogadro added the following notions: that equal volumes of different gases at the same temperature and pressure contain the same number of molecules, and that some of the gaseous elements are found in two-atom molecules rather than as independent atoms. These theories explained why only half a volume of oxygen was needed to combine with a volume of carbon monoxide (CO) to form carbon dioxide ($CO_2$). Oxygen gas is made of two-atom molecules, and one oxygen molecule reacts with two molecules of carbon monoxide: $O_2$ + 2CO{long right arrow}2$CO_2$.

### *Answer the questions:*

1. What scientist gave chemists the first sound understanding concerning the nature of chemical reactions?

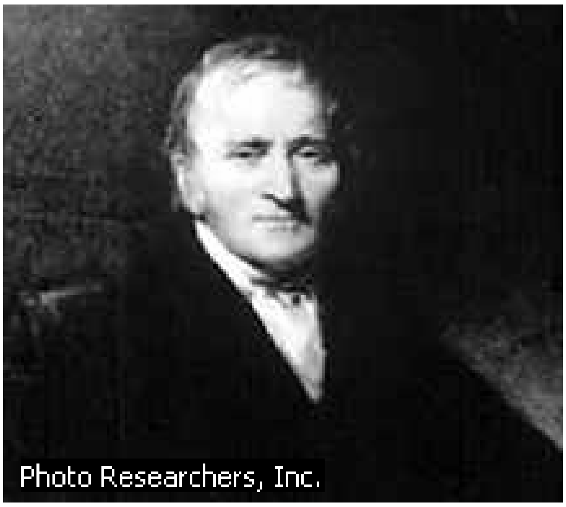
2. Matter is made up of small particles called atoms, is not it?

3. Do chemical changes take place between atoms or groups of atoms?

4. What did the Swedish chemist Jöns Jacob Berzelius find in a long series of experiments?

5. Equal volumes of different gases at the same temperature and pressure contain the same number of molecules, don’t they?

6. What was Avogadro’s hypothesis about?




# John Dalton (1766-1844),

British physicist and chemist John Dalton is best known for developing the atomic theory of elements and molecules, the foundation of modern physical science. While pondering the nature of the atmosphere during a meteorological study in the early 1800s, Dalton deduced the structure of carbon dioxide and proposed that an exact number of atoms constitute each molecule. He held that all atoms of a given element are identical and different from the atoms of every other element. The first to classify elements according to their atomic weights, Dalton set the stage for a revolution in scientific thought. He contributed a great deal to the field of meteorology and also, in 1794, became the first to describe the condition known as color blindness.

John Dalton developed the atomic theory upon which modern physical science is founded. Dalton was born on September 6, 1766, in Eaglesfield, Cumberland County, England. He was the son of a weaver and received his early education from his father and at a Quaker school in his native town, where he began teaching at the age of 12. In 1781 he moved to Kendal, where he conducted a school with his cousin and his elder brother. He went to Manchester in 1793 and spent the rest of his life there as a teacher, first at New College and later as a private tutor. He died in Manchester on July 27, 1844.

Dalton began a series of meteorological observations in 1787 that he continued for 57 years, accumulating some 200,000 observations and measurements on the weather in the Manchester area. Dalton's interest in meteorology led him to study a variety of phenomena as well as the instruments used to measure them. He was the first to prove the validity of the concept that rain is precipitated by a decrease in temperature, not by a change in atmospheric pressure.

Dalton's first work, *Meteorological Observations and Essays* (1793), attracted little attention, however. In the following year he presented a paper on color blindness, a condition from which Dalton himself suffered, before the Manchester Literary and Philosophical Society. This paper was the earliest description of this phenomenon of vision, which became known as Daltonism.

Dalton's most important contribution to science was his theory that matter is composed of atoms of differing weights and combine in simple ratios by weight. This theory, which Dalton first advanced in 1803, is the cornerstone of modern physical science.

In 1808 Dalton's *A New System of Chemical Philosophy* was published. In this book he listed the atomic weights of a number of known elements relative to the weight of hydrogen. His weights were not entirely accurate but they form the basis for the modern periodic table of the elements.

Dalton arrived at his atomic theory through a study of the physical properties of atmospheric air and other gases. In the course of this investigation he discovered the law of partial pressures of mixed gases, often known as Dalton's law, that is, the total pressure exerted by a mixture of gases is equal to the sum of the separate pressures that each of the gases would exert if it alone occupied the whole volume.

In 1804 and 1809 Dalton was invited to deliver courses at the Royal Institution in London. He was made a fellow of the Royal Society in 1822 and was awarded the society's gold medal in 1826. In 1830 Dalton became one of the eight foreign associates of the French Academy of Sciences.

## *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……
Well, it seems …..

1. He held that all atoms of a given element are identical and different from the atoms of every other element.

2. Dalton's interest in physics led him to study a variety of phenomena as well as the instruments used to measure them.

3. His weights were not entirely accurate but they form the basis for the modern periodic table of the compounds.

4. Dalton arrived at his atomic theory through a study of the physical properties of helium and other gases.

5. The total pressure exerted by a mixture of gases is equal to the sum of the separate pressures that each of the gases would exert if it alone occupied the whole volume.

## 2. *Fill in the blanks with the prepositions where necessary:*

1. British physicist and chemist John Dalton is best known ….. developing the atomic theory ….. elements and molecules.

2. The first to classify elements ….. ….. their atomic weights, Dalton set the stage ….. a revolution ….. scientific thought.

3. He contributed a great deal ….. the field ….. meteorology ….. 1794.

4. Dalton set the stage ….. a revolution ….. scientific thought.

5. Dalton's most important contribution ….. science was his theory that matter is composed ….. atoms ….. differing weights and combine ….. simple ratios ….. weight.

6. He was the son ….. a weaver and received his early education ….. his father and ….. a Quaker school ….. his native town, where he began teaching ….. the age ….. 12.

7. ….. the course ….. this investigation he discovered the law ….. partial pressures ….. mixed gases.

8. ….. 1804 and 1809 Dalton was invited to deliver courses ….. the Royal Institution ….. London.

## *3. Give the initial forms of the following words:*

physicist, developing, atomic, gases, weaver, foundation, held, teaching, blindness, accurate, periodic, earliest, known, periodic.

## *4. Put the verbs in brackets in the correct tense:*

1. Dalton (to deduce) the structure of carbon dioxide and (to propose) that an exact number of atoms (to constitute) each molecule.

2. He (to be) the son of a weaver and (to receive) his early education from his father.

3. In 1781 he (to move) to Kendal, where he (to conduct) a school with his cousin and his elder brother.

4. He (to go) to Manchester in 1793 and (to spend) the rest of his life there as a teacher

5. Dalton (to present) a paper on color blindness, a condition from which Dalton himself (to suffer).

6. He (to make) a fellow of the Royal Society in 1822 and (to award) the society's gold medal in 1826.

***5. Find sentences containing infinitive construction and translate them into Russian. State its function.***

1. The first to classify elements according to their atomic weights, Dalton set the stage for a revolution in scientific thought.

2. He became the first to describe the condition known as color blindness.

3. Dalton the first to prove the validity of the concept that rain is precipitated by a decrease in temperature, not by a change in atmospheric pressure.


*It took the mob only a moment to remove his head; a century will not suffice to reproduce it.*
**Joseph Louis Lagrange** (1736 - 1813)
French mathematician and astronomer.
Referring to the execution of the chemist Antoine-Laurent Lavoisier.

# Antoine Lavoisier (1743-1794),

French chemist, who is considered the founder of modern chemistry.

Lavoisier was born on August 26, 1743, in Paris and was educated at the Collège Mazarin. He was elected a member of the Academy of Sciences in 1768. He held many public offices, including those of director of the state gunpowder works in 1776, member of a commission to establish a uniform system of weights and measures in 1790, and commissary of the treasury in 1791. He attempted to introduce reforms in the French monetary and taxation system and in farming methods. As one of the farmers-general, he was arrested and tried by the revolutionary tribunal, and guillotined on May 8, 1794.

Lavoisier's experiments were among the first truly quantitative chemical experiments ever performed. He showed that, although matter changes its state in a chemical reaction, the quantity of matter is the same at the end as at the beginning of every chemical reaction. These experiments provided evidence for the law of the conservation of matter. Lavoisier also investigated the composition of water, and he named the components of water *oxygen* and *hydrogen.*

Some of Lavoisier's most important experiments examined the nature of combustion, or burning. Through these experiments, he demonstrated that burning is a process that involves the combination of a substance with oxygen. He also demonstrated the role of oxygen in animal and plant respiration. Lavoisier's explanation of combustion replaced the phlogiston theory, which postulates that materials release a substance called *phlogiston* when they burn.

With the French chemist Claude Louis Berthollet and others, Lavoisier devised a chemical nomenclature, or a system of names, which serves as the basis of the modern system. He described it in *Méthode de nomenclature chimique* (Method of Chemical Nomenclature, 1787). In *Traité élémentaire de chimie* (Treatise on Chemical Elements, 1789), Lavoisier clarified the concept of an element as a simple substance that could not be broken down by any known method of chemical analysis, and he devised a theory of the formation of chemical compounds from elements. He also wrote *Sur la combustion en general* (On Combustion, 1777) and *Considerations sur la nature des acides* (Considerations on the Nature of Acids, 1778).

***6. Read and translate the text "Antoine Lavoisier". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 5

## The Rise of Organic Chemistry

The vast new field of organic chemistry was opened in 1828 with Friedrich Wöhler's synthesis of urea, a compound present in certain body fluids of mammals, from inorganic materials in his laboratory. This disproved the assumption that such compounds could be formed only through the operation of a “life force” present in animals and plants. About this time chemists also began to realize that a molecule's geometric structure had a great effect on its chemical and biological properties. This applied especially to the structure of organic compounds, in which carbon atoms provide the basic framework. Chemists found, for example, that two organic compounds can have the same kinds and numbers of atoms but different properties because their molecules are put together differently. Such compounds are called isomers. The French chemist Louis Pasteur opened the way for the study of carbon's special three-dimensional bonding geometry in his investigation of the isomers of tartaric acid, an organic compound found in grapes.

The German chemist Friedrich Kekulé showed in 1858 that carbon atoms can combine with four other atoms and link with each other to form long chains. He also proposed the cyclic (ring) structure of benzene about this time. Another important field, electrochemistry, was born in the 1830s when Michael Faraday formulated its laws.

### *Answer the questions:*

1. Who was the father of organic chemistry?

2. What had a great effect on the chemical and biological properties of a molecule?

3. Carbon atoms provide the basic framework, don’t they?

4. Can two organic compounds have the same kinds and numbers of atoms?

5. What compounds are called isomers?

6. What scientist opened the way for the study of carbon's special three-dimensional bonding geometry?

7. What do carbon atoms form when they combine with four other atoms?

8. Was electrochemistry born in the 1830s or in the 1860s?

9. Who formulated its laws?


# Humphry Davy

## (1778-1829),

renowned British chemist, best known for his experiments in electrochemistry and for his invention of a miner's safety lamp.

Davy was born on December 17, 1778, in Penzance, Cornwall, England. In 1798 he began experiments on the medicinal properties of gases, during which he discovered the anesthetic effects of nitrous oxide (laughing gas). Davy was appointed assistant lecturer in chemistry at the newly founded Royal Institution in London in 1801 and the following year became professor of chemistry there.

During his early years at the Royal Institution, Davy started his investigations of the effects of electricity on chemical compounds. In 1807 he received the Napoleon Prize from the Institut de France for the theoretical and practical work begun the year before. He then constructed the largest battery ever built, with over 250 cells, and passed a strong electric current through solutions of various compounds suspected of containing undiscovered elements. Davy quickly isolated the elements potassium and sodium by this electrolytic method. He also prepared calcium by the same method. In later, unrelated experiments, he discovered boron and proved that the diamond is composed of carbon. Davy also showed that the so-called rare earths are oxides of metals rather than elements. His experiments with acids indicated that hydrogen, not oxygen, causes the characteristics of acids. Davy also made notable discoveries in heat.

In the field of applied science, Davy invented a safety lamp for miners in 1815. For this and for related research, he received the gold and the silver Rumford medals from the Royal Society. In 1823 he suggested a method of preventing the corrosion of the copper bottoms of ships by means of zinc and iron sheathing. He was knighted in 1812 and raised to a baronetcy in 1818. In 1820 he became president of the Royal Society. Davy died on May 29, 1829, in Geneva.

### *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….

I suppose ……
Well, it seems …..

1. Humphry Davy is a renowned British engineer, best known for his experiments in engineering and for his invention of an airplane.

2. In 1798 he began experiments on the medicinal properties of gases.

3. He discovered the anesthetic effects of sulphurous oxide (laughing gas).

4. Davy started his investigations of the effects of electricity on chemical compounds.

5. In later, unrelated experiments, he discovered boron and proved that the diamond is composed of nitrogen.

6. His experiments with acids indicated that ozone, not helium, causes the characteristics of acids.

7. In the field of applied science, Davy invented safety matches for miners in 1815.

8. In 1823 he suggested a method of preventing the corrosion of the copper bottoms of ships by means of brass and tin sheathing.

### *2. Fill in the blanks with the prepositions where necessary:*

1. Davy was appointed assistant lecturer ….. chemistry ….. the newly founded Royal Institution ….. London ….. 1801.

2. ….. his early years ….. the Royal Institution, Davy started his investigations ….. the effects ….. electricity ….. chemical compounds.

3. Davy passed a strong electric current ….. solutions ….. various compounds suspected ….. containing undiscovered elements.

4. Davy quickly isolated the elements potassium and sodium ….. this electrolytic method.

5. Davy also made notable discoveries ….. heat.

6. ….. the field ….. applied science, Davy invented a safety lamp ….. miners ….. 1815.

### *3. Put the verbs in brackets in the correct tense:*

1. In 1798 he (to begin) experiments on the medicinal properties of gases.

2. Davy also (to show) that the so-called rare earths (to be) oxides of metals rather than elements.

3. Davy also (to make) notable discoveries in heat.

4. He (to become) president of the Royal Society.

### *4. Find English equivalents to the next Russian expressions:*

начинать исследования, построить батарею, пропускать электрический ток через раствор, получать элементы, состоять из углерода, окислы металлов, экспериментировать с кислотами, сделать важное открытие, получить золотую и серебряную медаль, предотвращать коррозию, защитное покрытие

### *5. Find in the text sentences with Passive Voice constructions and translate them into Russian:*

### *6. Practice in pronouncing the following words using a transcription from the vocabulary:*

oxide, current, through, various, sodium, calcium, carbon, diamond, hydrogen, oxygen, cause, acid, research, compound, isolate.


## Jöns Jakob Berzelius (1779-1848),

Swedish chemist, considered one of the founders of modern chemistry.

Berzelius was born near Linköping. While studying medicine at the University of Uppsala, he became interested in chemistry. After practicing medicine and lecturing, he became a professor of botany and pharmacy at Stockholm in 1807. From 1815 to 1832 he was professor of chemistry at the Caroline Medico-Chirurgical Institute in Stockholm. He became a member of the Stockholm Academy of Sciences in 1808 and in 1818 became its permanent secretary. For his contributions to science, Berzelius was made a baron in 1835 by Charles XIV John, king of Sweden and Norway.

Berzelius's research extended into every branch of chemistry and was extraordinary for its scope and accuracy. He discovered three chemical elements—cerium, selenium, and thorium—and was the first to isolate silicon, zirconium, and titanium. He introduced the term *catalyst* into chemistry and was the first to elaborate on the nature and importance of catalysis. He introduced the present system of chemical notation, in which each element is represented by one or two letters of the alphabet. In addition, Berzelius was primarily responsible for the theory of radicals, which states that a group of atoms, such as the sulfate group, can act as a single unit through a series of chemical reactions. He developed an elaborate electrochemical theory that correctly stated that chemical compounds are made up of negatively and positively charged components. All of his theoretical work was supported by elaborate experimental measurement. His greatest achievement was the measurement of atomic weights.

***7. Read and translate the text "Jöns Jacob Berzelius". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 6

## More New Fields of Investigation

By the middle of the 19th century, about 60 elements were known. A few chemists had noticed that certain elements were much alike in their properties and saw a pattern emerge when elements were arranged according to atomic weight. The work of these men enabled the Russian chemist Dmitri Mendeleev, in 1869, to publish the first periodic table. Mendeleyev predicted correctly that the gaps left in his table would be filled by as yet undiscovered elements with properties that he also predicted. This table became the foundation of theoretical chemistry.

To this period belongs Robert Bunsen, whose most important contribution to chemistry was the organization of the field of spectroscopy, based on observations that each element when heated emits light having a characteristic color, or wavelength. To aid his research, he invented many instruments, including the spectroscope and the Bunsen burner.

### *Answer the questions:*

1. How many elements were known by the middle of the $19^{th}$ century?

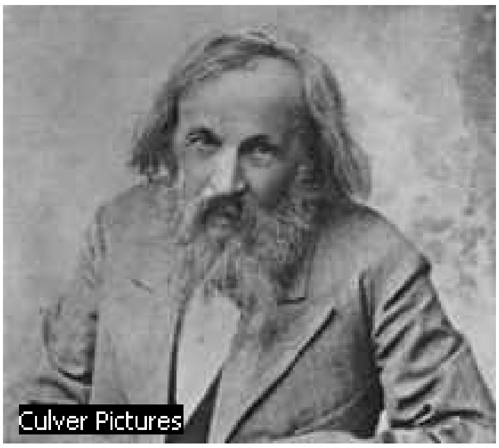
2. What had some chemists notice when elements were arranged according to atomic weight?

3. The work of these men enabled the Russian chemist Dmitri Mendeleev, in 1869, to publish the first periodic table, did not it?

4. Did Mendeleev predict correctly that the gaps left in his table would be filled by as yet undiscovered elements with properties that he also predicted?

5. What instruments did Bunsen invent?

## Dmitry Mendeleyev (1834-1907),




Russian chemist, best known for his development of the periodic law of the properties of the chemical elements. This law states that elements show a *periodicity* (regular pattern) of properties when they are arranged according to atomic weight.

Mendeleyev was born in Tobolsk, Siberia. He studied chemistry at the University of Saint Petersburg, and in 1859 he was sent to study at the University of Heidelberg. There he met the Italian chemist Stanislao Cannizzaro, whose views on atomic weight influenced his thinking. Mendeleyev returned to Saint Petersburg and became professor of chemistry at the Technical Institute in 1863. He became professor of general chemistry at the University of Saint Petersburg in 1866. Mendeleyev was a renowned teacher, and, because no good textbook in chemistry was available, he wrote the two-volume *Principles of Chemistry* (1868-1870), which became a classic.

During the writing of this book, Mendeleyev tried to classify the elements according to their chemical properties. In 1869 he published his first version of what became known as the periodic table, in which he demonstrated the periodic law. In 1871 he published an improved version of the periodic table, in which he left gaps for elements that were not yet known. His chart and theories gained increased acceptance when three predicted elements—gallium, germanium, and scandium—were subsequently discovered.

Mendeleyev's investigations also included the study of the chemical theory of solution, the thermal expansion of liquids, and the nature of petroleum. In 1887 he undertook a solo balloon flight to study a solar eclipse.

In 1890 he resigned from the university as a consequence of his progressive political views and his advocacy of social reforms. In 1893 he became director of the Bureau of Weights and Measures in Saint Petersburg and held this position until his death.

While attempting to organize the elements according to their chemical properties and atomic weight, Dmitry Mendeleyev developed the Periodic Table and formulated the periodic law. Because his classification revealed recurring patterns (periods) in the elements, Mendeleyev was able to leave spaces in his table for elements that he correctly predicted would be discovered. His forward-thinking attitude extended into his politics as well as his classroom and made him a popular but controversial professor.

### *1. State whether these sentences are true or false using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……

Well, it seems …..

1. Russian chemist Mendeleyev is best known for his development of the law of gravity.

2. In 1859 he was sent to study at the University of Cambridge.

3. Mendeleyev tried to classify the elements according to their chemical properties.

4. His chart and theories gained increased acceptance when four predicted elements—gallium, germanium, scandium selenium—were subsequently discovered.

## *2. Translate the words:*

химия, химик, химический
открывать, открытие, открыватель
исследовать, исследователь, исследование
растворять, раствор, растворитель
руководить, руководитель, руководство

## *3. Insert the missing form of the verb:*

sent ….. sent
….. met met
think thought …..
….. became become
write ….. written
know knew …..
…... undertook undertaken
be was/were …..
leave left …..
….. made made
….. showed shown
teach ….. taught

## *4. Fill in the blanks with necessary prepositions:*

1. Elements were arranged ….. atomic weight.

2. Mendeleyev returned ….. Saint Petersburg and became professor ….. chemistry ….. the Technical Institute ….. 1863.

3. He became professor ….. general chemistry ….. the University ….. Saint Petersburg ….. 1866.

4. ….. 1871 he published an improved version ….. the periodic table, ….. which he left gaps ….. elements that were not yet known.

5. Mendeleyev was able to leave spaces ….. his table ….. elements that he correctly predicted would be discovered.

## *5. Put the verbs in brackets in the correct tense:*

1. Mendeleyev (to return) to Saint Petersburg and (to become) professor of chemistry at the Technical Institute in 1863.

2. In 1887 he (to undertake) a solo balloon flight to study a solar eclipse.

3. Mendeleyev's investigations also (to include) the study of the chemical theory of solution, the thermal expansion of liquids, and the nature of petroleum

4. His classification (to reveal) recurring patterns (periods) in the elements.

5. His forward-thinking attitude (extend) into his politics as well as his classroom and (to make) him a popular but controversial professor.

## *6. Put the words in the correct word order:*

1. according, tried, the, Mendeleyev, elements, to, properties, classify, to, their, chemical.

2. was, able, correctly, spaces, in, his, table, Mendeleyev, for, to, leave, elements, that, he, predicted.

3. his, popular, extended, as, well, as, forward-thinking, into, his, politics, his, classroom, and, made, attitude, him, a, but, controversial, professor.

## *7. Practice in pronouncing the following words using a transcription from the vocabulary:*

weight, subsequently, liquid, petroleum, resign, view, bureau, measure, law, inversion.

## *8. Complete the sentences:*

1. During the writing of this book, Mendeleyev tried to classify the elements…….
2. In 1890 he resigned from the university as a consequence of …………..
3. Mendeleyev was able to leave spaces in his table for elements ………….

4. His chart and theories gained increased acceptance when three predicted elements……………………….
5. His forward-thinking attitude extended into his politics as well as …………..


## Robert Wilhelm Bunsen (1811-1899),

One of the greatest chemists of the 19th century, Robert Wilhelm Bunsen of Germany recognized that each chemical element has its own characteristic spectrum. His application of this principle led to the discovery of the elements cesium and rubidium. Contrary to popular belief, he did not invent the Bunsen burner, a gas burner commonly used in laboratories, although he improved its design and popularized its use.

Bunsen was born in Göttingen on March 31, 1811, and was educated at the University of Göttingen. Between 1836 and 1852 he taught successively at the Polytechnic Institute in Kassel and at the universities of Marburg and Breslau; thereafter he was professor at the University of Heidelberg until his retirement in 1889. Considered one of the greatest chemists in the world, Bunsen discovered (1834) the antidote that is still used today for arsenic poisoning: hydrated iron oxide. His research on the double cyanides confirmed the principle in organic chemistry that the nature of a compound depends on the radicals composing it. Contrary to popular belief, he had little to do with the invention of the Bunsen burner, a gas burner used in scientific laboratories. Although Bunsen improved and popularized the device, credit for its design should go to the British chemist and physicist Michael Faraday. Among Bunsen's inventions are the ice calorimeter, a filter pump, and the zinc-carbon electric cell. He used the cell to produce an electric-arc light and invented a photometer to measure its luminosity. The cell was used also in his development of an electrolytic method of producing metallic magnesium. Results of his research on waste gases of blast furnaces were published in the classic *Gasometric Methods* (1857). Bunsen died in Heidelberg on August 16, 1899.

***9. Read and translate the text “Robert Wilhelm Bunsen”. Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 7

## The Development of Physical Chemistry

The area where physics and chemistry overlap, which had been explored by Avogadro in his investigations of gas volumes, became prominent in the last quarter of the 19th century. Wilhelm Ostwald and Jacobus Van't Hoff used physical principles to describe the energy changes accompanying reactions in solution that go on simultaneously in opposite directions (reactants to products and products to reactants). Svante August Arrhenius proposed the idea that compounds such as acids and bases form ions (electrically charged particles) when they dissolve in water, and that these ions allow the solutions to conduct electricity.

The American chemist Willard Gibbs developed the “phase rule,” a mathematical formula showing how temperature and pressure affect the capacity of substances to exist in equilibrium in as many as three different states of matter, or phases (solid, liquid, and gas). Accurate atomic weight determinations were the work of Theodore Richards. Between 1894 and 1898, the efforts of the chemist William Ramsay and the physicist Lord Rayleigh (John William Strutt) resulted in the isolation of helium on Earth (the element previously had been detected in the sun) and the discovery of the other noble gases.

After 1900, chemists began receiving invaluable aid from discoveries made in physics about the electrical nature of the atom. Henry Moseley, working with X rays emitted from atoms of the different elements, reorganized the elements using atomic number—a quantity equal to the positive charge of the atomic nucleus—rather than atomic weight. Max von Laue and Sir William Bragg and his son Lawrence Bragg laid the basis for determining the atomic structure of substances in crystal form by means of X rays. Francis W. Aston developed the mass spectrograph, a device that separates atoms or molecular fragments of different mass, and used it to discover isotopes of many elements. Later Harold C. Urey isolated deuterium, an isotope of hydrogen with one neutron. Deuterium has become important as a chemical tracer, in thermonuclear weapons, and in fusion power research.

### *Answer the following questions:*

1. What method did Ostwald and Hoff use to describe the energy changes accompanying reactions in solution?

2. Do acids and bases form ions (electrically charged particles) when they dissolve in water?

3. Do these ions allow the solutions to conduct electricity or heat?

4. The "phase rule," a mathematical formula shows how temperature and pressure affect the capacity of substances to exist in equilibrium in as many as three different states of matter, doesn't it?

5. What element previously had been detected in the sun?

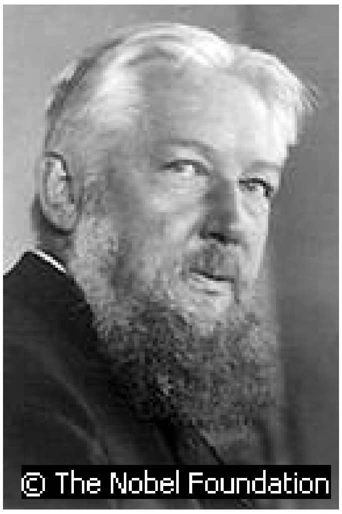
6. Whom did chemists begin to get invaluable aid from?

7. How did Henry Moseley reorganize the elements?

8. Who laid the basis for determining the atomic structure of substances in crystal form by means of X rays?

9. The mass spectrograph is a device that separates atoms or molecular fragments of different mass, isn't it?

10. What element has become important as a chemical tracer, in thermonuclear weapons, and in fusion power research?




## Wilhelm Ostwald (1853-1932),

German physical chemist and Nobel laureate, considered one of the founders of modern physical chemistry. He was born in Rīga, Latvia, and educated at the University of Dorpat (now Tartu State University). In 1881 he was appointed professor of the Rīga Polytechnic Institute and from 1887 to 1906 served as professor of physical chemistry and director of the chemical laboratory at the University of Leipzig, Germany. Ostwald is especially known for his contributions to the field of electrochemistry, including important studies of the electrical conductivity and electrolytic dissociation of organic acids. He invented a viscometer that is still used for measuring the viscosity of solutions. In 1900 he discovered a method of preparing nitric acid by oxidizing ammonia. This method, known as the Ostwald process, was used by Germany during World War I for manufacturing explosives after the Allied blockade had cut off the regular German supply of nitrates, and it is still used. Ostwald received the 1909 Nobel Prize in chemistry. His works include *Natural Philosophy* (1902; trans. 1910) and *Colour Science* (1923; trans. 1931). Also a famous scientist, his son, Wolfgang Ostwald, is generally regarded as the founder of colloid chemistry. German physical chemist Wilhelm Ostwald won the 1909 Nobel Prize in chemistry Also a famous scientist, his son, Wolfgang Ostwald, is generally regarded the fundamental principles governing chemical equilibrium and rates of reaction.

## *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……
Well, it seems …..

1. The French physical chemist and Nobel laureate Wilhelm Ostwald is considered one of the founders of modern physical chemistry.

2. In 1881 he was appointed professor of the Leipzig Polytechnic Institute.

3. Ostwald is especially known for his contributions to the field of radio physics.

4. He invented a viscometer that is still used for measuring the density of solutions.

5. A method of preparing nitric acid by oxidizing ammonia was used by Germany during World War I for manufacturing explosives.

## *2. Give the initial forms of the following words:*

physical, founder, educated, known, including, electrical, dissociation, measuring, famous, generally, won, fundamental, reaction.

## *3. Put the verbs in brackets in the correct tense:*

1. He (to be born) in Rīga, Latvia, and (to educate) at the University of Dorpat.

2. Ostwald (to be known) especially for his contributions to the field of electrochemistry.

3. In 1881 he (to be appointed) professor of the Rīga Polytechnic Institute.

4. His son, Wolfgang Ostwald, (to be regarded) generally as the founder of colloid chemistry.

## *4. Translate the following sentences paying attention to the words with (-ing) endings and state their grammar form:*

1. Ostwald is especially known for his contributions to the field of electrochemistry, including important studies of the electrical conductivity and electrolytic dissociation of organic acids.

2. He invented a viscometer that is still used for measuring the viscosity of solutions.

3. In 1900 he discovered a method of preparing nitric acid by oxidizing ammonia.

4. The Ostwald process was used by Germany during World War I for manufacturing explosives.

5. Ostwald won the award for his research into the fundamental principles governing chemical equilibrium and rates of reaction.

## *5. Fill in the blanks with the prepositions where necessary:*

1. He was born ….. Rīga, Latvia, and educated ….. the University of Dorpat.

2. Ostwald is especially known ….. his contributions ….. the field ….. electrochemistry.

3. ….. 1900 he discovered a method ….. preparing nitric acid ….. oxidizing ammonia.

4. The Ostwald process was used ….. Germany ….. World War I ….. manufacturing explosives.

5. Deuterium has become important as a chemical tracer, ….. thermonuclear weapons, and …..  fusion power research.

## *6. Put the words in the correct word order:*

1. served from 1887 director to  chemistry 1906 as of physical and of the chemical laboratory professor.

2. contributions is especially for his the field Ostwald to of electrochemistry known.

3. had cut the Allied  supply of off the regular German nitrates blockade.

4. in a method oxidizing 1900 he of preparing nitric discovered acid by ammonia.

### *7. Insert the English equivalents instead of Russian:*

found основатель foundation

химия chemist chemical

educate educator обучать

включать inclusion inclusive

oxidize окисление oxide

правительство govern governess

react реакция reactive

### *8. Practice in pronouncing the following words using a transcription from the vocabulary:*

nitrate, supply, viscometer, educate, chemistry, acid, measure, manufacture, govern, equilibrium, famous.

### *9. Complete the sentences:*

1. Ostwald is especially known for his contributions to …………………

2. Also a famous scientist, his son, Wolfgang Ostwald, is generally regarded ………

3. This method, known as the Ostwald process, was used by Germany……………

5. In 1881 he was appointed professor ……………………


## Jacobus van't Hoff (1852-1911),

Dutch physical chemist and Nobel laureate, known for his studies of the structure of organic compounds. He was born in Rotterdam, and was educated at the Technical University of Delft and the universities of Leiden, Bonn, Paris, and Utrecht. In 1876 he became a lecturer in physics at the Veterinary School in Utrecht and was professor of chemistry, mineralogy, and geology at the University of Amsterdam in 1878. He was appointed professor of chemistry at Leipzig in 1887 and at Berlin in 1896. Often called the father of physical chemistry, he achieved prominence very early when, in 1874, he put forward a theory to explain the structure of organic compounds. His relation of the optically active carbon compounds to asymmetrical and three-dimensional structures laid the basis for the science of stereochemistry. In 1901 he was awarded the first Nobel Prize in chemistry for his work relating thermodynamics to chemical reactions and his studies of the properties of solutions. His later research on salt deposits was important to the German chemical industry. Dutch chemist Jacobus van't Hoff won the 1901 Nobel Prize in chemistry. Van't Hoff investigated the structure of organic compounds and came to be known as the "father of physical chemistry." Wilhelm Ostwald and Jacobus Van't Hoff used physical principles to describe the energy changes accompanying reactions in solution that go on simultaneously in opposite directions (reactants to products and products to reactants).

***10. Read and translate the text "Jacobus van't Hoff". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 8

## Nuclear Chemistry and Atomic Structure

In 1896, Henri Becquerel and Marie and Pierre Curie discovered the phenomenon of radioactivity. Thus scientists were shown that atoms were not permanent and changeless, and the basis was laid for nuclear chemistry and nuclear physics. Having found that atoms sometimes transmuted into other elements on their own, scientists attempted to do the same in the laboratory. In 1919 Ernest Rutherford became the first to succeed, using natural radioactivity to transmute nitrogen atoms into atoms of oxygen and hydrogen.

In 1934 Frédéric and Irène Joliot-Curie made radioactive isotopes of elements that were not normally radioactive. Five years later Otto Hahn, Fritz Strassmann, and Lise Meitner discovered that the uranium nucleus could be made to fission, or split into the nuclei of lighter elements, by bombarding it with uncharged particles called neutrons.

By the early 1940s nuclear reactions had been used to make radioactive isotopes of all elements; Glenn Seaborg contributed much to this work. In the 1940s and '50s Seaborg and his co-workers also made several elements not known to exist in nature. The new elements had atomic numbers greater than 92, the atomic number of uranium. By the early 21st century nuclear scientists were adding new elements to the periodic tale with atomic numbers higher than 110.

Rutherford's discovery in 1911 that the atom has a tiny massive nucleus at its center allowed chemists and physicists such as Gilbert Lewis, Irving Langmuir, and Niels Bohr over the next 20 years to explain chemical bonding and atomic structure in terms of the behavior of electrons orbiting the nucleus. In the late 1920s and early 1930s, Linus Pauling contributed much to knowledge of the nature of the chemical bond and of the relationship between the structure of atoms and molecules and their properties.

### *Answer the questions:*

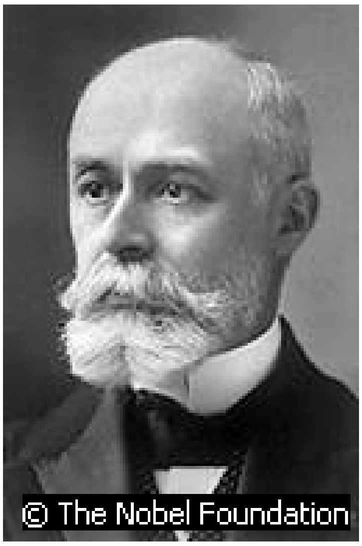
1. What scientists discovered the phenomenon of radioactivity?

2. In 1919 Ernest Rutherford became the first to succeed, using natural radioactivity to transmute nitrogen atoms into atoms of oxygen and hydrogen, didn't he?

3. When did Seaborg and his co-workers also make several elements not known to exist in nature?

4. Did Fritz Strassmann, and Lise Meitner discover that the uranium nucleus could be made to fission, or split into the nuclei of lighter elements?

5. Who contributed much to knowledge of the nature of the chemical bond and of the relationship between the structure of atoms and molecules and their properties?




## Antoine Henri Becquerel (1852-1908),

The French physicist who discovered radioactivity through his investigations of uranium and other substances was Henri Becquerel. In 1903 he shared the Nobel prize for physics with the chemists Pierre and Marie Curie.

Antoine-Henri Becquerel was born on Dec. 15, 1852, in Paris. He received his scientific education from 1872 to 1874 at the École Polytechnique and studied engineering from 1874 to 1877 at the École des Ponts et Chaussées (Bridges and Highways School).

A member of the Académie des Sciences since 1889, Becquerel had become a highly respected physicist by 1896. For several years he researched the rotation of plane-polarized light by magnetic fields. Even more important than his research were his expertise with phosphorescent materials, his familiarity with uranium compounds, and his general skill in laboratory techniques, including photography. These were to place the discovery of radioactivity within his reach.

After the discovery of the X ray in 1895, Becquerel began to investigate whether there was a fundamental connection between this form of invisible radiation and visible light. He theorized that luminescent materials, however stimulated, may yield X rays just as they emitted visible light. He tested this hypothesis by placing phosphorescent crystals on a sealed photographic plate that had been wrapped in opaque paper and never exposed to direct light. After the plate was developed, images were visible on it. He passed the results on to Madame Curie, who named this phenomenon radioactivity.

### *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……
Well, it seems …..

1. The Dutch physicist who discovered radioactivity through his investigations of uranium and other substances was Henri Becquerel.

2. A member of the University of London since 1889, Becquerel had become a highly respected chemist by 1896.

3. For several years he researched the movement of plane-polarized light by magnetic fields.

4. After the discovery of the X ray in 1895, Becquerel began to investigate whether there was a fundamental connection between this form of invisible radiation and radio waves.

5. He tested this hypothesis by placing phosphorescent crystals on a sealed photographic plate that had been wrapped in newspaper and never exposed to direct light.

## *2. Put the verbs in brackets in the correct tense:*

1. The French physicist who (to discover) radioactivity through his investigations of uranium and other substances (to be) Henri Becquerel.

2. In 1903 he (to share) the Nobel prize for physics with the chemists Pierre and Marie Curie.

3. For several years he (to research) the rotation of plane-polarized light by magnetic fields.

4. After the plate (to develop), images (to be) visible on it.

5. He (to pass) the results on to Madame Curie, who (to name) this phenomenon radioactivity.

## *3. Put the words in the correct word order:*

1. a, had, become, of, the, since, 1889, Becquerel, Académie des Sciences, a, highly, respected, physicist, by, 1896, member.

2. education, he, his, scientific, École, received, from, 1872, to, 1874, at, the, Polytechnique.

3. Pierre, and, he, the, Nobel, prize, shared, with, the, chemists, Marie, in, 1903, for, physics, Curie.

## *4. Fill in the blanks with the prepositions where necessary:*

1. ….. 1903 he shared the Nobel prize ….. physics …… the chemists Pierre and Marie Curie.

2. Antoine-Henri Becquerel was born ….. Dec. 15, 1852, ….. Paris.

3. He tested this hypothesis ….. placing phosphorescent crystals ….. a sealed photographic plate that had been wrapped ….. opaque paper and never exposed ….. direct light.

4. ….. several years he researched the rotation ….. plane-polarized light ….. magnetic fields.

## *5. Complete the sentences:*

1. A member of the Académie des Sciences since 1889, Becquerel had …………….

2. After the plate was developed, ……………..

3. He passed the results on to Madame Curie, ………………..

4. These were to place the discovery ……………………….

## *6. Translate the following sentences paying attention to the words with (-ing) endings and state their grammar form:*

1. Even more important than his research were his expertise with phosphorescent materials, his familiarity with uranium compounds, and his general skill in laboratory techniques, including photography.

2. He tested this hypothesis by placing phosphorescent crystals on a sealed photographic plate that had been wrapped in opaque paper and never exposed to direct light.

3. He received his scientific education from 1872 to 1874 at the École Polytechnique and studied engineering from 1874 to 1877 at the École des Ponts et Chaussées

## Marie Curie

## (1867-1934),


Polish-born French chemist who, with her husband Pierre Curie, was an early investigator of radioactivity. Radioactivity is the spontaneous decay of certain elements into other elements and energy. The Curies shared the 1903 Nobel Prize in physics with French physicist Antoine Henri Becquerel for fundamental research on radioactivity. Marie Curie went on to study the chemistry and medical applications of radium. She was awarded the 1911 Nobel Prize in chemistry in recognition of her work in discovering radium and polonium and in isolating radium.

Marie Curie's maiden name was Maria Skłodowska, and her nickname while growing up was Manya. She was born in Warsaw at a time when Poland was under Russian domination after the unsuccessful revolt of 1863. Her parents were teachers, but soon after Manya (their fifth child) was born, they lost their teaching posts and had to take in boarders. Their young daughter worked long hours helping with the meals, but she nevertheless won a medal for excellence at the local high school, where the examinations and some classes were held in Russian. No higher education was available to women in Poland at that time, so Manya took a job as a governess. She sent part of her earnings to Paris to help pay for her older sister's medical studies. Her sister qualified as a doctor and married a fellow doctor in 1891. Manya went to join them in Paris, changing her name to Marie. She entered the Sorbonne (now the Universities of Paris) and studied physics and mathematics, graduating at the top of her class. In 1894 she met the French chemist Pierre Curie, and they were married the following year.

From 1896 the Curies worked together on radioactivity, building on the results of German physicist Wilhelm Roentgen (who had discovered X rays) and Henri Becquerel (who had discovered that uranium salts emit similar radiation). Marie Curie discovered that the metallic element thorium also emits radiation and found that the mineral pitchblende emitted even more radiation than its uranium and thorium content could cause. The Curies then carried out an exhaustive search for the substance that could be producing the radioactivity. They processed an enormous amount of pitchblende, separating it into its chemical components. In July 1898 the Curies announced the discovery of the element polonium, followed in December of that year with the discovery of the element radium. They eventually prepared 1 g (0.04 oz) of pure radium chloride from 8 metric tons of waste pitchblende from Austria. They also established that beta rays (now known to consist of electrons) are negatively charged particles.

In 1906 Marie took over Pierre Curie's post at the Sorbonne when he was run down and killed by a horse-drawn carriage. She became the first woman to teach there, and she concentrated all her energies into research and caring for her daughters. The Curies' older daughter, Irene, later married Frédéric Joliot and became a famous scientist and Nobel laureate herself (*see* Irene Joliot-Curie; Frédéric Joliot-Curie). In 1910 Marie worked with French chemist André Debierne to isolate pure radium metal. In 1914 the University of Paris built the Institut du Radium (now the Institut Curie) to provide laboratory space for research on radioactive materials.

At the outbreak of World War I in 1914, Marie Curie helped to equip ambulances with X-ray equipment, which she drove to the front lines. The International Red Cross made her head of its Radiological Service. She and her colleagues at the Institut du Radium held courses for medical orderlies and doctors, teaching them how to use the new technique. By the late 1920s her health began to deteriorate: Continued exposure to high-energy radiation had given her leukemia. She entered a sanatorium at Haute Savoie and died there on July 4, 1934, a few months after her daughter and son-in-law, the Joliot-Curies, announced the discovery of artificial radioactivity.

Throughout much of her life Marie Curie was poor, and she and her fellow scientists carried out much of their work extracting radium under primitive conditions. The Curies refused to patent any of their discoveries, wanting them to benefit everyone freely. The Nobel Prize money and other financial rewards were used to finance further research. One of the outstanding applications of their work has been the use of radiation to treat cancer, one form of which cost Marie Curie her life.

***7. Read and translate the text "Marie Curie". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 9

# New Synthetic Materials

Some of the most notable achievements in modern chemistry have come from efforts to create whole new classes of materials. Early plastics such as celluloid, invented in the late 1860s, relied on large molecules found in natural substances. In 1909, however, the Belgian-born inventor Leo H. Baekeland took out a United States patent for a hard, chemically resistant, electrically nonconductive plastic that he called Bakelite. Made from the chemical combination of synthetic compounds called formaldehydes and phenols, Bakelite proved to be exceptionally useful as an electrical insulator and as a structural material for such consumer goods as radio cabinets, telephone housings, and even jewelry.

The commercial success of Bakelite sparked great interest and investment in the plastics industry, in the study of coal-tar products and other organic compounds, and in the theoretical understanding of complex molecules. These research activities led not only to new dyes, drugs, and detergents but also to the successful manipulation of molecules to produce dozens of materials with particular qualities such as hardness, flexibility, or transparency.

Techniques were developed, often requiring catalysts and elaborate equipment, to make these polymers—that is, complex molecules built up from simpler structures. From the field of polymer chemistry, the synthetic rubber and synthetic fiber industries have grown. Synthetic fibers are used in fabrics, carpets, rope, and brush bristles and for producing synthetic rubber.

Another dramatic result of the growth in chemical knowledge has been the expansion of the modern pharmaceutical industry. Notable early achievements include the development of the synthetic drugs acetylsalicylic acid (aspirin) in 1897, Salvarsan (for treating the bacterial disease syphilis) in 1910, and Prontosil (the first sulfa drug for treating bacterial infections) in 1932, as well as the discovery of the antibiotic penicillin (produced naturally by a mold) in 1928.

Since the late 20th century the rapid growth in the understanding of chemical processes in general, and of organic and biochemical reactions in particular, has revolutionized the treatment of disease. Most drugs available today do not occur naturally but are made in the laboratory from elements and inorganic and organic compounds. Others are derived from animals, plants, microorganisms, and minerals, by pharmaceutical researchers who often use chemical reactions to modify molecular structures in order to make drugs that are more effective and have fewer harmful side effects.

## *Answer the questions:*

1. When was celluloid invented?

2. What was Bakelite made from?

3. Where is it used?

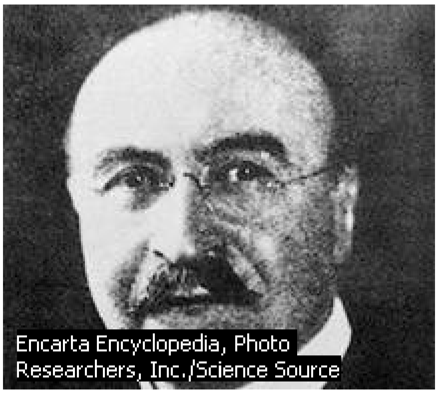
4. The commercial success of Bakelite sparked great interest and investment in the plastics industry, did not it?

5. Has organic and biochemical reactions revolutionized the treatment of disease?

6. Do most drugs available today occur naturally?

7. Where are drugs derived from?

8. What do pharmaceutical researchers often use to modify molecular structures in order to make drugs that are more effective and have fewer harmful side effects?




# Leo Baekeland (1863-1944),

Belgian-American chemist, known for his invention, about 1906, of the synthetic resin later known as Bakelite. Born in Ghent (Gent) and educated at the University of Ghent, Baekeland immigrated to the United States in 1889. He manufactured photographic papers and developed a new type of paper (Velox) that could be developed under artificial light. The founder of modern plastics, he received many honors, including the Nichols Medal of the American Chemical Society in 1909 and the Franklin Medal of the Franklin Institute in 1940 and served as president of the American Chemical Society in 1924.

Baekeland received his doctorate *maxima cum laude* from the University of Ghent at the age of 21 and taught there until 1889, when he went to the U.S. and joined a photographic firm. He soon set up his own company to manufacture his invention, Velox, a photographic paper that could be developed under artificial light. Velox was the first commercially successful photographic paper. In 1899 Baekeland sold his company and rights to the paper to the U.S. inventor George Eastman for $1,000,000.

Baekeland's search, begun in 1905, for a synthetic substitute for shellac led to the discovery of Bakelite, a condensation product of formaldehyde and phenol that is produced at high temperature and pressure. Though the material had been reported earlier, Baekeland was the first to find a method of forming it into the thermosetting plastic.

### *1. Say whether these sentences are true or wrong using the following clichés:*

As far as I know …….
I must disappoint you ……
In my opinion ……
If I'm not mistaken ……
Frankly speaking …….
To tell the truth …….
I suppose ……
Well, it seems …..

1. He manufactured magnetic tapes and developed a new type of paper (Velox) that could be developed under sun light.

2. In 1899 Baekeland sold his company and rights to the paper to the U.S. inventor Thomas Edison $1,000,000.

3. Velox, a photographic paper that could be developed under artificial light.

4. Baekeland's search, begun in 1905, for a synthetic substitute for resin led to the discovery of Bakelite

### *2. Fill in the blanks with the prepositions where necessary:*

1. Born ….. Ghent (Gent) and educated ….. the University ….. Ghent, Baekeland immigrated ….. the United States ….. 1889.

2. A new type ….. paper (Velox) that could be developed ….. artificial light.

3. Baekeland received his doctorate *maxima cum laude* ….. the University ….. Ghent ….. the age ….. 21.

4. ….. 1899 Baekeland sold his company and rights ….. the paper ….. the U.S. inventor George Eastman ….. $1,000,000.

5. Baekeland's search, begun ….. 1905, ….. a synthetic substitute ….. shellac led ….. the discovery ….. Bakelite.

### *3. Put the verbs in brackets in the correct tense:*

1. He (to manufacture) photographic papers and (to develop) a new type of paper (Velox).

2. Baekeland (to receive) his doctorate *maxima cum laude* from the University of Ghent at the age of 21 and (to teach) there until 1889.

3. In 1899 Baekeland (to sell) his company and rights to the paper to the U.S. inventor George Eastman for $1,000,000.

4. He (to go) to the U.S. and (to join) a photographic firm.

### *4. Translate the following sentences paying attention to the words with (-ing) endings and state their grammar forms:*

1. The founder of modern plastics, he received many honors, including the Nichols Medal of the American Chemical Society in 1909.

2. Baekeland was the first to find a method of forming it into the thermosetting plastic.

### *5. Practice in pronouncing the following words using a transcription from the vocabulary:*

resin, invent, manufacture, develop, artificial, search, synthetic, substitute, shellac, discover, phenol, produce, pressure, plastics, method.[

### *6. Insert the missing form of the verb:*

to know ….. known

to bear bore …..

….. was/were ….

to teach taught …..

….. set set

to sell sold …..

to begin began …..

….. found …..

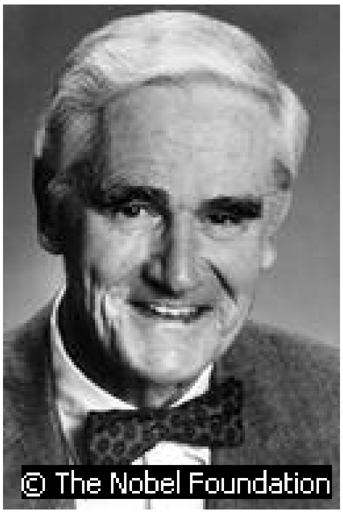
### *7. Complete the sentences:*

1. He manufactured photographic papers and developed ……………….

2. Baekeland was the first to find a method of …………………..

3. He soon set up his own company to manufacture his invention, Velox, …………..

4. Born in Ghent (Gent) and educated at the University of Ghent, ………………..




## Donald J. Cram (1919–2001),

U.S. chemist Donald J. Cram, along with Charles J. Pedersen and Jean-Marie Lehn, was awarded the 1987 Nobel prize for chemistry for his creation of molecules that mimic the chemical behavior of molecules found in living systems. He was regarded as one of the most important chemists of the 20th century.

Donald James Cram was born on April 22, 1919, in Chester, Vt. As a result of his father's death when Donald was nearly 4, he began as a child to work a variety of odd jobs and continued to do so into his teens. He won a scholarship to Rollins College in Florida, where he received an undergraduate degree in chemistry. He earned a master's degree in organic chemistry at the University of Nebraska. During World War II, he researched penicillin then earned a doctorate in organic chemistry from Harvard University in 1947. He joined the faculty of the University of California at Los Angeles (UCLA) in 1947 and became a full professor there in 1956 and emeritus in 1990.

Cram amplified and expanded upon Pedersen's groundbreaking synthesis of the crown ethers—basically two-dimensional organic compounds that are able to recognize and selectively combine with the ions of certain metal elements. The goal of this field of science, known as host-guest chemistry, was to mimic the chemical reactions that occur in living cells. Cram synthesized molecules that took this chemistry into three dimensions, creating an array of differently shaped molecules that could interact selectively with other chemicals because of their complementary three-dimensional structures. His work represented a large step toward the synthesis of functional laboratory-made mimics of enzymes and other natural molecules whose special chemical behavior is due to their characteristic structure. The molecules have been used in sensors and electrodes.

In later work, Cram created large “prison” molecules that completely enclose and stabilize smaller molecules. He speculated that some of the prison molecules might one day be used to treat cancer by encapsulating small radioactive or poisonous molecules that could be delivered to the site of a tumor, allowing the molecules to attack the cancer without coming into direct contact with healthy tissue.

Over the course of four decades while at UCLA, Cram published more than 400 research papers and seven books on organic chemistry. He was perhaps best known for several editions of *Organic Chemistry*, the classic undergraduate chemistry textbook that he wrote with George Hammond of the California Institute of Technology and that was first published in 1959. Cram also was regarded as an excellent and creative lecturer, who would play a guitar and sing folk songs in class at the end of each semester. He died in Palm Desert, Calif., on June 17, 2001.

***8. Read and translate the text “Donald J. Cram”. Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 10

# The New Branch of Chemistry

The 1996 Nobel Prize for Chemistry was awarded to a group of British and U.S. researchers who discovered fullerenes, a previously unrecognized form of carbon, the discovery of which opened a new branch of chemistry. Fullerenes are hollow, spherical clusters of carbon atoms bonded together into highly symmetrical, cagelike structures. Bonds in the prototype molecule, $C_{60}$, resemble the seams on a soccer ball. Geometrically, $C_{60}$ is a polygon with 60 vertices and 32 faces, 12 of which are pentagons and 20 of which are hexagons. In the 1985 paper describing their work, the discoverers chose a whimsical name for $C_{60}$. They called it buckminsterfullerene after R. Buckminster Fuller, the U.S. architect whose geodesic dome design, the best-known example of which was the U.S. pavilion for Expo 67 in Montreal in 1967, had a similar structure. Chemists began calling $C_{60}$ molecules buckyballs. The name and the elegant netlike structure of fullerenes galvanized public fancy in a way that few other basic advances in chemistry had.

Placing large atoms inside the soccer ball structure could result in materials with many unusual properties. Chemists had previously created holes in buckminsterfullerene that were marked by rings of 11 or 14 carbon atoms, but these holes were too small to insert large atoms through. Scientists in 1996 reported the synthesis of a molecule that contains a cobalt atom attached to what is effectively a 15-membered ring hole in the buckminsterfullerene molecule. Poised above the opening, the cobalt atom is in an excellent position to be forced inside the fullerene.

“For chemists the proposed structure was uniquely beautiful and satisfying,” the Royal Swedish Academy of Sciences said in its citation. “It corresponds to an aromatic, three-dimensional system in which single and double bonds alternated, and was thus of great theoretical significance.”

The prize, worth $1,120,000, was shared by Richard E. Smalley and Robert F. Curl, Jr., of Rice University, Houston, Texas, and Sir Harold W. Kroto of the University of Sussex, Brighton, Eng. Kroto, Curl, and Smalley did their landmark experiment over a period of 11 days in 1985. The Swedish Academy noted the assistance of their graduate students James R. Heath and Sean C. O'Brien, who did not share in the award.

## Answer the following questions:

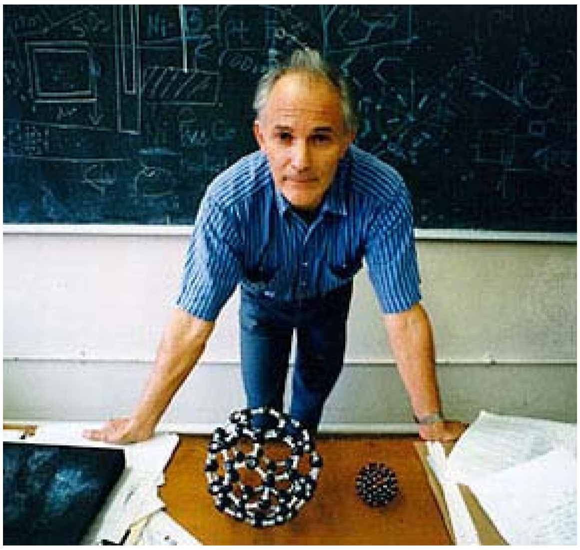
1. What was the 1996 Nobel Prize for Chemistry awarded to a group of British and U.S. researchers for?

2. Did the discovery of  fullerenes open a new branch of chemistry?

3. What are fullerenes?

4. What do bonds in the prototype molecule, $C_{60}$, resemble?

5. What name did the discoverers choose for $C_{60}$C ?



## Kroto, Sir Harold W. born Oct. 7, 1939,

**Wisbech, Cambridgeshire, Eng.**

Sir Harold W. Kroto with models of fullerenes, 1996.

Sir Harold W. Kroto, born in 1939, British chemist and Nobel laureate. Kroto's inquiry into the origins of carbon produced by stars led to the accidental discovery of a new family of carbon molecules known as fullerenes. Unknown before 1985, fullerenes now constitute the fourth major form of carbon, along with graphite, diamond, and amorphous carbon. The discovery and synthesis of fullerenes created a new and extremely active branch of chemistry in the early 1990s.

Kroto was born in Wisbech in Cambridgeshire, England. He earned his undergraduate degree in chemistry in 1961 and his Ph.D. degree in chemistry in 1964, both from the University of Sheffield. After three years of postdoctoral research in Canada and the United States, Kroto joined the faculty of the University of Sussex, becoming a professor in 1985. In 1991 he was made Royal Society Research Professor.

Throughout the 1970s Kroto's area of concentration was microwave spectroscopy. He used radio astronomy to capture and analyze traces of molecules produced in interstellar space. In particular, he was intrigued by his detection of long-chained molecules of carbon and nitrogen. Kroto surmised that these chains are formed in the atmospheres of carbon-rich giant stars called carbon stars; what he needed was a way of mimicking the conditions under which the chains are created.

The answer was found at Rice University in Houston, Texas, where Kroto's acquaintance Robert F. Curl, Jr., along with another Rice professor, Richard E. Smalley, were conducting research in cluster chemistry. Using a specialized laser that Smalley had designed, the Rice chemists were vaporizing substances and creating *clusters*—tiny formations of atoms that could be analyzed.

In September 1985 Kroto traveled to Houston. Over an 11-day period, Kroto, Smalley, and Curl, with graduate students James R. Heath and Sean C. O'Brien, created carbon clusters. Smalley's laser blasted carbon atoms from graphite, mixing them with the inert gas helium and cooling the mixture in a vacuum chamber. Examining the minuscule clusters, the team had a surprise: Instead of the long chains they expected, they found evidence of closed, symmetrical, cagelike arrangements of carbon atoms, with a 60-atom structure being the most abundant.

Ultimately, the team theorized that the new $C_{60}$ molecule's structure resembled that of a soccer ball. The structure also resembled the geodesic domes designed by American architect R. Buckminster Fuller. Kroto and his colleagues dubbed the molecules buckminsterfullerene, or buckyballs for short.

The team published the results of their work in late 1985, presenting their hypothesis of a brand-new family of sphere-shaped carbon molecules, but many scientists were skeptical. Kroto returned to England, working on a way to synthesize large quantities of the molecules now known as fullerenes. He and colleagues successfully developed a method in 1990, but they were dismayed when another team announced its own method, beating Kroto's team to publication by only days. Nevertheless, the structure of fullerenes was confirmed, and the field of fullerene chemistry exploded almost overnight.

Chemists have now developed thousands of fullerene variations, including sturdy tubelike and wirelike structures of fullerenes that can be made to carry other atoms, bringing the promise of important applications in industry and biomedicine. For their discovery, Kroto, Smalley, and Curl shared the 1996 Nobel Prize in chemistry. Kroto was knighted in 1996.

## *1. State whether these sentences are true or false using the following clichés:*

I must disappoint you ….
If I'm not mistaken ….
To my mind….
It seems to me….
I think that ….

1. Fullerenes now constitute the fourth major form of carbon, along with graphite, diamond, and amorphous carbon.

2. Throughout the 1970s Kroto’s area of concentration was microwave oven.

3. He was intrigued by his detection of long-chained molecules of carbon and nitrogen.

4. Smalley’s laser blasted carbon atoms from graphite, mixing them with the inert gas helium and cooling the mixture in a vacuum cleaner.

5. Ultimately, the team theorized that the new $C_{60}$ molecule’s structure resembled that of a ballon.

## *2. Practice in pronunciation with the help of transcription in the chemical dictionary:*

fullerenes, inquiry, graphite, diamond, carbon, microwave, analyze, vaporize, vacuum, hypothesis, colleague.

## *3. Fill in the blanks with necessary prepositions:*

1. Kroto’s inquiry ….. the origins ….. carbon produced ….. stars led ….. the accidental discovery ….. a new family ….. carbon molecules known as fullerenes.

2. ….. particular, he was intrigued ….. his detection ….. long-chained molecules ….. carbon and nitrogen.

3. Smalley’s laser blasted carbon atoms ….. graphite, mixing them ….. the inert gas helium and cooling the mixture ….. a vacuum chamber.

4. Kroto returned ….. England, working ….. a way to synthesize large quantities ….. the molecules now known as fullerenes.

5. Another team announced its own method, beating Kroto’s team ….. publication ….. only days.

## *4. Find English equivalents to the following Russian expressions:*

привести к случайному открытию, создать новую отрасль химии, получить ученую степень, стать профессором, образовывать цепи, выглядеть как футбольный мяч, окрестить, успешно развивать метод, применять в промышленности.

## *5. Insert the missing forms of irregular verbs:*

***lead* ….. …..**

**….. *knew* …..**

***bear* …… *born***

**….. *made made***

***find* …… *found***

**….. *could* …..**

***bring* ….. ……**

## *6. Put the verbs in brackets in the correct Tense:*

1. He (to earn) his undergraduate degree in chemistry in 1961.

2. The Rice chemists (to vaporize) substances and (to create) *clusters*—tiny formations of atoms that (can) be analyzed.

3. The new $C_{60}$ molecule's structure (to resemble) that of a soccer ball.

4. He and colleagues successfully (to develop) a method in 1990.

5. Chemists now (to develop) thousands of fullerene variations.

## *7. Underline Passive Voice constructions and translate them:*

1. In 1991 he was made Royal Society Research Professor.

2. Kroto surmised that these chains are formed in the atmospheres of carbon-rich giant stars.

3. What he needed was a way of mimicking the conditions under which the chains are created.

4. They were dismayed when another team announced its own method, beating Kroto's team to publication by only days.

5. The structure of fullerenes was confirmed, and the field of fullerene chemistry exploded almost overnight.

6. Kroto was knighted in 1996.

# Richard E. Smalley
# (June, 6, 1943 -), Akron, Ohio, U.S.,

American chemist, physicist, and Nobel laureate. In 1985 a group led by Smalley at Rice University in Houston, Texas, discovered a new family of carbon molecules known as fullerenes.

These closed, shell-like arrangements of carbon atoms constitute a distinct form of carbon separate from the element's previously known forms—graphite, diamond, and amorphous carbon. Since the early 1990s the study of fullerenes has been one of the most active branches of chemistry.

Smalley was born in Akron, Ohio, and attended Hope College in Holland, Michigan, from 1961 to 1963. He earned his bachelor's degree in chemistry from the University of Michigan in 1965 and earned his Ph.D. degree in chemistry from Princeton University in New Jersey in 1973. After three years as a research associate at the University of Chicago, he joined the chemistry department at Rice University in 1976, becoming a full professor in 1981. Since 1990 he has also been a professor of physics at Rice.

In the early 1980s Smalley and his Rice colleague Robert F. Curl explored *cluster chemistry,* examining the arrangements of atoms in tiny quantities of substances such as silicon, germanium, gallium arsenide, and other semiconductors. Smalley designed and built a specialized laser that was capable of vaporizing almost any material for analysis.

In September 1985 British chemist and microwave spectroscopist Harold W. Kroto arrived at Rice with a new project for Smalley's device. Kroto had detected traces of long-chain carbon molecules in interstellar space, and he theorized that these chains had been formed in the atmospheres of carbon-rich giant stars. Kroto believed that Smalley's vaporization device might be able to re-create the conditions under which these carbon chains are formed in space.

Over an 11-day period, Smalley, Curl, Kroto, and graduate students James R. Heath and Sean C. O'Brien vaporized samples of graphite, mixing the carbon atoms with the inert gas helium. Carbon clusters were created when the mixture cooled in a vacuum chamber. Analyzing the tiny clusters, Smalley and the others were surprised to find what appeared to be cagelike arrangements of carbon atoms instead of long chains of carbon. A 60-atom structure was the most common form produced. The team realized that the atoms were arranged to form a structure that resembled a soccer ball. The team named this C60 molecule buckminsterfullerene, or buckyballs for short, because of the similarity between the molecules and the geodesic domes designed by American architect and inventor R. Buckminster Fuller.

Many scientists were skeptical of the proposed spherical structure of the new molecular family, which is collectively referred to as the fullerenes. However, in 1990 another group succeeded in developing a method for mass-producing fullerenes, confirming the hypotheses of Smalley and his colleagues and opening fullerene chemistry to worldwide investigation. For their discovery of fullerenes, Smalley, Kroto, and Curl shared the 1996 Nobel Prize in chemistry.

Smalley and others have continued to develop and refine fullerene structures, creating tiny atomic tubes and wirelike arrangements of great strength. Chemists have demonstrated that it is possible to place specific atoms within these structures, raising the possibility of many applications in industry and medicine.

***8. Read and translate the text "Richard E. Smalley". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 11

# A New Era of Electronics Based on Conducting Polymers

It was once common knowledge that plastics—polymeric materials that can be molded or shaped—are fundamentally different from metals in their properties. Plastics, for example, are used around the copper wires in power cords because their insulating characteristics protect people from electric shocks and equipment from short circuits. In the 1970s the three scientists who shared the 2000 Nobel Prize for Chemistry turned that idea upside down. Alan G. MacDiarmid of the University of Pennsylvania, Hideki Shirakawa of the University of Tsukuba, Japan, and Alan J. Heeger of the University of California, Santa Barbara (UCSB), showed that certain plastics can be chemically modified to conduct electricity almost as readily as metals.

The discovery of electrically conductive polymers provided insights into the nature of polymers and electrical conductivity and opened up new fields of chemical and physical research. The materials, which are light in weight and can be fabricated as films, found practical applications as well. By the end of the 20th century, conductive polymers were used in, or were being developed for, corrosion inhibitors, antistatic coatings on photographic film, "smart" windows that automatically darkened in strong sunlight to keep buildings cool, light-emitting diodes, flexible solar cells, displays for mobile telephones and other small electronic devices, and thin wall-sized, roll-up computer displays.

## Answer the following questions:

1. Can polymeric materials be molded or shaped?

2. Are they fundamentally different from metals in their properties?

3. Where are plastics used in?

4. Why do plastics protect people from electric shocks and equipment from short circuits?

5. What scientists showed that certain plastics can be chemically modified to conduct electricity almost as readily as metals?

6. The discovery of electrically conductive polymers opened up new fields of chemical and physical research, did not it?

# Shirakawa, Hideki,

born in 1936, Japanese chemist and cowinner of the 2000 Nobel Prize in chemistry. Shirakawa shared the prize with American physical chemist Alan J. Heeger and New Zealand-born American chemist Alan G. MacDiarmid for the discovery and development of polymers that conduct electricity. In the late 1970s Shirakawa and his colleagues were the first to demonstrate that plastics and other polymers, properly modified, can conduct electricity in a manner similar to metals. These scientists' achievement launched scientific research to develop polymer materials for use as conductors, as semiconductors, and in many new applications.

Shirakawa as born in Tokyo, Japan. He was educated in polymer chemistry at the Tokyo Institute of Technology, earning a doctoral degree in 1966. He remained at the Tokyo Institute as a research associate until 1979, when he moved to the Institute of Materials Science at the University of Tsukuba. In 2000 he retired and became Professor Emeritus.

Shirakawa's role in the discovery of conducting polymers actually resulted from a laboratory mistake and a chance meeting at a scientific seminar. Shirakawa was refining a method for creating thin films made of polyacetylene, an organic polymer. While performing an experiment, a graduate student misunderstood Shirakawa's instructions and added 1,000 times too much catalyst to the polyacetylene. The result was a silvery, metallic film. Shirakawa, not knowing exactly what the film was, set it aside. In 1975, Shirakawa attended a scientific meeting in Tokyo where MacDiarmid mentioned a polymer film that he and Heeger had created at the University of Pennsylvania. During a coffee break, Shirakawa mentioned to MacDiarmid the strange polyacetylene film produced in his own experiments. MacDiarmid invited Shirakawa to join him at the University of Pennsylvania to investigate the film.

At the University of Pennsylvania, the three scientists experimented with adding and removing electrons from the polyacetylene, a process known as doping. After adding an iodine vapor to the mixture, the trio observed that the polymer's electrical conductivity shot up by a factor of 10 million. The iodine had removed some of the densely packed electrons in the polyacetylene, allowing the polymer to carry an electrical current. The three scientists published their results in a 1977 paper, and a new field of research opened as scientists hurried to explore the conductive properties of polymers.

Electronics technology based on the conducting polymers pioneered by Shirakawa and his colleagues is expected to transform the workplace and household. The materials are being developed for use in numerous devices, including flat-screen televisions, displays for cellphones and computers, and road signs that glow in the dark. Computer scientists are also working to harness organic polymers in the next generation of ultrasmall computers, in which single organic molecules will carry impulses.

### *1. State whether these sentences are true or false using the following clichés:*

I must disappoint you ….
If I'm not mistaken ….
To my mind….
It seems to me….
I think that ….

1. In the late 1970s Shirakawa and his colleagues were the first to demonstrate that plastics and other polymers, properly modified, can conduct electricity in a manner similar to metals.

2. Shirakawa was refining a method for creating thick films made of polyacetylene, an organic polymer.

3. During a dance break, Shirakawa mentioned to MacDiarmid the strange polyacetylene film produced in his own experiments.

4. At the University of Pennsylvania, the three scientists experimented with adding and removing molecules from the polyacetylene, a process known as doping.

5. The bromine had removed some of the densely packed electrons in the polyacetylene, allowing the polymer to carry an electrical current.

### *2. Practice in pronunciation with the help of transcription in the dictionary:*

colleague, polymer, achievement, scientific, research, conduct, acetylene, educate, create, metallic.

### *3. Fill in the blanks with necessary prepositions:*

1. Plastics and other polymers, properly modified, can conduct electricity ….. a manner similar ….. metals.

2. Shirakawa's role ….. the discovery ….. conducting polymers actually resulted ….. a laboratory mistake and a chance meeting ….. a scientific seminar.

3. ….. a coffee break, Shirakawa mentioned ….. MacDiarmid the strange polyacetylene film produced ….. his own experiments.

4. ….. the University of Pennsylvania, the three scientists experimented ….. adding and removing electrons ….. the polyacetylene, a process known as doping.

5. Electronics technology based ….. the conducting polymers pioneered ….. Shirakawa and his colleagues is expected to transform the workplace and household.

### *4. Find English equivalents to the following Russian expressions:*

проводить электричество, также как и, начинать научные исследования, случайная встреча, тонкая пленка, проводить электрический ток, исследовать свойства полимеров, использовать в различных устройствах.

### *5. Insert the missing forms of irregular verbs:*

***can ….. ….***

***bear ….. born***

***..... was/were …..***

***become became …..***

***mistake ….. mistaken***

***….. met met***

***understand ….. …..***

***know ….. known***

***….. ….. shot***

### *6. Put the verbs in brackets in the correct Tense:*

1. Shirakawa (to attend) a scientific meeting in Tokyo where MacDiarmid (to mention) a polymer film that he and Heeger (to create) at the University of Pennsylvania.

2. The iodine (to remove) some of the densely packed electrons in the polyacetylene.

3. The three scientists (to publish) their results in a 1977 paper, and a new field of research (to open) as scientists (to hurry) to explore the conductive properties of polymers.

4. Computer scientists (to work) also to harness organic polymers in the next generation of ultrasmall computers, in which single organic molecules (to carry) impulses.

***7. Underline the words with ing-endings, define them and their functions, and translate them:***

1. He was educated in polymer chemistry at the Tokyo Institute of Technology, earning a doctoral degree in 1966.

2. Shirakawa was refining a method for creating thin films made of polyacetylene, an organic polymer.

3. While performing an experiment, a graduate student misunderstood Shirakawa's instructions.

4. Shirakawa, not knowing exactly what the film was, set it aside.

5. At the University of Pennsylvania, the three scientists experimented with adding and removing electrons from the polyacetylene, a process known as doping.

6. After adding an iodine vapor to the mixture, the trio observed that the polymer's electrical conductivity shot up by a factor of 10 million.

7. The iodine had removed some of the densely packed electrons in the polyacetylene, allowing the polymer to carry an electrical current.

8. Electronics technology based on the conducting polymers pioneered by Shirakawa and his colleagues is expected to transform the workplace and household.

# Alan G. MacDiarmid,

born in 1927, New Zealand-born American chemist and cowinner of the 2000 Nobel Prize in chemistry. MacDiarmid shared the prize with American chemist Alan J. Heeger and Japanese chemist Hideki Shirakawa for the discovery and development of so-called conducting polymers—plastics that conduct electricity. Before MacDiarmid and his colleagues made their discovery in the late 1970s, compounds such as metals and silicon were known to be electrical conductors, but no one had demonstrated conductivity in plastics and other polymers. MacDiarmid and his fellow Nobel honorees opened up a new field of research in conducting polymers. This technology is now being harnessed in the development of numerous electronic devices.

Born in 1927 in Masterton, New Zealand, MacDiarmid studied chemistry at the University of New Zealand, earning his master's degree in 1950. He went on to earn a Ph.D. from the University of Wisconsin-Madison in 1953 and another Ph.D. from Cambridge University two years later. He joined the faculty of the University of Pennsylvania in 1955 and has remained there ever since.

In the mid-1970s MacDiarmid and Heeger were examining the properties of a polymer known as sulfur nitride. They created a thin, metallic-looking film made of the substance. MacDiarmid happened to mention the film during a seminar in Japan. During a coffee break, he was approached by Shirakawa, a researcher then working at the Tokyo Institute of Technology. Shirakawa had recently created his own thin film by accident, after a graduate student in his lab mistakenly added too much catalyst to a batch of another polymer, polyacetylene.

MacDiarmid invited Shirakawa to the University of Pennsylvania, where, together with Heeger, they worked on Shirakawa's silvery polyacetylene film. The scientists experimented with removing and adding electrons to the film, a process known as doping. After they diffused iodine into the film, they found that the polyacetlylene's electrical conductivity shot up by a factor of 10 million. The iodine had chemically released some of the densely packed electrons in the plastic, permitting the movement of an electric current. The three scientists published their results in 1977. The work was immediately recognized as revolutionary, and a new field was born—one that today combines the efforts of scientists from diverse fields, including chemistry, physics, and electrical engineering.

Scientists have found numerous applications for conducting polymers. Some photographic films, for example, use a layer of conducting polymers to draw off static electricity that might otherwise damage the film. Research into conducting and semiconducting plastics will soon produce new displays for cellphones, computers, flat-screen TVs, and other devices. Scientists continue to pursue applications based on plastic electronics, including tiny computers in which impulses will be carried not by silicon chips but by single organic molecules.

In addition to the Nobel Prize, MacDiarmid has received many other distinctions. He was awarded the British Royal Society of Chemistry Centenary Medal and Lectureship in 1983 and the Chemistry of Materials Award from the American Chemical Society in 1999.

***8. Read and translate the text "Alan G. MacDiarmid". Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Alan J. Heeger,

born in 1936, American physical chemist and cowinner of the 2000 Nobel Prize in chemistry. Heeger received the Nobel Prize along with Japanese chemist Hideki Shirakawa and Alan G. MacDiarmid, a New Zealand-born American chemist, for the discovery and development of polymers that conduct electricity. Polymers are large molecules comprising many smaller repeating patterns of atoms strung together in a long chain. In the late 1970s Heeger and his colleagues discovered that plastics and other polymers, if properly modified, can conduct an electrical charge in a manner similar to metals and other standard conducting materials. This work launched the field of polymer-based electronic research. Building on the advances of Heeger and his coworkers, scientists today are developing polymer conductors and semiconductors for many applications.

Born in Sioux City, Iowa, in 1936, Heeger graduated from the University of Nebraska in 1957 and earned his doctoral degree in 1961 from the University of California, Berkeley. In 1962 he joined the faculty of the University of Pennsylvania, Philadelphia, working there until 1982, when he became a professor of physics at the University of California, Santa Barbara. In 1990 Heeger founded UNIAX Corporation, a company that develops commercial applications for conducting polymers.

In 1975 at the University of Pennsylvania, Heeger and MacDiarmid collaborated in modifying the properties of sulfur nitride, a polymer. During this work, the two scientists created a thin film made of the substance. MacDiarmid happened to mention the film while giving a talk at a scientific meeting in Tokyo, Japan. During a coffee break, MacDiarmid was approached by Shirakawa, who was conducting his own research on polymers at the Tokyo Institute of Technology. Shirakawa told MacDiarmid that he too had created a polymer-based film, the accidental result of too much catalyst added to a mixture of the polymer polyacetylene. MacDiarmid invited Shirakawa to join him and Heeger at the University of Pennsylvania to investigate these polymer films.

The three scientists experimented with adding and removing electrons from the polyacetylene—a process known as doping. When they diffused iodine into the polymer, the team was surprised to observe that the substance's electrical conductivity increased by a factor of 10 million. The iodine, in effect, had loosened the densely packed electrons in the polyacetylene, allowing the material to carry an electric charge. Heeger, MacDiarmid, and Shirakawa published their results in

1977, launching a worldwide effort to pursue the new technology of conducting polymers.

A new era of electronics based on conducting polymers has begun. These materials are less expensive, more flexible, and easier to work with than conventional conductors. The conducting polymers are being developed for use in displays for cell phones and other handheld devices, flat-screen televisions, and video displays so flexible they can be folded. One day, miniaturized polymer-based circuitry will likely serve as the basis of new computers, with individual organic molecules performing the work now done by silicon chips.

***9. Read and translate the text “Alan J. Heeger”. Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

# Unit 12

# The Kazan School of Chemists

**The main building of Kazan University**

The Kazan school of chemists has won world-wide recognition. Its history is closely connected with the Kazan University which was founded in 1804.

The first chemical laboratory was organized in 1806 and F.E. Efest was its first professor of chemistry. N.N. Zinin and K. Klaus can be mentioned among the founders of the Kazan school of chemists. Thanks to their tireless activity the fame of the Kazan University has been risen to an exceedingly high level.

In 1919 a new department of physical chemistry was founded. The main scientific interests of the department lay in the production and study of the properties of the colloidal metals.

In 1922 the department of analytical chemistry was founded with Professor A.M.Vasilyev holding the chair. The scientists of the department investigated the methods of simplified and speedy analyses.

On June $18^{th}$, 1928 the first session of the fifth Mendeleyev Congress on pure and applied chemistry was held in Kazan. In his closing speech the chairman of the Congress Professor A.E. Favorsky called Kazan the Russian "chemical Mecca."

1933 gave rise to a new department comprising the chair of organic and inorganic chemistry.

B.A. Arbusov and G.H. Kamay were on the staff of the chair of organic chemistry. For his research of arsenic organic compounds G.H. Kamay was awarded the State Prize. During the Great Patriotic War Kazan cordially welcomed and accommodated the evacuated institutes of the Academy of Sciences. The fact that a number of institutes and research institutes from Moscow and Leningrad stayed in Kazan during the war greatly contributed to the development and fostering of the chemical science in this city. In spite of the great difficulties of the war time period the Chemical Department kept training specialists and directed its research work to fostering the defense capacity of our country.

## *1. Answer the following questions:*

1. When was the Kazan University founded?

2. When was the first chemical laboratory organized?

3. Who was its first professor?

4. Thanks to the tireless activity of professors the fame of the Kazan University has been risen to an exceedingly high level, has not it?

5. Where did the main scientific interests of the department lie in?

6. What did the scientists of the department investigate?

7. Was the first session of the fifth Mendeleyev Congress on pure and applied chemistry was held in Kazan or in Moscow?

8. Who called Kazan the Russian "chemical Mecca"?

9. What greatly contributed to the development and fostering of the chemical science in this city?

**Aleksandr Mikhaylovich Butlerov**

**(1828 - 1886),**

Russian chemist who helped advance the theory of structure in chemistry, especially with regard to tautomerism, the facile interconvertibility of certain structurally similar compounds.

Joining the faculty of Kazan University in 1849, Butlerov took up the new theories of the French chemists Auguste Laurent and Charles Gerhardt and worked on new methods of synthesizing known compounds and on entirely new synthetics.

A.M. Butlerov's scientific activity resulted in the well-known Butlerov's synthesis of trimethyl carbonyl, the first representative of tertiary alcohol.

In 1861 Butlerov stated his concept of chemical structure: that the chemical nature of a molecule is determined not only by the number and type of atoms but also by their arrangement. He foresaw and demonstrated the existence of isomers (molecules composed of the same atoms but in different arrangements), such as the two butanes and three pentanes. In 1866 he synthesized isobutane. Two years later he discovered that unsaturated organic compounds contain multiple bonds.

Alongside with his experimental work A.M. Butlerov proceeded with working out the theory of chemical structure. D.I. Mendeleyev wrote: "A.M. Butlerov is one of the greatest Russian scientists, Russian by his education and by the originality of his works. It was in Kazan, not anywhere else, that Butlerov became a chemist. Here in Kazan he keeps creating his own school, a Butlerov trend in chemistry."

Many well-known scientists worked under Butlerov's supervision and made outstanding discoveries in his laboratory. They are: V.V.Markovnikov, A.M. Popov, A.M. Zaitzev, A.E. Arbusov, and others. They followed the best traditions of the Kazan School of Chemists. V.V. Markovnikov took up the investigation of petroleum, which marked the beginning of new organic petroleum industries, such as oil cracking, the production of benzenes, petroleum aromatization, etc. In 1911 A.E. Arbusov was appointed professor of organic chemistry. It was he who began the systematic studies of organic phosphorus derivatives.

### *1. State whether these sentences are true or false using the following clichés:*

I must disappoint you ….
If I'm not mistaken ….
To my mind….
It seems to me….
I think that ….

1. Butlerov took up the new theories of the American chemists Auguste Laurent and Charles Gerhardt.

2. The physical nature of a molecule is determined not only by the number and type of atoms but also by their arrangement.

3. He foresaw and demonstrated the existence of polymers.

4. Alongside with his experimental work A.M. Butlerov proceeded with working out the theory of chemical structure.

5. A.E. Arbusov took up the investigation of petroleum, which marked the beginning of new organic petroleum industries, such as oil cracking.

## *2. Practice in pronunciation with the help of transcription in the chemical dictionary:*

tautomersm, synthesize, synthetics, synthesis, trimethyl, carbonyl, alcohol, isomer, butane, pentane, isobutane, petroleum, benzene, phosphorus.

## *3. Fill in the blanks with necessary prepositions:*

1. Butlerov took ….. the new theories ….. the French chemists Auguste Laurent and Charles Gerhardt and worked ….. new methods ….. synthesizing known compounds.

2. The chemical nature ….. a molecule is determined not only ….. the number and type ….. atoms but also ….. their arrangement.

3. ….. ….. his experimental work A.M. Butlerov proceeded ….. working ….. the theory ….. chemical structure.

4. Many well-known scientists worked ….. Butlerov's supervision and made outstanding discoveries ….. his laboratory.

5. ….. 1911 A.E. Arbusov was appointed professor ….. organic chemistry.

## *4. Find English equivalents to the following Russian expressions:*

разрабатывать новые методы, определять химическую природу, расположение атомов, предвидеть существование, состоять из атомов, продолжить работу над теорией, создавать собственную школу, направление в химии, работать под наблюдением, сделать выдающиеся открытие, следовать лучшим традициям, заниматься исследованием, означать начало, назначать профессором.

## *5. Give three forms of the irregular verbs:*

to take, to foresee, to write, to become, to know, to make, to begin.

## *6. Underline Passive Voice constructions and translate them:*

1. The chemical nature of a molecule is determined not only by the number and type of atoms but also by their arrangement.

2. In 1911 A.E. Arbusov was appointed professor of organic chemistry

### 7. *Put the verbs in brackets in the correct Tense:*

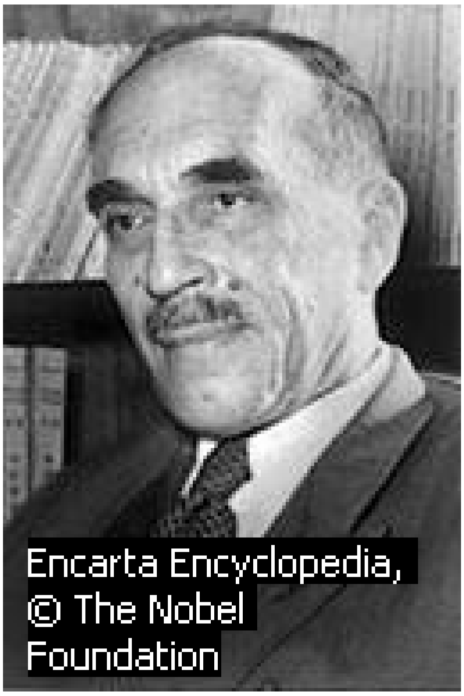
1. In 1861 Butlerov (to state) his concept of chemical structure:

2. He (to foresee) and (to demonstrate) the existence of isomers.

3. Two years later he (to discover) that unsaturated organic compounds (to contain) multiple bonds.

4. Many well-known scientists (to work) under Butlerov's supervision and (to make) outstanding discoveries in his laboratory.

5. V.V. Markovnikov (to take) up the investigation of petroleum, which (to mark) the beginning of new organic petroleum industries, such as oil cracking.




## Nikolai Nikolaevich Semenov

## (1896 -1986),

Soviet physical chemist and physicist and the first citizen of the Soviet Union to win a Nobel award. He shared the 1956 Nobel Prize in chemistry with British chemist Sir Cyril Norman Hinshelwood.

Semenov was born in Saratov, Russia, and graduated from the University at Saint Petersburg, in 1917. He worked at the Physico-Technical Institute there from 1920 to 1928, and in 1931 he became a full member of the Union of Soviet Socialist Republics (USSR) Academy of Sciences. When the Physico-Technical Institute became the Institute of Chemical Physics of the Academy in 1931, Semenov became its first director, a position he held until his death in 1986.

Semenov was always interested in the branch of physical chemistry that concerns the rates and conditions of chemical processes, a discipline known as chemical kinetics. His greatest contributions in the field of chemical kinetics involved investigating thermal combustion, in which the heat given off by some gaseous explosions does not dissipate but instead raises the temperature around the explosion, which could cause additional explosions.

One type of explosion, the chain reaction, is a series of explosions that perpetuates itself, and is caused by the regeneration of a free radical (highly reactive molecules or ions with unpaired electrons). Semenov researched a type of chain reaction called branched chain reaction. This reaction is caused when a free radical not only regenerates, but multiplies, causing the chain reaction to go faster and faster. Semenov's research into branched chain reactions and their role in thermal combustion mirrored much of the work of Hinshelwood. Semenov's experiments with thermal combustions led to a greater understanding of free radicals—in particular the discovery that energy-rich free radicals are formed when molecules disintegrate.

Semenov was awarded the Order of Lenin seven times, and he also received the Order of the Red Banner of Labor. In 1958 he was made a foreign member of the Royal Society.

Semyonov was educated in St. Petersburg, graduating from the city's university in 1917, the year of the Russian Revolution, and taught for a time at the University of Tomsk in western Siberia. Associated with the Leningrad A.F. Ioffe Physicotechnical Institute from 1920 to 1931, he became a professor at the Leningrad (St. Petersburg) Polytechnic Institute in 1928. He was director of the Institute of Chemical Physics at the Academy of Sciences of the U.S.S.R. after 1931 and became a professor at Moscow State University in 1944.

Like Hinshelwood, Semyonov conducted research on the mechanism of chemical chain reactions and their significance in relation to explosions. Semyonov was the first to show that chain reactions are the norm in chemical transformations of matter. He published the influential book “Some Problems in Chemical Kinetics and Reactivity”, 1954.

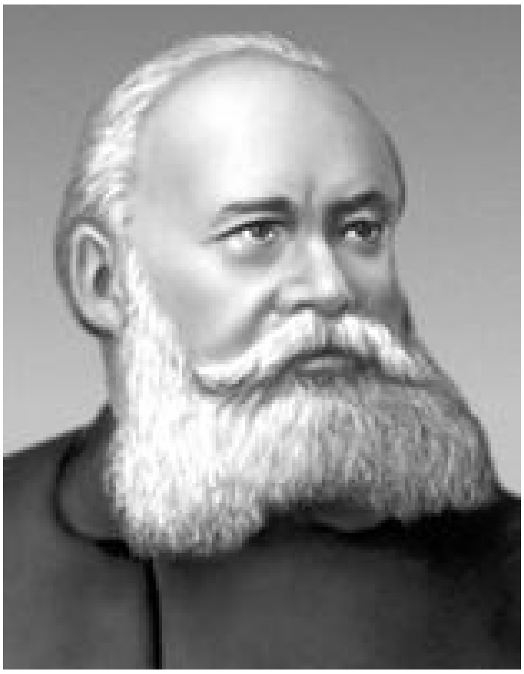
***8. Read and translate the text “Nikolai Nikolaevich Semenov”. Dictionaries are allowed. Divide the text into logical parts and find the topical sentences of each part. Write a short summary of the text using the topical sentences.***

## Nikolai Nikolaevich Zinin,

## (1812 – 1880),

a graduate of the Kazan University, combined pedagogical activity with fruitful scientific work. It6 is sufficient to mention the reaction of changing nitrocompounds into aminocompounds. The significance of his discovery can hardly be overestimated. It was a foundation to the development of the aniline-dyeing industry.

N.N. Zinin had many followers who took up his line. Zinin's talented disciple A.M. Butlerov has become the pride of the Russian science.



## Vladimir Vasilyevich Markovnikov

## (1837 – 1904),

Russian organic chemist who contributed to structural theory and to the understanding of the ionic addition (Markovnikov addition) of hydrogen halides to the carbon-carbon double bond of alkenes.

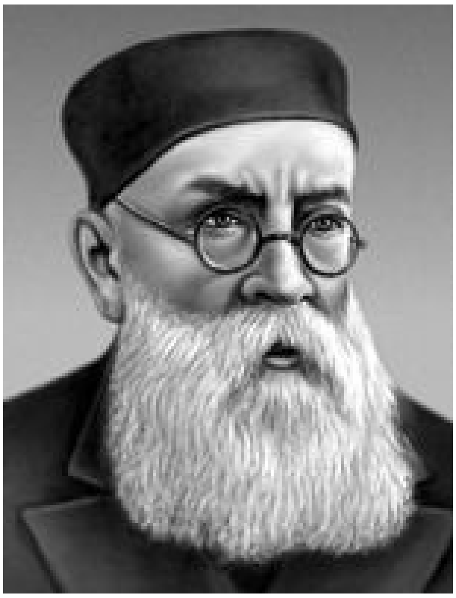
After studying at the universities of Kazan and St. Petersburg, Markovnikov taught at the universities of Kazan, Odessa, and Moscow (1873–98). Through his experiments he showed that butyric and isobutyric acids have the same chemical formula but different structures; *i.e.,* they are isomers. In 1869, while developing his theory of the mutual influence of atoms in chemical compounds, he noted that when hydrogen halides are added to an alkene, the hydrogen attaches to the carbon with more hydrogens already attached, whereas the halogen attaches to the carbon with fewer hydrogens attached. Why hydrogen bromide exhibited both Markovnikov as well as reversed-order, or anti-Markovnikov, addition, however, was not understood until Morris Selig Kharasch offered an explanation in 1933.

## Lebedev Sergey Vasilyevich

**(1874-1934),**

Russian chemist who developed a method for industrial production of synthetic rubber.

Lebedev joined the faculty of St. Petersburg University in 1902 and in 1910, while researching processes by which small molecules combine to form large ones, Lebedev produced an elastic rubber from butadiene. He founded the Laboratory for Petroleum Refining in 1925 and served as director of the Laboratory of Synthetic Rubber in Leningrad (1928–30). He was made a fellow of the Soviet Academy of Sciences in 1932. During World War II his process of obtaining butadiene from ethyl alcohol was used not only by the Soviet, but also the German, rubber industry. In 1910 S.V. Lebedev polymerized butadiene, which he obtained from ethyl alcohol.

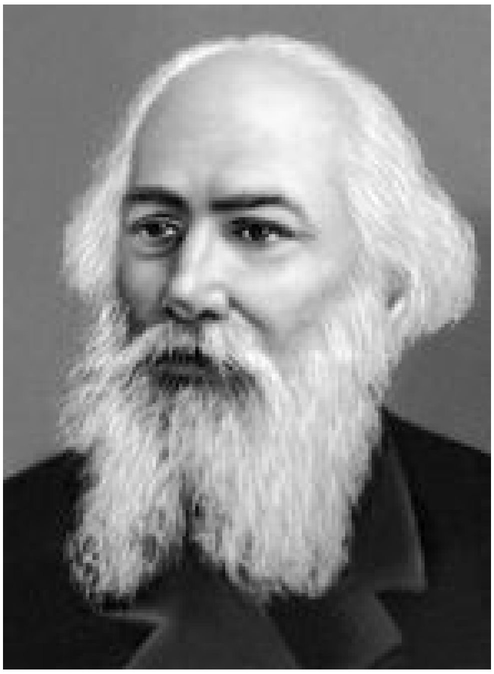


## Фаворский Алексей Евграфович (1860 – 1945),

советский химик-органик, академик АН СССР. В 1882 окончил Петербургский университет, где работал у Д. И. Менделеева и А. М. Бутлерова. С 1896 профессор Петербургского (Ленинградского) университета, работал также в Ленинградском химико-технологическом институте и в АН СССР, где был первым директором (1934–38) созданного по его инициативе института органической химии. Основные труды в области химии ненасыщенных органических соединений. Первые работы Ф. положили начало теоретическим исследованиям в области изомерных превращений органических соединений, привели к синтезу новых углеводородов с тройной связью, а также к открытию способа получения виниловых эфиров. Изомерные превращения органических соединений Ф. рассматривал в свете представлений о взаимном влиянии атомов и радикалов, входящих в состав молекулы, конкретизируя и развивая соответствующие идеи Бутлерова и В. В. Марковникова. В 1900–05, изучая конденсацию ацетиленовых углеводородов с кетонами под влиянием едкого кали, Ф. открыл новый метод синтеза третичных ацетиленовых спиртов. Ф. создал одну из школ сов. химиков-органиков. Работы Ф. и его учеников в области непредельных соединений явились теоретической основой промышленного синтеза каучука в СССР. Государственная премия СССР (1941). Награжден 4 орденами Ленина, орденом Трудового Красного Знамени и медалями.

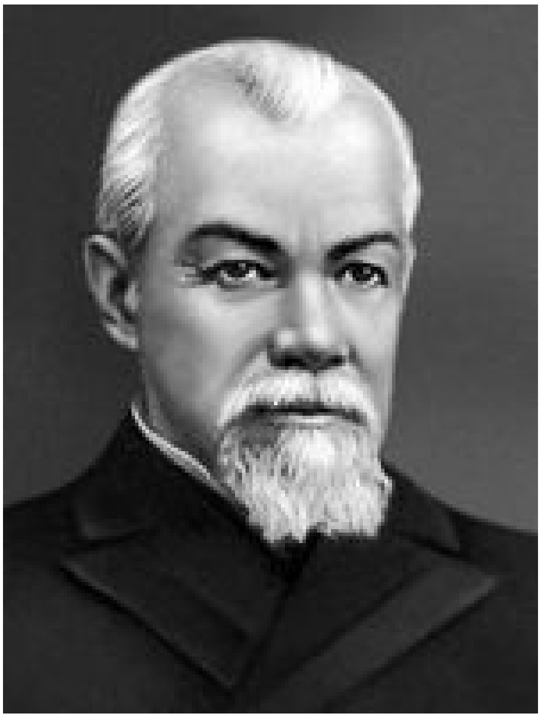
## Бекетов Николай Николаевич

## (1827–1911),



русский физико-химик, академик Петербургской АН (1886). Окончив Казанский университет в 1849, работал у Н. Н. Зинина. С 1855 адъюнкт химии, в 1859—87 профессор Харьковского университета. В 1886 переехал в Петербург, где работал в академической химической лаборатории и преподавал на Высших женских курсах. В 1890 читал в Московском университете курс «Основные начала термохимии». Б. открыл вытеснение металлов из растворов их солей водородом под давлением, установил, что магний и цинк при высоких температурах вытесняют другие металлы из их солей. В 1859—65 показал, что при высоких температурах алюминий восстанавливает металлы из их окислов; позднее эти опыты послужили отправной точкой для возникновения алюминотермии.

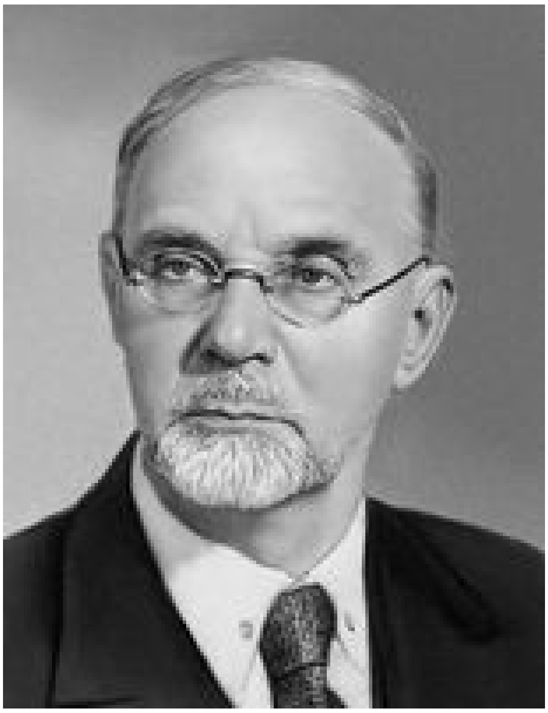
Огромной заслугой Б. является развитие физической химии как самостоятельной научной и учебной дисциплины. Ещё в 1860 в Харькове Б. читал курс «Отношение физических и химических явлений между собой», а в 1865 — курс «Физическая химия». В 1864 по предложению Б. в Харьковском университете учреждено физико-химическое отделение, на котором наряду с чтением лекций был введён практикум по физической химии и проводились физико-химические исследования.



**Зайцев Александр Михайлович (1841 – 1910),**

русский химик-органик, член-корреспондент Петербургской АН (1885). Ученик А. М. Бутлерова. По окончании Казанского университета работал (1862—65) в лабораториях Кольбе и Вюрца. В 1870 защитил докторскую диссертацию «Новый способ превращения жирных кислот в соответствующие им алкоголи» и был утвержден экстраординарным, а в 1871 — ординарным профессором Казанского университета.

Исследования З. способствовали развитию и укреплению химического строения теории Бутлерова. С 1870 З. вёл исследования предельных спиртов, причём разработал общий способ их синтеза восстановлением хлорангидридов жирных кислот амальгамой натрия. В частности, он получил нормальный первичный бутиловый спирт, существование которого было предсказано теорией строения. В 1873 З. синтезировал диэтилкарбинол действием цинка на смесь йодистого этила и муравьино-этилового эфира. Эта работа положила начало исследованиям французских химиков Ф. Барбье, В. Гриньяра и др. (см. Гриньяра реакция). В 1885 З. предложил новый метод синтеза третичных предельных спиртов действием цинка на смесь алкилгалогенида и кетона. В 1875—1907 З. синтезировал ряд непредельных спиртов. Разработанные З. и его учениками методы синтеза при помощи галоген-цинкорганических соединений позволили получить большое число предельных и непредельных спиртов и их производных. Совместно с учениками З. синтезировал ряд непредельпых углеводородов (бутилен, диаллил и др.). Особенно большое теоретическое значение имеют исследования З. о порядке присоединения элементов галогеноводородов (НХ) к непредельным углеводородам и отщепления НХ от алкилгалогенидов. (Ряд работ З. и его учеников посвящен многоатомным спиртам и окисям, получению непредельных кислот, оксикислот и лактонов — класса органических соединений, открытого З. в 1873. З. воспитал большую школу химиков (Е. Е. Вагнер, А. Е. Арбузов, С. Н. Реформатский, А. Н. Реформатский, И. И. Канонников и др.).



## Арбузов Александр Ерминингельдолвич

## (1877-1968),

советский химик-органик, академик АН СССР (1942; член-корреспондент 1932), Герой Социалистического Труда (1957). Ученик А. М. Зайцева. В 1900 окончил Казанский университет, в 1911—30 профессор там же. С 1930 профессор Казанского химико-технологического института. В 1945—63 председатель Казанского филиала АН СССР. В магистерской диссертации «О строении фосфористой кислоты и её производных» (1905) А. установил строение этой кислоты и её эфиров и открыл перегруппировку средних эфиров той же кислоты, получившую наименование Арбузова реакции и являющуюся одним из важнейших методов синтеза фосфорорганических соединений. В докторской диссертации «О явлениях катализа в области превращений некоторых соединений фосфора» (1915) А. распространил свои представления на эфиры фенилфосфинистых и других кислот, а также показал единство сил, ускоряющих каталитические процессы изомеризации, с силами, влияющими на скорость обычных химических реакций. Взгляды А. подтверждены современной теорией гомогенного катализа. Ряд работ А. посвятил таутомерии диалкиловых эфиров фосфористой кислоты и реакциям их металлических производных. Исследуя эти соединения, А. совместно с Б. А. Арбузовым открыл новый способ получения свободных радикалов триарилметилового ряда. А. провёл исследования по теории подсочки и истечения смолы-живицы из хвойных деревьев. А. установил наличие высокого давления в 0,2—0,3 *Мн/м*$^2$ (2—3 *кгс/см*$^2$) в смоляных ходах этих растений. Им была разработана техника сбора живицы без потери летучих, что способствовало быстрому росту подсочного хозяйства СССР. Ценны работы А. по истории химии, показывающие вклад в науку, сделанный русскими химиками. Депутат Верх. Совета СССР 2—6-го созывов. Государственная премия СССР (1943, 1947). Награжден 5 орденами Ленина, орденом Трудового Красного Знамени и медалями.

# *Audio Supplement*

Acids are substances that release hydrogen ions in water. Alkalis are substances that release hydroxide ions (ions made up of hydrogen and oxygen) in water. If acids and alkalis are mixed, the two types of ions cancel each other out, and a new substance called a chemical salt is formed. The acidity or alkalinity of a substance can be measured using the pH (potential for hydrogen) scale, which runs from 1 to 14. All acids have a pH lower than 7; the stronger the acid, the lower the pH. All alkalis have a pH greater than 7; the stronger the alkali, the higher the ph. Neutral substances, such as water, are neither acidic nor alkaline. They have a pH of 7.

An important nonmetallic element, carbon occurs naturally in three forms, or allotropes. There are graphite, diamond and buckminsterfullerence. Carbon can form millions of different compounds (combinations of elements). This is because a carbon atom can bond with up to four atoms (of carbon or other elements) and because the carbon atoms can link up in chains and rings of different sizes and patterns.

Organic (carbon-containing) compounds can be divided into two major groups - aliphatic and aromatic compounds - according to the way in which the carbon atoms bond. In aliphatic compounds, the carbon atoms are linked in chains. These chains can contain anything from two to many thousands of carbon atoms, with other types of atoms attached to each carbon atom. In aromatic compounds, the carbon atoms are joined in a ring.

A chemical reaction occurs when substances change into new substances. For this to happen, the bonds between atoms and molecules must break and re-form in different ways. Because the bonds can be strong, energy, usually in the form of heat, is often needed to start a reaction. The new substances (products) have properties different from those of the original substances (reactants). Chemical reactions do not occur only in laboratories; they happen all around us - for example, when cars rust and when food is cooked.

Metals are a group of elements that share certain properties. They conduct heat and electricity well, which is why cooking pans and electrical wires are made of metal. They are also strong and can be shaped easily; this is why they are used to make structures such as bridges. Although there are many similarities between metals, there are also differences that determine how suitable a metal is for a particular use. Of the 109 elements known today, 87 are metals. They are rarely used in their pure state - they are usually mixed with other metals or nonmetals to form combinations known as alloys.

Many substances form crystals. A crystal is a type of solid matter that always forms the same shape. For example, crystals of common salt always for tiny cubes, and emerald crystals are always hexagonal (six-sided). Crystals often form when molten rocks cool down and solidify or when solutions containing minerals evaporate. Crystals can also be made in the laboratory. Some crystalline substances, such as rubies and diamonds, are used in jewelry. Others are useful in industry; quartz, for example, is used in watches.

A solid is a compact substance, created by closely packed atoms that form a regular pattern called a lattice. There are strong forces holding the atoms together, which allow only slight movement. The hardness of a solid depends on the pattern and movement of its atoms. The element carbon, for example, can exist in a soft form called graphite, or in one of the hardest solid forms on Earth, the diamond.

A solution forms when one substance (usually a solid) dissolves in another (usually a liquid). The solid (called the solute) breaks up into tiny particles and spreads throughout the liquid (the solvent) so that you can no longer see any solid. Solutions are always clear; if the mixture is cloudy, it is a suspension. In a suspension, solid particles spread throughout the liquid, but the particles are bigger than those of a solution. If you leave a suspension to stand, most of the solid particles will eventually sink. A solution will not separate out in this way.

At room temperatures, water is a clear, tasteless, and odorless liquid. It is made up of hydrogen and oxygen atoms grouped together as molecules. The molecules draw together at the surface of water to from surface tension, which acts like a kind of skin. They are also drawn to the molecules of other substances, which is why water "wets" things, like drinking glasses, or our bodies when we swim.

A compound is a substance in which the atoms of two or more elements are joined together by chemical bonds. Because of these bonds, it is very difficult to split a compound into its individual elements. The type and number of bonds formed depend on the electrons (particles with a negative electrical charge) in each atom. The properties of a compound can be very different from those of the elements it contains. For example, the salt we use in our food is a harmless compound, yet it is made up of two dangerous elements - sodium, which reacts violently with air; and chlorine, which is poisonous in large quantities.

A molecule is group of atoms joined together by chemical bonds. The molecules of an element are identical and contain atoms of one type only. Oxygen gas, for example, has molecules made up of two oxygen atoms. The molecules of a compound are also identical, but in this case each molecule contains atoms of more than one type. In water, for example, each molecule is made up of two hydrogen atoms and one oxygen atom. All gases, most liquids, and many nonmetallic solids consist of molecules.

Organic chemistry is the study of compounds containing carbon. It is called "organic" because scientists used to think that these compounds were found only in living things or fossils. However, vast numbers of different carbon-containing compounds can now be produced artificially in laboratories and factories, for use in industry. For example, drugs, plastics, and pesticides are all synthetic organic substances. About 4.5 million of the 5 million compounds known today contain carbon.

All substances are made up of tiny particles called atoms; they are the building blocks of everything on Earth. Atoms are so small that a pinhead contains about 60 billion of them. The ancient Greeks first guessed that matter might be made up of small particles.  Atoms contain even smaller particles called protons, neutrons, and electrons.

Isotopes are different forms of the same element (simple type of substance). They have identical chemical properties and occupy the same place in the periodic table (the word isotope means "same place"). It is their physical properties that differ, because their atoms (tiny particles) have different masses. Each "isotopic form" has a different number of neutrons, in the nucleus (center) of its atoms, which gives it a different mass. Hydrogen gas, for example, can exist naturally in three isotopic forms: common hydrogen, heavy hydrogen, and radioactive hydrogen.

There are two types of nuclear reactions: nuclear fission and nuclear fusion. Nuclear power stations use fission to produce their energy. Fast-moving atomic particles called neutrons are fired at the nucleus (center) of an atom to split it. This splitting is called fission and it causes other atoms to split in a chain reaction. Some mass (the number of heavy particles inside an atom) is lost in the process. This is converted into large amounts of nuclear energy.

The study of the nucleus (center) of an atom is known as nuclear physics. As a result of this study, scientists have discovered ways of splitting the nucleus to release huge amounts of energy. One nucleus is split, causing many others to split, in what is called a nuclear chain reaction.  A controlled nuclear reaction inside a power station can be used to provide heat and light for our homes.

Everything consists of tiny atoms, which are made up of even smaller particles. Particle physics is the study of these smaller particles, which form the most basic building blocks of all matter in the univers. The study of particles enables scientists to learn more about the univers and the nature of all matter. Scientists generally agree that the universe started with a huge explosion in space, which they call the "big bang".

Matter is anything that occupies a space, including everything on the Earth and throughout the universe. Drops of water and specks of dust are kinds of matter, and so are plants, animals, and even planets. All matter has a mass, which is a measure of the particles (atoms and molecules) that is consists of. Particles can group together in many different ways, varying the structure of matter. That is why so many different kinds of matter exist. All kinds can be classified as either solid, liquid, or gas.

An element is a substance that contains only one kind of atom. Atoms cannot be broken down by chemical means, so it is impossible to break up an element into simpler substances by chemical changes. So far 109 elements have been discovered; 92 occur naturally, the other 17 are artificial elements that can be made only in the laboratory. There are two main kinds of elements - metals and nonmetals. Some elements chemically combine with other elements to form substances called compounds.

The Earth provides all the raw materials we need. The problem is to separate the substances we want from the mixtures in which they naturally exist. Chemists use a variety of different methods of separation, depending on the type of mixture and the properties of the substances it contains. We sometimes need to separate substances at home, too. In a coffee-maker, for example, a filter separates the ground coffee beans from the liquid coffee. This is known as filtration.

Gases, like other forms of matter, are made up of atoms that form groups called molecules.Gas molecules move very freely, spinning around at high speeds and filling up large spaces. As they move, the energetic gas molecules collide with one another and with the walls of their containers. Vapour can also be classified as a gas, although it behaves slightly differently.

Heat is a form of energy that transfers from one object or body to another if there is a difference in temperature between the two. When you are hot, for example, and the air outside your body is cooler, you lose heat to the air. A change in a body's level of heat results in a change in the energy of its molecules. This gives rise to a temperature change, which may in turn lead to a change of state.

Nuclear Fusion is a type of nuclear reaction that creates huge amounts of energy. It takes place naturally inside the sun, creating the heat energy that we need to survive on Earth. At temperatures of about 25 million F dgr. (14 million C dgr.) the nuclei (centers) of two hydrogen atoms fuse, or join together. In the process, some mass (the number of heavy particles inside an atom) is lost and converted into energy. Scientists are trying to develop this form of nuclear reaction as a safer alternative to the nuclear fission that takes place in power stations.

We determine how hot or cold something is by a measure called temperature. This tells us how much energy the atoms (tiny particles) inside a body contain. The more energy the atoms contain, the faster they move, and the higher the temperature. For each element (simple type of substance), there are specific temperatures at which changes of state occur. These are known as melting and freezing points. Scientists believe that absolute zero is the lowest possible temperature, below which atoms would have no energy.

A liquid is a substance that moves more freely than a solid, but not as freely as a gas. The tiny particles that make up liquids have more energy than those of solids, but not us much as those of gases. Liquids also differ from gases because they cannot be compressed into smaller spaces. The ability of a liquid to resist flowing is called its viscosity. Thick liquids, like syrup, have a high viscosity and flow slowly, whereas thin, runny liquids, like water, have a low viscosity.

Most animals are ectothermic, which means that their body temperature changes according to the outside temperature. Ectothermic animals are more active in the heat because chemical reactions inside cells work faster at higher temperatures. Animals behave in particular ways to control their body temperature. For example, lizards lie out on the rocks in the morning sun to gain heat. They burrow at night to conserve heat. Birds and mammalas are able to maintain a constant high body temperature. Such animals are called endothermic.

Unlike current electricity, static electricity does not flow. It is created when an electrically neutral substance loses or gains electrons (negatively charged particles), making it, respectively, positively or negatively charged. You can create static electricity by rubbing a balloon on your clothing. Electrons will move from the clothing to the balloon, making the balloon negatively charged and the clothing positively charged. The resulting static electricity on each will attract small, light objects such as pieces of paper.

Everything happens because of energy: without it, there would be no life on Earth. Scientists classify energy into several different types, including chemical energy, light energy, and nuclear energy. Most types of energy can switches from one form to another. It is when energy switches form that things happen, or work is done. In a car, for example, gasoline provides chemical energy, which turns into mechanical energy, heat energy, electrical energy, and sound energy when the engine is started.

An object made of metal is usually much heavier than a wooden one of the same volume. They are both occupying the same amount of space, but the metal object has a greater density. Density is the amount of mass, or atoms, that an object contains in a given space. The metal object contains more tightly packed atoms than the wooden therefore it has a greater density.

The different behavior of matter in its solid, liquid, and gaseous states is explained by kinetic theory. The state of any particular matter is determined by the amount of energy contained inside its atoms (the tiny particles that make up all matter). Changes of state occur when the energy levels of atoms change. The atoms in a gas have the most energy, those in a solid the least. The total amount of energy contained by the atoms of a substance is known as the kinetic energy of the substance. The substance's temperature and the pressure it is under affect its kinetic energy; so does the volume of its container.

Almost any form of energy can be converted into electricity. The most common methods of producing electricity are those used in batteries or generators. Power from batteries is generated by converting chemical energy into electrical energy. Most generators convert heat energy (from burning fuel) into electrical energy. Some generators exploit such natural resources as sunlight or wind to obtain electrical energy.

Magnets are attracted to iron and to any material that contains iron. Magnets have two poles, a north pole and a south pole. Unmagnetized iron and steel have magnetic regions of atoms called domains that are jumbled up and point in lots of different directions. When iron or steel becomes magnetized, the domains become aligned and they all point in the same direction. One end of each domain points toward the magnetic north pole.

Rays of light, like all forms of energy that travel in waves, can be reflected. Light rays are reflected when they hit a shiny or silvered surface, such as a still pool of water or a mirror. Reflection involves two light rays - the incident, or incoming ray, from an object, and the reflected, or outgoing, ray, which bounces off the reflecting surface. The two rays are at identical angles to the reflecting surface on either side of an imaginary line. Refraction is a property of all types of energy that travel in waves, including light. Light waves normally travel in straight lines, but when they pass from one transparent material to another, they usually refract, or bend. Refraction occurs because light travels at different speeds in different materials. As light from a material with a low density, such as air, enters a material with a high density, such as water, its speed is reduced. This causes it to bend (except when it enters a material at a right angle).

White light is a combination of lights of different colors: red, orange, yellow, green, blue, indigo, and violet. These colors are known as the spectrum and are revealed when white light passes through a prism. When an object is heated it begins to glow, giving off electromagnetic waves that we see as colors. The object changes color as it gets hotter (starting at red and ending at white) because the wavelengths become shorter.

Electricity is a flow of negative charges called electrons. (Electrons are particles that form a part of all atoms.) These electric charges are measured in units called coulombs. Electricity is a very versatile form of energy that can be converted into many other forms of energy, including light and heat. There are two types of electricity: direct current (DC), which flows in one direction only, and alternating current (AC), which changes direction 60 times per second.

The Earth is one of nine planets that travel around the sun in the solar system. Of these planets, the Earth is the third nearest the sun. It is the only planet known to support life. About 5 billion years ago, a cloud of gas and dust began to condense into a solid mass - the young Earth. At first, this mass was very cold, but later it was melted by radioactivity. Heavy metals collected at the center and rocks floated near the surface. After millions of years, the rocks formed a hard crust and the oceans and the atmosphere appeared.

Of all species, humans have the greatest effect on the environment. Some of our activities threaten the world's habitats and therefore the Earth's biodiversity (its range of plants and animals).The balance of nature is upset by activities such as overfishing, overhunting, and cutting down too many trees. We also damage the environment by polluting the land, the air, and oceans, rivers, and lakes. One of the causes of over-activity is the sheer number of people in the world. This number is rising.

Living things are sensitive to their surroundings. They can detect a stimulus and respond in a suitable way. Animals have sense organs, such as eyes and ears that rapidly send information to the nervous system's control center, the brain. The brain processes the information and responds by sending instructions to the parts of the body that need to react. These may be the muscles that make the animal produce sounds, or the muscles that enable it to bite into food.

Living organisms consist mostly of water. It is the substance in which chemicals are transported around the organism, and all the cells' chemical reactions happen in water. Whatever the conditions outside, a constant balance of water must be maintained inside the organism. The amounts of water taken in and lost have to be carefully controlled. Plants depend on water not only for cell metabolism and transporting chemicals, but also for cooling and support. Plants without water wilt and die. Plants close pores in their leaves to avoid losing water when it is in short supply and when the weather is hot.
Air is a mixture of gases that surrounds the Earth and supports all life on it. We breathe in air to stay alive, and rely on it for heat, as fire cannot burn without it. The layer of air that we breathe stretches for only 7 miles above the Earth's surface. The gases that make up air are mixed in approximately the same proportions all over the planet. Oxygen and nitrogen are the key elements, with water vapour, carbon dioxide, and other gases making up the total. The amount of water vapour in the air varies and is referred to as humidity.

The sun and the nine planets in orbit around it make up the solar system. The nine planets, which are drawn to the sun by its gravity, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. The sun is the heaviest of these bodies.

There are billions of stars in the univers. Stars are massive, energy-filled globes of fiery gases. The force of gravity holds these gases together. At a star's core, atoms of hydrogen join together to form helium in a process called nuclear fusion. The energy generated by this process produces a star's heat and light. Collections of stars are called galaxies, and each galaxy contains many different types of stars.

The part of the Earth and its atmosphere that can support living organisms is called the biosphere. This consists of the air and land, as well as lakes, rivers, and oceans. Organisms usually live alongside other members of the same species to form a population. Lots of different populations share the same habitat. Together, they all form a community. The members of a community constantly react with one another and their environment, creating a balanced, living system called an ecosystem, such as an ocean or a rain forest. The study of all these interactions is called ecology.

Some bacteria, viruses, protists, and fungi (often called germs) can invade living tissues, and may kill the organism unless it defends itself. Animals' skins act as germ-proof barriers, but if germs get into the body through cuts, breathing, or food, two defense mechanisms fight infection. One is nonspecific: germs are hunted and eaten by white blood cells that patrol the body. The other, the immune system, is specific: chemicals called antibodies are produced by white blood cells to destroy specific germs. Plants have only a protective epidermis, or "skin," to keep germs out.

# *Appendix*

## *The List of Great Chemists*

Roger Bacon [□r□□ər □beIkən]

Philippus Aureolus Paracelsus [fI□lIpəs □□rIələs perə□s□lsəs]

Robert Boyle [□r□bət □b□Il]

Johann Joachim Becher [□□ □hæn □ə□ □hIm □be□ə]

Georg Ernst Stahl [□I □□□ □□:nst □□t□:l]

Joseph Priestley [□□ə□zəf □pri:stlI ]

John Dalton [□□:n □dæltən ]

Antoine Lavoisier [əntu□en l□vuəz□jə]

Humphry Davy [□ h□mfrI □deIvI]

Jons Jacob Berzelius [□□ns □□ækəb brə□zIlIəs]

Dmitry Mendeleyev [□dmItrI mendə □leev]

Robert Bunsen [□r□bət □b□nsən]

Wilhelm Ostwald [□wIlhəlm □□stw□:ld]

Jacobus Hendricus van't Hoff [□□æk□bəs □hendrIkəs vænt □h□f]

Antoine Henri Becquerel [□æntuən □henrI □bIkurəl]

Marie Curie [mə □rIə kju □rI]

Leo Baekeland [□lI□ □bi:klənd ]

Donald James Cram [□d□nəld □□eImz □kræm]

Sir Harold W. Kroto [□s□: □hærəld □d□blju □kr□tə□]

Richard E. Smalley [□rI□əd □i: □smælI]

Shirakawa, Hideki, [□□Irəka: hI□dIkI]

Alan G. MacDiarmid [□ælən □i: mæk □daIəmId]

Alan J. Heeger, [□ælən □□eI □hi:□ə]

# *VOCABULARY*

## A

ability - способность
abound in - изобиловать
absorb - поглощать
abundant - распространенный
abundance -изобилие
accelerate - ускорять
according to -согласно
account - отчет
on account of - вследствие
accurate - точный
achieve - достигать
acid - кислота
acquire -приобретать
act - действовать
add - добавлять
addition – добавление
admixture - примесь
affect –воздействовать на
air - воздух
alkali - щелочь
alkaline - щелочной
alloy - сплав
alter -изменять
alternate - переменный
ammonia - аммиак
amount -количество
apparently - очевидно
appear – появляться
apply - применять
application - применение
appreciate - оценивать
aqueous - водный
argent - серебро
arrange - располагать
arrangement - расположение
artificial - искусственный
as – в качестве
ash -зола
attack – воздействовать на

attract - притягивать
available - доступный
average – средний

# B

balance - весы
band - диапазон
base – база  основание
basic - основной
bath - ванна
behave – вести себя
benzene - бензол
benzene - бензин
besides - кроме
bleach - отбеливать
body - тело
boil - кипятить
boiler - котел
boiling - кипячение
boiling point – точка  кипения
bond - связь
bottle - бутылка
bottom - дно
bowl - чаша
branch - отрасль
break down - разлагаться
brief - короткий
bright - яркий
brittle - хрупкий
bronze - бронза
bubble - пузырек
burn - гореть
burner -горелка
burning - горение
by-product – побочный продукт

# C

calculate - вычислять
capacity -емкость
carbon -углерод

carry out - осуществлять
cause - вызывать
chain - цепь
chamber - камера
change – изменять
charcoal – древесный уголь
charge - заряд
chemist - химик
chemistry -химия
chlorine - хлор
chlorate – хлорат
chloride - хлорид
clear - прозрачный
cloud – мутить
coal - уголь
coat - покрывать
coating - покрытие
colour - цвет
combination - соединение
combine – соединяться
combustible - горючий
combustion - горение
common - распространенный
common salt – поваренная соль
complex - сложный
complicate - усложнять
component – составная часть
compose - составлять
composition - состав
compound - соединение
compress - сжимать
condenser -холодильник
condition - условие
conduct - проводить
conductor - проводник
connect - соединять
connection - соединение
conserve - сохранять
consist of –состоять из
constituent -  составная часть
constitute -составлять
contain - содержать
container - сосуд
content - содержание
convert - превращать

cool - охлаждать
corrode - ржаветь
corrosion - ржавчина
crucible -тигель
crust - кора
current – ток

# D

deal - количество
decay - распад
decompose - разлагаться
decrease - уменьшаться
define - определять
dense - плотный
density - плотность
depend on – зависеть от
design - проектировать
dessicator - дессикатор
destroy - уничтожать
determine -определять
develop – разрабатывать
deviate - отклоняться
diamond - алмаз
differ from – отличаться от
diffuse - диффундировать
dilute - разбавлять
dilution - разбавление
dioxide - двуокись
disappear - исчезать
discharge - разряд
discover - открывать
disintegrate - распадаться
displace - вытеснять
display – выставлять проявлять
distinct - отчетливый
distinctive - отличительный
distinguish – различать(ся)
distribute - распределять
divide - делить
double - двойной
drop -капля
droplet - капелька

dry - сушить
due to - благодаря
durable - прочный

# E

earth –земля
easily - легко
effect - действие
emit - выделять
enrich -обогащать
equal -равняться
equation - уравнение
equip - оборудовать
equipment -оборудование
essential - необходимый
estimate - определять
ether - эфир
evaporate - испаряться
evident - очевидный
evolve - выделять
exact(ly) - точно
examine - исследовать
example - пример
exceed - превышать
except - кроме
excess - избыток
exert - оказывать
exhibit - проявлять
exist - существовать
expand - расширяться
explode - взрывать
explore - исследовать
explosion - взрыв
expose – выставлять на
extent - степень
to some extent – до некоторой степени
external - внешний
extract - извлекать

# F

facilitate -способствовать

failure - неудача
fertilizer -удобрение
fiber - волокно
fill - наполнять
fine - мелкий
fire - огонь
firm - прочный
fit - годиться
fix - устанавливать
flame -пламя
flask - колба
force - сила
form - образовывать
fraction - фракция
frequency - частота
full - полный
fume - дымить
fumes -пары
furnace - печь
fuse – плавить

# G

gain - приобретать
gas -газ
gaseous - газообразный
gasoline -бензин
gauze – металлическая решетка
glass - стекло
grade - марка
graduated - градуированный
ground - земля

# H

handle - обращаться
hard - твердый
harmful - вредный
heat - тепло
heavy - тяжелый
hydrocarbon - углеводород
hydrochloric acid – соляная кислота
hydrogen - водород

hydrogen peroxide – перекись водорода
hydroxide - гидроокись

# I

identical - одинаковый
ignite - воспламеняться
immerse - погружать
impurity - примесь
incandescence - накал
increase -увеличивать
indicate - указывать
indivisible - неделимый
inflame - воспламеняться
inflammable - горючий
influence – влияние
initial - начальный
insist on – настаивать на
insoluble - нерастворимый
instance - пример
instead - вместо
invent - изобретать
invisible - невидимый
iodine - йод
iron - железо
isolate – выделять

# K

kind – вид  сорт
kindling temperature  -  температура воспламенения

# L

lacquer - лак
lattice - решетка
layer - слой
lead - свинец
length - длина
level - уровень
liberate - выделять
light – свет  легкий

lime - известь
link - связь
liquefy - сжижать
liquid - жидкость
lustre - блеск
lustrous – блестящий

# M

machinery  - машинное оборудование
make - производить
manner - способ
manufacture - производить
marble - мрамор
matter - вещество
means - средства
   by means of - посредством
measure - измерять
melt - плавиться
melting point – точка плавления
mercury - ртуть
mica - слюда
mix - смешивать
mixture - смесь
mode - способ
modify - видоизменять
moist - влажный
moisture - влага
mould - формовать
move - двигаться
movement - движение
multiply –умножать

# N

narrow -узкий
necessary - необходимый
natrium - натрий
nitrate - нитрировать
nitric acid – азотная кислота
nitric oxide – окись азота
nitrogen - азот

nitrous acid – азотная кислота
non-conductor - изолятор
note- замечать
notice – замечать
nuclear – ядерный
nuclei - ядра
nucleous – ядро

# O

object - предмет
observe - наблюдать
obtain - получать
obvious - очевидный
occur - происходить
odour - запах
odourless – без запаха
ore - нефть
owing to - благодаря
oxidation - окисление
oxide - окись
oxidizing agent - окислитель
oxygen – кислород

# P

paint - краска
particle- частица
pass - пропускать
pattern - строение
pentoxide - пятиокись
per cent - процент
peroxide - перекись
petroleum - нефть
phenomenon – явление
plant- растение  завод
plastics - пластмасса
plate - пластинка
point - точка
poison - яд
poisonous - ядовитый
porcelain - фарфор

possess - обладать
potassium - калий
powder -порошок
power – мощь  энергия
precipitate - осаждать
precise - точный
prepare - приготовлять
pressure - давление
proceed - протекать
produce - производить
production - производство
property - свойство
protect -защищать
prove -доказывать
provide – снабжать
pure - чистый
purification - очистка
purify – очищать

# Q

quality - качество
quantity - количество
quantum -квант
quick- быстрый

# R

raise - повышать
range – диапазон
rapid - быстрый
raw -сырой
readily - легко
reduce - восстанавливать
reducing agent - восстановитель
reduction - восстановление
refine - очищать
reflect - отражать
replace - замещать
require - требовать
research - исследовать
resemble in – быть похожим
resist - сопротивляться

resistance - сопротивление
retard - замедлять
reveal - обнаруживать
rock – горная порода
rod - палочка
rubber - резина
rust - ржавчина

# S

safe - безопасный
salt -соль
sample - образец
saturatенасыщать
scale - накипь
semiconductor - полупроводник
separate - разделять
settle - оседать
shape - форма
shell - оболочка
silicon - кремний
silver - серебро
similar - похожий
size - размер
slightly - слегка
smell - запах
sodium - натрий
sophisticated - сложный
soft - мягкий
soil - почва
solar - солнечный
solid – твердое вещество
solubility - растворимость
soluble- растворимый
solute – растворяемое вещество
solution - раствор
solve - растворять
solvent - растворитель
spark - искра
species - образец
specific gravity – удельный вес
specimen - образец
speed - скорость
stage – фаза стадия

steadily - постоянно
steam - пар
steel - сталь
stone – камень
sublimate - возгонять
suitable - годный
sulphur - сера
sulphuric - серный
sulphurous - сернистый
surface – поверхность

# T

table -таблица
tap -кран
taste - вкус
test – испытывать
test-tube - пробирка
tin - олово
tint - оттенок
top - вершина
trace - след
treat - обрабатывать
tube – труба

# U

undergo - подвергаться
unit - единица
unless – если не
until - до тех пор, пока не
use - использовать
utilize – применять

# V

valence - валентность
valuable - ценный
value - ценность
vaporize - испаряться
vapour - пар
variety - разнообразие
various - различный

vary - изменяться
velocity - скорость
vessel -сосуд
vigorously – энергично  бурно
violently – энергично  бурно
visible - видимый
volatile - летучий
volume - объем

# W

warm  - нагревать
water - вода
wave - волна
wax - воск
weak - слабый
weigh - весить
weight -вес
withstand - выдержать
wood - дерево
wool - шерсть
wrong - ошибочный

# Y,  Z

yield - выход
zero-нуль
zinc - цинк

## *Contents:*



### *Unit 1*



### *Unit 2*



### *Unit 3*



### *Unit 4*



### *Unit 5*

**Unit 6**



**Unit 7**



**Unit 8**



**Unit 9**



**Unit 10**



**Unit 11**

## *Unit 12*