普通高等教育“十二五”规划教材

化学化工专业外语

杨永珍　刘旭光　主编

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·北京·

本书根据高等院校化学化工类硕士研究生的教学要求，为化学化工专业师生提供一本英语和日语兼顾的专业外语教学用书。

主要特色：①英语和日语兼收，采取三种方式引入日语，即主要词汇给出日语、英语和日语双语、以日语介绍英语；②从基础化学到英语科技论文写作，针对目前基础英语教学中重语法教学、轻应用教学的现状，在讲述专业外语的过程中，增加科技论文和相关写作的课程和读写训练；③内容涵盖化学和化学工程一级学科下的所有二级学科，专业跨度较大；④排版新颖，方便阅读和记笔记。对欲提高科技英语阅读和翻译水平的化学化工及相关专业科技人员、研究生和大中专学生有参考价值。

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前　　言

自 2000 年起，本书编者连续 11 年讲授硕士研究生化学化工类专业外语。在教学过程中总结教学经验，广泛搜集资料，不断摸索改进，最终在多年教学积累的基础上形成本书。通过本书的学习，使化学化工类硕士研究生掌握下列内容：基本词汇、基本表述、基本规范；掌握科技论文写作的详细规范；配合基础日语教学进行适当的专业日语学习。通过本书的学习，可以积累化学化工类专业英语和日语词汇、构词法和命名，提高读者的双语学习、阅读、写作、科研工作和对外交流能力。

本教材具有以下特点。①英语和日语兼收。针对化学化工类硕士研究生专业外语教学过程中主要为英语学生，同时又有少量日语学生、而且英语学生多以日语为第二外语的现状，在专业外语的教学过程中，结合基础日语教学进度，采取三种方式逐渐引入日语介绍：第一，主要词汇给出日语，如教材中的划线词汇；第二，英语和日语双语，如 Lecture 7；第三，以日语介绍英语，如 Lecture 18 和 Lecture 19。②从基础化学到英语科技论文写作，使化学化工专业英语课程与其学科发展相适应。针对目前基础英语教学中重语法、轻应用以及硕士研究生外语能力重听读、轻说写的现状，在讲述专业外语的过程中，增加科技论文和相关写作的课程和读写训练，并介绍先进的科学成果。通过 40 学时的专业外语学习，对基础化学与化工、仪器分析、化学前沿、化学写作等领域的专业表述有系统的了解。③内容涵盖化学和化学工程一级学科下的所有二级学科，专业跨度较大。④排版方式新颖，方便读者阅读和记笔记。对欲提高科技英语阅读和翻译水平的科技人员、研究生和大中专学生有参考价值。

本书的内容设置，是在综合比较现有若干版本的专业外语教材的基础上，针对理工科院校化学化工类硕士研究生专业外语课程的内容要求和学时要求，从基础化学入手，在积累一定词汇量的基础上，用较多的篇幅介绍仪器分析的专业外语，从而有助于处于第三学期论文调研阶段的硕士生更好地进行课题调研。教材分为 Lecture 1（前言）、四个单元和附录部分。其中，Lecture 1（前言）主要是让学生了解本书涵盖的内容、学习外语的方法和应具备的科学态度；第一单元为“基础化学”部分，包括无机化学、有机化学、物理化学、分析化学、仪器分析和环境化学，其中环境化学采用英语和日语对照的方式，并涵盖生物化工和分离科学的部分内容，利于专业日语的学习；第二单元为“前沿化学”部分，包括富勒烯 C_{60} 化学的一些基本知识；第三单元为“化学工程”部分，包括化学工程中的基本计算、动力学、传热、干燥、石油和煤炭、分子筛和沸石；第四单元为“写作”部分，包括写作的基本技巧、写作提高、科学论文写作、国际会议基础和信函写作，其中科技论文写作采用英语和日语对照的方式，国际会议基础和信函写作采用以日语介绍英语的方式；附录包括元素周期表、化合物命名基本规则、数字和公式的读法以及基本化学器皿读法。每课后均附有单词表。

本书主要作为高等学校化学化工类专业的硕士研究生科技英语教材，也适合于其他相关专业。对欲提高科技英语和日语阅读、翻译和写作水平的研究生、科技人员、大中专学生均

可参考阅读。

本书由刘旭光统筹，英文部分由杨永珍统稿，日语部分由刘旭光统稿。需要本书电子课件的教师，请与刘旭光联系，Liuxuguang@tyut.edu.cn。

尽管编者尽全力而为之，但限于水平，难免有不足与疏漏之处，望广大读者不吝指正，使本书不断改进和完善。

编　者

2011 年 3 月

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Lecture 1　Preface　前書き

Roll-call and self introduction　出欠の調べと自己紹介：自分の名前、出身、専攻と指導教官

Students' objectives in studying this section are to be able to:
(1) Describe what scientific branches this course covers;
(2) Know some experience in the aspect of how to learn a foreign language;
(3) Understand what the scientific attitude is.

Introduction speech　緒言

Now, society is asking more for you than ever before and will ask even more in the future. Those who want to get a good job, a good salary or a good chance to show their intellectual ability after graduation must have the ability to master well their speciality knowledge, as well as English and computer. I hope this course can provide you with a chance to learn more special English in the field of chemical engineering.

I want to know who in your class knows this poem and gives its best translation into Chinese:

I advise you not to cherish your cloth of gold
but to honor the day of youth
When flowers bloom they need to be plucked
wait not to grasp in vain at empty twigs

In fact, this textbook is sometimes bilingual, that is, written mainly in English and partly in Japanese. The majority of postgraduate students learn English as their first foreign language and Japanese as the second one. Therefore, this textbook is designed to help the students get familiar with corresponding Japanese expressions while they learn the English expressions in their speciality knowledge.

What will this course cover? この課程の内容について

Being the special English in the field of chemistry and chemical engineering, this course is designed to cover the following branches: ①elementary chemistry, such as inorganic chemistry, organic chemistry, analytical chemistry, physical chemistry and so on; ②catalysis and catalysts, including some basic knowledge of reaction kinetics; ③instrumental analysis and characterization means, such as GC, IR, UV, XRD, and TG; ④chemical technologies and processes, such as drying, condensing, extraction, and distillation; ⑤some applied or advanced branches of chemistry, such as coal, petroleum, and nanomaterials; ⑥some typical literatures or papers found in latest research; ⑦the writing of letters and research papers.

Some way to the gainful learning of a foreign language 外国語が上手になる方法について

The ability to learn a foreign language is quite different from one to another. Even with equal period of time and equal endeavor, different students often give different results. Why? The appropriate method is one important reason. Moreover, whether one can learn a foreign language well often depends much on his/her language-mastering ability.

Language differs from mathematics in that, as we have well known, in mathematics, different variables can have definite relationships, which means a given value of a variable can definitely result in the value of another variable by their functional expression. Contrary to this, there exists some untranslatability in languages. Some times, we can hardly find the counterpart of a word in another language. Therefore, a wiser manner to understand what the word means is to understand its function or meaning in current place.

We are often confused by the fact that we must select one appropriate meaning for a new word from its many explanations in dictionary to match the sentence or the paragraph we are reading. The only way to make the choice easier is to broaden our knowledge through extensive reading of relative literatures.

Sufficient volume of glossary is essential for us to become good at foreign language.

Some students often put the learning of grammar in his/her first place. They pay too much attention on it but finally find that the writing and reading can not become easier though they think they have mastered enough grammar. Why? Grammar is only a tool that serves our learning. Remember that grammar is not the destination of our learning a foreign language.

The scientific attitude 科学の態度

What is the nature of the scientific attitude, the attitude of the man or woman who studies and applies physics (物理学), biology (生物学), chemistry (化学), geology (地学), engineering (工学), medicine (医学) or any other science?

We all know that science plays an important role in the societies in which we live. Many people believe, however, that our progress depends on two different aspects of science. The first of these is the application of the machines, products and systems of applied knowledge that scientists and technologists develop. Through technology, science improves the structure of society and helps man to gain increasing control over his environment. New fibers and drugs, faster and safer means of transport, new systems of applied knowledge (psychiatry (サイキアトリ), operational research (オペレーション リサーチ), etc.) are some examples of this aspect of science.

The second aspect is the application by all members of society, from the government official to the ordinary citizen, of the special methods of thought and action that scientists use in their work.

What are these special methods of thinking and acting? First of all, it seems that a successful scientist is full of curiosity—he wants to find out how and why the universe works. He usually directs his attention towards problems which he notices have no satisfactory explanation, and his curiosity makes him look for underlying relationships even if the data available seems to be unconnected. Moreover, he thinks he can improve the existing conditions, whether of pure or applied knowledge, and enjoys trying to solve the problems which this involves.

He is a good observer (look at things in right perspective), accurate (as chemical balance), patient and objective and applies persistent and logical thought to the observations he makes (as penetrating as a scalpel used in a surgical operation). He utilizes the facts he observes to the fullest extent. For example, trained observers obtain a very large amount of information about a star (e.g. distance, mass, velocity, size, etc.) mainly from the accurate analysis of the simple lines that appear in a spectrum.

He is skeptical—he does not accept statements which are not based on the most complete evidence available—and therefore rejects authority as the sole basis for truth. Scientists always check statements and make experiments carefully and objectively to verify them.

Furthermore, he is not only critical of the work of others, but also of his own, since he knows that man is least reliable of scientific instruments and that a number of *factors tend to disturb impartial and objective investigation.*

Lastly, he is highly imaginative since he often has to look for relationships in data which are not only complex but also frequently incomplete. Furthermore, he needs imagination if he wants to make hypotheses of how processes work and how events take place.

These seem to be some of the ways in which a successful scientist or technologist thinks and acts.

New Words and Expressions

analytical	*a.* 分析的	instrumental	*a.* 仪器的
bilingual	*a.* 双语的	kinetics	*n.* 动力学
catalysis	*n.* 催化	nanomaterial	*n.* 纳米材料
catalyst	*n.* 催化剂，触媒	operational	*a.* 运筹的
critical	*a.* 批评的，决定性的	psychiatry	*n.* 精神病学
extraction	*n.* 萃取	scalpel	*n.* 解剖刀，手术刀
functional	*a.* 函数的	spectrum	*n.* 光谱，波谱
inorganic	*a.* 无机的	variable	*n.* 变量

Unit 1 Basic Chemistry 基礎化学

Lecture 2 Elements and Basic Inorganic Chemistry

元素とやさしい無機化学

Students' objectives in studying this section are to be able to:

(1) Know the Periodic Table of the Elements and its format;

(2) Understand some basic knowledge about elements;

(3) Learn some basic inorganic chemistry including basic concepts and basic reactions.

1. The Periodic Table of the Elements 元素の周期律の表

Very early in the history of chemistry it was realized that the ever-increasing knowledge of chemical behavior must be systematized. Many attempted this task, but it was not until the latter half of the nineteenth century that much success was achieved when Mendeleev and Meyer independently classified the known elements in order of increasing atomic weight and observed a significant pattern of chemical behavior. It is a refinement of this idea that leads to the modern version of the periodic classification of elements.

Even now new attempts are being made to present the periodic table in a more convenient form, but by far the most usual way is that usually available in which the elements are arranged in order of increasing atomic number and are arranged horizontally in periods (周期) and vertically in groups (族). The two special families of elements consist of 14 rare-earth elements respectively, called Lanthanide series and Actinide series.

While we must remember that the periodic classification of elements was achieved by considering the chemical properties of the elements, it is perhaps more satisfactory to consider that the above classification is a direct consequence of the electronic structure (電子構造) of atoms which we have learned in some university courses such as inorganic chemistry or structural chemistry.

Based on the fact that the electronic structure of the elements is a periodic function of their atomic numbers, i.e. a pattern exists which repeats itself in a more or less regular fashion. It would seem reasonable to assume that the other atomic properties may exhibit periodicity. For example, if we plot the atomic radii (原子半径) against their atomic numbers, we can readily see that atomic size is a periodic function of atomic number (原子番号).

Some common elements are given in Table 1, which we can meet very easily in our research fields.

Table 1 Some Common Elements in the Periodic Table of the Elements
元素の周期律の表

H	hydrogen	水素	Mn	manganese	マンガン
He	helium	ヘリウム	Fe	iron=ferrum	鉄
Li	lithium	リチウム	Co	cobalt	コバルト
B	boron	ホウ(硼)素	Ni	nickel	ニッケル
C	carbon	炭素	Cu	copper=cuprum	銅
N	nitrogen	窒素	Zn	zinc	亜鉛
O	oxygen	酸素	As	arsenic	ヒ(砒)素
F	fluorine	フッ(弗)素	Br	bromine	臭素
Na	Sodium =natrium	ナトリウム	Mo	molybdenum	モリブデン
Mg	magnesium	マグネシウム	Ru	ruthenium	ルテニウム
Al	aluminum	アルミニウム	Rh	rhodium	ロジウム
Si	silicon	ケイ(珪)素	Pd	palladium	パラジウム
P	phosphorus	リン(燐)	Ag	silver=argentum	銀
S	sulfur	硫黄	Sn	tin=stannum	スズ(錫)
Cl	chlorine	塩素	I	iodine	ヨウ(沃)素
K	potassium =kalium	カリウム	W	tungsten=wolfram	タングステン
Ca	calcium	カルシウム	Pt	platinum	白金
Ti	titanium	チタン	Au	gold=aurum	金
V	vanadium	バナジウム	Hg	mercury	水銀
Cr	chromium	クロム	Pt	lead=plumbum	鉛(なまり)

2. Elements 元素

Elements are pure substances that cannot be decomposed into simpler substances by ordinary chemical changes. At the present time there are 112 or more known elements. Element 114 or so is man-made and as yet unnamed. Some common elements that are familiar to you have been given in Table 1. The elements are the building blocks of matter just as the numerals 0 through 9 are the building blocks for numbers. To the best of our knowledge, the elements that have been found on the earth also comprise the entire universe.

About 85% of the elements can be found in nature, usually combined with other elements in minerals and vegetable matter or in substances like water and carbon dioxide. Copper, silver, gold, and about 20 other elements can be found in highly pure forms. More than twenty elements are not found in nature; they have been produced in generally small amounts in nuclear explosions and nuclear research. They are man-made elements.

Nearly 99% of the earth's crust is made up of only eight of the 112 elements. The human body is composed primarily of only six elements. Oxygen is the predominant element in each, as shown in Table 2.

Table 2 The Elemental Compositions of the Earth's Crust (地壳) and the Average Human Body

Element	in the Earth's Crust, wt%	Element	in the Average Human Body, wt%
oxygen	46.60	oxygen	65.0
silicon	27.72	carbon	18.0
aluminum	8.13	hydrogen	10.0
iron	5.00	nitrogen	3.0
calcium	3.53	calcium	2.0
sodium	2.82	phosphorus	1.0
potassium	2.59		
magnesium	2.09		

The names of many of the elements are derived from Latin or Greek terms that usually describe one of their properties. Chlorine comes from the Greek "chloros", which means "greenish yellow", the color of chlorine gas. Phosphorus comes from the Greek "phosphoros", meaning "light bearing", for its "glow in the dark" property. Other elements are named after people or places such as einsteinium (for Albert Einstein), curium (for Madame Curie), californium (for the state), and uranium (for the planet Uranus).

Element 112 is the heaviest element in the periodic table, 277 times heavier than hydrogen. It is produced by a nuclear fusion, when bombarding zinc ions onto a lead target. As the element already decays after a split second, its existence can only be proved with the help of extremely fast and sensitive analysis methods. Twenty-one scientists from Germany, Finland, Russia and Slovakia have been involved in the experiments that led to the discovery of element 112. In honor of scientist and astronomer Nicolaus Copernicus (1473—1543), the discovering team suggested the name copernicium with the element symbol Cp for the new element 112, discovered at the GSI Helmholtzzentrum für Schwerionenforschung (Center for Heavy Ion Research) in Darmstadt.

Just as symbols and abbreviations are widely used in medical areas to simplify communications, chemists used symbols to represent the names of the elements. Each element has a different symbol made up of one or two letters. If one letter is used, as it is for 14 of the elements, it is written as a capital: oxygen, O; nitrogen, N. If two letters are used, only the first is capitalized: calcium, Ca; aluminum, Al. The symbols are more than just abbreviations since they also stand for certain amounts of the element. The symbol H means not only hydrogen, but also one atom of hydrogen.

Most symbols suggest the name of the element they represent, while others seem unrelated to their English names. The symbols for this latter class of elements are derived from their early names (often Latin), which were widely used in the past.

When you write symbols that use two letters, it is important that only the first letter be capitalized. The symbol for nickel is Ni, but if it were written NI it would indicate a substance formed from the elements nitrogen (N) and iodine (I). No such substance exists. If CO were written for the element cobalt (Co), it would be taken to mean carbon monoxide, a toxic gas made form carbon (C) and oxygen (O).

3. Common acids and bases in inorganic chemistry 酸と塩基

(1) Sulfuric acid (硫酸)

Sulfuric acid (H_2SO_4), perhaps the most well-known mineral acid (鉱酸), is widely used in the manufacture of fertilizers (肥料), textiles (織物) and paper (紙). It is itself a fairly cheap chemical, the basic raw material being sulfur (硫黄) or a sulfur containing ore such as FeS_2 (pyrites: 硫化鉱). The sulfur is easily converted to gaseous SO_2 (sulfur dioxide: 二酸化硫黄、無水亜硫酸) which may then be oxidized to sulfuric acid.

The oxidation of SO_2 to SO_3 (sulfur trioxide: 三酸化硫黄、無水硫酸) is achieved by means of a heterogeneous catalyst (不均一系触媒), such as platinized asbestos (白金石綿) or the cheaper vanadium pentoxide (五酸化バナジウム). This reaction is exothermic (発熱).

In practice it is found that the absorption of SO_3 in water is not very successful, but it is readily absorbed in sulfuric acid itself to yield pyrosulfuric acid ($H_2S_2O_7$: 焦硫酸、パイロ硫酸), which can be converted to sulfuric acid by the addition of water.

Sulfuric acid is a strong dibasic acid (二塩基酸), ionizing (イオン化) readily in aqueous solution in two stages, thus it is possible to make two types of salts: acid salts (酸性塩) and normal salts (正塩), such as $NaHSO_4$ (sodium bisulfate: 硫酸水素ナトリウム) and Na_2SO_4 (sodium sulfate: 硫酸ナトリウム).

When reacting with hydrocarbons (炭化水素), sulfuric acid can form another interesting series of acids called sulfonic acids (サルフォン酸), such as $HO_3S\text{-}Ph\text{-}C_{10}H_{21}$ and so on. They are monobasic acids (一塩基酸), and their salts are important commercially as detergents (洗浄剤).

(2) Hydrochloric acid (塩酸)

Hydrochloric acid is the name commonly given to a solution of HCl in water, while pure HCl, which is a gas, is referred to simply as hydrogen chloride (塩化水素).

HCl can be prepared by the action of sulfuric acid on metal chlorides. It can also be prepared as a by-product (副産物、副生物) from the chlorination of organic materials, and this source is becoming increasingly important.

$CH_3CH_3 + Cl_2 \longrightarrow CH_3CH_2Cl + HCl$ chloroethane, ethyl chloride: (塩化エチル)

Apart from undergoing the usual reactions with metals, with the evolution of hydrogen, hydrochloric acid in concentrated solution can act as a complexing agent (錯化剤). A very powerful solvent can be made by mixing three parts of concentrated hydrochloric acid with one part concentrated nitric acid. This mixture, called aqua regia

(王水), owes its high solvent power to the combination of the oxidizing properties of nitric acid with the complexing properties of the hydrochloric acid. Metallic gold, for example, which is insoluble in either of the acids alone, dissolves in aqua regia to form the complex anion (陰イオン、負イオン) $[AuCl_4]^-$.

(3) Nitric acid (硝酸)

Nitric acid, like HCl, can be simply prepared by the action of sulfuric acid on metal nitrates, but the bulk of commercial nitric acid is obtained from the hydrolysis (加水分解) of NO_2, which is in turn obtained by the oxidation of ammonia (アンモニア).

The high temperature oxidation of ammonia can yield two main products, nitrogen or nitric oxide (NO). NO reacts readily with metals and metal oxides to form nitrates which are generally soluble (溶性) than salts of other acids.

In the majority of its reactions, nitric acid acts as an oxidizing agent (酸化剤). In *its reactions with metals, the gaseous product evolved is not usually hydrogen*, but oxides of nitrogen. For example, a fairly non-reactive (不反応性) metal like copper *will reduce nitric acid to* NO_2 or NO, depending on whether the concentration of the acid used is high or low.

(4) Sodium carbonate (炭酸ナトリウム)

Sodium carbonate is probably the most important alkali metal salt in industrial chemistry, being the cheapest available alkali. It is widely used in the manufacture of, for example, soap, glass and sodium hydroxide. The main method of manufacture is by the Solvay process, where CO_2 gas is bubbled through a solution of ammoniacal brine (安かん水、アンモニアかん水) to form sodium bicarbonate (重炭酸ナトリウム) which can readily be converted by heating to sodium carbonate.

Carbonic acid is a weak acid which does not ionize to any appreciable extent. However, the presence of NH_3 (アンモニア), which can combine with protons to form NH_4^+ ion, greatly increases the ionization of the weak acid. The bicarbonate is converted to carbonate simply by heating, at the same time yielding CO_2 which can be recycled.

(5) Sodium hydroxide (水酸化ナトリウム)

Sodium hydroxide is manufactured either by a causticizing (苛性化) process or by electrolysis (電解). The electrolysis method involves the electrolysis of brine (塩水、海水) solution using a carbon anode and mercury cathode. Chlorine is evolved at the anode, and the sodium generated at the cathode dissolves in the mercury to form an amalgam (アマルガム) which can then react with water in a separate cell to form sodium hydroxide solution.

(6) Some oxides (酸化物)

monoxide	一酸化塩素	Cl_2O	oxide	酸化窒素	NO
dioxide	二酸化塩素	ClO_2	sesquioxide	三二酸化窒素	N_2O_3
trioxide	三酸化塩素	Cl_2O_6	dioxide	二酸化窒素	NO_2
hemiheptoxide	七酸化二塩素	Cl_2O_7	tetraoxide	四酸化窒素	N_2O_4
tetraoxide	四酸化塩素	ClO_4	pentoxide	五酸化窒素	N_2O_5
monoxide	一酸化窒素	N_2O	peroxide	過酸化窒素	NO_3

New Words and Expressions

Abbreviation	*n.* 缩写	hydrochloric acid	盐酸
actinide	*n.* 锕系元素	hydrolysis	*n.* 水解
alkali	*n.* 碱	ionize	*v.* 电离
amalgam	*n.* 汞齐	lanthanide	*n.* 镧系元素
anion	*n.* 阴离子	mineral acid	无机酸
anode	*n.* 阳极	monobasic acid	一元酸
aqueous	*a.* 水的	nitric acid	硝酸
by-product	*n.* 副产物	normal salt	正盐
cathode	*n.* 阴极	oxidizing agent	氧化剂
causticizing	*n.* 苛性化	periodic	*a.* 周期的
chlorination	*n.* 氯化	platinized asbestos	载铂石棉
classify	*v.* 分类	refinement	*n.* 完善
complexing agent	*n.* 络合剂	reactive	*a.* 反应的，反应性的
dibasic acid	二元酸		
electrolysis	*n.* 电解	soluble	*a.* 可溶的
evolution	*n.* 进化	sulfuric acid	硫酸
exothermic	*a.* 放热的	to the best of our knowledge	据我们所知
heterogeneous	*a.* 多相的，非均相的	detergent	*n.* 洗涤剂
hydrocarbon	*n.* 烃		

Lecture 3 Basic Organic Chemistry 基礎有機化学

Students' objectives in studying this section is to be able to:

(1) Know the basic nomenclature rules of main organic compounds;

(2) Remember the names of some basic organic compounds;

(3) Distinguish the difference between common nomenclature and IUPAC nomenclature.

The nomenclature of main organic compounds

The countless organic compounds can be divided into many series, such as alkanes (メタン系列, パラフィン: paraffins), unsaturated compounds (不飽和化合物), cyclic hydrocarbons (環状炭化水素), carboxylic acids (カーボン酸), alcohols and ethers (アルコールとエーテル), aldehydes and ketones (アルデヒドとケトン), phenols (フィノール), aromatic hydrocarbons (芳香族炭化水素) and so on. In this section the nomenclature rules (命名規則) for them are introduced series by series.

(1) Alkanes

The straight chain (直鎖) alkanes constitute a family of hydrocarbons in which a chain of —CH_2— groups is terminated at both ends by a hydrogen. They have the general formula H—$(CH_2)_n$—H or C_nH_{2n+2}. Such a family of compounds, which differ from each other by the number of CH_2 groups in the chain, is called an homologous series (同族列). The individual members of the family are known as homologs (同族体) of one another. Straight chain alkanes are called normal (正常) alkanes, or simply n-alkanes, to distinguish them from the branched (枝分かれ) alkanes, which will be introduced briefly later.

Alkanes are sometimes called saturated hydrocarbons (飽和炭化水素). This term means that the carbon skeleton is "saturated" with hydrogen. That is, in addition to its bonds (結合) to other carbons, each carbon bonds to enough hydrogens to give a maximum covalence (共有原子価) of 4. In saturated hydrocarbons, there are only single bonds (単結合). Later, the unsaturated hydrocarbons will be introduced, which contain double or triple C-C bonds (二重結合と三重結合). The normal alkanes are named according to the number of carbon atoms in the chain, as shown in Table 1.

Table 1 The Names for n-alkanes

Series No.	Molecular Formula	English Name	Japanese Name
1	CH_4	methane	メタン
2	CH_3CH_3	ethane	エタン
3	$CH_3CH_2CH_3$	propane	プロパン
4	$CH_3(CH_2)_2CH_3$	butane	ブタン
5	$CH_3(CH_2)_3CH_3$	pentane	ペンタン
6	$CH_3(CH_2)_4CH_3$	hexane	ヘキサン
7	$CH_3(CH_2)_5CH_3$	heptane	ヘプタン
8	$CH_3(CH_2)_6CH_3$	octane	オクタン
9	$CH_3(CH_2)_7CH_3$	nonane	ノナン
10	$CH_3(CH_2)_8CH_3$	decane	デカン
11	$CH_3(CH_2)_9CH_3$	undecane	ウンデカン
12	$CH_3(CH_2)_{10}CH_3$	dodecane	ドデカン
13	$CH_3(CH_2)_{11}CH_3$	tridecane	トリデカン
14	$CH_3(CH_2)_{12}CH_3$	tetradecane	テトラデカン
15	$CH_3(CH_2)_{13}CH_3$	pentadecane	ペンタデカン
20	$CH_3(CH_2)_{18}CH_3$	eicosane	エイコサン
21	$CH_3(CH_2)_{19}CH_3$	heneicosane	ヘンアイコサン
22	$CH_3(CH_2)_{20}CH_3$	docosane	ドコサン
30	$CH_3(CH_2)_{28}CH_3$	triacontane	トライアコンサン
40	$CH_3(CH_2)_{30}CH_3$	tetracontane	テトラコンタン

These names derive from the generic name alkane with the alk-stem replaced by a stem characteristic of the number of carbons in the chain. The first four members of this series, methane, ethane, propane, and butane, are names assigned to compounds before organic chemistry evolved as an organized science. The remaining names derive quite obviously from Greek numbers. We should memorize the names of the n-akanes up through dodecane and know the logical procedure for developing names for larger compounds.

A radical (基、原子団) is a portion of a molecule in which a collection of atoms is considered together as a unit. For purposes of naming more complicated compounds, it is necessary to have names for such radicals. A radical name is derived by replacing the -ane of the corresponding alkane name by the suffix (接尾辞) -yl, as shown in Table 2.

Table 2 Some Examples of the Radicals of Alkanes

CH_3—	methyl	メチル	CH_3—OH	methyl alcohol	メチルアルコール
CH_3CH_2—	ethyl	エチル	CH_3CH_2—Cl	ethyl chloride	塩化エチル
$CH_3CH_2CH_2$—	propyl	プロピル	$CH_3CH_2CH_2$—Br	propyl bromide	臭化プロピル

Except for methane, ethane and propane, there are other isomeric compounds (異性体) having exactly the same formula (分子式) with lager normal alkanes. Isomers are defined as compounds that have identical formulas but differ in the nature or sequence of bonding of their atoms or in the arrangement of their atoms in space. For example, one of the C_4H_{10} isomers is butane, discussed previously. The other is isobutane.

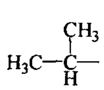
In general, isomers have different physical and chemical properties. Of the two C_4H_{10} isomers, isobutane has lower melting point and boiling point. The lower boiling point reflects the branched chain structure of isobutane, which provides less effective contact area for Van der Waals attraction.

The iso- prefix (接頭辞) serves to name one of the isomers, and another prefix neo- provides an additional name. However, these are the only special prefixes in general use. With more carbons the number of possible isomers increases rapidly. There are 5 possible hexanes, 9 heptanes, 75 decanes and 366319 eicosanes. With larger alkanes the number of possible isomers becomes astronomic. Clearly, in this situation an essential requirement is a systematic nomenclature so that each different compound may be assigned an unambiguous name.

This problem was solved by an international group of chemists that met in Geneva as part of the first meeting of the International Union of Pure and Applied Chemistry. The Geneva rules of 1892 are being continuously updated and extended as new kinds of compounds are discovered. They now comprise a consistent and detailed nomenclature known as the IUPAC rules. The IUPAC system of alkane nomenclature is based on the simple fundamental principle of considering all compounds to be derivatives of the longest single carbon chain present in the compound. The modifying prefixes, di-, tri-, tetra-, penta-, hexa-, and so on, are used to indicate multiple identical appendages.

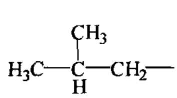
Several common radicals have special names that must be memorized:

isopropyl



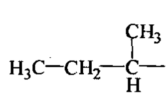
イソプロピル

isobutyl



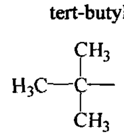
イソブチル

sec-butyl



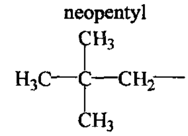
セクブチル

tert-butyl



第三ブチル

neopentyl



ニーオペンチル

(2) Unsaturated hydrocarbon compounds