"十三五"普通高等教育本科规划教材

English for Chemical Engineering with Energy

能源化工专业英语

吕晓娟　王淑勤　合编

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内 容 提 要

能源化工专业英语教材是在参考大量文献的基础上，根据作者多年的教学经验，选定7章43篇课文，9篇阅读材料，内容不仅涉及化工原理、工业催化、煤化工、化学反应工程、碳一化学等专业必修课，还涉及洁净煤技术、电厂化学、化工安全与环保、测试表征技术、新能源概论等多门课程涵盖的能源、材料、污染防治等方面的问题。每篇课文之后附有英汉对照的生词，部分课文后附有难句解释和注解。

本书主要用作能源化工专业英语课程的教材，同时也可供应用化学专业的学生及相关工程技术人员学习参考。

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前　言
Preface

随着全球化进程步伐的加快，各行各业工作者和国际之间的交流合作日益增多，和不同行业特色相关的专业英语成为交流合作的纽带。纵观能源化工专业课程设置，在大学一、二年级开设大学英语课程的基础上，三、四年级开设了能源化工专业英语，这是保证大学生外语不断线的必要措施。虽然基础英语是大学各个专业普遍开设的课程，但是仅仅学习基础英语是不够的，因为专业英语相比于基础英语来说，无论是在词汇、文法、语法等方面都带有各自专业的特色，所以在基础英语之后开设专业英语是十分必要的。专业英语的学习能够让学生在学习中或者今后工作时更快、更有效地利用英语这一工具为本专业服务。一本基于专业特色的专业英语教材是讲授专业英语课程的关键。

专业英语课程的任务是继续强化学生的听、说、读、写、译能力，使学生达到较少借助字典阅读和笔译本专业的英文文献，熟悉科技英语的表达方式、英文科研论文摘要、公式、表格的写作特点等内容，旨在培养学生未来从事本专业所必需的英语基本知识和基本技能，为今后更好地从事专业技术工作奠定基础。

编者在总结多年教学经验的基础上，结合本专业特色，精心编写了能源化工专业英语教材。本书旨在为能源化学工程专业提供一本比较系统的专业英语教学用书。在选编课文时，根据能源化工专业的特色，涵括了化工原理、化工技术、能源及其利用技术、测试与表征技术、能源环境保护、电厂化学技术以及科技论文的撰写共 7 章内容。通过阅读本教材，可以对本专业的研究内容及文章体裁有一个相对全面的了解。

每章均包括精读课文、词汇表以及阅读材料。精读课文和阅读材料都选自英文原版著作，文字流畅，内容准确，可以使学生了解地道的英语表达方式，掌握更多的专业词汇、专业文献阅读和翻译技巧，熟悉专业论文写作方法，掌握常用的写作句型，并能够运用专业英语与外国专家进行简单的专业技术交流，有助于提高学生的综合素质。本书由吕晓娟、王淑勤主编，由于编者水平有限，不妥之处，恳请读者批评指正。

编　者
2015 年 6 月

Contents

Chapter 1 Basic knowledge and Principles of Chemical Engineering with Energy

Unit 1 The Chemistry of Fuels and Energy Resources

Energy is necessary for everything we do. Look around you—energy is involved in anything that is moving or is emitting light, sound, or heat. Heating and lighting your home, propelling your automobile, powering your laptop computer—all are commonplace examples in which energy is used, and all are, at their origin, primarily based on chemical processes. In this chapter, we want to examine how chemistry is fundamental to understanding and addressing current energy issues.

Supply and Demand: The Balance Sheet on Energy

We take for granted that energy is available and that it will always be there to use. But will it? The late Richard Smalley, a chemist and Nobel Prize winner, stated that among the top 10 problems humanity will face over the next 50 years, the energy supply ranks as number one. What is the source of this prediction? Information such as the following is often quoted in the popular press:

- Global demand for energy has almost tripled in the past 40 years (Figure 1.1) and may triple again in the next 50 years. Most of the demand comes from industrialized nations, but most of the increase is coming from developing countries.
- Fossil fuels account for 85% of the total energy used by humans on our planet. (Of this total, petroleum accounts for 37%, coal 25%, and natural gas 23%.) Nuclear, biomass, and hydroelectric power contribute about 13% of the total energy budget. The remaining 2% derives from solar, wind, and geothermal energy generating facilities.
- With only about 5% of the world's population, the United States consumes 23% of all the energy used in the world. This usage is equivalent to the consumption of 7 gallons of oil or 70 pounds of coal per person per day.
- China and India, growing economic powerhouses, are increasing their energy usage by about 8% per year. In 2007, China passed the United States as the number one emitter of greenhouse gases in the world. Two basic issues, *energy resources* and *energy usage*, instantly leap out from these statistics and form the basis for this discussion of energy.

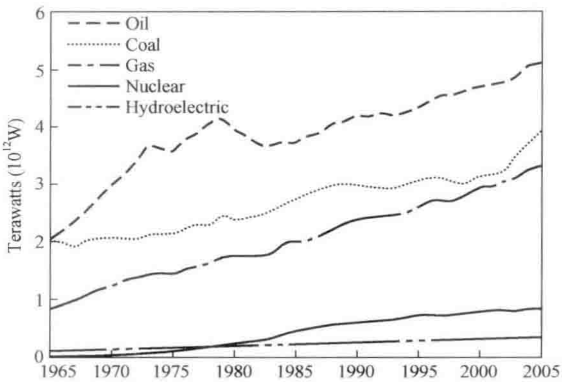

Figure 1.1 Changes in world energy usage, 1965-2005

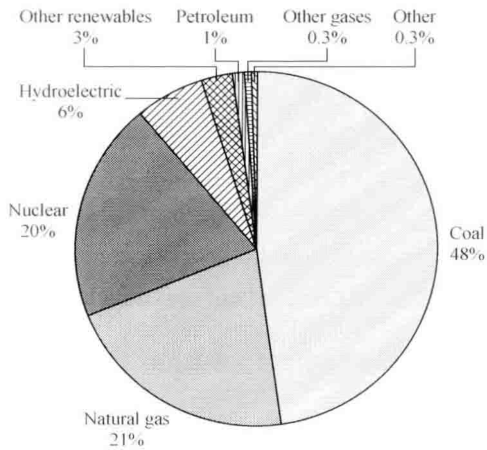

Figure 1.2 Fuel used in the electric power industry in the United States, 2008

Energy Resources

The world is hugely dependent on fossil fuels as a source of energy. Almost 70% of the electricity in the United States is generated using fossil fuels, mostly coal and natural gas (Figure 1.2), and over 80% of the energy consumed for all purposes is derived from fossil fuels (Figure 1.3).

Why is there such a dominance of fossil fuels on the resource side of the equation? An obvious reason is that fossil fuels are cheap raw materials compared to other energy sources. In addition, societies have made an immense investment in the infrastructure needed to distribute and use this energy. Power plants using coal or natural gas cannot be converted readily to accommodate another fuel. The infrastructure for distribution of energy—gas pipelines, gasoline dispensing for cars, and the grid distributing electricity to users—is already in place. The system works well.

Since the system using fossil fuels works well, why do we worry about using fossil fuels? One major problem is that fossil fuels are *nonrenewable energy sources*. Nonrenewable sources are those for which the energy source is used and not concurrently replenished. Fossil fuels are the obvious example.

Nuclear energy is also in this category. Conversely, energy sources that involve using the sun's energy are examples of *renewable resources.* These include solar energy and energy derived from wind, biomass, and moving water. Likewise, geothermal energy is a renewable resource.

There is a limited supply of fossil fuels. No more sources are being created. As a consequence, we must ask how long our fossil fuels will last. Regrettably, there is not an exact answer to this question. One current estimate suggests that at current consumption rates the world's oil reserves will be depleted in 30-80 years. Natural gas and coal supplies are projected to last longer: 60-200 years for natural gas and from 150 to several hundred years for coal. These numbers are highly uncertain, however-in part because the estimates are based on guesses regarding fuel reserves not yet discovered, in part because assumptions must be made about the rate of consumption in future years. If the use of a commodity (such as oil) continues to rise by a fixed percentage every year, then we say that we are experiencing "exponential growth" for that usage. Even though the amount of oil consumed every year might rise by only 2%-4%, this still is a rapid growth in the total used if we look forward many years. A global growth rate of 4% per year for oil will reduce the estimate of petroleum resources lasting 80 years to only 36 years. A growth rate of 2% per year changes this estimate to 48 years. Estimates of how long these resources will last do not mean anything unless assumed growth rates are accurate.

We cannot ignore the fact that a change away from fossil fuels must occur someday. As supply diminishes and demand increases, expansion to other fuel types will inevitably occur. Increased cost of energy based on fossil fuels will encourage these changes. The technologies to facilitate change, and the answers regarding which alternative fuel types will be the most efficient and cost-effective, can be aided by research in chemistry.

One energy source that has been exploited extensively in some countries is nuclear power. For example, several countries in Europe generate more than 40% of their electricity using nuclear power plants (Figure 1.4). Certain regions on the planet (such as Iceland and New Zealand) are also able to exploit geothermal power as an energy source, and Germany and Spain plan on meeting 25% of their electrical energy needs with wind by the year 2020.

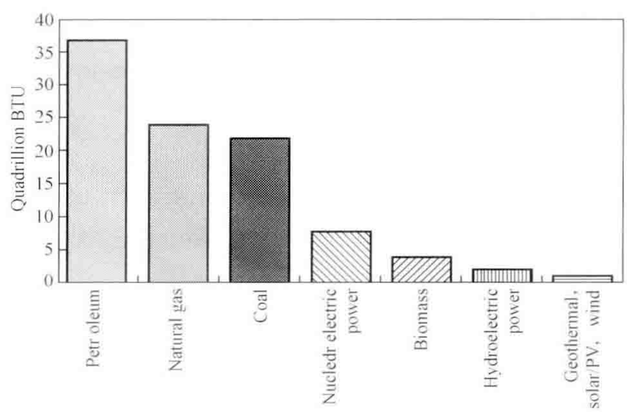

Figure 1.3 Primary sources of energy consumed for all purposes in the United States, 2008

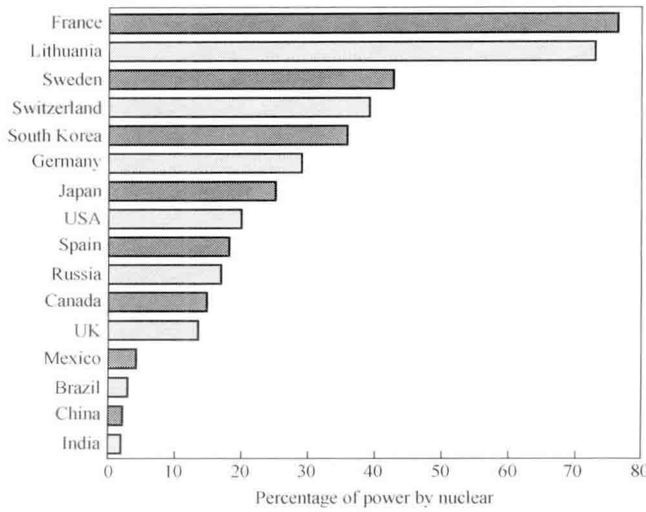

Figure 1.4 Use of nuclear power for electricity generation

Energy Usage

Many studies indicate that energy usage is related to the degree to which a country has industrialized. The more industrialized a country, the more energy is used by individuals on a per capita basis (Figure 1.5). As developing nations become more industrialized, personal energy usage worldwide will surely increase proportionally. There has been rapid growth in energy usage over the past two decades, and it is predicted that there will be continued rapid growth in the next half-century (Figure 1.1). One way to alter energy consumption is through conservation. This can mean consciously using less energy (such as driving less, turning off lights when not in use and turning the thermostat down [for heating] or up [for cooling]). It can also mean using energy more efficiently. Some examples of this latter approach are:

- Aluminum is recycled because recovering aluminum requires only one third of the energy needed to produce the metal from its ore.
- Light-emitting diodes (LEDs) are now used in streetlights, and compact fluorescent lights are finding wider use in the home. Both use a fraction of the energy required by incandescent bulbs (in which only 5% of the energy used is delivered in the form of light; the remaining 95% is wasted as heat).
- Hybrid cars offer up to twice the gas mileage available with conventional cars.
- Many newer appliances (from refrigerators to air conditioners) are designed to use less energy per delivered output.

One of the exciting areas of current research in chemistry relating to energy conservation focuses on superconductivity. Superconductors are materials that, at temperatures of 30-150 K, offer virtually no resistance to electrical conductivity. When an electric current passes through a typical conductor such as a copper wire, some of the energy is lost as heat. As a result, there is substantial energy loss in power transmission lines. Substituting a superconducting wire for copper has the potential to greatly decrease this loss, so the search is on for materials that act as superconductors at moderate temperatures.

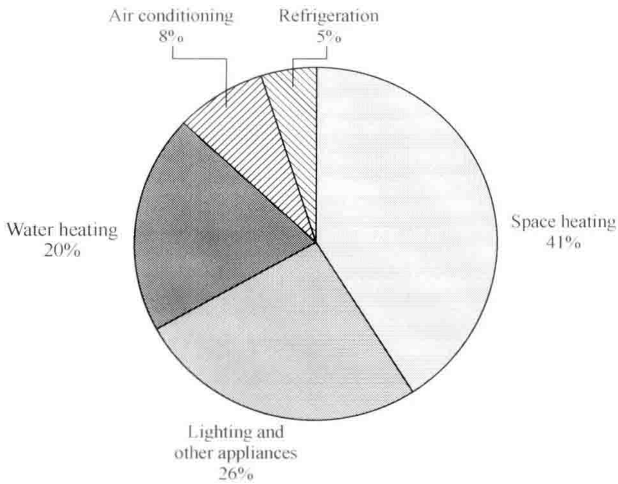

Figure 1.5 Energy use in homes in the United States, 2005

Fossil Fuels

Fossil fuels originate from organic matter that was trapped under the earth's surface for many millennia. Due to the particular combination of temperature, pressure, and available oxygen, the decomposition process of the compounds that constitute organic matter resulted in the hydrocarbons we extract and use today: coal, crude oil, and natural gas—the solid, liquid, and gaseous forms of fossil fuels, respectively.

Fossil fuels are simple to use and relatively inexpensive to extract, compared with the current cost requirements of other sources for the equivalent amount of energy. To use the energy stored in fossil fuels, these materials are burned. The combustion process, when it goes to completion, converts fossil fuels to CO_2 and H_2O. The thermal energy is converted to mechanical and then electrical energy.

The hydrocarbons of fossil fuels have varying ratios of carbon to hydrogen, and their energy output from burning (Table 1.1) is related to that ratio. You can analyze this relationship by considering data on enthalpies of formation and by looking at an example that is 100% carbon and another that is 100% hydrogen. The oxidation of 1.0 mol (12.01 g) of pure carbon produces 393.5 kJ of energy or 32.8 kJ/g.

$$C(s)+O_2(g)\rightarrow CO_2(g) \tag{1-1}$$

$$\Delta rH^\circ = -393.5 \text{ kJ/mol-rxn or } -32.8 \text{ kJ/gC}$$

Burning hydrogen to form water is much more exothermic on a per-gram basis, with about 120 kJ evolved per gram of hydrogen consumed.

$$H_2(g)+1/2O_2(g)\rightarrow H_2O(g) \tag{1-2}$$

$$\Delta rH^\circ = -241.8 \text{ kJ/mol-rxn or } -119.9 \text{ kJ/g } H_2$$

Coal is mostly carbon, so its heat output is similar to that of pure carbon. In contrast, methane is 25% hydrogen (by mass), and the higher-molecular-weight hydrocarbons in petroleum and products refined from petroleum average 16%-17% hydrogen content. Therefore, their heat output on a per-gram basis is greater than that of pure carbon but less than that of hydrogen itself.

While the basic chemical principles for extracting energy from fossil fuels are simple, complications arise in practice.

Table 1.1 Energy released by combustion of fossil fuels

Substance	Energy Released (kJ/g)
Coal	29-37
Crude petroleum	43
Gasoline (refined petroleum)	47
Natural gas (methane)	50

Environmental Impacts of Fossil Fuel Use

We are a carbon-based society. As mentioned earlier, about 85% of the energy used in the world today comes from fossil fuels. As energy usage increases, the amount of gaseous emissions of carbon compounds into our environment continues to rise (Figure 1.6). These include mainly CO_2 but also CH_4 and CO.

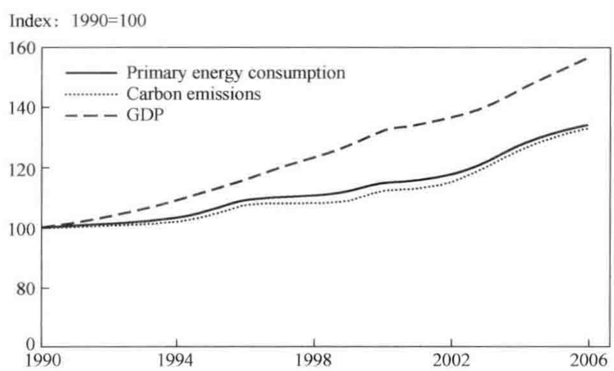

Figure 1.6 World energy usage, carbon emission, and GDP, 1990-2006. Notice that there is a strong correlation between carbon emissions and energy use. Also, gross domestic product (GDP) is rising faster than energy use, indicating increased energy efficiency

The "**greenhouse effect**" is a name given to the trapping of energy in the earth's atmosphere by a process very similar to that occurring in glass-enclosed greenhouses in which plants are grown (Figure 1.7). The atmosphere, like window glass, is transparent to incoming solar radiation. This is absorbed by the earth and re-emitted as infrared radiation. Gases in the atmosphere, like window glass, trap some of these longer infrared rays, keeping the earth warmer than it would otherwise be.

In the last century, there has been an increase in concentrations in the atmosphere of carbon dioxide and other so-called greenhouse gases (methane, nitrogen oxides) due to increases in fossil fuel burning. There has also been a corresponding increase in global average temperatures that most scientists attribute to increases in these greenhouse gas concentrations (Figure 1.8). The increase in global temperatures correlates well with increased concentrations of CO_2 in the atmosphere. For the next two decades, a warming of about 0.2℃ per decade is projected by some models. Such temperature changes will affect the earth's climate in many ways, such as more intense storms, precipitation changes, and sea level rise.

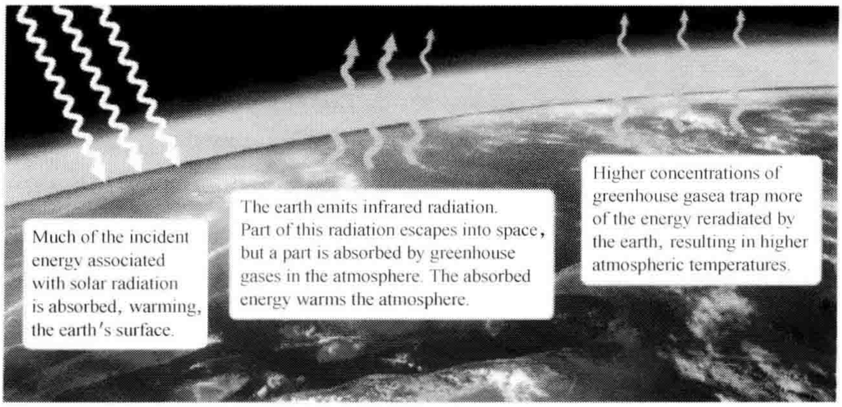

Figure 1.7 The greenhouse effect

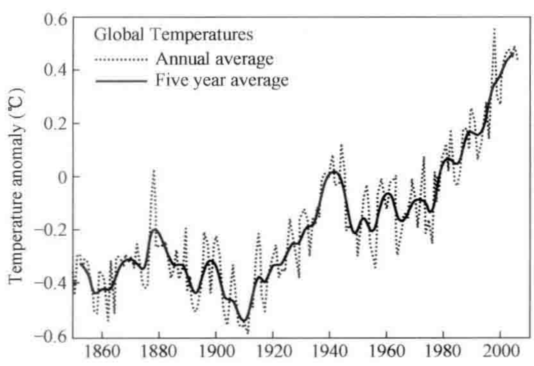

Figure 1.8 Variation in global mean surface temperatures for 1850 to 2006. These are relative to the period 1961-1990

Global warming—the increase in average global temperatures—and accompanying climate change have become major social and political issues worldwide. Indeed, many of the steps made in the last decade to put increased emphasis on renewable energies is due to the concern for the earth's climate.

Another problem due to increased burning of fossil fuels is local and international air pollution. The high temperature and pressure used in the combustion process in automobile engines have the unfortunate consequence of also causing a reaction between atmospheric nitrogen and oxygen that results in some NO formation. The NO can then react further with oxygen to produce nitrogen dioxide. This poisonous brown gas is further oxidized to form nitric acid, HNO_3, in the presence of water.

$$N_2(g)+O_2(g) \rightarrow 2\ NO(g)\ \Delta rH° = 180.58\ kJ/mol\text{-}rxn \tag{1-3}$$

$$2\ NO(g)+O_2(g) \rightarrow 2\ NO_2(g)\ \Delta rH° = -114.4\ kJ/mol\text{-}rxn \tag{1-4}$$

$$3\ NO_2(g)+H_2O(l) \rightarrow 2\ HNO_3(aq)+NO(g)\ \Delta rH° = -71.4\ kJ/mol\text{-}rxn \tag{1-5}$$

To some extent, the amounts of pollutants released can be limited by use of automobile catalytic converters. Catalytic converters are high-surface-area metal grids that are coated with platinum or palladium. These very expensive metals catalyze complete combustion, helping to combine oxygen in the air with unburned hydrocarbons or other by-products in the vehicle exhaust. As a result, the products of incomplete combustion can be converted to water and carbon dioxide (or other oxides). In addition, nitrogen oxides can be decomposed in the catalytic converter back into N_2 and O_2. However, some nitric acid and NO_2 inevitably remain in automobile exhaust, and these compounds are major contributors to environmental pollution in the form of acid rain and smog. The brown acidic atmospheres in highly congested cities such as Beijing, Los Angeles, Mexico City, and Houston result largely from the automobile emissions. Such pollution problems have led to stricter emission standards for automobiles, and the development of lowemission or emission-free vehicles is a high priority in the automobile industry (motivated in part by emission standards of such states as California).

New Words and Expressions

fossil fuels *n.* 化石燃料

dominance *n.* 优势；支配；统治；优性

concurrently *adv.* 同时地

replenished *v.* 补充；重新装满

deplete *vt.* 耗尽，用尽；使枯竭；[医]减液，放血；*vi.* 耗尽；减少，损耗

commodity *n.* 商品；日用品；有价值的物品；有利，有益

exponential *n.* 指数；倡导者；演奏者；例子；adj. 指数的，幂数的；越来越快的

thermostat *n.* 恒温（调节）器

diodes *n.* 二极管

fluorescent *adj.* 荧光的；发荧光的；（颜色、材料等）强烈反光的；发亮的
n. <美口>荧光灯；日光灯

incandescent *adj.* <术>白热的；白炽的；<正>十分明亮的；<正>感情强烈的

millennia *n.* 一千年（millennium 的名词复数）；千年期；千禧年

enthalpy *n.* [热]焓；[物]热函；热含量

methane *n.* <化>甲烷，沼气

greenhouse effect 温室效应

precipitation *n.* 匆促；沉淀；（雨等）降落；某地区降雨等的量

catalytic *adj.* 接触反应的；起催化作用的；*n.* 催化剂；刺激因素

exhaust *vt.* 用尽，耗尽；使筋疲力尽；排出；彻底探讨；*vi.* 排气
n.（排出的）废气；排出；排气装置
congested *adj.* 拥挤的；堵塞的 *v.* 拥挤（congest 的过去式和过去分词）；堵塞

Unit 2 The Periodic Table

As our picture of the atom becomes more detailed, we find ourselves in a dilemma. With more than 100 elements to deal with, how can we keep all this information straight? One way is by using the periodic table of the elements. The periodic table neatly tabulates information about atoms. It permits us to calculate the number of neutrons in the most common isotope for most elements. It even stores information about how electrons are arranged in the atoms of each element. The most extraordinary thing about the periodic table is that it was largely developed before anyone knew there were protons or neutrons or electrons in atoms.

Not long after Dalton presented his model for the atom (an indivisible particle whose mass determined its identity), chemists began preparing listings of elements arranged according to their atomic weights. While working out such tables of elements, these scientists observed patterns among the elements. For example, it became clear that elements that occurred at specific intervals shared a similarity in certain properties. Among the approximately 60 elements known at that time, the second and ninth showed similar properties, as did the third and tenth, the fourth and eleventh, the fifth and twelfth, and so on.

In 1869, Dmitri Ivanovich Mendeleev, a Russian chemist, published his periodic table of the elements. Mendeleev prepared his table by taking into account both the atomic weights and the periodicity of certain properties of the elements. The elements were arranged primarily in order of increasing atomic weight. In a few cases, Mendeleev placed a slightly heavier element before a lighter one. He did this only when it was necessary in order to keep elements with similar chemical properties in the same row. For example, he placed tellurium (atomic weight=128) ahead of iodine (atomic weight=127) because tellurium resembled sulfur and selenium in its properties, whereas iodine was similar to chlorine and bromine.

Mendeleev left a number of gaps in his table. Instead of looking upon those blank spaces as defects, he boldly predicted the existence of elements as yet undiscovered. Furthermore, he even predicted the properties of some of these missing elements. In succeeding years, many of the gaps were filled in by the discovery of new elements. The properties were often quite close to those Mendeleev had predicted. The predictive value of this great innovation led to the wide acceptance of Mendeleev's table.

It is now known that properties of an element depend mainly on the number of electrons in the outermost energy level of the atoms of the element. Sodium atoms have one electron in their outermost energy level (the third). Lithium atoms have a single electron in their outermost level (the second). The chemical properties of sodium and lithium are similar. The atoms of helium and neon have filled outer electron energy levels, and both elements are similar, that is, they do not undergo chemical reactions readily. Apparently, not only are similar chemical properties shared by elements whose atoms have similar electron configurations (arrangements) but also certain configurations appear to be more stable (less reactive) than others.

In Mendeleev's table, the elements were arranged by atomic weights for the most part, and this arrangement revealed the periodicity of chemical properties. Because the number of electrons determines the element's chemical properties, that number should (and now does) determine the order of the periodic table. In the modern periodic table, the elements are arranged according to atomic number. Remember, this number indicates both how many protons and how many electrons there are in a neutral atom of the element. The modern table, arranged in order of increasing atomic number, parallels one another because an increase in atomic number is generally accompanied by an increase in atomic weight. In only a few cases (noted by Mendeleev) do the weights fall out of order. Atomic weights do not increase in precisely the same order as atomic numbers because both protons and neutrons contribute to the mass of an atom. It is possible for an atom of lower atomic number to have more neutrons than one with a higher atomic number. Thus, it is possible for an atom with a lower atomic number to have a greater mass than an atom with a higher atomic number. Thus the atomic mass of Ar (no.18) is more than that of K (no.19), and Te (no.52) has a mass greater than that of I (no.53); see the periodic table.

The modern periodic table has vertical columns called groups or families. Each group includes elements with the same number of electrons in their outermost energy levels and, therefore, with similar chemical properties. The horizontal rows of the table are called periods. Each new period indicates the opening of the next main electron energy level. For example, sodium starts row three, and the outermost electron in sodium is the first electron to be placed in the third energy level. Because each row begins in a new energy level, we can predict that the size of atoms increases from top to bottom. And since electrons are easier to remove when farther from the nucleus, we can also predict that the larger the atom the lower its ionization energy, the energy needed to remove an electron.

In chemistry, the elements are grouped into one of two broad classifications: metals and nonmetals. Metals are generally hard, lustrous elements that are ductile (can be drawn into wires) and malleable (can be pounded into thin sheets). We also know they readily conduct electricity and heat. Many metals form the strong framework on which our modern society is built. The discovery and use of metals over 5000 years ago moved civilization beyond the Stone Age. The second type of element is noted by its lack of metallic properties. These are the nonmetals. Nonmetals are generally gases or soft solids that do not conduct electricity. There are some notable exceptions to these general properties, however. There are also examples of very hard nonmetals and very soft metals. For example, a form of the nonmetal carbon (diamond) is one of the hardest substances known. Mercury, a metal, is a liquid at room temperature. Still, almost everyone has a general idea of what a metal is like. In addition to these physical properties, there are some very important chemical differences between metals and nonmetals. The division between metallic and nonmetallic properties is not sharp, so some elements have intermediate properties and are sometimes classified as a separate group.

Classifying the elements doesn't stop with the division of elements into these two groups. We find that all metals are not the same, so further classification is possible. It's like classifying the human race into two genders, men and women, but then finding that they can be further subdivided into personality types (e.g., extroverts and introverts). The first thing we note about metals is that some are chemically unreactive. That is, elements such as copper, silver, and gold are very resistant to the chemical reactions of corrosion and rust. These are the metals of coins and jewelry, not only because of their comparative rarity and beauty but also because of this chemical inertness. For this reason, they are known as the noble metals. Gold and silver coins on the ocean bottom, deposited from ships that foundered hundreds of years ago, can be easily polished to their original luster. Other metals are very much different. They are extremely reactive with air. In fact, metals such as lithium, sodium, and potassium must be stored under oil because they react violently (to the point of explosion). These metals are among those known as the active metals. Thus, copper, silver, and gold can be placed into one family of metals and lithium, sodium, and potassium into another. Similar relationships among other elements were also noticed and appropriate grouping were made.

So far, our main emphasis concerning the periodic table has been on the vertical columns, which contain the families of elements. In fact, there are common characteristics in the horizontal rows as well. Horizontal rows of elements in the table are called periods. Each period ends with a member of the family of elements called the noble gases. These elements, like the noble metals, are chemically unreactive and are composed of individual atoms. The first period contains only two elements, hydrogen and helium. The second and third contain 8 each, the fourth and fifth contain 18 each, the sixth 32, and the seventh 26. (The seventh would also contain 32 if there were enough elements.)

Each group is designated by a number at the top of the group. The most commonly used label employs Roman numerals followed by an A or a B. Another method, which eventually may be accepted, numbers the groups 1 through 18. It is not clear at this time which method will win out, or if some alternative will yet be proposed and universally accepted.

From Inorganic chemistry by T. W. Swaddle

New Words and Expressions

tabulate *vt.* 把……制成表格
isotope *n.* 同位素
atomic weight *n.* 原子量
tellurium *n.* 碲
chlorine *n.* 氯
iodine *n.* 碘