核工程与核技术专业英语

Specialty English for Nuclear Engineering and Nuclear Technology

李　然　刘义保　编写

原子能出版社

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前　言

中国核工业走过了50多年的历程，形成了完整的生产体系。由于20世纪80年代核工业军转民，在企业改制过程中，大量核专业人才流失，核专业人才培养处于停滞状态，核技术和核电研发的投入也有限，核工业从20世纪80年代到20世纪末一直处于举步维艰的境地。进入"十一五"发展期间，由于核能核电发展的带动，中国的核工业迎来了第二个春天，国家制定了核电中长期发展规划，到2020年，核电装机容量将由现在的910万千瓦发展到4 000万千瓦，届时在建装机容量1 800万千瓦，从近几年的发展来看，中长期发展规划的目标大有超越之势。核电发展的新的大好形势，要求我国核能核电技术及管理满足形势的发展，但是，目前我国核电设计、建设和营运的水平以及核电专业人才储备难以满足规划的要求，因此，我国采取引进、吸收、消化国外先进核电技术，在此基础上发展具有知识产权的新一代核电技术，这样，对核专业人才及人才培养提出了更高的要求。核专业人才不仅要有核专业的知识和应用能力，同时必须娴熟地通晓和掌握国外先进核能核电技术和工艺，基于此，我们在核专业人才培养计划中设置了核专业英语课程，并自编教材与之配套。教材内容覆盖了核科学与技术的主要研究及应用领域，原理表述较为通俗；不但可用于英语学习，亦可与其他专业课教学相呼应、加深学生对于基本概念的理解。同时，我们也希望本教材对核能相关行业从业人员提高专业英语能力有所帮助。本教材已在东华理工大学使用了三届，此次作了较全面的修订，并正式出版，受编者专业知识、英语能力、教学经验的不足所限，本教材水平尚存诸多缺陷，欢迎批评指正。

本教材内容分为课文、注释与练习及附录。课文内容（依所占比例排序）选自参考文献【1】、【2】和【3】，并依编排需要进行了适当修改。

编排体例主要参照文献【4】，采用了一侧注释的方式，将明显属于公共英语范畴的或非基础性的专业生词在初次出现时给出符合文意的释义，而不再给出全面解释，以免篇幅过长；至于重要的专业术语等知识点均插有注释序号，如"[A-1]"、"[B-1]"，读者可在每章后找到对应的解析与扩展。注释内容中，专业名词的解释主要参考自文献【2】、【3】，以及Britannica Concise Encyclopedia Online（在线简明大英百科全书: www. britanica. com)，其余短语、生词释义主要通过电子翻译工具转引自《21世纪英汉汉英双向词典》、《朗道英汉字典》，版本复杂，恕不细述。介词的搭配内容主要借鉴自文献【9】。

考虑到单词识记在外语学习中的首要地位，本教材专门参考了文献【10】，对常见的重要字根进行了举一反三的知识扩展，以期帮助学生形成科学的单词记忆方法。

对于语法的解析则参考了文献【11】、【12】，而对科技英语表述习惯的总结则参考了文献【7】、【13】、【5】，关于科技写作知识的介绍主要来自文献【8】。

练习题全部为原创。

考虑到核工程与核技术专业之《专业英语》课开课于第五学期，此时专业课程多未开设

（或同期开设），学生尚缺乏足够的专业知识积累（尤其在核工程方面），将后四篇课文作为选读内容，不辅之以练习。

教材的出版得到了江西省核技术及应用重点建设学科、核技术及应用示范性硕士点、江西省高校升级教改招标课题（JXJG-09-8-1）的资助。教材在编制和使用过程中得到了东华理工大学核工程技术学院核工系全体老师的支持和帮助，核工程与核技术、核技术专业05级06级07级同学提出了不少宝贵意见和建议，东华理工大学外国语学院院长卢仁顺教授审校了本部教材，在此一并表示感谢。

编者

2010年9月14日

CONTENTS

Part III Nuclear Engineering

Appendix

Chapter 1 Atoms and Nuclei /原子与原子核

A complete understanding of the microscopic structure of matter and the exact nature of the forces acting is yet to be realized. However, excellent models have been developed to predict behavior to an adequate degree of accuracy for most practical purposes.[E-1] These models are descriptive or mathematical, often based on analogy with large-scale processes, on experimental data, or on advanced theory.

adequate *adj.* 适当的
accuracy *n.* 准确度
descriptive *adj.* 描述性的
mathematical *adj.* 计算性的
analogy *n.* 比拟

1.1 Atomic Theory

The most elementary concept is that matter is composed of individual particles—atoms—[F-1]that retain[B-1] their identity[B-2] as elements in ordinary physical and chemical interactions. Thus a collection of helium atoms that forms a gas has a total weight that is the sum of the weights of the individual atoms.[E-2] Also, when two elements combine to form a compound (e.g.[F-2], if carbon atoms combine with oxygen atoms to form carbon monoxide molecules), the total weight of the new substance is the sum of the weights of the original elements.

retain *vt.* 保持
identity *n.* 特性
carbon monoxide *n.* 一氧化碳

There are more than 100 known elements. Most are found in nature; some are artificially produced. Each is given an atomic number in the periodic table of the elements—examples are hydrogen (H) 1, helium[A-1] (He) 2, oxygen (O) 8, and uranium[A-2] (U) 92. The symbol Z is given to the atomic number, which is also the number of electrons in the atom and determines its chemical properties.

periodic table *n.* 周期表
chemical property *n.* 化学性质

Generally, the higher an element is in the periodic table, the heavier are its atoms. The atomic mass M is the mass in grams of a definite number of atoms, 6.02×10^{23}, which is Avogadro's number, N_A. For the example elements above, the values of M are approximately H 1.008, He 4.003, O 16.00, and U 238.0. We can easily find the number of atoms per cubic centimeter in a substance if its density ρ in grams[C-1] per cubic centimeter is known. For example, if we had a container of helium gas with density 0.00018 g/cm^3, each cubic centimeter would contain a fraction 0.000 18/4.003 of Avogadro's number of helium atoms, i.e., 2.7×10^{19}. This procedure can be expressed as a convenient formula for

cubic centimeter *n.* 立方厘米
fraction *n.* 比例，分数

finding N, the number per cubic centimeter for any material:

$$N = \frac{\rho}{M} N_A .$$

Thus in uranium with density 19 g/cm^3, we find $N = (19 / 238)(6.02 \times 10^{23}) = 0.048 \times 10^{24}$ cm^{-3}.[C-2] The relationship holds for[D-1] compounds as well, if M is taken as the molecular weight. In water, H_2O, with ρ = 1.0 g/cm^3 and $M = 2 \times 1.008 + 16.00 \approx 18.0$, we have $N = (1/18)(6.02 \times 10^{23}) = 0.033 \times 10^{24}$ cm^{-3}. (The use of numbers times 10^{24} will turn out to be convenient later.)

compound *n.* 化合物

1.2 Gases

Substances[B-3] in the gaseous state[A-3] are described approximately by the perfect gas law[A-4], relating pres-sure, volume, and absolute temperature,

$$pV = nkT$$

where n is the number of particles and k is Boltzmann constant[A-5]. An increase in the temperature of the gas due to[D-2] heating causes greater molecular motion, which results in[D-3] an increase of particle bombardment of a container wall and thus of pressure on the wall.[E-3] The particles of gas, each of mass m, have a variety of[D-4] speeds v in accord with[D-5] Maxwell's gas theory, as shown in Fig. 1.1.

substance *n.* 物质

absolute temperature *n.* 绝对温度（现称为‘热力学温度’，thermodynamic temparature）

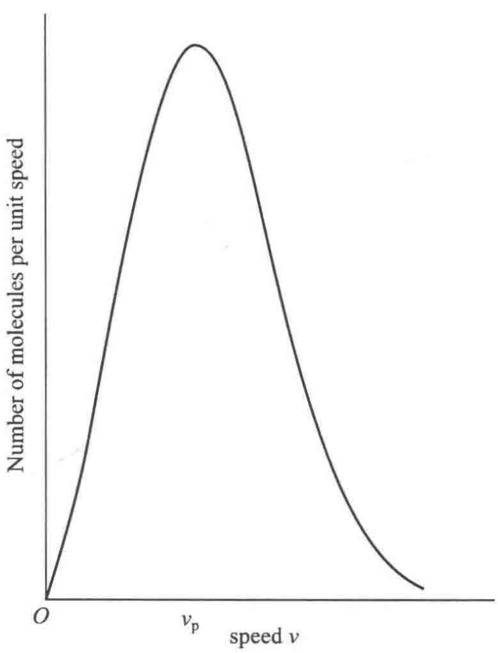

Fig. 1.1 Distribution of molecular speeds.

The most probable speed[A-6], at the peak of[D-6] this maxwellian distribution, is dependent on[D-7] temperature according to the relation[B-4]

$$v_{\mathrm{p}} = \sqrt{\frac{2kT}{m}}.$$

The kinetic theory of gases provides a basis for calculating properties such as the specific heat[A-7]. Using the fact that the average energy of gas molecules is proportional to[D-8] the temperature, $\bar{E} = \frac{3}{2}kT$, we can deduce that the specific heat capacity of a gas consisting only of atoms is $c = \frac{3k}{2m}$, where m is the mass of one atom. We thus see an intimate relationship between mechanical and thermal properties of materials.

deduce *vt.* 推论，演绎出

intimate *adj.* 密切的

1.3 The Atom and Light

Until the 20th century the internal[B-5] structure of atoms was unknown, but it was believed that electric charge and mass were uniform. Rutherford performed some crucial experiments in which gold atoms were bombarded by charged particles. He deduced in 1911 that most of the mass and positive charge of an atom were concentrated in a nucleus of radius only about 10^{-5} times that of the atom, and thus occupying a volume of about 10^{-15} times that of the atom.[E-4] The new view of atoms paved the way for[D-9] Bohr to find an explanation for the production of light.

uniform *adj.* 均匀、均一的

crucial *adj.*关键的，决定性的

It is well known that the color of a heated solid or gas changes as the temperature is increased, tending to[D-10] go from the red end of the visible region toward the blue end, i.e., from long wave lengths to short wavelengths.[E-5] The measured distribution of light among the different wavelengths at a certain temperature can be explained by the assumption that light is in the form of photons. These are absorbed and emitted with definite amounts[B-6] of energy E that are proportional to the frequency ν, according to

visible region *n.* 可见光区

assumption *n.* 假设

$$E = h\nu,$$

where h is Planck constant[A-8], 6.63×10^{-34} J•s. For example, the energy corresponding to[D-11] a frequency of 5.1×10^{14} is $(6.63\times10^{-34})(5.1\times10^{14}) = 3.4\times10^{-19}$ J, which is seen to be a very minute amount of energy. The emission and absorption of light from incandescent hydrogen gas was first explained by Bohr, using a novel model of the

minute *adj.* 微小的

incandescent *adj.* 白热的

novel *adj.* 新颖的

hydrogen atom. He assumed that the atom consists of[D-12] a single electron moving at constant speed in a circular[B-7] orbit about a nucleus—proton—as sketched[B-8] in Fig. 1.2. Each mass that is 1 836 times that of the electron. The radius of the orbit is set by the equality of electrostatic force, attracting the two charges toward each other, to centripetal force, required to keep the electron on a circular path.[E-6] If sufficient[B-9] energy is supplied to the hydrogen atom from the outside, the electron is caused to jump to a larger orbit of definite radius. At some later time, the electron falls back spontaneously[B-10] to the original orbit, and energy is released in the form of a photon of light. The energy of the photon $h\nu$ is equal to the difference between energies in the two orbits. The smallest orbit has a radius $R_1 = 0.53 \times 10^{-10}$ m, while the others have radii increasing as the square of integers (called quantum numbers[A-9]). Thus if n is 1, 2, 3, ... , the radius of the nth orbit is $R_n = n^2R_1$. Fig. 1.3 shows the allowed electron orbits in hydrogen. The energy

proton *n.* 质子

sketch *vt.* 描述

electrostatic *adj.* 静电（学）的

sufficient *adj.* 足够的

spontaneously *adv.* 自然地

square *n.* 平方

integer *n.* 整数

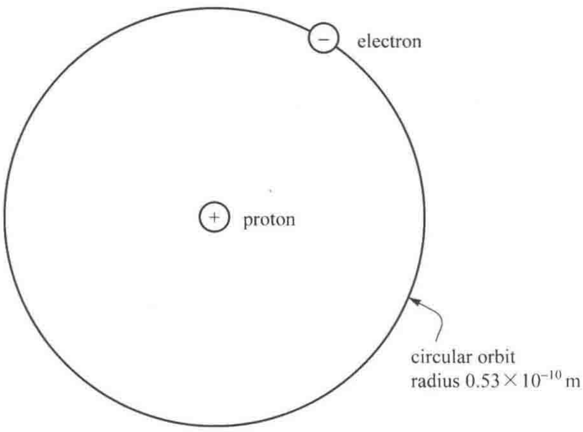

Fig. 1.2 Hydrogen atom.

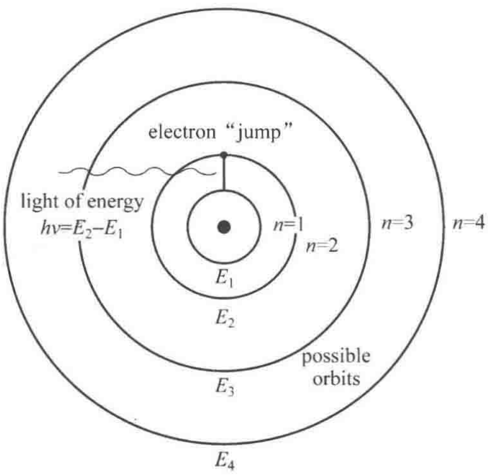

Fig. 1.3 Electron orbits in hydrogen (Bohr theory).

of the atom system when the electron is in the 1st orbit is $E_1 = -13.5$ eV, where the negative sign means that energy must be supplied to remove the electron to a great distance and leave the hydrogen as a positive ion. The energy when the electron is in the nth orbit is $E_n = E_1/n^2$. The various discrete levels are sketched in Fig. 1.4.

ion *n.* 离子

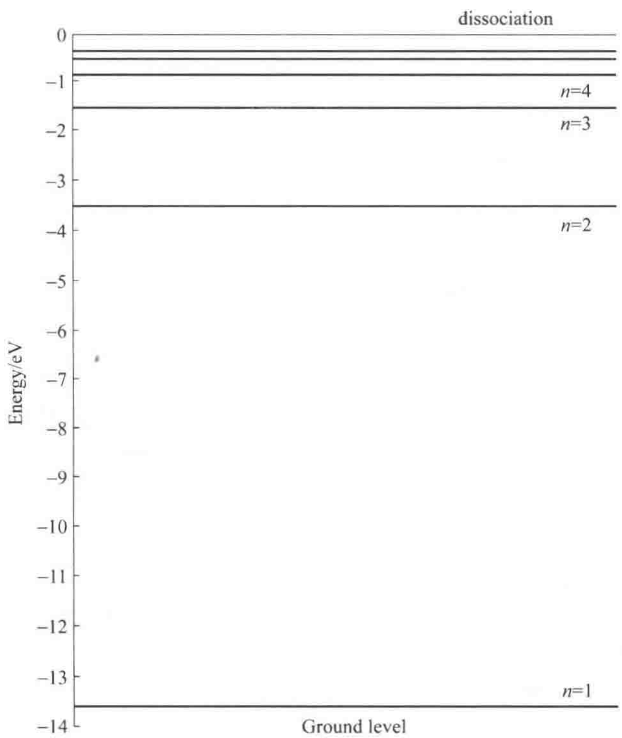

Fig. 1.4 Energy leves in hydrogen atom.

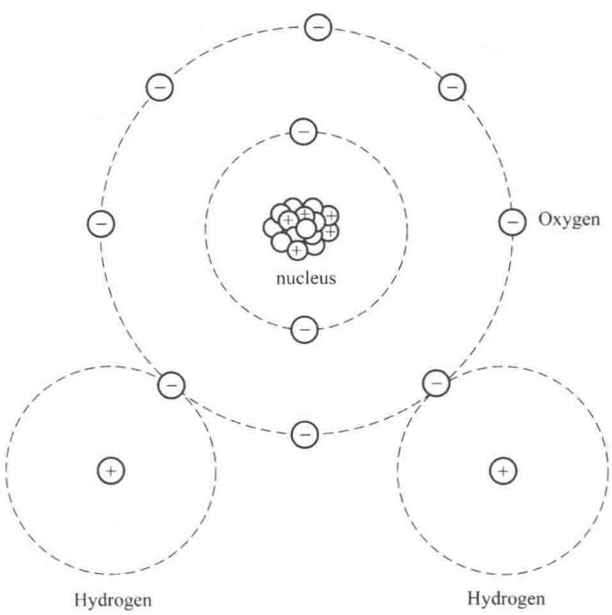

Fig. 1.5 Water molecule.

The electronic[B-11] structure of the other elements is described by the shell model, in which a limited number of electrons can occupy a given orbit or shell. The atomic number Z is unique for each chemical element, and represents both the number of positive charges on the central massive nucleus of the atom and the number of electrons in orbits around the nucleus. [E-7] The maximum allowed numbers of electrons in orbits as Z increases for the first few shells are 2, 8, and 18,. The chemical behavior of elements is determined by the number of electrons in the outermost or valence shell. For example, oxygen with $Z = 8$ has two electrons in the inner shell, six in the outer. Thus oxygen has an affinity for[D-13] elements with two electrons in the valence shell. The formation of molecules from atoms by electron sharing is illustrated by Fig. 1.5, which shows the water molecule.

shell *n.*（电子）壳层
unique *adj.* 唯一的
valence *n.* 化合价，原子价
affinity *n.* 亲和力
formation *n.* 形成，构成。强调结合的形式

1.4 Laser Beams

laser beam *n.* 激光束

Ordinary light as in the visible range is a mixture of many frequencies, directions, and phases. In contrast[D-14,15], light from a laser[A-10] (light amplified by stimulated emission of radiation) consists of a direct beam of one color and with the waves in step[D-16]. The device[B-12] consists of a tube of material to which energy is supplied, exciting the atoms to higher energy states. A photon of a certain[C-3] frequency is introduced. It strikes an excited atom, causing it to fall back to the ground state and in so doing emit another photon of the same frequency. The two photons strike other atoms, producing four identical photons, and so on. The ends of the laser are partially reflection, which causes the light to be trapped and to build up[D-17] inside by a combination of reflection and stimulation. An avalanche of photons is produced that makes a very intense[B-13] beam. [E-8] Light moving in directions other than[D-18] the long axis of the laser is lost through the sides, so that the beam that escapes from the end proceeds in only one direction.[E-9] The reflection between the two end mirrors assures a coherent beam; i.e., the waves are in phase[D-19].

device *n.* 装置
photon 光子
ground state *n.* 基态
identical *adj.* 全同的，同一的
reflection *n.* 反射
stimulation *n.* 刺激，激发
avalanche *n.* 雪崩，山崩
intense *adj.*（光，温度）强烈的
beam *n.*（射线）束
assure *vt.* 确保
coherent beam *n.* 相干光束

Lasers can be constructed from several materials. The original one (1960) was the crystalline gem ruby. Others use gases such as a helium-neon mixture, or liquids with dye in them, or semiconductors. The external supply of energy can be chemical reactions, a discharge produced by accelerated electrons, energetic particles from nuclear reactions, or another laser. Some lasers operate continuously while

crystalline gem ruby *n.* 红宝石
neon *n.* 氖
dye *n.* 染料
semiconductor *n.* 半导体
external *adj.* 外部的

others produce pulses of energy as short as a fraction of a nanosecond[F-3] (10^{-9} s) with a power of a terawatt (10^{12} watts). Because of the high intensity, laser light if viewed directly can be hazardous to the eyes.

Lasers are widely used where an intense well-directed beam is required[B-14], as in metal cutting and welding, eye surgery and other medical applications, and accurate surveying and range[B-15] finding. Newer applications are noise-free phonographs, holograms (3D images), and communication between airplane and submarine.

Later, we shall describe several nuclear applications—isotope separation, thermonuclear fusion [A-11], and military weapons.

intensity *n.* 强度
surgery *n.* 外科（学）
accurate surveying *n.*精确测量
range finding *n.* 测距
phonograph *n.* 电唱机
hologram *n.* 全息（照相）
communication *n.* 通信

1.5 Nuclear Structure

Most elements are composed of particles of different weight, called isotopes. For instance[D-20], hydrogen has three isotopes of weights in proportion 1, 2, and 3—ordinary hydrogen, heavy hydrogen (deuterium[A-12]), and tritium[A-13]. Each has atomic number $Z = 1$ and the same chemical properties, but they differ in the composition of the central nucleus, where most of the weight resides. The nucleus of ordinary hydrogen is the positively charged proton; the deuteron[A-14] consists of a proton plus a neutron, a neutral particle of weight very close to that of the proton; the triton[A-15] contains a proton plus two neutrons. To distinguish isotopes, we identify the mass number A, as the total number of nucleons, the heavy particles in the nucleus. [E-10] A complete shorthand description is given by the chemical symbol with subscript A value and subscript Z value, e.g. ${}^1_1H$, ${}^2_1H$, ${}^3_1H$. Figure 1.6 shows the nuclear and atomic structure of the three hydrogen isotopes. Each has one electron in the outer shell, in accord with the Bohr theory described earlier.

proportion *n.* 比例
heavy hydrogen *n.* 重氢
reside *vi.* 居住，天然存在
nucleon *n.* 核子
shorthand *n.* 速记
subscript *n.* 下标

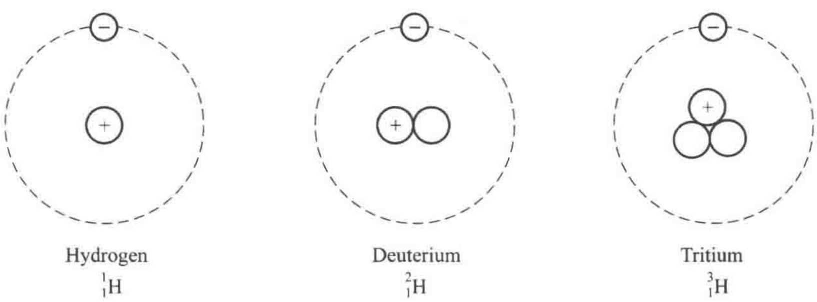

Fig. 1.6 Isotopes of hydrogen.

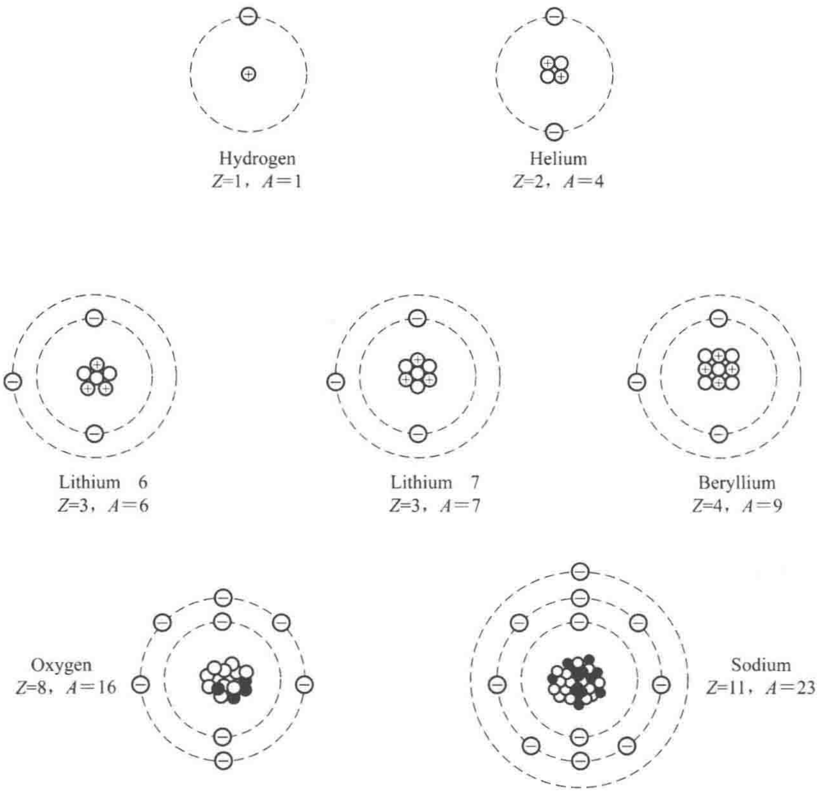

Fig. 1.7 Atomic and nuclear structure

The structure of some of the lighter elements and isotopes is sketched in Fig. 1.7. In each case, the atom is neutral[B-16] because the negative charge of the Z electrons in the outer shell balances the positive charge of the Z protons in the nucleus. The symbols for these are ${}^{1}_{1}\mathrm{H}$, ${}^{4}_{2}\mathrm{He}$, ${}^{6}_{3}\mathrm{Li}$, ${}^{7}_{3}\mathrm{Li}$, ${}^{9}_{4}\mathrm{Be}$, ${}^{16}_{8}\mathrm{O}$, and ${}^{23}_{11}\mathrm{Na}$. In addition to[D-21] the atomic number Z and the mass number A, we often need to write the neutron number N, which is , of course, A—Z. For the set of isotopes listed, N is 0, 2, 3, 4, 5, 8, and 12, respectively.

set *n.* 集合，群，组

respectively *adv.* 分别地

When we study nuclear reactions, it is convenient to let the neutron be represented by the symbol ${}^{1}_{0}\mathrm{n}$, implying a mass comparable to that of hydrogen ${}^{1}_{1}\mathrm{H}$, but with no electronic charge, $Z = 0$. Similarly[B-17], the electron is represented by ${}^{0}_{-1}\mathrm{e}$, suggesting nearly zero mass in comparison with[D-22][C-4] that of hydrogen, but with negative charge. An identification of isotopes frequently used in qualitative[B-18] discussion consists of the element name and it's A value, thus sodium-23 and uranium-235, or even more simply Na-23 and U-235.

imply: *vt.* 暗示，意味

suggest *vt.* 使想起，暗示

identification *n.* 辨认，鉴定

qualitative *adj.* 定性的

1.6 Sizes and Masses of Nuclei

The dimensions of nuclei are found to be very much smaller than those

dimension *n.* 尺度

of atoms. Whereas the hydrogen atom has a radius of about 5×10^{-9} cm, its nucleus has a radius of only about 10^{-13} cm. Since the proton weight is much larger than the electron weight, the nucleus is extremely dense. The nuclei of other isotopes may be viewed as closely packed particles of matter—neutrons and protons—forming a sphere whose volume, $\frac{4}{3}\pi R^3$, depends on A, the number of nucleons.[E-11] A useful rule of thumb[C-5] to calculate radii of nuclei is

$$R(\text{cm}) = 1.4\times10^{-13}A^{1/3}.$$

Since A ranges from 1 to about 250, we see that all nuclei are smaller than 10^{-12} cm.

whereas *conj.* 然而，反之，鉴于，尽管

dense *adj.* 密集的，浓厚的

range *vt.* 伸展，延及

The masses of atoms, labeled M[F-4], are compared on a scale in which an isotope of carbon $^{12}_{6}C$ has a mass of exactly 12. For $^{1}_{1}H$, the atomic mass is $M = 1.007\,835$, for $^{2}_{1}H$, $M = 2.014\,102$, and so on. The mass of the proton on this scale is 1.007 277, of the neutron 1.008 665, the difference being only about 0.1%[F-5]. The mass of the electron on this scale is 0.000 549.

scale *n.* 尺度，比例（尺）

The atomic mass unit (u) [A-16], as 1/12 the mass of $^{12}_{6}C$, corresponds to an actual mass of 1.66×10^{-24} g. To verify this, merely[B-19] divide 1 g by Avogadro's number[A-17] 6.02×10^{23}. It is easy to show that 1 u is also equivalent to[D-23] 931 MeV. We can calculate the actual masses of atoms and nuclei by multiplying the mass in atomic mass units by the mass of 1 u. Thus the mass of the neutron is $(1.008\,665)(1.66\times10^{-24}) = 1.67\times10^{-24}$ g.

actual *adj.* 实际的

verify *vt.* 检验，校验，查证，核实

1.7 Binding Energy[A-18]

The force of electrostatic repulsion between like charges, which varies inversely[B-20] as[D-24][F-6] the square of their separation, would be expected to be so large that nuclei could not be formed.[E-12] The fact that they do exist is evidence[B-21] that there is an even larger force of attraction. The nuclear force is of[C-6] very short range, as we can deduce from the above rule of thumb. The radius of a nucleon is approximately 1.4×10^{-13} cm; the distance of separation of centers is about twice that. The nuclearforce acts only when the nucleons are very close to each other, and binds them into a compact structure. Associated with the net force is a potential energy of binding.[E-13] To disrupt[B-22] a nucleus and separate it into its component nucleons, energy must be supplied from the outside. Recalling Einstein's relation between mass and energy[A-19],

repulsion *n.* 排斥

evidence *n.* 证据，迹象

compact *adj.* 紧凑的

net *adj.* 净余的，纯粹的

disrupt *vt.* 分裂

component *adj.* 组成的

this is the same as saying that a given nucleus is lighter than the sum of its separate nucleons, the difference being the binding mass-energy. Let the mass of an atom including nucleus and external electrons be M, and let m_n and m_H be the masses of the neutron and the proton plus matching electron. Then the binding energy is

$$B = \text{total mass of separate particles} - \text{mass of the atom}$$

or

$$B = Nm_n + Zm_H - M$$

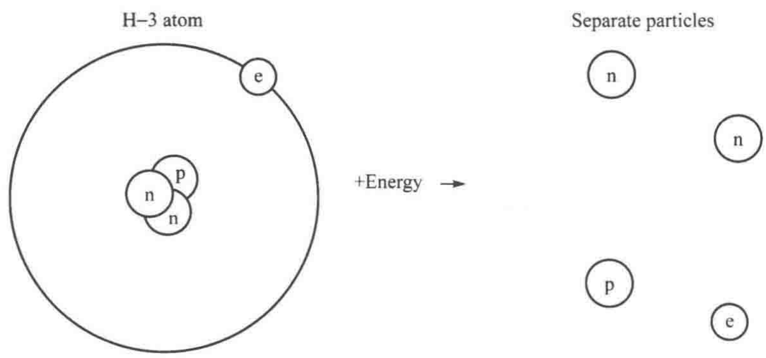

Fig. 1.8 Dissociation of tritium.

(Neglected[B-23] in this relation is a small energy of atomic or chemical binding.) Let us calculate B for tritium, the heaviest hydrogen atom. Fig. 1.8 shows the dissociation[B-24] that would take place[C-7] if a sufficient energy were provided. Now $Z = 1$, $N = 2$, $m_n = 1.008\ 665$, $m_H = 1.007\ 825$, and $M = 3.016\ 049$. Then

neglect *vt.* 省略，忽略

dissociation *n.* 分裂

$$B = 2(1.008\ 665) + 1(1.007\ 825) - 3.016\ 049$$

$$B = 0.009\ 106\ \text{u}.$$

Converting by use of the relation 1 u = 931 MeV, the binding energy is B =8.48 MeV. Calculations such as these are required for several purposes—to compare the stability of one nucleus with that of another, to find the energy release in a nuclear reaction, and to predict[B-25] the possibility of fission of a nucleus. [E-14]

convert *vt.* 转化

predict *vt.* 预测

We can speak of [D-25] the binding energy associated with one particle such as a neutron. Suppose [B-26] that M_1 is the mass of an atom and M_2 is its mass after absorbing a neutron. The binding energy of the additional neutron of mass m_n is then

$$B_n = M_1 + m_n - M_2$$