МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

САНКТ-ПЕТЕРБУРГСКИЙ НАЦИОНАЛЬНЫЙ
ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ
ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ, МЕХАНИКИ И ОПТИКИ

ИНСТИТУТ ХОЛОДА И БИОТЕХНОЛОГИЙ

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АНГЛИЙСКИЙ ЯЗЫК

CRYOLOGY

Учебное пособие

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Предназначено для бакалавров, магистрантов и аспирантов, обучающихся по направлению 141200 Холодильная, криогенная техника и системы жизнеобеспечения.

Цель пособия – подготовить студентов к чтению оригинальной литературы по специальности «Криология».

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В 2009 году Университет стал победителем многоэтапного конкурса, в результате которого определены 12 ведущих университетов России, которым присвоена категория «Национальный исследовательский университет». Министерством образования и науки Российской Федерации была утверждена программа его развития на 2009–2018 годы. В 2011 году Университет получил наименование «Санкт-Петербургский национальный исследовательский университет информационных техно-логий, механики и оптики».

ВВЕДЕНИЕ

Учебное пособие подготовлено для обучения английскому языку по курсу «Криология».

Пособие состоит из трех разделов, включающих в себя 18 уроков (Units), содержащих словарь, текст, лексические и грамматические упражнения. Каждый раздел включает в себя шесть уроков и заканчивается контрольным заданием, направленным на выявление остаточных знаний у студентов и закрепление пройденного материала. Контрольное задание состоит из трех частей (Comprehension, Speaking, Writing), в которых представлены упражнения, отвечающие современным стандартам обучения иностранному языку. Выполнение данных упражнений способствует как более глубокому пониманию предмета, так и развитию творческого воображения.

Тексты для уроков подобраны таким образом, чтобы по возможности отразить все исторические аспекты становления криологии как науки и современные тенденции ее развития.

Перед текстом каждого урока приведен список лексических единиц, которые являются специфическими для данного раздела, могут вызывать трудности при переводе и общем понимании текста.

Лексические упражнения построены таким образом, чтобы расширить словарный запас студента, активизировать уже имеющиеся знания, а также научить морфологическому членению слов изучаемого языка.

Грамматические упражнения отражают все структуры, знание которых необходимо для правильного перевода технических текстов в рамках данного пособия и последующего самостоятельного чтения технической литературы.

В конце учебного пособия представлен словарь трудной и специфической лексики, содержащейся в текстах и упражнениях.

При работе с данным пособием рекомендуется использовать следующие словари:

1. Мюллер В.К. Большой англо-русский словарь (в новой редакции). – М.: Цитадел-Трейд; Рипол классик, 2005.

2. Розенберг М.Б. Англо-русский словарь по холодильной и криогенной технике. – М.: Русский язык, 1978.

3. Электронный словарь ABBYY Lingvo 12.

UNIT 1

achieve – достигать
agriculture – сельское хозяйство
application – применение
be aware of – осознавать, быть в курсе
benign – доброкачественный
blood – кровь
cancer – рак
cell – клетка
depend on – зависеть от
lesion – повреждение, поражение
malignant – злокачественный
meet requirements – удовлетворить потребности
missile – ракета, космический корабль
obtain – получать
preserve – сохранять, консервировать
propel – двигать, приводить в движение
refer to – ссылаться на, относиться к
rely on – полагаться на
specimen – образец, экземпляр
steel mill – сталелитейный завод
surgery – хирургия
treat – лечить
vehicle – транспортное средство

CRYOGENICS

The word «kryos» is known to be used by the ancient Greeks to mean icy cold.

To these people living in a land with mild sunny winters, «kryos» could scarcely have meant very low temperatures. It might have been used to describe their summer drinks which the rich cooled with carefully stored ice or snow. It might also have been used to describe early Greek attempts at food preservation. But however «kryos» was used in ancient times, it was in 1880 that scientists working on ways of obtaining lower and lower temperatures used it in forming the word «cryogenics». They used cryogenics to refer to the field of extremely low temperatures, a field of science which is now becoming very important to us.

But just what is this low temperature region? What are its uses? How do we cool things to these low temperatures and what happens to them when we do? What strange effects are found which do not exist at room temperature? And how does cryogenics affect us and our way of life now and in the future? These are some of the questions to be answered.

Although cryogenics is more than a hundred years old, it is in the past few decades that it has grown from a field in which scientists were working in the laboratory to learn more about the laws of nature at low temperature to include many areas outside the laboratory. While some industrial applications of cryogenics were found many years ago, most of their work was pure scientific research. Practical applications are now growing very rapidly.

In the world that we know and see around us, where are these low temperatures used? For example, low temperatures are used in space experiments, for most large missiles and space vehicles depend on cryogenic products to propel them.

Industry relies on cryogenics to meet certain gas requirements; steel mills, for example, use hundreds of tons a day of liquid oxygen (obtained from the air through the use of cryogenics). New electronic devices such as lasers are cooled by cryogenics. Cryogenics is used in agriculture and in medicine during surgery and to preserve blood and biological specimens. It is surprising to realize not only how rapidly and widely the application of this field of science has grown, but also how much every one of us depends on cryogenics without even being aware of it.

There are a lot of branches of chemistry and engineering that involve the study of very low temperatures, how to produce them, and how materials behave at those temperatures. For example, cryobiology is the branch of biology involving the study of the effects of low temperatures on organisms (most often for the purpose of achieving cryopreservation); cryosurgery and cryotherapy are branches of medicine applying very low temperatures (down to –196 °C) to destroy malignant tissue, e.g. cancer cells, or to treat benign lesions; cryoelectronics is the field of research regarding superconductivity at low temperatures; cryotronics is the practical application of cryoelectronics, etc.

EXERCISES

1. Translate the words of the same root:
cool – coolant – cooler – coolness; extreme – extremely; pure – impure – purely – purify – purifier – purity – impurity; predict – prediction – unpredictable – predictably; apply – application – applicable – applicability; practice – practical – practicable.

2. What part of speech do these words belong to?
carefully, scarcely, rapidly, early, particularly, extremely, widely.

3. Translate into English:
первые попытки, область чрезвычайно низких температур, комнатная температура, образ жизни, законы природы, промышленное применение, космические корабли, сталелитейные заводы, жидкий кислород, хирургия.

4. Translate into Russian:
icy cold, food preservation, low temperature region, pure scientific research, space experiments, large missiles, to meet gas requirements, electronic devices, biological specimens.

5. Mind the emphatic construction **IT IS … THAT (WHO, WHEN, WHICH)**. Translate into Russian the following sentences, paying attention to the pronoun **IT:**
a) **It** is necessary to know what happens when things are cooled to low temperatures. b) **It** was Greeks **who** made first attempts to preserve food. c) **It** was nature of things at low temperatures **that** the scientists wanted to know. d) What did the word «kryos» mean? **It** meant «icy cold». e) **It** is interesting to note that every one of us depends very much on cryogenics. f) **It** is cryogenics **that** is now widely used in all spheres of our life. g) **It** was in 1911 **when** Heike Kamerlingh Onnes was experimenting with metals at low temperatures. h) **It** was atomic nature of matter **which** was not well understood at that time.

6. Mind the functions of the word **TO MEAN, MEAN, MEANING, BY MEANS OF:**
a) Cryogenics **means** the field of extremely low temperature. b) Cryogenic fluids are produced **by means of** lowering the temperature of gas. c) Maintaining low temperatures is one of the **means** of preserving blood. d) To speak of cryogenics **means** to speak of very low temperatures. e) The **mean** temperature of the gas can be taken from the table. f) The work

of Kamerlingh Onnes provided convenient **means** for investigating different cryogenic problems. g) It is seen that the method of geometric **means** may lead to more satisfactory results than that of arithmetic means. h) The term «heat» has more than one **meaning**. j) The temperature can be lowered **by means of** a liquefied gas. k) What does the word «cryogen» **mean**? l) This term **meaning** «radiant heat» may be employed with regard to the action of rays upon an absorbing substance. m) One should clearly understand the concept of «**mean** temperature», when using it in the calculations.

UNIT 2

acquire – получать, приобретать
boil – кипеть
breathe – дышать
condense – конденсировать, сгущать
consider – рассматривать, считать
dangerous – опасный
encounter – встречаться, сталкиваться
evaporate – испаряться
eventually – в конечном итоге
explosion – взрыв
explosive – взрывчатый
expose – подвергать воздействию
fluid – текучая среда (жидкость или газ)
handle – обращаться, управляться
(in)expensive – (не)дорогой
in reverse – наоборот
insulate – изолировать
lower – понижать
lubricating oil – смазочное масло, смазка
occur – происходить
reach – достигать
refrigerant – хладагент
scale – шкала
self-contradicting – противоречащий сам себе
store – хранить, накапливать
take on – приобретать
temperature range – диапазон температур
tint – оттенок
weigh – весить

CRYOGENIC LIQUIDS

We know gas to be a state of matter as the liquid state and the solid state.

When the temperature of a substance which is normally considered to be a gas is lowered, the substance will become a liquid or if it is lowered even further it may enter the solid state. This is true for all gases, except helium, and so includes oxygen, hydrogen, neon and even the air we breathe. (Helium will become a liquid, but will not become a solid at atmospheric pressure no matter how low the temperature goes.)

The substances which are liquid in the cryogenic temperature range are often called cryogenic fluids. Since we are most familiar with these in the gaseous state at room temperature, we often use the self-contradicting term «liquid gas». A large cryogenic industry has grown up around these fluids and their cryostats, which is the name given to the insulated containers they are stored in.

The various cryogenic fluids, which become gases long before they reach room temperature, and their properties are of great interest. Here we shall be able to consider only two of them.

Liquid oxygen, or LOX, is at the high end of the cryogenic temperature scale, its boiling point being 90.1 K. It has a light blue colour, but otherwise looks much like water. As it is still chemically active liquid oxygen can be dangerous to handle. Several serious explosions are known to have occurred when liquid oxygen came in contact with lubricating oils. Therefore liquid nitrogen is used instead of it when possible for laboratory practice. Liquid oxygen is encountered chiefly in the process of obtaining oxygen gas from air, as an oxidizer for rockets, and for storing and transporting oxygen for use as a gas.

Liquid nitrogen is the workhorse of the cryogenic fluids, used widely because it is inexpensive, chemically inert, and a good refrigerant. It is a clear colourless liquid which weighs about eight tenths as much as water. One litre of it will make almost seven hundred litres of nitrogen gas at atmospheric pressure and room temperature. As we know, both liquid nitrogen and liquid oxygen are normally obtained from air. They can be separated by means of their different boiling temperatures. This, however, can also work in reverse. Nitrogen boils at a lower temperature than oxygen, and a nitrogen-filled container, particularly one with a wide top, should never be left directly exposed to the atmosphere for very long. The air above the nitrogen will be cooled until some of the oxygen in the air itself becomes a liquid. It will then mix with the liquid nitrogen. As the nitrogen constantly evaporates and the oxygen condenses, the liquid in the container will eventually acquire the blue tint characteristic of liquid oxygen, and can even reach the point where a large part of the fluid is liquid oxygen. In this way, the formerly inert liquid takes on the dangerous properties of liquid oxygen and can become explosive.

EXERCISES

1. Define what parts of speech the following words are:
frost – froster – frostproof; heavy – heavily – heaviness; advantage – advantageous – disadvantage; combustion – combustible – combustibility; explosive – explosion.

2. Translate these words into Russian:

Noun	Verb
frost	to frost
burn	to burn
load	to load
waste	to waste
term	to term
trap	to trap

3. Translate into English:
жидкое или твердое состояние, атмосферное давление, газообразное состояние, криостат, хранить в чем-либо, подвергать атмосферному воздействию, температурная шкала, смазка.

4. Translate into Russian:
state of matter, cryogenic temperature range, cryogenic fluid, self-contradicting term, insulated container, LOX, oxidizer, dangerous properties, become explosive.

5. Mind the different meanings of the word **ONLY:**
a) Cryogenics is used not **only** in industry but in agriculture and medicine as well. b) Not long ago ice and snow were the **only** means of cooling food. c) In ancient Greece the word «kryos» meant icy cold **only** but not low temperatures. d) Rocketry is not the **only** field where cryogenics is applied. e) The **only** way of solving this problem is to correlate experimental data with theoretical ones.

6. Remember the ways of translating **FOR:**
a) **For** many years cryogenics was a pure scientific research. b) Space vehicles depend on cryogenics **for** cryogenics products propel them. c) Cryogenics is of great importance both **for** industry and agriculture.

d) **For** the problem to be solved many experiments should be carried out. e) Cryogenics is a young science **for** it appeared in 1880. f) It is necessary to know what cryogenic fluid is **for** it is very widely used now. g) In this experiment the state of matter is remained unchanged **for** 2 hours. h) And still he continued his search **for** a solution, as he was not a man who would accept a defeat. j) The tendency was **for** the gas to become liquefied. k) It follows that this is not a satisfactory method **for** attaining low temperatures. l) It is not possible **for** a liquid to be compressed nearly as much as a gas. m) The data obtained cannot be regarded as accurate **for** the system is greatly complicated by other reactions. n) **For** that reason exact determinations are difficult. o) As **for** the arrangement of layers, the insulation may contain one, two, or more than two layers. p) **For** the reaction to take place you must substitute chlorine for hydrogen. q) Cryogenic insulation calls **for** a high degree of effectiveness. u) The temperature falls 0.25 °C for 1 atm.

UNIT 3

account for – объяснять
alloy – сплав
brittle – ломкий, хрупкий
cease – прекращать(ся)
cite – цитировать, ссылаться на что-либо
collapse – разрушаться
contract – сжиматься
copper – медь
crack – трескаться, раскалываться
crumble – разрушаться
happen – происходить, случаться
mention – упоминать
notion – идея, представление
purpose – цель
rubber – резина
shatter – разбиваться вдребезги
stainless steel – нержавеющая сталь
strain – напряжение, нагрузка
strengthen – усиливать
undergo – испытывать, переносить; подвергаться чему-либо
untempered glass – незакаленное стекло
valuable – ценный
visualize – мысленно представлять

CERTAIN CHANGES IN PROPERTIES OF MATTER AT LOW TEMPERATURES

Many people, before they understand cryogenics, think that as temperature goes down, everything becomes brittle and breaks. So, they consider, when absolute zero is reached, or nearly reached, all motion of atoms and electrons ceases and everything crumbles.

While this is not true, there are some things that do happen at low temperatures that account for this notion. We know of many substances, such as plastic and rubber, which become brittle at cold temperatures (though far above the cryogenic region). Because of this striking change, they are often cited in describing low temperature effects. The idea of mechanical breakdown at absolute zero was strengthened by the brittleness of steel at low temperatures and the collapse of steel constructions when used for cryogenic purposes.

The belief that everything falls apart at absolute zero was based on an early theory for the atomic composition of matter. The realization that this did not, in fact, occur led scientists to a new and more accurate theory.

It is certainly true that steel, one of the most widely used materials, becomes brittle at low temperature but it is also one of the few metals which does. Most metals, including aluminium, copper, and even many types of stainless steel, do not become brittle at all at low temperature, and, in fact, even become much stronger.

Why is it that some metals are satisfactory for use at low temperature and others are not? Scientists have found that there is a direct relationship between the crystal structure of atoms making up a metal and its degree of brittleness at low temperature. Metals and alloys whose molecules have a body-centred cubic structure become brittle at low temperature. Steel is one of these. On the other hand, those whose molecules have a face-centred cubic structure, such as aluminium, copper, and nickel do not. It is the type of crystal structure of these metals that makes them valuable for cryogenic purposes. These crystal structures are quite easily understood. Visualize a cube, with an atom in each corner. If there is also a single atom in the centre of the cube, we have the body-centred cubic structure we mentioned in relation to the structure of steel. If, instead, there are six additional atoms, one centred on each of the six surfaces of the cube, we have the face-centred cubic structure.

Most plastics become brittle at low temperature; others are usable but will crack or shatter if cooled too rapidly. This rate-of-cooling problem is often encountered with poor heat-conducting materials when they undergo rapid temperature change. Take for example, a glass container. Fill it with boiling water and put it in very cold water. When exposed to the cold, the outside of the container contracts. Untempered glass being a poor heat conductor, the inside of the container is still warm and does not contract. This produces a strain and the glass will probably break. If we only gradually expose it to the cold, however, this is less likely to happen. So we have learned that if temperature is lowered slowly, the temperature is lowered uniformly throughout the material. This explains the fact that when handled with reasonable care, many plastics have been used successfully in building cryogenic equipment at liquid helium temperature.

EXERCISES

1. When you deal with the verbs with postpositions mind the difference in their meanings:

to make – делать	to make up – составлять
to fall – падать	to fall apart – распадаться
to account – считать	to account for – объяснять что-либо
to build – строить	to build up – поднимать, увеличивать

2. Remember the meaning of the prefix SEMI-. Translate the words: semicircle, semiconductor, semi-fluid, semiautomatic, semi-axis.

3. Translate into English:
абсолютный ноль, механическое разрушение, поломка (выход из строя) стальных конструкций, более точная теория, пространственно–центрированная кубическая структура, гранецентрированная кубическая структура, незакаленное стекло, температура жидкого гелия.

4. Translate into Russian:
notion, striking change, low temperature effects, cryogenic purposes, atomic composition of matter, stainless steel, crystal structure, rate-of-cooling problem, poor heat-conductor.

5. Mind the functions of the **INFINITIVE**. Translate the following sentences:
a) To cool substances to low temperatures is to change their properties. b) To obtain liquid oxygen from the air we must lower the temperature of the latter. c) Low temperatures are used in medicine to preserve blood. d) The problems to be discussed here are associated with cryogenics. e) The scientists hope to obtain lower temperatures than those that are available. f) We know cryogenic fluids to be used in the field of rocketry. g) For a gas to become a liquid its temperature should be lowered. h) Cryogenic fluids appear to be substances which are liquids in the cryogenic temperature range. j) The transportation of liquid oxygen is considered to be very profitable. k) For the rocket to be provided with oxygen for burning fuel it must have its own oxygen supply. l) Scientists proved lightweight container for carrying liquid oxygen to have some advantages. m) It seems likely at least in theory that these processes will allow

to obtain very low temperatures. n) More experiments are able to prove the validity of the postulate. o) There seems to be no formal body that is responsible for definition of the Fahrenheit and Rankine scales. p) A simple empirical relationship has been found to be suitable for carbon resistors. q) No portion of the pressure tube is likely to be colder than the vapour bulb. r) The engineers seem happy to leave the task of measuring the absolute values to those who use the Kelvin scale. s) This phenomenon corresponds to the usual situation which can be found in thermal equilibrium. t) The techniques of using semiconductors as thermometers happened to be improved. v) Nuclear spin entropy begins to appear in this region. u) The temperatures near absolute zero proved to be obtainable. w) Thermistors are likely to be widely used soon down to temperatures near liquid helium.

UNIT 4

appearance – внешний вид
bind (bound, bound) – связывать
detect – обнаруживать
dirigible – дирижабль
due to – благодаря, вследствие
environment – среда
ground state – основное (квантовое) состояние
latent heat – скрытая теплота
liquefy – ожижать
pump – накачивать, нагнетать
recognise – признавать
refraction – преломление, рефракция
release – выпускать, высвобождать
rise (rose, risen) – подниматься
separate – отделять, разделять
solar eclipse – солнечное затмение
solidify – затвердевать, становиться твердым
superfluidity – сверхтекучесть
support – поддерживать
upper atmosphere – верхние слои атмосферы
value – ценить
vaporization – испарение

LIQUID HELIUM AND ITS PROPERTIES

Helium has some very strange and interesting properties, particularly as a liquid. In fact, scientists find helium so interesting that in spite of its rarity and the difficulties encountered in liquefying it, they have studied it more than any other liquid except water.

Helium is the final gas on our temperature scale to become a liquid and so it gives us the lowest-temperature liquid environment. In addition, helium is a safe cryogenic fluid to use. It does not burn like hydrogen, or support burning like oxygen. It cannot be made into a solid by pumping on it, no matter how low the temperature gets. Below 2.2 K properties of the liquid helium suddenly change, and it does things that do not happen in any other liquid at any temperature. We will consider these particular properties, especially one called «superfluidity», later on.

Helium is the second lightest element. Only hydrogen is lighter. Because it is so light, when it is released it rises to the upper atmosphere. This means that in the atmosphere within our reach there is almost no helium. Helium forms very few chemical compounds, and is seldom found with other elements in liquids or solids. In fact, it is very hard to find at all. Helium was detected first on the sun by analysing the light during a solar eclipse in 1868. This light was recognised to be due to a new element three years later. For many years helium was valued as a safe gas for dirigibles, but this is no longer an important use.

It has been mentioned that liquid helium does not become a solid at low temperature. Even at the ground state that atoms have at absolute zero, these helium atoms still move too much and are too widely separated. Therefore they cannot be bound together into a solid by the forces that would hold them in rigid positions. This can only be done through the use of pressure as well as low temperature, which makes the atoms stay close enough together for these forces to act. For helium to solidify requires a pressure of about 20 times that of the atmosphere, and a temperature of 3 K, or less.

The helium atom has only two electrons. This means that the nucleus of the atom has two protons. The helium nucleus can have either one or two neutrons. If it has one neutron it is called the Helium-3 Isotope (1 neutron plus 2 protons equal three). Similarly, the helium atom with two neutrons in the nucleus is Helium-4 Isotope.

Helium-3 and Helium-4 boil at different temperatures and this helps to separate them; Helium-4 becomes a liquid at 4.2 K.

Like most cryogenic fluids, liquid helium has the appearance of water and is clear and colourless. However, it is only about one-tenth as heavy as water. It has a very low index of refraction. Thus, it is hard to tell where the liquid level is when you look through a transparent strip in a glass cryostat. Helium's very low latent heat of vaporization makes it very difficult to use and to keep.

Helium is the refrigerant that provides the low temperature environment for all experiments conducted below 5 K, and so it is often used as an instrument for conducting other research.

EXERCISES

1. Remember the way of translating the following prepositions:
in spite of; **in order to**; **due to**; **instead of**; **because of**.
a) **In spite of** helium rarity it is still a very interesting element to study and use. b) **In order to** solidify helium one needs pressure of about 20 times of the atmosphere. c) Foams generally provide a barrier to heat conduction **due to** their low density. d) **Because of** it being so light when it is released helium rises to the upper atmosphere. f) **Instead of** using helium one can use other cryogenic liquids **because of** their simplicity in use.

2. Give opposites of the following words using the given prefixes:
UN-: necessary, equal, able, altered, balanced, known, limited, usual, attached, common, prepared;
IN-: correct, definite, dependent, effective, divisible, significant, complete;
IM-: measurable, practicable, movable;
IL-: logical, legal, limitable;
IR-: regular, responsible, removable, relative.

3. Translate into English:
редкость, сжижение, температурная шкала, откачивать, сверхтекучесть, верхние слои атмосферы, образовать химические соединения, солнечное затмение.

4. Translate into Russian:
to support burning, the second lightest element, rigid position, low temperature environment, too widely separated, latent heat of vaporisation.

5. Translate into Russian paying attention to **MODAL VERBS** and their equivalents.
a) As nitrogen boils at a temperature even lower than that of liquid oxygen, a nitrogen-filled container **should** never be left directly exposed to the atmosphere for a long time. b) We know that hydrogen is explosive and **must** be handled very carefully. c) One **will be able** to separate both liquid gases making use of their boiling temperatures. d) As steel was found to become brittle at low temperature, scientists **had to** look for other materials for liquid oxygen containers. e) The experiments on investigating the properties of the new material **were to** be started by the end of the year. f) One **ought to** consider the crystal structure of matter in order to understand the changes in its properties at cryogenic temperatures. g) No person **was allowed to** enter the laboratory till it was properly ventilated.

6. Pay attention to **PARTICIPLE II**. What is the function of this non-finite form of the verb? Translate the following sentences:

a) Given the volume and the specific gravity, it is easy to calculate the weight of the body. b) When shown this book, pay attention to the last table. c) Until translated into other languages, this article was not widely known. d) Seen in this context, the ranges of applicability and reliability of this method may be determined. e) The temperature of the liquid obtained remained constant. f) The problems associated with the design have been mentioned above. g) The pressure in this tube constructed by Brown in 1897 was about 5 millionth of an atmosphere.

UNIT 5

Heike Kamerlingh Onnes – Хейке Камерлинг-Оннес (голландский физик и химик)
approach – достигать
bismuth – висмут
curve – кривая
decrease – уменьшаться
determine – определять
drop – падать
eliminate – исключать, устранять
flat – плоский
impurity – примесь
mercury – ртуть
permit – позволять
pure – чистый, без примесей
purify – очищать
regain – восстанавливать
remain – оставаться
resistance – сопротивление
retain – удерживать, сохранять
suggest – предполагать
support – опора, основа, подложка
value – значение
wire – проволока

ELECTRICAL RESISTANCE OF METALS AT LOW TEMPERATURES

At present we know that liquid helium permitted to reach temperatures far below any which had ever been achieved before. In 1911 Heike Kamerlingh Onnes, a Dutch physicist and Nobel laureate, was experimenting with metals at low temperatures. He was interested in finding out what happened to the electrical resistance of metals as they were cooled to near absolute zero. The atomic nature of matter was not well understood at that time, and a number of theories had been suggested. One step in determining which was correct was to find out what actually happened to the electrical resistance of metals near absolute zero.

We have already seen that electrical and thermal resistance of metals decrease together as temperature decreases. The electrical resistance appears to be going to zero at absolute zero. But as scientists experimented with platinum wires in liquid helium, they found this decrease did not continue at this low temperature.

The resistance curves became flat and retained resistance even as they approached absolute zero. Kamerlingh Onnes used different platinum wires and found that curves became flat at different values of resistance. He decided this must be due to different amounts of impurities in the platinum, and to eliminate it he had to use a purer metal.

Mercury is easy to obtain in a pure state. Since it evaporates at very low temperature, we can purify it like water, by repeated distillation. Mercury is a liquid at a room temperature. If you put some into a small glass tube and put it into a cold part of your refrigerator, it will solidify at –38 °C.

When mercury wire was cooled, scientists discovered a very strange effect. While the resistance had been decreasing in the expected way as the temperature became lower, it suddenly dropped to zero, when the temperature reached 4.2 K. Absolutely no resistance remained in the mercury wire below this temperature. Since zero resistance means the metal is perfect conductor, this state was called superconductivity.

This experiment has been repeated many times with different metals and alloys, and it has been found that at least twenty-two elements and hundreds of alloys become superconductive. These become superconductive at different temperatures, the highest being 11 K for an element and 18.5 K for an alloy. A few of these superconducting alloys are made up of two elements, neither of them being a superconductor by itself. It is now thought that if metals can be made very pure, particularly if all the iron or nickel which they contain can be removed, many more elements are found to become superconductive.

Other elements, bismuth and iron are both superconductors, if they are allowed to evaporate and condense, thus forming a film on a support cooled to liquid helium temperature. Once this support is warmed, however, the crystal structure of the films changes, the superconductivity cannot be regained upon recooling and is lost forever.

EXERCISES

1. Give opposites using the prefix DIS- and translate the words obtained:
a) connect, continue, cover, place;
b) order, qualification, appearance, ability, advantage;
c) connected.

2. Form words with the given prefixes and translate them into Russian:
OVER-: heat, work, charge, flow, estimate, load, weigh.
UNDER-: estimate, line, ground, graduate, value.

3. Translate into English:
ряд теорий, тепловое сопротивление материалов, кривая сопротивления, повторное охлаждение.

4. Translate into Russian:
atomic nature of matter, different amounts of impurities, pure state, repeated distillation, perfect conductor.

5. Mind the functions of **GERUND.** Translate the sentences:
a) Scientists were interested in finding out what happened to the electrical resistance of metals at the temperature near absolute zero. b) He tried using different platinum wires in his experiment. c) Current is able to circulate through the wire without requiring the addition of energy or removal of heat. d) Only in 1961 scientists found a way of making superconductive magnets with a very high magnetic field. e) Superconductivity can be detected by observing and measuring the current flow. f) Now we know of the scientists having produced liquid helium. g) Purifying mercury is very much like distillation of water. h) The first step was analysing what actually happened to electrical resistance near absolute zero.

6. Translate into Russian, paying attention to the pronouns **SOME, ANY, NO** and their derivatives:
a) This discovery may give us **some** idea of what happens in a superconductor. b) Absolutely **no** electrical resistance remains in mercury wire when the temperature is below 4.2 K. c) It is not possible to measure **something** that has zero value. d) Even with instruments able to measure a change with a high degree of accuracy, it is impossible to find **any** change in this current. e) **Some** scientists thought that superconductivity was the same as perfect conductivity. f) Since the neutron has **no** electrical

charge, the different superconductive properties of isotopes must be due to the different mass, or size of the atoms. g) Liquid helium permitted to reach temperatures far below **any** which had ever been achieved before.

UNIT 6

apply – применять
assume – признавать
attainment – достижение
attribute – относить, классифицировать
come into one's own – возникать
concern – заниматься, интересоваться, беспокоиться, опасаться
considerable – значительный
constitute – составлять, основывать
conventional – обычный
deal with – иметь дело с
define – определять
develop – развивать, разрабатывать
employ – применять
evidence – доказательство
exploit – использовать
indication – показатель, признак
insulation – изоляция
intend – предназначать
invent – изобретать
investigate – исследовать, изучать
means – средство(а)
neighbourhood – область
pattern – модель
perform – выполнять
polar explorer – полярный исследователь
provide – обеспечивать, снабжать
realm – сфера, область
refer to – ссылаться на, *зд.*: говорить о
regard – рассматривать, расценивать, считать
result in – приводить к
rule out – исключать
significant – значительный, существенный
sophistication – усложнение, усовершенствование
stubborn gases – упрямые газы
terrestrial – земной

THE FIELD OF CRYOGENICS

The word «cryogen» was created by the Dutch physicist Heike Kamerlingh Onnes, one of the early workers in the field of low temperatures. He intended the word to refer to the liquids which he and others were obtaining in their laboratories at the time (ca. 1900) by refrigerating those gases having low boiling temperatures. The work of these pioneer scientists in developing techniques of performing low-temperature refrigeration efficiently and of liquefying gases, has provided convenient means for investigating much more than just the various aspects of low-temperature refrigeration. Since then the Greek word «kryos», meaning simply «cold» has became common. There has been invented a number of terms to designate the fields of science dealing with equipment, processes and products of low-temperature refrigeration. The word «cryology» now commonly refers to everything which relates to very low temperatures (in principle below 120 K); it is separated into «cryophysics» and «cryogenics», i.e. techniques used to produce and to apply very low temperatures.

The lower limit of the field of cryogenics is fixed by the third law of thermodynamics, which rules out the attainment of an absolute zero of temperature. The upper limit, however, must be arbitrarily established, since it depends upon the point of view. To the organic chemist concerned with reaction rates, temperatures in the neighbourhood of 0 °C are often referred to as low enough to stop significant action, and he might therefore consider this a region of low temperatures. The polar explorer is primarily concerned with the lowest terrestrial temperatures he is likely to encounter; hence the range from 0 °F to –100 °F may constitute his low temperature realm. Among those working in the field of cryogenics at present, it is common to regard the upper limit of the field in the neighbourhood of –150 °C, or about 123 K. However, the limit is purely one of choice, since there is no outstanding evidence that clearly defines an upper limit. The temperature of –150 °C is chosen to indicate temperatures below which it is usual to employ methods of refrigeration and insulation commonly attributed to present day cryogenics rather than to conventional refrigeration techniques.

The first systematic investigation of low-temperature problems and of liquefaction of gases was made by the English chemist and physicist, Michael Faraday, beginning in 1823. But cryogenics really came into its own near the turn of the 20th century when the two most stubborn gases of all the elements were finally liquefied: hydrogen by Sir James Dewar in 1898, and helium by Kamerlingh Onnes in 1908.

The field of cryogenics is now following a familiar pattern of development. The original curiosity of the low-temperature physicist with the liquefaction of gases has been replaced by an interest in superconductivity, the superfluidity of liquid helium, and other properties of matter. After the physicist the cryogenic engineer has arrived to develop perfect, and exploit those activities which are largely academic only a short time ago. About fifty or sixty years after Dewar's liquefaction of hydrogen, the need for large quantities of the liquid for a thermonuclear device, and a few years later for a rocket fuel, resulted in considerable sophistication of cryogenic techniques. Even superconductivity is now beginning to see engineering application in computer technology. If all the interesting discoveries of low temperature physics have not yet been put to practical ends, it may be safely assumed that this is a strong indication of the growth potential of the field and not of its limitations.

EXERCISES

1. Mind the shift of the stress in the following words:_

to per'fect – 'perfect
to con'duct – 'conduct
to con'tact – 'contact
to pre'sent – 'present
to re 'cord – 'record
to sub'ject – 'subject
to in'crease – 'increase

How does it change the meaning of the words?

2. Remember the words of the same root:

efficient – efficiently – efficiency – coefficient
apply – application – applicable – applicant
define – definition – definite – definitely – indefinite
continue – continuous – continuation – discontinue
convenient – conveniently – convenience

3. Translate into Russian:

to come to one's own, to be academic, a thermonuclear device, engineering application, computer technology, arbitrarily, conventional refrigeration techniques, considerable sophistication.

4. Translate into English:
придумать слово, осуществлять низкотемпературное охлаждение, исключать, приводить к, называться, выяснять, приписывать (чему-либо), встречаться, криология, физика низких температур (криофизика), техника низких температур (криогеника), упрямые газы, температура Земли, область температур, привычный тип развития, ракетное топливо.

5. Find all the **PARTICIPLES AND NAPC**. Translate the following sentences into Russian:
a) When cooled to low temperatures gas becomes a liquid. b) Cooling things to low temperatures we change their properties. c) Liquid oxygen obtained from the air is widely used now. d) Cryogenics, being more than a hundred years old, is now applied in all spheres of our life. e) Having carried out a number of experiments the researchers found the way of liquefying gas. f) The methods used will be further developed by the scientists. g) Having learned how to liquefy gases we solved the problem of their transportation. h) The temperature being reduced, pure materials with a well-arranged crystal lattice become even better heat conductors. j) Liquid argon is a common cryogenic fluid, its boiling point being 87.3 K. k) All rare gases are chemically inert, their usage being restricted due to their expensiveness. l) Ordinary carbon steel becoming too brittle at low temperature, some special alloys are successfully employed to build cryogenic equipment. m) Liquid hydrogen has the second lowest boiling temperature of any element, with only helium having a lower temperature.

6. Remember the ways the verbs **SHOULD** and **WOULD** are translated into Russian. Translate the following sentences:
a) The question of just how much metal **should** be added to the mixture is an important one. b) The comparison of the two insulating materials in an actual installation **should** be made. c) It was decided that the support members **would** be made smaller. d) **Should** any need in precise temperature measurement arise, the engineer **would** be concerned about the coincidence of his own and the absolute scales. e) Sodium has been suggested as a material that **would** provide advantages if used in a low-temperature magnet. f) If the resistance were zero, there **would** be no power consumed.

LANGUAGE PRACTICE UNITS 1–6

Comprehension

Revise texts 1–6 and answer the following questions:

1. What is cryogenics?
2. What are most used cryogenic liquids?
3. What are the properties of matter at low temperatures?
4. Why did scientists get interested in helium?
5. What did you know about electrical resistance of metals before reading the text? What do you know now?
6. Can you name the most prominent scientists in the field of cryogenics?

Speaking

Choose a topic and make a short presentation.

1. Properties of liquid oxygen and liquid nitrogen.
2. Properties of metals at low temperatures.
3. The field of cryogenics.

Speaking tips

1. Give clear examples.
2. Make your notes as short as possible.
3. Speak from memory – don't read.

Writing

Write a short composition on the topic «Why I decided to become a cryogenist».

UNIT 7

ambient – окружающий
apply for a patent – подать заявку на выдачу патента
appropriate – подходящий, соответствующий
attempt – попытка
attractive forces – силы притяжения
average – средний
compression – сжатие
conservation – сохранение
counter-current – противоточный
efficiency – эффективность
(heat)exchanger – (тепло)обменник
expand – расширяться
expansion – расширение
external – внешний
extract – извлекать, выделять
force – *зд*.: пропускать
give (gave, given) up – оставить, бросить
imply – подразумевать, значить
inspire – вдохновлять
multistage – многоступенчатый
per (hour) – в (час)
precisely – точно
provisional specification – предварительная спецификация (документ, определяющий, например, состав или содержание процесса или изделия)
recover – извлекать, получать, выделять, восстанавливать
state – устанавливать
submit – представлять на рассмотрение
transfer – передавать
valve – клапан

FROM THE HISTORY OF GAS LIQUEFACTION

The liquefaction of gases is a complicated process that uses various compressions and expansions to achieve high pressures and very low temperatures.

Carl Paul Gottfried Linde (1842–1934) was a German engineer who developed refrigeration and gas separation technologies. Linde began work on liquefaction of air in 1894. At first he tried expansion with external work, recovering heat in appropriate exchangers. There were attempts to use the same principle before but the scientists had been unable to get below –92 °C. Linde soon gave up recovering the work of the expansion and had the fruitful idea of the Joule–Thompson effect. This thermodynamic effect had been discovered in 1852, but for 40 years had no application. In thermodynamics, the Joule–Thomson effect describes the temperature change of a gas or liquid when it is forced through a valve so that no heat is exchanged with the environment. At room temperature, all gases except hydrogen, helium and neon cool upon expansion by the Joule–Thomson process. As a gas expands, the average distance between molecules grows. Because of intermolecular attractive forces, expansion causes an increase in the potential energy of the gas. If no external work is extracted in the process and no heat is transferred, the total energy of the gas remains the same because of the conservation of energy. The increase in potential energy thus implies a decrease in kinetic energy and therefore in temperature.

Using a CO_2 compressor, a pressure of 65 atm, and expanding at 25 atm, Carl Linde obtained 3 litres per hour of liquid air on May 29, 1895. He applied for a patent on June 5, 1895. We shall soon see why these dates are so precisely stated. When the air so liquefied was exposed to atmospheric pressure, the temperature fell to –190 °C (83 K) and resultant liquid contained 70 % oxygen. Linde afterwards constructed special multistage compressors reaching 200 atm and expanding at 40 to 50 atm. In 1898, a machine produced 50 1/h of liquid air. This was intended for use in a chemical factory and this liquid air became an industrial product. This was the birth of «heavy cryogenics».

A British physicist, W. Hampson (1854–1926) had the idea of using Joule–Thompson expansion to liquefy air at the same time as Linde. Hampson submitted a provisional specification at the Patent Office in London on May 23, 1895, i.e. several days before Linde obtained 3 1/h of liquid air. But Hampson’s complete specification was not submitted until April 1896. His first apparatus was shown only in March, 1896. Thus priority in liquefaction of air belongs to Linde. Hampson’s apparatus was simpler, using a counter-current heat exchanger of high efficiency and was very convenient for producing small quantities in the laboratory. Dewar, in liquefying hydrogen, and Kamerlingh Onnes in liquefying helium were inspired by Hampson's apparatus.

Liquefaction of helium (^4He) with the Hampson–Linde cycle led to a Nobel Prize for Heike Kamerlingh Onnes in 1913. At ambient pressure the boiling point of liquefied helium is 4.22 K (–268.93 °C). Below 2.17 K liquid ^4He becomes a superfluid. Pyotr Kapitsa got a Nobel Prize for this discovery in 1978.

EXERCISES

1. Word formation: find the roots in the following chains of words. What parts of speech do these words belong to?

sufficient – insufficient – sufficiency – sufficiently; attract – attractive – attraction; additional – add – addition.

2. Form the nouns from the given verbs using suffixes -TION, -MENT:
a) to occupy, to vaporize, to separate, to purify, to liquefy;
b) to accomplish, to require, to develop, to move.

3. Translate into Russian:
liquefaction of gases, to achieve high pressures, give up work, intermolecular attractive forces, to be exposed to atmospheric pressure, superfluid, multistage compressor, counter-current heat exchanger of high efficiency, ambient pressure, boiling point of liquefied helium, intermolecular attractive forces.

4. Translate into English:
подходящий теплообменник, термодинамический эффект, охлаждать, сохранение энергии, среднее расстояние между молекулами, увеличение потенциальной энергии газа.

5. Remember how the **PASSIVE VOICE** is translated into Russian. Translate the following sentences:
a) The result of the experiment is shown in the table. b) Consider an ideal process by which gas liquefaction can be accomplished. c) A similar explanation was offered by many other researchers. d) It is well known that particles interact. e) One additional consideration, important in the liquefaction of hydrogen, is not involved with other gases. f) Satisfactory handling system for liquid fluorine has been operated also. g) More developed cryogenic techniques are required to handle hydrogen than oxygen.

6. Mind the proper translation of the words: **TO CAUSE, CAUSE, BECAUSE, BECAUSE OF**. Translate the following sentences:

a) Heat **causes** all bodies to expand. b) The **cause** that made the gas to escape was not clear. c) Food products are **caused** to freeze by spraying liquid refrigerant. d) Solid fuel rockets are better than those using cryogenic liquid fuel **because of** greater «make ready» time of the latter. e) The temperature drop is **caused** by the pressure drop. f) The liberated heat is enough to **cause** evaporation of about 70 % of hydrogen. g) Certain types of liquid fuels have an advantage **because** they can be stored at room temperature. h) The **cause** of space exploration is impossible without the progress of cryogenics.

UNIT 8

accomplish – выполнять
air separation – воздушная сепарация
allow – позволять, разрешать
availability – наличие
carrier – носитель
constituent – составная часть
exist – существовать
flask – баллон
introduce – вводить
liquid petroleum gas – сжиженный нефтяной газ
mitigate – смягчать
pollute – загрязнять
power – служить источником энергии
pressure – давление
pressurize – поддерживать, создавать повышенное давление
regenerative cooling – регенеративное охлаждение
remove – отводить, удалять
renewable – возобновляемый
revert – возвращаться
sufficient – достаточный, обоснованный
virtually – фактически

LIQUEFACTION OF GASES

Liquefaction of gases is physical conversion of a gas into a liquid state. The processes are used for scientific, industrial and commercial purposes. Many gases can be put into a liquid state at normal atmospheric pressure by simple cooling; a few, such as carbon dioxide, require pressurization as well. Liquefaction is used for analyzing the fundamental properties of gas molecules (intermolecular forces), for storage of gases, e.g. liquid petroleum gas (LPG), and in refrigeration and air conditioning.

The liquefaction of any gas is accomplished by removing sufficient thermal energy to allow the attractive forces of its molecules (or atoms in the case of monatomic substances) to become effective. It means that substances whose constituent particles have least attraction for each other will have the lowest temperature of condensation. The condensation of such hard-to-liquefy gases is one of the major occupations of cryogenic engineering. The process can be thought of in two steps: 1) removal of sufficient heat to bring the substance to its condensation temperature, and 2) removal of the latent heat of condensation (heat of vaporisation). Gas liquefaction therefore requires only the availability of enough refrigeration to extract heat at sufficiently low temperatures. Only two gases, namely, air and hydrogen will be considered here.

Liquid air is air that has been cooled to very low temperatures (cryogenic temperatures), so that it has condensed into a pale blue mobile liquid. To protect it from room temperature, it must be kept in a vacuum flask. Liquid air can absorb heat rapidly and revert to its gaseous state. It is often used for condensing other substances into liquid and/or solidifying them, and as an industrial source of nitrogen, oxygen, argon, and other inert gases through a process called air separation. The most common process for the preparation of liquid air is the Hampson–Linde cycle using the Joule–Thomson effect.

Hydrogen exists naturally in a gaseous form. It liquefies at 20.24 K, or –252.87 °C. Achieving this low temperature consumes a great deal of energy, but the Joule–Thomson effect mitigates this somewhat. Manufacturers of liquid hydrogen commonly use regenerative cooling by first introducing the cooled hydrogen to a concentration of liquid nitrogen, which lowers its temperature more. When the gas expands, it takes heat from its surroundings, and passes through a heat exchanger. In the case of liquid hydrogen, it expands through a valve that contacts the liquid nitrogen. The hydrogen can then be repressurized and the process can be repeated until liquefaction. Liquid hydrogen is the fuel that has propelled the space shuttle and other rockets since the 1970s. Hydrogen fuel cells power the shuttle's electrical systems, producing pure water, which is used by the crew as drinking water. In the future, however, hydrogen will join electricity as an important energy carrier, since it can be made safely from renewable energy sources and is virtually non-polluting.

EXERCISES

1. Form the nouns from the given words using proper suffixes; translate them into Russian:

to convert, to improve, to achieve, to arrange, to insulate, to modify, to eliminate, to stimulate, to represent.

2. How do the prefixes PRE-, and COUNTER- change the meaning of the following words?
prearrange, precondition, precool, preheat, predetermine, counteract, countercurrent, counterflow, countermove.

3. Translate into Russian:
LPG, monoatomic substance, space shuttle, air separation, constituent particles, to propel, non-polluting, energy carrier.

4. Translate into English:
хранение газов, температура конденсации, регенеративное охлаждение, бледно-голубая подвижная жидкость, вакуумный баллон, водородная топливная батарея, возобновляемые источники энергии, служить источником энергии.

5. Mind the different words: **THROUGH, THROUGHOUT, THOUGH, THOROUGH, THOROUGHLY, THROTTLE, THOUGHT.** Translate into Russian:
a) The refrigerant is first allowed to expand **through** a **throttling** device. b) Losses from friction, turbulence and acceleration of the refrigerant **throughout** the cycle have been neglected. c) One should thoroughly check the results of the experiment. d) All aspects of cryogenics are often **thought** of as belonging to one science. e) **Though** the experiment was carried out successfully, the scientist was not satisfied. f) Without **thorough** knowledge of the physical principles involved in the process, it is not possible to select a proper material.

6. Translate the sentences paying attention to the forms of the **SUBJUNCTIVE MOOD**:
a) It was important that a safe gas should be used for dirigibles. b) If helium were readily obtainable today, it would find more practical applications. c) Superfluid helium-II can leak through such materials where ordinary liquid helium would be blocked. d) The scientist suggested that special equipment should be designed to study the properties of the superfluidity. e) The liquid gas behaves as if it were viscous at all. f) Special safety measures were taken lest the both gases should be mixed. g) The director ordered that all the experiments be interrupted immediately.

UNIT 9

close – близкий, тесный
demand – спрос
inherent – неотъемлемый, присущий, свойственный
initiate – начать
inversion – обратное преобразование
precise – точный
pronounced – четкий, определенный, ярко выраженный
raise – поднимать, повышать
reading – показания прибора
reference – справка
ship – транспортировать
similar – подобный, похожий
split (split, split) – распределять, делить на части
stream – поток
substantial – важный, значительный
surface – поверхность
throttle valve – дроссельный клапан
vital – жизненно важный, насущный, существенный, необходимый

LIQUEFACTION OF HELIUM

Liquid helium is vital for experiments on superconductivity in many fields of research and technological innovation, and also for the functioning of superconducting components. What is more, when helium is shipped from around the world, economics dictates that it must be in liquid form. It is these factors above all that create a demand for helium liquefaction systems.

The process of liquefying helium involves compression followed by cooling in countercurrent heat exchangers.

You might think that there is hardly any difference between liquefaction of hydrogen and that of helium and probably it is quite similar at the surface but there are a few inherent differences which differentiate them.

Helium is the only substance which means fluid at temperatures below –259 degrees Celsius, and its inversion point is much lower than that of hydrogen – namely around –233 degrees Celsius. The boiling point of helium is just around –267 degrees Celsius which is quite close to absolute zero on the Kelvin scale. Just for historic reference, helium was discovered more than a century later than hydrogen, 129 years to be precise.

The reason for more difficulty in liquefaction of helium is that it is a noble gas, which in turn means that the inter-atomic forces are quite weak and it has a low atomic mass, thereby bringing it closer to the properties of an ideal gas as compared with other gases. And we know that the Joule–Thomson effect is less pronounced on gases which are close to being ideal (though no gas is fully ideal).

Given below is the process for production of liquid helium. It may seem a bit similar to producing liquid hydrogen studied earlier, but you will note the substantial difference in the temperature and pressure readings along various points of the process.

Initially helium is compressed to a pressure of 20 atmospheres which raises its temperature to the region of 300 degrees Kelvin. This compressed high temperature helium is then split into two flows.

The first flow is cooled in a heat exchanger with the help of helium vapours while the other part passes through another heat exchanger to be cooled with hydrogen vapours. Both these streams combine to be passed through the third heat exchanger with liquid hydrogen before finally again getting cooled in the fourth one by helium vapours.

Finally, the throttle valve is used to initiate the Joule–Thomson effect, and helium is collected in the liquid state in the helium separator.

Though the process described above is general in nature, in actual practice there are two main isotopes of Helium used for liquefaction, namely ^4He and ^3He, and there is a slight difference between the properties of the two in terms of their boiling point, critical temperature and so forth. The properties talked about earlier are those of ^4He, while the boiling point of ^3H is even one degree lower.

Liquid helium is used extensively for application in superconducting magnets which need to be cooled to extremely low temperatures.

EXERCISES

1. Mind the suffix -OUS forming adjectives in the following words and form adverbs from them adding the suffix -LY:
various, tremendous, continuous, previous, nervous.

2. Define the meaning of the prefix DIS-:
disuse, disable, disappear, discharge, disadvantage.

3. Translate into Russian:
technological innovation, low atomic mass, inversion point, compressed high temperature helium, weak inter-atomic forces, throttle valve, in terms of, superconducting magnets.

4. Translate into English:
показания, а именно, быть близким к абсолютному нулю по шкале Кельвина, благородный газ, в свою очередь, по сравнению с.

5. Mind the different functions of the **ING**- forms in the following sentences:
a) When studying the compound we have to know the chemical formulae of the elements involved. b) Having obtained the necessary compound we can proceed with our experiment. c) This replaces the necessity of making a temperature measurement with the simpler task of measuring pressure in the cryostat. d) A vacuum pump is used for lowering the pressure within the cryostat. e) We account for the incompleteness of a reaction by its being reversible. f) Can matter change from one state into another without temperature or pressure changing? g) All cryogens resemble each other in having low boiling temperatures.

6. Mind the other meanings of the word **SINCE:**
a) **Since** the first gas liquefier was designed, all the elements of this device have been largely improved. b) **Since** the liquefaction of hydrogen by James Dewar cryogenics really came into being. c) The first systematic investigation of low-temperature problems was made by Michael Faraday in 1823, and this branch of science has **since** been much developed. d) **Since** the throttling process is thermodynamically irreversible, only the coordinates of the initial and final states can be predetermined.

UNIT 10

absorb – поглощать, впитывать
aerogel – аэрогель
annular – кольцевой
composite – композит, композиционный материал
efficient – эффективный
encourage – поддерживать, поощрять
evacuated – вакуумный
exposure – воздействие
fill – наполнять
fissure – трещина
foam glass – пеностекло
foil – фольга
glass fiber – стекловолокно
high-performance – высокоэффективный
humid – влажный
impact – воздействие
(per) inch – (на) дюйм (1 дюйм = 2,5 см)
incursion – попадание, проникновение
inhibit – подавлять
leak – утечка
low-maintenance – не требующий тщательного ухода, обслуживания
make demand – предъявлять требования
moisture – влага
multilayer – многослойный
mylar – майлар
plant – установка
prevent – предотвращать, предупреждать
radiation barrier – защитный экран от излучения
radiation shield – радиационная защита
reflective – отражательный
result from – происходить, получаться из-за чего-либо
save – сохранять, сберегать
spacer – прокладка
stack – штабелировать, укладывать правильными слоями
tremendous – огромный, громадный

withstand – выдерживать
wrap – обертывать

INSULATION

In today's world, the use of cryogenics and low-temperature refrigeration is taking a more and more significant role. From the food industry, transportation, energy, and medical applications to the space shuttle, cryogenic liquids must be stored, handled, and transferred from one point to another. To minimize heat leaks into storage tanks and transfer lines, high-performance materials are needed to provide high levels of thermal isolation. Complete knowledge of thermal insulation is a key part of the development of efficient, low-maintenance cryogenic systems. It is important to save money and to effectively control a system.

The insulation of a cryogenic plant makes high demands of the material to be used. Important selection criteria are low evaporation losses, the lowest possible energy losses during reliquefaction and, of course, safe storage of the refrigerants. Condensation must be prevented and the risk of corrosion under the insulation must be minimized. Furthermore, the insulation must absorb the tremendous vibrations and impact resulting from the extreme temperature cycles and withstand external mechanical strain. Apart from the materials used, the technical construction of the insulation system plays a critical role.

Foam insulation requires no vacuum. Foams generally provide a barrier to heat conduction due to their low density. In addition, foams inhibit convective heat transfer by limiting convection to the individual cells, fissures, or other spaces within the foam structure. Foam insulation generally includes some form of moisture barrier. When moisture is allowed to accumulate within the spaces of the foam structure the thermal conductivity rapidly increases. Typical foam insulation includes polyurethane foam, polyamide foam, and foam glass.

Foam insulation has a number of disadvantages in cryogenic application. Such insulation is likely to crack due to thermal cycling and environmental exposure. Cracks permit incursions of moisture and humid air that will form ice and greatly increase the surface area for heat transfer. Therefore, other insulation systems are preferred for cryogenic purposes.

One common radiation barrier used in cryogenic applications is known as Multilayer Insulation (MLI), or Super insulation. The space program encouraged the development of MLI around 1960. The MLI generally contains multiple layers of reflective material separated by spacers with low conductivity. MLI consists of many radiation shields stacked in parallel as close as possible without touching one another. MLI will typically contain about 60 layers per inch. Each layer is isolated from the other by spacer material such as polyester, nylon, or mylar. The aluminum foil is carefully wrapped around the container so that it covers the entire surface of the inner vessel. Spacer material is placed between the layers to completely prevent the separate coverings of foil from contacting.

Other types of cryogenic insulation systems include those where the evacuated annular spaces (space between an inner and outer vessel) contains bulk filled materials i.e. glass fiber, silica aerogel, or composites.

EXERCISES

1. What do prefixes -UNDER and -OVER mean?

a) underestimate, underdeveloped, underload, underpopulated, underdo;
b) overestimate, overload, overpopulated, overdo, overfill.

2. Remember the suffix -ANT which is typical of both nouns and adjectives:

resultant, propellant, dominant, refrigerant, coolant.

3. Translate into Russian:

foam insulation, low-temperature refrigeration, reliquefaction, heat leaks into storage tanks and transfer lines, extreme temperature cycles, important selection criteria, bulk filled materials, space between an inner and outer vessel, multilayer insulation.

4. Translate into English:

космический корабль, перемещать из одной точки в другую, ряд недостатков, предотвращать, высокоэффективный материал, воздействие окружающей среды, без соприкосновения друг с другом, выдерживать механические нагрузки.

5. Try not to confuse the words **CASE, OF COURSE, CAUSE:**

a) This illustrates the principle, but, **of course**, for accurate measurements the actual apparatus are considerably more complicated. b) In some **cases** this type of thermometer may be used for high temperatures. c) The formation of ice can **cause** an abnormal pressure gradient.

6. Remember the different meanings of the word **AS.** Translate the sentences:

a) **As** the temperature became lower and reached 4.2 K, the resistance of mercury suddenly dropped to zero. b) **As long as** the electrons can stay together in pairs the metal acts like a superconductor. c) **As** zero resistance means the metal is a perfect conductor, this state was called superconductivity. d) **As soon as** the ball starts to fall into a coil, the magnetic field of the coil pushes it back. e) Hundreds of alloys **as well as** many elements can become superconductive.

UNIT 11

approximately – приблизительно
barrel – мера емкости (английский – 163,3 л; американский – 119 л)
cap – крышка, колпачок
capacity – емкость
design – конструировать
dispense – распределять, перекачивать
flask – сосуд (Дьюара)
gallon – мера емкости (английский – 4,54 л; американский – 3,78 л)
lid – крышка
loose fitting – неплотно прилегающий
mount – устанавливать, монтировать
nitrous oxide – закись азота
plug – пробка, заглушка
pressure relief device – устройство для понижения давления, устройство для сброса давления
range – предел, диапазон
rapid – быстрый
safety relief valve – предохранительный клапан
truck chassis – шасси грузового автомобиля
vacuum-jacketed – с вакуумной рубашкой
vent – вентилировать, выпускать
wide-mouthed – с широким горлышком

CRYOGENIC CONTAINERS

Cryogenic gases are needed to be stored in special containers, which are usually thermally insulated containers, specifically designed to bear rapid temperature changes and extreme differences in temperature. Some of the popular storage containers of cryogenic gases are Dewar flasks, cryogenic liquid cylinders and tanks.

Dewar flask, named after its inventor Sir James Dewar, is a non-pressurized, vacuum-jacketed vessel, having a loose fitting plug or cap to prevent air and moisture from entering. At the same time, such flasks allow excess pressure to vent. Dewar flasks are also known as vacuum flasks. Vacuum is used for thermal insulation. The gas inside is not in vacuum conditions. These flasks maintain cryogenic gases at a temperature higher or lower than ambient temperature. Dewar flasks containing hydrogen, argon, oxygen, helium, and other low-boiling liquids have an outer vessel of liquid nitrogen for insulation. Dewar flasks are available in various sizes. There are laboratory dewar flasks which do not have lids or covers but wide-mouthed openings, in small sizes used in laboratories for temporary storage.

Also known as liquid containers, cryogenic liquid cylinders are portable vacuum-insulated pressurized containers, specifically designed for cryogenic liquids. The liquid cylinders are an easy and economical means of storing, transporting, and dispensing liquefied gases. These cylinders have valves for filling and dispensing the cryogenic liquid. There are three main types of cryogenic liquid cylinders which are designed for storing: only liquid; only gas; liquid or gas. Liquid cylinders have two primary advantages. Firstly, at relatively low pressure compared to compressed gas cylinders, these cryogenic cylinders can hold a large volume of gas. Secondly, these cylinders are an easy source of cryogenic liquid that can be easily handled.

While nitrogen, argon, oxygen, helium, hydrogen are stored in their liquid states, nitrous oxide and carbon dioxide are kept as refrigerated liquids, but at higher temperature and pressure. These cylinders are well insulated but at times the extremely low temperatures of the cryogenic liquids can lead to constant heat leak and vaporization. The cryogenic product when not used will lead to pressure in the cylinder and often vent via the container's pressure relief device. However, this is a normal and safe function of the cylinder.

Tanks are large double-walled, insulated storage containers, spherical or cylindrical in shape used for storing cryogenic liquids or gases, their capacities ranging from approximately hundreds of gallons to thousands of barrels. They are designed in such a way that they can be easily mounted in fixed locations as stationary vessels or on truck chassis or railroad car for easy transportation. The pressure inside the tank is kept normal. The space between inner and outer surface is vacuum and there are safety relief valves to protect the tanks.

EXERCISES

1. Group the words into families according to their suffixes. Give their Russian equivalents:

excess, successive, exceed, successively, process, exceedingly, succeed, excessive, success, excessively, processing.

2. Some nouns borrowed from Latin form their plural in a special way:

Singular:	Plural:
nucleus	nuclei
datum	data
criterion	criteria
thesis	theses

Form the plurals of the following words:

phenomenon, medium, radius, basis, analysis.

3. Translate into Russian:

to prevent air and moisture from entering, to allow excess pressure to vent, vacuum-jacketed vessel, pressure relief device, doubled-walled, wide-mouthed opening, ambient temperature.

4. Translate into English:

пространство между внешней и внутренней поверхностями, стационарный сосуд, криогенный танк, жидкостный контейнер, криогенный жидкостный цилиндр, временное хранение, железнодорожный вагон.

5. Pay attention to the proper translation of sentences with **PASSIVE VOICE**:

a) The problem of heat transfer mechanisms is concerned with in the following chapter. b) Slowing down the transfer of thermal energy into cryogenic containers is affected by modern techniques. c) The process can be thought of in two steps. d) The presence of hydrogen is looked upon with some disfavour. e) The Dewar vessel will be referred to in the following paragraphs. f) The design of a Dewar vessel is dealt with in the text.

6. Mind the difference between the words **VOLUME, VALUE, VALVE**. Translate the following sentences:

a) A throttling **valve** regulates the flow of the refrigerant on its way to the evaporator. b) It is assumed that the derivative has a constant **value**. c) Information on the **volume** of the reservoir is required. d) An expansion **valve** is a device in steam engine that improves engine efficiency. e) With increasing temperature, the volume of liquid expands. f) His research was of little practical **value**.

UNIT 12

arise (arose, arisen) – возникать, появляться
deviation – отклонение
diamagnet – диамагнит
distortion – искажение, деформация
expel – исключать, вытеснять
fail – потерпеть неудачу
fascinating – очаровательный, пленительный, захватывающий
inward – внутрь
lattice – решетка
loop – петля
magnetically-levitated – на магнитной подвеске
moderate – умеренный
notable – примечательный, заметный, видный
observe – наблюдать
pull – тянуть
repulsive force – сила отталкивания
revolutionize – производить коренные изменения
row – ряд
scatter – рассеиваться, разбегаться
translational symmetry – трансляционная симметрия (тип симметрии, при которой свойства рассматриваемой системы не изменяются при сдвиге на определённый вектор)
vibration – колебание

SUPERCONDUCTIVITY

The history of superconductivity is fascinating. The phenomenon was discovered in 1911 and for half a century no notable use was made of it. From 1955 research intensified, and important applications started in the beginning of the 1960s. Promise for the future seems to be quite fantastic.

Superconductivity is a quantum phenomenon. This extraordinary property of electrical conductors was discovered by Kamerlingh Onnes. Onnes at once thought of an electromagnet exploiting the phenomenon, but failed to achieve this. The reason was that, with the metals available at the time, the property disappeared as soon as moderate magnetic field appeared.

Superconductivity is a phenomenon observed in several metals and ceramic materials. When these materials are cooled to temperatures ranging from near absolute zero, their electrical resistance drops with a jump down to zero. The temperature at which electrical resistance is zero is called the critical temperature, and this temperature is a characteristic of the material. The value of the critical temperature is dependent on the current density and the magnetic field. The cooling of the materials is achieved using liquid nitrogen or liquid helium for even lower temperatures.

Electrical resistance in metals arises because electrons moving through the metal are scattered due to deviations from translational symmetry. These are produced either by impurities or by the vibrations of the lattice in the metal.

In a superconductor below its critical temperature, there is no resistance because these scattering mechanisms are unable to slow down the motion of the current carriers. When a negatively charged electron moves through the space between two rows of positively charged atoms, it pulls the atoms of the lattice inward. This distortion attracts a second electron to move in behind it. The two electrons form a weak attraction, travel together in a pair and encounter less resistance overall. In a superconductor, electron pairs are constantly forming, breaking and reforming, but the overall effect is that electrons flow with little or no resistance. The current is carried then by electrons moving in pairs.

Below the critical temperature these superconducting materials have no electrical resistance, and so they can carry large amounts of electrical current for long periods of time without losing energy. For example, loops of superconducting wire have been shown to carry electrical currents for several years with no measurable loss. This property offers tremendous opportunities in the modern world.

Another property of superconducting materials is the Meissner effect. It was observed that, as a magnet is brought near a superconductor, the magnet encounters a repulsive force. It can be said that the superconductor completely expels the magnetic field and behaves as a perfect diamagnet.

This property can be applied for making high-speed magnetically-levitated trains, small powerful superconducting magnets, etc.

The future of superconductivity research is to find materials that can become superconductors at room temperature. Once this happens, the whole world of electronics, power and transportation will be revolutionized.

EXERCISES

1. Translate the following words paying attention to the meaning of the prefix RE-:
remake, reform, retell, re-equip, rebuild, remove, replace, reproduce, reconstruct, remain, retain, re-activate.

2. a) Form nouns from the given words adding the suffix -NESS:
thick, effective, exact, complete, straight.

b) Form adjectives from the given nouns using the suffix -LESS. Translate into Russian:
motion, purpose, weight, number, end, use, friction.

3. Translate into Russian:
quantum phenomenon, promise for the future, Meissner effect, electrons moving in pairs, resistance, lattice, electromagnet exploiting, distortion, to pull inward.

4. Translate into English:
отклонение, значение критической температуры, положительно заряженные атомы, отрицательно заряженные электроны, высокоскоростные поезда на магнитной подвеске, произвести коренные изменения, примеси, колебания.

5. Mind a **clause of proportion.** Translate the following sentences:
a) The thinner the layers of foil and glass-fibre paper, the more layers of insulation may be used in the vacuum space. b) The higher is the heat capacity of the copper cylinder, the higher is the equilibrium temperature. c) The lower the equilibrium temperature of the copper cylinder, the less heat it will radiate to the cold wall of the vessel. d) The lower the pressure in the vacuum space, the more gases are desorbed. e) The more gases are desorbed, the greater is the danger of pressure rise. f) The colder the charcoal, the more efficient is an absorber. g) The more reflective is the insulation, the less is the heat transport. h) The more rugged the vessel, the more reliable is storage for liquefied gases.

6. Remember the proper translation of the following conjunctions **UNTIL, UNLESS**. Translate the following sentences:
a) Thermistors will not be employed for measuring low temperatures **until** new polycrystalline compounds are invented which are usable at low temperatures. b) It is impossible to obtain accurate measurements **unless** the engineer uses the calibrated instruments. c) The chamber is evacuated **until** the very low vacuum is obtained. d) No discoveries are possible **unless** the laboratory is equipped with modern apparatus.

LANGUAGE PRACTICE UNITS 7–12

Comprehension

Revise texts 7–12 and decide which statements are true or false:

1. Linde and Hampson were the first who obtained liquid air in 1895.
2. To liquefy a gas you should cool it to a very low temperature.
3. The process of liquefying helium involves compression followed by heating in countercurrent heat exchanger.
4. Foam insulation is the best one for cryogenic purposes.
5. Special cryogenic containers are required to store cryogenic fluids.
6. Nowadays scientists are looking for materials which can become superconductors at room temperature.

Speaking

1. Choose a topic and discuss it with your partner.
2. The history of gas liquefaction.
3. Liquefaction of gases.
4. Types of insulation and cryogenic containers.

Speaking tips

a) Explain things clearly.
b) Use some of your own ideas.
c) Consider your partner opinion.

Helpful phrases

To begin with, I would suggest...
Would you go along with that...
No, I rather think that...
Well, you certainly have a point, but...
Don't you think...?
That's absolutely right...
May I just cut in here...

Writing

Revise the text 12, collect the information and write an article explaining what superconductivity is.

UNIT 13

build (built, built) up – накапливать
devise – разрабатывать, изобретать
distinguish – различать, отмечать
fountain effect – фонтанный эффект
insert – вставить, ввести
install – установить
lambda point – лямбда-точка
odd – необычный, странный
porous – пористый
push through – проталкивать
quantum gravity – квантовая гравитация
restore – восстанавливать, возвращать в прежнее состояние
squirt – бить струей
tiny – крошечный
turn on/off – включить/выключить
viscosity – вязкость
warm up – подогревать

SUPERFLUIDITY

For helium 4, cryogenics distinguishes two liquid forms: helium I and helium II. Helium I is the warmer form; helium II is the colder one. The transition temperature, called the «lambda point», is 2.17 K. Helium I, the «warm» form, acts more or less like a conventional liquid.

Helium II has some strange properties. In some situations, it behaves as though it had no viscosity. Viscosity is a measure of how «thick» a liquid is: honey has high viscosity, water has low viscosity. Helium II can be pushed through tiny capillaries that would be too narrow for most liquids to flow through. When this is done, it is found that the liquid which flows through the capillary is cooler than the liquid that stays behind. If Helium II's viscosity is measured, it is found that the viscosity depends on the method used to measure it.

One of the oddest properties is the fountain effect, in which a helium II fountain can be turned on and off by turning a heater on and off. The fountain effect is one of a number of effects called «thermomechanical effects». Here’s how to see the fountain effect. Take a tube with a wide opening at one end and a tiny opening at the other. Install a small heater inside the tube, then block the wide opening with a porous plug. The porous plug can be made of small metal particles, of ceramic, or of other substances, as long as it has tiny pores in it. Insert the tube into the helium II, with the large blocked end below the surface. Apply a small amount of heat to the heater. Pressure builds up in the tube until a small fountain of liquid helium flows from the tiny opening at the top.

To explain the strange behavior of helium II, scientists devised the two-fluid model. Helium II is pictured as a mixture of two fluids: normal helium and superfluid helium. At temperatures just below the lambda point, the mixture is almost entirely normal. As the temperature drops, more and more of the mixture becomes superfluid.

The superfluid helium II has a number of properties: 1) it carries no thermal energy (no entropy): all of the heat energy is in the normal component; 2) it has no viscosity: it can flow through tiny holes; 3) it flows towards areas where the helium II is heated. Heat causes superfluid to convert to normal. A flow of superfluid into the heated area cools that area and restores the uniform mixture of normal and superfluid.

Here is the explanation of the fountain effect. When the heater in the tube is turned on, the liquid helium in the tube begins to warm up. Since superfluid helium flows from cool areas to warm ones, it flows into the tube through the porous plug. Normal fluid is too viscous to flow out through the porous plug. Therefore, when the tube fills with liquid helium, the only way out for the normal fluid is to squirt out the hole in the top.

While originally this phenomenon was discovered in liquid helium, recently it finds applications not only in the theory of liquid helium but also in astrophysics, high-energy physics and theory of quantum gravity. In liquid helium the superfluidity effect was discovered by Pyotr Kapitsa and John F. Allen. This process is similar to the electron pairing in superconductivity.

EXERCISES

1. What is the meaning of the prefix SUPER-? Translate the following words:

supersecret, superhuman, superheat, superconductivity, superfluidity.

2. Form the nouns with the help of the given suffixes:
-ER/-OR: to radiate, to indicate, to operate, to accelerate, to conduct, to resist;
-ION: to contract, to operate, to lubricate, to accelerate, to transmit, to instruct, to construct;
-MENT: to attach, to improve, to measure, to manage;
-NESS: brittle, useful;
-SHIP: friend, relation.

3. Translate into Russian:
transition temperature, porous plug, electron pairing, astrophysics, a number of properties, mixture of two liquids, two-fluid model, to squirt out the hole on the top, theory of quantum gravity.

4. Translate into English:
фонтанный эффект, вязкость, термомеханический эффект, включить, выключить, лямбда-точка, сверхпроводимость, наполнять жидким гелием, обычная жидкость.

5. Remember the types of subordinate **CLAUSES OF CONDITION**. Translate the following sentences:
a) Were oxygen carried in gaseous state, it would require large, thick-walled and heavy containers. b) If oxygen is carried in liquid state, light-weight containers are used. c) Had the atmosphere provided oxygen enough for burning fuel, the problem of rocketry would have been solved much easier. d) If the temperature of a gas is lowered, it will become a liquid. e) Such complicated investigations would be hardly possible if our scientists didn't work in close collaboration.

6. Remember the different meanings of the word **SINCE.** Translate the sentences:
a) The importance of liquid neon in cryogenics increases **since** its cost decreases. b) **Since** World War II cryogenics made its way to industry due to the use of liquid oxygen. c) **Since** the atmosphere cannot provide the rocket with oxygen needed, it must have its own oxygen supply. d) Scientists have found the way to liquefy gases, **since** the transportation of liquids is more profitable than that of gases. e) Liquid oxygen is used in rockets **since** 1945.

UNIT 14

accurate – точный
bending effect – эффект искривления
bimetallic strip thermometer – биметаллический термометр
bond – связывать, соединять
bring (brought, brought) about – вызывать
bulb – колба
capillary – капилляр (трубка с очень узким каналом)
contraction – сжатие
durable – долговечный, прочный, надежный
inscribe – наносить
inverted glass vessel – перевернутый стеклянный сосуд
junction – соединение
long-lasting – долговечный, с длительным сроком службы
make up – составлять
meniscus – мениск (граница между жидкостью и воздухом)
numerical – числовой
span – диапазон
succeeding – последующий
unlike – в отличие
vary – варьироваться, изменяться
voltage-measuring device – прибор для измерения напряжения

THERMOMETERS

A thermometer (from the Greek *thermos*, meaning «hot» and *metron*, «measure») is a device that measures temperature using a variety of different principles. A thermometer has two important elements: the temperature sensor (e.g. the bulb on a mercury thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a numerical value (e.g. the scale on a mercury thermometer).

Temperature measurement is important to a wide range of activities, including manufacturing, scientific research, and medical practice.

The accurate measurement of temperature developed relatively recently in human history. The first thermometer was invented by the Italian mathematician-physicist Galileo Galilei (1564–1642). In his instrument, built about 1592, the changing temperature of an inverted glass vessel produced an expansion or contraction of the air within it, which in turn changed the level of the liquid with which the vessel's long, openmouthed neck was partially filled. This general principle was perfected in succeeding years by experimenting with liquids such as mercury and by providing a scale to measure the expansion and contraction brought about in such liquids by rising and falling temperatures.

Any substance that somehow changes with alterations in its temperature can be used as the basic component in a thermometer. Gas thermometers work best at very low temperatures. Liquid thermometers are the most common type in use. They are simple, inexpensive, long-lasting, and able to measure a wide temperature span. The liquid is almost always mercury, sealed in a glass tube with nitrogen gas making up the rest of the volume of the tube.

The alcohol thermometer or spirit thermometer is an alternative to the mercury-in-glass thermometer, and functions in a similar way. But unlike the mercury-in-glass thermometer, the contents of an alcohol thermometer are less toxic and will evaporate away fairly quickly. An organic liquid is contained in a glass bulb which is connected to a capillary of the same glass and the end is sealed. The space above the liquid is a mixture of nitrogen and the vapor of the liquid. For the working temperature range, the meniscus is within the capillary. With increasing temperature, the volume of liquid expands and the meniscus moves up the capillary. The position of the meniscus shows the temperature against an inscribed scale. It is an important need for science experiments.

Electrical-resistance thermometers use platinum and operate on the principle that electrical resistance varies with changes in temperature. Thermocouples are among the most widely used industrial thermometers. They consist of two wires made of different materials joined together at one end and connected to a voltage-measuring device at the other. A temperature difference between the two ends creates a voltage that can be measured and translated into a measure of the temperature of the junction end. The bimetallic strip thermometer is the most trouble-free and durable one. It is simply two strips of different metals bonded together and held at one end. When heated, the two strips expand at different rates, resulting in a bending effect that is used to measure the temperature change.

Other thermometers operate by sensing sound waves or magnetic conditions associated with temperature changes. The lower the temperature, the more efficient are magnetic thermometers. It makes them extremely useful in measuring very low temperatures.

EXERCISES

1. Find the common elements in the following words. Translate them into Russian:
a) equilibrium, equilibrist, equivalent, equation, equality, equal, adequate, equator;
b) thermal, thermometer, thermostatic, thermometry, thermodynamics, thermocouple, isotherm, thermostat;
c) describe, subscribe, inscribe.

2. Form adjectives with the help of suffixes -IC, -FUL:
period, electron, success, power, peace, wonder, use, base, atom, cube, atmosphere.

3. Translate into Russian:
numerical value, sound wave, temperature difference, voltage-measuring device, spirit thermometer, working temperature range, inverted glass vessel, temperature span, trouble-free, two wires made of two different metals.

4. Translate into English:
термометр сопротивления, газовый термометр, биметаллический термометр, термопара, жидкостный термометр, расширение, сжатие, повышение и падение температуры, сосуд с широким горлышком.

5. Mind the difficulties in translation:
a) The containers the liquid oxygen is transported are light weighted. b) Substances we can liquefy to low temperatures are called cryogenic fluids. c) When scientists solve the problems they are working at now, the application of cryogenics will be extended. d) The method of research we are looking for now should meet the following requirements: simplicity, convenience and reliability. e) Cryostats are containers fluids are stored in. f) The data the scientists have obtained are of great interest from the point of view of theory and practice as well.

6. Mind the usage of **AS** in the following sentences:
a) **As** temperature increases electrical conductivity decreases. b) They could not continue the experiment **as** they had no liquid helium. c) The

value rose **as** rapidly as they expected. d) The theory is valid **as long as** it agrees with the experiment. e) The mass of an electron is so small **as** to be neglected. f) These metals are usually protected by oil **so as** to exclude air. g) There was a computer **as well as** another expensive equipment there. h) Metal powders are used now **as** insulation.

UNIT 15

accuracy – точность, достоверность
circuit – цепь, схема, контур
convenience – удобство
correspondingly – соответственно
engine – мотор, двигатель
exhaust – выход, выхлоп (газа)
experience – испытывать
improve – улучшать
involve – вовлекать, включать
kiln – печь для обжига и сушки
leg – плечо (цепи)
length – участок, отрезок
magnitude – величина
oppose – противодействовать, препятствовать
output – мощность
precision – точность, четкость
predictable – предсказуемый
reference junction – холодный спай (термопары)
repeatable – повторяющийся
resolution – разрешающая способность, разрешение
sensitivity – чувствительность
temperature gradient – градиент температуры
thermocouple junction – спай (термопары)
vicinity – зона, район, близость

THERMOCOUPLE

A thermocouple consists of two conductors of different materials (usually metal alloys) that produce a voltage in the vicinity of the point where the two conductors are in contact. The voltage produced is dependent on, but not necessarily proportional to, the difference of temperature of the junction to other parts of those conductors. Thermocouples are a widely used type of temperature sensor for measurement and control and can also be used to convert a temperature gradient into electricity. Commercial thermocouples are inexpensive, interchangeable, are supplied with standard connectors, and can measure a wide range of temperatures.

Any junction of dissimilar metals will produce an electric potential related to temperature. Thermocouples for practical measurement of temperature are junctions of specific alloys which have a predictable and repeatable relationship between temperature and voltage. Different alloys are used for different temperature ranges. Properties such as resistance to corrosion may also be important when choosing a type of thermocouple. Electronic instruments can compensate for the varying characteristics of the thermocouple, and so improve the precision and accuracy of measurements.

Thermocouples are widely used in science and industry; applications include temperature measurement for kilns, gas turbine exhaust, diesel engines, and other industrial processes

In 1821, the German–Estonian physicist Thomas Johann Seebeck discovered that when any conductor is subjected to a thermal gradient, it will generate a voltage. This is now known as the thermoelectric effect or Seebeck effect. Any attempt to measure this voltage necessarily involves connecting another conductor to the «hot» end. This additional conductor will then also experience the temperature gradient, and develop a voltage of its own which will oppose the original. Fortunately, the magnitude of the effect depends on the metal in use. Using a dissimilar metal to complete the circuit creates a circuit in which the two legs generate different voltages, leaving a small difference in voltage available for measurement.

The voltage is not generated at the junction of the two metals of the thermocouple but rather along that portion of the length of the two dissimilar metals that is subjected to a temperature gradient. Because both lengths of dissimilar metals experience the same temperature gradient, the end result is a measurement of the difference in temperature between the thermocouple junction and the reference junction.

Certain combinations of alloys have become popular as industry standards. Selection of the combination is driven by cost, availability, convenience, melting point, chemical properties, stability, and output. Different types are usually selected for different applications based on the temperature range and sensitivity needed. Thermocouples with low sensitivities have correspondingly lower resolutions. Other selection criteria include the inertness of the thermocouple material, and whether it is magnetic or not.

EXERCISES

1. What is the meaning of the prefix:
a) inter-: intermolecular, interchangeable, international, interaction, interconnected;
b) dis-: dissimilar, discharge, disorganize, disorder.

2. Pay attention to how the abbreviations are read:
ca. – (Lat.: circa), Eng.: about, Rus.: около, приблизительно;
e.g.– (Lat.: exempli gratia), Eng.: for example, Rus.: например;
etc.– (Lat.: et cetera), Eng.: [et'setre]; Rus.: и т.д.;
i.e. – (Lat.: id est), Eng.: that is, Rus.: то есть;
vs. – (Lat.: versus), Eng.: ['və:ses] «against», Rus.: против, в отличие от, в сравнении с.

3. Translate into Russian:
sensor, gas turbine exhaust, relationship between temperature and voltage, to convert a temperature gradient into electricity, circuit, thermocouple junction. .

4. Translate into English:
эффект Зеебека, сплав, взаимозаменяемый, дизельный двигатель, поставляться со стандартными соединителями, разнородные материалы, точность измерения, устойчивость к коррозии.

5. Mind the different functions of **SHOULD** and **WOULD**. Translate into Russian:
a) To liquefy the gas one **should** use a very low temperature of about 4 K. b) The professor tried to persuade the young man that he was wrong but the latter **would** not listen to him. c) The experimenter **should** have been more careful while registering the readings of the instrument. d) The laboratory assistant said he **would** finish the work by the end of the week.

6. Mind the prepositions ending in **-ING.** Translate the sentences:
a) According to the theory, the reaction rate is easily determined. b) During the process described below there may be some complexities. c) Notwithstanding the pressure difference the process can be carried out to the end. d) No information is available concerning the reaction mechanism. e) A desirable rocket propellant will have exhaust products of low molecular weight, providing these products are at the highest temperature. f) Considerations regarding the choice of the storage method are discussed in detail.

UNIT 16

adjustment – корректировка, подгонка
adopt – принимать
condition – условие, состояние
latter – последний (из упомянутых)
revise – изменять, исправлять

TEMPERATURE SCALES

There are three main temperature scales in use today: Fahrenheit, Celsius and Kelvin.

The Fahrenheit temperature scale is a scale based on 32 for the freezing point of water and 212 for the boiling point of water, the interval between the two being divided into 180 parts. The 18th century the German physicist Daniel Gabriel Fahrenheit originally took as the zero of his scale the temperature of an equal ice-salt mixture and selected the values of 30 and 90 for the freezing point of water and normal body temperature, respectively; these later were revised to 32 and 96, but the final scale required an adjustment to 98.6 for the latter value.

Until the 1970s the Fahrenheit temperature scale was in general common use in English-speaking countries; the Celsius, or centigrade, scale was employed in most other countries and for scientific purposes worldwide. Since that time, however, most English-speaking countries have officially adopted the Celsius scale. The conversion formula of these two scales is $F = 9/5\ °C + 32$.

The Celsius temperature scale, also called the centigrade temperature scale, is the scale based on 0 for the freezing point of water and 100 for the boiling point of water. It was invented in 1742 by the Swedish astronomer Anders Celsius. The Celsius scale is used wherever metric units have become accepted and in scientific work everywhere.

The Kelvin temperature scale is the base unit of thermodynamic temperature measurement in the International System (SI) of measurement. It is defined as 1/273.16 of the triple point (equilibrium among the solid, liquid, and gaseous phases) of pure water. The Kelvin (symbol K without the degree sign) is also the fundamental unit of the Kelvin scale, an absolute temperature scale named for the British physicist William Thomson, Baron Kelvin. Such a scale has as its zero point absolute zero, the theoretical temperature at which the molecules of a substance have the lowest energy. Many physical laws and formulae can be expressed more simply when an absolute temperature scale is used. Accordingly, the Kelvin scale has been adopted as the international standard for scientific temperature measurement.

Many methods have been developed for measuring temperature. Most of them rely on measuring some physical property of a working material that varies with temperature. One of the most common devices for measuring temperature is the glass thermometer. This consists of a glass tube filled with mercury or some other liquid, which acts as the working fluid. Temperature increase causes the fluid to expand, so the temperature can be determined by measuring the volume of the fluid. Such thermometers are usually calibrated so that one can read the temperature simply by observing the level of the fluid in the thermometer.

Under some conditions heat from the measuring instrument can cause a temperature gradient, so the measured temperature is different from the actual temperature of the system. In such a case the measured temperature will vary not only with the temperature of the system, but also with the heat transfer properties of the system.

EXERCISES

1 What part of speech does the suffix -MENT signify?
equipment, attainment, development.

2. Fill in the missing forms:

Verb:	Adjective:
to measure	measurable
to apply	–
to obtain	–
to flame	–
to rely	–

3. Translate into Russian:_
centigrade scale, conversion formula, International system of measurement, ice-salt mixture, calibrate, heat transfer properties.

4. Translate into English:
точка замерзания воды, точка кипения воды, физические законы и формулы, наблюдать, объем жидкости, тройная точка, измерение физических свойств, стеклянная трубка, заполненная ртутью.

5. Translate into Russian paying attention to **ONE, THAT, THOSE:**
a) This idea suggests **that** a superconductor has properties similar to **those** of super fluid helium. b) There are many explanations of superconductivity, scientists continuing to study which is the most accurate **one**. c) This theory is an extremely complicated **one** and we can follow only a few of its major points. d) The superconducting electromagnet is much more efficient than an ordinary **one**. e) It is now thought that metals can be made very pure, particularly **those** containing iron and nickel. f) This new theory, which does much to explain superconductivity, was the result of improving on many earlier **ones**.

6. Mind different ways of expressing **negation** in English and Russian sentences. Translate the following sentences:
a) There is **no** certainty that molecules in a gas must behave in the same way as in a liquid. b) The frost that forms act as an insulator, but with **nowhere** near effectiveness necessary for most cryogenic devices. c) Since there can exist **no** voltage drop along a superconductor, there can be no thermoelectric effect. d) This type of measurement **does not** present difficulties. e) This type of measurement presents **no** difficulties. f) One has **never** known where the limit for the human knowledge is. g) **No one** has ever been able to obtain the temperature of absolute zero. h) No information is available concerning the mechanism of this reaction.

UNIT 17

analgesia – обезболивание
blood vessel – кровеносный сосуд
cellular – клеточный
cryogenic chamber – криогенная камера
cytosol – цитозоль (внутриклеточная жидкость)
damage – повреждение
destroy – разрушать
disorder – расстройство
endorphin – эндорфин (гормон)
goal – цель
immersion – погружение
inflammation – воспаление
insomnia – бессонница
joint – сустав
metabolism – обмен веществ
mole – родимое пятно
muscle – мышца
pain – боль
promote – способствовать
release – выделять, высвобождать
relief – облегчение
skin tag – папиллома
socks – носки
suppress – подавлять, сдерживать
survival – выживание, долговечность
tear (tore, torn) apart – разрывать
treatment – лечение
underwear – нижнее белье
vasoconstriction – сужение кровеносных сосудов
wart – бородавка

CRYOTHERAPY

What is known about cryotherapy nowdays? Cryotherapy is the local or general use of extremely low temperatures in medical therapy. Cryotherapy is used to treat a variety of diseases. The term «cryotherapy» comes from the Greek *cryo* (κρυο) meaning *cold*, and *therapy* (θεραπεια) meaning *cure*. Cryotherapy has been used as early as since the seventeenth century.

Its goal is to decrease cellular metabolism, inflammation, reduce pain and spasm, increase cellular survival, promote vasoconstriction, destroy cells by crystallizing the cytosol, using extreme low temperatures (below –160 °C). General cryotherapy is usually referred to using cryogenic chambers, group and individual ones (cryosaunas). Local cryotherapy can be used in some kinds of therapy or in surgery (cryosurgery). General cryotherapy is sometimes called Whole Body Cryotherapy (WBC) as it consists of whole body immersion into a cold space. WBC is a treatment where a patient is placed in a cryogenic chamber for a short time, around 5 minutes. WBT originated in Japan in 1978, but later engineers from Poland and Russia started to investigate this sphere and advanced the technology and equipment.

The chamber is cooled typically with liquid nitrogen, usually to a temperature from –120 °C to –160 °C. The patient is protected from cold with socks, special shoes and underwear. During treatment the average skin temperature drops to 12 °C, while the coldest skin temperature can be 5 °C. Therapy triggers the release of endorphins which induce analgesia (immediate pain relief). The immediate effect of skin cooling and analgesia lasts for 5 minutes, but the release of endorphins can have a lasting effect, where the pains and signs of inflammation as found in blood tests remain suppressed for weeks. The effects of extreme cold and endorphin release are scientifically studied. It is reported that using cryotherapy successfully helps in treating of psychological stress, insomnia, rheumatism, muscle and joint pain, psoriasis, neurodermatitis, eczema, increases metabolism. Nowadays some other researches have appeared in successful using cryotherapy in sport medicine, sport training process and cosmetology.

Cryosurgery is the application of extreme cold to destroy abnormal or diseased tissue. Cryosurgery is used to treat a number of diseases and disorders, especially skin conditions like warts, moles, skin tags, etc. Liquid nitrogen is usually used to freeze the tissues at the cellular level. The procedure is applied often because of its efficiency and low rates of side effects. Cryosurgery works by taking advantage of the destructive force of freezing temperatures on cells. At low temperatures, ice crystals form inside the cells, which can tear them apart. More damage occurs when blood vessels supplying the diseased tissue freeze.

EXERCISES

1. What does the prefix INTER- signify?
interaction, interatomic, interchange, intergovernmental, intermediate.

2. Remember the three most productive suffixes to form verbs: -IZE, -FY, -ATE:
a) simplify, liquefy, solidify, signify;
b) maximize, minimize, vaporize, mechanize;
c) insulate, evaporate, calculate, penetrate. .

3. Translate the following word combinations into Russian:
cryotherapy, destructive force, insomnia, lasting effect, cryosauna, analgesia, release of endorphins, psychological stress, sport training process.

4. Translate the following word combinations into English:
общая терапия, обмен веществ, криогенная камера, сужение сосудов, быстрое снятие боли, спортивная медицина, криохирургия, лечение.

5. Mind the various meanings of the words: **APPEAR, SEEM, HAPPEN, TURN OUT, FIND, LIKELY, ALLOW**. Translate the sentences:
a) Some metal surfaces which **appear** dull are better reflectors in the infrared than some which **appear** shiny. b) It may **seem** at first glance that the perfect conductor should be a perfect reflector. c) It **turns out** that superconductors are not suited to the purpose. d) A nuclear reactor **turned out** to be the best method of heating hydrogen. e) It has been **found** that the addition of certain protective agents to some organisms will allow them to survive the freezing cycle. f) What **happens** in some cases is that the glycerol lowers the temperature at which ice begins to form. g) Expansion has taken place too fast to **allow** any vaporisation. h) This idea **seems** a bit advanced. i) It is **likely** that the method will **find** its greatest application. j) Germanium has been **found** to be the best of the **likely** candidates for temperature measurements for reasons of stability.

6. Mind the translation of the following words: **(N)EITHER... (N)OR; THE FORMER, THE LATTER:**
a) Heat is conducted along **whatever** solids touch both inner and outer container, **either** as supports for the inner container **or** as components

of the insulating material. b) **Neither** rocketry **nor** computer electronics can develop without cryogenics. c) Rocketry and cryogenics were joined together when cryogens were used in the first rocket. Since then **either** science depends on the other. d) Both hydrogen and helium are used as thermometric substances in vapour pressure thermometry, but **neither** can be used for measuring temperatures above 40 K. e) The metal can exist in **either** the normally conducting or the superconducting state depending on whether or not it is in a magnetic field. f) The rates and molecular weights are affected by lowering the temperature, the **former** being decreased and the **latter** increased. g) Both glass and stainless steel are used for manufacturing dewars, but the **former** has the tendency for low-temperature embrittlement, while the **latter** has considerably greater heat conduction.

UNIT 18

behavior – поведение
cryonics – крионика
emergency medicine – неотложная медицинская помощь, медицина катастроф
intention – намерение
magnetic resonance imaging – магниторезонансная томография (МРТ)
novel – новый, новаторский
preservation – сохранение
propellant – ракетное топливо
radio-frequency pulse – высокочастотный импульс
rare – редкий
refer to as – называть
relaxation of protons – релаксация протонов
revival – оживление
rheology – реология
seek (sought, sought) – искать
throughput – производительность
waste of power – потери энергии

APPLICATIONS OF CRYOGENICS

As it was mentioned earlier, cryogenics is the study of the production of very low temperatures (below –150 °C, –238 °F or 123 K) and the behavior of materials at those temperatures. A person who studies elements under extremely cold temperature is called a cryogenicist or an extremely low temperatures region physicist.

Among the fields of cryogenics application it is possible to define the following ones. Cryobiology is the branch of biology involving the study of the effects of low temperatures on organisms (most often for the purpose of achieving cryopreservation). Cryosurgery is the branch of surgery applying very low temperatures (down to –196 °C) to destroy malignant tissue, e.g. cancer cells. Cryotherapy, a branch of physiotherapy, applies very low temperatures for treatment the range of diseases, such as psychological stress, insomnia, rheumatism, muscle and joint pain, psoriasis, neurodermatitis, eczema etc. Cryonics is the novel medical technology of cryopreserving humans and animals with the intention of future revival. Researchers in the field seek to apply the results of many sciences, including cryobiology, cryogenics, rheology, emergency medicine, blood banking (storage of rare blood groups) etc. Cryoelectronics is the field of research on superconductivity at low temperatures. Cryotronics is the practical application of cryoelectronics.

Another important use of cryogenics is cryogenic fuels. Cryogenic fuels, mainly liquid hydrogen, have been used as rocket fuels. Liquid oxygen is used as an oxidizer of hydrogen, but oxygen is not, strictly speaking, a fuel. For example, NASA's space shuttles used cryogenic hydrogen/oxygen propellant as its primary means of getting into orbit, and all of the rockets built for the Soviet space program by Sergei Korolev used liquid oxygen as their oxidizer.

The Russian aircraft manufacturer Tupolev developed a version of its popular design Tu-154 with a cryogenic fuel system, known as Tu-155. The plane used a fuel referred to as liquefied natural gas or LNG, and made its first flight in 1989.

Magnetic resonance imaging (MRI) is a method of imaging objects that uses a strong magnetic field to detect the relaxation of protons that have been influenced by a radio-frequency pulse. This magnetic field is generated by electromagnets, and high field strengths can be achieved by using superconducting magnets. Traditionally, liquid helium is used as a cooling agent because it has a boiling point of around 4 K at ambient pressure, and cheap metallic superconductors can be used.

Also it is necessary to mention electric power transmission in big cities. It is difficult to transmit power by overhead cables in big cities, so underground cables are used. But underground cables get heated, and the increased resistance of the wire leads to waste of power. Superconductors could be used to increase power throughput, although they would require cryogenic liquids such as nitrogen or helium to cool special alloy-containing cables to increase power transmission.

EXERCISES

1. Give all the words containing the Greek morpheme CRYO, which you come across in the book.

2. Remember some of the words often used in scientific literature to connect sentences:

for (союз) – ибо, так как – показывает, что сказанное есть причина того, что упомянуто выше;

the former … the latter – первый (из двух упомянутых) … последний (из двух упомянутых) – средство выделить одну или другую группу существительного в предыдущем предложении;

hence – отсюда, в результате – означает закономерность последующего утверждения;

however – однако, тем не менее – означает неожиданный поворот в ходе рассуждения;

therefore – поэтому, следовательно – указывает, что последующее предложение есть результат того, что сказано выше;

thus – таким образом – обычно указывает на связь между предложениями или его членами;

in addition – кроме того – служит для введения дополнительных сведений.

3. Translate into Russian:

cryogenicist, rheology, cryotronics, cryopreservation, extremely low temperatures region physicist, refer to as, magnetic resonance imaging, rare blood group, blood banking, primary means.

4. Translate into English:

новейшая медицинская технология, сжиженный природный газ, надземный кабель, подземный кабель, космический корабль, передача электроэнергии, потери энергии, окислитель, авиаконструктор.

5. Remember how **NAPC** is translated into Russian:

a) Both metallic and non-metallic materials are used, the major consideration being to provide sufficient strength for the structure. b) Another advantage of the thermocouple is that no power supply is necessary, the element generating its own signal. c) The temperature being not too high, the superheated conditions can be maintained for an indefinite time.

6. Mind that sometimes the **NAPC** may be preceded by the preposition **WITH** which is not translated into Russian:

a) With the reaction rate between salts and the cell walls retarded, dehydration is not catastrophic. b) The vacuum jacket of some cryogenic vessels is filled with many layers of aluminium foil separated by thin glass fibre paper, with the resultant insulation having an extremely low conductivity. c) With cryogenic techniques applied, blood can be stored for years.

LANGUAGE PRACTICE UNITS 13–18

Comprehension

Revise texts 13–18 and chose the correct answer:

Helium II is…

a) …the warmer form of Helium 4.
b) …the colder form of Helium 4.
c) … a conventional liquid.

Speaking

Choose a topic and discuss it in a group.

1. Superfluidity.
2. Temperature scales.
3. Thermometers.

Speaking tips

a) Take everyone's point of view into account.
b) Don't speak about too many things.
c) Choose one or two facts you know well and give examples.
d) Use your own ideas.

Helpful phrases

As far as I know...
Don't you know...?
I would like to add...
Well, I totally agree with you...
Don't you think...?
Have you heard...?
May I just cut in here...

Writing

Revise the texts 17–18 and write a letter to your scientific supervisor telling him/her which areas of cryogenics you would like to specialize in and why.

VOCABULARY

absorb – поглощать, впитывать
accomplish – выполнять
account for – объяснять
accuracy – точность, достоверность
accurate – точный
achieve – достигать
acquire – получать, приобретать
adjustment – корректировка, подгонка
adopt – принимать
aerogel – аэрогель
agriculture – сельское хозяйство
air separation – воздушная сепарация
allow – позволять, разрешать
alloy – сплав
ambient – окружающий
analgesia – обезболивание
annular – кольцевой
appearance – внешний вид
application – применение
apply – применять
apply for a patent – подать заявку на выдачу патента
approach – достигать
appropriate – подходящий, соответствующий
approximately – приблизительно
arise (arose, arisen) – возникать, появляться
assume – признавать
attainment – достижение
attempt – попытка
attractive forces – силы притяжения
attribute – относить, классифицировать
availability – наличие
average – средний
barrel – мера емкости (английский – 163,3 л; американский – 119 л)
be aware of – осознавать, быть в курсе
behavior – поведение
bending effect – эффект искривления

benign – доброкачественный
bimetallic strip thermometer – биметаллический термометр
bind (bound) – связывать
bismuth – висмут
blood – кровь
blood vessel – кровеносный сосуд
boil – кипеть
bond – связывать, соединять
breathe – дышать
bring (brought) about – вызывать
brittle – ломкий, хрупкий
build up – накапливать
bulb – колба
cancer – рак
cap – крышка, колпачок
capacity – емкость
capillary – капилляр (трубка с очень узким каналом)
carrier – носитель
cease – прекращать(ся)
cell – клетка
cellular – клеточный
circuit – цепь, схема, контур
cite – цитировать, ссылаться на что-либо
close – близкий, тесный
collapse – разрушаться
come into one's own – возникать
composite – композит, композиционный материал
compression – сжатие
concern – заниматься, интересоваться, беспокоиться, опасаться
condense – конденсировать, сгущать
condition – условие, состояние
conservation – сохранение
consider – рассматривать, считать
considerable – значительный
constituent – составная часть
constitute – составлять, основывать
contract – сжиматься

contraction – сжатие
convenience – удобство
conventional – обычный, традиционный
copper – медь
correspondingly – соответственно
counter-current – противоточный
crack – трескаться, раскалываться
crumble – разрушаться
cryogenic chamber – криогенная камера
cryonics – крионика
curve – кривая
cytosol – цитозоль (внутриклеточная жидкость)
damage – повреждение
dangerous – опасный
deal with – иметь дело с
decrease – уменьшаться
define – определять
demand – спрос
depend on/upon – зависеть от
design – конструировать
destroy – разрушать
detect – обнаруживать
determine – определять
develop – развивать, разрабатывать
deviation – отклонение
devise – разрабатывать, изобретать
dirigible – дирижабль
disorder – расстройство
dispense – распределять, перекачивать
distinguish – различать, отмечать
distortion – искажение, деформация
drop – падать
due to – благодаря, вследствие
durable – долговечный, прочный, надежный
efficiency – эффективность
efficient – эффективный
eliminate – исключать, устранять

emergency medicine – неотложная медицинская помощь, медицина катастроф
employ – применять
encounter – встречаться, сталкиваться
encourage – поддерживать, поощрять
endorphin – эндорфин (гормон)
engine – мотор, двигатель
environment – среда
evacuated – вакуумный
evaporate – испаряться
eventually – в конечном итоге
evidence – доказательство
exhaust – выход, выхлоп (газа)
exist – существовать
expand – расширяться
expansion – расширение
expel – исключать, вытеснять
experience – испытывать
exploit – применять, использовать
explosion – взрыв
explosive – взрывчатый
expose – подвергать воздействию
exposure – воздействие
external – внешний
extract – извлекать, выделять
fail – потерпеть неудачу
fascinating – очаровательный, пленительный, захватывающий
fill – наполнять
fissure – трещина
flask – баллон, сосуд (Дьюара)
flat – плоский
fluid – текучая среда (жидкость или газ)
foam glass – пеностекло
foil – фольга
force – *зд.* пропускать
fountain effect – фонтанный эффект
gallon – мера емкости (английский – 4,54 л; американский – 3,78 л)

give (gave, given) up – оставить, бросить
glass fiber – стекловолокно
goal – цель
ground state – основное (квантовое) состояние
handle – обращаться, управляться
happen – происходить, случаться
high-performance – высокоэффективный
humid – влажный
immersion – погружение
impact – воздействие
imply – подразумевать, значить
improve – улучшать
impurity – примесь
in reverse – наоборот
incursion – попадание, проникновение
indication – показатель, признак
inflammation – воспаление
inherent – неотъемлемый, присущий, свойственный
inhibit – подавлять
initiate – начать
inscribe – наносить
insert – вставить, ввести
insomnia – бессонница
inspire – вдохновлять
install – установить
insulate – изолировать
insulation – изоляция
intend – предназначать
intention – намерение
introduce – вводить
invent – изобретать
inversion – обратное преобразование
inverted glass vessel – перевернутый стеклянный сосуд
investigate – исследовать, изучать
involve – вовлекать, включать
inward – внутрь
joint – сустав

junction – соединение
kiln – печь для обжига и сушки
lambda point – лямбда-точка
latent heat – скрытая теплота
latter – последний (из упомянутых)
lattice – решетка
leak – утечка
leg – плечо (цепи)
length – участок, отрезок
lesion – повреждение, поражение
lid – крышка
liquefy – сжижать
liquid petroleum gas – сжиженный нефтяной газ
long-lasting – долговечный, с длительным сроком службы
loop – петля
loose fitting – неплотно прилегающий
lower – понижать
low-maintenance – не требующий тщательного ухода, обслуживания
lubricating oil – смазочное масло, смазка
magnetic resonance imaging – магниторезонансная томография (МРТ)
magnetically-levitated – на магнитной подвеске
magnitude – величина
make demand – предъявлять требования
make up – составлять
malignant – злокачественный
means – средство(а)
meet requirements – удовлетворить потребности
meniscus – мениск (граница между жидкостью и воздухом)
mention – упоминать
mercury – ртуть
metabolism – обмен веществ
missile – ракета, космический корабль
mitigate – смягчать
moderate – умеренный
moisture – влага
mole – родимое пятно
mount – устанавливать, монтировать

multilayer – многослойный
multistage – многоступенчатый
muscle – мышца
mylar – майлар
neighbourhood – область
nitrous oxide – закись азота
notable – примечательный, заметный, видный
notion – идея, представление
novel – новый, новаторский
numerical – числовой
observe – наблюдать
obtain – получать
occur – происходить
odd – необычный, странный
oppose – противодействовать, препятствовать
output – мощность
pain – боль
pattern – модель
per (hour) – в (час)
perform – выполнять
permit – позволять
plant – установка
plug – пробка, заглушка
polar explorer – полярный исследователь
pollute – загрязнять
porous – пористый
power – служить источником энергии
precise – точный
precisely – точно
precision – точность, четкость
predictable – предсказуемый
preservation – сохранение
preserve – сохранять, консервировать
pressure – давление
pressure relief device – устройство для понижения давления, устройство для сброса давления
pressurize – поддерживать, создавать повышенное давление

prevent – предотвращать, предупреждать
promote – способствовать
pronounced – четкий, определенный, ярко выраженный
propel – двигать, приводить в движение
propellant – ракетное топливо
provide – обеспечивать, снабжать
provisional specification – предварительная спецификация (документ, определяющий, например, состав или содержание процесса или изделия)
pull – тянуть
pump – накачивать, нагнетать
pure – чистый, без примесей
purify – очищать
purpose – цель
push through – проталкивать
quantum gravity – квантовая гравитация
radiation barrier – защитный экран от излучения
radiation shield – радиационная защита
radio-frequency pulse – высокочастотный импульс
raise – поднимать, повышать
range – предел, диапазон, область, сфера
rapid – быстрый
rare – редкий
reach – достигать
reading – показания
realm – сфера, область
recognise – признавать
recover – извлекать, получать, выделять, восстанавливать
refer to – ссылаться на, относиться к; *зд.*: говорить о
refer to as – называть
reference – справка
reference junction – холодный спай (термопары)
reflective – отражательный
refraction – преломление, рефракция
refrigerant – хладагент
regain – восстанавливать
regard – рассматривать, расценивать, считать
regenerative cooling – регенеративное охлаждение

relaxation of protons – релаксация протонов
release – выделять, высвобождать
relief – облегчение
rely on – полагаться на
remain – оставаться
remove – отводить, удалять
renewable – возобновляемый
repeatable – повторяющийся
repulsive force – сила отталкивания
resistance – сопротивление
resolution – разрешающая способность, разрешение
restore – восстанавливать, возвращать в прежнее состояние
result from – происходить, получаться из-за чего-либо
result in – приводить к
retain – удерживать, сохранять
revert – возвращаться
revise – изменять, исправлять
revival – оживление
revolutionize – производить коренные изменения
rheology – реология
rise (rose, risen) – подниматься
row – ряд
rubber – резина
rule out – исключать
safety relief valve – предохранительный клапан
save – сохранять, сберегать
scale – шкала
scatter – рассеиваться, разбегаться
seek – искать
self-contradicting – противоречащий сам себе
sensitivity – чувствительность
separate – отделять, разделять
shatter – разбиваться вдребезги
ship – транспортировать
shuttle – космический корабль
significant – значительный, существенный
similar – подобный, похожий

skin tag – папиллома
socks – носки
solar eclipse – солнечное затмение
solidify – затвердевать, превращаться в твердое состояние
sophistication – усложнение, усовершенствование
spacer – прокладка
span – диапазон
specimen – образец, экземпляр
split (split, split) – распределять, делить на части
squirt – бить струей
stack – штабелировать, укладывать правильными слоями
stainless steel – нержавеющая сталь
state – устанавливать
steel mill – сталелитейный завод
store – сохранять, накапливать
strain – напряжение, нагрузка
stream – поток
strengthen – усиливать
stubbornly gases – упрямые газы
submit – представлять на рассмотрение
substantial – важный, значительный
succeeding – последующий
sufficient – достаточный, обоснованный
suggest – предполагать
superfluidity – сверхтекучесть
support – опора, основа, подложка
support – поддерживать
suppress – подавлять, сдерживать
surface – поверхность
surgery – хирургия
survival – выживание, долговечность
take on – приобретать
tear (tore, torn) apart – разрывать
temperature gradient – градиент температуры
terrestrial – земной
thermocouple junction – спай (термопары)
throttle valve – дроссельный клапан

throughput – производительность
tint – оттенок
tiny – крошечный
transfer – передавать
translational symmetry – трансляционная симметрия (тип симметрии, при которой свойства рассматриваемой системы не изменяются при сдвиге на определённый вектор)
treat – лечить
treatment – лечение
tremendous – огромный, громадный
truck chassis – шасси грузового автомобиля
turn on/off – включить/выключить
undergo – испытывать, переносить; подвергаться чему-либо
underwear – нижнее белье
unlike – в отличие
untempered glass – незакаленное стекло
upper atmosphere – верхние слои атмосферы
vacuum-jacketed – с вакуумной рубашкой
valuable – ценный
value – значение
value – ценить
valve – клапан
vaporization – испарение
vary – варьироваться, изменяться
vasoconstriction – сужение кровеносных сосудов
vehicle – транспортное средство
vent – вентилировать, выпускать
vibration – колебание
vicinity – зона, район, близость
virtually – фактически
viscosity – вязкость
visualize – мысленно представлять
vital – жизненно важный, насущный, существенный, необходимый
voltage-measuring device – прибор для измерения напряжения
warm up – подогревать
wart – бородавка
waste of power – потери энергии

weigh – весить
wide-mouthed – с широким горлышком
wire – проволока
withstand – выдерживать
wrap – обертывать

СПИСОК ЛИТЕРАТУРЫ

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